Solid State Drive Specification

Ultrastar SSD400S

2.5" **Serial Attached SCSI (SAS) Solid State Drive**

Models: HUSSL4040ASS600
HUSSL4020ASS600
HUSSL4010ASS600

Version: 2.0

21 September 2012

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1st Edition (Rev 2.0) (21 September 2012)

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1.0 General

1.1 Introduction

This document describes the specifications of the following HGST 2.5 inch SAS drives.

Table 1: Product ID table

Drive Name	Model Name	Type	Capacity (GB)	Interface
Ultrastar SSD400S-400	HUSSL4040ASS600	UCSSSR400	400	2.5" SAS
Ultrastar SSD400S-200	HUSSL4020ASS600	UCSSSR200	200	2.5" SAS
Ultrastar SSD400S-100	HUSSL4010ASS600	UCSSSR100	100	2.5" SAS

Note: The specifications in this document are subject to change without notice.
For technical and ordering information, please visit our website at http://www.HGST.com.

1.2 Glossary

Word	Meaning
BMS	Background Media Scan
Kb	Kilobit = 1000 bits
Mb	Megabit = 1,000,000 bits
GB	Gigabyte = 1,000,000,000 bytes
SSD	Solid State Drive
MB	Megabyte = 1,000,000 bytes
KB	Kilobyte = 1000 bytes
SAS	Serial Attached SCSI
SFF	Small Form Factor
SMART	Self-Monitoring and Reporting Technology

1.3 Caution

This drive can be damaged by ESD (Electric Static Discharge). Any damage incurred to the drive after its removal from the shipping package and the ESD protective bag are the responsibility of the user.

2 Outline of the Drive

- Storage capacities of 400GB, 200 GB, and 100 GB
- 1.5 Gbps, 3.0 Gbps and 6 Gbps SAS-2 interface
- Supports dual-ported operations
- Supports full duplex operations
- Variable sector size (512B, 520B, and 528B), production releases do not support 4096B
- Tagged Command Queuing support
- Automatic read/write data transfer
- Adaptive read ahead algorithm
- Write Cache via PLI protection.
- XOR Function
- ECC On The Fly correction
- Automatic defect reallocation
- Self diagnostics at power on
- Use of SLC NAND Flash.
- SMART
- ANSI T10 Protection Information (End-to-End)

3.0 Solid State Drive

3.1 Control Electronics

The drive is electronically controlled by a microprocessor, logic modules, digital/analog modules and various drivers and receivers. The control electronics perform the following major functions:

- Monitors incoming power to insure safe writes
- Provides temporary back-up power in the event of a power loss
- Maintains data integrity through CRC, ECC and Power Loss Imminent detection

4.0 Drive Characteristics

4.1 Formatted Capacity

Table 2: Formatted Capacity

Description	HUSSL4040ASS600	HUSSL4020ASS600	HUSSL4010ASS600
Label capacity	400 GB	200 GB	100 GB
Total data bytes (512 bytes/sector)	400,088,457,216	200,049,647,616	100,030,242,816
Total logical data blocks	781,422,768 (2E9390B0h)	390,721,968 (1749F1B0h)	195,371,568 (BA52230h)

4.2 Data Sheet

Table 3: Data Sheet

Host Interface Transfer Rate	1.5 Gbps, 3.0 Gbps or 6.0 Gbps
Flash Media	34nm Single Level Cell NAND
SDRAM size	512 MB

4.3 Inquiry Information

4.3.1 Product ID

Product ID in Section 16.5.1.1, “Inquiry Data Format - EVPD = 0, Page Code = 0” on page 66, is as follows:

Table 4: Product ID in Inquiry Command

Product ID	Description
HUSSL4040ASS600	400 GB, SAS
HUSSL4020ASS600	200 GB, SAS
HUSSL4010ASS600	100 GB, SAS

4.4 World Wide ID - Block Assignment

Block Assignment of World Wide ID is as follows:

Table 5: Block assignment of World Wide ID in INQUIRY Command

Manufacturing Site	Product	Block Assignment
China	**HUSSL4040ASS600**	001h(1)
	HUSSL4020ASS600	001h(1)
	HUSSL4010ASS600	001h(1)

Note (1) - Additional block assignment will be issued as needed based on actual production volume.

