GEM 5 SCSI Specification

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Revision History

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

Table of Contents

1 Introduction

1.1 Scope

This document covers the SCSI commands and device model supported by storage enclosures running GEM or GEMLite version 5.

1.2 Terms and Abbreviations

ANSI	American National Standards Institute
ASC	Additional Sense Code
ASCII	American Standard Code for Information Interchange
ASCQ	Additional Sense Code Qualifier
CDB	Command Descriptor Block
CLI	Command Line Interface
EEPROM	Electrically Erasable Programmable Read-Only Memory
ESP	Enclosure Services Process
FRU	Field Replaceable Unit
GEM	Generic Enclosure Management
I/O	Input/Output
I_T	Initiator to Target
ID	Identifier
LED	Light-Emitting Diode
NAA	Network Address Authority
PSU	Power Supply Unit
SAS	Serial Attached SCSI
SCSI	Small Computer System Interface
SEP	Storage Enclosure Processor
SES	SCSI Enclosure Services
SP	SCSI Processor
VPD	Vital Product Data
WWN	World Wide Number

Application client	An object that is the source of SCSI commands.
Attached ESP	An ESP that is attached to a separate SCSI target device
Standalone ESP	An ESP that contains a SCSI target device.

1.3 Notation Conventions

<value>b	Denotes a binary number, e.g., *1010b*
<value>h	Denotes a hexadecimal number, e.g., *23h*
<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.
[default: valueX..valueY]	This indicates the default value “default”, with possible alternatives.
[XX]	This indicates variable values.
Grey text in a table	This indicates a value defined in a standard but not implemented by the product

1.4 References

[1] SCSI Architectural Model – 5 (SAM-5) Revision 36n
[2] SCSI Primary Commands – 4 (SPC-4) Revision 36n
[3] SCSI Block Commands – 4 (SBC-3) Revision 36n
[4] GEM 5 ANSI SES-3 Specification
[5] GEM 5 Command Line Specification

2 SCSI Device Model

Seagate storage enclosures utilizing the GEM enclosure management firmware are broadly divided into two categories: low-density enclosures and high-density enclosures. Low density enclosures typically utilize one or more I/O modules that directly attach to the drives, whereas high-density enclosures typically provide additional I/O expansion devices between the I/O modules and the drives to increase the maximum drive count possible.

2.1 Low-density Enclosures

A low-density storage enclosure consists of the main enclosure chassis, encompassing replaceable units such as I/O modules, disk drives, fan modules and power supplies. In such an enclosure the I/O modules contain I/O expansion devices, such as SAS expanders, that permit a small number of host-port connections on the rear of the enclosure to attach to a larger number of drives in the front of the enclosure. These expansion devices embed SCSI end devices that present enclosure management status and control capabilities that can be utilized by the host storage controller.

The SCSI end device within each I/O module reports itself as an Enclosure Services Device with ENCSERV set to ‘1b’ when queried using the INQUIRY command (see 3.3.1) which informs the host that the device supports the SCSI Enclosure Services standard (SES) for enclosure management (see [4]).

Where multiple I/O modules are present in an enclosure, the individual SCSI Enclosure Services end devices communicate with each other to form a single enclosure services device representing the entire enclosure. This is as opposed to a single enclosure with separate enclosure services devices, each responsible for their own portion of the enclosure management duties. From a logical view the enclosure can be viewed as a single Enclosure Services device with multiple SCSI target ports; one for each I/O module inserted. This view is conveyed through INQUIRY EVPD Page 83h (see 3.3.2.3), where all I/O modules report the same Device Identifier (the enclosure WWN) but individually report a unique Target Port Identifier.

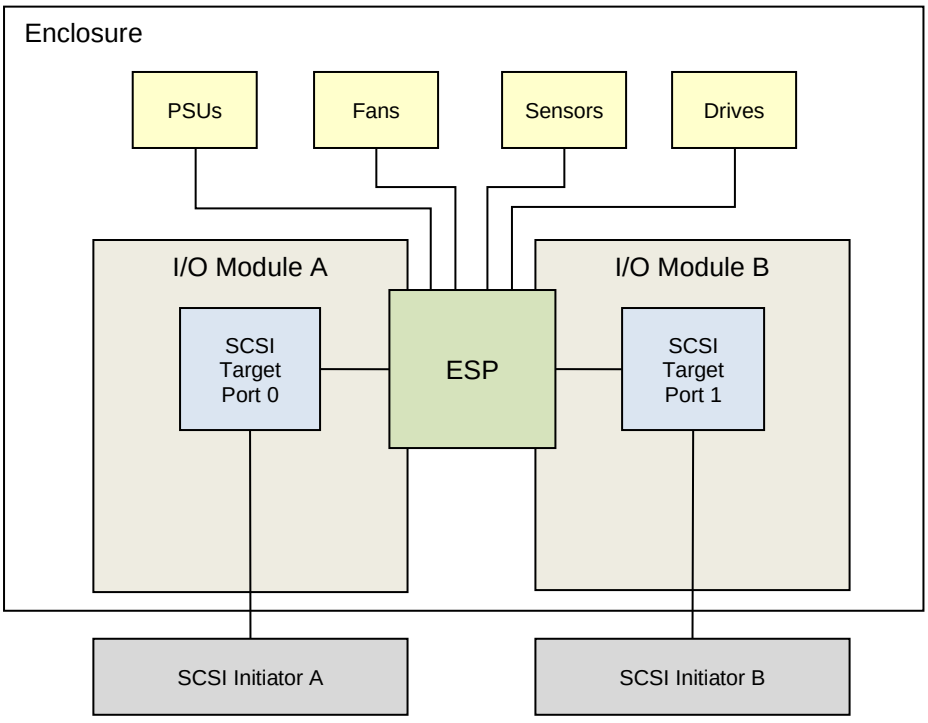

Figure 1 - Logical device model within a low-density enclosure

This device model is used to reflect the fact that the GEM enclosure firmware represents a consistent and unified view of the enclosure regardless of which I/O module's end device is accessed for status or control.

2.2 High-density Enclosures

A high-density enclosure implements a superset of the low-density enclosure detailed in 2.1. These enclosures maintain the same device model as the low-density enclosure with respect to Enclosure Services devices but extends it with additional I/O expansion devices to achieve the higher disk drive population. The additional I/O expansion devices also include SCSI end devices, however, these do not support SES and are not intended to be queried by host management applications for status beyond initial SCSI device discovery.

As these expansion devices do not support SES, they implement a limited version of GEM software, known as GEMLite. Whilst not directly controllable by the host SCSI initiator devices, the GEMLite devices do participate in enclosure management duties, however, they do this by sharing information they collect with the GEM devices in the I/O Modules so that it can be made available via SES. This approach allows the Enclosure services device model to remain the same between low-density enclosures and high-density enclosures, minimizing development effort in supporting both types of enclosure.

In Seagate high-density enclosures, the GEM and GEMLite devices may communicate in-band through the SCSI data-path. They do this using a proprietary protocol layered on top of the SCSI WRITE BUFFER command called GEMNet.

The GEMLite devices in an enclosure can be distinguished from the GEM devices through their INQUIRY data (see 3.3.1). GEMLite devices will be reported as SCSI Processor devices with the ENCSERV bit set to '0b'. In addition to this, unlike the GEM devices described in section 2.1, the GEMLite devices each report individual Device Identifiers in INQUIRY EVPD Page 83h. This is to indicate that they are to be treated as single port devices that are separate to the Enclosure Services device (see Figure 2).

