GEM 5 SES-3 Specification

205213700-00-A
March 2023

Revision History

Revision	Date	Description
00-A	2023-03-30	Initial Release

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1 Introduction

1.1 Scope

This document provides details of the GEM 5 enclosure firmware's support for the ANSI T-10 SES-3 standard. It details the standard and vendor defined diagnostic pages supported by the Seagate storage enclosures range of enclosures running GEM firmware.

1.2 Terms and Abbreviations

AC	Alternating Current
ACPI	Advanced Configuration and Power Interface
ANSI	American National Standards Institute
ASC	Additional Sense Code
ASCII	American Standard Code for Information Interchange
ASCQ	Additional Sense Code Qualifier
BBU	Battery Backup Unit
BIOS	Basic Input/Output System
BMC	Baseboard Management Controller
CDB	Command Descriptor Block
CLI	Command Line Interface
CPU	Central Processor Unit
CRC	Cyclic Redundancy Check
DC	Direct Current
DWORD	Double Word
ECC	Error Correction Code
EEPROM	Electrically Erasable Programmable Read-Only Memory
EM	Enclosure Management
ESI	Enclosure Services Interface Processor
ESP	Enclosure Services Process
FC	Fibre Channel
FC-AL	Fibre Channel – Arbitrated Loop
FIFO	First In First Out
FRU	Field Replaceable Unit
GEM	General Enclosure Management
HW	Hardware
I_T	Initiator to Target
I^2C	Inter-Integrated Circuit
ID	Identifier
IERR	Internal Error
IPC	Inter-Processor Communication
IPMB	Intelligent Platform Management Bus
IPMI	Intelligent Platform Management Interface
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
NAA	Network Address Authority
OCP	Over-Current Protection
OEM	Original Equipment Manufacturer
OTP	Over-Temperature Protection
PCI	Peripheral Component Interconnect
PCM	Power and Cooling Module
PDB	Power Distribution Board
PID	Proportional-Integral-Derivative
PN	Part Number
POST	Power-On Self-Test

PSU	Power Supply Unit
QSFP	Quad-SFP
RAM	Random Access Memory
ROM	Read Only Memory
RPM	Revolutions Per Minute
RX	Receive
SAM	SCSI Architectural Model
SAS	Serial Attached SCSI
SATA	Serial AT Attachment
SBB	Storage Bridge Bay
SBBMI	SBB Midplane Interconnect
SCSI	Small Computer System Interface
SEL	System Event Log
SEP	Storage Enclosure Processor
SES	SCSI Enclosure Services
SFF	Small Form Factor
SFP	Small Form-factor Pluggable
SHA256	Secure Hash Algorithm 256-bit
SMP	Serial Management Protocol
SN	Serial Number
SPC	SCSI Primary Commands
SPL	SAS Protocol Layer
SSP	Serial SCSI Protocol
STP	SATA Tunnelling Protocol
SW	Software
TWI	Two Wire Interface
TX	Transmit
UVP	Under-Voltage Protection
VPD	Vital Product Data
WWN	World Wide Name

Application client	An object that is the source of SCSI commands.
Attached ESP	An ESP that is attached to another device server.
Critical condition	An enclosure condition established when one or more elements inside the enclosure have failed or are operating outside of their specification. The failure of the element makes continued normal operation of at least some elements in the enclosure impossible. Some elements within the enclosure may be able to continue normal operation.
Information condition	An enclosure condition that should be made known to the application client. The condition is not an error and does not reduce the capabilities of the devices in the enclosure.
Noncritical condition	An enclosure condition established when one or more elements inside the enclosure have failed or are operating outside of their specifications. The failure of the elements does not affect continued normal operation of the enclosure. All SCSI devices in the enclosure continue to operate according to their specifications. The ability of the devices to operate correctly if additional failures occur may be reduced by a noncritical condition.
Standalone ESP	An ESP that is also the device server.
Subenclosure	An enclosure accessed through a primary subenclosure's ESP.
Unrecoverable condition	An enclosure condition established when one or more elements inside the enclosure have failed and have disabled some functions of the enclosure. The enclosure may be incapable of recovering or bypassing the failure and requires repairs to correct the condition.

1.3 Notation Conventions

<value>h	Denotes a hexadecimal number, e.g., *23h.*
<value>b	Denotes a binary number, e.g., *1010b.*
<value>	A value without leading zeroes and no suffix denotes a decimal number, e.g., *34.*
[option0, option1]	This indicates possible options for this field.
[valueX..valueY]	This indicates options range from valueX to valueY.
[defaultX: valueX..valueY]	This indicates the default value “defaultX”, with possible alternatives.
[XX]	This indicates variable values.
FIELD NAME	A greyed-out field name in a table indicates that the field is defined but not supported by the GEM firmware.

1.4 References

[1] SCSI Enclosure Services – 3 (SES-3) Revision 6, ANSI T-10
[2] SCSI Primary Commands - 4 (SPC-4) Revision 36n, ANSI T-10
[3] GEM 5 SCSI Specification
[4] GEM Firmware Upgrade Guide
[5] SFF-8636 Specification for Common Management Interface - Rev 1.4 April 12, 2013

2 Overview

2.1 SCSI Enclosure Services

SCSI Enclosure Services (SES) is an ANSI T-10 standard that provides an interface for controlling and querying storage enclosure devices. It is defined as a set of control and status pages that are accessed using the SEND DIAGNOSTIC and RECEIVE DIAGNOSTIC RESULTS SCSI commands (see [2] and [3] for details on SEND DIAGNOSTIC and RECEIVE DIAGNOSTIC RESULTS).

The SCSI device located within the storage enclosure that is capable of servicing SES requests is known as the SES Target. It can be identified by locating the SCSI device that has the ENCSERV bit set to '1' or has a DEVICE TYPE of ENCLOSURE SERVICES DEVICE in its SCSI INQUIRY response (see [2]).

2.2 Enclosure Services Process

The Enclosure Services Process (ESP) is either attached to, or runs within, the SES Target device. It is responsible for processing the SES requests sent to the SES Target. In addition to this, the Enclosure Services Process may provide other enclosure management services, such as FRU management and management of hardware devices located within the physical enclosure itself.

The ESP is accessed by the host using the SES pages accessed by the SEND DIAGNOSTIC and RECEIVE DIAGNOSTIC RESULTS SCSI commands. As most Seagate direct attached storage enclosures utilize SAS expander devices to provide SEP functionality, the ESP can be directly accessed as an independent SCSI device on the Expander's dedicated SSP target.

2.3 SES Compliance

GEM 5 is compliant to version 3 of the ANSI T-10 SES specification.

3 Enclosure Management

The GEM enclosure management firmware running within the Seagate storage enclosure is responsible for performing the role of the ESP. It typically runs on a processor embedded within each enclosure I/O Module that has an attachment to the SES Target Device. In most cases this is a SAS Expander device.

As there are multiple instances of GEM running in the enclosure (at least one for each I/O Module), GEM synchronizes its SES status and control information to provide a consolidated view of the enclosure. This means that from an SES Initiator perspective, the enclosure appears as a single multi-ported ESP device, as illustrated in Figure 3.1.

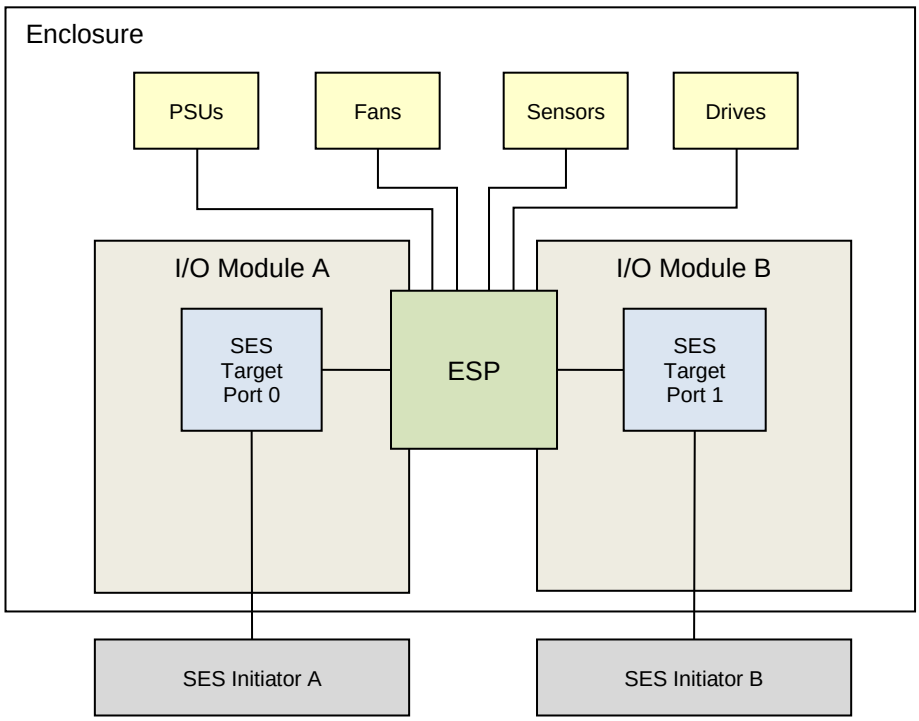

Figure 3.1 - Logical SES view of a GEM Enclosure

GEM is designed to manage all internal functions of the enclosure, e.g., Thermal Management, Fan Failure and Power Management. It is not necessary for an SES application client to actively manage any of these functions; only to report status where desirable. Although GEM doesn't have the direct ability to set visual and audible indicators based on faults with the disk media or logical volume condition, it does provide an interface for the host do this.

3.1 Command Processing

Each instance of GEM maintains its own SCSI queue for processing commands. By default, GEM maintains support for up to 7 SES initiators and maintains a queue depth of 8 tasks. SEND and RECEIVE DIAGNOSTIC commands received by GEM are queued and processed serially in the order they are received. Once the queue depth has been exceeded, GEM will return a BUSY status.

When processing SES control requests, GEM retains the right to deny or ignore the command under the following circumstances:

a) The request is invalid
b) The request would result in undesirable enclosure operation
c) There is insufficient resource to handle the request

d) The request valid but is unsupported by the enclosure.
e) The request conflicts with another request of higher priority.

When an SES request is ignored, rather than rejected, no CHECK CONDITION or INVOP status is set. If invalid SES requests are received by the enclosure, the INVOP bit is not set but the SEND DIAGNOSTIC command is terminated with the CHECK CONDITION status to inform the client application of the error. As such the SES initiator is required to check the element status after a control operation to confirm that the operation has been honored by the enclosure.

3.2 Subenclosures

SES Subenclosures provide a mechanism for partitioning an Enclosure Service's device into multiple physical or logical sub-components. For example, each enclosure FRU, such as a PSU, could be represented as an individual sub-enclosure device.

When a single enclosure is present, it is considered the primary subenclosure. When multiple enclosures are present, the primary subenclosure is the enclosure whose ESP provides access to the enclosure services information of all other subenclosures. Any other subenclosures are considered secondary subenclosures. The enclosure services information from multiple subenclosures is combined to form a single set of SES diagnostic pages.

GEM does not currently support multiple subenclosures and represents all of the enclosure's subcomponents as members of subenclosure 0 (the primary subenclosure).

3.3 Element Indexing

SES utilizes multiple indexing schemes for referring to the location of elements within diagnostic pages. These schemes are covered in sections 3.3.1 to 3.3.3.

3.3.1 Absolute Element Index

An absolute SES element index refers to the position of an element starting from the first element in the page. It is zero-based and inclusive of the overall elements.

3.3.2 Type-Relative Element Index

A type-relative SES element index refers to the position of an element starting from the first individual element in the page of the same type as the element being referenced. It is zero-based and exclusive of the overall elements.

3.3.3 Global Element Index

A global SES element index refers to the position of an element starting from the first individual element in the page. It is zero-based and exclusive of the overall elements. Element position calculations using global indexes have to factor in the overall elements that appear prior to the element being referenced.

4 Application Client Implementation Notes

4.1 Identifying a SCSI Enclosure Services Device

The application client should issue a SCSI INQUIRY command (see SPC-4 [2]) to each target within the Storage topology. Within its INQUIRY response, an enclosure services processes shall set the ENCSERV bit to one and the DEVICE TYPE to ENCLOSURE SERVICES DEVICE.

4.2 Dual Interface Module operation

An enclosure fitted with dual I/O Modules will operate in a primary and secondary relationship. The primary module is responsible for controlling enclosure hardware and synchronizing its state with the secondary. The secondary is responsible for forwarding any local state to the primary along with any control operations it receives. Regardless of operating role, both interface modules are designed to report the same SES status and handle SES requests from the host controller. The host is not required to have any knowledge of the operating role of the interface modules. Despite this, it is possible to determine which I/O module is running in the primary role by querying the ACTIVE bit in the Enclosure Services Controller Electronics element in SES page 02h (see 7.9).

When the Enclosure Services Process running on an I/O module receives an SES control page, it will replicate the control requests and synchronize them with the SEP running on the partner interface module. If the request can be satisfied by the SEP that received the command it is processed locally, otherwise the partner module will perform the control operation.

The process of routing control requests to the other Interface Module is subject to a typical latency of the order of 100ms. This, however, can extend to a maximum latency of 20 seconds if the IPC communications link is faulty. If communications with the partner enclosure process is not possible, the SEP returns a CHECK CONDITION with ASC/ASCQ set to ENCLOSURE SERVICES UNAVAILABLE; see Table 1.

If the application client wishes to check on the progress of a previously submitted command, it would need to check the Status Page for INVOP and/or Element status bits.

4.3 Guidelines for SES application client implementation

4.3.1 SES Page Decoding

It is recommended that SES application clients follow the spirit of ANSI SES-3, which is to make the page handling flexible by using the Type Descriptor Header List (see 6.2.2) in the Configuration Page (SES page 01h) to determine page structure. While it is possible to create hard-coded page maps, it is a less flexible approach that doesn't easily cope with changes in page structure.

4.3.2 Default Element Handlers

The application client should provide a default handler for element types that are not immediately recognized. This will ensure the application client can handle new SES element types as they are introduced by either Seagate or ANSI. Element types that are not recognized should not be treated as an error.

4.3.3 GENERATION CODE

The GENERATION CODE field is a 4-byte wrapping counter that shall be incremented by one every time the enclosure configuration is modified such that the Configuration Page changes. The counter shall not be changed by status changes for elements already described by the configuration page. This means that if the format of the configuration page changes, the generation code is increased. Changes in the configuration page may be caused by changes in the number of elements supported or by changes in the number or configuration of secondary subenclosures. Enclosures that do not change in configuration use a fixed value of 00000000h for the GENERATION CODE field. This is currently the case for enclosures running the GEM firmware.

Enclosure services processes shall establish a UNIT ATTENTION condition (see SAM-4 and SPC-4) for all I_T nexuses when there is a change in value of the GENERATION CODE field. The additional sense code for the UNIT ATTENTION condition shall be TARGET OPERATING CONDITIONS HAVE CHANGED. The UNIT ATTENTION condition shall be cleared for all I_T nexuses without being reported if a RECEIVE DIAGNOSTIC RESULTS command is processed that requests a Configuration diagnostic page (i.e., the PAGE CODE field set to 01h).

Attached enclosure services processes shall verify that the value of the generation code field has not unexpectedly changed, since no unit attention condition is established by such devices.

In an SES control page, the generation code written by the application client shall have the value expected to be found in the generation code field of the configuration page. To prevent the misinterpretation of the overall control and element control fields, the enclosure services process shall verify that the value of the generation code field matches the generation code value known by the enclosure services process. If there is a generation code mismatch the application client shall be notified with a CHECK CONDITION status.

The application client should check the Generation Code for all pages read from the enclosure to determine if this value has changed from the value read back from the Configuration diagnostic page. A change in the Generation Code is a signal to the application client that the page layout has changed. If the Generation Code has changed, then the Configuration Page 01h should be reread and the Type Descriptor Header List re-parsed to determine the page layouts. If this is not performed, there is a risk that the application client will decode the pages incorrectly.

The application client should not interpret the Generation Code as a fixed page format version field. The Generation Code is purely a signaling mechanism for indicating that the page layouts have changed.

Although not used today, GEM does support the generation code field and therefore it is recommended that application clients also support it.

4.3.4 ENCLOSURE DESCRIPTOR LENGTH

The Configuration diagnostic page (6.2) contains a variable length region for Vendor Information. To ensure the correct length of this region, the ENCLOSURE DESCRIPTOR LENGTH should be used.

4.3.5 Uniquely Identifying an Enclosure

An enclosure can be uniquely identified using the ENCLOSURE LOGICAL IDENTIFIER field in SES Page 01h or the vendor unique PRODUCT SERIAL NUMBER field, also in SES Page01h.

The ENCLOSURE LOGICAL IDENTIFIER contains the NAA 5 WWN for the enclosure. This number is retrieved by GEM from a non-volatile VPD device located in the enclosure chassis. As such, the same value is reported by all I/O Modules present in the enclosure and will not change after FRU replacements.

If, for any reason, the ENCLOSURE LOGICAL IDENTIFIER cannot be retrieved after an I/O Module reset, an invalid WWN of either 0000000000000000h or 5858585858585858h shall be reported (A valid WWN is defined to be prefixed with the Network Address Authority, NAA 0101b or 0010b).

4.4 Invalid Field Errors

For a standalone enclosure services process, any invalid fields included in the CDB or parameters of a SEND DIAGNOSTIC command and any invalid fields in the CDB of a RECEIVE DIAGNOSTIC RESULTS command shall be detected by the SEP. The SEP shall analyze these parameters before performing the requested operations and, if there is an error, the command shall be terminated with a CHECK CONDITION status. The sense key shall be set to ILLEGAL REQUEST and the additional sense code shall identify the location of the invalid fields - in CDB or parameter data.

An example whereby the SEP encounters an invalid field in the CDB is when the parameter list length field in the CDB does not match the page length in the diagnostic page. In such a scenario the SEP will respond with a status of CHECK CONDITION with a sense key of ILLEGAL REQUEST and ASC/ASCQ of INVALID FIELD IN CDB.

4.5 CHECK CONDITION Status

As with all SCSI devices, the SEP indicates invalid operations, warning conditions and failure conditions by terminating the command with a CHECK CONDITION status with the sense key and ASC describing the indication. A subsequent RECEIVE DIAGNOSTIC RESULTS command requesting an Enclosure Status diagnostic page may be required to clarify the indication and to identify the element causing the indication.

The table below defines additional sense codes that are used to indicate invalid send/receive diagnostic requests. The values are assigned in SPC-4.

Table 1 – Additional Sense Codes

Sense Key/ ASC/ASCQ	Description	Cause
1/0B/02	RECOVERED ERROR/WARNING – ENCLOSURE DEGRADED	A control request has caused an informational or non-critical condition to be detected by the enclosure. For example, an attempt has been made to set a temperature warning threshold in SES page 05h so that the current reading exceeds it.
2/35/02	NOT READY – ENCLOSURE SERVICES UNAVAILABLE	The ESP is unable to handle the current request. The ESP may become available at a later point in time. This condition may be received during a soft reboot where some aspects of the SCSI target may be available, but others have yet to start.
5/20/00	ILLEGAL REQUEST – INVALID COMMAND OPERATION CODE	The command operation code is not supported by the enclosure.
5/24/00	ILLEGAL REQUEST – INVALID FIELD IN CDB	A field specified in the CDB for a command is invalid. For example, the CDB parameter list length does not match the length of data supplied for a SEND DIAGNOSTIC page.
5/25/00	ILLEGAL REQUEST – LOGICAL UNIT NOT SUPPORTED	The specified LUN is not supported by the enclosure.
5/26/00	ILLEGAL REQUEST – INVALID FIELD IN PARAMETER LIST	A field specified in the parameter list for a command is invalid. For example, the diagnostic page length does not match the length of data supplied for a SEND DIAGNOSTIC page.
5/35/01	ILLEGAL REQUEST – UNSUPPORTED ENCLOSURE FUNCTION	An unsupported page request has been made. For example, a SEND DIAGNOSTIC control request has been issued with a page code of 00h.

Sense Key/ ASC/ASCQ	Description	Cause
5/35/03	ILLEGAL REQUEST – ENCLOSURE SERVICES TRANSFER FAILURE	An internal failure has meant the request cannot be processed. GEM returns this status if it cannot find an I_T Nexus for an in-flight command. For, example a DATA frame is received from an initiator that has never instigated a COMMAND frame.
5/35/04	ILLEGAL REQUEST – ENCLOSURE SERVICES TRANSFER REFUSED	An internal failure (e.g., device communications loss) has meant that the requested command cannot be processed successfully by the ESP.
6/29/00	UNIT ATTENTION – COMMANDS CLEARED BY ANOTHER INITIATOR	The commands belonging to the current I_T Nexus have been cleared by another initiator. For example, an initiator has used the CLEAR TASK SET task management function.
6/29/01	UNIT ATTENTION – POWER ON OCCURRED	An ESP power on condition has occurred. Any outstanding commands will have been lost.
6/29/02	UNIT ATTENTION – BUS RESET OCCURRED	An ESP reset has occurred. Any outstanding commands will have been lost.
6/29/03	UNIT ATTENTION – BUS DEVICE RESET FUNCTION OCCURRED	An initiator has reset the SCSI target by issuing a LOGICAL UNIT RESET task management function. All outstanding commands have been lost.
6/29/07	UNIT ATTENTION – NEXUS LOSS OCCURRED	An I_T Nexus with the initiator has been lost. Any outstanding commands will have been lost.
6/3F/00	UNIT ATTENTION – TARGET OPERATING CONDITIONS CHANGED	The SES GENCODE has changed. SES Page 01h must be re-read to determine the updated configuration.
B/4E/00	ABORTED COMMAND – OVERLAPPED COMMANDS ATTEMPTED	An initiator has two commands in progress with the same TASK TAG.

4.6 BROADCAST (SES) Primitive for SAS Enclosures

The SAS BROADCAST (SES) primitive is transmitted when the enclosure services process updates the contents of an SES status page.

When the SES application client receives this primitive, it can use it as a trigger to perform a status poll of the enclosure SES pages to determine the source of the change.

As the BROADCAST (SES) primitive doesn't contain details of its originator, the application client must poll all enclosure services devices within the SAS domain on which the broadcast was received.

GEM uses BROADCAST (SES) to asynchronously notify the host of the following conditions.

a) The generation code has changed.
b) The PRDFAIL bit or the ELEMENT STATUS CODE field in a page 02h element has changed.
c) An element change has occurred that didn't result in an update of the PRDFAIL bit or the ELEMENT STATUS CODE.
d) The Element Descriptor diagnostic page (07h) has been updated.
e) The Additional Element Status diagnostic page (0Ah) has been updated.
f) The Download Microcode Status diagnostic page (0Eh) changes to a code indicating download completion.
g) The Subenclosure Nickname Status diagnostic page (0Fh) has been updated.
h) A change in Power consumption of 'n' Watts

To prevent broadcast storms, GEM restricts the rate at which it transmits BROADCAST(SES) primitives to a maximum of one every 2 seconds.

4.7 Recognizing IPC Failure

If an Interface Module is unable to communicate with its partner I/O Module, the SES Status Page shall report a COMMON STATUS code of '06h' (UNKNOWN) against the partner Interface Module's Enclosure Services Controller Electronics element (see 7.9). This means that the host attached I/O Module is currently unable to synchronize or obtain status from its partner. In this situation, all status information associated with the partner I/O Module should be considered out-of-date. This information may include:

- Configuration Diagnostic Page (01h) – Other Interface Module Firmware Revision Level
- Enclosure Status Diagnostic Page (02h) – All elements associated with the partner IOM
- Threshold In Diagnostic Page (05h) – All elements associated with the partner IOM
- Element Descriptor Diagnostic Page (07h) – All elements associated with partner IOM

4.8 Recognizing Device I^2C Failure

Many enclosure sensor peripherals are accessed using the I^2C protocol. If the enclosure services process is unable to communicate to a device due to an I^2C bus failure, the Enclosure Status Diagnostic Page (02h) shall report a status code of '04h' 'Unrecoverable' or '06h' Unknown for the element associated with that device. This shall be reported on all SES interfaces. Please refer to the COMMON STATUS for the specific element in sections 7 and 9 to determine which value is used to represent device communications failure. For Seagate storage enclosures, I^2C bus failure information is reported in the vendor unique SBB MIDPLANE INTERFACE element (see 9.1).

4.9 Supported SCSI Commands

Table 2 lists the SCSI commands supported by the GEM firmware along with the T-10 specifications they are compliant with. See [3] for full details.

Table 2 - Supported SCSI Commands

Command	Comments	Compliance
INQUIRY	Used for identifying the enclosure and I/O modules. Provides access to INQUIRY VPD pages 00h, 80h and 83h	SPC-4
REQUEST SENSE	Used for collecting and clearing outstanding sense data associated with the initiator.	SPC-4
TEST UNIT READY	Tests whether expander is ready to handle commands.	SPC-4
REPORT LUNS	Returns the list of LUNS supported by the expander.	SPC-4
SEND DIAGNOSTIC	Used for sending SES pages to the SES target.	SPC-4, SES-3
RECEIVE DIAGNOSTIC RESULTS	Used for reading SES pages from the SES target.	SPC-4, SES-3
WRITE BUFFER	Used for private GEMNet communications as well as an alternative CLI interface.	SPC-4
READ BUFFER	Used for private GEMNet communications as well as an alternative CLI interface.	SPC-4

5 Supported Diagnostic Pages and Elements

5.1 Supported ANSI SES-3 Pages

Table 3 lists the complete set of ANSI SES pages supported by GEM. To determine which pages are supported by a specific product, please refer to the GEM 5 SES Addenda document for that product.

Table 3 – Supported ANSI SES-3 pages

Page Code	Description	Control/Status
00h	Supported Diagnostics Pages Diagnostic Page (see 6.1)	Status
ANSI SES Pages		
01h	Configuration Diagnostic Page (see 6.2)	Status
02h	Enclosure Diagnostic Page (see 6.3)	Control and Status
05h	Threshold Out Diagnostic Page (see 6.5)	Control and Status
07h	Element Descriptor Diagnostic Page (see 6.6)	Status
0Ah	Additional Element Status Diagnostic Page (see 6.7)	Status
0Dh	Supported SES Diagnostics Pages Diagnostic Page (see 6.8)	Status
0Eh	Download Microcode Control Diagnostic Page (see 6.9)	Control and Status
0Fh	Enclosure Nickname Diagnostic Page (see 6.10)	Control and Status

The SES status pages read by the SCSI RECEIVE DIAGNOSTIC RESULTS command must have the PCV (Page Code Valid) bit set to ‘1’ and the PAGE CODE field set to the page number to be retrieved. If the PCV bit is not set to ’1’, a CHECK CONDITION shall be returned with a sense key of ILLEGAL REQUEST and an ASC/ASCQ of INVALID FIELD IN CDB.

5.2 Supported ANSI SES-3 element types

Table 4 lists the complete set of ANSI SES elements supported by GEM. To determine which elements are supported by a specific product, please refer to the GEM 5 SES Addenda document for that product.

Table 4 - Supported SES elements

Element Type	Description
01h	Device (see 7.2)
02h	Power Supply (see 7.4)
03h	Cooling Element (see 7.5)
04h	Temperature Sensor (see 7.6)
05h	Door Lock Sensor (see 7.7)
06h	Audible Alarm (see 7.8)
07h	Enclosure Services Controller Electronics (see 7.9)
0Ch	Display (see 7.10)
0Eh	Enclosure (see 7.11)
11h	Communication Port (see 7.16)
12h	Voltage Sensor (see 7.12)
13h	Current Sensor (see 7.13)

Element Type	Description
17h	Array Device (see 7.3)
18h	SAS Expander (see 7.14)
19h	SAS Connector (see 7.15)

5.3 Supported vendor unique Diagnostic Pages

Table 5 lists the complete set of Vendor-unique diagnostic pages supported by GEM. To determine which pages are supported by a specific product, please refer to the GEM 5 SES Addenda document for that product.

Table 5 – Supported vendor unique Diagnostic pages

Page Code	Description	Control/Status
84h	In-band CLI – I/O Module A Diagnostic Page (see 8.1)	Control and Status
85h	In-band CLI – I/O Module B Diagnostic Page (see 8.1)	Control and Status
90h	Reserved	
91h	Enclosure Statistics Diagnostic Page (see 8.2)	Control and Status
92h	Extended Element Status Diagnostic Page (see 8.3)	Status
93h	LED Status Diagnostic Page (see 8.4)	Status
94h	Reserved	

The diagnostic status pages read by the SCSI RECEIVE DIAGNOSTIC RESULTS command must have the PCV (Page Code Valid) bit set to ‘1’ and the PAGE CODE field set to the page number to be retrieved. If the PCV bit is not set to ’1’, a CHECK CONDITION shall be returned with a sense key of ILLEGAL REQUEST and an ASC/ASCQ of INVALID FIELD IN CDB.

5.4 Supported vendor unique element types

Table 6 lists the complete set of vendor unique elements supported by GEM. To determine which elements are supported by a specific product, please refer to the GEM 5 SES Addenda document for that product.

Table 6 – Vendor unique SES elements

Element Type	Description
86h	SBB Midplane Interconnect (see 9.1)
87h	Processor (see 9.2)
88h	Enclosure Power (see 9.3)
89h	Enclosure Electronics Power (see 9.4)
8Ah	Enclosure Settings (see 9.5)
8Bh	Enclosure Electronics Diagnostics (see 9.6)
8Ch	BMC (see 0)
8Dh	Reserved
8Eh	Reserved
8Fh	PDB (see 9.8)
90h	Sideplane (9.9)
91h	Reserved)

6 Supported ANSI SES-3 Page Definitions

This specification covers generic SES and diagnostic page structure only. The exact page layouts for a specific product can be found in the corresponding GEM 5 SES Addenda document.

6.1 Diagnostic Page 00h

6.1.1 Page 00h Control

There is no SEND DIAGNOSTIC page for Page 00h.

6.1.2 Page 00h Status

Diagnostic status page 00h lists all diagnostic pages supported by the enclosure. It is not classed as an SES page as its specification is covered by the SPC standard (see [2]). As such, a device that supports Diagnostic page 00h is not guaranteed to be an enclosure services device.

The format of Diagnostic status page 00h is shown in Table 7.

Table 7 – Diagnostic Status Page 00h Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (00h)							
1	Reserved							
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4		SUPPORTED PAGE LIST						
n								

PAGE CODE is the diagnostic page code. This will be set to 00h, indicating this page is the Supported Diagnostic Pages Diagnostic Page.

PAGE LENGTH is the length of the returned status page in bytes, excluding the 4 page header bytes.

SUPPORTED PAGE LIST contains a 1-byte entry for each diagnostic page supported by the enclosure. Each entry shall be set to the PAGE CODE of the supported page.

6.2 SES Page 01h – Configuration Diagnostic Page

6.2.1 SES Page 01h Control

There is no Configuration Diagnostic control page.

6.2.2 SES Page 01h Status

SES status page 01h is used to determine enclosure identity as well as provide information on the structures of SES pages 02h, 05h and 07h.

The format of page 01h is shown in Table 8.

Table 8 – Diagnostic Status Page 01h Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (01h)							
1	NUMBER OF SECONDARY SUBENCLOSURES							
2	(MSB)							
3	PAGE LENGTH (n-3)							(LSB)
4	(MSB)							
7	GENERATION CODE							(LSB)
	Enclosure Descriptor List							
8	First Enclosure Descriptor							
	...							
	Last Enclosure Descriptor							
	Type Descriptor Header List							
	First Type Descriptor Header							
	...							
	Last Type Descriptor Header							
	Type Descriptor Text List							
	First Type Descriptor Text							
	...							
	Last Type Descriptor Text							
n								

PAGE CODE is the diagnostic page code. This will be set to 01h, indicating this page is the Configuration Diagnostic Page.

NUMBER OF SECONDARY SUBENCLOSURES is used to determine the number of subenclosure descriptors that appear in the Enclosure Descriptor List after Enclosure Descriptor 0. See section 3.2 for details on subenclosures.

PAGE LENGTH is the length of the returned status page in bytes, excluding the 4 page header bytes.

GENERATION CODE contains the current generation code for the SEP (see section 4.3.3)

The Enclosure Descriptor List contains an enclosure descriptor (see section 6.2.2.1) for the primary enclosure along with any subenclosures supported by it. The Enclosure Descriptor list must contain at least one entry for the primary subenclosure present at the start of the list.