4.5 Performance characteristics

Drive performance is characterized by the following parameters:

- •Command overhead
- •Data transfer speed
- •Buffering operation (read ahead/write cache)

Note: All the above parameters contribute to drive performance. There are other parameters that contribute to the performance of the actual system. This specification tries to define the bare drive characteristics, not system throughput, which depends on the system and the application.

4.5.1 Drive ready time

Table 6: Drive ready time

Model	
400/200/100 (GB)	<10 seconds to Data Ops, <1 second to Interface Response

4.5.2 SSD Command Overhead

Table 7: SSD Command Overhead

Model	
400/200/100 (GB)	30 usec

4.5.3 SSD Response Time

Table 8: SSD Response time

Model	Typical (Sec)	Max (Sec)
400/200/100 (GB)	100 Micro Second	20 Milli Second

4.5.4 Data transfer speeds (Drive can sustain performance up to these values)

SSD400S	SLC SAS Single Port
Random Read IOPS	
4KB, 4K-aligned, QD=1	8K
4KB, 4K-aligned, QD=4	28K
4KB, 4K-aligned, QD=32	41K
8KB, 4K-aligned, QD=1	7K
8KB, 4K-aligned, QD=4	20K
8KB, 4K-aligned, QD=32	24K
Random Write IOPS	
4KB, 4K-aligned, QD=1	11K
4KB, 4K-aligned, QD=4	21K
4KB, 4K-aligned, QD=32	18K
8KB, 4K-aligned, QD=1	8K
8KB, 4K-aligned, QD=4	13K
8KB, 4K-aligned, QD=32	12K
Random 70/30% Read/Write IOPS	
4KB, 4K-aligned, QD=1	9K
4KB, 4K-aligned, QD=4	22K
4KB, 4K-aligned, QD-32	24K
8KB, 4K-aligned, QD=1	7K
8KB, 4K-aligned, QD=4	15K
8KB, 4K-aligned, QD=32	15K
Sequential Read Data Transfer Rate (MB/s)	
64KB, 4K-aligned, QD=8	500
Sequential Write Data Transfer Rate (MB/s)	
64KB, 4K-aligned, QD=8	450

Notes:

Drive performance varies with model capacity and actual drive use.
For this table, '1 MB / Sec' should be interpreted as ***1024X1024*** bytes per Second

4.5.5 Random writes over the life of the drive

Model	100 GB	200 GB	400GB
Worst Case (PB)	11	21.6	41.3

5.0 Data Integrity

The SSD employs a fail-safe write cache that insures customer data is committed to the media in the event of a power loss. This fail-safe write cache cannot be disabled. On a given write command, if all data has been received by the SSD and the RESPONSE frame has been sent to the Initiator with good status, it is guaranteed that all write data will be committed to the media in the event of a power loss. If the RESPONSE frame was not sent and some (or all) of the data was received by the SSD, some (or all) of the data may be committed to the media in the event of a power loss. In this case, it is guaranteed that all affected blocks will be readable without error, but not all blocks may return the newly written data.

5.1 Equipment Status

Equipment status is available to the host system any time the drive is not ready to READ or WRITE. This status normally exists at power-on time and will be maintained until the following conditions are satisfied:

- Self-check of drive is complete

Appropriate error status is made available to the host system if any of the following conditions occur after the drive has become ready:

- SMART error is detected

5.2 Error Recovery Procedure

Errors occurring with the drive are handled by the error recovery procedure.

Errors that are uncorrectable after application of the error recovery procedures are reported to the host system as non-recoverable errors.

6.0 Electrical Interface

6.1 SAS Connector

The drive uses the standard 29 pin Serial Attached SCSI (SAS) connector which conforms to the mechanical requirements of SFF 8482. The connector is expected to be used in an environment which uses a common connector structure for racking drives in a cabinet. The connector allows for plugging a drive directly into a backplane by providing the necessary electrical connection. Mechanical stability and device retention must be provided by a mechanism outside the drive.

6.1.1 29 pin Serial Attached SCSI (SAS) Connector Definition

Diagram of top and bottom of connector showing pinouts.