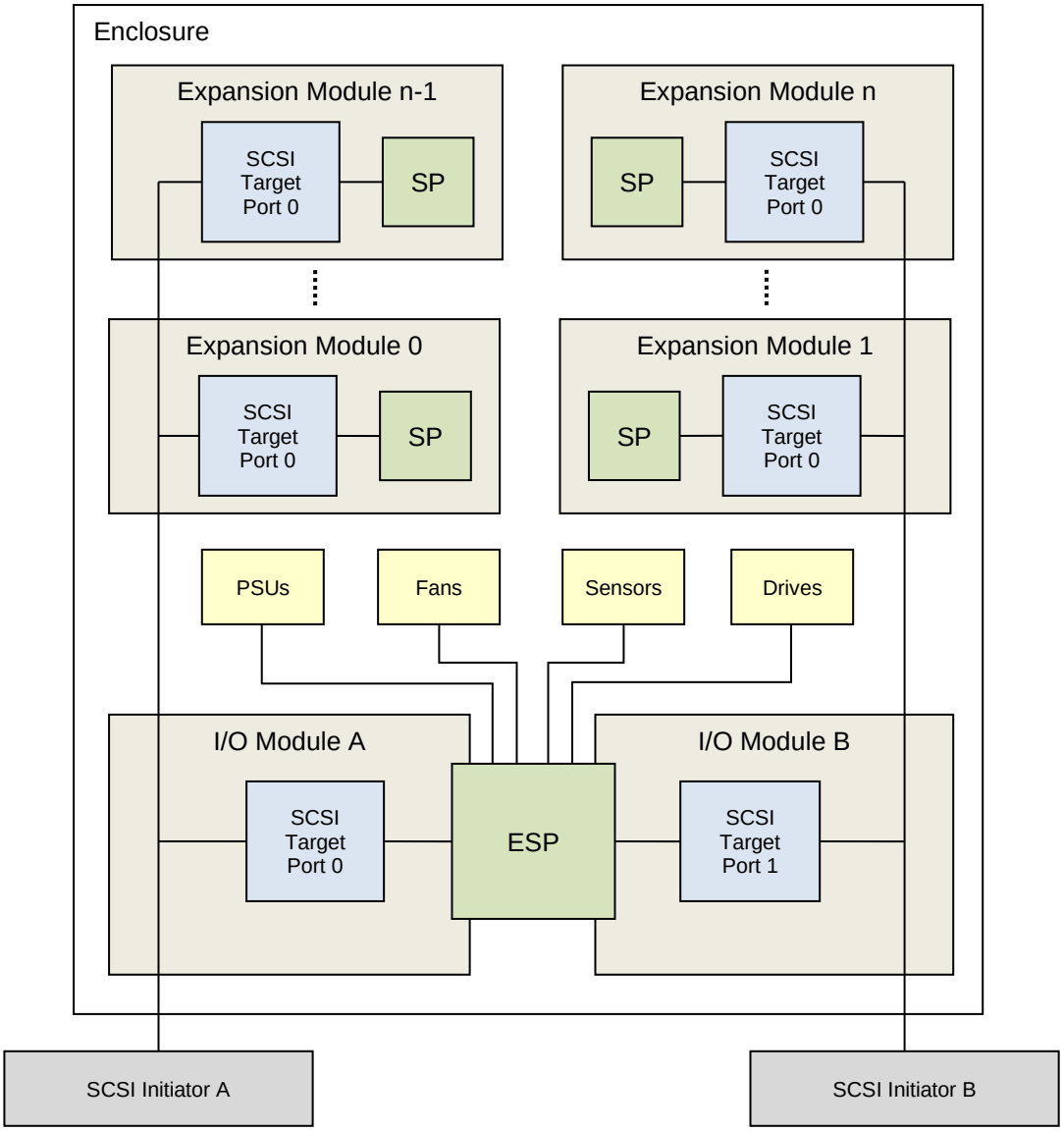

Figure 2 - Logical device model within a high-density enclosure

3 SCSI Target

3.1 SCSI Task Processing

The GEM SCSI target conforms to the Task Management specification outlined in [2] and [1].

3.1.1 Multi-Initiator Awareness

The number of concurrent initiators GEM and GEMLite devices support varies from product-to-product. In general, low-density products are configured to support up-to 8 concurrent I_T nexuses, whereas high-density products are configured for up-to 16 concurrent I_T nexuses. A single task pool is shared amongst all I_T nexuses, which allows a single initiator to utilize all available task queue slots if required. By default, the task queue size is set to the number of supported I_T nexuses; meaning a SCSI target supporting 16 initiators will support a queue-depth of 16.

If the number of attached initiators exceeds the maximum number of supported I_T nexuses, GEM will re-use the least recently used I_T nexus context structure for the first command the new initiator instigates. This will effectively remove the I_T nexus for the least recently active connection. If the “logged-out” initiator initiates a new command, it too will acquire an existing in-use I_T nexus context and will receive a UNIT ATTENTION condition in response to the command.

3.1.2 Task Queue Processing

GEM’s task queue depth is set to a level that allows at least one task per initiator. The task pool itself is shared amongst all initiators, allowing a single initiator to queue up-to 8 commands for a low-density enclosure and 16 commands for a high-density enclosure. If a task queue entry is unavailable when an initiator issues a CDB, GEM will respond with either a BUSY status, if the initiator currently has no existing tasks queued, or TASK SET FULL if the initiator does have outstanding tasks in progress.

GEM adheres to the simple task processing model only, allowing the task processor to determine the best task scheduling to use based upon the resources available. Each task processing executor takes its tasks from the head of the incoming task queue; however, additional rules may be in place to prevent task concurrency under certain circumstances. This is to satisfy the requirements of commands that are not designed for simultaneous processing, such as SES.

Commands that can’t support concurrency are known as ordered commands within GEM. When a SCSI executor takes an ordered command from the queue, it validates whether other executors are currently handling a command of the same ordered type. If they are not, the command is permitted to proceed to the execution phase. If they are, the command is placed back in its current position in the queue and the next command is selected for processing. This sequence proceeds until a command is found that can be executed.

A task processing executor is freed up to process the next command once it has sent the command response or has recognized that a request has been received to abort the command.

It should be noted that aborted commands may not complete execution and free utilized resource immediately. Due to the way commands are processed, the abort status is checked in-line with task execution and therefore may only be noted once the execution phase of the command is complete. If an abort is received during the command execution phase, it is likely the command will be allowed to complete internally but the response phase will be suppressed.

3.1.3 Task Management Functions

Table 1 - Supported Task Management functions

Function	Description
ABORT TASK	Aborts a task with the specified tag in the task set of the initiator issuing the task management request.
ABORT TASK SET	Aborts all tasks for the initiator issuing the task management request.
CLEAR TASK SET	Aborts all tasks for all initiators (TST is set to 0 on GEM SCSI Targets)
LOGICAL UNIT RESET	Aborts all tasks for all initiators and resets the Task management engine.
QUERY TASK	Returns whether the specified task tag for the initiator issuing the task management request is in the task set.

Section 3.1.2 covers details on how task aborts are processed.

3.1.4 Initiator Response Timeout

The GEM and GEMLite SCSI targets monitor the progress of the data phase for transfers from the initiator to the target. If there is a delay in excess of 4 seconds between data frames, or the last data frame and the end of the data phase, the target will abort the command. This is to protect the SCSI queue from being stalled due to either non-compliant initiators or cases where an initiator is removed from the SCSI bus during the data phase (this is possible in SAS where the initiator is behind a chain of SAS expanders). If this occurs, the initiator will receive a UNIT ATTENTION indicating its task was aborted.

3.1.5 Command Completion Timeouts

Most commands issued to the GEM and GEMLite SCSI targets will complete in a sub-second time period. It should be noted, however, that some Firmware download transfers and commands that directly update VPD EEPROMs may take many seconds to complete. As such it is recommended that to facilitate the longer running commands, the initiator is configured with a command completion timeout of at least 30 seconds for firmware downloads and commands that update non-volatile memory. All other commands may use a shorter command timeout if required.

3.2 Command completion status

3.2.1 Response status codes

SCSI commands complete with status codes indicating whether the command was successful or has failed. Table 2 lists all of the current status codes defined in SAM-5, indicating the status codes not currently returned by GEM and GEMLite SCSI targets with grey text. Non-good completion statuses are often supplemented with sense data, as described in 3.2.2. The SAM standard permits sense data to be returned with any command completion status, however, GEM and GEMLite SCSI targets will only return sense data for a non-good completion status. See [1] for a more detailed description of the individual status codes employed by SCSI devices.