The Type Descriptor Header List contains one type descriptor (see section 6.2.2.2) for each element type supported by a subenclosure. The number of type descriptors present in page 01h is determined by summing the NUMBER OF TYPE DESCRIPTOR HEADERS fields in the subenclosure descriptors. The Type Descriptor Header List is used to determine the page structure of pages 02h, 05h and 07h.

Type Descriptor Headers shall be listed in this order, regardless of their subenclosure identifiers:

a) Device elements and Array Device elements (i.e., those elements defining SCSI devices); and
b) Elements of other types.

The elements of an enclosure shall be listed in the same order as in the configuration page, for the enclosure status and control pages (page 02h), the threshold in and out pages (page 05h) and element descriptor page (page 07h).

The Type Descriptor Text List is used to provide a string description of the element type for use in management applications. As the ANSI element type descriptions are well known, GEM only provides text descriptions for vendor unique element types. The strings are stored one after the other, in the order listed in the Type Descriptor Header List. The length of each string is determined by the TYPE DESCRIPTOR TEXT LENGTH in the corresponding type descriptor header (see section 6.2.2.2).

6.2.2.1 Enclosure Descriptor

The enclosure descriptor provides identity and configuration information for the primary subenclosure and any secondary subenclosures that may be present. Its format is described in Table 9.

Table 9 - Enclosure Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved	RELATIVE ENCLOSURE SERVICES PROCESS IDENTIFIER			Reserved	NUMBER OF ENCLOSURE SERVICES PROCESSES		
1	SUBENCLOSURE IDENTIFIER							
2	NUMBER OF TYPE DESCRIPTOR HEADERS							
3	ENCLOSURE DESCRIPTOR LENGTH (60)							
4	ENCLOSURE LOGICAL IDENTIFIER							
11								
12	ENCLOSURE VENDOR IDENTIFICATION							
19								
20	PRODUCT IDENTIFICATION							
35								
36	PRODUCT REVISION LEVEL							
39								
Vendor Specific Enclosure Information								
40	PRODUCT SERIAL NUMBER							
54								
55	ENCLOSURE CONFIGURATION SETTINGS							
56	ENCLOSURE ID							
58								
59	Reserved							
62								
63	ENCLOSURE OPTIONAL SETTINGS							

RELATIVE ENCLOSURE SERVICES PROCESS IDENTIFIER is set to the bay number of the I/O Module in which the enclosure services process is running. It will be set to 1 if running in I/O Module A and 2 if running I/O Module B. As both I/O Modules run active GEM firmware concurrently, this field can be used to determine the slot ID of the attached I/O Module.

NUMBER OF ENCLOSURE SERVICES PROCESSES is set to the number of I/O Modules in the enclosure capable of running the GEM firmware. For most enclosures, this will be set to 2.

SUBENCLOSURE IDENTIFIER is the ID of the subenclosure that the descriptor is associated with. The primary subenclosure will always have a SUBENCLOSURE IDENTIFIER set to 0.

ENCLOSURE DESCRIPTOR LENGTH is set to 60 for GEM 5 enclosures. This gives a total descriptor length (including the descriptor header) of 64 bytes.

ENCLOSURE LOGICAL IDENTIFIER contains a unique 8-byte WWN to identify the enclosure. Seagate uses the NAA 5 format shown in Table 10, however, this field can be customized to use a customer's own OUI and WWN range if required.

Table 10 – Enclosure Identifier Format for NAA 5h

Byte \ Bit	7	6	5	4	3	2	1	0
0	NETWORK ADDRESS AUTHORITY (5h)				(MSB)			
1	IEEE COMPANY ID (00 50 CCh) (24 bits)							
2								
3				(LSB)	(MSB)			
4	VENDOR SPECIFIC IDENTIFIER (36 bits)							
5								
6								
7								(LSB)

ENCLOSURE VENDOR IDENTIFICATION is a left-aligned 8-character ASCII string containing the vendor name. Any unused bytes must be padded with ASCII space characters. This field is typically set to the string “SEAGATE “, however, it may be customized to use an alternative vendor ID.

The field contents are read from the VPD EEPROM at boot-up. If the ENCLOSURE VENDOR IDENTIFICATION cannot be retrieved for any reason, the default string “SEAGATE ” (with trailing ASCII space character) will be reported.

PRODUCT IDENTIFICATION is a left-aligned 16-character ASCII string containing the name of the enclosure product. Any unused bytes must be padded with ASCII space characters. The product name displayed in this field is generated from a combination of 2 separate 8-character product IDs, one contained in the Enclosure Chassis and the other in the I/O Module. This allows the product ID to automatically change based upon the enclosure configuration used. The product ID can be changed; however, any customization must adhere to the 8-character enclosure string/8-character I/O Module string format.

PRODUCT REVISION LEVEL is a 4-character ASCII string reporting the GEM firmware version running on the I/O Module. The format of the string is “Mmrr” where *M* is the Major version number, *m* is the minor version number and *rr* is the revision number. Each field in the string is in base-16 format using the characters ‘0’-‘9’, ‘A’-‘F.’

PRODUCT SERIAL NUMBER is a vendor unique field containing the serial number of the enclosure. The format of the serial number is a 15-character ASCII string.

ENCLOSURE CONFIGURATION SETTINGS is a legacy field and is no longer relevant for Seagate storage enclosure family. Its value is set to 00h by GEM.

ENCLOSURE ID, also known as the “Shelf ID” is a 3-character ASCII string containing a customer configurable ID in the range “000” to “099”. This ID is often displayed on a numerical display on the chassis Operations Panel for easy enclosure identification when installed in a rack. If the ENCLOSURE ID is not enabled or is unknown, the field will be filled with ASCII space characters (20h).

ENCLOSURE OPTIONAL SETTINGS contains enclosure configuration settings applied at manufacturing. The encoding of this field is described in Table 11.

Table 11 - ENCLOSURE OPTIONAL SETTINGS FIELDS

Bit	Name	Description
0	OPS PANEL MUTED MODE	If this bit is cleared, the enclosure Audible Alarm when muted with the Operations Panel mute button will transition to the MUTE state. If this bit is set, then the enclosure Audible Alarm when muted with the Operations Panel mute button will transition to REMIND mode
1	SYSTEM POWER REDUNDANCY INDICATION	If this bit is cleared, then the enclosure will not indicate system power redundancy (See Enclosure Functional Specification). If this bit is set, then the enclosure will indicate system power redundancy.
2	ENCLOSURE ID MODE	If this bit is cleared the Enclosure ID is enabled and will be reported in the ENCLOSURE ID field. If this bit is set, Enclosure ID is disabled.
3-7	Reserved	Reserved

6.2.2.2 Type Descriptor Header Format

The Type Descriptor Header indicates the element type being described, the number of such elements and the subenclosure to which they associated. The format of the Type Descriptor Header is shown in Table 12.

Table 12 - Type Descriptor Header Format

Bit / Byte	7	6	5	4	3	2	1	0
0	ELEMENT TYPE							
1	NUMBER OF POSSIBLE ELEMENTS							
2	SUBENCLOSURE IDENTIFIER							
3	TYPE DESCRIPTOR LENGTH							

ELEMENT TYPE indicates the element type being described in the type descriptor. See Table 4 and Table 6 for the list of elements supported by GEM. The same element type may be used in multiple Type Descriptor Headers if they belong to separate subenclosures or have different text descriptions.

NUMBER OF POSSIBLE ELEMENTS indicates the maximum number of elements of the described type it is possible to install in the subenclosure. If this field is set to 0, a single overall element shall be rendered in its place in SES pages 02h, 05h, 07h and 92h, with no individual elements.

SUBENCLOSURE IDENTIFIER lists the subenclosure to which the elements being described by the Type Descriptor Header belong.

TYPE DESCRIPTOR LENGTH indicates the number of bytes in the type descriptor text (see 6.2.2.3), if any. If the ELEMENT TYPE field is set to a vendor specific value, then the TYPE DESCRIPTOR TEXT LENGTH field shall be set to a nonzero value and shall have type descriptor text adequate to identify the element to an application client. All other element types have a TYPE DESCRIPTOR TEXT LENGTH field set to 00h.

6.2.2.3 Type Descriptor Text List

The type descriptor text list shall contain type descriptor text strings in the same order as the type descriptor headers. If the TYPE DESCRIPTOR TEXT LENGTH field is set to zero in the type descriptor header, there is no type descriptor text.

The type descriptor text is a text string from 0 to 255 bytes for each type descriptor header (see 6.2.2.2). The text string, if it has a length greater than 0, may contain any descriptive information about the element type that may be useful to an application client that is displaying the configuration of the enclosure (e.g., the manufacturer's part number for a replacement element, a brief description of the element and its properties, or instructions about configuration limitations and redundancy requirements of the elements of that type).
The type descriptor text uses the character encoding and language indicated by the Language element.

6.3 SES Page 02h – Enclosure Diagnostic Page

The SES Enclosure Diagnostic Page (SES Page 02h) is the primary page for retrieving enclosure status and performing enclosure control operations.

6.3.1 Page 02h Control

The Enclosure Control diagnostic page (SES Control Page 02h) is used to issue application client control requests to the enclosure. The control requests supported by the enclosure are element type specific but typically relate to power control and fault reporting functions. See section 7 for the control operations supported by each element type.

Table 13 – SES Control Page 02h Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (02h)							
1	Reserved				INFO	NON-CRIT	CRIT	UNRECOV
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4	(MSB)	EXPECTED GENERATION CODE						
7								(LSB)
Control Descriptor List								
8	First Control descriptor							
11								
	...							
	Last Control descriptor							
n								

PAGE CODE is the diagnostic page code. This will be set to 02h, indicating this page is the Diagnostic Control Page.

INFO set to '1' instructs the enclosure to report an informational condition. Setting INFO to '0' shall have no effect. This bit is not supported by GEM and will be set to 0.

NON-CRIT set to ‘1’ instructs the enclosure to report a non-critical condition. Setting NON-CTRIT to ‘0’ clears any existing non-critical condition indicated by the application client. This bit is not supported by GEM and will be set to 0.

CRIT set to ‘1’ instructs the enclosure to report a critical condition. Setting CRIT to ‘0’ clears any existing critical condition indicated by the application client. This bit is not supported by GEM and will be set to 0.

UNRECOV set to ‘1’ instructs the enclosure to report an unrecoverable condition. Setting UNRECOV to ‘0’ clears any existing unrecoverable condition indicated by the application client. This bit is not supported by GEM and will be set to 0.

PAGE LENGTH is the length of the control page in bytes, excluding the 4 page header bytes.

EXPECTED GENERATION CODE should be set to the current value of the SEP’s generation code (see section 4.3.3). If there is a mismatch between the EXPECTED GENERATION CODE and the GENERATION CODE field in any of the SES status pages, the enclosure will respond with a CHECK CONDITION status with sense key set to ILLEGAL REQUEST and ASC/ASCQ set to INVALID FIELD IN PARAMETER DATA.

The Control Descriptor List contains one control descriptor (see Table 14) for each entry in the Type Descriptor Header List in SES Page 01h. The length of the control descriptor is determined by the NUMBER OF POSSIBLE ELEMENTS within the corresponding Type Descriptor Header. The order of the control descriptor list must match the order of the Type Descriptor Header List.

Table 14 – Control Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Overall Control Element							
3								
Individual Control Element List								
4	First Individual Control Element							
7								
	...							
m - 3	Last Individual Control Element							
m								

The Overall Control Element provides combined control for all individual elements within the control descriptor. The general format of the overall control element is defined in section 7. Control operations to the overall element are not supported by GEM and any request received to change an overall element will be ignored.

The Individual Control Element List contains an entry for each of the possible elements identified by the NUMBER OF POSSIBLE ELEMENTS in the corresponding Page 01h Type Descriptor Header. The general format of the control element is defined in section 7 .

6.3.2 Page 02h Status

The Enclosure Status diagnostic page (SES Status Page 02h) is used to retrieve element status from the enclosure. The status information supported by the enclosure is element type specific. See section 7 for the status information supported by each element type.

Table 15 – SES Status Page 02h Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (02h)							
1				INVOP	INFO	NON CRIT	CRIT	UNRECOV
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Status Descriptor List								
8	First Status Descriptor							
11								
	...							
n-3	Last Status Descriptor							
n								

PAGE CODE is the diagnostic page code. This will be set to 02h, indicating this page is the Diagnostic Status Page.

INVOP (Invalid Operation Requested) shall be set if an enclosure control page with an invalid field has previously been transmitted to the enclosure services process and an application client has not already been informed of the error.

The enclosure services process shall set the INVOP bit to one the first time it returns the Enclosure Status diagnostic page to the same I_T nexus that transmitted the invalid control page and shall set the INVOP bit to zero for subsequent requests.

INFO is set to ‘1’ if one or more information conditions have been detected or set in the enclosure.

The enclosure services process shall set the INFO bit to ‘1’ the first time it returns the Enclosure Status diagnostic page to each I_T nexus and shall set the INFO bit to ‘0’ for subsequent requests.

GEM sets the INFO bit when it detects a change in Page 02h status. The INFO bit shall not be set for LED changes unless there is also an SES visible change associated with the LED change (e.g., change to FAULT or INFO bit in SES element). When GEM sets the INFO bit, it also originates a BROADCAST (SES) primitive (see section 4.6).

NON-CRIT set to ‘1’ indicates that the enclosure has detected one or more non-critical conditions. This bit shall stay set until all non-critical conditions have been corrected.

CRIT set to ‘1’ indicates that the enclosure has detected one or more critical conditions. This bit shall stay set until all critical conditions have been corrected.

UNRECOV set to ‘1’ indicates that the enclosure has detected one or more unrecoverable conditions. This bit shall stay set until all unrecoverable conditions have been corrected.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes.

GENERATION CODE is set to the current value of the SEP's generation code (see section 4.3.3).

The Status Descriptor List contains one status descriptor (see Table 16) for each entry in the Type Descriptor Header List in SES Page 01h. The length of the status descriptor is determined by the NUMBER OF POSSIBLE ELEMENTS within the corresponding Type Descriptor Header. The order of the status descriptor list must match the order of the Type Descriptor Header List.

Table 16 - Status Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Overall Status Element							
3								
Individual Status Element List								
4	First Individual Status Element							
7								
	...							
m - 3	Last Individual Status Element							
m								

The Overall Status Element provides a status summary for all individual elements within the status descriptor. The general format of the overall status element is defined in section 7 . Where there is a conflict between individual element status and overall element status, the individual element status shall be used. GEM may use the overall element to indicate conditions that can't be displayed using individual elements, for example a power supply redundancy fault where the individual power supplies are operating normally but the enclosure no longer has a redundant power source.

The Individual Status Element List contains an entry for each of the possible elements identified by the NUMBER OF POSSIBLE ELEMENTS in the corresponding Page 01h Type Descriptor Header. The general format of the status element is defined in section 7.

6.4 SES Page 03h – Help Text Diagnostic Page

6.4.1 SES Page 03h Control

There is no Help Text Diagnostic control page.

6.4.2 SES Page 03h Status

The Help Text Diagnostic status page provides a human readable summary of the current enclosure fault status. The page format is described in Table 17

Table 17 - SES Status Page 03h Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (**03h**)							
1	Reserved							
2	(MSB)			PAGE LENGTH (**n-3**)				
3								(LSB)
4				Current alarm list				
n								

PAGE CODE is the diagnostic page code. This will be set to 03h, indicating this page is the Help Text Diagnostic status page.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes.

The current alarm list field contains an ASCII text list of the alarm fault codes currently active on the enclosure. Each alarm fault entry in the list is variable length, consisting of a two-digit hexadecimal fault code, a hyphen (‘-‘) field separator, a short text description of the fault and a newline delimiter character (ASCII 10h). An example of this output is shown below.

```
01 – PCM Failure – minimal redundancy
06 – AC Missing – minimal redundancy
2B – Drive power control warning
```

The possible fault codes and text descriptions are shown in Table 18

Table 18 – Help Text Fault Codes and Description

Fault Code (Hex)	Description
00	PCM Failure - redundant
01	PCM Failure - minimal redundancy
02	PCM Failure - non-redundant
03	PCM Removed – redundant
04	PCM Removed - minimal redundancy
05	PCM Removed - non-redundant

Fault Code (Hex)	Description
06	AC Missing – redundant
07	AC Missing - minimal redundancy
08	AC Missing - non-redundant
09	PCM comms failure
0A	Mixed PCM types
0B	Insufficient power available
0C	Fan failure – redundant
0D	Fan failure - minimal redundancy
0E	Fan failure - non-redundant
0F	Fan tolerance warning
10	VPD comms failure
11	Invalid VPD
12	Drive power control fault
13	Drive Fault
14	Auxiliary module removed
15	Auxiliary module fault
16	Incompatible auxiliary modules
17	Auxiliary module comms fault
18	I/O module removed
19	Incompatible I/O modules
1A	I/O module fault
1B	High temperature
1C	Over temperature
1D	Low temperature
1E	Under temperature
1F	Temp sensor failure – redundant
20	Temp sensor failure - minimal redundancy
21	Temp sensor failure - non-redundant
22	Ops-Panel failure
23	Enclosure Electronics failure
24	SES Intermittent Alert
25	Host enabled drive fault
26	Host enabled array info
27	Host enabled array warning
28	Comms layer fault – redundant
29	Drive removed – Deprecated
2A	SES Unrecoverable Alert
2B	Drive power control warning
2C	Service sync warning
2D	Service sync failure
2E	Unsupported configuration
2F	Reboot requested
30	Comms layer fault - minimal redundancy
31	Comms layer fault - non-redundant

Fault Code (Hex)	Description
32	Elec sensor failure
33	Elec sensor comms fail
34	Sled power control fault
35	Sled power control warning
36	Sled fault
37	Host enabled IO Module fault
38	Processor system fault
39	Processor system config
3A	BMC fault
3B	BMC Warning
3C	Door Lock Intrusion Detected
3D	Door Lock Left Open
3E	IPMIIF Intermittent Alert
3F	IPMIIF Unrecoverable Alert
40	PSU Fail Request
41	Enclosure Fail Request
42	Host Port Critical
43	Host Port Warning
44	Host Port Unrecoverable
45	Enclosure Warn Requested
46	OS Boot fault
47	Shutdown temp exceeded
48	Host enabled Fan Fault
49	Host enabled Drive Predicted fault
4A	PCM Unsupported

6.5 SES Page 05h – Enclosure Threshold Diagnostic Page

The Enclosure Threshold In page (SES Status Page 05h) allows an application client to view enclosure threshold limits for enclosure elements that are supported. The Threshold Out page (SES Control Page 05h) allows the application client to set threshold limits that are supported.

It should be noted that the threshold values that are written by an application client are volatile. If an enclosure power-on-reset were to occur, previous threshold limits would be lost, and enclosure default values shall be used.

The threshold values from the application client are checked by GEM to ensure they are reasonable before being applied. GEM has the right to refuse a new threshold value if it detects that it would exceed the design limits of the enclosure or determines that the value is in conflict with another threshold value.

Not all elements support SES page 05h thresholds. Where an element does not support a threshold status, it shall set its Threshold Status Element to all 0s, i.e. [00 00 00 00 h]. If an element does not support threshold control, it shall silently ignore any attempt by the application client to change the thresholds. See 6.5.1.1 for details on Threshold In and Out support for each element type supported by GEM.

6.5.1 Page 05h Control

The Enclosure Threshold Out diagnostic page (SES Control Page 05h) is used to issue application client control requests to update the thresholds used by an SES element. The control requests supported by the enclosure are element type specific but typically relate to sensor type elements, see 6.5.1.1.

Table 19 – SES Control Page 05h Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (05h)							
1	Reserved							
2	(MSB)			PAGE LENGTH (n-3)				
3								(LSB)
4	(MSB)			EXPECTED GENERATION CODE				
7								(LSB)
Threshold Control Descriptor List								
8	First Threshold Control descriptor							
11								
	...							
n-3	Last Threshold Control descriptor							
n								

PAGE CODE is the diagnostic page code. This must be set to 05h, indicating this page is the Threshold Out Diagnostic Page.

PAGE LENGTH is the length of the control page in bytes, excluding the 4 page header bytes.

EXPECTED GENERATION CODE should be set to the current value of the SEP's generation code (see section 4.3.3). If there is a mismatch between the EXPECTED GENERATION CODE and the GENERATION CODE field in any of the SES status pages, the enclosure will respond with a CHECK CONDITION status with sense key set to ILLEGAL REQUEST and ASC/ASCQ set to INVALID FIELD IN PARAMETER DATA.

The Threshold Control Descriptor List contains one control descriptor (see Table 20) for each entry in the Type Descriptor Header List in SES Page 01h. The length of the control descriptor is determined by the NUMBER OF POSSIBLE ELEMENTS within the corresponding Type Descriptor Header. The order of the control descriptor list must match the order of the Type Descriptor Header List.

Table 20 – Threshold Control Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Overall Threshold Control Element							
3								
Individual Threshold Control Element List								
4	First Individual Threshold Control Element							
7								
	...							
m - 3	Last Individual Threshold Control Element							
m								

The Overall Threshold Control Element provides combined control for all individual elements within the control descriptor. The general format of the overall threshold control element is type specific and can be found within section and 6.5.1.1. Threshold Out control operations to the overall element are not supported by GEM and any request received to change an overall element will be ignored.

The Individual Threshold Control Element List contains an entry for each of the possible elements identified by the NUMBER OF POSSIBLE ELEMENTS in the corresponding Page 01h Type Descriptor Header. The general format of the individual threshold control element can be found in section 6.5.1.1.

6.5.1.1 Threshold control for all other elements

The ANSI defined threshold element control format is shown in Table 21.

Table 21 – Threshold control element format for other elements

Bit / Byte	7	6	5	4	3	2	1	0
0	REQUESTED HIGH CRITICAL THRESHOLD							
1	REQUESTED HIGH WARNING THRESHOLD							
2	REQUESTED LOW WARNING THRESHOLD							
3	REQUESTED LOW CRITICAL THRESHOLD							

REQUESTED HIGH CRITICAL THRESHOLD indicates the configured high critical threshold for the associated element. The enclosure indicates a critical condition if the element detects a value higher than the high critical threshold. A HIGH CRITICAL THRESHOLD of 00h indicates that the element does not support the threshold. The numerical format of the threshold is element type specific; refer to the element descriptions in sections 7 and 9 for details.

REQUESTED HIGH WARNING THRESHOLD indicates the configured high warning threshold for the associated element. The enclosure indicates a noncritical condition if the element detects a value higher than the high warning threshold. A HIGH WARNING THRESHOLD of 00h indicates that the element does not support the threshold. The numerical format of the threshold is element type specific; refer to the element descriptions in sections 7 and 9 for details.

REQUESTED LOW WARNING THRESHOLD indicates the configured low warning threshold for the associated element. The enclosure indicates a noncritical condition if the element detects a value lower than the low warning threshold. A LOW WARNING THRESHOLD of 00h indicates that the element does not support the threshold. The numerical format of the threshold is element type specific; refer to the element descriptions in sections 7 and 9 for details.

REQUESTED LOW CRITICAL THRESHOLD indicates the configured high critical threshold for the associated element. The enclosure indicates a critical condition if the element detects a value lower than the low critical threshold. A LOW CRITICAL THRESHOLD of 00h indicates that the element does not support the threshold. The numerical format of the threshold is element type specific; refer to the element descriptions in sections 7 and 9 for details.

6.5.2 Page 05h Status

The Enclosure Threshold In page allows an application client to view enclosure threshold limits for elements that supported it.

Table 22 – SES Status Page 05h Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (05h)							
1	Reserved			INVOP	Reserved			
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Threshold Status Descriptor List								
8	First Threshold Status Descriptor							
11								
	...							
n-3	Last Threshold Status Descriptor							
n								

PAGE CODE is the diagnostic page code. This will be set to 05h, indicating this page is the Threshold In Diagnostic Page.

INVOP (Invalid Operation Requested) shall be set if an enclosure control page with an invalid field has previously been transmitted to the enclosure services process and an application client has not already been informed of the error. This bit is not currently supported for by GEM for SES Page 05h.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes.

GENERATION CODE is set to the current value of the SEP's generation code (see section 4.3.3).

The Threshold Status Descriptor List contains one status descriptor (see Table 16) for each entry in the Type Descriptor Header List in SES Page 01h. The length of the status descriptor is determined by the NUMBER OF POSSIBLE ELEMENTS within the corresponding Type Descriptor Header. The order of the status descriptor list must match the order of the Type Descriptor Header List.

Table 23 - Status Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Overall Threshold Status Element							
3								
Individual Threshold Status Element List								
4	First Individual Threshold Status Element							
7								
	...							
m - 3	Last Individual Threshold Status Element							
m								

The Overall Threshold Status Element provides shared threshold status for all elements described by the Type Descriptor Header. The general format of the overall threshold status element is defined in section 6.5.2.1. GEM does not support overall threshold status and sets its status to [00 00 00 00 h].

The Individual Status Element List contains an entry for each of the possible elements identified by the NUMBER OF POSSIBLE ELEMENTS in the corresponding Page 01h Type Descriptor Header. The general format of the status element is defined in section 6.5.2.1.

6.5.2.1 Threshold status for all other elements

The ANSI defined threshold element format is shown in Table 24.

Table 24 – Threshold status element format for other elements

Bit / Byte	7	6	5	4	3	2	1	0
0	HIGH CRITICAL THRESHOLD							
1	HIGH WARNING THRESHOLD							
2	LOW WARNING THRESHOLD							
3	LOW CRITICAL THRESHOLD							

HIGH CRITICAL THRESHOLD indicates the configured high critical threshold for the associated element. The enclosure indicates a critical condition if the element detects a value higher than the high critical threshold. A HIGH CRITICAL THRESHOLD of 00h indicates that the element does not support the threshold. The numerical format of the threshold is element type specific; refer to the element descriptions in sections 7 and 9 for details.

HIGH WARNING THRESHOLD indicates the configured high warning threshold for the associated element. The enclosure indicates a noncritical condition if the element detects a value higher than the high warning threshold. A HIGH WARNING THRESHOLD of 00h indicates that the element does not support the threshold. The numerical format of the threshold is element type specific; refer to the element descriptions in sections 7 and 9 for details.

LOW WARNING THRESHOLD indicates the configured low warning threshold for the associated element. The enclosure indicates a noncritical condition if the element detects a value lower than the low warning threshold. A LOW WARNING THRESHOLD of 00h indicates that the element does not support the threshold. The numerical format of the threshold is element type specific; refer to the element descriptions in sections 7 and 9 for details.

LOW CRITICAL THRESHOLD indicates the configured high critical threshold for the associated element. The enclosure indicates a critical condition if the element detects a value lower than the low critical threshold. A LOW CRITICAL THRESHOLD of 00h indicates that the element does not support the threshold. The numerical format of the threshold is element type specific; refer to the element descriptions in sections 7 and 9 for details.

6.6 SES Page 07h – Element Descriptor Diagnostic Page

6.6.1 Page 07h Control

There is no Element Descriptor Control Page.

6.6.2 Page 07h Status

The element descriptor page returns a list of variable length fields, one for each element in the Enclosure Status Diagnostic page (SES Page 02h). The fields return vendor specific descriptive text for each element.

Table 25 – SES Status Page 07h Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (07h)							
1	Reserved							
2	(MSB)			PAGE LENGTH (n-3)				
3								(LSB)
4	(MSB)			GENERATION CODE				
7								(LSB)
Element Descriptor by Type List								
8				First Element Descriptor by Type Descriptor				
11								
	...							
				Last Element Descriptor by Type Descriptor				
n								

PAGE CODE is the diagnostic page code. This will be set to 07h, indicating this page is the Element Descriptor Diagnostic Page.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes.

GENERATION CODE is set to the current value of the SEP's generation code (see section 4.3.3).

The Element Descriptor by type List contains one element type descriptor (see Table 26) for each entry in the Type Descriptor Header List in SES Page 01h. The length of the status descriptor is determined by the NUMBER OF POSSIBLE ELEMENTS within the corresponding Type Descriptor Header. The order of the status descriptor list must match the order of the Type Descriptor Header List.

Table 26 – Element Descriptor by Type Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Overall Descriptor							
3								
Individual Element Descriptor List								
4	First Element Descriptor							
	...							
	Last Element Descriptor							
m								

The Overall Descriptor provides an overall description for elements of the same type. The general format of the overall descriptor element is shown in Table 27. The Overall element descriptor is not supported by GEM.

The Individual Element Descriptor List contains an entry for each of the possible elements identified by the NUMBER OF POSSIBLE ELEMENTS in the corresponding Page 01h Type Descriptor Header. The general format of the individual descriptor element can be found in Table 27.

Table 27 - Overall and element descriptor format for page 07h

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1								
2	(MSB)	DESCRIPTOR LENGTH (m-3)						
3								(LSB)
4	DESCRIPTOR							
m								

DESCRIPTOR LENGTH is set to the length of the descriptor in bytes excluding the 4 bytes used for the descriptor header. A descriptor length of 0 indicates that there is no descriptor data available for the element.

DESCRIPTOR contains a vendor unique ASCII description for the element. GEM uses this field to advertise part numbers, serial numbers, physical locations, firmware versions and type codes for FRUs associated with the element. The descriptor string is broken into semicolon delimited fields using the following format.

```
<field ID>=<field value>;
```

The field ID is used to advertise the data contained within the field value. The ID is alphanumeric and typically consists of 2-3 characters although there is no hard limit on this.

The field value contains data in the format described by the field ID. Although many fields may have fixed length data, this should not be relied upon. Instead, the field data should be read up to the ';' field delimiter character.

A variable number of these individual fields are concatenated together to form the entire descriptor string. For example:

```
BL=0500;FF1=04000001;SN=IMS92983C1400B8;
```

The full list of field IDs and their descriptions can be found in Table 28, however, the presence of each field ID in the descriptor will be product dependent. Refer to the respective SES Addendum to determine which fields are supported on a particular product.

Table 28 - Element Descriptor Field ID Keywords

Type descriptor text field ID	Description
AI	Firmware active image bank.
BL	Bootloader version.
CC	Fan module configuration version.
CR	GEM/GEMLite CPLD version.
CM	Configuration Mismatch indicator. Used in an element to indicate that GEM may not be running with data fully from the configuration being reported in the rest of the element. e.g., For the enclosure element a value of 00 means that GEM is running with configuration data from the current VPD. A value of 01 indicates that the VPD has been updated but a simultaneous reboot of the canisters has not yet occurred to activate the new configuration.
F#n	T-10 format firmware revision (limited to 4-ASCII characters, e.g., F1=5002 for GEM 5.0.0.2) for component #n, where #n is replaced with a number. This field is maintained for backwards compatibility reasons and is deprecated for future use. It is advised that the FF#n is used instead, as this field is capable of reporting the entire GEM version number.
FC	GEM configuration CRC.
FD	Firmware image SHA256 hash value.
CFC (Fan modules)	Fan controller firmware version.
FF#n	Full firmware revision information (limited to 8-ASCII characters, e.g., FF1=05000002 for GEM 5.0.0.2) for component #n. Where #n is replaced with a number indicating the component to which the firmware version relates.
FR	GEM configuration data format version.
GD	Globally Unique ID.
LO	Location string for determining FRU location.
NM	FRU/Sensor name.
PC	Power CPLD version.
PD	Package descriptor version.
PN	FRU Part number.
SN	FRU Serial Number. If the serial number is not available or the FRU is removed, the serial number will be set to: “SN=NO_PSN_PRESENT_” where PSN stands for “Part Serial Number”.
TP	FRU Descriptor. This is a two-digit hexadecimal code used to identify a specific model or type of FRU. If for any reason the FRU descriptor cannot be read, the field value will be set to the string “00”.

Type descriptor text field ID	Description
USM	Unified system management package name.
V	Ops Panel firmware version.
VC	VPD image CRC.
VR	VPD image data format version.
WN	WWN.

6.7 SES Page 0Ah – Additional Element Status Page

6.7.1 Page 0Ah Control

There is no Additional Element Status Control Page.