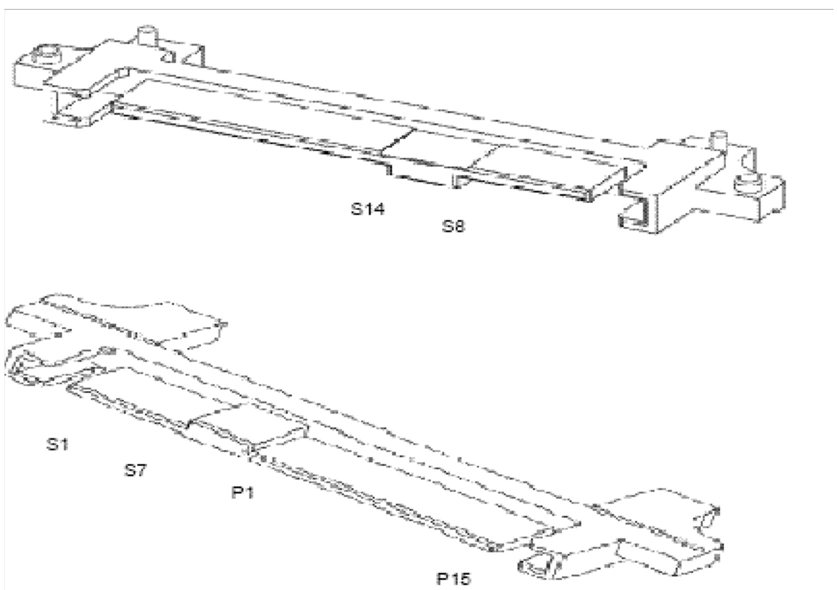


Table 9: 29-pin Connector Signal Definition

Pin Number	Signal	Description
S1	GND	GND for SAS Primary Port
S2	RP+	SAS Primary Port Receive (positive) signal
S3	RP-	SAS Primary Port Receive (negative) signal
S4	GND	GND for SAS Primary Port
S5	TP-	SAS Primary Port Transmit(negative) signal
S6	TP+	SAS Primary Port Transmit(positive) signal
S7	GND	GND for SAS Primary Port
S8	GND	GND for SAS Secondary Port
S9	RS+	SAS Secondary Port Receive(Positive) signal
S10	RS-	SAS Secondary Port Receive (negative) signal
S11	GND	GND for SAS Secondary Port
S12	TS-	SAS Secondary Port Receive (negative) signal
S13	TS+	SAS Secondary Port Receive (positive) signal
S14	GND	GND for SAS Secondary Port
P1	+3.3V	NOT USED (Pins P1-P3 tied internally)
P2	+3.3V	NOT USED (Pins P1-P3 tied internally)
P3	+3.3V	NOT USED (Pins P1-P3 tied internally)
P4	GND	GROUND
P5	GND	GROUND
P6	GND	GROUND
P7	+5V-Charge	Pre-charge pin for +5V
P8	+5V	+5V power supply input
P9	+5V	+5V power supply input
P10	GND	GROUND
P11	READY LED	READY LED output

Pin Number	Signal	Description
P12	GND	GROUND
P13	+12V=Charge	Pre-charge pin for +12V
P14	+12V	+12V power supply input
P15	+12V	+12V power supply input

6.1.2 Voltage and Ground Signals

The 12V and 5V contacts provide all of the voltages required by the drive. The two voltages share a common ground plane to which all of the ground contacts are connected.

6.1.3 Ready LED output

The drive provides an open-drain driver with 15mA of current sink capability to the Ready LED Output signal. The cathode of the LED should be connected to this signal. The LED and the current-limiting resistor must be provided by the enclosure.

7.0 Environment

7.1 Temperature and humidity

Table 10: Operating and non-operating conditions

Operating conditions	
Ambient Temperature	0°C to 60ºC
Relative humidity	5 to 90%, non-condensing
Maximum wet bulb temperature	29.4ºC, non-condensing
Maximum surface temperature gradient	20 ºC/hour
Altitude	-305 to 3,048 m
Shipping conditions	
Ambient Temperature	-55°C to 95ºC
Relative humidity	5 to 95%, non-condensing
Maximum wet bulb temperature	35ºC, non-condensing
Maximum surface temperature gradient	30ºC/hour
Altitude	-305 to 12,192 m
Storage conditions	
Ambient Temperature	0°C to 60ºC
Relative humidity	5 to 95%, non-condensing
Maximum wet bulb temperature	35ºC, non-condensing
Altitude	-305 to 12,192 m

7.2 Storage requirements

7.2.1 Packaging

The drive or option kit is shipped in a sealed ESD bag by HGST.