Table 2 - Command Status Codes

Value	Description
00h	GOOD
02h	CHECK CONDITION
04h	CONDITION MET
08h	BUSY
18h	RESERVATION CONFLICT
28h	TASK SET FULL
30h	ACA ACTIVE
40h	TASK ABORTED
Others	Reserved

3.2.2 Sense Data

The GEM and GEMLite SCSI targets return sense data using the fixed format (Response Code 70h or 71h). Full details on sense data can be found in section 4.5 of [2]). The fixed sense data format is described in Table 3.

Table 3 – Fixed Sense Data Format

Bit / Byte	7	6	5	4	3	2	1	0
0	VALID (**0b**)	RESPONSE CODE (**70h or 71h**)						
1	Obsolete (**00h**)							
2	FILEMARK (**0b**)	EOM (**0b**)	ILI (**0b**)	SDAT_OVFL	SENSE KEY			
3	(MSB)	INFORMATION (**00000000h**)						
6								(LSB)
7	ADDITIONAL SENSE LENGTH (**n-7**)							
8	(MSB)	COMMAND SPECIFIC INFORMATION (**00000000h**)						
11								(LSB)
12	ADDITIONAL SENSE CODE							
13	ADDITIONAL SENSE CODE QUALIFIER							
14	FIELD REPLACEABLE UNIT CODE							

Bit / Byte	7	6	5	4	3	2	1	0
15	SKSV (**0b**)	SENSE KEY SPECIFIC INFORMATION (**000000h**)						
16								
17								
18	ADDITIONAL SENSE BYTES							
n								

VALID set to ‘1’ indicates that the INFORMATION field contains valid content. When set to ‘0’ it indicates that the INFORMATION field contains no valid content. GEM and GEMLite devices set this value to ‘0’ for all command responses.

RESPONSE CODE reports the format of the response data. GEM and GEMLite SCSI targets report fixed format response data only. Deferred response information (i.e., response data associated with a previous action) will be returned with a RESPONSE CODE of 71h whereas current response data (i.e., response data associated with the current command) is returned with a RESPONSE CODE of 70h.

FILEMARK is not applicable to commands or device types implemented by GEM and GEMLite SCSI targets. It is therefore set to ‘0’.

EOM (End-of-Medium) is not applicable to commands or device types implemented by GEM and GEMLite SCSI targets. It is therefore set to ‘0’.

ILI (Incorrect Length Indicator) is not applicable to commands or device types implemented by GEM and GEMLite SCSI targets. It is therefore set to ‘0’.

SDAT_OVFL when set to ‘1’ indicates that the SCSI target device has truncated its response sense data to fit within the boundaries set by the MAXIMUM SENSE DATA LENGTH field in the Control Extension Mode page (where supported).

SENSE KEY reports a generic code describing the type of condition reported by the response. Table 4 lists the possible values to which SENSE KEY may be set.

Table 4 - Supported SENSE KEY Values

Value	Sense Key	Description
0h	NO SENSE	No sense data is available
1h	RECOVERED ERROR	Command completed successfully after recovery action was taken. The sense data may reveal the necessary recovery actions
2h	NOT READY	The logical unit is not ready
3h	MEDIUM ERROR	The command completed with an un-correctable error that was either caused by an error in the storage medium or resulted in the storage medium being left in an erroneous condition
4h	HARDWARE ERROR	The command completed with an un-correctable hardware error
5h	ILLEGAL REQUEST	The command issue is either not supported or was illegally constructed
6h	UNIT ATTENTION	A change in operating condition is being signaled by the device
7h	DATA PROTECT	A read or write has been attempted on a protected

Value	Sense Key	Description
		block
8h	BLANK CHECK	Blank media has been detected when not expected
9h	VENDOR SPECIFIC	Vendor specific sense information
Ah	COPY ABORTED	A copy command was aborted before all data could be duplicated
Bh	ABORTED COMMAND	The command was aborted
Ch	Reserved	Reserved for future use
Dh	VOLUME OVERFLOW	A buffered data transfer has overflowed the end of the partition
Eh	MISCOMPARE	The source data does not match the content read back from the media
Fh	COMPLETED	Command completed sense data is available

The ADDITIONAL SENSE LENGTH field indicates the number of bytes that are present in the response data beyond the ADDITIONAL SENSE LENGTH field itself. GEM and GEMLite SCSI targets transmit 10 bytes of additional sense data, where such data is present.

COMMAND SPECIFIC INFORMATION contains sense data specific to the command that generated it. Not all commands will generate commands specific sense information.

ADDITIONAL SENSE CODE combined with the ADDITIONAL SENSE CODE QUALIFIER is used to provide a more detailed description of the sense condition. The sense codes that may be returned by GEM and GEMLite SCSI targets are detailed in Table 5.

Table 5 – 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.

Sense Key/ ASC/ASCQ	Description	Cause
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.
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.

3.3 Supported SCSI Commands

GEM's SCSI layer is extensible, allowing command support to be expanded as required. The commands supported are listed in Table 6. Note that all commands may not be enabled on all products and firmware versions.

Table 6 - Supported SCSI Commands

Command	Comments	Compliance	Section
INQUIRY	Used for identifying the enclosure and I/O modules. Provides access to INQUIRY VPD pages 00h, 80h and 83h	SPC-4	3.3.1
REQUEST SENSE	Used for collecting and clearing outstanding sense data associated with the initiator.	SPC-4	3.3.3
TEST UNIT READY	Tests whether expander is ready to handle commands.	SPC-4	3.3.4
REPORT LUNS	Returns the list of LUNS supported by the expander.	SPC-4	3.3.5
RECEIVE DIAGNOSTIC RESULTS [2]	Used for reading SES pages from the SES target.	SPC-4, SES-3	3.3.6
SEND DIAGNOSTIC [2]	Used for sending SES pages to the SES target.	SPC-4, SES-3	3.3.7
READ BUFFER	Alternative CLI & optional firmware update	SPC-4	3.3.8
WRITE BUFFER	Alternative CLI & optional firmware update	SPC-4	3.3.9
SET TIMESTAMP [1]	Used to set the enclosure system time	SPC-4	3.3.10
REPORT TIMESTAMP [1]	Used to read the current enclosure system time	SPC-4	3.3.11

[1] Available on GEM 5.2 and above

[2] Not implemented on GEMLite devices

3.3.1 INQUIRY command

The SCSI INQUIRY command is used to identify the basic capabilities of a SCSI device as well as to provide a mechanism for retrieving identification information such as product name, manufacturer, and revision.

3.3.1.1 CDB

Table 7 - INQUIRY CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (12h)							
1	Reserved						Obsolete	EVPD
2	PAGE CODE							
3	(MSB)	ALLOCATION LENGTH						
4								(LSB)
5	CONTROL							

OPERATION CODE defines the command that the SCSI target device should perform. For the INQUIRY command, this must be set to 12h.

EVPD when set to ‘1’ instructs the SCSI target device to return the VPD page selected by the PAGE CODE field. When EVPD is set to ‘0’, the SCSI target device returns the Standard Inquiry Data as per section 3.3.1.2

PAGE CODE is used to specify the EVPD page to retrieve when the EVPD bit is set to ‘1’

ALLOCATION LENGTH specifies the maximum number of bytes that shall be returned in the command data. If the inquiry data requested is shorter than the requested allocation length, the data phase shall return only the valid inquiry bytes.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.1.2 Standard Inquiry Data

The Standard Inquiry Data is returned by the SCSI target device when an INQUIRY CDB is issued with the EVPD bit set to '0'. The PERIPHERAL DEVICE TYPE for GEM devices will be set to 0Dh (Enclosure Services Device) and will be set to 03h (SCSI Processor Device) for GEMLite devices.