6.7.2 Page 0Ah Status

This page provides protocol information with respect to Device, Array Device, SAS Expander, SCSI Initiator Port, SCSI Target Port and Enclosure Services Controller Electronics elements. The Additional Element Status diagnostic page returns additional element status descriptor for each of these element types that have been advertised by the NUMBER OF POSSIBLE ELEMENTS field in the corresponding type descriptor header in the Configuration diagnostic page. The additional element status descriptors are rendered in the same order as the ELEMENT STATUS fields in the Enclosure Status Diagnostic page 02h.

There are two modes of operation GEM can use for rendering SES page 0Ah. These are selected via a configuration option.

- Single I/O Module Topology Status - In this mode, SES page 0Ah only reports information that is local to the I/O module. Status for elements associated with the partner I/O module is left blank. This results in pages that a different based upon which I/O module is queried.

- Dual I/O Module Topology Status - In this mode, SES page 0Ah reports information for both I/O modules. The device elements in this page report phy status for both drive ports. Phy descriptors for Expander element descriptors associated with the partner I/O module are also reported. Consequently, the page is identical on both I/O modules.

The default mode of operation is Single I/O module topology status.

Table 29 shows the format of SES status page 0Ah.

Table 29 – SES Status Page 0Ah Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (0Ah)							
1	Reserved							
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Additional Element Status Descriptor List								
8	First Additional Element Status Descriptor							
	...							
	Last Additional Element Status Descriptor							
n								

PAGE CODE is the diagnostic page code. This will be set to 0Ah, indicating this page is the Additional Element Status Diagnostic Page.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes.

GENERATION CODE is set to the current value of the SEP's generation code (see section 4.3.3).

The Additional Element Status Descriptor List contains an additional element status for each element for which the enclosure services process provides additional information. Only Device/Array Device SAS Expander, SCSI Initiator Port, SCSI Target Port and Enclosure Services Controller Electronics elements have ANSI defined additional status descriptors. The descriptors rendered in page 0Ah are product specific; refer to the SES addendum for the product of interest for specific details.

The descriptors all retain the same descriptor header as defined in Table 30. The header format used by GEM utilizes the EIP bit, allowing the descriptors to be mapped to specific page 02h elements.

Table 30 – Additional Element Status Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	INVALID	Reserved		EIP (1b)	PROTOCOL IDENTIFIER			
1	ADDITIONAL ELEMENT STATUS DESCRIPTOR LENGTH (m-1)							
2	Reserved							EIIOE (0b)
3	ELEMENT INDEX							
4	Protocol-specific Information							
m								

INVALID when set to '1' indicates the data contained within the protocol-specific information is invalid and should not be used. When set to '0' the protocol-specific information is valid.

EIP set to ‘1’ indicates the two bytes containing the ELEMENT INDEX and EIIOE bits are present in the descriptor. All additional element status descriptors reported by GEM set the EIP bit to ‘1’.

PROTOCOL IDENTIFIER reports the protocol being referred to by the contents of the Protocol-specific Information. Possible values for this field are shown in Table 31.

EIIOE when set to ‘1’ indicates ELEMENT INDEX is an absolute index (see 3.3.1). When set to ‘0’, ELEMENT INDEX is a global index (see 3.3.3). GEM sets this bit to ‘0’.

ELEMENT INDEX indicates the index of the page 02h status element that this descriptor is describing. The indexing scheme used is based upon the status of the EIIOE bit.

Table 31 - PROTOCOL IDENTIFIER field values

Protocol Identifier	Description
0h	Fibre Channel Protocol for SCSI
1h	SCSI Parallel Interface
2h	Serial Storage Architecture SCSI-3 Protocol
3h	Serial Bus Protocol for IEEE 1394
4h	SCSI RDMA Protocol
5h	iSCSI
6h	SAS
7h	Automation/Drive Interface Transport Protocol
8h	AT Attachment Interface
9h	USB Attached SCSI
Ah	SCSI over PCI-E
Bh-Eh	Reserved
Fh	No Specific Protocol

The contents of the Protocol-specific Information specific information bytes depend on the PROTOCOL IDENTIFIER field. GEM only supports SAS protocol specific information currently and this is documented in. The SAS protocol descriptors supported by GEM are:

- Device/Array Device Slot Additional Status (see 6.7.2.1)
- SAS Expander Additional Status (see 6.7.2.2)
- Enclosure Services Controller Electronics Additional Status (see 6.7.2.3)

6.7.2.1 Additional Status Descriptor for SAS Device/Array Device elements

Table 32 defines the format of the SAS Protocol-specific information header for SAS Device and Array Device additional element status.

Table 32 – SAS Device Slot Additional Element Status Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	NUMBER OF PHY DESCRIPTORS							
1	DESCRIPTOR TYPE (00b)		Reserved					NOT ALL PHYS
2	Reserved							
3	DEVICE SLOT NUMBER							
Phy descriptor list								
4	First Phy Descriptor (see Table 33)							
31								
	...							
x-27	Last Phy Descriptor (see Table 33)							
x								

NUMBER OF PHY DESCRIPTORS is set to the number of phy descriptors present in the Phy descriptor list.

DESCRIPTOR TYPE is set to 00b indicating this is a Device Slot descriptor.

NOT ALL PHYS set to ‘1’ indicates that not all device phys are represented in the phy descriptor list. When set to ‘0’ all phys are represented.

DEVICE SLOT NUMBER indicates the drive bay number that the device/array device is occupying.

The phy descriptor list contains a phy descriptor for each phy counted in the NUMBER OF PHY DESCRIPTORS field. See Table 33 for details of the phy descriptor format for SAS device slot additional element status descriptors.

Table 33 – SAS Device Slot Phy Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved	DEVICE TYPE			Reserved			
1	Reserved							
2	Reserved				SSP INITIATOR PORT	STP INTIATOR PORT	SMP INTIATOR PORT	Reserved
3	SATA PORT SELECTOR	Reserved			SSP TARGET PORT	STP TARGET PORT	SMP TARGET PORT	SATA DEVICE
4	(MSB)	ATTACHED SAS ADDRESS						
11								(LSB)
12	(MSB)	SAS ADDRESS						
19								(LSB)
20	PHY IDENTIFIER							
21		Reserved						
27								

DEVICE TYPE indicates the type of SAS device present in the device slot. This information is extracted from the IDENTIFY ADDRESS FRAME of the attached device (for SAS), however, it is expected that this value will always be set to 001b (SAS or SATA Device) if the enclosure is operated as intended.

For SAS devices, SSP INITIATOR PORT, STP INITIATOR PORT, SMP INITIATOR PORT, SSP TARGET PORT, STP TARGET PORT and SMP TARGET port will reflect the status of the equivalent bits transmitted in the attached device's IDENTIFY ADDRESS FRAME. For SATA devices, these bits will be set to '0'.

SATA PORT SELECTOR is set to '1' if the attached device is SATA MUX. For all other devices it'll be set to '0'.

SATA DEVICE is set to '1' if the attached device uses the SATA protocol. For SAS devices, this bit will be set to '0'.

ATTACHED SAS ADDRESS contains the SAS address of the expander to which the device is attached.

SAS ADDRESS contains the SAS address of the SAS device, or the SAS address of the STP bridge in the case of a SATA device.

PHY IDENTIFIER is set to phy identifier transmitted in the SAS device's IDENTIFY ADDRESS FRAME. For SATA devices, this field will be set to 0.

6.7.2.2 Additional Status Descriptor for SAS Expander elements

Table 34 defines the format of the SAS Protocol-specific information header for SAS Expander additional element status.

Table 34 – SAS Expander Additional Element Status Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	NUMBER OF EXPANDER PHY DESCRIPTORS							
1	DESCRIPTOR TYPE (01b)		Reserved					
2	Reserved							
3								
4	(MSB)	SAS ADDRESS						
11								(LSB)
Expander Phy descriptor list								
12	First Phy Descriptor (see Table 35)							
13								
	...							
x-1	Last Phy Descriptor (see Table 35)							
x								

NUMBER OF EXPANDER PHY DESCRIPTORS is set to the number of expander phy descriptors reported in the Expander Phy Descriptor List.

DESCRIPTOR TYPE is set to 01b indicating this is a SAS port style descriptor.

SAS ADDRESS is set to the SAS address of the expander device described by the descriptor.

The phy descriptor list contains an expander phy descriptor for each phy counted in the NUMBER OF EXPANDER PHY DESCRIPTORS field. See Table 35 for details of the phy descriptor format for SAS device slot additional element status descriptors.

Table 35 – SAS Expander Phy Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	CONNECTOR ELEMENT INDEX							
1	OTHER ELEMENT INDEX							

CONNECTOR ELEMENT INDEX is the global element index (see 3.3.3) of the SAS connector element to which the phy is attached. If there is no corresponding SAS connector element for the phy, the CONNECTOR ELEMENT INDEX is set to FFh.

OTHER ELEMENT INDEX is the global element index (see 3.3.3) of any other element to which the phy is associated. If there is no corresponding element for the phy, the OTHER ELEMENT INDEX is set to FFh.

6.7.2.3 Additional Status Descriptor for Enclosure Services Controller Electronics Elements

Table 36 defines the format of the SAS Protocol-specific information header for SAS Expander additional element status.

Table 36 – Enclosure Services Controller Electronics Additional Element Status Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	NUMBER OF PHY DESCRIPTORS							
1	DESCRIPTOR TYPE (01b)		Reserved					
2	Reserved							
3								
Phy descriptor list								
4	First Phy Descriptor (see Table 37)							
15								
	...							
x-11	Last Phy Descriptor (see Table 37)							
x								

NUMBER OF PHY DESCRIPTORS is set to the number of phy descriptors reported in the Phy Descriptor List.

DESCRIPTOR TYPE is set to 01b indicating this is a SAS port style descriptor.

The phy descriptor list contains a phy descriptor for each phy counted in the NUMBER OF PHY DESCRIPTORS field. See Table 37 for details of the phy descriptor format for SAS device slot additional element status descriptors.

Table 37 – Enclosure Services Controller Electronics Phy Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	PHY IDENTIFIER							
1	Reserved							
2	CONNECTOR ELEMENT INDEX							
3	OTHER ELEMENT INDEX							
4	SAS ADDRESS							
11								

PHY IDENTIFIER is set to phy identifier of the enclosure services controller electronics device's target port described by this descriptor.

CONNECTOR ELEMENT INDEX is the global element index (see 3.3.3) of the SAS connector element to which the phy is attached. If there is no corresponding SAS connector element for the phy, the CONNECTOR ELEMENT INDEX is set to FFh.

OTHER ELEMENT INDEX is the global element index (see 3.3.3) of any other element to which the phy is associated. If there is no corresponding element for the phy, the OTHER ELEMENT INDEX is set to FFh.

SAS ADDRESS is set to the SAS address of the enclosure service electronics device's target port described by the descriptor.

6.8 SES Page 0Dh – Supported SES Diagnostic Pages

6.8.1 Page 0Dh Control

There is no Supported SES Diagnostic Pages control page.

6.8.2 Page 0Dh Status

The supported SES Diagnostic Pages SES page lists all supported SES pages between 01h and 2Fh inclusive. The format of this page is described in Table 38.

Table 38 – SES Page 0Dh Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (0Dh)							
1	Reserved							
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4	SUPPORTED SES PAGE LIST							
	PAD							
n								

PAGE CODE is the diagnostic page code. This will be set to 0Dh, indicating this page is the Supported SES Pages Diagnostic Page.

PAGE LENGTH is the length of the returned status page in bytes, excluding the 4 page header bytes. The page length must be a multiple of 4 bytes.

SUPPORTED SES PAGE LIST contains a 1-byte entry for each SES diagnostic page supported by the enclosure. Each entry shall be set to the PAGE CODE of the supported page. Pages must be listed in ascending order.

PAD contains bytes of value 00h necessary to ensure the page length is a multiple of 4. As such, PAD may consist of 0, 1, 2 or 3 bytes.

6.9 SES Page 0Eh – Download Microcode Diagnostic Page

The Download Microcode control and status pages are used to perform firmware upgrade for a number of enclosure components. These include but are not limited to:

- SEP firmware and configuration
- VPD EEPROMs
- FRU firmware and configuration
- PLD firmware

The Download Microcode diagnostic control page is used to transmit firmware image data to the control memory space of the ESP. The image data from the control page buffer is saved to non-volatile storage, either incrementally after each block transfer or once the entire image has been transferred.

The Download Microcode diagnostic status page is used to retrieve the status of a firmware download once started. It may also be used to determine whether a download is already in progress on the enclosure.

The Download Microcode Control diagnostic page is written using the SCSI SEND DIAGNOSTIC command. In most cases the firmware image is sent using multiple SEND DIAGNOSTIC commands as the image size is often larger than the control page buffer size. If the complete set of SEND DIAGNOSTIC commands required to deliver the firmware image to its destination is not received before the download process completes, the incomplete firmware image shall not be used. This situation could occur when the download process is interrupted by:

a. A logical unit reset
b. A SEP reset
c. An I_T nexus loss
d. A Power loss

A new download can be initiated only if the status page indicates no download is currently in progress. Attempting to initiate a new download whilst another is in progress will result in a CHECK CONDITION status being returned with a SENSE KEY of ILLEGAL REQUEST and an ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED.

A new download must start at BUFFER OFFSET 00000000h, with each subsequent block transfer incrementing sequentially through the file. If GEM detects an out-of-order offset, a CHECK CONDITION status will be returned with a SENSE KEY of ILLEGAL REQUEST and an ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED.

For microcode downloads that span multiple transfer requests, GEM maintains a timeout of 30 seconds between sequential transfer blocks. If the next data block is not transferred within that period, the download is aborted and any data already transferred will be discarded.

The maximum amount of data that can be transferred in a single control request is dependent upon the SCSI buffer size implemented on the specific product being used. It is, however, recommended that a page size of 4096 bytes (4073 byte data payload) be used for best performance.

If during the download an error is detected, the ESP shall abort the firmware download operation and set the SUBENCLOSURE DOWNLOAD MICROCODE STATUS field to an appropriate value in the Download Microcode Status diagnostic page.

Once all data has been transferred, the new microcode will need to be activated either manually by the host application, using the appropriate download mode, or automatically by the enclosure. The activation action will differ based upon the image being downloaded but it typically results in one of the following:

- Soft Reset of local/remote SEP
- Hard Reset of local/remote SEP

- No action
- Manual power cycle required

For full details on the activation actions required by specific firmware images, refer to the GEM Firmware Upgrade Guide for the product [4].

6.9.1 Page 0Eh Control

The format of the Download Microcode Control diagnostic page is shown in Table 39.

Table 39 - Download Microcode Control diagnostic page

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (0Eh)							
1	SUBENCLOSURE IDENTIFIER							
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4	(MSB)	EXPECTED GENERATION CODE						
7								(LSB)
8	DOWNLOAD MICROCODE MODE							
9		Reserved						
10								
11	BUFFER ID							
12	(MSB)	BUFFER OFFSET						
15								(LSB)
16	(MSB)	MICROCODE IMAGE LENGTH						
19								(LSB)
20	(MSB)	MICROCODE DATA LENGTH (m-23)						
23								(LSB)
24		MICROCODE DATA						
m								
m+1		PAD						
n								

PAGE CODE is the diagnostic page code. This must be set to 0Eh, indicating this page is the Download Microcode diagnostic control Page.

SUBENCLOSURE IDENTIFIER is the ID of the subenclosure to which the microcode is to be transferred. Only the primary subenclosure is supported by GEM. Setting this field to any value other than 0 will result in a CHECK CONDITON status with a SENSE KEY of ILLEGAL REQUEST and ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED. Such an error will also cause the download to be aborted and the SUBENCLOSURE DOWNLOAD MICROCODE STATUS in the status page will be set to 80h.

PAGE LENGTH is the length of the control page in bytes, excluding the 4 page header bytes. It must be a multiple of 4 bytes, with the PAD field being used to append additional bytes if necessary. If the PAGE LENGTH does not match length of data transferred, a CHECK CONDITION status will be returned with

a SENSE KEY of ILLEGAL REQUEST and an ASC/ASCQ of INVALID FIELD IN CDB. If the PAGE LENGTH is not a multiple of 4, a CHECK CONDITION status will be returned with a SENSE KEY of ILLEGAL REQUEST and an ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED. Both errors will also cause the download to be aborted and the SUBENCLOSURE DOWNLOAD MICROCODE STATUS in the status page will be set to 80h.

EXPECTED GENERATION CODE must be set to the current value of the SEP's generation code (see section 4.3.3). If the EXPECTED GENERATION CODE does not match the SEP's generation code, the transfer will be aborted with a CHECK CONDITION status with a SENSE KEY of ILLEGAL REQUEST and an ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED. Such an error will also cause the download to be aborted and the SUBENCLOSURE DOWNLOAD MICROCODE STATUS in the status page will be set to 80h.

DOWNLOAD MICROCODE MODE dictates which mode the enclosure should use to download the firmware. The modes supported by GEM are covered in Table 40. Once a download has been started, the DOWNLOAD MICROCODE MODE must not change from the value used in the first transfer request (a mode 0Fh activation request is treated as a separate download operation). Changing the mode during a transfer will result in a CHECK CONDITON status with a SENSE KEY of ILLEGAL REQUEST and ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED. Such an error will also cause the download to be aborted and the SUBENCLOSURE DOWNLOAD MICROCODE STATUS in the status page will be set to 80h.

Table 40 - Supported DOWNLOAD MICROCODE MODE values

Code	Description
07h	**Download microcode with offsets, save and activate.** After the last SEND DIAGNOSTIC command delivering a Download Microcode Control diagnostic page to the subenclosure completes, the enclosure services process shall verify the complete microcode image (e.g., perform a vendor-specific checksum) and save the new microcode image into non-volatile storage (e.g., flash ROM). If there are no errors in the microcode image or in the save operation, then the enclosure services process shall return the SUBENCLOSURE DOWNLOAD MICROCODE STATUS field set to one of the following values in the Download Microcode Status diagnostic page, if requested, and activate the new microcode when specified: a) 10h: activate the new microcode image after: A) returning the Download Microcode Status diagnostic page; B) power on; or C) for standalone enclosure services processes, hard reset; b) 11h: for standalone enclosure services processes only. Activate the new microcode image after: A) power on; or B) hard reset; c) 12h: activate the new microcode image after power on.

Code	Description
0Eh	**Download microcode with offsets, save, and defer activate.** After the last SEND DIAGNOSTIC command delivering a Download Microcode Control diagnostic page to the subenclosure completes, the enclosure services process shall verify the complete microcode image (e.g., perform a vendor-specific checksum), save the new microcode image into non-volatile storage (e.g., flash ROM), and defer activation of the new microcode. If there are no errors in the microcode image or in the save operation, then the enclosure services process shall return the SUBENCLOSURE DOWNLOAD MICROCODE STATUS field set to 13h in the Download Microcode Status diagnostic page, if requested, and activate the new microcode after: a) processing a Download Microcode Control diagnostic page with the DOWNLOAD MICROCODE MODE field set to 0Fh (i.e., Activate deferred microcode); b) power on; or c) hard reset.
0Fh	**Activate deferred microcode.** After the SEND DIAGNOSTIC command specifying this mode completes, the enclosure services process shall activate the new microcode image.

BUFFER ID specifies the destination buffer for the microcode being downloaded. GEM uses this field to direct the download data to specific I/O Modules, allowing the internal destination flags within the GFF download files to be overridden (see [4]). Table 41 shows the BUFFER ID values supported by GEM. Once a download has been started, the BUFFER ID must not change from the value used in the first transfer request. Changing the BUFFER ID during a transfer will result in a CHECK CONDITON status with a SENSE KEY of ILLEGAL REQUEST and ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED. Such an error will also cause the download to be aborted and the SUBENCLOSURE DOWNLOAD MICROCODE STATUS in the status page will be set to 80h.

Table 41 - Supported BUFFER ID values

Buffer ID	Description
00h	Instructs the ESP to use the I/O Module routing options stipulated by the firmware download file.
01h	Instructs the ESP to route the firmware download file through I/O Module A. If the ESP handling the SES request is physically located within I/O module B, the file will be transferred across the IPC link to I/O Module A for processing. If the ESP handling the SES request is in I/O Module A, the IPC link is not used.
02h	Instructs the ESP to route the firmware download file through I/O Module B. If the ESP handling the SES request is physically located within I/O module A, the file will be transferred across the IPC link to I/O Module B for processing. If the ESP handling the SES request is in I/O Module B, the IPC link is not used.
03h	Instructs the ESP to route the firmware download file through the primary I/O Module. If the ESP handling the SES request is physically located within the secondary I/O Module, the file will be transferred across the IPC link to the primary for processing. If the ESP handling the SES request is in the primary, the IPC link is not used.

Buffer ID	Description
04h	Instructs the ESP to route the firmware download file through the secondary I/O Module. If the ESP handling the SES request is physically located within the primary I/O Module, the file will be transferred across the IPC link to the secondary for processing. If the ESP handling the SES request is in the secondary, the IPC link is not used.
05h-FFh	Reserved – Attempts to use a reserved BUFFER ID will result in a CHECK CONDITION status with sense key ILLEGAL REQUEST and ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED.

BUFFER OFFSET specifies the offset in bytes within the buffer to which the microcode data is written and shall be set to a multiple of 4 bytes. The ESP will require that the BUFFER OFFSET field be contiguously increasing in consecutive SEND DIAGNOSTIC commands, exempting retry attempts that send microcode data to the same offset as used in the immediately preceding command (where retries are supported). If the ESP does not accept the specified buffer offset, it will return a CHECK CONDITON status with a SENSE KEY of ILLEGAL REQUEST and ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED. Such an error will also cause the download to be aborted and the SUBENCLOSURE DOWNLOAD MICROCODE STATUS in the status page will be set to 80h.

MICROCODE IMAGE LENGTH specifies the total number of bytes in the microcode image the host application intends to send to the specified buffer ID.

MICROCODE DATA contains the actual microcode data payload itself. The amount of data that can be transmitted with each separate control request will depend upon the maximum SCSI buffer size for the specific product used. For performance and compatibility purposes it is recommended that a maximum of 4072 bytes of microcode data is transmitted per request.

PAD contains bytes of value 00h necessary to ensure the page length is a multiple of 4. As such, PAD may consist of 0, 1, 2 or 3 bytes.

6.9.2 Page 0Eh Status

The format of the Download Microcode Status diagnostic page is shown in Table 42.

Table 42 - Download Microcode Status diagnostic page

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (0Eh)							
1	NUMBER OF SECONDARY SUBENCLOSURES (00h)							
2	(MSB)	PAGE LENGTH (20)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Primary Subenclosure microcode status descriptor								
8	Reserved							
9	SUBENCLOSURE IDENTIFIER (00h)							
10	SUBENCLOSURE DOWNLOAD MICROCODE STATUS							
11	SUBENCLOSURE DOWNLOAD MICROCODE ADDITIONAL STATUS							
12	(MSB)	SUBENCLOSURE DOWNLOAD MICROCODE MAXIMUM SIZE						
15								(LSB)
16		Reserved						
18								
19	SUBENCLOSURE DOWNLOAD MICROCODE EXPECTED BUFFER ID							
20	(MSB)	SUBENCLOSURE DOWNLOAD MICROCODE EXPECTED BUFFER OFFSET						
23								(LSB)

PAGE CODE is the diagnostic page code. This will be set to 0Eh, indicating this page is the Download Microcode diagnostic status Page.

NUMBER OF SECONDARY SUBENCLOSURES is set to the number of secondary subenclosures supported by the enclosure. This field is set to 00h, indicating the ESP only supports the primary subenclosure.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes. This will be set to 14h.

GENERATION CODE is set to the current value of the SEP's generation code (see section 4.3.3).

SUBENCLOSURE IDENTIFIER is set to 00h, indicating that the status descriptor is for the primary subenclosure.

SUBENCLOSURE DOWNLOAD MICROCODE STATUS indicates the status of the current or last download microcode operation for the subenclosure. Supported values are defined in Table 43. After reporting a code indicating completion (with or without errors), the enclosure services process shall set the SUBENCLOSURE DOWNLOAD MICROCODE STATUS field to 00h and shall set the SUBENCLOSURE DOWNLOAD MICROCODE ADDITIONAL STATUS field to 00h

Table 43 - Supported SUBENCLOSURE DOWNLOAD MICROCODE STATUS codes

Code	Description
Interim status codes	
00h	No download microcode operation in progress.
01h	Download microcode operation in progress. The enclosure services process has received one or more Download Microcode Control diagnostic pages and is awaiting additional microcode data.
02h	Download microcode operation data transfer complete, currently updating non-volatile storage.
03h	The enclosure services process is currently updating non-volatile storage with deferred microcode.
04h to 0Fh	Reserved
Successful completion codes	
10h	Download microcode operation completed with no error. The enclosure services process begins using the new microcode after returning this status.
11h	Download microcode operation completed with no error. The enclosure services process begins using the new microcode after the next hard reset or power on. This status code persists until it is read by the host. The ADDITIONAL STATUS field reports the reboot status of each slot or domain using the following values: • Bit 7 is set when the reboot status is supported. • Bit 6 is set when a reboot has been scheduled or will be scheduled (on activation) for any Slot 0 expander. • Bit 5 is set when a reboot has been scheduled or will be scheduled (on activation) for any Slot 1 expander • Bits 4-3 – Activation type for Slot 0, that is, no activation, disruptive activation or non-disruptive activation. • Bits 2-1 – Activation type for Slot 1, that is, no activation, disruptive activation or non-disruptive activation. • Bit 0 – Reserved ▪ Activation Type Combinations: 00 = No activation required 01 = Non-disruptive activation 10 = Disruptive activation 11 = Invalid This status will persist until read by the host. Note: Certain GEM 5.x versions might not have support for activation type details in bits 1 to 4.
12h	Download microcode operation completed with no error. The enclosure services process begins using the new microcode after the next power on.
13h	Download microcode operation completed with no error. The enclosure services process begins using the new microcode after a firmware activation request (DOWNLOAD MODE 0Fh) is sent.
14h to 16h	Reserved

Code	Description
Vendor unique successful completion codes	
70h to 7Fh	Vendor specific – Not used by GEM.
Failure completion codes	
80h	Error in one or more of the Download Microcode Control diagnostic page fields, new microcode discarded. The SUBENCLOSURE DOWNLOAD MICROCODE ADDITIONAL STATUS field shall be set to the offset of the lowest byte of whichever field in the Download Microcode Control diagnostic page which is in error. Examples in which this status code is returned: • An invalid BUFFER ID is received. • An invalid DOWNLOAD MICROCODE MODE is received. • An invalid MICROCODE DATA LENGTH is received, e.g., Data length of 0 bytes is received. • An incorrect BUFFER OFFSET is received, e.g., the data offset does not point to the start of the image in a new download. • An incorrect MICROCODE IMAGE LENGTH is received, e.g., the image length differs during download.
81h	Microcode image error (e.g., a problem detected by a vendor-specific check of the microcode image, such as a checksum), new microcode discarded. The SUBENCLOSURE DOWNLOAD MICROCODE ADDITIONAL STATUS field shall have a value of 1h on image signature validation error or to 0h for all other cases.
82h	Download microcode timeout, new microcode discarded. The enclosure services process may discard microcode data after a vendor-specific amount of time if it does not receive the entire microcode image. GEM download microcode timeout is set to 30seconds.
83h	Internal error in the download microcode operation; new microcode image is needed before a hard reset or power on (e.g., a flash ROM write failed and no backup ROM image is available).
84h	Internal error in the download microcode operation; hard reset and power on safe (e.g., the enclosure services process will use a backup ROM image on hard reset or power on). Examples in which this status code is returned: • In GEM, this status code is returned when a PCM (Power Cooling Module) firmware download is attempted on the only PCM currently providing power. During PCM firmware upgrade, the PCM is not supplying power and so the firmware download is rejected by the enclosure service process.
85h	Processed a Download Microcode Control diagnostic page with the DOWNLOAD MICROCODE MODE field set to 0Fh (i.e., activate deferred microcode) when there is no deferred microcode.
86h to EFh	Reserved
Vendor unique failure completion codes	
F0h to FFh	Vendor specific – Not used by GEM.

SUBENCLOSURE DOWNLOAD MICROCODE ADDITIONAL STATUS provides additional status for specified SUBENCLOSURE DOWNLOAD MICROCODE STATUS values. These are covered in Table 43.

SUBENCLOSURE DOWNLOAD MICROCODE MAXIMUM SIZE indicates the maximum size in bytes of the microcode image that the enclosure services process accepts. The image may be delivered using one or more Download Microcode Control diagnostic pages.

SUBENCLOSURE DOWNLOAD MICROCODE EXPECTED BUFFER ID indicates the next value that the enclosure services process expects in the BUFFER ID field in the Download Microcode Control diagnostic page.

SUBENCLOSURE DOWNLOAD MICROCODE EXPECTED BUFFER OFFSET indicates the next value that the enclosure services process expects in the BUFFER OFFSET field in the Download Microcode Control diagnostic page.

6.10 SES Page 0Fh – Subenclosure Nickname Diagnostic Pages

The Subenclosure Nickname Diagnostic pages allow individual subenclosures to be given a 32-character user-defined human-readable nickname. For GEM, this only applies to the primary subenclosure (secondary subenclosures are not currently supported by GEM), for which the nickname is persisted to non-volatile memory within the enclosure itself.

The control page is used to set the nickname to a new value, whereas the status page is used to read the current value if the nickname and confirm the status of previous nickname update operations.

6.10.1 Page 0Fh Control

The format of the Subenclosure Nickname Control diagnostic page is shown in Table 44.

Table 44 – Subenclosure Nickname Control diagnostic page

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (0Fh)							
1	SUBENCLOSURE IDENTIFIER							
2	(MSB)	PAGE LENGTH (0024h)						
3								(LSB)
4	(MSB)	EXPECTED GENERATION CODE						
7								(LSB)
8		SUBENCLOSURE NICKNAME						
39								

PAGE CODE is the diagnostic page code. This must be set to 0Fh, indicating this page is the Subenclosure Nickname diagnostic control Page.

SUBENCLOSURE IDENTIFIER is the ID of the subenclosure to which the nickname is to be written. Only the primary subenclosure is supported by GEM. Setting this field to any value other than 0 will result in a CHECK CONDITION status with a SENSE KEY of ILLEGAL REQUEST and ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED. Such an error will also cause the control operation to be aborted and the SUBENCLOSURE NICKNAME STATUS in the status page will be set to 80h.

PAGE LENGTH is the length of the control page in bytes, excluding the 4 page header bytes. It must be a multiple of 4 bytes. If the PAGE LENGTH is set to any value other than 24h, a CHECK CONDITION status will be returned with a SENSE KEY of ILLEGAL REQUEST and an ASC/ASCQ of INVALID FIELD IN CDB. Such an error will also cause the download to be aborted and the SUBENCLOSURE NICKNAME STATUS in the status page will be set to 80h.

EXPECTED GENERATION CODE must be set to the current value of the SEP's generation code (see section 4.3.3). If the EXPECTED GENERATION CODE does not match the SEP's generation code, the transfer will be aborted with a CHECK CONDITION status with a SENSE KEY of ILLEGAL REQUEST and an ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED. Such an error will also cause the download to be aborted and the SUBENCLOSURE NICKNAME STATUS in the status page will be set to 80h.

SUBENCLOSURE NICKNAME specifies the new 32 ASCII character nickname to be written to the subenclosure. If the desired NICKNAME is shorter than 32 characters, the remaining unused characters shall be set to 20h (ASCII space).

6.10.2 Page 0Fh Status

The format of the Subenclosure Nickname Status diagnostic page is shown in Table 45.

Table 45 - Subenclosure Nickname Status diagnostic page

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (0Fh)							
1	NUMBER OF SECONDARY SUBENCLOSURES (00h)							
2	(MSB)	PAGE LENGTH (002Ch)						
3								(LSB)
4	(MSB)	GENERATION CODE						
7								(LSB)
Primary Subenclosure nickname status descriptor								
8	Reserved							
9	SUBENCLOSURE IDENTIFIER (00h)							
10	SUBENCLOSURE NICKNAME STATUS							
11	SUBENCLOSURE NICKNAME ADDITIONAL STATUS							
12	Reserved							
13								
14	(MSB)	SUBENCLOSURE NICKNAME LANGUAGE CODE (0000h)						
15								(LSB)
16	(MSB)	SUBENCLOSURE NICKNAME						
47								(LSB)

PAGE CODE is the diagnostic page code. This will be set to 0Fh, indicating this page is the Subenclosure Nickname diagnostic status Page.