7.2.2 Storage time

Cumulative storage time in the package must not exceed one year.

After the drive is unpackaged, it must not remain inoperative for longer than six months.

7.3 Corrosion test

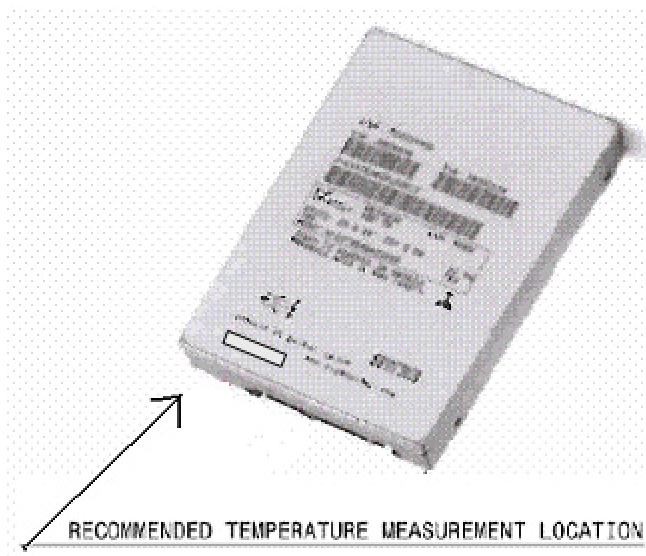
The SSD shows no signs of corrosion inside or outside of the drive assembly and remains functional after being exposed to a temperature of 50ºC and relative humidity of 90% for seven days.

7.4 Cooling requirements

Drive component temperatures must remain within the limits specified in the following table. Maximum component temperature ratings must not be exceeded under any operating condition. The drive may require forced air cooling to meet the specified, maximum operating temperatures.

Table 11: Maximum allowable surface temperatures

Module name	Location	Maximum allowable surface temperature
SDD base	as noted in picture	70ºC



8.0 DC Power Requirements

The following voltage specification applies at the drive power connector. Connections to the drive should be made in a safety extra low voltage (SELV) circuit. There is no power on or power off sequencing requirement.

Adequate secondary over-current protection is the responsibility of the system.

Table 12: Input Voltage and Capacitance

Supply	Tolerance	Absolute Max Spike Voltage	Supply Rise Time	Capacitance
5 V	+/- 5%	5.5 V	0-200 ms	47 uF
12 V	+/- 5%	15 V	0-400 ms	47 uF

8.1 Power Supply Current, Average and Peak

The following current and power requirements are typical when operating under the following conditions: Nominal 5 and 12V.

SAS 100G	12V (A)	5V (A)	Power (W)	IOPS/MBPS
no power before test (Mean)	0.000	0.000	0.00	NA
no power before test (Max)	0.069	0.058		
Idle (mean)	0.032	0.230	1.54	NA
Idle (max)	0.142	0.345		
standby (mean)	0.033	0.232	1.55	NA
standby (max)	0.147	0.318		
				NA
start up (max)	0.694	0.704		
4k QD32 ranrw 70/30 (mean)	0.064	0.356	2.54	26064
4k QD32 ranrw 70/30 (max)	0.309	0.689		
seqw (64K QD32) (mean)	0.173	0.392	4.03	422
seqw (64K QD32) (max)	0.360	0.756		
seqr (64K QD32) (mean)	0.073	0.378	2.77	483
seqr (64K QD32) (max)	0.209	0.782		

SAS 200G	12V (A)	5V (A)	Power (W)	IOPS/MBPS
no power before test (Mean)	0.000	0.000	0.00	NA
no power before test (Max)	0.066	0.066		
Idle (mean)	0.032	0.232	1.54	NA
Idle (max)	0.139	0.311		
standby (mean)	0.030	0.231	1.52	NA
standby (max)	0.140	0.308		
				NA
start up (max)	0.731	0.876		
4k QD32 ranrw 70/30 (mean)	0.061	0.386	2.66	25181
4k QD32 ranrw 70/30 (max)	0.338	0.689		
seqw (64K QD32) (mean)	0.165	0.460	4.28	393
seqw (64K QD32) (max)	0.437	0.985		
seqr (64K QD32) (mean)	0.072	0.433	3.03	475
seqr (64K QD32) (max)	0.213	0.861		