Table 8 - Standard INQUIRY data structure and values

Bit / Byte	7	6	5	4	3	2	1	0
0	PERIPHERAL QUALIFIER (0h)			PERIPHERAL DEVICE TYPE (0Dh or 03h)				
1	RMB (0b)	Reserved						
2	VERSION (06h)							
3	Reserved		NORM ACA (0b)	HI SUP (0b)	RESPONSE DATA FORMAT (2h)			
4	ADDITIONAL LENGTH (5Bh)							
5	SCCS (0b)	ACC (0b)	TPGS (0h)		3PC (0b)	Reserved		PROT (0b)
6	Obsolete	ENC SERV (1b or 0b)	Vendor Specific (0b)	MULTI P (1b or 0b)	Obsolete	Reserved		ADDR16 (0b)
7	Obsolete	Reserved	WBUS16 (0b)	SYNC (0b)	Obsolete	Reserved	CMDQUE (1b)	Vendor Specific (0b)
8 – 15	T10 VENDOR IDENTIFICATION							
16 – 31	PRODUCT IDENTIFICATION							
32 – 35	PRODUCT REVISION LEVEL							
36 – 55	Vendor Specific (All bytes set to 00h)							
56	Reserved				CLOCKING (0h)		QAS (0b)	IUS (0b)
57	Reserved							
58 – 73	VERSION DESCRIPTORS (Product dependent)							
74 – 95	Reserved							

See [2] for individual field descriptions and what the values listed in Table 8 correspond to.

T10 VENDOR IDENTIFICATION is set to the Vendor name stored in the Midplane VPD. By default it will be set to "SEAGATE " with a single padding space at the end. This field is customizable and can hold any 8-character string utilizing ASCII characters 00h and 20h to 7Eh as per SPC-4.

PRODUCT IDENTIFICATION is set to the concatenated values of the 8 byte Product IDs stored in the Midplane and I/O module VPD EEPROMs. For example, if the Midplane product ID is "SP-3584 " and the canister product ID is "-E12EBD ", the resultant ID reported in the PRODUCT IDENTIFICATION field will be "SP-3584-E12EBD" with any unused characters padded with spaces. Note that GEM

concatenates the last non-whitespace character in the Midplane product ID with the first non-whitespace character of the IOM product ID. For GEMLite devices, the data that populates this field is usually derived entirely from the expansion device VPD only.

PRODUCT REVISION LEVEL is set to an abbreviated representation of the full GEM/GEMLite firmware version. It represents the version in the format “Mmrr”. The full GEM/GEMLite firmware version number can be retrieved via the ENCLOSURE SERVICES CONTROLLER ELECTRONICS element descriptor in SES Page 07h (see [4])

The values reported by VERSION DESCRIPTORS are product dependent. For example, a 6G SAS product will report different SAS and SPL version support to a 12G product. SPC, SES and SAM versions are, however, nominally common across different transport level technologies. 12G SAS products will typically report the following version descriptor standards:

- SAM-5 (00A0h)
- SPC-4 (0460h)
- SES-3 (0580h) (GEM devices only)
- SPL-3 (20E0h)
- SAS-3 (0C60h)

The complete list of version descriptor values can be found in [2].

3.3.2 INQUIRY VPD Pages

INQUIRY VPD pages are returned in command data when an INQUIRY command is issued to the SCSI target with the EVPD bit set to ‘1’. The Inquiry VPD pages supported by GEM and GEMLite targets are detailed in Table 9.

Table 9 - Supported Inquiry VPD Pages

PAGE CODE	VPD Page Name
00h	Supported VPD Pages (see 3.3.2.1)
80h	Unit Serial Number (see 3.3.2.2)
83h	Device Identification (see 3.3.2.3)
Others	Not supported or reserved

3.3.2.1 INQUIRY VPD Page 00h

INQUIRY VPD page 00h, lists all of the supported INQUIRY VPD pages, including page 00h.

Table 10 - Supported VPD Pages VPD page data structure and values

Bit / Byte	7	6	5	4	3	2	1	0
0	PERIPHERAL QUALIFIER (0h)			PERIPHERAL DEVICE TYPE (0Dh or 03h)				
1	PAGE CODE (00h)							
2	(MSB)	PAGE LENGTH (0003h)						
3								(LSB)
Supported Page List								
4	Supported VPD Pages VPD Page (00h)							
5	Unit Serial Number VPD Page (80h)							
6	Device Identification Page (83h)							

3.3.2.2 INQUIRY VPD Page 80h

INQUIRY VPD page 80h, reports the enclosure serial number.

Table 11 – Unit Serial Number VPD page data structure and values

Bit / Byte	7	6	5	4	3	2	1	0
0	PERIPHERAL QUALIFIER (0h)			PERIPHERAL DEVICE TYPE (0Dh or 03h)				
1	PAGE CODE (80h)							
2	(MSB)	PAGE LENGTH (000Fh)						
3								(LSB)
Unit Serial Number								
4	SERIAL NUMBER							
18								

SERIAL NUMBER is typically a 15-ASCII character string read from the Midplane VPD for GEM targets and read from the expansion module VPD for GEMLite targets.

3.3.2.3 INQUIRY VPD Page 83h

INQUIRY VPD page 83h reports the identifiers for the various addressable components that make up the enclosure and its SSP targets. The identifiers used are most commonly NAA 5 WWNs allocated during enclosure and I/O module manufacture.

Table 12 displays the format for the identifier page typically exposed by GEM and GEMLite devices.

Table 12 – Device Identification VPD page data structure and values

Byte \ Bit	7	6	5	4	3	2	1	0
0	PERIPHERAL QUALIFIER (0h)			PERIPHERAL DEVICE TYPE (0Dh or 03h)				
1	PAGE CODE (83h)							
2	(MSB)			PAGE LENGTH (0048h)				
3								(LSB)
Identifier Descriptor 1 – Binary NAA 5 WWN for the Logical Unit								
4	PROTOCOL IDENTIFIER (0h)				CODE SET (1h)			
5	PIV (0b)	Reserved		ASSOCIATION (0h)	DESIGNATOR TYPE (3h)			
6	Reserved							
7	DESIGNATOR LENGTH (08h)							
8	(MSB)			LOGICAL UNIT WWN				
15								(LSB)
Identifier Descriptor 2 – Binary NAA 5 WWN for the expander Virtual SSP target								
16	PROTOCOL IDENTIFIER (6h)				CODE SET (1h)			
17	PIV (1b)	Reserved		ASSOCIATION (1h)	DESIGNATOR TYPE (3h)			
18	Reserved							
19	DESIGNATOR LENGTH (08h)							
20	(MSB)			TARGET PORT WWN				
27								(LSB)
Identifier Descriptor 3 – Binary relative target port ID for the expander Virtual SSP target								
28	PROTOCOL IDENTIFIER (6h)				CODE SET (1h)			
29	PIV (1b)	Reserved		ASSOCIATION (1h)	DESIGNATOR TYPE (4h)			
30	Reserved							
31	DESIGNATOR LENGTH (04h)							
32				Reserved				
33								
34	(MSB)			RELATIVE TARGET PORT ID				
35								(LSB)
Identifier Descriptor 4 – Binary NAA 5 WWN for the Device containing the Logical Unit								
36	PROTOCOL IDENTIFIER (6h)				CODE SET (1h)			
37	PIV (1b)	Reserved		ASSOCIATION (2h)	DESIGNATOR TYPE (3h)			
38	Reserved							
39	DESIGNATOR LENGTH (08h)							
40	(MSB)			DEVICE WWN				
47								(LSB)

Bit / Byte	7	6	5	4	3	2	1	0
Identifier Descriptor 5 – UTF-8 identifier string for the Device containing the Logical Unit								
48	PROTOCOL IDENTIFIER (6h)				CODE SET (3h)			
49	PIV (1b)	Reserved	ASSOCIATION (2h)		DESIGNATOR TYPE (8h)			
50	Reserved							
51	DESIGNATOR LENGTH (18h)							
52	(MSB)	DEVICE NAME STRING						
75								(LSB)

LOGICAL UNIT WWN is set to the same value as the WWN for the Device containing the Logical Unit. This is because GEM only supports a single LUN.

TARGET PORT WWN, is set to the SAS address of the expander's virtual SSP phy.