NUMBER OF SECONDARY SUBENCLOSURES is set to the number of secondary subenclosures supported by the enclosure. This field is set to 00h, indicating the ESP only supports the primary subenclosure.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes. This will be set to 2Ch.

GENERATION CODE is set to the current value of the SEP's generation code (see section 4.3.3).

SUBENCLOSURE IDENTIFIER is set to 00h, indicating that the status descriptor is for the primary subenclosure.

SUBENCLOSURE NICKNAME STATUS indicates the status of the last nickname write operation for the subenclosure. Supported values are defined in Table 46. After reporting a code indicating completion (with or without errors), the enclosure services process shall set the SUBENCLOSURE NICKNAME STATUS field and SUBENCLOSURE NICKNAME ADDITIONAL STATUS fields to 00h.

Table 46 - SUBENCLOSURE NICKNAME STATUS codes

Code	Description
00h	No errors
80h	Error in one or more of the Subenclosure Nickname Control diagnostic page fields. The SUBENCLOSURE NICKNAME ADDITIONAL STATUS field shall be set to the offset of the lowest byte of the field in the control page that had the error.
81h	Internal error. The nickname is lost.
82h	Internal error. The previous nickname is preserved.
All others	Reserved

SUBENCLOSURE NICKNAME ADDITIONAL STATUS provides additional status information for specific values of the SUBENCLOSURE NICKNAME STATUS field. See Table 46 for details.

SUBENCLOSURE NICKNAME LANGUAGE CODE is set to 0000h, indicating that the NICKNAME is encoded using the English ASCII character set conformant with ISO/IEC 8859-1.

SUBENCLOSURE NICKNAME reports the current value for the subenclosure nickname.

7 Supported ANSI SES-3 Element Definitions

This section contains the element definitions for SES pages 02h (see 6.3).

7.1 Common Page 02h Element formats

All page 02h control and status elements conform to the same basic format. Each element consists of 4 control/status bytes incorporating 1 byte for information commonly used among all element types.

7.1.1 Fields common to all control page elements

Page 02h control elements contain a COMMON CONTROL byte that includes bits that all elements (overall and individual) must define, but do not necessarily have to support. For example, GEM ignores all control requests performed to overall elements.

Table 47 defines the control element format that all page 02h elements must comply with.

Table 47 – Common Page 02h control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	Element type specific control information							
3								

SELECT is used to indicate that an element in the control page has control data that is to be processed by the enclosure. If the SELECT bit is set to ‘0’, all other bits within the element, regardless of state, will be ignored. If the SELECT bit is set to ‘1’ the state of all other supported bits within the element will be applied.

PRDFAIL is used to set a predicted failure indication against the element. GEM does not support predicted failure indications and, as such, the state of this bit is ignored.

DISABLE is used to instruct the ESP to disable the element. The specific behavior for what constitutes disabling an element is element type specific and not all elements support this bit (although they must define it). Refer to the specific element type to determine whether support for this bit is present.

RST SWAP is used to clear the SWAP bit in the corresponding status element. Setting RST SWAP to ‘1’ sets the SWAP bit to ‘0’. Setting the RST SWAP bit to ‘0’ has no effect on the SWAP bit status. The RST SWAP bit only affects the SWAP bit status for the I_T Nexus that has set it.

The element type specific control information is unique for each element type. Control information containing conflicting bits may cause unpredictable behavior or may cause the enclosure services process to set the INVOP bit to the application client if the application client has not already been informed of the error.

7.1.2 Fields common to all status page elements

Page 02h status elements contain a COMMON STATUS byte that includes bits that all elements (overall and individual) must define, but do not necessarily have to support.

Table 48 defines the status element format that all page 02h elements must comply with.

Table 48 – Common Page 02h status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	Element type specific status information							
3								

PRDFAIL is set to ‘1’ when the predicted failure status has been set against the element, otherwise it is set to ‘0’. GEM does not support predicted failure status and will set this bit to ‘0’.

DISABLED is set to ‘1’ when the element has been requested to be disabled using the DISABLE bit. For all other cases, DISABLED is set to ‘0’. The specific behavior for what constitutes disabling an element is element type specific and not all elements support this bit (although they must define it). Refer to the specific element type to determine whether support for this bit is present.

SWAP is set to ‘1’ to indicate that the device associated with the element has been removed and the same device or new device has been inserted in the same location since the last time the RST SWAP control bit was set in the control element. The SWAP status is maintained on a per I_T Nexus basis, meaning that clearing it from one I_T Nexus will not clear it for a separate I_T Nexus. The SWAP bit is cleared when the RST SWAP control bit is set and remains cleared until a device has been both removed and inserted in the device slot.

When the ESP is reset (power-on-reset, soft-reset or hard-reset), the SWAP status will be cleared for all I_T Nexuses and elements, with the exception of the elements associated with the I/O module. On boot, the SWAP bits for all elements associated with the I/O Module will be set, whereas all other elements will have their SWAP bits cleared.

It should be noted that FRU removals and re-insertions taking less than 0.2 seconds may cause the swap to be missed by the enclosure firmware, leaving the associated SWAP bits in a cleared state.

ELEMENT STATUS CODE provides a brief status for the element. For overall elements, this field may contain a status perceived as the worst-case status among the individual elements of the same type, or it could be used convey a status pertaining to the function that the combined individual elements provide, for example, system power redundancy in the case of PSU elements. Table 49 lists the element status codes supported by GEM.

Table 49 – Supported values for ELEMENT STATUS CODE

Code	Name	Description
0h	Unsupported	Status detection is not implemented for this element.
1h	OK	Element is installed and no error conditions are known.
2h	Critical	A critical condition has been detected.
3h	Noncritical	A non-critical condition has been detected.
4h	Unrecoverable	An unrecoverable condition has been detected.
5h	Not Installed	Element is not installed.
6h	Unknown	Element status is unknown. This is most commonly a result of a communications failure for the device providing the element status.
7h	Not Available	Element is installed but status is not yet available. This status is most commonly returned shortly after a reboot of the ESP, before it has been able to retrieve synchronized status information from a partner I/O Module or read the status from the hardware.
8h	No Access Allowed	The initiator port from which the RECEIVE DIAGNOSTIC RESULT command was received does not have access to this element. This status is used to enforce SAS zoning rules within the SES target.
9h to Fh	Reserved	

7.2 Device Slot Element

The device slot element is used to control and retrieve status from hardware associated with a disk drive bay provided by the enclosure.

7.2.1 Device slot element common status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the Device slot element are outlined in Table 50.

Table 50 – Supported ELEMENT STATUS CODE values for the Device slot element

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	The device is bypassed via the host on all accessible ports.
3h	Noncritical	The device cannot be powered off or the drive has been bypassed on one of its accessible ports (other ports can still be accessed).
5h	Not Installed	The device slot is empty.
6h	Unknown	A device is installed but the enclosure services process is unable to retrieve status from it. This may be due to a communications or device slot power failure.
7h	Not Available	A device is installed but status is not yet available for it. This status is most commonly returned shortly after a reboot of the ESP, before it has been able to retrieve synchronized status information from a partner I/O Module or read the status from the hardware.
8h	No Access Allowed	The port to which the device is attached is not accessible by the port requesting the SES page. For example, the port has incorrect zone permissions to access device status.

7.2.2 Device slot status element

Table 51 - Device slot status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	SLOT ADDRESS							
2	APP CLIENT BYPASSED A	DO NOT REMOVE	ENC BYPASSED A	ENC BYPASSED B	READY TO INSERT	RMV	IDENT	REPORT
3	APP CLIENT BYPASSED B	FAULT SENSED	FAULT RQSTD	DEVICE OFF	BYPASSED A	BYPASSED B	DEVICE BYPASSED A	DEVICE BYPASSED B

SLOT ADDRESS is set to the physical drive bay slot number.

APP CLIENT BYPASSED A is set to ‘1’ when the host application sets the ENABLE BYP A bit in the control element, indicating the A side device port has been bypassed/disabled by the host. If the ENABLE BYP A bit is set to ‘0’ in the control element, the APP CLIENT BYPASSED A will be set to 0 indicating the A side device has not been bypassed/disabled by the host.

DO NOT REMOVE indicates the status of the corresponding DO NOT REMOVE control bit. When set to ‘1’ it specifies that the device should not be removed. A DO NOT REMOVE bit set to ‘0’ specifies that the device may be removed. This bit is only supported on high-density enclosures where a single drive carrier may contain more than one device slot. See 7.2.4 for recommended usage of this bit for multi-device carriers.

ENC BYPASSED A is set to ‘1’ when the Enclosure Services Process has bypassed/disabled device port A autonomously, rendering it inaccessible to the host. When set to ‘0’, it indicates the enclosure has not bypassed/disabled device port A autonomously. Although GEM supports this bit, it currently does not take any action to autonomously disable device ports.

ENC BYPASSED B is set to ‘1’ when the Enclosure Services Process has bypassed/disabled device port B autonomously, rendering it inaccessible to the host. When set to ‘0’, it indicates the enclosure has not bypassed/disabled device port B autonomously. Although GEM supports this bit, it currently does not take any action to autonomously disable device ports.

READY TO INSERT set to ‘1’ indicates the device slot is ready to receive a device. Set to ‘0’, it indicates a new device must not be inserted into the device slot. This bit is not supported by GEM as devices may be inserted into an empty bay at any time.

RMV set to ‘1’ indicates that the device slot has been prepared for the removal of the device. The RMV bit is set to ‘0’ if it the RQST REMOVE control bit is not implemented or that the device cannot be removed from the device slot. This bit is only supported on high-density enclosures where a single drive carrier may contain more than one device slot. See 7.2.4 for recommended usage of this bit for multi-device carriers.

IDENT set to ‘1’ indicates that the RQST IDENT control bit has been set and the device slot is visually identifying its location using an LED or similar device. When set to ‘0’, the device slot is not displaying an identification indication.

REPORT is set to set to ‘1’ to indicate that the enclosure status page is being transferred through the device described by this ELEMENT STATUS field. The REPORT bit is set to ‘0’ if the enclosure status page is being transferred through another device or through an enclosure services device. As GEM resides within a dedicated ESP, this bit is always set to ‘0’.

APP CLIENT BYPASSED B is set to ‘1’ when the host application sets the ENABLE BYP B bit in the control element, indicating the B side device port has been bypassed/disabled by the host. If the ENABLE BYP B bit is set to ‘0’ in the control element, the APP CLIENT BYPASSED B will be set to 0 indicating the B side device has not been bypassed/disabled by the host.

FAULT SENSED is set to ‘1’ to indicate that the enclosure has detected a device power on, spin-up, power off fault or fail to retrieve drive status. This fault will be identified by a visual fault indication. The FAULT SENSED bit is set to ‘0’ when none of the above device fault conditions is detected by the enclosure.

FAULT RQSTD is set to ‘1’ to indicate that the RQST FAULT control bit has requested that the device slot display a visual fault indication. The FAULT REQSTD bit is set to ‘0’ when the RQST FAULT control bit has been cleared.

DEVICE OFF is set to ‘1’ to indicate that the device has been powered off. A DEVICE OFF bit set to ‘0’ indicates that the device slot is powered.

BYPASSED A is a logical OR of the DEVICE BYPASSED A, ENC BYPASSED A and APP CLIENT BYPASSED A bits. When set to ‘1’, it indicates that device port A has been bypassed/disabled and is no longer accessible to the host. When set to ‘0’, it indicates that device port A is not bypassed/disabled and should be accessible to the host, provided there are no other faults.

BYPASSED B is a logical OR of the DEVICE BYPASSED B, ENC BYPASSED B and APP CLIENT BYPASSED B bits. When set to ‘1’, it indicates that device port B has been bypassed/disabled and is no longer accessible to the host. When set to ‘0’, it indicates that device port B is not bypassed/disabled and should be accessible to the host, provided there are no other faults.

DEVICE BYPASSED A is set to ‘1’ when the device has bypassed/disabled its own port A autonomously, rendering it inaccessible to the host. When set to ‘0’, it indicates the device has not bypassed/disabled port A autonomously.

DEVICE BYPASSED B is set to ‘1’ when the device has bypassed/disabled its own port B autonomously, rendering it inaccessible to the host. When set to ‘0’, it indicates the device has not bypassed/disabled port B autonomously.

7.2.3 Device slot control element

Table 52 - Device slot control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	Reserved							
2	RQST ACTIVE	DO NOT REMOVE	Reserved	RQST MISSING	RQST INSERT	RQST REMOVE	RQST IDENT	Reserved
3	Reserved		RQST FAULT	DEVICE OFF	ENABLE BYP A	ENABLE BYP B	Reserved	

RQST ACTIVE is used by the host to enable activity indication on the device to show that it is in use. Setting it to ‘1’ enables the activity indication, whereas setting it to ‘0’ disables it. The activity indication must be refreshed within 0.5 seconds otherwise it will be disabled by the enclosure. GEM manages device activity indication autonomously and therefore does not support this bit.

DO NOT REMOVE, when set to ‘1’, specifies that the device should not be removed. A DO NOT REMOVE bit set to ‘0’ specifies that the device may be removed. A corresponding DO NOT REMOVE indication may be displayed on the device or device carrier to indicate that it must not be removed from the enclosure. Such an indication is enclosure specific. This bit is only supported on high-density enclosures where a single drive carrier may contain more than one device slot. See 7.2.4 for recommended usage of this bit for multi-device carriers.

RQST MISSING, when set to ‘1’, requests that the enclosure display a visual “device missing” indication on the device slot. When set to ‘0’, the enclosure should turn-off any active “device missing” indication on the device slot. This bit is not supported by GEM.

RQST INSERT, when set to ‘1’, requests that the enclosure should prepare the device slot for a device insertion. Seagate storage enclosures support device hot-plugs without notification and, as such, any attempt to set this bit will be ignored.

RQST REMOVE, when set to ‘1’, requests that the enclosure should prepare the device slot for a device removal. Seagate storage enclosures support device hot-plugs without notification and, as such, any attempt to set this bit will be ignored. This bit is only supported on high-density enclosures where a single drive carrier may contain more than one device slot. See 7.2.4 for recommended usage of this bit for multi-device carriers.

RQST IDENT, when set to ‘1’, requests that the identify indicator be turned on for the corresponding device, e.g., the drive fault LED will flash at a rate of 1s on and 1s off to identify the slot position. The RQST IDENT bit is set to ‘0’ to request that the identify indicator be turned off. The blink pattern and LED used for device identification is product specific.

RQST FAULT is set to ‘1’ to request that the device slot visually indicate that fault is present on the device, e.g., the drive fault LED will be turned on. When the RQST FAULT bit is set to ‘0’, the application client requested fault indication shall be cleared. Note that the fault indication may still be displayed when the RQST FAULT bit is set to 0 if the enclosure has autonomously detected a fault with the device.

DEVICE OFF is set to ‘1’ to request that the device be powered off. A DEVICE OFF bit set to ‘0’ specifies that the device may be turned on if all other prerequisites are met, such as sufficient power available.

ENABLE BYP A, when set to ‘1’, requests that the enclosure bypasses port A of the device. On SAS expanders this functionality is disables the port rather than bypassing it (as would be done for FC-AL). When set to ‘0’, the port shall become un-bypassed if no other source is requesting the bypass. See 7.2.5 for more details on port bypass.

ENABLE BYP B, when set to ‘1’, requests that the enclosure bypasses port B of the device. On SAS expanders this functionality is disables the port rather than bypassing it (as would be done for FC-AL). When set to ‘0’, the port shall become un-bypassed if no other source is requesting the bypass. See 7.2.5 for more details on port bypass.

7.2.4 Device Removal for a Multi-Drive Carrier

For enclosures that support multi-drive carriers, the host must be made aware that the removal of a device in a multi-drive carrier results in the removal of other devices as well. Therefore, the RMV/RQST REMOVE/DO NOT REMOVE bits are supported in GEM to identify drives that belong to a common carrier.

The DO NOT REMOVE bit in the device element status is not set by default. If the host desires to remove a device from the enclosure, it will need to set the RQST REMOVE bit for that device. GEM will set the corresponding RMV bit in the device element status and after a grace period of 20 seconds, GEM will set the RMV bits for all the other devices in that carrier. It will be up to the attached hosts during this grace period to realize that the first RMV bit is set on a drive whose carrier is shared by drive(s) that are being used. At this point the hosts must mark drives on which operations are being performed by using the DO NOT REMOVE bit. GEM will then clear the RMV bit on these drives when this happens. Once all hosts have completed the final actions, they may clear the DO NOT REMOVE bit and GEM will then set the RMV bit for all devices in the corresponding carrier. At this point, the carrier may be removed from the enclosure.

7.2.5 Port Bypass for Domain A and B

Port bypass is typically associated with FC-AL products where problematic device ports need to be isolated to prevent overall loop degradation. GEM carries the concept of port bypass over to SAS and SATA products but uses this feature to disable a device port rather than to bypass it.

A device slot commonly has one or two ports and SES makes provision for these to be bypassed either by the physical disk device itself, the enclosure or application client. For SAS and SATA products, only the host may bypass the device port; the enclosure or device will never autonomously disable the phy as part of error recovery.

If a device port is misbehaving or the attached device is unsupported, it may be isolated by the application client using SES to prevent it from interfering with the remainder of the system. This is achieved by setting the device ‘ENABLE BYP A’ and ‘ENABLE BYP B’ bits. The port(s) are only reset (i.e., bypass disabled) upon SES device control, device hot plug, enclosure power on reset or I/O Module hot plug or failover (if configured to do so). By default, device bypass will persist I/O module hard and soft resets.

- **Port Bypass Control Domain A**. The Port Bypass control on Domain A for a device can be controlled by submitting a request to the device element. Setting 'ENABLE BYP A' shall request that the port be bypassed, and the device be removed from the domain. Clearing the 'ENABLE BYP A' shall request that the port bypass be disabled, and the device shall be incorporated into the domain. Note that if the physical disk device or enclosure has requested that it be bypassed, it overrides the SES process with the result that the device shall not be incorporated into the domain.

- **Port Bypass Control Domain B**. The Port Bypass control on Domain B for a device can be controlled by submitting a request to the device element. Setting 'ENABLE BYP B' shall request that the port be bypassed, and the device be removed from the domain. Clearing the 'ENABLE BYP B' shall request that the port bypass be disabled, and the device shall be incorporated into the domain. Note that if the physical disk device or enclosure has requested that it be bypassed, it overrides the SES process with the result that the device shall not be incorporated into the domain.

GEM internally maintains a set of primary drive states, which map to SES status as shown in Table 53.

Table 53 – GEM Primary drive state to SES element state mapping

Drive State	Description	SES element state
REMOVED	Device is absent from bay	SES Device/Array device element status is set to Not Installed (05h).
OFF	Device is present, powered off and the ports are disabled	SES Device/Array device element status is set to a value other than Not Installed (05h) and the DEVICE OFF status bit is set.
IDLE	Device is present, powered on and the ports are disabled.	SES Device/Array device element status is set to a value other than Not Installed (05h) and the DEVICE OFF status bit is not set.
HOLD	Device is present, powered on and the ports are enabled.	
ONLINE	Device is present, powered on, the ports are enabled, and the storage medium is available.	

Rules based on these states determine when port bypass may be applied and when it shall be ignored or overridden by GEM. These are summarized as follows.

a) Device ports may be bypassed from any state except for REMOVED and OFF.

b) Applying port bypass on all device ports pauses the state for that device (the drive state will remain the same as it was before bypass).

c) Device port bypass is cleared when a drive is removed from the enclosure.

d) If an I/O Module is soft rebooted and NDR is enabled, any previously set port bypass state is re-applied at start-up. Bypassed drive ports do not persist over an enclosure power cycle.

e) If an I/O Module is hard rebooted, any previously set port bypass state is re-applied at start-up.

f) For enclosures where drives are attached via additional expanders (such as high-density enclosures), bypass state is also preserved if those expanders are soft reset or hard reset.

g) Any drive power commands received via SES overrides any previously set drive port bypass for the conditions shown in Table 54.

Table 54 – Valid DEVICE OFF and Drive Bypass SES Control Commands

DEVICE OFF	ENABLE BYP A/B		Consequence of SES request
1	X	X	Drive powered off, existing power bypass state overridden and cleared.
0	1	0	Drive port A bypassed.
0	0	1	Drive port B bypassed.
0	1	1	Drive port A and B bypassed.
0	0	0	Drive powered on and port A and B bypass cleared.
1 – Set 0 – Cleared X – N/A			

7.3 Array Device Slot Element

The array device slot element is used to control and retrieve status from hardware associated with a disk drive bay that may form part of a storage array. It is used as an alternative to the device element where RAID array indications are required.

7.3.1 Array device slot element common status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the Array device slot element are outlined in Table 55.

Table 55 – Supported ELEMENT STATUS CODE values for the Array device slot element

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	The array device is bypassed by the host on all accessible ports.
3h	Noncritical	The array device cannot be powered off, a fault has been detected that may affect satisfactory drive performance/operation or the drive has been bypassed on one of its accessible ports (other ports can still be accessed).
5h	Not Installed	The device slot is empty.
6h	Unknown	An array device is installed but the enclosure services process is unable to retrieve status from it. This may be due to a communications or device slot power failure.
7h	Not Available	An array device is installed but status is not yet available for it. This status is most commonly returned shortly after a reboot of the ESP, before it has been able to retrieve synchronized status information from a partner I/O Module or read the status from the hardware.
8h	No Access Allowed	The port to which the device is attached is not accessible by the port requesting the SES page. For example, the port has incorrect zone permissions to access device status.

7.3.2 Array device slot status element

Table 56 – Array device slot status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	OK	RSVD DEVICE	HOT SPARE	CONS CHECK	IN CRIT ARRAY	IN FAILED ARRAY	REBUILD/ REMAP	R/R ABORT
2	APP CLIENT BYPASSED A	DO NOT REMOVE	ENC BYPASSED A	ENC BYPASSED B	READY TO INSERT	RMV	IDENT	REPORT
3	APP CLIENT BYPASSED B	FAULT SENSED	FAULT RQSTD	DEVICE OFF	BYPASSED A	BYPASSED B	DEVICE BYPASSED A	DEVICE BYPASSED B

OK, when set to ‘1’, indicates that the device okay visual indicator is lit. When set to ‘0’, it indicates the device okay indicator is not lit.

RSVD DEVICE, when set to ‘1’, indicates that the reserved device visual indicator is lit. When set to ‘0’, it indicates the reserved device indicator is not lit. Seagate enclosures do not implement a reserved device indicator and therefore this bit is not supported and will be set to ‘0’.

HOT SPARE, when set to ‘1’, indicates that the hot spare visual indicator is lit. When set to ‘0’, it indicates the hot spare indicator is not lit. Seagate enclosures do not implement a hot spare indicator and therefore this bit is not supported and will be set to ‘0’.

CONS CHECK, when set to ‘1’, indicates that the device consistency check visual indicator is lit. When set to ‘0’, it indicates the device consistency check indicator is not lit. Seagate enclosures do not implement a separate consistency check indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

IN CRIT ARRAY, when set to ‘1’, indicates that the device “in critical array” visual indicator is lit. When set to ‘0’, it indicates the device “in critical array” indicator is not lit. Seagate enclosures do not implement a separate “in critical array” indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

IN FAILED ARRAY, when set to ‘1’, indicates that the device “in failed array” visual indicator is lit. When set to ‘0’, it indicates the device “in failed array” indicator is not lit. Seagate enclosures do not implement a separate “in failed array” indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

REBUILD/REMAP, when set to ‘1’, indicates that the device rebuild/remap visual indicator is lit. When set to ‘0’, it indicates the device rebuild/remap indicator is not lit. Seagate enclosures do not implement a separate rebuild/remap indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

R/R ABORT, when set to ‘1’, indicates that the device rebuild/remap abort visual indicator is lit. When set to ‘0’, it indicates the device rebuild/remap abort indicator is not lit. Seagate enclosures do not implement a separate rebuild/remap abort indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

For byte 2 and 3 field descriptions see 7.2.2.

7.3.3 Array device slot control element

Table 57 – Array device slot control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST OK	RQST RSVD DEVICE	RQST HOT SPARE	RQST CONS CHECK	RQST IN CRIT ARRAY	RQST IN FAILED ARRAY	RQST REBUILD /REMAP	RQST R/R ABORT
2	RQST ACTIVE	DO NOT REMOVE	Reserved	RQST MISSING	RQST INSERT	RQST REMOVE	RQST IDENT	Reserved
3	Reserved		RQST FAULT	DEVICE OFF	ENABLE BYP A	ENABLE BYP B	Reserved	

RQST OK set to ‘1’ specifies that the device okay indicator be turned on. When set to ‘0’, this bit specifies that the device okay indicator be turned off.

RQST RSVD DEVICE set to ‘1’ specifies that the reserved device indicator be turned on. When set to ‘0’, this bit specifies that the reserved device indicator be turned off. Seagate enclosures do not implement a reserved device indicator and therefore this bit is not supported. Any attempt to set the RQST RSVD DEVICE bit will be ignored.

RQST HOT SPARE set to ‘1’ specifies that the hot spare indicator be turned on. When set to ‘0’, this bit specifies that the hot spared indicator be turned off. Seagate enclosures do not implement a hot spare indicator and therefore this bit is not supported. Any attempt to set the RQST HOT SPARE bit will be ignored.

RQST CONS CHECK set to ‘1’ specifies that the consistency check indicator be turned on. When set to ‘0’, this bit specifies that the consistency check indicator be turned off. Seagate enclosures do not implement a separate consistency check indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

RQST IN CRIT ARRAY set to ‘1’ specifies that the “in critical array” indicator be turned on. When set to ‘0’, this bit specifies that the “in critical array” indicator be turned off. Seagate enclosures do not implement a separate “in critical array” indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

RQST IN FAILED ARRAY set to ‘1’ specifies that the “in failed array” indicator be turned on. When set to ‘0’, this bit specifies that the “in failed array” indicator be turned off. Seagate enclosures do not implement a separate “in failed array” indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

RQST REBUILD/REMAP set to ‘1’ specifies that the rebuild/remap indicator be turned on. When set to ‘0’, this bit specifies that the rebuild/remap indicator be turned off. Seagate enclosures do not implement a separate rebuild/remap indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

RQST R/R ABORT set to ‘1’ specifies that the rebuild/remap abort indicator be turned on. When set to ‘0’, this bit specifies that the rebuild/remap abort indicator be turned off. Seagate enclosures do not implement a separate rebuild/remap abort indicator. Instead, they typically use a specific array condition indication pattern on the drive fault LED for this purpose.

For byte 2 and 3 field descriptions see 7.2.3

7.3.4 Indicator state priority

In many cases, IDENT, FAIL and array indications (CONS CHECK, IN CRIT ARRAY, IN FAILED ARRAY, REBUILD/REMAP, R/R ABORT) share the same physical visual indicator but may use different blink patterns to distinguish between indication types. Where this is the case, a priority is applied to the indicator, allowing more important indications to take precedence over less important ones where they are both active concurrently. This priority is shown in Table 58.

Table 58 – Device/Array Device indication priority

Array Indication	RQST FAIL	RQST IDENT	Enclosure detected fault	Displayed indication
1	0	0	0	Array indication
X	1	0	X	Failure indication
X	X	0	1	Failure indication
X	X	1	X	Identification indication
0	0	0	0	No indication
1 – Set 0 – Cleared X – N/A				

7.3.5 Device Removal for a Multi-Drive Carrier

The behavior of the RMV/RQST REMOVE/DO NOT REMOVE bits on the array device element are identical to the behavior of the same bits in the device element. See section 7.2.4 for more information

7.4 Power Supply Element

The power supply element provides status information for each PCM/PSU present in the enclosure along with basic control for setting power and indicator states.

7.4.1 Overall power supply element status codes

The overall power supply element may use its ELEMENT STATUS CODE (see 7.1.2) to indicate power redundancy and incompatibility issues within the enclosure. This means that while each power supply may be functional, the overall element may indicate a fault condition. The status codes supported by the overall power supply element are shown in Table 59.

Table 59 – Supported ELEMENT STATUS CODE values for the overall power supply element

Code	Name	Description
0h	Unsupported	The enclosure does not support power supply redundancy status using the overall element.
1h	OK	The system power supply configuration and redundancy are okay.
2h	Critical	In the event of a power supply failure or removal, there is no combination of remaining power supplies that would be able to supply the maximum amount of power necessary to support full enclosure operation, i.e., all inserted power supplies are essential contributors to the overall power budget.
3h	Noncritical	In the event of a power supply failure or removal, not all combinations of remaining power supplies would be able to supply the maximum amount of power that could be required by the enclosure.
6h	Unknown	The power redundancy/compatibility status is unknown.

The overall power supply status is prioritized within the GEM firmware as follows:

1. Critical (Highest)
2. Noncritical
3. Unsupported
4. OK (Lowest)

7.4.2 Individual power supply element status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the power supply element are outlined in Table 60.

Table 60 – Supported ELEMENT STATUS CODE values for individual power supply elements

Code	Name	Description
0h	Unsupported	The power supply is not supported in the enclosure configuration.
1h	OK	Element is installed and no error conditions are known.
2h	Critical	The power supply is not providing power because: • AC supply not present • DC output failure • Internal shutdown protection (OTP, OCP, UVP, etc.). • Firmware detected PCM error
3h	Noncritical	The power supply is providing power but has detected a warning condition such as: • Over-temperature warning • Over-current warning • Under-voltage warning
4h	Unrecoverable	The power supply could not be successfully detected. This may occur because the VPD EEPROM on the power supply FRU cannot be read or has become corrupted.
5h	Not Installed	The power supply bay is empty.
6h	Unknown	A communications fault is preventing power supply status retrieval.
7h	Not Available	The firmware has yet to retrieve status from the power supply. This could occur shortly after a reboot or power supply insertion.

7.4.3 Power supply status element

Table 61 – Power supply status element format

Bit Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	Reserved						
2	Reserved				DC OVER VOLTAGE	DC UNDER VOLTAGE	DC OVER CURRENT	Reserved
3	HOT SWAP	FAIL	RQSTED ON	OFF	OVERTEMP FAIL	TEMP WARN	AC FAIL	DC FAIL

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the power supply is visually identifying its location using an LED or similar device. When set to ‘0’, the power supply is not displaying an identification indication.

DC OVER VOLTAGE, when set to ‘1’, indicates the power supply has detected a DC output over-voltage condition. When set to ‘0’ it indicates no DC over-voltage condition has been detected by the power supply.

DC UNDER VOLTAGE, when set to ‘1’, indicates the power supply has detected a DC output under-voltage condition. When set to ‘0’ it indicates no DC under-voltage condition has been detected by the power supply. This bit is latched on detection of a fault and may only be cleared with a control operation setting the RQST FAIL bit to ‘1’ followed by a second control operation setting RQST FAIL to ‘0’.

DC OVER CURRENT, when set to ‘1’, indicates the power supply has detected a DC output over-current condition. When set to ‘0’ it indicates no DC over-current condition has been detected by the power supply.

HOT SWAP, when set to ‘1’, indicates the power supply is not critical to maintaining enclosure power and may be removed, replaced, or taken offline. When set to ‘0’, the power supply is essential for maintaining enclosure power. Any attempt to remove, replace or take the power supply offline when HOT SWAP is set to ‘0’ could result in the enclosure shutting down.

FAIL, when set to ‘1’, indicates that the RQST FAIL bit has been set to ‘1’ by the host and the power supply is visually indicating a failure. When set to ‘0’ the RQST FAIL bit has been set to ‘0’ by the host. Note that the power supply may still be visually indicating a failure even if this bit is set to ‘0’.

RQSTED ON, when set to ‘1’, indicates that the power supply has been manually turned on or has been requested to turn on by setting the RQST ON bit to ‘1’. This bit is not supported by GEM and is set to ‘0’.

OFF, when set to ‘1’, indicates the power supply is not providing power. The OFF bit shall be set to ‘1’ if the power supply is turned off manually or a failure has caused the power supply to stop providing power. The OFF bit shall be set to ‘0’ when the power supply is providing its specified output.

OVERTEMP FAIL, when set to ‘1’, indicates that the power supply has detected an over-temperature failure condition. When set to ‘0’ it indicates no over-temperature failure condition has been detected by the power supply.