SAS 400G	12V (A)	5V (A)	Power (W)	IOPS/MBPS
no power before test (Mean)	0.000	0.000	0.00	NA
no power before test (Max)	0.053	0.051		
Idle (mean)	0.036	0.221	1.54	NA
Idle (max)	0.130	0.308		
standby (mean)	0.036	0.220	1.54	NA
standby (max)	0.126	0.293		
				NA
start up (max)	0.902	0.907		
4k QD32 ranrw 70/30 (mean)	0.072	0.384	2.78	22830
4k QD32 ranrw 70/30 (max)	0.381	0.689		
seqw (64K QD32) (mean)	0.201	0.519	5.00	455
seqw (64K QD32) (max)	0.459	1.058		
seqr (64K QD32) (mean)	0.090	0.465	3.40	513
seqr (64K QD32) (max)	0.225	0.913		

8.2 Ripple Voltage

Table 13: Power Supply Generated Ripple at Drive Power Connector

	Maximum (mV pp)	MHz
+5 V DC	250	0-10
+12 V DC	250	0-10

During drive start up, 12 volt ripple is generated by the drive (referred to as dynamic loading). If the power of several drives is daisy chained, the power supply ripple plus other drive dynamic loading must remain within the regulation tolerance of +5%. A common supply with separate power leads to each drive is a more desirable method of power distribution.

To prevent external electrical noise from interfering with the drive's performance, the drive must be held by four screws in a user system frame that has no electrical level difference at the four screw positions. The drive enclosure must not be used in the current return path of the drive power supply. The maximum common-mode noise current passing through the drive must not exceed 20 mA.

8.3 Power Consumption Efficiency Index

Table 14: Power Consumption Efficiency Index

Model	400 GB Model	200 GB Model	100 GB Model
Power Consumption Efficiency Index -Idle Mode (W/GB)	0.00385	0.0077	0.0154

9.0 Reliability

9.1 Data Reliability

- 22 bit correction per sector
- Offline full sector recovery through XOR for every N sectors (100G, N = 68: 200G, N = 136: 400G, N = 134)
- LBA seeded 32 bit CRC for ECC miscorrect detection
- Probability of uncorrectable data error is 1 in 1x10^16 bits read

9.2 Failure prediction (S.M.A.R.T)

A recoverable equipment error is an error other than a read error that is detected and corrected by the drive error recovery procedure. Examples are *Drive Not Ready* and internal drive errors.

SMART Monitoring Parameters are checked predict drive failure conditions before they occur. The primary parameters monitored for the SSD include:

1. Remaining Reserves: Ensures that the remaining spare erase blocks are at a sufficient level to guarantee proper operation of device.
2. Volatile Memory Backup: Self tests measure the capacitance of the power loss imminent circuitry to guarantee drive is able to commit data to media during unsafe power loss operations.
3. Wear Indicator: Endurance tracking mechanism based on maximum number of NAND erase operations performed on any band over the life of the device.

See “Log Sense Page 2F” on page 108 for tracking percentage of failure threshold for these parameters.

Non-recoverable equipment errors indicate a defective drive.

9.3 MTBF (Mean Time Between Failure): 2M hours.

This MTBF target is based on a sample population and is estimated by statistical measurements and acceleration algorithms under nominal operating conditions. MTBF ratings are not intended to predict an individual drive’s reliability. MTBF does not constitute a warranty.

9.4 Preventive Maintenance

None.

9.5 Temperature Warning

Temperature Warning is enabled by setting the EWASC (Enable Warning Additional Sense Code) bit to 1 and setting DEXCPT (Disable Exception Control) bit to 0 in Mode Page 1C. For mode page settings, refer to Section “Mode Page 1C (Informational Exceptions Control)” on page 140. The warning is issued as sense data (Sense Key 01h, Code 0Bh, Qual 01h).

The drive temperature is reported in Log Sense page 2F. Refer to Section “Log Sense Page 2F” on page 108.