RELATIVE TARGET PORT ID is set to the canister slot position in the enclosure. This can be 00000001h for slot A or 00000002h for slot B for GEM devices. GEMLite devices will always report 0 for this value.

DEVICE WWN is set to the ENCLOSURE LOGICAL WWN stored in the Midplane VPD for GEM devices and a dedicated identifier derived from the SAS address range stored in the expansion module VPD for GEMLite devices.

DEVICE NAME STRING is the UTF-8 string representation of the DEVICE WWN. It takes the form "naa.XXXXXXXXXXXXXXXX", e.g., "naa.50050cc10c201583"

3.3.3 REQUEST SENSE

The REQUEST SENSE command will return the next set of outstanding sense data stored against the I_T nexus over which the command is received. Once the sense data is returned, it is cleared on the target device. GEM/GEMLite only maintains one set of outstanding sense data for each initiator. As GEM returns sense data in the command response for all commands, the only conditions that normally result in sense data being made available via this command are procedures that result in a UNIT ATTENTION condition.

3.3.3.1 CDB

Table 13 – REQUEST SENSE CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (03h)							
1	Reserved							DESC
2	Reserved							
3								
4	ALLOCATION LENGTH							
5	CONTROL							

OPERATION CODE defines the command that the SCSI target device should perform. For the REQUEST SENSE command, this must be set to 03h.

DESC when set to ‘0’, instructs the target device to return its sense data in the fixed format. When set to ‘1’, the target device shall return its sense data in the descriptor format, if supported. If the target device does not support descriptor format sense data and DESC is set to ‘1’, the target device will terminate the command with a CHECK CONDITION status, a sense key of ILLEGAL REQUEST and an ASC/ASCQ of INVALID FIELD IN CDB. GEM and GEMLite devices do not support descriptor format sense data.

ALLOCATION LENGTH specifies the maximum number of bytes that shall be returned in the command data. If the data requested is shorter than the requested allocation length, the data phase shall return only the valid bytes.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.3.2 Data In

The REQUEST SENSE command returns the outstanding sense data during the data phase rather than response phase. See 3.2.2 for details of the fixed sense data format returned in the command data.

3.3.4 TEST UNIT READY

The TEST UNIT READY command reports the target device's state of readiness. If the device is ready, it will complete the command with a GOOD status. If the device is not ready, it will terminate the command with a CHECK CONDITION status and a sense key of NOT READY.

3.3.4.1 CDB

Table 14 – TEST UNIT READY CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (00h)							
1	Reserved							
4								
5	CONTROL							

OPERATION CODE defines the command that the SCSI target device should perform. For the TEST UNIT READY command, this must be set to 00h.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.4.2 Data

The TEST UNIT READY command returns no data.

3.3.5 REPORT LUNS

The REPORT LUNS command reports a list of LUNs supported by the enclosure. GEM and GEMLite devices only support a single LUN; LUN 0.

3.3.5.1 CDB

Table 15 – REPORT LUNS CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (A0h)							
1	Reserved							
2	SELECT REPORT							
3	Reserved							
5								
6	(MSB)	ALLOCATION LENGTH						
9								(LSB)
10	Reserved							
11	CONTROL							

OPERATION CODE defines the command that the SCSI target device should perform. For the TEST UNIT READY command, this must be set to 00h.

SELECT REPORT specifies the type of logical unit addresses that shall be reported in the REPORT LUNS command data. GEM and GEMLite devices report SELECT REPORT field values of 00h-02h only. The values are defined in Table 16.

Table 16 – Supported SELECT REPORT values

Code	Description
00h	The list shall contain the logical units accessible to the I_T nexus with the following addressing methods: a) simple logical unit addressing method b) logical unit addressing method c) peripheral device addressing method d) flat space addressing method e) extended flat space addressing method f) long extended flat space addressing method If there are no logical units to report, the LUN LIST LENGTH field shall be set to zero
01h	The list shall contain only well-known logical units, if any. If there are no well-known logical units, the LUN LIST LENGTH field shall be zero
02h	The list shall contain all logical units accessible to the I_T nexus
Others	Not supported or reserved (see SPC-4)

ALLOCATION LENGTH specifies the maximum number of bytes that shall be returned in the command data. If the data requested is shorter than the requested allocation length, the data phase shall return only the valid bytes.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.5.2 Data In

Table 17 – REPORT LUNS Data-In Format for SELECT REPORT 00h and 02h

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			LUN LIST LENGTH (8)				
3								(LSB)
4				Reserved				
7								
LUN List								
8				LUN 0 (00 00 00 00 00 00 00 00h**)**				
15								

Table 18 – REPORT LUNS Data-In Format for SELECT REPORT 01h

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			LUN LIST LENGTH (0)				
3								(LSB)
4				Reserved				
7								
LUN List								

3.3.6 RECEIVE DIAGNOSTIC RESULTS

GEM utilizes the RECEIVE DIAGNOSTIC RESULTS command for receiving Diagnostic and SES Pages. GEM does not support the self-test interface and any attempt to issue a RECEIVE DIAGNOSTIC RESULTS command with the PCV bit set to ‘0’, will result in a CHECK CONDITION status with sense key ILLEGAL REQUEST and additional sense data of INVALID FIELD IN CDB.

3.3.6.1 CDB

Table 19 – RECEIVE DIAGNOSTIC RESULTS CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (1Ch)							
1	Reserved							PCV
2	PAGE CODE							
3	(MSB)			ALLOCATION LENGTH				
4								(LSB)
5	CONTROL							

OPERATION CODE defines the command that the SCSI target device should perform. For the RECEIVE DIAGNOSTIC RESULTS command, this must be set to 1Ch.

PCV, when set to ‘1’ indicates that the PAGE CODE field in the CDB is valid. When the page code field is valid, the target device shall return the request diagnostic page. When PCV is set to ’0’, the target device shall return the results from the previously issued SEND DIAGNOSTIC command with PF=0. GEM devices only support RECEIVE DIAGNOSTIC RESULTS commands with PCV set to ‘1’.

ALLOCATION LENGTH specifies the maximum number of bytes that shall be returned in the command data. If the data requested is shorter than the requested allocation length, the data phase shall return only the valid bytes.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.6.2 Data In

See [4] for details of the RECEIVE DIAGNOSTIC RESULTS page formats.

3.3.7 SEND DIAGNOSTIC

GEM utilizes the SEND DIAGNOSTIC command for writing Diagnostic and SES Pages. GEM does not support the self-test interface and any attempt to use the SEND DIAGNOSTIC command without the PF bit set to '1' will result in a CHECK CONDITION status with sense key ILLEGAL REQUEST and additional sense data of INVALID FIELD IN CDB.

3.3.7.1 CDB

Table 20 – SEND DIAGNOSTIC CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (1Dh)							
1	SELF TEST CODE			PF	Reserved	SELF TEST	DEVOFFL	UNITOFFL
2	Reserved							
3								
4	PARAMETER LIST LENGTH							
5	CONTROL							

OPERATION CODE defines the command that the SCSI target device should perform. For the SEND DIAGNOSTIC command, this must be set to 1Dh.

See [2] for details on SELF TEST CODE, SELF TEST, DEVOFFL and UNITOFFL

PF when set to '1' indicates that the Parameter List contains data in the diagnostic page format. This must be set to '1' for all SEND DIAGNOSTIC requests issued to a GEM device.

PARAMETER LIST LENGTH specifies the maximum number of bytes that shall be transferred from the Data-Out Buffer to the specified page.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.7.2 Data Out

See [4] for details of the SEND DIAGNOSTIC page formats.

3.3.8 READ BUFFER (10)

The READ BUFFER command is used to read information from the enclosure. The information read by the READ BUFFER command is defined by the MODE and BUFFER ID fields specified within the CDB.

3.3.8.1 CDB

Table 21 – READ BUFFER (10) CDB Format

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (3Ch)							
1	MODE SPECIFIC			MODE				
2	BUFFER ID							
3	(MSB)	BUFFER OFFSET						
5								(LSB)
6	(MSB)	ALLOCATION LENGTH						
8								(LSB)
9	CONTROL							

OPERATION CODE defines the command that the SCSI target device should perform. For the READ BUFFER (10) command, this must be set to 3Ch.