TEMP WARNING, when set to ‘1’, indicates that the power supply has detected an over/under temperature warning condition. When set to ‘0’ it indicates no over/under temperature warning condition has been detected by the power supply.

AC FAIL, when set to ‘1’, indicates that the power supply has no compliant input power source. When set to ‘0’ it indicates that the power supply is receiving a compliant input power source.

DC FAIL, when set to ‘1’, indicates that a power supply DC output has failed. When set to ‘0’ it indicates all power supply DC outputs are operating correctly.

7.4.4 Power supply control element

Table 62 – Power supply control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	Reserved						
2	Reserved							
3	Reserved	RQST FAIL	RQST ON	Reserved				

RQST IDENT, when set to ‘1’, instructs the enclosure to display a visual identification indication on the corresponding power supply. When set to ‘0’, any visual identification indication on the power supply will be turned off. Note that on Seagate storage enclosures the logic within the power supplies can override any IDENT indication when it wishes to display its own fault status. This means that in some circumstances, requested IDENT indications may not be visible on the power supply module.

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual fault indication on the corresponding power supply. When set to ‘0’, any host requested visual fault indication on the power supply will be turned off. Note that even if the RQST FAIL bit is set to ‘0’ the power supply may continue to display enclosure detected fault conditions. The RQST FAIL bit is also used to clear latched status element bits by first setting it ‘1’, followed by a second operation setting it back to ‘0’ again. See 7.4.3 for information on which status bits are latched.

RQST ON, when set to ‘1’, instructs the enclosure to power on the power supply. When set to ‘0’ it instructs the enclosure to power off the power supply. GEM provides high level enclosure power control operations via the vendor unique ENCLOSURE ELECTRONICS POWER element (see 9.4), as such this bit is not supported.

7.4.5 Power Supply AC/DC Failure Detection

The condition of the power supply can be determined using Table 63. It shows how the PSU Condition can be determined from the SES power supply status element.

Table 63 – PSU Condition and SES PSU element relationship

PSU Condition	ELEMENT STATUS CODE	FAIL (transient)	OFF (transient)	AC FAIL (transient)	DC FAIL (transient)
Good	01h OK	0	0	0	0
DC Failure	02h CRITICAL	1	1	X	1
AC Failure	02h CRITICAL	1	1	1	X
1 – Set 0 – Cleared X – N/A					

It should be noted that in the above table, where ‘transient’ is stated, the ANSI SES definition states that these bits should reflect the current state of the power supply. These bits are not latched and therefore if an application client does not poll for status whilst these bits are set, the state change of these bits

could be lost despite the short status INFO bit being set. GEM does, however, retain a log of such failures which may be retrieved via the CLI if such an error condition is suspected.

7.5 Cooling Element

The cooling element provides status information for each fan or similar cooling device present in the enclosure, along with basic control for cooling module indicator states where supported.

7.5.1 Overall cooling element status codes

The overall cooling element may use its ELEMENT STATUS CODE (see 7.1.2) to indicate cooling redundancy and incompatibility issues within the enclosure. This means that while each cooling element may be functional, the overall element may indicate a fault condition. The status codes supported by the overall cooling element are shown in Table 64.

Table 64 – Supported ELEMENT STATUS CODE values for the overall cooling element

Code	Name	Description
1h	OK	The system cooling configuration and redundancy is okay.
2h	Critical	System cooling is potentially insufficient for maintaining long term system operation.
3h	Noncritical	A system cooling failure has been detected but cooling is sufficient.
6h	Unknown	The system cooling redundancy status is unknown.

7.5.2 Individual cooling element status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the cooling element are outlined in Table 65.

Table 65 – Supported ELEMENT STATUS CODE values for individual cooling elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	The cooling device has failed and is unable to contribute to enclosure cooling.
3h	Noncritical	The cooling device is operating outside its permitted tolerance.
5h	Not Installed	The cooling device is not present.
6h	Unknown	A communications fault is preventing cooling element status retrieval.
7h	Not Available	The firmware has yet to retrieve status from the cooling device. This could occur shortly after a reboot or cooling device insertion.

7.5.3 Cooling status element

Table 66 – Cooling status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	Reserved				(MSB)		
2	ACTUAL FAN SPEED							(LSB)
3	HOT SWAP	FAIL	RQSTED ON	OFF	Reserved	ACTUAL SPEED CODE		

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the module containing the cooling device is visually identifying its location using an LED or similar device. When set to ‘0’, the module containing the cooling device is not displaying an identification indication.

ACTUAL FAN SPEED displays the rotational speed of the cooling device in units of 10 revolutions per minute (RPM). For example, an ACTUAL FAN SPEED value of 200 would equate to a cooling device rotational speed of 2000 RPM.

HOT SWAP, when set to ‘1’, indicates the cooling device is not critical to maintaining enclosure cooling and the module containing it may be removed, replaced, or taken offline. When set to ‘0’, the cooling device is essential for maintaining enclosure cooling. Any attempt to remove, replace or take the cooling device offline when HOT SWAP is set to ‘0’ could result in the enclosure overheating. If the power supply and cooling elements share a common physical module, as in the case of a PCM, the HOT SWAP bits for both elements will be linked, meaning that the cooling device must not be removed if it risks enclosure power capability and vice-versa.

FAIL, when set to ‘1’ indicates the RQST FAIL control bit has been set or GEM detected a failure and the module containing the cooling device is visually indicating a failure using an LED or similar device. When set to ‘0’, the module containing the cooling device is not displaying a failure indication. Note that the module containing the cooling device may still be visually indicating a failure even if this bit is set to ‘0’.

RQSTED ON, when set to ‘1’, indicates that the cooling device has been manually turned on or has been requested to turn on by setting the RQST ON bit to ‘1’. This bit is not supported by GEM and is set to ‘0’.

OFF, when set to ‘1’, indicates the cooling device is not providing cooling. The OFF bit shall be set to ‘1’ if a failure has caused the cooling element to stop operating or the cooling element is turned off manually. The OFF bit shall be cleared when the cooling element is operating.

ACTUAL SPEED CODE contains a discrete code for advertising the cooling device’s current speed or rate of cooling. Table 67 shows the values supported by this field.

Table 67 – ACTUAL FAN SPEED codes

Code	Description
000b	Cooling device has stopped.
001b	Cooling device is running at its minimum RPM.
010b	Cooling device is running at 2/7 of its RPM range.
011b	Cooling device is running at 3/7 of its RPM range.

Code	Description
100b	Cooling device is running at 1/2 of its RPM range.
101b	Cooling device is running at 5/7 of its RPM range.
110b	Cooling device is running at 6/7 of its RPM range.
111b	Cooling device is running at its maximum RPM.

7.5.4 Cooling control element

Table 68 – Cooling control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	Reserved						
2	Reserved							
3	Reserved	RQST FAIL	RQST ON	Reserved		REQUESTED SPEED CODE		

RQST IDENT, when set to ‘1’, instructs the enclosure to display a visual identification indication on the corresponding cooling module. When set to ‘0’, any visual identification indication on the cooling module will be turned off.

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual fault indication on the corresponding cooling module. When set to ‘0’, any host requested visual fault indication on the cooling module will be turned off. This bit is not supported by GEM.

RQST ON, when set to ‘1’, instructs the enclosure to power on the cooling device. When set to ‘0’ it instructs the enclosure to power off the cooling device. GEM does not support this bit.

REQUESTED SPEED CODE, allows the SES client to take control of the cooling device’s rotational speed using discrete speed codes (see Table 67). GEM does not permit host control of fan speed and as such, this field is not supported.

7.6 Temperature Sensor Element

The temperature sensor element provides status information for each temperature sensor device present in the enclosure.

7.6.1 Overall temperature sensor element status codes

The overall temperature sensor element may use its ELEMENT STATUS CODE (see 7.1.2) to indicate temperature sensor redundancy issues or thermal threshold problems within the enclosure. This means that while each temperature sensor element present may be functional, the overall element may indicate a fault condition. The status codes supported by the overall temperature sensor element are shown in Table 69.

Table 69 – Supported ELEMENT STATUS CODE values for the overall temperature sensor element

Code	Name	Description
1h	OK	Enclosure temperature sensing is okay.
3h	Noncritical	One or more temperature sensors have breached a warning/critical threshold or are indicating a failure.
4h	Unrecoverable	Enclosure thermal reporting failure due to a failure in all sensors caused by loss of communications or inability to maintain stable readings
6h	Unknown	The thermal status is unknown.

7.6.2 Overall temperature sensor status element

Table 70 – Overall temperature sensor status element format

Byte \ Bit	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	RESERVED				NO OF SETTABLE SENSORS			
2	RESERVED							
3	RESERVED							

NO OF SETTABLE SENSORS, this shall specify the number of customer settable thermal zone elements to show. The range of valid values for this field is 0 to 15.

7.6.3 Individual temperature sensor element status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the temperature sensor element are outlined in Table 71.

Table 71 – Supported ELEMENT STATUS CODE values for individual temperature sensor elements

Code	Name	Description
0h	UNSUPPORTED	The customer settable thermal element is disabled, i.e., not yet set or has been disabled by sending 0.
1h	OK	Element is installed and no error conditions are known. For customer settable thermal elements, is enabled and the values supplied are in a good state.
2h	Critical	The temperature sensor has breached a critical threshold (see 7.6.6) or a temperature sensor critical to cooling has become unavailable.
3h	Noncritical	The temperature sensor has breached a warning threshold (see 7.6.6).
4h	Unrecoverable	Communications with the temperature sensor have been lost.
5h	Not Installed	The temperature sensor is removed or not fitted.

Code	Name	Description
6h	Unknown	An inter-canister communications fault is preventing temperature sensor status retrieval.
7h	Not Available	The firmware has yet to retrieve status from the temperature sensor. This could occur shortly after a reboot or module insertion.

7.6.4 Temperature sensor status element

Table 72 – Temperature sensor status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	FAIL	Reserved					
2	TEMPERATURE							
3	Reserved				OT FAILURE	OT WARNING	UT FAILURE	UT WARNING

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the module containing the temperature sensor is visually identifying its location using an LED or similar device. When set to ‘0’, the module containing the temperature sensor is not displaying an identification indication. GEM does not support this bit.

FAIL, when set to ‘1’ indicates the RQST FAIL control been set and the module containing the temperature sensor is visually indicating a failure using an LED or similar device. When set to ‘0’, the module containing the temperature sensor is not displaying a failure indication. GEM does not support this bit.

TEMPERATURE indicates the temperature reading reported by the sensor in degrees Celsius, offset by +20°C. The value 00h is reserved, allowing a temperature reporting range of -19°C to 235°C. To convert the value of TEMPERATURE to the actual temperature in Celsius, subtract 20 from the reported value. For example, a value of 72 equates to a temperature reading of 52°C (72-20=52).

OT FAILURE, when set to ‘1’, indicates that temperature reading reported by the sensor has exceeded the OVER TEMPERATURE CRITICAL THRESHOLD in SES Page 05h. When set to ‘0’, it indicates that the sensor reading has not exceeded the over-temperature critical threshold. Once an OT FAILURE has been detected, it will not be cleared until the sensor reading falls 2°C below the OVER TEMPERATURE CRITICAL THRESHOLD value.

OT WARNING, when set to ‘1’, indicates that temperature reading reported by the sensor has exceeded the OVER TEMPERATURE WARNING THRESHOLD in SES Page 05h. When set to ‘0’, it indicates that the sensor reading has not exceeded the over-temperature warning threshold. Once an OT WARNING has been detected, it will not be cleared until the sensor reading falls 2°C below the OVER TEMPERATURE WARNING THRESHOLD value.

UT FAILURE, when set to ‘1’, indicates that temperature reading reported by the sensor has dropped below the UNDER TEMPERATURE CRITICAL THRESHOLD in SES Page 05h. When set to ‘0’, it indicates that the sensor reading has not dropped below the under-temperature critical threshold. Once a UT FAILURE has been detected, it will not be cleared until the sensor reading rises 2°C above the UNDER TEMPERATURE CRITICAL THRESHOLD value.

UT WARNING, when set to ‘1’, indicates that temperature reading reported by the sensor has dropped below the UNDER TEMPERATURE WARNING THRESHOLD in SES Page 05h. When set to ‘0’, it indicates that the sensor reading has not dropped below the under-temperature warning threshold. Once a UT WARNING has been detected, it will not be cleared until the sensor reading rises 2°C above the UNDER TEMPERATURE WARNING THRESHOLD value.

7.6.5 Temperature sensor control element

Table 73 – Temperature sensor control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	RQST FAIL	Reserved					
2	Reserved							
3								

RQST IDENT, when set to ‘1’, instructs the enclosure to display a visual identification indication on the module containing the temperature sensor. When set to ‘0’, any visual identification indication on the module containing the temperature sensor will be turned off. GEM does not support this bit.

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual fault indication on the module containing the temperature sensor. When set to ‘0’, any visual fault indication on the module containing the temperature sensor will be turned off. GEM does not support this bit.

7.6.6 Temperature sensor threshold status element

The temperature sensor element reports the thresholds it uses for warning and critical alerts in SES Page 05h. The format of the temperature sensor threshold status element is shown in Table 74. As with the page 02h temperature sensor element TEMPERATURE field (see 7.6.4), the threshold values are offset by +20°C, with a value of 00h being reserved.

Table 74 - Temperature sensor threshold status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	OVER TEMPERATURE CRITICAL THRESHOLD							
1	OVER TEMPERATURE WARNING THRESHOLD							
2	UNDER TEMPERATURE WARNING THRESHOLD							
3	UNDER TEMPERATURE CRITICAL THRESHOLD							

OVER TEMPERATURE CRITICAL THRESHOLD reports the threshold at which the OT FAILURE bit will be set in the temperature sensor status element (see 7.6.4). The OT FAILURE bit will be set when the temperature reported by the sensor exceeds this threshold by one or more degrees Celsius.

OVER TEMPERATURE WARNING THRESHOLD reports the threshold at which the OT WARNING bit will be set in the temperature sensor status element (see 7.6.4). The OT WARNING bit will be set when the temperature reported by the sensor exceeds this threshold by one or more degrees Celsius.

UNDER TEMPERATURE WARNING THRESHOLD reports the threshold at which the UT WARNING bit will be set in the temperature sensor status element (see 7.6.4). The UT WARNING bit will be set when the temperature reported by the sensor drops below this threshold by one or more degrees Celsius.
UNDER TEMPERATURE CRITICAL THRESHOLD reports the threshold at which the UT FAILURE bit will be set in the temperature sensor status element (see 7.6.4). The UT FAILURE bit will be set when the temperature reported by the sensor drops below this threshold by one or more degrees Celsius.

7.6.7 Temperature sensor threshold control element

The temperature sensor element permits adjustment of the thresholds it uses for warning and critical alerts in SES Page 05h. The format of the temperature sensor threshold control element is shown in Table 74. As with the page 02h temperature sensor element TEMPERATURE field (see 7.6.4), the threshold values are offset by +20°C, with a value of 00h being reserved to mean “no change”.

Table 75 - Temperature sensor threshold control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	REQUESTED OVER TEMPERATURE CRITICAL THRESHOLD							
1	REQUESTED OVER TEMPERATURE WARNING THRESHOLD							
2	REQUESTED UNDER TEMPERATURE WARNING THRESHOLD							
3	REQUESTED UNDER TEMPERATURE CRITICAL THRESHOLD							

REQUESTED OVER TEMPERATURE CRITICAL THRESHOLD sets the threshold at which the OT FAILURE bit will be set in the temperature sensor status element (see 7.6.4). The OT FAILURE bit will be set when the temperature reported by the sensor exceeds this threshold by one or more degrees Celsius. GEM does not permit the modification of critical temperature thresholds and will ignore any values entered in this field.

OVER TEMPERATURE WARNING THRESHOLD sets the threshold at which the OT WARNING bit will be set in the temperature sensor status element (see 7.6.4). The OT WARNING bit will be set when the temperature reported by the sensor exceeds this threshold by one or more degrees Celsius. Writing a value of 00h will instruct GEM to preserve the existing threshold value.

UNDER TEMPERATURE WARNING THRESHOLD sets the threshold at which the UT WARNING bit will be set in the temperature sensor status element (see 7.6.4). The UT WARNING bit will be set when the temperature reported by the sensor drops below this threshold by one or more degrees Celsius. Writing a value of 00h will instruct GEM to preserve the existing threshold value.

UNDER TEMPERATURE CRITICAL THRESHOLD sets the threshold at which the UT FAILURE bit will be set in the temperature sensor status element (see 7.6.4). The UT FAILURE bit will be set when the temperature reported by the sensor drops below this threshold by one or more degrees Celsius. GEM does not permit the modification of critical temperature thresholds and will ignore any values entered in this field.

7.7 Door Lock Element

The door lock element reports the status of enclosure drive drawers and chassis access panels where fitted.

7.7.1 Individual door lock element status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the door lock element are outlined in Table 76.

Table 76 – Supported ELEMENT STATUS CODE values for individual door lock elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	The drive drawer or access panel has been left open for an extended period of time (time period is product specific). Enclosure cooling may be at risk.
5h	Not Installed	The door lock sensor is removed or not fitted.
6h	Unknown	Door lock sensor status cannot be retrieved.
7h	Not Available	The firmware has yet to retrieve status from the door lock sensor. This could occur shortly after a reboot or module insertion.

7.7.2 Door lock status element

Table 77 – Door lock sensor status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	FAIL	Reserved					
2	Reserved							
3	Reserved						OPEN	UNLOCKED

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the module containing the door lock sensor is visually identifying its location using an LED or similar device. When set to ‘0’, the module containing the door lock sensor is not displaying an identification indication. This bit is not supported by GEM and shall be set to ‘0’.

FAIL, when set to ‘1’, indicates the RQST FAIL control bit has been set and the module containing the door lock sensor is visually indicating a failure using an LED or similar device. When set to ‘0’, the module containing the door lock sensor is not displaying a failure indication. This bit is not supported by GEM and shall be set to ‘0’.

OPEN, when set to ‘1’, indicates that the associated drive drawer or chassis access panel is currently open. When set to ‘0’ this bit indicates that the drive drawer or chassis access panel is closed.

UNLOCKED, when set to ‘1’, indicates that the associated drive drawer or chassis access panel is currently unlocked. When set to ‘0’ this bit indicates that the drive drawer or chassis access panel is locked. This bit is not supported by GEM and shall be set to ‘0’.

7.7.3 Door lock control element

Table 78 – Door lock sensor control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	RQST FAIL	Reserved					
2	Reserved							
3	Reserved							UNLOCK

RQST IDENT, when set to ‘1’, instructs the enclosure to display a visual identification indication on the corresponding module containing the door lock sensor. When set to ‘0’, any visual identification indication on the module containing the door lock sensor will be turned off. This bit is not supported by GEM and shall be ignored.

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual failure indication on the corresponding module containing the door lock sensor. When set to ‘0’, any visual failure indication on the module containing the door lock sensor will be turned off. This bit is not supported by GEM and shall be ignored.

UNLOCK, when set to ‘1’, instructs the enclosure to unlock the drive drawer or access panel associated with the door lock element. When set to ‘0’, the drive drawer or access panel will be locked. This bit is not supported by GEM and shall be ignored.

7.8 Audible Alarm Element

The audible alarm element is used to read and write enclosure alarm status. This element is associated with overall fault status reported by the enclosure ops panel and may be represented whether a buzzer is fitted or not. The buzzer and ops panel LED state for each of the audible alarm severity tones is configurable and may vary between product and customer configurations. The fault states that the enclosure ops panel can display are shown in Table 79.

Table 79 – Enclosure alarm state codes

Alarm State	Description
S0	No alarm (silent buzzer tone). Enclosure operation is good.
S1	Non-critical alarm (intermittent buzzer tone). Enclosure is functional but some operation may be degraded.
S2	Remind alarm (remind buzzer tone). Enclosure is functional but some operation may be degraded.
S3	Muted alarm (silent buzzer tone). Enclosure is functional but some operation may be degraded.
S4	Critical alarm (continuous buzzer tone). Immediate risk to enclosure operation has been detected.

7.8.1 Individual audible alarm element status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the audible alarm element are outlined in Table 76.

Table 80 – Supported ELEMENT STATUS CODE values for individual audible alarm elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
4h	Unrecoverable	Unable to communicate with the ops panel.
5h	Not Installed	The ops panel is not installed.
6h	Unknown	Ops panel status cannot be retrieved.
7h	Not Available	The firmware has yet to retrieve ops panel status. This could occur shortly after a reboot.

7.8.2 Audible alarm status element

Table 81 – Audible alarm status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	FAIL	Reserved					
2	Reserved							
3	RQST MUTE	MUTED	Reserved	REMIND	TONE URGENCY INDICATOR			
					INFO	NON-CRIT	CRIT	UNRECOV

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the module containing the ops panel is visually identifying its location using an LED or similar device. When set to ‘0’, the module containing the ops panel is not displaying an identification indication. This bit is not supported by GEM and shall be set to ‘0’.

FAIL, when set to ‘1’, indicates the RQST FAIL control bit has been set and the module containing the ops panel is visually indicating a failure using an LED or similar device. When set to ‘0’, the module containing the ops panel is not displaying a failure indication. This bit is not supported by GEM and shall be set to ‘0’.

RQST MUTE, when set to ‘1’, indicates the RQST MUTE bit in the control element or a physical mute button on the ops panel has been set. When set to ‘0’, it indicates that no request to mute the buzzer is currently registered with the enclosure.

MUTED, when set to ‘1’, indicates that the enclosure buzzer is currently silent. When set to ‘0’, it indicates that the enclosure buzzer is emitting a tone.

REMIND, when set to ‘1’, indicates that the enclosure buzzer has transitioned from an “intermittent” tone to a “remind” tone (a reduced rate tone that is used to remind the user that a fault still exists). When set to ‘0’, this bit indicates that the buzzer is not currently emitting a remind tone.

INFO, when set to ‘1’, indicates that the enclosure ops panel is currently reporting an informational alert. When set to ‘0’, this bit indicates the enclosure ops panel is not currently reporting an informational alert.

NON-CRIT, when set to ‘1’, indicates that the enclosure ops panel is currently reporting a non-critical alert. When set to ‘0’, this bit indicates the enclosure ops panel is not currently reporting a non-critical alert.

CRIT, when set to ‘1’, indicates that the enclosure ops panel is currently reporting a critical alert. When set to ‘0’, this bit indicates the enclosure ops panel is not currently reporting a critical alert.

UNRECOV, when set to ‘1’, indicates that the enclosure ops panel is currently reporting an unrecoverable alert. When set to ‘0’, this bit indicates the enclosure ops panel is not currently reporting an unrecoverable alert.

7.8.3 Audible alarm control element

Table 82 – Audible alarm control element format

Byte \ Bit	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	RQST FAIL	Reserved					
2	Reserved							
3	Reserved	SET MUTE	Reserved	SET REMIND	TONE URGENCY CONTROL			
					INFO	NON-CRIT	CRIT	UNRECOV

RQST IDENT, when set to ‘1’, instructs the enclosure to display a visual identification indication on the corresponding module containing the alarm indicators. When set to ‘0’, any visual identification indication on the module containing the alarm indicators will be turned off. This bit is not supported by GEM and shall be ignored.

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual failure indication on the corresponding module containing the alarm indicators. When set to ‘0’, any visual failure indication on the module containing the alarm indicators will be turned off. This bit is not supported by GEM and shall be ignored.

SET MUTE, when set to ‘1’, instructs the enclosure to mute (S1 state) any current alarm indication. When set to ‘0’, the alarm shall be un-muted and will be permitted to emit an audible tone. GEM ignores requests to mute the alarm if the enclosure alarm state is in state S0 or S4. If this bit is set in conjunction with the SET REMIND bit, the SET MUTE bit takes precedence and the SET REMIND request will be ignored.

SET REMIND, when set to ‘1’, instructs the enclosure to set the remind indication on the system buzzer. When set to ‘0’, the alarm shall be taken out of the “remind” (S2) state. GEM ignores requests to set the “remind” state if the enclosure alarm state is in S0 or S4. If this bit is set in conjunction with the SET MUTE bit, the SET MUTE bit takes precedence and the SET REMIND request will be ignored.

INFO, when set to ‘1’, instructs the enclosure to set an informational alert on the enclosure ops panel. When set to ‘0’, the alarm will stop indicating a host requested informational alert. Note that even if set to ‘0’ any enclosure detected informational alarms will still be displayed on the ops panel.

NON-CRIT, when set to ‘1’, instructs the enclosure to set a non-critical alert on the enclosure ops panel. When set to ‘0’, the alarm will stop indicating a host requested non-critical alert. Note that even if set to ‘0’ any enclosure detected non-critical alarms will still be displayed on the ops panel.

NON-CRIT, when set to ‘1’, instructs the enclosure to set a critical alert on the enclosure ops panel. When set to ‘0’, the alarm will stop indicating a host requested critical alert. Note that even if set to ‘0’ any enclosure detected critical alarms will still be displayed on the ops panel.

UNRECOV, when set to ‘1’, instructs the enclosure to set an unrecoverable alert on the enclosure ops panel. When set to ‘0’, the alarm will stop indicating a host requested unrecoverable alert. Note that even if set to ‘0’ any enclosure detected unrecoverable alarms will still be displayed on the ops panel.

7.8.4 Tone urgency control bits

The TONE URGENCY bits are not mutually exclusive, and the host may set more than one bit at the concurrently. If this is done, GEM will apply a priority to determine which urgency tones take precedence on the ops panel where the alerts utilize the same physical indicators. Table 83 shows the precedence rules GEM applies to the TONE URGENCY bits.

Table 83 – Tone urgency priority

TONE URGENCY	Precedence
INFO	Lowest priority – will be overridden by NON-CRT, CRIT and UNRECOV tones.
NON-CRIT	2nd lowest priority – will be overridden by CRIT and UNRECOV tones. Will override INFO tone.
CRIT	2nd highest priority – will be overridden by UNRECOV tone. Will override INFO and NON-CRIT tones.
UNRECOV	Highest priority – will override INFO, NON-CRT and CRIT tones.

7.8.5 Enclosure alarm state to SES status mapping

GEM’s internal alarm state codes (see Table 79) can be determined using the SES status as shown in Table 84.

Table 84 – Enclosure alarm state to SES status mapping

Alarm State	MUTED	REMIND	INFO	NON-CRIT	CRIT	UNRECOV
S0	0	0	0	0	0	0
S1	0	0	1	X	X	0
	0	0	X	1	X	0
	0	0	X	X	1	0
S2	0	1	X	X	X	0
S3	1	X	X	X	X	0
S4	X	X	X	X	X	1

1 – Set
0 – Cleared
X – N/A

7.8.6 Alarm mute and remind modes

S1 alarms may be placed in a muted (S3) or remind (S2) state using the enclosure mute button or SET MUTE and SET REMIND control bits. In the mute state, the ops panel is silenced whereas in the remind state, the period between audible tones is reduced to once every 20secs. Remind mode is entered automatically after a single S1 alarm has been active for 2 minutes.

It should be noted that after an S1 alarm has placed into a muted or remind state, it may return to S1 if a new fault condition is detected by the enclosure or the severity of the fault increases to a critical S4 alarm.

7.9 Enclosure Services Controller Electronics Element

The Enclosure Services Controller Electronics (ESCE) elements report the status of the two I/O Modules that can be inserted into the enclosure to provide services for the enclosure process. Each I/O Module typically provides access to each redundant storage domain provided by the enclosure and its storage devices.

7.9.1 Individual enclosure services controller electronics status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the ESCE element are outlined in Table 85.

Table 85 – Supported ELEMENT STATUS CODE values for individual ESCE elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	One of the following fault conditions has been detected. • I/O Module temperature sensing failure. • I/O Module VPD EEPROM read failure. • I/O Module local I^2C bus failure. • Failure of at least I/O Module Midplane I^2C bus. Communications maintained via redundant buses.
3h	Noncritical	Failure of dedicated inter-canister communications link. Communication with partner I/O Module has been maintained via a redundant link.
4h	Unrecoverable	A failure of all I/O Module Midplane I^2C buses has occurred.
5h	Not Installed	The I/O Module is not installed.
6h	Unknown	Failure to retrieve I/O Module status from partner canister.

7.9.2 Enclosure services controller electronics status element

Table 86 – Enclosure services controller electronics status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	FAIL	Reserved					
2	Reserved							REPORT
3	HOT SWAP	Reserved						

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the I/O Module is visually identifying its location using an LED or similar device. When set to ‘0’, the I/O Module is not displaying an identification indication.

FAIL, when set to ‘1’, indicates that the RQST FAIL control bit has been set and the I/O Module is visually identifying a fault using an LED or similar device. When set to ‘0’, the I/O Module is not displaying a host requested failure indication. Note that even if the FAIL bit is set to 0, the I/O Module will still indicate enclosure detected failures.

REPORT, when set to ‘1’, indicates that the I/O Module is operating as the “primary” controller in the enclosure. When set to ‘0’, this bit indicates that the I/O Module is operating as the “secondary” controller. See 4.2 for details on High Availability operating modes.

HOT SWAP, when set to ‘1’, indicates that the I/O Module may be removed, rebooted, or taken offline without compromising access to the storage devices, i.e., a partner I/O Module is available to provide uninterrupted access to the storage medium. When set to ‘0’, this bit indicates that the I/O Module is essential to storage medium access or enclosure function.

7.9.3 Enclosure services controller electronics control element

Table 87 – Enclosure services controller electronics control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	RQST FAIL	Reserved					
2	Reserved							SELECT ELEMENT
3	Reserved							

RQST IDENT, when set to ‘1’, instructs the corresponding I/O Module to display a visual identification indication. When set to ‘0’, any visual identification indication on the I/O Module will be turned off.

RQST FAIL, when set to ‘1’, instructs the corresponding I/O Module to display a visual failure indication. When set to ‘0’, any host requested visual failure indication on the I/O Module will be turned off. Note that even if this bit is set to ‘0’, the I/O Module will continue to indicate any enclosure detected failure conditions.

SELECT ELEMENT, when set to ‘1’, instructs the I/O Module to take on the primary role in the enclosure. When set to ‘0’ it instructs the I/O Module to relinquish the primary role. GEM’s I/O Module High Availability roles are entirely self-managed and, as such, this bit is not supported.

7.10 Display Element

The display element is used to relay status information for intelligent enclosure operations panels, where fitted. Such ops panels usually contain a microcontroller, offering additional features above those provided by non-intelligent panels, such as LCD status displays, etc.

7.10.1 Individual display status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the display element are outlined in Table 88.

Table 88 – Supported ELEMENT STATUS CODE values for individual display elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
3h	Noncritical	Display/ops panel misconfiguration detected.
4h	Unrecoverable	Display/ops panel communications failure detected.
5h	Not Installed	The display/ops panel is not installed or fitted.
6h	Unknown	Failure to retrieve display/ops panel status from partner canister.
7h	Not Available	The firmware has yet to retrieve display/ops panel status. This could occur shortly after a reboot.

7.10.2 Display status element

Table 89 – Display status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	FAIL	Reserved					DISPLAY MODE STATUS
2	DISPLAY CHARACTER STATUS							
3	Reserved							

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the module containing the display is visually identifying its location using an LED or similar device. When set to ‘0’, the module containing the display is not displaying an identification indication. This bit is not supported by GEM and shall be set to ‘0’.

FAIL, when set to ‘1’, indicates the RQST FAIL control bit has been set and the module containing the display is visually indicating a failure using an LED or similar device. When set to ‘0’, the module containing the display is not displaying a failure indication. This bit is not supported by GEM and shall be set to ‘0’.

DISPLAY MODE STATUS reports the display’s operating mode. Supported values for this field are shown in Table 90.

Table 90 – DISPLAY MODE STATUS codes

Code	Description
00b	The enclosure services process is autonomously controlling the display, Display element control of the display is not supported.
01b	The enclosure services process is autonomously controlling the display, Display element control of the display is supported.
10b	The display is being controlled by the display element.
11b	Reserved

DISPLAY CHARACTER STATUS reports the value a single user controllable ASCII character shown on the display when DISPLAY MODE 01b or 10b is used. If display mode 00b is used, the DISPLAY CHARACTER STATUS field becomes reserved. As GEM only supports mode 00h, this field will always return 00h.