MODE specifies the buffer transfer function being performed. The full list of modes is defined in SPC is shown in Table 22. 3.4 lists the modes supported by GEM/GEMLite.

Table 22 – READ BUFFER MODE values

MODE	Description
00h	Obsolete
01h	Vendor Specific
02h	Data
03h	Descriptor
04-09h	Reserved
0Ah	Read data from echo buffer
0Bh	Echo buffer descriptor
0Ch – 0Eh	Reserved
0Fh	Read microcode status
10h-19h	Reserved
1Ah	Obsolete
1Bh	Reserved
1Ch	Error history
1Dh-1Fh	Reserved

MODE SPECIFIC is specific to the mode being used.

BUFFER ID, combined with the mode specifies the ID of the buffer to read. 3.4 lists the buffer IDs supported by GEM/GEMLite.

BUFFER OFFSET specifies the offset in bytes within the buffer from which to read.

ALLOCATION LENGTH specifies the maximum number of bytes that shall be returned in the command data. If the data requested is shorter than the requested allocation length, the data phase shall return only the valid bytes.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.8.2 Data In

The command data returned is defined by the MODE and BUFFER ID. See 3.4 for supported buffer modes and IDs, along with their data formats.

3.3.8.3 Read microcode status mode (0Fh)

In this mode, the device server returns parameter data that contains information about microcode status. The BUFFER ID field specifies the download microcode buffer within the logical unit for which microcode status is requested. The MODE SPECIFIC field and the BUFFER OFFSET field are reserved.

Table 23 defines the format of the read microcode status descriptor.

Table 23 – Read microcode status descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	ACTIVATED MICROCODE STATUS							
1	REDUNDANT MICROCODE STATUS							
2	DOWNLOAD MICROCODE STATUS (see Table 24)							
3	Reserved							
4	(MSB)	DOWNLOAD MICRCODE MAXIMUM SIZE						
7								(LSB)
8	(MSB)	Reserved						
11								(LSB)
12	(MSB)	DOWNLOAD MICROCODE EXPECTED BUFFER OFFSET						
15								(LSB)

ACTIVATED MICROCODE STATUS and REDUNDANT MICROCODE STATUS are not used and are set to 0

The DOWNLOAD MICROCODE STATUS field indicates the status of download microcode operations and is defined in Table 24. Enclosure services devices may set the DOWNLOAD MICROCODE STATUS field to any value defined for the SUBENCLOSURE DOWNLOAD MICROCODE STATUS field for the Download Microcode Status diagnostic (see SPC-6). After activating microcode, the device server shall set the DOWNLOAD MICROCODE STATUS field to 00h.

Table 24 – DOWNLOAD MICROCODE STATUS

MODE	Description
35h	Download of deferred microcode completed with no error. The new microcode activation occurs after: a) processing a WRITE BUFFER command specifying the activate deferred microcode mode; b) hard reset; c) power on; or d) other events (e.g., vendor specific events). Microcode activation due to processing a WRITE BUFFER command that specifies the activate deferred microcode mode affects only the logical unit containing that device server.
36h to 6Fh	Reserved
Other codes that may indicate conditions that are not errors	
70h to 7Fh	Vendor specific
Codes indicating completion with errors	
80 to 8Fh	Restricted (see SPC-6)
90h	There was an error in one or more of the WRITE BUFFER command fields and the new micro-code was discarded. The DOWNLOAD MICROCODE ADDITIONAL STATUS field shall be set to the offset of the lowest byte of the field in the WRITE BUFFER command that was in error
91h	A microcode image error was detected (e.g., by a vendor specific check of the microcode image such as a checksum) and the new microcode was discarded.
92h	A download microcode vendor specific timeout occurred and the new microcode was discarded.
93h	An internal error occurred in the download microcode operation and no valid persistent microcode image is available for use after a hard reset or power on.
94h	An internal error occurred in the download microcode operation and a valid persistent microcode image is available.
95h	The device server processed a WRITE BUFFER command with the MODE field set to 0Fh (i.e., activate deferred microcode), when there was no deferred microcode. If a download microcode operation was in progress then that microcode was discarded.
96h to EFh	Reserved
Other codes that may indicate conditions that are errors	
F0h to FFh	Vendor specific

The DOWNLOAD MICROCODE MAXIMUM SIZE field indicates the maximum size in bytes of the microcode image that the device server accepts. The image may be delivered using one or more WRITE BUFFER command download microcode modes.

The DOWNLOAD MICROCODE EXPECTED BUFFER OFFSET field indicates the next value that the device server expects in the BUFFER OFFSET field in the WRITE BUFFER command. If the device server accepts arbitrary BUFFER OFFSET field values, then it shall set the DOWNLOAD MICROCODE EXPECTED BUFFER OFFSET field to FFFFFFFFh.

3.3.9 WRITE BUFFER

The WRITE BUFFER command is used to write data to the enclosure. The information that may be written with the WRITE BUFFER command is defined by the MODE and BUFFER ID fields specified within the CDB.

3.3.9.1 CDB

Table 25 – WRITE BUFFER CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (3Bh)							
1	MODE SPECIFIC			MODE				
2	BUFFER ID							
3	(MSB)			BUFFER OFFSET				
5								(LSB)
6	(MSB)			PARAMETER LIST LENGTH				
8								(LSB)
9	CONTROL							

OPERATION CODE defines the command that the SCSI target device should perform. For the WRITE BUFFER command, this must be set to 3Bh.

MODE specifies the buffer transfer function being performed. The full list of modes is defined in SPC is shown in Table 26. 3.4 lists the modes supported by GEM/GEMLite.

Table 26 – WRITE BUFFER MODE values

MODE	Description
00h	Obsolete
01h	Vendor Specific
02h	Data
03h	Reserved
04h	Download microcode and activate
05h	Download microcode, save and activate
06h	Download microcode with offsets and activate
07h	Download microcode with offsets, save and activate
08h-09h	Reserved
0Ah	Write data to echo buffer
0Bh-0Ch	Reserved
0Dh	Download microcode with offsets, select activation events, save, and defer activate
0Eh	Download microcode with offsets, save, and defer activate
0Fh	Activate deferred microcode
10h-19h	Reserved
1Ah	Obsolete

MODE SPECIFIC is specific to the mode being used.

BUFFER ID, combined with the mode specifies the ID of the buffer to write. 3.4 lists the buffer IDs supported by GEM/GEMLite.

BUFFER OFFSET specifies the start offset in bytes within the buffer where data will be written.

PARAMETER LIST LENGTH specifies the maximum number of bytes that shall be transferred from the Data-Out Buffer to be stored in the specified buffer beginning at the buffer offset.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.9.2 Data Out

The command data returned is defined by the MODE and BUFFER ID. See 3.4 for supported buffer modes and IDs, along with their data formats.

3.3.10 SET TIMESTAMP

The SET TIMESTAMP command may be used by an initiator to set the current time on a SCSI target device. GEM/GEMLite uses this command to update its internal system time, which will be reflected on the CLI and in logs.

3.3.10.1 CDB

Table 27 – SET TIMESTAMP CDB Format

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (A4h)							
1	Reserved			SERVICE ACTION (0Fh)				
2	Reserved							
5								
6	(MSB)	PARAMETER LIST LENGTH						
9								(LSB)
10	Reserved							
11	CONTROL							

OPERATION CODE and SERVICE ACTION define the command that the SCSI target device should perform. For the SET TIMESTAMP command, this must be set to A4h and 0Fh correspondingly.

PARAMETER LIST LENGTH specifies the maximum number of bytes that shall be transferred from the Data-Out Buffer.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.10.2 Data Out

Table 28 – SET TIMESTAMP Data-Out Format

Bit / Byte	7	6	5	4	3	2	1	0
0	Reserved							
3								
4	(MSB)	TIMESTAMP						
9								(LSB)
10	Reserved							
11								

TIMESTAMP specifies the value to which the system time shall be set. The timestamp is the number of milliseconds that have elapsed since 00:00:00 1 January 1970 UTC. If the most significant byte in the TIMESTAMP field is greater than F0h, the device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER LIST

3.3.11 REPORT TIMESTAMP

The REPORT TIMESTAMP command may be used by an initiator to read the current system time on a SCSI target device.

3.3.11.1 CDB

Table 29 – REPORT TIMESTAMP CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (A3h)							
1	Reserved			SERVICE ACTION (0Fh)				
2	Reserved							
5								
6	(MSB)	ALLOCATION LENGTH						
9								(LSB)
10	Reserved							
11	CONTROL							

OPERATION CODE and SERVICE ACTION define the command that the SCSI target device should perform. For the REPORT TIMESTAMP command, this must be set to A3h and 0Fh correspondingly.

ALLOCATION LENGTH specifies the maximum number of bytes that shall be returned in the command data. If the data requested is shorter than the requested allocation length, the data phase shall return only the valid bytes.

CONTROL is defined in SAM-5. GEM and GEMLite devices do not accept a CONTROL field value other than 0.

3.3.11.2 Data In

Table 30 – REPORT TIMESTAMP Data-In Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)	TIMESTAMP PARAMETER DATA LENGTH (000Ah)						
1								(LSB)
2	Reserved					TIMESTAMP ORIGIN		
3								
4	(MSB)	TIMESTAMP						
9								(LSB)
10	Reserved							
11								

TIMESTAMP ORIGIN specifies the source for the current value of the system clock. Valid values for the TIMESTAMP ORIGIN are shown in Table 31.

Table 31 – TIMESTAMP ORIGIN values

MODE	Description
0h	Device clock initialized to 0 at power-on/reset
1h	Reserved
2h	Device clock initialized by SET TIMESTAMP
3h	Device clock initialized by non-SPC defined method
5h-8h	Reserved

TIMESTAMP specifies the current value of the system time. The timestamp is the number of milliseconds that have elapsed since 00:00:00 1 January 1970 UTC.

3.4 READ/WRITE BUFFER IDs

READ BUFFER and WRITE BUFFER commands are used for common communications functionality shared between GEM and GEMLite devices. GEM and GEMLite targets implement the following functions using READ and WRITE BUFFER commands.

Table 32 - Supported BUFFER IDs for READ/WRITE BUFFER

MODE	BUFFER ID	Description	R/W
01h	0	Supported Vendor Specific Buffer Protocols (3.4.2)	R
01h	1	In-band CLI (3.4.3)	R/W
01h	2	Reserved for Seagate internal GN use	W
01h	4	SCSI Initiator Test Interface	W
07h, 0Eh, 0Fh	0	Firmware download[1] (3.4.1)	W
[1] Available on all versions of GEMLite and GEM 5.2 onwards			

3.4.1 Firmware download

GEM and GEMLite firmware may be transferred to the SCSI target device using WRITE BUFFER modes 07h, 0Eh and 0Fh. When this is performed, the data transferred to the enclosure from the Data-Out buffer is the firmware payload itself. For both mode 07h and mode 0Eh transfers, the initiator performing the firmware download, is expected to transfer the firmware in blocks no larger than 4kB. For payloads including devices that are slow to update, such as PSUs and Fans, a smaller transfer size may be used in order to reduce the command completion time. Where multiple WRITE BUFFER transfers are required in order to write all firmware data, the initiator will increment the BUFFER OFFSET by the PARAMETER LIST LENGTH after each successful command.

It should be noted that the preferred mechanism for transferring firmware to the enclosure is through SES Page 0Eh (see [4]), which provides more options for controlling the update. All GEMLite devices implement the WRITE BUFFER firmware download mechanism, however, it has only been enabled on GEM devices since GEM 5.2

3.4.1.1 Mode 07h

When a transfer is performed using mode 07h, the new firmware will activate automatically after the entire file transfer is complete. Depending on the firmware transferred, the activation may be a soft reset, hard reset, no reset or manual reset required.

3.4.1.2 Mode 0Eh and 0Fh

When a transfer is performed using mode 0Eh, the new firmware will not activate automatically after the file transfer is complete. The initiator must activate the new firmware, when ready, by issuing a WRITE BUFFER command using mode 0Fh. The mode 0Fh command shall have a zero-length PARAMETER LIST LENGTH.

3.4.2 Supported Vendor Specific Buffer Protocols

Vendor Specific mode Buffer ID 0 provides a list of the Vendor Specific Buffer Protocols supported by a GEM/GEMLite target device. If this page isn't supported, the host may assume the target supports protocol IDs 0100h (In-band CLI v1), 0200h (GEMNet v1) and 0400h (SCSI Test Interface v1).

Table 33 – Read Supported Vendor Specific Buffer Protocols READ BUFFER CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (3Ch)							
1	MODE SPECIFIC (0h)			MODE (1h)				
2	BUFFER ID (0h)							
3	(MSB)			BUFFER OFFSET				
5								(LSB)
6	(MSB)			ALLOCATION LENGTH (n)				
8								(LSB)
9	CONTROL							

See 3.3.8 for full details of the READ BUFFER CDB fields. The MODE must be set to 1h (Vendor Specific) and the BUFFER ID must be set to 0h (Supported Vendor Specific Buffer Protocols) to read the Supported Vendor Specific Buffer Protocols list.

Table 34 – Read CLI Command Output READ BUFFER Data-In Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			PROTOCOL LIST LENGTH (n-1)				
1								(LSB)
Protocol List								
2	(MSB)			PROTOCOL ID 0				
3								(LSB)
	…							
n-1	(MSB)			PROTOCOL ID N				
n								(LSB)

PROTOCOL LIST LENGTH is set to the number of bytes in the protocol list. The number of items in the protocol list is equal to PROTOCOL LIST LENGTH / 2.

The Protocol List contains a 2-byte entry for each PROTOCOL ID supported. The general scheme for protocol enumeration is for the MSB to contain the protocol identifier (normally the BUFFER ID) and the LSB to contain the protocol generation/version. If multiple versions of a READ/WRITE buffer protocol are supported by a GEM/GEMLite device, all supported protocol versions will be listed in the table. The protocol IDs are listed in Table 35.

Table 35 – Supported Vendor Specific PROTOCOL IDs for READ/WRITE BUFFER

PROTOCOL ID	Description
0000h	Supported Vendor Specific Buffer Protocols v1 (3.4.2)
0001h-00FFh	Reserved for future Supported Vendor Specific Buffer Protocol versions
0100h	In-band CLI v1 (3.4.3)
0101h	In-band CLI v2 (3.4.3)
0102h-01FFh	Reserved for future In-band CLI versions
0200h	GEMNet v1 (Internal use only - not defined in this document)
0201h-02FFh	Reserved for future GEMNet versions
0300h-03FFh	Reserved
0400h	SCSI Initiator Test Interface v1 (not defined in this document)
0401h-04FFh	Reserved for future SCSI Initiator Test Interface versions
0500h-FFFFh	Reserved

3.4.3 In-band CLI

The in-band CLI is vendor specific functionality that utilizes WRITE and READ BUFFER commands to run CLI commands on the GEM/GEMLite target. It utilizes MODE 01h (Vendor Specific) and BUFFER ID 1 to transfer the command line to the target device using WRITE BUFFER and then retrieve the command response using READ BUFFER.

There are two supported In-band CLI buffer protocols. In-band CLI v1 (0100h) and In-band CLI v2 (0101h). The versions supported by a GEM/GEMLite target are listed in the Supported Vendor Specific Protocols buffer (3.4.2). This document describes the In-band CLI v2 protocol, however, GEM/GEMLite targets that implement the v2 protocol are required to support the v1 protocol described in previous versions of this document.

3.4.3.1 CLI command execution

A CLI command is executed on the GEM/GEMLite target device by first sending a WRITE BUFFER command with MODE 01h and BUFFER ID 01h containing the command line that is to be run. The format of the CDB and data for the Send CLI Command write buffer command are shown in Table 36 and Table 37.