7.10.3 Display control element

Table 91 – Display control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	RQST FAIL	Reserved					DISPLAY MODE
2	DISPLAY CHARACTER							
3	Reserved							

RQST IDENT, when set to ‘1’, instructs the enclosure to display a visual identification indication on the corresponding module containing the display. When set to ‘0’, any visual identification indication on the module containing the display will be turned off. This bit is not supported by GEM and shall be ignored.

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual failure indication on the corresponding module containing the display. When set to ‘0’, any visual failure indication on the module containing the display will be turned off. This bit is not supported by GEM and shall be ignored.

DISPLAY MODE selects the operating mode of the display. This field is not supported by GEM and shall be ignored.

DISPLAY CHARACTER allows for a user selectable ASCII character to be rendered on the display when display modes 01b and 10b are supported (see Table 90). GEM only supports display mode 00h and therefore this field shall be ignored.

7.11 Enclosure Element

The enclosure element provides overall status and control for the storage enclosure and its FRUs.

7.11.1 Individual enclosure status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the enclosure element are outlined in Table 92.

Table 92 – Supported ELEMENT STATUS CODE values for individual enclosure elements

Code	Name	Description
1h	OK	No enclosure error conditions are known.
2h	Critical	One or more of the following faults has been detected. • Unsupported enclosure configuration. • One of more Midplane I^2C bus (bus 0, 1 or 2) has failed.
3h	Noncritical	The redundant Midplane VPD EEPROMs contain mismatched content.
4h	Unrecoverable	One or more of the following faults has been detected. • Failed to read Midplane VPD EEPROM. • Both Midplane peripheral I^2C buses have failed (buses 1 and 2). • Midplane SGPIO has failed.
7h	Not Available	The firmware has yet to retrieve enclosure status. This could occur shortly after a reboot.

7.11.2 Enclosure status element

Table 93 – Enclosure status element format

Bit Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	Reserved						
2	TIME UNTIL POWER CYCLE						FAIL IND	WARN IND
3	REQUESTED POWER OFF DURATION						FAIL RQSTD	WARN RQSTD

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the I/O Module is visually identifying its location using an LED or similar device. When set to ‘0’, the enclosure is not displaying an identification indication.

TIME UNTIL POWER CYCLE reports the remaining time in minutes before the enclosure will be power cycled. This field is not supported by GEM and will report a value of 00h. Enclosure power cycle operations are performed using the vendor unique Enclosure Electronics Power element (see 9.4) or enclosure control element (see 7.11.3).

FAIL IND, when set to ‘1’, indicates that the enclosure is visually identifying a failure using an LED or similar device (for Seagate storage enclosures this is typically the ops panel Module fault LED). When set to ‘0’, the enclosure is not displaying a failure indication.

WARN IND, when set to ‘1’, indicates that the enclosure is visually identifying a warning using an LED or similar device (for Seagate storage enclosures this is typically the ops panel Module fault LED). When set to ‘0’, the enclosure is not displaying a warning indication.

REQUESTED POWER OFF DURATION reports the duration in minutes over which the enclosure shall remain powered off when a power cycle is performed. This field is not supported by GEM and will report a value of 00h. Enclosure power cycle operations are performed using the vendor unique Enclosure Electronics Power element (see 9.4) or enclosure control element (see 7.11.3).

FAIL RQSTD, when set to ‘1’, indicates that the RQST FAIL control bit has been set. When set to ‘0’, the host has not requested a failure indication.

WARN RQSTD, when set to ‘1’, indicates that the RQST WARN control bit has been set. When set to ‘0’, the host has not requested a warning indication.

7.11.3 Enclosure control element

Table 94 – Enclosure control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	Reserved						
2	POWER CYCLE RQST	POWER CYCLE DELAY						
3	POWER OFF DURATION						RQST FAIL	RQST WARN

RQST IDENT, when set to ‘1’, instructs the enclosure to display a visual identification indication. When set to ‘0’, any visual identification indication on the enclosure will be turned off.

POWER CYCLE RQST is used to instruct the enclosure to perform a power cycle or cancel an existing scheduled power cycled. Cancelling an existing scheduled power cycle is not supported by GEM and will be ignored.

POWER CYCLE DELAY is used to specify the delay in minutes before a power cycle operation, commanded using POWER CYCLE RQST, is performed. This field is not supported by GEM and will be ignored.

POWER OFF DURATION is used to specify the delay in minutes between the enclosure powering off and re-powering when a power cycle operation is performed. This field is not supported by GEM and will be ignored.

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual failure indication. When set to ‘0’, any host requested visual failure indication on the enclosure will be turned off. Note that even if this bit is set to ‘0’, the enclosure will continue to indicate any self- detected failure conditions.

RQST WARN, when set to ‘1’, instructs the enclosure to display a visual warning indication. When set to ‘0’, any host requested visual warning indication on the enclosure will be turned off.

7.12 Voltage Sensor Element

The voltage sensor element provides status information for each voltage sensor device present in the enclosure.

7.12.1 Individual voltage sensor element status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the voltage sensor element are outlined in Table 95.

Table 95 – Supported ELEMENT STATUS CODE values for individual voltage sensor elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
4h	Unrecoverable	One or more of the following faults has been detected. • The voltage reading is significantly out of acceptable tolerance for the sensor. • Communications with the sensor have failed.
5h	Not Installed	The voltage sensor is removed or not fitted.
6h	Unknown	The sensor reading is unavailable, possibly because the device containing it is being updated with new firmware.
7h	Not Available	The firmware has yet to retrieve status from the voltage sensor. This could occur shortly after a reboot or module insertion.

7.12.2 Voltage sensor status element

Table 96 – Voltage sensor status element format

Bit Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	FAIL	Reserved		WARN OVER	WARN UNDER	CRIT OVER	CRIT UNDER
2	(MSB)	VOLTAGE						
3								(LSB)

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the module containing the voltage sensor is visually identifying its location using an LED or similar device. When set to ‘0’, the module containing the voltage sensor is not displaying an identification indication. GEM does not support this bit.

FAIL, when set to ‘1’ indicates the RQST FAIL control bit has been set and the module containing the voltage sensor is visually indicating a failure using an LED or similar device. When set to ‘0’, the module containing the voltage sensor is not displaying a failure indication. GEM does not support this bit.

WARN OVER, when set to ‘1’, indicates that voltage reading reported by the sensor has exceeded the OVER VOLTAGE WARNING THRESHOLD. When set to ‘0’, it indicates that the sensor reading has not exceeded the over-voltage warning threshold. This bit is not supported by GEM and shall be set to ‘0’.

WARN UNDER, when set to ‘1’, indicates that voltage reading reported by the sensor has dropped below the UNDER VOLTAGE WARNING THRESHOLD. When set to ‘0’, it indicates that the sensor reading has not dropped below the under-voltage warning threshold. This bit is not supported by GEM and shall be set to ‘0’.

CRIT OVER, when set to ‘1’, indicates that voltage reading reported by the sensor has exceeded the OVER VOLTAGE CRITICAL THRESHOLD. When set to ‘0’, it indicates that the sensor reading has not exceeded the over-voltage critical threshold. This bit is not supported by GEM and shall be set to ‘0’.

CRIT UNDER, when set to ‘1’, indicates that voltage reading reported by the sensor has dropped below the UNDER VOLTAGE CRITICAL THRESHOLD. When set to ‘0’, it indicates that the sensor reading has not dropped below the under-voltage critical threshold. This bit is not supported by GEM and shall be set to ‘0’.

VOLTAGE indicates the voltage reading reported by the sensor in units of 10mV for DC and units of 10mV RMS for AC. The number format is 16-bit 2’s compliment allowing an expressible range of -327.68V to 327.67V.

7.12.3 Voltage sensor control element

Table 97 – Voltage sensor control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	RQST FAIL	Reserved					
2	Reserved							
3								

RQST IDENT, when set to ‘1’, instructs the enclosure to display a visual identification indication on the module containing the voltage sensor. When set to ‘0’, any visual identification indication on the module containing the voltage sensor will be turned off. This bit is not supported but GEM and will be ignored.

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual fault indication on the module containing the voltage sensor. When set to ‘0’, any visual fault indication on the module containing the voltage sensor will be turned off. This bit is not supported but GEM and will be ignored.

7.13 Current Sensor Element

The current sensor element provides status information for each current sensor device present in the enclosure.

7.13.1 Individual current sensor element status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the current sensor element are outlined in Table 98.

Table 98 – Supported ELEMENT STATUS CODE values for individual current sensor elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
4h	Unrecoverable	One or more of the following faults has been detected. • The current reading has exceeded the maximum rating for the supply. • Communications with the sensor have failed.
5h	Not Installed	The current sensor is removed or not fitted.
6h	Unknown	The sensor reading is unavailable, possibly because the device containing it is being updated with new firmware.
7h	Not Available	The firmware has yet to retrieve status from the current sensor. This could occur shortly after a reboot or module insertion.

7.13.2 Current sensor status element

Table 99 – Current sensor status element format

Bit Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	FAIL	Reserved		WARN OVER	Reserved	CRIT OVER	Reserved
2	(MSB)	CURRENT						
3								(LSB)

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the module containing the current sensor is visually identifying its location using an LED or similar device. When set to ‘0’, the module containing the current sensor is not displaying an identification indication. GEM does not support this bit.

FAIL, when set to ‘1’ indicates the RQST FAIL control bit has been set and the module containing the current sensor is visually indicating a failure using an LED or similar device. When set to ‘0’, the module containing the current sensor is not displaying a failure indication. GEM does not support this bit.

WARN OVER, when set to ‘1’, indicates that current reading reported by the sensor has exceeded the OVER CURRENT WARNING THRESHOLD. When set to ‘0’, it indicates that the sensor reading has

not exceeded the over-current warning threshold. This bit is not supported by GEM and shall be set to ‘0’.

CRIT OVER, when set to ‘1’, indicates that current reading reported by the sensor has exceeded the OVER CURRENT CRITICAL THRESHOLD. When set to ‘0’, it indicates that the sensor reading has not exceeded the over-current critical threshold. This bit is not supported by GEM and shall be set to ‘0’.

CURRENT indicates the current reading reported by the sensor in units of 10mA for DC and units of 10mA RMS for AC. The number format is 16-bit 2’s compliment allowing an expressible range of -327.68A to 327.67A.

7.13.3 Current sensor control element

Table 100 – Current sensor control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	RQST FAIL	Reserved					
2	Reserved							
3								

RQST IDENT, when set to ‘1’, instructs the enclosure to display a visual identification indication on the module containing the current sensor. When set to ‘0’, any visual identification indication on the module containing the current sensor will be turned off. This bit is not supported but GEM and will be ignored.

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual fault indication on the module containing the current sensor. When set to ‘0’, any visual fault indication on the module containing the current sensor will be turned off. This bit is not supported but GEM and will be ignored.

7.14 SAS Expander Element

The SAS expander element provides status for each SAS expander located within the enclosure. For most Seagate storage enclosures these are typically located in the I/O Modules and EM Cards, however, high density enclosures may contain additional downstream expanders (referred to as remote expanders) on Sideplane, Midplane and Baseplane components. Information reported by the expanders may differ based upon where they are located.

7.14.1 Individual I/O Module SAS expander status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by I/O Module/EM Card SAS expander elements are outlined in Table 101.

Table 101 – Supported ELEMENT STATUS CODE values for individual I/O Module SAS expander elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
5h	Not Installed	The SAS expander is removed or not fitted.
6h	Unknown	The SAS expander status is unavailable. This may be due two reasons, being: a) GEM is not configured to retrieve partner domain SAS topology information (see 6.7.2). b) There is a communications fault with the partner I/O Module.
7h	Not Available	The firmware has yet to retrieve status from the SAS expander. This could occur shortly after a reboot or module insertion.

7.14.2 Individual remote SAS expander status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by remote SAS expander elements are outlined in Table 102.

Table 102 – Supported ELEMENT STATUS CODE values for individual remote SAS expander elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	One or more remote expander I^2C buses have failed
4h	Unrecoverable	One or more of the following faults has been detected. • The remote expander cannot read from its VPD EEPROM. • The remote expander failed to successfully complete its POST.
5h	Not Installed	The SAS expander is removed or not fitted.
6h	Unknown	The expander status is unavailable; possibly because it is being rebooted.
7h	Not Available	The firmware has yet to retrieve status from the remote expander. This could occur shortly after a reboot or module insertion.

7.14.3 SAS expander status element

Table 103 – SAS expander status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	FAIL	Reserved					
2	Reserved							
3								

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the module containing the expander is visually identifying its location using an LED or similar device. When set to ‘0’, the module containing the expander is not displaying an identification indication. This bit is not supported by GEM and will be set to ‘0’.

FAIL, when set to ‘1’, indicates that the RQST FAIL control bit has been set and the module containing the expander is visually identifying a fault using an LED or similar device. When set to ‘0’, the module containing the expander is not displaying a host requested failure indication. This bit is not supported by GEM and will be set to ‘0’.

7.14.4 SAS expander control element

Table 104 – SAS expander control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	RQST FAIL	Reserved					
2	Reserved							
3								

RQST IDENT, when set to ‘1’, instructs the corresponding module containing the expander to display a visual identification indication. When set to ‘0’, any visual identification indication on the module containing the expander will be turned off. This bit is not supported by GEM and will be ignored.

RQST FAIL, when set to ‘1’, instructs the corresponding module containing the expander to display a visual failure indication. When set to ‘0’, any host requested visual failure indication on the module containing the expander will be turned off. This bit is not supported by GEM and will be ignored.

7.15 SAS Connector Element

The SAS connector element report status information for both external and internal SAS port connectors. This also includes SAS ports that do not have a physical connector, for example, an on-board SAS controller to expander port.

7.15.1 Individual SAS connector status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by SAS connector elements are outlined in Table 105.

Table 105 – Supported ELEMENT STATUS CODE values for individual SAS connector elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	A critical cable fault has been detected. All connector functionality has been lost (supported by managed cable types only).
3h	Noncritical	One of the following non-critical conditions has been detected: a) A non-critical cable fault has been detected. Partial connector functionality has been retained but some loss of features or performance may occur. (Supported by managed cable types) b) One or more of the physical links in the port have been disabled (only applies if using vendor-unique extensions)
4h	Unrecoverable	An unrecoverable condition of failing to read a cable VPD and GEM is not configured to ignore cable VPD read failures.
5h	Not Installed	The SAS connector is removed or not fitted.
6h	Unknown	The SAS connector status is unavailable. This may be due two reasons, being: a) GEM is not configured to retrieve partner domain SAS topology information (see 6.7.2). b) There is a communications fault with the partner I/O Module. c) The managed portion of the connector could not be contacted.
7h	Not Available	The firmware has yet to retrieve status from the SAS connector. This could occur shortly after a reboot or module insertion.

7.15.2 SAS connector status element

Table 106 – SAS connector status element format

Bit Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	CONNECTOR TYPE						
2	CONNECTOR PHYSICAL LINK							
3	MATED	FAIL	OC	Reserved				

IDENT, when set to ‘1’, indicates that the RQST IDENT control bit has been set and the SAS connector is visually identifying its location using an LED or similar device. When set to ‘0’, the SAS connector is not displaying an identification indication. GEM only supports this bit for external port connectors.

CONNECTOR TYPE reports the physical connector type for the corresponding SAS connector. Table 107 lists supported SAS connector type codes.

Table 107 – CONNECTOR TYPE codes

Code	Description
00h	No information (GEM will use this code for internal links where no physical connector is present).
External connectors	
01h	SFF-8470 SAS 4x receptacle
02h	SFF-8088 Mini SAS 4x receptacle
03h	SFF-8436 QSFP+ receptacle
04h	SFF-8088 Active Mini SAS 4x receptacle
05h	SFF-8644 Mini SAS HD 4x receptacle
06h	SFF-8644 Mini SAS HD 8x receptacle
07h	SFF-8644 Mini SAS HD 16x receptacle
08h to 0Eh	Reserved for future external connectors
0Fh	Vendor specific external connector
Internal wide connectors	
10h	SFF-8484 SAS 4i plug
11h	SFF-8087 Mini SAS 4i receptacle
12h	SFF-8643 Mini SAS HD 4i receptacle
13h	SFF-8643 Mini SAS HD 8i receptacle
14h to 1Fh	Reserved for future internal wide connectors
Internal connectors to end devices	
20h	SFF-8482 SAS Drive backplane receptacle
21h	SATA host plug
22h	SFF-8482 SAS Drive plug
23h	SATA device plug

Code	Description
24h	Micro SAS receptacle
25h	Micro SATA device plug
26h	SFF-8486 Micro SAS plug
27h	SFF-8486 Micro SAS/SATA plug
28h to 2Eh	Reserved for future internal connectors to end devices
2Fh	SAS virtual connector
Internal connectors	
30h to 3Eh	Reserved for future internal connectors
3Fh	Vendor specific internal connector
Other	
40h to 6Fh	Reserved
70h to 7Fh	Vendor specific

CONNECTOR PHYSICAL LINK indicates the physical link in the connector represented by this element. GEM will report this field as FFh, indicating that the connector element represents all physical links for the port unless the port contains only a single physical link, in which case GEM will report 00h.

A MATED bit set to ‘1’ indicates that the connector represented by this element is mated (i.e., mechanically connected). A MATED bit set to ‘0’ indicates that the connector represented by this element is not mated or does not report connector mating status.

FAIL, when set to ‘1’, indicates that the RQST FAIL control bit has been set and the SAS connector is visually identifying a fault using an LED or similar device. When set to ‘0’, the SAS connector is not displaying a host requested failure indication. GEM only supports this bit for external Mini SAS HD connectors.

An overcurrent (OC) bit set to ‘1’ indicates that an overcurrent condition exists on the connector represented by this element. An OC bit set to ‘0’ indicates that an overcurrent condition does not exist on the connector represented by this element or the connector does not report overcurrent conditions.

7.15.3 SAS connector control element

Table 108 – SAS connector control element format

Byte \ Bit	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	Reserved						
2	Reserved							
3	Reserved	RQST FAIL	Reserved					

RQST IDENT, when set to ‘1’, instructs the corresponding SAS connector to display a visual identification indication. When set to ‘0’, any visual identification indication on the SAS connector will be turned off. GEM only supports this bit for external SAS connectors. Setting this bit for any other connector type will have no effect.

RQST FAIL, when set to ‘1’, instructs the corresponding SAS connector to display a visual failure indication. When set to ‘0’, any host requested visual failure indication on the SAS connector will be turned off. GEM only supports this bit for external Mini SAS HD connectors. Setting this bit for any other connector type will have no effect.

7.16 Communication Port Element

The communication port element reports status information for on-board communication ports. This includes Ethernet ports that do not have a physical connector, for example, an on-board Ethernet port to internal devices.

7.16.1 Individual Communication Port status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by communication port elements are outlined in Table 105.

Table 109 – Supported ELEMENT STATUS CODE values for individual communication port elements

Code	Name	Description
1h	OK	Element is installed and functional
3h	Noncritical	The communication port is present, enabled, and functional, but the link is down (for example if the connection at the other side of the link is down)
4h	Unrecoverable	An unrecoverable condition of failing to read status for the communications port
5h	Not Installed	The Communication Port Element is removed or disabled
7h	Not Available	The firmware has yet to retrieve status from the communication port element. This could occur shortly after a reboot or module insertion.

7.16.2 Communication port status element

Table 110 – Communication port status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT	FAIL	LINK	Reserved	PORT TYPE			DUPLEX
2	SPEED MANTISSA				SPEED EXPONENT			
3	Reserved							DISABLED

IDENT is not supported and shall remain cleared

FAIL is not supported and shall remain cleared

LINK indicates the physical link state of the communication port represented by this element. This field will be set to ‘1’ when the link is up or ‘0’ when the link is down.

The following fields are vendor specific and may need to be revised should the ANSI standard provide more definition to this element.

PORT TYPE reports the physical connector type for the corresponding communications port. Table 111 – Communication Port Type codes lists supported SAS connector type codes.

Table 111 – Communication Port Type codes

Code	Description
00h	Ethernet
01h	InfiniBand
02h-07h	Reserved

DUPLEX, where appropriate, when set to ‘1’, indicates that the port is operating in full duplex mode. When set to ‘0’, indicates that the port is operating in half duplex mode.

SPEED MANTISSA represents the mantissa component of the link speed of the port in bits per second (bps). See Table 112 – Communication Port for a description of the supported mantissa and exponent values, and the speed they represent.

SPEED EXPONENT represents the exponent component of the link speed of the port in bps. See Table 112 – Communication Port for a description of the supported mantissa and exponent values, and the speed they represent.

Table 112 – Communication Port Speed values

Speed	Mantissa	Exponent
10 Mbps	1	7
100 Mbps	1	8
1 Gbps	1	9
40 Gbps	4	10

DISABLED when set to ‘1’ indicates that the communication port described by this element has been disabled.

7.16.3 Communication Port control element

Only the COMMON CONTROL fields of the communication port element are supported.

8 Supported Vendor Unique Page Definitions

This specification covers generic vendor-unique diagnostic page structure only. The exact page layouts for a specific product can be found in the corresponding GEM 5 SES Addenda document.

8.1 Diagnostic Pages 84h and 85h – In-band CLI

The in-band CLI pages permit the execution of a GEM CLI command using SEND DIAGNOSTIC and RECEIVE DIAGNOSTIC RESULTS. This allows for the execution of GEM CLI commands without the requirement of having separate out-of-band serial or Ethernet cabling.

Diagnostic page 84h is used to invoke CLI commands on the I/O Module in enclosure slot A and retrieve the CLI output for these commands. Diagnostic page 85h is used to perform the same function for the I/O Module in enclosure slot B. If a page 85h request is received on the target port running in I/O Module in slot A or a page 84h request is received on the target port for the I/O Module in slot B, the command will be routed for execution on the partner canister (if present) across the IPC link.

The in-band CLI pages work by transmitting the command line to be executed by SES target using a SEND DIAGNOSTIC request and retrieving output from that command using RECEIVE DIAGNOSTIC RESULTS requests until command execution terminates.

8.1.1 Multi-initiator handling

The in-band CLI pages are capable of handling requests from multiple initiators concurrently but will only permit one initiator to execute a command at a time. Requests from other initiators will be rejected during this time without affecting the command in progress.

Once an initiator's request to execute a CLI command is accepted, it can be considered to have an exclusive lock on the GEM in-band CLI connection until it has either collected all of the command output for the invoked command or the command has timed out. For example, if initiator A has an in-band CLI command in progress, and initiator B requests a new command to be executed, the request from initiator B will be rejected with a BUSY status command response.

If an initiator does not collect its CLI command output within a period of 20s, the command will be timed out and aborted (note that the command may still need to repeat some processing, however, any CLI output as a result of this will be discarded in the background). This timeout prevents an initiator from indefinitely blocking other initiators from issuing in-band CLI commands.

If an initiator has a command in progress, then the same initiator is permitted to either abort its own command or pre-empt the completion of the command with a new command. When an initiator pre-empts one command with another, the in-progress command is first aborted and then the new command executed immediately afterwards; the initiator holds exclusive lock of the in-band CLI connection for the entire duration.

An initiator is not permitted to abort commands invoked by another initiator. If this is attempted, the command will be terminated with a BUSY status.

If a command is invoked using one page number, it is illegal to abort the command using the other page number. For example, a command initially invoked using page 84h cannot be aborted with a request sent to page 85h. If such a scenario occurs, the second request will be rejected with a CHECK CONDTION status with a sense key of ILLEGAL REQUEST and ASC/ASCQ of ENCLOSURE SERVICES TRANSFER REFUSED.

8.1.2 Command output retrieval

Command output is retrieved using RECEIVE DIAGNOSTIC RESULTS requests sent to same page on which the command was instigated. Command output may span multiple status page reads before collection can be marked as complete.

The initiator retrieving CLI output over the in-band CLI via its status pages should adhere to the following rules.

a) Only the initiator which originally invoked the command can retrieve the command's CLI output. If a different initiator attempts to retrieve the output, the request will be refused. The status page returned to the second initiator will contain an appropriate user error message in the CLI COMMAND OUTPUT field and have the STOP bit set (see 8.1.5).

b) If an initiator invokes a command using one page number and then attempts to retrieve the CLI output for the command using a different page number, e.g., the command was invoked using page 84h control, then an attempt was made to retrieve CLI output using page 85h, the status request will be refused. The status page returned will contain an appropriate user error message and the STOP bit (see 8.1.5) will be set.

c) The host buffer size specified in the status request must be sufficient to hold the minimum status page size of 13. If it is not, the status request will be rejected with a CHECK CONDITION status with sense key ILLEGAL REQUEST and ASC/ASCQ of INVALID FIELD IN CDB.

d) If an initiator attempts to retrieve CLI output but has not in fact first executed a command with a control request, the status page returned will contain an appropriate user error message in the CLI Output field and the STOP bit (see 8.1.5) will be set.

e) To achieve best performance during command output retrieval, it is recommended that the initiator does not attempt to issue status page requests quicker than once every 10ms. This is to ensure the command buffers have a chance to fill before they are retrieved.

f) To achieve best performance and compatibility during command retrieval it is recommended that the initiator uses a page size of 512 bytes, allowing up to 500 bytes of command output to be retrieved at a time.

8.1.3 Authentication

Authentication was added to GEM 5.2 to permit the in-band CLI to support the same username and password protection afforded to out-of-band CLI interfaces. Support for authentication can be confirmed by reading the page 84h/85h status and confirming the value of the AUTH bit. For testing whether authentication is supported without reading command data, the ALLOCATION LENGTH for the RECEIVED DIAGNOSTIC RESULTS command issued to read the page, should be set to 8. Truncated page reads of this nature were not supported prior to the introduction of authentication and would result in a CHECK CONDITION status with sense key of ILLEGAL REQUEST and ASC/ASCQ set to INVALID FIELD IN PARAMETER LIST. If this check condition is received in response to a truncated page request of size 8, then it can be considered equivalent to having AUTH set to '0'.

When AUTH is set to '1', the client must supply a Password Descriptor (8.1.4.1) and a Username Descriptor (8.1.4.2) when issuing the Command Control request. If these descriptors are not supplied, the command will be terminated with a CHECK CONDITION status, with sense key ILLEGAL REQUEST and ASC/ASCQ set to INVALID FIELD IN PARAMETER LIST. If the authentication descriptors are provided, but they contain invalid credentials, the SEND DIAGNOSTIC command will complete successfully, but the command output read back from the subsequent status request will contain an "Authentication failed" error message.

8.1.4 Page 84h/85h Control

The in-band CLI control pages are used to transmit command line information detailing the command that is to be executed on the targeted I/O Module. The format for control page 84h and control page 85h is shown in Table 113.

Table 113 – Diagnostic control page 84h and 85h

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (84h/85h)							
1	Reserved							
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4		Reserved						
7								
Command Control Descriptor								
8	GEMSAT	Reserved				ABORT	Reserved	EXTENDED
9	Reserved							
10	(MSB)	CLI COMMAND STRING LENGTH (m-12)						
11								(LSB)
12		CLI COMMAND STRING						
m								
Extended Descriptor List								
m+1		Extended Descriptor 0						
	…							
		Extended Descriptor N						
n								

PAGE CODE should be set to 84h for CLI commands to be sent to I/O Module A and 85h for CLI commands to be sent to I/O Module B.

PAGE LENGTH is the length of the control page in bytes, excluding the 4 page header bytes.

GEMSAT, when set to ‘1’, indicates that the command should be executed on the GEMSAT expander instead of the attached GEM on BMC. This is only supported in canisters that use the GEM on BMC and GEMSAT architecture.

ABORT, when set to ‘1’, instructs GEM to abort any currently outstanding CLI commands. Note that an aborted command may still need to complete background processing before a new command can be run. Any commands instigated after an aborted command will be blocked until the aborted command completes. When set to ‘0’ no abort operation will be performed.

EXTENDED, when set to ‘1’, indicates that Extended Descriptors are present after the CLI COMMAND STRING field. When set to ‘0’, it indicates there are no Extended Descriptors after the command field.

CLI COMMAND STRING LENGTH indicates the number of bytes contained in CLI COMMAND STRING field.

CLI COMMAND STRING contains the 7-bit ASCII command line string to be passed to the GEM CLI for execution. The CLI COMMAND STRING field must be between 1 and 128 characters in length when executing a command and is not required to be null terminated. The CLI COMMAND STRING field is permitted to be 0 bytes in length if the ABORT bit is set. Unlike other CLI interfaces, CLI commands specified using page 84h and 85h must not be appended with a '-' character to instruct GEM to target the partner I/O module.

The Extended Descriptor List contains additional descriptors that may be used to provide extra metadata to the command processor within GEM. For example, it may be used to supply username and password information for CLI implementations that have authentication enabled as indicated by the AUTH bit in the page 84h/85h status (8.1.5). The Extended Descriptor formats are described in the following subsections. If a descriptor in the Extended Descriptor List is not supported by GEM or its current operating mode, it will be ignored.

8.1.4.1 Password Descriptor

The Password Descriptor is only required when the AUTH bit in the status page is set to '1' (8.1.5). If the AUTH bit is not set, the descriptor will be ignored by GEM. Table 114 describes the format of the Password Descriptor.

Table 114 – Password Extended Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	DESCRIPTOR ID (01h)							
1	DESCRIPTOR LENGTH (n-2)							
2								
3	PASSWORD							
n								

DESCRIPTOR ID must be set to 01h, indicating that the descriptor contains the CLI password.

DESCRIPTOR LENGTH indicates the length in bytes of the PASSWORD field.

PASSWORD contains the password string for granting CLI command execution rights. The password string is not required to be NUL ('\0') terminated, however, NUL terminated strings will be handled by GEM. Any characters in the password string appearing after a NUL character will be ignored.

8.1.4.2 Username Descriptor

The Username Descriptor is only required when the AUTH bit in the status page is set to ‘1’ (8.1.5). If the AUTH bit is not set, the descriptor will be ignored by GEM. Table 115 describes the format of the Username Descriptor.

Table 115 – Username Extended Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	DESCRIPTOR ID (02h)							
1	DESCRIPTOR LENGTH (n-2)							
2								
3	USERNAME							
n								

DESCRIPTOR ID must be set to 02h, indicating that the descriptor contains the CLI username.

DESCRIPTOR LENGTH indicates the length in bytes of the USERNAME field.

USERNAME contains the username string for granting CLI command execution rights. The username string is not required to be NUL (‘\0’) terminated, however, NUL terminated strings will be handled by GEM. Any characters in the username string appearing after a NUL character will be ignored.

8.1.5 Page 84h/85h Status

The in-band CLI status pages are used to retrieve output data from a CLI command executing on the targeted I/O Module. The format for status page 84h and status page 85h is shown in Table 116.

Table 116 – Diagnostic status page 84h and 85h

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (84h/85h)							
1	Reserved							
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4	Reserved							AUTH
5	Reserved							
7								
Command Status Descriptor								
8	Reserved							STOP
9	(MSB)	OUTPUT OFFSET						
11								(LSB)
12	CLI COMMAND OUTPUT							
n								

PAGE CODE will be set to either 84h or 85h, dependent upon which I/O Module's command output buffer is being read.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes.

AUTH, when set to '1' indicates that the CLI has authentication enabled. When set to '0', the CLI may be used without authentication.

STOP, when set to '1', indicates that this status page contains the last of the command output and the command has completed execution. When set to '0', it indicates that the command has not completed execution and more output may be expected.

OUTPUT OFFSET is the (byte) offset in the full command response message where the supplied portion of command output is to be placed. Note: all portions of command output are supplied to the host in the correct sequence for simple concatenation, however this offset value may prove useful as a basic integrity check in case of string corruption during the SES transmission.

CLI COMMAND OUTPUT contains the outstanding command output read from the output buffer. The command output is formatted as a 7-bit ASCII string. The number of bytes in the command output is calculated by subtracting 8 from the PAGE LENGTH field. A zero-length command output will be returned if no command output is currently awaiting collection. Note that in this scenario the command may still be executing but is not generating any new output. As such, a zero-length command string must not be interpreted as an indication that the command is complete — that is handled exclusively by the STOP bit.

8.2 Diagnostic Page 91h – Enclosure Statistics

Diagnostic page 91h reports statistics counters for both canisters. Such statistics may include SAS phy error counters and other protocol specific counters. Each statistics element in page 91h has an associated element of the same type code defined in SES page 02h allowing statistical data to be mapped to a specific enclosure component.