Table 36 – Send CLI Command WRITE BUFFER CDB Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (3Bh)							
1	MODE SPECIFIC (0h)			MODE (01h)				
2	BUFFER ID (01h)							
3	(MSB)	BUFFER OFFSET (000000h)						
5								(LSB)
6	(MSB)	PARAMETER LIST LENGTH (n+1)						
8								(LSB)
9	CONTROL							

See 3.3.9 for details of the WRITE BUFFER CDB fields.

Table 37 – Send CLI Command WRITE BUFFER Data-Out Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	OBSOLETE LENGTH (0h)							
	OBSOLETE (no bytes)							
1	(MSB)	SIGNATURE (F0AAF0AAh)						
4								(LSB)
5	HEADERS LENGTH (m)							
Command Header List								
2	Header 0							
m								
	…							
m+1	Header n							
k								
Command Data								
k+1	COMMAND LINE							
N								

OBSOLETE LENGTH was used by a previous version of the In-band CLI protocol and must be set to 0h.

OBSOLETE was used by a previous of the In-band CLI protocol and should be set to an empty string (no bytes) by clients implementing the v2 protocol.

SIGNATURE is used to identify that the v2 protocol is being used. A client implementing the In-band CLI v2 protocol as described here must set this value to F0AAF0AAh.

HEADERS LENGTH contains the number of bytes occupied by the command headers. If no headers are present, this field will be set to 0h. The header length field is also used to locate the start of command data. If the Protocol List in the Supported Vendor Specific Protocols buffer does not contain the In-band CLI v2 (0101h) PROTOCOL ID, the client must be set this field to 0h.

The Command Header List contains the extensible header list for the CLI command. The headers are used to provide additional metadata that describe how the command is to be executed. Additional headers may be added over time. If a header is supplied by a client but isn't supported by a GEM/GEMLite target, it will be ignored. The supported command headers are described in 3.4.3.2.

COMMAND LINE contains the entire null-terminated command line ACSII string for the command to be executed. For example, *"logdump r new 10"*. It is not possible to split the command line over multiple WRITE BUFFER requests. The same command line syntax rules are supported as for the serial or telnet command line interfaces (see [5]).

CLI command execution commences once the WRITE BUFFER command containing the command line completes with good status. The initiator is then expected to read BUFFER ID 01h using the READ BUFFER command with MODE 01h (see 3.4.3.3) to collect the CLI command output (if any) until

execution completes. If an existing in-band CLI command is in the process of being executed, any new requests will be terminated with a CHECK CONDITION status until the outstanding command completes or times out.

3.4.3.2 Command Header List

The command header List is a feature of the In-band CLI v2 protocol and is not present in earlier versions of the protocol. The headers are used to provide additional information to the GEM/GEMLite target beyond the basic command line parameters. Such information may include a username and password or instructions specifying how the command is to be executed. The basic format implemented by all headers is described in Table 38.

Table 38 – Send CLI Command WRITE BUFFER Header Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	HEADER TYPE							
1	HEADER LENGTH							
2	HEADER DATA							
n								

HEADER TYPE lists the format of the HEADER DATA field. Table 39 lists the possible HEADER TYPE values supported by GEM/GEMLite

Table 39 - Supported HEADER TYPE IDs for READ/WRITE BUFFER

HEADER TYPE	Description
00h	Username and Password Header
01h-FFh	Reserved

3.4.3.2.1 Username and Password Header

The Username and Password Header is used by a client to supply username and password information to the GEM/GEMLite target in order to invoke a CLI command. This header is required if the enclosure supports in-band CLI authentication (AUTH bit in the read buffer is set to 1h).

Table 40 – Send CLI Command WRITE BUFFER Header Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	HEADER TYPE (00h)							
1	HEADER LENGTH (n-1)							
2	USERNAME LENGTH (m-2)							
3	USERNAME							
m4								
m+1	PASSWORD							
n								

HEADER TYPE and HEADER LENGTH are described in 3.4.3.2.

USERNAME LENGTH is the length in bytes of the USERNAME field.

USERNAME is an ASCII string containing the CLI username to use for invoking the command. The USERNAME string is not required to be NUL (‘\0’) terminated, however, NUL termination will be handled by the GEM/GEMLite target if detected and any characters following the first NUL character will be ignored.

PASSWORD is an ASCII string containing the CLI password to use for invoking the command. The PASSWORD string is not required to be NUL (‘\0’) terminated, however, NUL termination will be handled by the GEM/GEMLite target if detected and any characters following the first NUL character will be ignored.

The offset of the PASSWORD field within the buffer is calculated as USERNAME LENGTH + 3. The length of the PASSWORD field in bytes is calculated as HEADER LENGTH – (USERNAME LENGTH + 1).

3.4.3.3 CLI command output collection

The initiator performs CLI command output collection by reading from MODE 01h - BUFFER ID 01h using READ BUFFER requests until the command completes. If there is data in the output buffer that the initiator fails to collect within 30 seconds of it being populated, the CLI command will be terminated. In some cases, CLI command termination will result in the command running to completion in the background with its output being discarded. This will result in a delay before a new CLI command may be initiated. The format of the CDB and data for the Read CLI Command Output READ BUFFER command are shown in Table 41 and Table 42.

Table 41 – Read CLI Command Output READ BUFFER CDB Format

Bit / Byte	7	6	5	4	3	2	1	0
0	OPERATION CODE (3Ch)							
1	MODE SPECIFIC				MODE			
2	BUFFER ID							
3	(MSB)			BUFFER OFFSET (000000h)				
5								(LSB)
6	(MSB)			ALLOCATION LENGTH (n)				
8								(LSB)
9	CONTROL							

See 3.3.8 for details of the READ BUFFER CDB fields. The recommended ALLOCATION LENGTH for the collection buffer is 2048 bytes, which is the size GEM/GEMLite uses for its command output buffer.

Table 42 – Read CLI Command Output READ BUFFER Data-In Format

Byte \ Bit	7	6	5	4	3	2	1	0
0	(MSB)			COMMAND OUTPUT LENGTH				
1								(LSB)
2	Reserved					AUTH VALID	AUTH	PENDING
3				COMMAND OUTPUT				
n								

COMMAND OUTPUT LENGTH reports the length in bytes of the data in the COMMAND OUTPUT field.

PENDING, when set to ‘1’, indicates that the CLI command has not yet completed and the initiator needs to follow-up with a further READ BUFFER request. When set ‘0’, the CLI command execution has completed and no further output needs to be collected.

AUTH, when set to ‘1’ indicates that the In-band CLI interface is authenticated, see 3.4.3.4. When set to ‘0’, the CLI is not authenticated. The AUTH bit is only applicable to targets implementing the In-band CLI v2 protocol and only reports a valid value when AUTH VALID is set to ‘1’.

AUTH VALID, when set to ‘1’, indicates that the AUTH bit contains valid data. AUTH VALID will be set to ‘0’ when the PENDING bit is set to ‘0’ for backwards compatibility reasons. When AUTH VALID is set to ‘0’ the value of the AUTH should not be used.

COMMAND OUTPUT contains an ASCII string with the CLI command output. The data in this buffer is not null-terminated.

3.4.3.4 Authentication Support

Some GEM/GEMLite targets implementing the In-band CLI v2 protocol support authentication, where a username and password must be supplied to invoke a CLI command. Not supplying the username and password to the target when issuing the command (or using a protocol version without authentication support) will result in the WRITE BUFFER request being rejected with a CHECK CONDITION status with ASC/ASCQ of INVALID FIELD IN PARAMETER LIST.

GEM/GEMLite targets advertise the presence of authentication by setting the AUTH bit in the In-band CLI READ BUFFER response to ‘1’. Clients may read this value without retrieving CLI command output by issuing a READ BUFFER request for the In-band CLI buffer (3.4.3.3) with the allocation length set to 3 bytes.

When issuing an authenticated CLI command, the client must provide a WRITE BUFFER request (3.4.3.1) using the CLI v2 protocol format containing the Username and Password header (3.4.3.2.1). If either the username or password are invalid, the WRITE BUFFER command will complete, however the READ BUFFER response will contain an “Authentication failed” message.