8.2.1 Page 91h Control

The enclosure statistics control page is used to manipulate the statistics counters reported in the status page (see 8.2.3). Each group of statistics counters may be controlled individually. See Table 117 for the enclosure statistics control page format. The control page layout is the same as for the status page.

Table 117 – Enclosure statistics control page 91h

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (91h)							
1	Reserved							
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4		Reserved						
7								
Statistics control descriptor list (see 8.2.2)								
8		First statistics control descriptor						
	…							
		Last statistics control descriptor						
n								

PAGE CODE must be set to 91h for the enclosure statistics control page.

PAGE LENGTH is the length of the control page in bytes, excluding the 4 page header bytes.

See section 8.2.2 for details on the statistics control descriptors. The control descriptors that form the page are product specific. Refer to the corresponding SES addenda document for the specific product for the implemented page details.

8.2.2 Statistics Control Descriptors

The statistics control descriptors are used group statistics counters by their corresponding page 02h element. The following subsections list the statistics control descriptors supported by GEM.

8.2.2.1 SAS Expander Statistics Control Descriptor

The SAS expander statistics control descriptor is used to group statistics counters for each SAS Expander element in SES Page 02h. The format of the SAS Expander statistics control descriptor is shown in Table 118.

Table 118 – SAS Expander statistics control descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	ELEMENT TYPE CODE (18h)							
1	ELEMENT INDEX							
2	FORMAT REVISION (01h)							
3	NUMBER OF DESCRIPTORS							
4	DESCRIPTOR LENGTH							
5	Reserved							
7								
SAS phy statistics counter control descriptor list								
8	First SAS phy statistics counter control descriptor (see Table 119)							
35								
	…							
n-27	Last SAS phy statistics counter control descriptor (see Table 119)							
m								

ELEMENT TYPE CODE should be set to the same value as the status page. This will be set to 18h for the SAS expander statistics status descriptor, indicating that this descriptor is associated with a SAS expander Page 02h element.

ELEMENT INDEX is set to the type relative index (see 3.3.2) of the element in SES page 02h corresponding to this status descriptor.

FORMAT REVISION is set to the version of the data format used by this descriptor. SAS expander statistics status descriptors compliant with this specification should be set to a FORMAT REVISION of 01h.

NUMBER OF DESCRIPTORS is set to number of status descriptors contained in the SAS phy statistics counter status descriptor list. This should be set to the same value as the status page.

DESCRIPTOR LENGTH is set to the length in bytes of each individual descriptor contained in the SAS phy statistics counter status descriptor list.

The SAS phy statistics counter control descriptor format is described in Table 119.

Table 119 – SAS phy statistics counter control descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	SELECT	RQST CLEAR	RQST HOLD	Reserved				
2	Reserved							
27								

SELECT is used to indicate that the phy statistics counter control descriptor has control data that is to be processed by the enclosure. If the SELECT bit is set to ‘0’, all other bits within the descriptor, regardless of state, will be ignored. If the SELECT bit is set to ‘1’ the state of all other supported bits within the descriptor will be applied.

RQST CLEAR, when set to ‘1’, instructs the enclosure to reset all counters in the corresponding SAS phy statistics counter status descriptor (see 8.2.4.1), i.e. INVALID DWORD COUNT, RUNNING DISPARITY ERROR COUNT, LOSS OF DWORD SYNCHRONIZATION COUNT, PHY RESET PROBLEM COUNT and will clear the wrap indication on the PHY CHANGE COUNT counter. Note that the RQST CLEAR bit is processed before the HOLD bit so setting both RQST CLEAR and RQST HOLD at the same time will cause the cleared values to be held. When a wrap condition is cleared on the PHY CHANGE COUNT counter, the value will be set to the current value reported by the expander hardware which may be a non-zero value.

When this bit is set to ‘0’, the phy statistics counters shall retain their current values.
RQST HOLD, when set to ‘1’, instructs the enclosure to freeze the counters within the corresponding SAS phy statistics counter status descriptor (see 8.2.4.1) at their current value. When set to ‘0’, this bit instructs the enclosure to unfreeze the counters within the SAS phy statistics counter status descriptor. When frozen, the counters will continue to increment in the background, but any changes will not be shown in the status page until unfrozen.

8.2.3 Page 91h Status

The enclosure statistics status page is used to report the statistics counters recorded by the enclosure. See Table 120 for the enclosure statistics status page format.

Table 120 – Enclosure statistics status page

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (91h)							
1	Reserved							
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4		Reserved						
7								
Statistics status descriptor list (see 8.2.4)								
8		First statistics status descriptor						
	…							
		Last statistics status descriptor						
N								

PAGE CODE is the diagnostic page code. This will be set to 91h, indicating this page is the enclosure statistics status Page.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes.

See section 8.2.4 for details on the statistics status descriptors. The status descriptors that form the page are product specific. Refer to the corresponding SES addenda document for the specific product for the implemented page details.

8.2.4 Statistics Status Descriptors

The statistics status descriptors are used group statistics counters by their corresponding page 02h element. The following subsections list the statistics status descriptors supported by GEM.

8.2.4.1 SAS Expander Statistics Status Descriptor

The SAS expander statistics status descriptor is used to group statistics counters for each SAS Expander element in SES Page 02h. The format of the SAS Expander statistics status descriptor is shown in Table 121.

Table 121 – SAS Expander statistics status descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	ELEMENT TYPE CODE (18h)							
1	ELEMENT INDEX							
2	FORMAT REVISION (01h)							
3	NUMBER OF DESCRIPTORS							
4	DESCRIPTOR LENGTH							
5	(MSB)	EXPANDER CHANGE COUNT						
6								(LSB)
7	Reserved							
SAS phy statistics counter status descriptor list								
8	First SAS phy statistics counter status descriptor (see Table 122)							
35								
	…							
n-27	Last SAS phy statistics counter status descriptor (see Table 122)							
M								

ELEMENT TYPE CODE is set to type code of the corresponding SES page 02h element for this descriptor. This will be set to 18h for the SAS expander statistics status descriptor, indicating that this descriptor is associated with a SAS expander Page 02h element.

ELEMENT INDEX is set to the type relative index (see 3.3.2) of the element in SES page 02h corresponding to this status descriptor.

FORMAT REVISION is set to the version of the data format used by this descriptor. SAS expander statistics status descriptors compliant with this specification will report a FORMAT REVISION of 01h.

NUMBER OF DESCRIPTORS is set to number of status descriptors contained in the SAS phy statistics counter status descriptor list.

DESCRIPTOR LENGTH is set to the length in bytes of each individual descriptor contained in the SAS phy statistics counter status descriptor list.

EXPANDER CHANGE COUNT is set the EXPANDER CHANGE COUNT value reported in the corresponding SAS expander's SMP REPORT GENERAL response.

The SAS phy statistics counter status descriptor format is described in Table 122.

Table 122 – SAS phy statistics counter status descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	PHY INDEX							
1	Reserved						HOLD	INVALID
2	Reserved							
5								
6	(MSB)	INVALID DWORD COUNT						
9								(LSB)
10	(MSB)	RUNNING DISPARITY ERROR COUNT						
13								(LSB)
14	(MSB)	LOSS OF DWORD SYNCHRONIZATION COUNT						
17								(LSB)
18	(MSB)	PHY RESET PROBLEM COUNT						
21								(LSB)
22	(MSB)	PHY CHANGE COUNT						
25								(LSB)
26	NEGOTIATED LINK RATE							
27	Reserved							

PHY INDEX is the index expander phy associated with these counters.

HOLD, when set to ‘1’, indicates that the statistics counter values have been frozen using the RQST HOLD bit in the corresponding control descriptor (see 8.2.2.1). When set to ‘0’, this bit indicates the counter values reported by the status descriptor are live.

INVALID, when set to ‘1’, indicates that the statistics counter values reported by this descriptor are invalid. When set to ‘0’, the statistics counter values are valid.

INVALID DWORD COUNT contains the value of the INVALID DWORD COUNT field reported by the SMP REPORT PHY ERROR LOG response for the associated expander phy. This counter saturates at FFFFFFFFh.

RUNNING DISPARITY ERROR COUNT contains the value of the RUNNING DISPARITY ERROR COUNT field reported by the SMP REPORT PHY ERROR LOG response for the associated expander phy. This counter saturates at FFFFFFFFh.

LOSS OF DWORD SYNCHRONIZATION COUNT contains the value of the LOSS OF DWORD SYNCHRONIZATION field reported by the SMP REPORT PHY ERROR LOG response for the associated expander phy. This counter saturates at FFFFFFFFh.

PHY RESET PROBLEM COUNT contains the value of the PHY RESET PROBLEM COUNT field reported by the SMP REPORT PHY ERROR LOG response for the associated expander phy. This counter saturates at FFFFFFFFh.

PHY CHANGE COUNT contains the value of the PHY CHANGE COUNT field reported by the SMP DISCOVER response for the associated expander phy. When this count wraps in hardware it is set to FFFFFFFFh. In this case the hardware counter is only 8 bits, and therefore wraps when reaching FFh and resets to 0.

NEGOTIATED LINK RATE contains the value of the NEGOTIATED LINK RATE field reported by the SMP DISCOVER response for the associated expander phy. The values supported by this field are shown in Table 123. The link rate field will not be reset by RQST CLEAR bit in the corresponding control descriptor.

Table 123 – Supported NEGOTIATED LINK RATE values

NEGOTIATED LINK RATE	Description
00h	Link rate unknown
01h to 07h	Reserved
08h	1.5 Gbps
09h	3 Gbps
0Ah	6 Gbps
0Bh	12 Gbps
0Ch to FFh	Reserved

8.2.5 Multi-Initiator Support

As the statistic pages have the potential to be very large, it is impractical from a memory utilization perspective to duplicate the statistics for each supported initiator. As such, multi-initiator support is achieved through the use of the RQST HOLD bit. It is anticipated that an initiator will set the RQST HOLD bit to freeze statistics allowing it and other initiators to retrieve the same values. After all initiators have read the stats, the RQST HOLD bit is cleared allowing the counts to be updated.

8.3 Diagnostic Page 92h – Extended Element Status

The extended element status diagnostic page reports additional information for the elements described in SES page 02h. This provides a means of reporting information that may not be reported by the element in SES page 02h due to its 4-byte element size constraint or to extend the status information reported for an element whilst still conforming to the ANSI standard page 02h element definition.

8.3.1 Page 92h Control

There is no extended element status control page.

8.3.2 Page 92h Status

The extended element status page returns a list of variable length fields, one for each element in the Enclosure Status Diagnostic page (SES Page 02h). The fields return supplemental element state information to the status provided by Page 02h.

Table 124 – Diagnostic Status Page 92h Format

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (92h)							
1	Reserved				INFO	Reserved		
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
4		Reserved						
7								
Extended Element Status by Type Descriptor List								
8		First Extended Element Status by Type Descriptor						
11								
	...							
		Last Extended Element Status by Type Descriptor						
n								

PAGE CODE is the diagnostic page code. This will be set to 92h, indicating this page is the Extended Element Status Diagnostic Page.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes.

The Extended Element Status by Type Descriptor List contains one element type descriptor (see Table 125) for each entry in the Type Descriptor Header List in SES Page 01h. The length of the status descriptor is determined by the NUMBER OF POSSIBLE ELEMENTS within the corresponding Type Descriptor Header. The order of the status descriptor list must match the order of the Type Descriptor Header List.

Table 125 – Extended Element Status by Type Descriptor Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Overall Extended Status Descriptor							
3								
Individual Extended Status Element Descriptor List								
4	First Extended Status Element Descriptor							
	...							
		Last Extended Status Element Descriptor						
m								

The Overall Extended Status Element Descriptor provides an overall status for elements of the same type. The general format of the overall extended status element is shown in Table 126. The Overall Extended Status Element Descriptor is not supported by GEM.

The Individual Extended Status Element Descriptor List contains an entry for each of the possible elements identified by the NUMBER OF POSSIBLE ELEMENTS in the corresponding Page 01h Type Descriptor Header. The general format of the individual descriptor element can be found in Table 126.

Table 126 - Overall and individual extended status element descriptor format

Bit / Byte	7	6	5	4	3	2	1	0
0	EXTENDED STATUS FORMAT							
1	Reserved							
2	(MSB)	DESCRIPTOR LENGTH (m-3)						
3								(LSB)
4		EXTENDED STATUS						
m								

EXTENDED STATUS FORMAT specifies the format of the data in the EXTENDED STATUS field. The values supported by this field are element type specific.

DESCRIPTOR LENGTH is set to the length of the descriptor in bytes excluding the 4 bytes used for the descriptor header. A descriptor length of 0 indicates that there is no extended status available for the element.

EXTENDED STATUS contains the extended status for the element. The element types that support extended status are listed in section 8.3.3.

8.3.3 Extended Status Element Support

The element type codes that support extended element status are listed in Table 127.

Table 127 – Supported Extended Status Element Descriptors

Element Type Code	Element Description
02h	Extended PSU Element Status (see 8.4.4)
19h	Extended SAS Connector Element Status (see 8.4.5)
87h	Extended Processor Element Status (see 8.3.6)
8Ch	Extended BMC Element Status (see 8.4.7)

8.3.4 Extended PSU Element Status Definitions

8.3.4.1 Overall PSU Element Status

The Energy Star reading is calculated from the sum of Total input Power of all the PSUs in the system.

Table 128 - Format of PSU Energy Star Status

Byte \ Bit	7	6	5	4	3	2	1	0
0	PSU DATA VERSION							
1	Reserved							
2	(MSB)	DESCRIPTOR LENGTH						
3								(LSB)
4	ERROR CODE				Reserved	THRESHOLD HI	THRESHOLD LO	ENABLED
5	(MSB)	ENERGY STAR INPUT VALUE						
8								(LSB)
9	(MSB)	ENERGY STAR SES BROADCAST VALUE						
10								(LSB)

PSU DATA VERSION specifies the format of the data extended status field in byte offset 4 onwards. The value for the PSU Data Version is currently defined as 03h.

DESCRIPTOR LENGTH specifies the length of the descriptor in bytes excluding the 4 bytes used for the descriptor header.

ENABLED specifies the status of the Energy Star global enable.

THRESHOLD LO is set to 1 when the Energy Star value is below the broadcast threshold value.

THRESHOLD HI is set to 1 when the Energy Star value is above the broadcast threshold value.

ERROR CODE is to be the area where any errors in the Energy Star implementation are described. This is for future development and should currently return 0000h.

ENERGY STAR INPUT POWER VALUE specifies the power in 10-Watt units, calculated from a 30s rolling average of the summed total input power values of all PSUs in the system.

ENERGY STAR SES BROADCAST VALUE specifies the power in Watts at which a SES broadcast will be triggered. It triggers if the current value is greater/lesser than the power baseline figure +/- the pre-configured threshold value.

8.3.4.2 Individual PSU Element Status

The Silent Fail status can be sensed by accessing the 'Extended Status Code' of each Power Supply. GEM will look for a PSU providing very little current into the system and if this condition continues for an hour will declare the PSU as critical in the corresponding SES page 02h PSU element. The one-hour timer starts when the silent failure is first detected.

Table 129 - Format of PSU Rail Silent Fail Status

Bit / Byte	7	6	5	4	3	2	1	0
COMMON HEADER								
0	FORMAT REVISION							
1	Reserved							
2	(MSB)	Descriptor Length						
3								(LSB)
DESCRIPTOR								
4	Reserved							
5	Rail 1 Silent Fail Status[1]							
6	Rail 2 Silent Fail Status[1]							
7	Overall Silent Fail Status							

[1] For PSUs with 5V and 12V, Rail 1 is 5V and Rail 2 is 12V. For 12V only PSUs, Rail 1 is 12V

FORMAT REVISION set to 01h indicates that the field content of the Extended PSU Element Descriptor conforms to the format outlined in this specification

DESCRIPTOR LENGTH specifies the length of the descriptor in bytes. The length excludes the descriptor header bytes (bytes 0-3).

The Rail 1 and 2 Silent Fail Status fields report the current silent fault status detected by the enclosure firmware for PSU output rails 1 and 2. Supported values for the Rail Silent Fail Status are listed in Table 130

Table 130 - Supported Silent Fail Status Codes

Silent Fail Status Code	Description
00h	Rail OK
01h	Potential issue detected, no PSU or BBU downloads should be attempted. This is essentially when the timer active for this rail.
02h	Issue has been detected, no PSU or BBU downloads should be attempted. This status is set if the output rail is still determined to be faulty after a defined timeout has elapsed. This is considered a hard failure and the PSU or BBU should be replaced.
03h-FFh	Reserved

The Overall Silent Fail Status provides a summary of the silent PCM failure detection algorithm; it reports the most severe rail silent fail status as per Table 131.

Table 131 - Overall Silent Fail Status with respect to Rail 1 and Rail 2

RAIL 1 SILENT FAIL STATUS	RAIL 2 SILENT FAIL STATUS	OVERALL SILENT FAIL STATUS
00h	00h	00h
00h	01h	01h
00h	02h	02h
01h	00h	01h
01h	01h	01h
01h	02h	02h
02h	00h	02h
02h	01h	02h
02h	02h	02h

For single output rail PSUs, the OVERAL SILENT FAIL STATUS is equivalent to the RAIL 1 SILENT FAILT STATUS.

8.3.5 Extended SAS Connector Element Status Definitions

The extended status for the SAS connector element contains information specific to SAS connectors that support cables with management interfaces, such as Mini SAS HD. Table 132 defines the format of the SAS Connector Extended Status Descriptor.

Table 132 - SAS Connector Extended Status Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	CONNECTOR DATA FORMAT TYPE							
1	Reserved							
2	(MSB)	DESCRIPTOR LENGTH						
3								(LSB)
4		CONNECTOR DATA						
643								

CONNECTOR DATA FORMAT TYPE defines the format of the data in the CONNECTOR DATA field. Its supported values are defined in Table 133.

Table 133 - DESCRIPTOR FORMAT TYPE

CONNECTOR DATA FORMAT TYPE	Description
00h	Undefined
01h	SFF-8636 format (see 8.3.5.1)
02h to FFh	Reserved

DESCRIPTOR LENGTH specifies the length of the descriptor in bytes. The length excludes the descriptor header bytes (bytes 0-3). The page length will depend on the descriptor content. For cables unmanaged cables/connectors that do not provide cable status or VPD data, the descriptor may be zero-length.

CONNECTOR DATA contains the connector data in the format specified by CONNECTOR DATA FORMAT TYPE.

8.3.5.1 SFF-8636 Connector Data Format

The SFF-8636 connector data format is based upon the SFF-8636 specification. Please refer to the SFF-8636 specification [5] for the full details on each area within the data map.

Table 134 - SFF-8636 connector data format

Bit / Byte	7	6	5	4	3	2	1	0
Lower Page 0h Data								
0	IDENTIFIER							
1	STATUS							
2								
3	INTERRUPT FLAGS							
21								
22	FREE SIDE MONITORS							
33								
34	CHANNEL MONITORS							
81								
82	RESERVED							
107								
108	FREE SIDE DEVICE PROPERTIES							
111								
112	RESERVED							
127								
Upper Page 0h Data								
128	BASE ID FIELDS							
191								
192	EXTENDED ID FIELDS							
223								
224	VENDOR SPECIFIC ID FIELDS							
255								
Upper Page 1h Data								

Bit / Byte	7	6	5	4	3	2	1	0
256	CC_APPS							
257	Reserved		AST TABLE LENGTH					
258	APPLICATION CODE ENTRIES							
383								
Upper Page 2h Data								
384	USER EEPROM DATA							
511								
Upper Page 3h Data[1]								
512	SFF and Vendor-defined transceiver data							
639								

NOTE[1] Cable page 3h is not supported on all GEM versions. It was introduced on the 4U106 in GEM 5.2 USM 2021.13.0. Refer to the SES Addendum for the specific product for more details

The SFF-8636 data format in Table 134 deviates from the SFF-8636 specification in the following ways.

a) The SFF-8636 upper page structure has been flattened to create a single contiguous memory map containing all supported pages.

b) Only upper pages 0h, 1h, 2h and 3h are exposed by GEM. Note that upper page 3h is a recent addition to the GEM 5 code and wasn't historically supported. Support for upper page 3h can verified by reading the DESCRIPTOR LENGTH, which will be set to 640 when page 3h is present.

c) The SFF-8636 data is read only. Cable registers that are write only or read/write are not supported. In some cases, GEM may expose read/write registers as read-only if they contain data that is useful for diagnostics purposes.

8.3.6 Extended Processor Element Status Definitions

The extended status for the processor element contains information specific to processor devices located in the I/O Modules, such as Intel x86 processors. The format of the processor extended status descriptor is defined in Table 135.

Table 135 - Processor Extended Status Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	PROCESSOR DATA VERSION (01h)							
1	Reserved							
2	(MSB)	DESCRIPTOR LENGTH (4)						
3								(LSB)
Processor Data								
4	POWER FAIL 8	POWER FAIL 7	POWER FAIL 6	POWER FAIL 5	POWER FAIL 4	POWER FAIL 3	POWER FAIL 2	POWER FAIL 1
5	POWER FAIL 16	POWER FAIL 15	POWER FAIL 14	POWER FAIL 13	POWER FAIL 12	POWER FAIL 11	POWER FAIL 10	POWER FAIL 9
6	Reserved							
7								

PROCESSOR DATA VERSION specifies the format of the Processor Data fields. Elements compliant to this specification will have this field set to 01h.

DESCRIPTOR LENGTH specifies the length of the descriptor in bytes. The length excludes the descriptor header bytes (bytes 0-3).

POWER FAIL #n, when set to ‘1’, indicates failure on voltage rail #n. The voltage rails are specified in the relevant SES addenda document.

8.3.7 Extended BMC Element Status Definitions

The extended status for the BMC element contains information specific to BMC devices located in the I/O Modules. The format of the BMC extended status descriptor is defined in Table 136.

Table 136 - BMC Extended Status Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	BMC DATA VERSION (02h)							
1	Reserved							
2	(MSB)	DESCRIPTOR LENGTH (m-3)						
3								(LSB)
BMC Data								
4	POWER LINE FAIL 8	POWER LINE FAIL 7	POWER LINE FAIL 6	POWER LINE FAIL 5	POWER LINE FAIL 4	POWER LINE FAIL 3	POWER LINE FAIL 2	POWER LINE FAIL 1
5	POWER LINE FAIL 16	POWER LINE FAIL 15	POWER LINE FAIL 14	POWER LINE FAIL 13	POWER LINE FAIL 12	POWER LINE FAIL 11	POWER LINE FAIL 10	POWER LINE FAIL 9

Byte \ Bit	7	6	5	4	3	2	1	0
6	LAST WATCHDOG ASSERT TYPE							WDOG EXPIRED
7	SW ERROR TYPE							SW ERROR
8	Reserved					MEMORY RESIZE	MEMORY ERROR CONFIG	MEMORY ERROR ECC
9	POST VALUE							
10	Reserved					LAST SHUTDOWN SOURCE		Reserved
11	LAST RESET TYPE							BOARD RESET ASSERT
12	LAST RESET SOURCE							
13	SEL STATUS							
	Reserved		SEL WARN	SEL FULL	SEL DISABLED	SEL EMPTY	Reserved	
14	POWER LINE FAIL 24	POWER LINE FAIL 23	POWER LINE FAIL 22	POWER LINE FAIL 21	POWER LINE FAIL 20	POWER LINE FAIL 19	POWER LINE FAIL 18	POWER LINE FAIL 17
15	POWER LINE FAIL 32	POWER LINE FAIL 31	POWER LINE FAIL 30	POWER LINE FAIL 29	POWER LINE FAIL 28	POWER LINE FAIL 27	POWER LINE FAIL 26	POWER LINE FAIL 25
16	Reserved							
17								
18	PCI CARD PRESENCE 8	PCI CARD PRESENCE 7	PCI CARD PRESENCE 6	PCI CARD PRESENCE 5	PCI CARD PRESENCE 4	PCI CARD PRESENCE 3	PCI CARD PRESENCE 2	PCI CARD PRESENCE 1
19	Reserved							
20								
21	NUMBER OF DIMMS							
22	(MSB) First DIMM status							
23								(LSB)
	…							
m-1	(MSB) Last DIMM status							
m								(LSB)

BMC DATA VERSION specifies the format of the BMC Data fields. Elements compliant to this specification will have this field set to 01h.

DESCRIPTOR LENGTH specifies the length of the descriptor in bytes. The length excludes the descriptor header bytes (bytes 0-3).

POWER LINE FAIL #n, when set to‘1’, indicates failure on voltage rail #n. The voltage rails are specified in the relevant SES addenda document.

WDOG EXPIRED, when set to ‘1’ indicates, the watchdog has expired and that the LAST WATCHDOG ASSERT TYPE field is valid.

LAST WATCHDOG ASSERT TYPE indicates the cause of the last watchdog assert. Supported values for this field are listed in Table 137.

Table 137 - LAST WATCHDOG ASSERT TYPE

Code	Description
00h	Timer expired status only
01h	Hard Reset
02h	Power Down
03h	Power Cycle
05h to 7Fh	Reserved

SW ERROR, when set to ‘1’, indicates a BMC software error has occurred.

SW ERROR TYPE reports the software error type when the SW ERROR bit is set to ‘1’. Table 138 lists the values supported by the SW ERROR TYPE field.

Table 138 – SW ERROR TYPE

Code	Description
00h	Internal error
01h	Event overflow
02h to 7Fh	Reserved

MEMORY ERROR ECC, when set to ‘1’, indicates an un-correctable ECC or other un-correctable memory error.

MEMORY ERROR CONFIG, when set to ‘1’, indicates a memory configuration error.

MEMORY RESIZE, when set to ‘1’, indicates a memory resize operation has been detected.

POST VALUE reports the LSB of the 2 byte BIOS POST status code.

SHUTDOWN VALID, when set to ‘1’, indicates the LAST SHUTDOWN SOURCE field is valid.

LAST SHUTDOWN SOURCE reports whether the last shutdown was initiated by the user or autonomously. Table 139 lists the values supported by the LAST SHUTDOWN SOURCE field.

Table 139 – LAST SHUTDOWN SOURCE

Code	Description
00h	No shutdown source
01h	User initiated
02h	Autonomous
03h	Reserved

BOARD RESET ASSERT, when set to ‘1’, indicates a reset has been detected and the RESET TYPE and RESET SOURCE fields are valid.

LAST RESET TYPE reports the last reset type. Table 140 lists the values supported by the LAST RESET TYPE field.

Table 140 – LAST RESET TYPE

Code	Description
00h	No reset type
01h	Warm reset
02h	Cold reset
03h – 7Fh	Reserved

LAST RESET SOURCE reports the last reset type. Table 141 lists the values supported by the LAST RESET SOURCE field.

Table 141 – LAST RESET SOURCE

Code	Description
00h	IPMI watchdog
01h	IPMI Command
02h	CHECKSTOP interrupt
03h	RST interrupt
04h	Reset button
05h	Power up
06h	Leg init watchdog
07h	Leg prog watchdog
08h	Software initiated
09h	Setup reset
0Ah	Power cycle reset
0Bh	Unknown reset
0Ch	Power button
0Dh – FFh	Reserved

SEL STATUS reports the current status of the System Event Log. Table 142 lists the values supported by SEL STATUS field.

Table 142 – SEL STATUS

Code	Description
00h	Log entries present
01h	SBE memory Logging disabled (Reserved for future use)
02h	Bus , Proc & PCI Err logging disabled (Reserved for future use)
04h	SEL Empty (The BMC enters a record when records deleted and so state N/A)
08h	SEL Disabled (Disabled by IPMI I/F not supported)
10h	SEL full (All 1023 record entries are occupied, clear log or delete some records)
20h	SEL almost full (50 or fewer records remaining)
40h	Reserved for correctable machine check error logging
80h	Reserved

PCI CARD PRESENCE #n, when set to ‘1’, indicates a card is present in PCI slot #n.

NUMBER OF DIMMS reports the total number of DIMM slots on the board.

DIMM STATUS reports the 16-bit IPMI sensor status for each DIMM managed by the BMC.

8.4 Diagnostic Page 93h – LED Status

8.4.1 Page 93h Control

There is no control page for diagnostic page 93h.

8.4.2 Page 93h Status

Vendor unique diagnostic status page 93h reports the state of all GEM controlled LEDs visible to ESP on which request is received.

The format of Diagnostic status page 93h is shown in Table 143.

Table 143 – Diagnostic status page 93h

Bit / Byte	7	6	5	4	3	2	1	0
0	PAGE CODE (93h)							
1	Reserved							
2	(MSB)	PAGE LENGTH (n-3)						
3								(LSB)
LED Status Descriptor List								
4	First LED status descriptor							
7								
	...							
n-3	Last LED status descriptor							
n								

PAGE CODE is the diagnostic page code. This will be set to 93h, indicating this page is the LED Status Diagnostic Page.

PAGE LENGTH is the length of the status page in bytes, excluding the 4 page header bytes.

The LED Status Descriptor List provides LED status descriptors for each LED visible to the ESP. Note that this typically extends to enclosure-wide LEDs and local I/O Module LEDs. GEM does not synchronize remote I/O Module LED status. The format of the LED status descriptor is shown in Table 144.

Table 144 - LED Status Descriptor

Bit / Byte	7	6	5	4	3	2	1	0
0	LED TYPE							
1	LED STATE							
2	Reserved				LED COLOR			
3	Reserved							

LED TYPE is set to the type code of the LED described by the descriptor. See Table 145 for a list of the values supported for LED TYPE.

Table 145 - LED TYPE

Code	Description
00h	Unknown LED Type
01h	Disk Activity LED
02h	Disk Fault LED
03h	PCM Fault LED
04h	PCM Status LED
05h	Module Fault LED
06h	Cooling Module Status LED
07h	Unit Identifier LED
08h	Logic Fault LED
09h	Cooling Module Fault LED
0Ah	Card Fault LED
0Bh	Card Status LED
0Ch	Disk Array LED
0Dh	Port Activity LED
0Eh	PCM Warning LED
0Fh	PCM Shutdown LED
10h	Display Segment Digit 1
11h	Display Segment Digit 2
12h	Display Segment Decimal 1
13h	Display Segment Decimal 2
14h	Display Segment
15h	Port Link State LED
16h	Shelf Link State LED
17h	GEM Health LED
18h	Canister Identifier LED
19h	Sled Cable Fault LED
1Ah	Sled Drive Fault LED
1Bh	Sled Fault LED
1Ch	Sled Card Fault LED
1Dh	Sled Card Status LED
1Eh	Cooling Module Good LED
1Fh	Port IDENT LED
20h	Sideplane Off LED
21h	LED Port Fault
22h	System Ready
23h	Standby
24h	Power
25h	Module Fault Rear

Code	Description
26h	Module Fault Side
27h	Port Link Status A
28h	Port Link Status B
29h	Disk Ident
2Ah	Disk Activity Control Enable
2Bh-FFh	Reserved

LED STATE is set to the blink pattern currently active on the LED described by the descriptor. See Table 146 for a list of the values supported for LED STATE.

Table 146 – LED STATE

Code	Description
00h	Off
01h	On
02h	Blink 0.25s on, 0.25s off
03h	Blink 0.5s on, 0.5s off
04h	Blink 1s on, 1s off
05h	Blink 1s on, 3s off
06h	Blink 2s on, 1s off
07h	Blink 2s on, 2s off
08h	Blink 3s on, 1s off
09h	Blink 0.5s off, 0.5s on
0Ah	Blink 1s off, 1s on
0Bh	Phy Activity
0Ch	Led not present
0Dh	Led state unknown
0Eh-FFh	Reserved

LED COLOR is a bit field describing the current color being indicated on the LED described by the descriptor. It is possible for an LED to have more than one LED color active at the same time in the case of bi/tri-color LEDs. Table 147 lists the values supported by the color field.

Table 147 – LED COLOR

LED COLOR	Description
00h	Default
01h	Red
02h	Green
04h	Amber
08h	Blue

9 Vendor-Specific SES Elements

This section defines the vendor-specific elements for SES pages 02h (see 6.3).

9.1 SBB Midplane Interconnect Element

The SBB Midplane Interconnect element reports status associated with peripheral interface between the SBB I/O Modules and the Midplane. There shall be a SBB Midplane Interconnect (SBBMI) element for each IO Module in the enclosure. In an SBB enclosure, the I^2C (0, 1 and 2) and SGPIO bus connections to the Midplane VPD EEPROMs are common resources to both I/O Modules. Although these resources are shared by both I/O Modules, a bus access fault may only exist on one I/O Module but not on the other. For instance, an I/O Module may be able to read the Midplane VPD EEPROM successfully, but its partner may fail to do so.

9.1.1 Individual SBB Midplane Interconnect status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by SBB Midplane Interconnect elements are outlined in 9.1.

Table 148 – Supported ELEMENT STATUS CODE values for individual SBB Midplane Interconnect elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	Midplane I^2C bus 1 or 2 has failed. At least one Midplane I^2C bus remains functional.
3h	Noncritical	One of the following non-critical conditions has been detected: a) The Midplane VPD EEPROMs have mismatched content. b) I^2C bus 0 failure, inter-canister communications maintained on remaining buses.
4h	Unrecoverable	One of the following unrecoverable conditions has been detected: a) The Midplane VPD could not be read and the canister is operating in isolation mode. b) The Midplane SGPIO bus has failed. c) Both I^2C bus 1 and 2 have failed. Midplane peripheral communications is no longer possible
5h	Not Installed	The I/O Module associated with the SBBMI element is removed or not fitted.
6h	Unknown	Failure to retrieve I/O Module SBBMI status from partner canister.

9.1.2 SBB Midplane Interconnect status element

Table 149 – SBB Midplane Interconnect status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	Reserved							
2	BMC LINK FAIL	EXPANDER LINK FAIL	I2C 8 FAIL	I2C 7 FAIL	I2C 6 FAIL	I2C 5 FAIL	I2C 4 FAIL	I2C 3 FAIL
3	Reserved		MID VPD MISMATCH	MID VPD READ FAIL	SGPIO FAIL	I2C 2 FAIL	I2C 1 FAIL	I2C 0 FAIL

BMC LINK FAIL, when set to ‘1’ indicates that the IPMB link to the BMC has failed. When set to ‘0’ this bit indicates that the IPMB link to the BMC is operational. Not supported in SBB enclosures.

EXPANDER LINK FAIL, when set to ‘1’ indicates that the link between GEM on BMC and GEMSAT has failed. When set to ‘0’ this bit indicates that the link between GEM on BMC and GEMSAT is operational. Not supported in SBB enclosures.

I2C 8 FAIL, when set to ‘1’, indicates that Midplane I^2C bus 8 has failed. When set to ‘0’, this bit indicates that Midplane I^2C 8 bus is operational. Not supported in SBB enclosures.

I2C 7 FAIL, when set to ‘1’, indicates that Midplane I^2C bus 7 has failed. When set to ‘0’, this bit indicates that Midplane I^2C 7 bus is operational. Not supported in SBB enclosures.

I2C 6 FAIL, when set to ‘1’, indicates that Midplane I^2C bus 6 has failed. When set to ‘0’, this bit indicates that Midplane I^2C 6 bus is operational. Not supported in SBB enclosures.

I2C 5 FAIL, when set to ‘1’, indicates that Midplane I^2C bus 5 has failed. When set to ‘0’, this bit indicates that Midplane I^2C 5 bus is operational. Not supported in SBB enclosures.

I2C 4 FAIL, when set to ‘1’, indicates that Midplane I^2C bus 4 has failed. When set to ‘0’, this bit indicates that Midplane I^2C 4 bus is operational. Not supported in SBB enclosures.

I2C 3 FAIL, when set to ‘1’, indicates that Midplane I^2C bus 3 has failed. When set to ‘0’, this bit indicates that Midplane I^2C 3 bus is operational. Not supported in SBB enclosures.

MID VPD MISMATCH, when set to ‘1’, indicates that the VPD content of Midplane EEPROM A does not match the VPD content of Midplane EEPROM B. When set to ‘0’, it indicates that the VPD content of Midplane EEPROMs A and B both match.

MID VPD READ FAIL, when set to ‘1’, indicates that the I/O Module was unable to successfully read the VPD content of EEPROMs A and B. When set to ‘0’, it indicates that the VPD content from at least one of the Midplane EEPROMs could be read.

SGPIO FAIL, when set to ‘1’, indicates the SGPIO bus to the Midplane has failed. When set to ‘0’, this bit indicates the Midplane SGPIO bus is operational.

I2C 2 FAIL, when set to ‘1’, indicates that Midplane I^2C bus 2 has failed. When set to ‘0’, this bit indicates that Midplane I^2C 2 bus is operational.

I2C 1 FAIL, when set to ‘1’, indicates that Midplane I^2C bus 1 has failed. When set to ‘0’, this bit indicates that Midplane I^2C 1 bus is operational.

I2C 0 FAIL, when set to ‘1’, indicates that Midplane I²C bus 0 has failed. When set to ‘0’, this bit indicates that Midplane I²C 0 bus is operational.

9.1.3 SBB Midplane Interconnect control element

Table 150 – SBB Midplane Interconnect control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	Reserved							
2								
3	Reserved							Reserved

9.2 Processor Element

The processor element reports information and status associated with the main processing elements of application I/O Module, such as Intel x86 CPUs. There will be one processor element per CPU present in the enclosure.

9.2.1 Individual Processor status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the processor element are outlined in Table 151.

Table 151 – Supported ELEMENT STATUS CODE values for individual processor elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	A fatal CPU error has been detected.
3h	Noncritical	The CPU is throttling its speed.
4h	Unrecoverable	Failed to read CPU status.
5h	Not Installed	The processor is removed or not fitted.
6h	Unknown	Failure to retrieve processor status from partner canister.
7h	Not Available	The firmware has yet to retrieve status from the processor. This could occur shortly after a reboot or module insertion.

9.2.2 Processor status element

One of two status page formats may be used for the processor status element. The format implemented by the enclosure is determined by its support for vendor unique diagnostic page 92h. Table 152 defines the processor status element format when page 92h is not supported by the enclosure. Table 153 defines the processor status element when page 92h is supported.

Table 152 – Processor status element format without page 92h support

Bit Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	Reserved							
2	THROTTLING LEVEL							
3	IERR	THROTTLED	Reserved		POWER FAIL 4	POWER FAIL 3	POWER FAIL 2	POWER FAIL 1

THROTTLING LEVEL reports the temperature in degrees Celsius at which processor throttling starts.

POWER FAIL #n, when set to ‘1’, indicates a failure on processor voltage rail #n. The voltage rails assignments are specified in the relevant SES addenda document for the product.
THROTTLED, when set to ‘1’, **i**ndicates the CPU is currently throttled due to an elevated operating temperature. When set to ‘0’, this bit indicates the CPU is running optimally.

IERR, when set to ‘1’, indicates an IERR condition on the CPU.

Table 153 – Processor status element format with page 92h support

Bit Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	Reserved							
2	THROTTLING LEVEL							
3	IERR	THROTTLED	Reserved					POWER FAIL

THROTTLING LEVEL reports the temperature in degrees Celsius at which processor throttling starts.

POWER FAIL, when set to ‘1’, indicates a failure on a processor voltage rail is being reported in the extended element status for the processor element (see 8.3.6). The voltage rails assignments are specified in the relevant SES addenda document for the product.

THROTTLED, when set to ‘1’, **i**ndicates the CPU is currently throttled due to an elevated operating temperature. When set to ‘0’, this bit indicates the CPU is running optimally.

IERR, when set to ‘1’, indicates an IERR condition on the CPU.

9.2.3 Processor control element

Table 154 – Processor control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1								
2		Reserved						
3								

9.3 Enclosure Power Element

The enclosure power element provides enclosure level power control. It should be noted that not all power control operations are supported by all enclosure hardware.

In a dual I/O module configuration both IO modules have to enter the required state within a specific timeout period (usually 4 seconds). This can be at the host level or as a configuration option in the module firmware, known as the power cycle policy. This policy is read from the Midplane VPD. There are two options.

Mode 1 - A request sent to either IO module by SES or a CLI command will, under firmware control, manage the enclosure power request on both I/O Modules.

Mode 2 – A request must be sent by SES or a CLI command to both I/O Modules within the pre-defined timeout period.

9.3.1 Individual Enclosure Power status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the Enclosure power element are outlined in Table 155.

Table 155 – Supported ELEMENT STATUS CODE values for individual Enclosure Power elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
5h	Not Available	The firmware has yet to retrieve enclosure power control status. This could occur shortly after a reboot or module insertion.

9.3.2 Enclosure Power status element

Table 156 – Enclosure Power status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	Reserved							
3								

9.3.3 Enclosure Power control element

Table 157 – Enclosure Power control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	Reserved							
2								
3	Reserved					RQST RESTART	RQST STANDBY	RQST SHUTDOWN

RQST RESTART, when set to ‘1’, instructs the enclosure to enter the standby state for 4 seconds before repowering. Setting RQST RESTART to ‘0’ has no effect on enclosure power.

RQST STANDBY, when set to ‘1’, instructs the enclosure to permanently enter the standby state. Enclosure power may be resumed via a push button, Wake-on-LAN or via a lights-out management processor, such as a BMC. Setting RQST STANDBY to ‘0’ has no effect on enclosure power.

RQST SHUTDOWN, when set to ‘1’, instructs the enclosure to enter a deep power-off state. Typically, enclosure power is re-applied by cycling AC to the power supplies. Setting RQST SHUTDOWN to ‘0’ has no effect on enclosure power.

9.4 Enclosure Electronics Power Element

The enclosure electronics power element provides control for I/O Module and enclosure power.

9.4.1 Individual Enclosure Electronics Power status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the enclosure electronics power element are outlined in Table 158.

Table 158 – Supported ELEMENT STATUS CODE values for individual Enclosure Electronics Power elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
5h	Not Installed	The I/O Module associated with this element is removed or not fitted.
6h	Unknown	The power state of the I/O associated Module this element is not known.
7h	Not Available	The firmware has yet to retrieve I/O module power control status. This could occur shortly after a reboot or module insertion.

9.4.2 Enclosure Electronics Power status element

Table 159 – Enclosure Electronics Power status element format

Bit Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	GEMSAT WDOG	GEMSAT RESET COUNT						GEM READY
2	POWER CONTROL ACTIVATION CODE							
3	Reserved	RESET COUNT			LAST RESET TYPE			

GEM READY reports the state of the system and drives during start-up of the enclosure and can be used as an indication that the enclosure management services have started. This is not implemented on all products.

Table 160 – GEM Ready Values

Value	Description
00b	Offline
01b	Enclosure Initializing
10b	GEM Ready
11b	GEM Ready but in a known degraded state

POWER CONTROL ACTIVATION CODE reports an activation code value that needs to be written to the POWER CONTROL ACTIVATE field in the control element to perform any requested power control operations.

RESET COUNT reports the number of I/O Module resets that have occurred since the last power cycle or the last time the RESET COUNT was reset using the REERT bit. The RESET COUNT saturates at 7 resets and must be cleared before further resets will be counted.

GEMSAT RESET COUNT reports the number of I/O Module resets that have occurred since the last power cycle or the last time the RESET COUNT was reset using the REERT bit. The GEMSAT RESET COUNT saturates at 7 resets and must be cleared before further resets will be counted. Specific to GEM-on-BMC platforms – the RESET COUNT refers to GEM-on-BMC resets.

GEMSAT WDOG bit reports whether the last reset of the expander was due to a watchdog regardless of which component reset last.

LAST RESET TYPE reports the last reset type for the ESP associated with the element. The support values for the reset type are listed in Table 161. The reset type is of the last component to be reset. The reset type source will be the expander if bit 3 is a 1.

Table 161 – LAST RESET TYPE

LAST RESET TYPE	Description
0h	Hard reset
1h	Power-on reset
2h	Push button reset/Reset from auxiliary subsystem, e.g., BMC
3h	Soft reset
4h	Watchdog reset
5h	Crash reset
6h	Reserved
7h	No reset type – data cleared
8h[1]	Hard reset of Expander
9h[1]	Power-on reset
Ah[1]	Reserved
Bh[1]	Soft reset of Expander
Ch[1]	Watchdog reset of Expander
Dh[1]	Crash reset of Expander
[1] Reset types 8h-Dh are only supported on GEM-on-BMC Application Platforms.	

9.4.3 Enclosure Electronics Power control element

Table 162 – Enclosure electronics power control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	REERT	Reserved			PWR CTRL TYPE			
2	Reserved							
3	POWER CONTROL ACTIVATE							

REERT (Reset Enclosure Electronics Reset Type), when set to ‘1’, will reset the RESET COUNT and LAST RESET TYPE fields in the status element to 0h and 7h respectively. When set to ‘0’, this bit will have no effect.

PWR CTRL TYPE is set in conjunction with the POWER CONTROL ACTIVATE field to request the associated I/O module to perform the specified power control operation. The power control operations supported by the PWR CTRL TYPE field are list in Table 163.

Table 163 - PWR CTRL TYPE

PWR CTRL TYPE	Description	Applies to
0h	Hard reset ESP	All Platforms
	Hard reset Expander and GEM-on-BMC	GEM-on-BMC Application Platforms
1h	Soft reset ESP	All Platforms
	Soft reset Expander and GEM-on-BMC	GEM-on-BMC Application Platforms
2h	Request application subsystem OS shutdown	Application Platforms
3h	Request immediate application subsystem shutdown	Application Platforms
4h	I/O Module power cycle	Application Platforms
5h	I/O Module system reset	Application Platforms
6h	Wake from standby	Application Platforms
7h	No operation	All platforms
8h	Hard reset Expander Only	GEM-on-BMC Application Platforms
9h	Soft reset Expander Only	GEM-on-BMC Application Platforms
Ah	Soft Reset only GEM-on-BMC	GEM-on-BMC Application Platforms
Bh	Hard reset only GEM-on-BMC	GEM-on-BMC Application Platforms

POWER CONTROL ACTIVATE is set in conjunction with the PWR CTRL TYPE field to request enclosure power control operations. For the power control operation to be accepted, the POWR CONTROL ACTIVATE field must be written with the value read from the POWER CONTROL ACTIVATION CODE field in the corresponding status element.

9.5 Enclosure Settings Element

The enclosure settings element reports general ops panel enclosure settings and status, e.g., Enclosure ID.

9.5.1 Individual Enclosure Settings status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the Enclosure settings element are outlined in Table 164.

Table 164 – Supported ELEMENT STATUS CODE values for individual Enclosure settings elements

Code	Name	Description
0h	Unsupported	The enclosure ops panel does not have a display to report the enclosure ID.
1h	OK	Element is installed and no error conditions are known.
2h	Critical	This indicates the enclosure ID has changed since start-of-day and the enclosure needs to be restarted for the new value to take effect. This behavior is intended for Fibre Channel enclosures and is not enabled for SAS I/O modules. For SAS I/O modules, the enclosure ID will take effect immediately
6h	Unknown	The current enclosure settings status cannot be retrieved.
7h	Not Available	The firmware has yet to retrieve ops panel status. This could occur shortly after a reboot or module insertion.

9.5.2 Enclosure settings status element

Table 165 – Enclosure settings status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	ENCL SETTINGS CHANGED	Reserved						
2	RQST ENCL ID FAILED	ENCL ID NOT SUPPORTED	OPS PANEL REMOVED	ENCL ID ACTIVE	Reserved		(MSB)	
3	ENCLOSURE ID							(LSB)

ENCL SETTINGS CHANGED, when set to ‘1’, this bit indicates that a request has been made to update the enclosure settings, namely the ENCLOSURE ID, have changed since their initial start-of-day value.

The behavior of this bit depends on how GEM is configured. For SAS enclosures, GEM will accept enclosure settings changes without requiring a system reset. The enclosure will change the enclosure ID immediately and report the new enclosure ID in any future status requests. When GEM is running in this mode the ENCL SETTING CHANGED bit will never be set.

For Fibre Channel enclosures it is possible to configure GEM to require a reboot for settings changes to take effect. When GEM is configured to run in this mode the ENCL SETTINGS CHANGED bit is set to indicate that the Enclosure Settings have changed.

RQST ENCL ID FAIL, when set to '1', indicates that a request to change Enclosure ID using the RQST ENCLOSURE ID field in the control element has failed. This could be due to one of the following reasons.

a) The value specified in RQST ENCLOSURE ID exceeds the permitted range.

b) Another RQST ENCLOSURE ID operation is currently in progress.

c) The enclosure ID could not be written to non-volatile memory.

If the enclosure ID fails to be set, the RQST ENCL ID FAIL bit will be set to '1' for I_T Nexus that originally made the request. The RQST ENCL ID FAIL bit will be reset to '0' on the first page 02h status read after the fault was detected.

ENCL ID NOT SUPPORTED, when set to '1', indicates that the Enclosure ID is not supported by this enclosure. When this bit is set to '0', it indicates that Enclosure ID is supported and can be reported on the ops panel display, depending on the state of the ENCL ID DISPLAY ACTIVE bit.

OPS PANEL REMOVED, when set to '1', indicates that the enclosure ops panel is not supported, or it has been removed. When set to '0', this bit indicates that the front ops panel of the enclosure is present.

ENCL ID DISPLAY ACTIVE**,** when set to '1', indicates that the enclosure ID display is currently displaying the programmed enclosure ID. When set '0', this bit indicates that the enclosure ID display is turned off. Note that support for this bit is optional and may not be enabled on all products. If this bit is not supported, it will report 0.

ENCLOSURE ID reports the current Enclosure ID programmed in non-volatile data. When setting the Enclosure ID to a new value, the behavior of the field can vary based upon the enclosure configuration.

For Fibre Channel I/O Modules, the enclosure ID is not permitted to change until a reboot is performed. When a new ID is set using the REQUEST ENCLOSURE ID control field, the ENCLOSURE SETTINGS element will change its status to CRITICAL, the ENCL SETTING CHANGED bit will be set to '1' and the REQUESTED ENCLOSURE ID field will continue to display to original value read at start-of-day. Once both I/O modules have been rebooted, the REQUESTED ENCLOSURE ID field will display the newly programmed value, the ENCL SETTING CHANGED but will be set to '0' and the CRITICAL status will be cleared.

For SAS I/O Modules, the enclosure ID is permitted to change instantly. When a new ID is set using the REQUEST ENCLOSURE ID control field, the ENCL SETTING CHANGE bit will be set to '1' and the REQUESTED ENCLOSURE ID field will change to the newly programmed value once it has been written to non-volatile memory. During the write to persist the new ID, the ENCLOSURE SETTINGS element status may change to CRITICAL. This will clear once the write is complete.

9.5.3 Enclosure settings control element

Table 166 – Enclosure settings control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	Reserved							
2	Reserved			ACTIVATE ENCL ID DISPLAY	Reserved		(MSB)	
3	REQUEST ENCLOSURE ID (LSB)							

ACTIVATE ENCL ID DISPLAY, when set to ‘1’, instructs GEM to turn the enclosure ID display on. If this bit is set to ‘0’, the enclosure will turn the ID display off. Note that support for this bit is optional and may not be supported on all products. If this bit is not supported, it will be ignored.

REQUEST ENCLOSURE ID is used to instruct GEM to write a new enclosure ID value to the ops panel display. The default supported range for the enclosure ID is 0-99. If the value specified in REQUEST ENCLOSURE ID is the same as the value reported by ENCLOSURE ID in the status page, no change will occur.

9.6 Enclosure Electronics Diagnostics Element

The enclosure electronics diagnostics element provides status and control of the software diagnostic components within GEM. It can be used to determine if there is diagnostic data to be collected from the enclosure or alert the host when system logs are about to saturate or wrap.

9.6.1 Individual Enclosure Electronics Diagnostics status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the enclosure electronics diagnostics element are outlined in Table 167.

Table 167 – Supported ELEMENT STATUS CODE values for individual Enclosure Electronics Diagnostics elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
5h	Not Installed	The I/O Module associated with the Enclosure Electronics Diagnostics element is removed or not fitted.
6h	Unknown	Failure to retrieve I/O Module diagnostics status from the partner canister.

9.6.2 Enclosure Electronics Diagnostics status element

Table 168 – Enclosure Electronics Diagnostics status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	USR NEW	SYS NEW	USR FULL	Reserved	NVLOG FULL WARN	NVLOG FULL	RLOG FULL WARN	RLOG FULL
2	Reserved							
3								

USR NEW**,** when set to ‘1’, indicates that an uncollected user-initiated State Save is available for collection. This bit will be cleared once an initiator sets the READ bit in the control element, providing the State Save data has been read via the CLI commands *ddump* or *ddump_statesave*.

SYS NEW**,** when set to ‘1’, indicates that an uncollected system-initiated State Save data is available for collection. This bit will be cleared once an initiator sets the READ bit in the control element, signifying that it has successfully read the State Save data.

USR FULL**,** when set to ‘1’, indicates that no further State Saves may be initiated by the user until the READ bit is set or a configured time period elapses.

NVLOG FULL WARNING**,** when set to ‘1’, indicates that the non-volatile log is nearly full and has reached its log-full warning threshold. The warning threshold is configurable in GEM. When set to ‘0’, this bit indicates that the non-volatile log has not yet exceeded its log-full warning threshold.

NVLOG FULL**,** when set to ‘1’, indicates that the non-volatile log is full. If the log is full, its associated FULL WARNING bit is also set. If the non-volatile log wraps, this bit is set at the first point before the log wraps round. When set to ‘0’, this bit indicates that the non-volatile log is not yet full or that the user has cleared the log.

RLOG FULL WARNING**,** when set to ‘1’, indicates that the RAM log is nearly full and has reached its log-full warning threshold. The warning threshold is configurable in GEM. When set to ‘0’, this bit indicates that the RAM log has not yet exceeded its log-full warning threshold or that the user has cleared enough log messages so that the log-full level is below the threshold.

RLOG FULL, when set to ‘1’, indicates that the RAM log is full. If the log is full, its associated FULL WARNING bit is also set. If the RAM log wraps, his bit is set at the first point before the log wraps round. When set to ‘0’, this bit indicates that the RAM log is not full or that the user has cleared the log.

9.6.3 Enclosure Electronics Diagnostics control element

Table 169 – Enclosure Electronics Diagnostics control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	INIT USR	READ	Reserved					
2	Reserved							
3								

INIT USR**,** when set to ‘1’, requests that a user-initiated State Save operation should be performed. It should be noted that the number of user-initiated State Saves permitted within a given period may be restricted. This is to prevent undue wear of the flash part used to persist the data. Both the number of permitted State Saves and the time interval is configurable. Note that a user state save may be taken even if the USR FULL bit is set in the status page. This will, however, overwrite an existing user state save snapshot.

READ, when set to ‘1’, informs the enclosure that the host/initiator has finished with any backed-up State Save data. Once this bit is set the State Save data will be cleared if it has been read by the host; either via the *ddump* or *ddump_statesave* CLI commands.

9.7 BMC Element

The BMC element reports the status of the BMC on server and application platforms. This element is reported in SES page 02h and diagnostic page 92h. The vendor unique diagnostic page 92h reports a detailed status for each of the sensors accessible from the BMC (see 8.3.7), while SES page 02h reports a compact status for the sensors.

9.7.1 Individual BMC status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the BMC element are outlined in Table 170.

Table 170 – Supported ELEMENT STATUS CODE values for individual BMC elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	Failure detected on one or more elements within the BMC
4h	Unrecoverable	Unable to communicate with the BMC
5h	Not Installed	The I/O Module associated with the BMC element is removed or not fitted.
7h	Not Available	The firmware has yet to retrieve BMC status. This could occur shortly after a reboot or module insertion.

9.7.2 BMC status element

Table 171 – BMC status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	Reserved							
2	ACPI STATUS				Reserved	MB APPLICATION STATUS		OS BOOT
3	Reserved		BIOS WDOG ASSERT	POWER LINE FAILURE	BOARD RESET ASSERT	MEMORY ERROR	SW ERROR	OS WDOG ASSERT

OS BOOT, when set to ‘1’, indicates that the OS running on the application/server platform has booted. When set ‘0’, this bit indicates the OS has not booted.

MB APPLICATION STATUS reports the status of the motherboard application. The supported values for MB APPLICATION STATUS are listed in Table 172.

Table 172 – MB APPLICATION STATUS

MB APPLICATION STATUS	Description
0h	No Reading or Busy
1h	Idle
2h	Active
3h	Reserved

ACPI STATUS reports the ACPI state of the server/application platform. The supported values for ACPI STATUS are listed in Table 173.

Table 173 – ACPI STATUS

ACPI STATUS	Description
0h	S0/G0 Working
1h to 2h	Reserved for S1 and S2
3h	S3
4h	S4
5h	S5/G2
6h to 9h	Reserved
Ah	S5 Override
Bh	Legacy On
Ch	Legacy Off
Dh	Reserved
Eh	Unknown

OS WDOG ASSERT, when set to ‘1’, indicates that there has been an OS watchdog assert. The reason for the assertion may be read from the WATCHDOG ASSERT TYPE field of the BMC Element status for diagnostic page 92h (see 8.3.7).

SW ERROR, when set to ‘1’, indicates that a BMC software error has been detected. The source of the error can be read from the SW ERROR TYPE field of the BMC element status for diagnostic page 92h (see 8.3.7).

MEMORY ERROR, when set to ‘1’, indicates that a memory error has nee detect by the BMC. One of three memory errors may be detected by the BMC, these being:

a) Uncorrectable ECC error
b) Memory Config error
c) Memory resized error

The exact reason can be read from the relevant bits in the BMC element status for diagnostic page 92h (see 8.3.7).

BOARD RESET ASSERT, when set to ‘1’, indicates that a Board Reset has been asserted. The Type and Source of the reset can be read from the RESET TYPE and RESET SOURCE fields of the BMC element status for diagnostic page 92h (see 8.3.7).

POWER LINE FAILURE**,** when set to ‘1’, indicates that one or more of the server/application subsystem power rails has failed. Information about the exact power supply voltage rail that has failed is provided in the BMC element status for diagnostic page 92h (see 8.3.7).

BIOS WDOG ASSERT, when set to ‘1’, indicates that there has been a BIOS watchdog assertion. The reason for the assertion may be read from the WATCHDOG ASSERT TYPE field in the BMC element status for diagnostic Page 92h (see 8.3.7).

9.7.3 BMC control element

Table 174 – BMC control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	Reserved							
3								

9.8 PDB Element

The PDB element reports status for each Power Distribution Board present in the enclosure.

9.8.1 Individual PDB status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the PDB element are outlined in Table 175.

Table 175 – Supported ELEMENT STATUS CODE values for individual PDB elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	A critical condition has been detected meaning the PDB has failed or is not supplying power.
4h	Unrecoverable	An unrecoverable condition has been detected. This will be set if there is a problem communicating with the PDB VPD EEPROM.
6h	Unknown	Status could not be retrieved from the PDB.
7h	Not Available	The firmware has yet to retrieve PDB status. This could occur shortly after a reboot or module insertion.

9.8.2 PDB status element

Table 176 – PDB status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	Reserved							
2	Reserved		INTERNAL DC FAULT	FAN FAIL	DC OVER VOLT	DC UNDER VOLT	DC OVER CURRENT	Reserved
3	Reserved	FAIL	Reserved					DC FAIL

INTERNAL DC FAULT, when set to ‘1’, indicates the PDB internal voltage protection has been triggered.

FAN FAIL, when set to ‘1’, indicates that the fan within the PDB has failed.

DC OVER VOLT, when set to ‘1’, indicates an over-voltage condition has been detected at the PDB output. The DC OVER VOLT bit is cleared by setting the RQST FAIL bit to ‘1’ in the PDB control element, followed by a subsequent request to set it to ‘0’.

DC UNDER VOLT, when set to ‘1’, indicates an under-voltage condition has been detected at the PDB output. The DC UNDER VOLT bit is cleared by setting the RQST FAIL bit to ‘1’ in the PDB control element, followed by a subsequent request to set it to ‘0’.

DC OVER CURRENT, when set to ‘1’, indicates an over-current condition has been detected at the PDB output. The DC OVER CURRENT bit is cleared by setting the RQST FAIL bit to ‘1’ in the PDB control element, followed by a subsequent request to set it to ‘0’.

FAIL, when set to ‘1’ indicates the RQST FAIL control bit has been set and the PDB is visually indicating a failure using an LED or similar device. When set to ‘0’, the PDB is not displaying a failure indication. Note that the PDB may still be visually indicating a failure even if this bit is set to ‘0’.

DC FAIL, when set to ‘1’, indicates that the PDB is unable to supply DC power to the enclosure. The DC FAIL bit is set to ‘0’ when normal DC power is being provided.

9.8.3 PDB control element

Table 177 – PDB control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	Reserved							
2								
3	Reserved	RQST FAIL	Reserved					

RQST FAIL, when set to ‘1’, instructs the enclosure to display a visual fault indication on the PDB. When set to ‘0’, any host requested visual fault indication on the PDB will be turned off. Note that even if the RQST FAIL bit is set to ‘0’ the PDB may continue to display enclosure detected fault conditions. The RQST FAIL bit is also used to clear latched status element bits by first setting it ‘1’, followed by a second operation setting it back to ‘0’ again. See 9.8.2 for information on which status bits are latched.

9.9 Sideplane Element

The Sideplane element reports status for each Sideplane I/O module present in the enclosure.

9.9.1 Individual Sideplane status codes

The ELEMENT STATUS CODE values (see 7.1.2) supported by the PDB element are outlined in Table 178.

Table 178 – Supported ELEMENT STATUS CODE values for individual Sideplane elements

Code	Name	Description
1h	OK	Element is installed and no error conditions are known.
2h	Critical	A non-redundant Sideplane cable fault has been detected.
5h	Not Installed	The Sideplane has been removed from the enclosure.
6h	Unknown	Status could not be retrieved from the Sideplane.
7h	Not Available	The firmware has yet to retrieve Sideplane status. This could occur shortly after a reboot or module insertion.

9.9.2 Sideplane status element

Table 179 – Sideplane status element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON STATUS (see 7.1.2)							
	Reserved	PRDFAIL	DISABLED	SWAP	ELEMENT STATUS CODE			
1	IDENT RQSTD	FAIL RQSTD	COVER REMOVED	POWERED	POWER FAULT	CABLE FAULT	FAULT	CABLE FAULT RQSTD
2	Reserved							
3								

IDENT RQSTD, when set to ‘1’, indicates that the SES client has requested that the enclosure display a visual identification indication pattern on the corresponding Sideplane. When set to ‘0’, the enclosure is not displaying a host requested identification indication.

FAIL RQSTD, when set to ‘1’, indicates that the SES client has requested that the enclosure display a visual failure indication pattern on the corresponding Sideplane. When set to ‘0’, the enclosure is not displaying a host requested failure indication.

COVER REMOVED, when set to ‘1’, indicates that the access cover has been removed on the corresponding Sideplane. When set to ‘0’, the Sideplane access cover is fitted.

POWERED, when set to ‘1’, indicates that the corresponding Sideplane is powered. When set to ‘0’, the Sideplane is not powered.

CABLE FAULT, when set to ‘1’, indicates that the enclosure has detected a SAS cable fault for the corresponding Sideplane. When set to ‘0’, the Sideplane SAS cable is operating as expected.

FAULT, when set to ‘1’, indicates that the enclosure has detected a general electronics fault for the corresponding Sideplane. When set to ‘0’, the Sideplane is operating as expected.

CABLE FAULT RQSTD, when set to ‘1’, indicates that the SES client has requested that the enclosure display a visual cable fault indication pattern on the corresponding Sideplane. When set to ‘0’, the enclosure is not displaying a host requested cable fault indication.

9.9.3 Sideplane control element

Table 180 – Sideplane control element format

Bit / Byte	7	6	5	4	3	2	1	0
0	COMMON CONTROL (see 7.1.1)							
	SELECT	PRDFAIL	DISABLE	RST SWAP	Reserved			
1	RQST IDENT	RQST FAIL	Reserved					RQST CABLE FAULT
2	Reserved							
3								

RQST IDENT, when set to ‘1’, will enable a visual identification indication pattern on the corresponding Sideplane. When set to ‘0’, any visual identification indication will be halted.

RQST FAIL, when set to ‘1’, will enable a visual failure indication pattern on the corresponding Sideplane. When set to ‘0’, any visual failure indication will be halted provided the enclosure is not indicating its own detected failure.

RQST CABLE FAULT, when set to ‘1’, will enable a visual cable fault indication pattern on the corresponding Sideplane. When set to ‘0’, any visual cable fault indication will be halted provided the enclosure is not indicating its own detected failure.