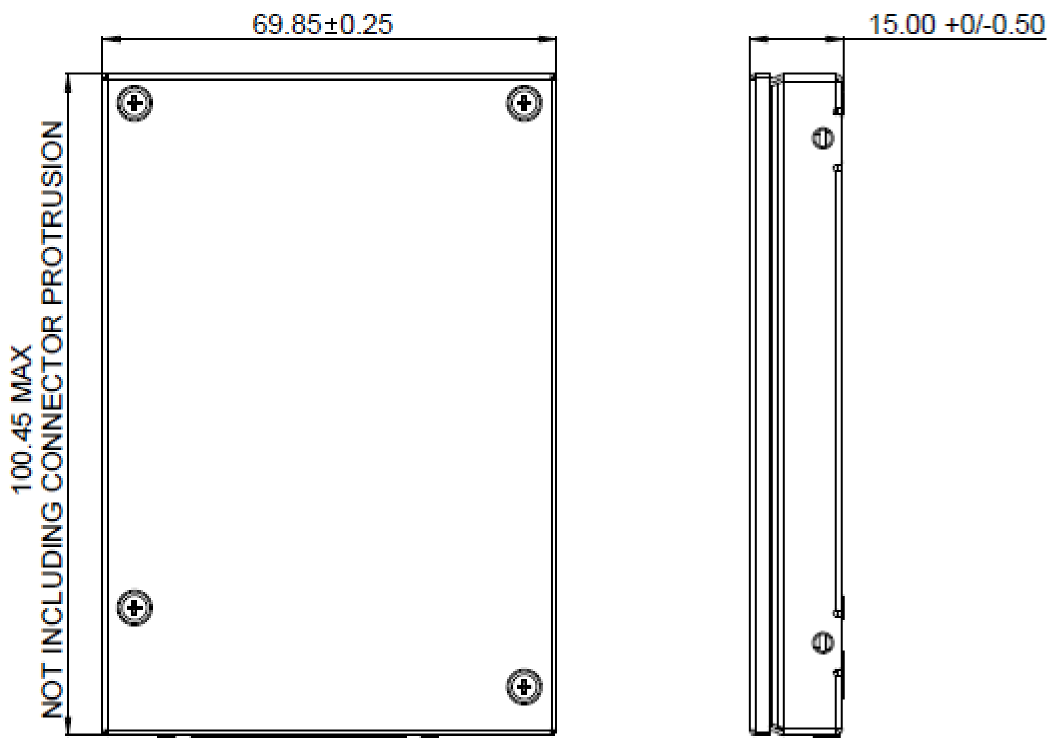
10.0 Mechanical Specifications

10.1 Outline

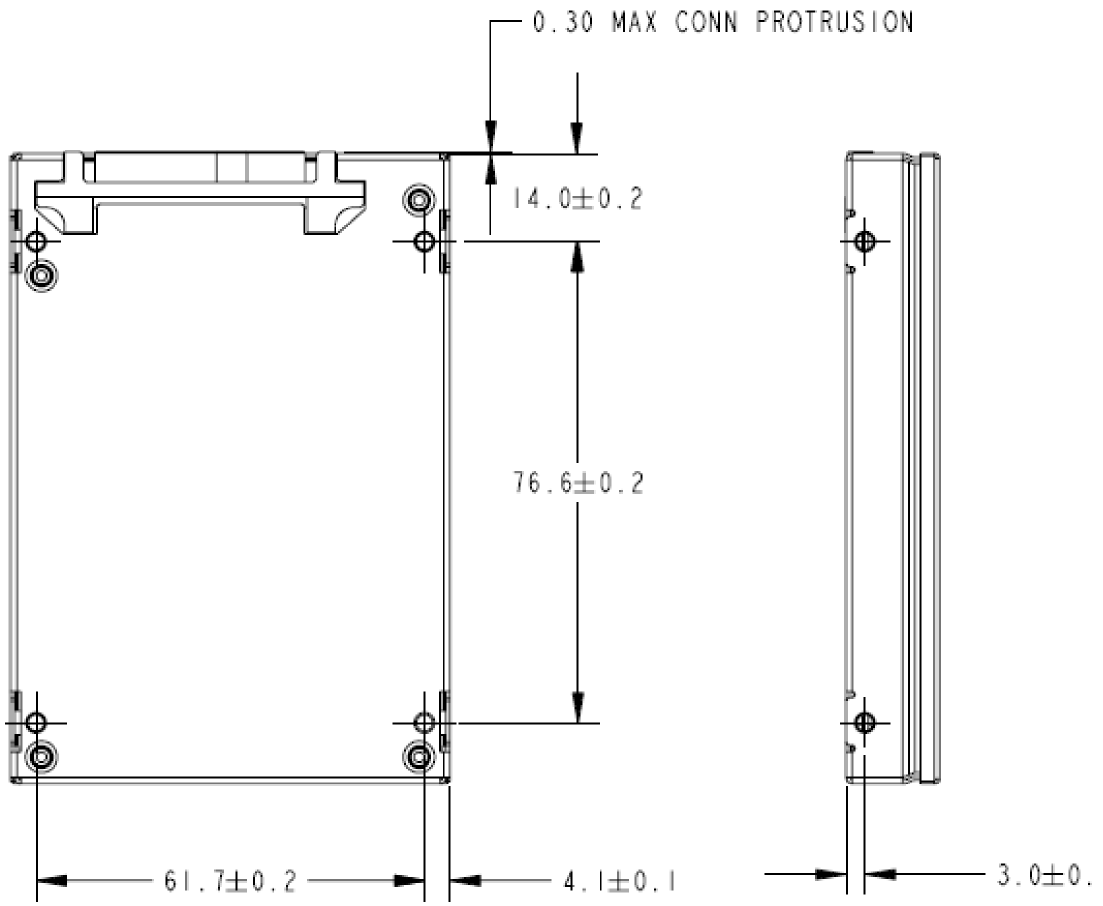
10.2 Mechanical Dimensions

Table 15: <XREF>Physical Dimensions

Height [mm]	15.00 +0.00 / -0.50
Width [mm]	69.85 ± 0.25
Length (base) [mm]	100.30 ± 0.15
Length (including connector) [mm]	100.60 ± 0.7
Weight [grams - maximum]	400 GB Model 166 grams 200 GB Model 159 grams 100 GB Model 128 grams

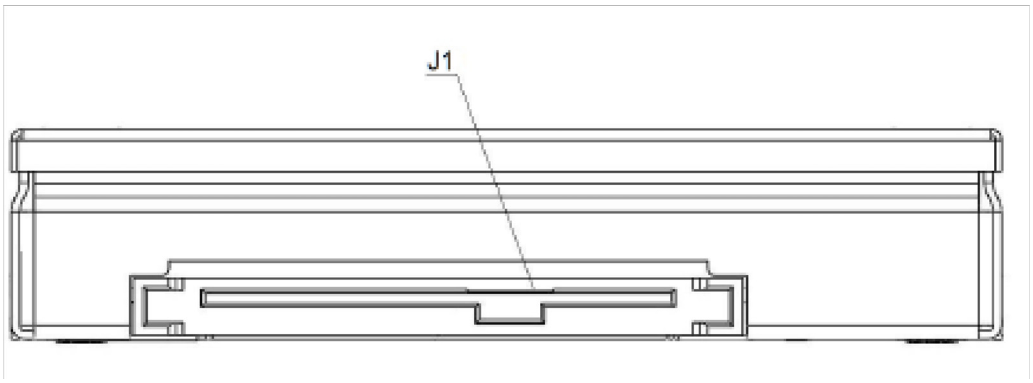

69.85±0.25
15.00 +0/-0.50
100.45 MAX
NOT INCLUDING CONNECTOR PROTRUSION

10.3 Mounting Positions and Tappings



10.4 Interface Connector

The interface conforms to the specification SFF-8223, 2.5 Drive Form Factor with Serial Connector.



10.5 Drive Mounting

The drive will operate in all axes (6 directions). Performance and error rate will stay within specification limits if the drive is operated in the other orientations from which it was formatted.

The recommended mounting screw torque is 0.45 Nm (4.5 Kgf-cm). The recommended mounting screw depth is 2.5 mm maximum for bottom and 3.0 mm maximum for horizontal mounting.

Drive level vibration tests and shock tests are to be conducted with the drive mounted to a table using the bottom four screws.

11.0 Acoustics, Vibration and Shock

11.1 Acoustics

All SSD models have no acoustics, (0 bels).

11.2 Operating Vibration

11.2.1 Random Vibration

The drive is designed to operate without unrecoverable errors while being subjected to the vibration levels as defined below.

The assessments are carried out during 30 minutes of random vibration using the power spectral density (PSD) levels as follows.

No Errors: 2.17 G RMS, 5-700 Hz, flat PSD profile for each of the three mutually perpendicular axes.

Note: The specified levels are measured at the mounting points.

11.2.2 Swept Sine Vibration

The drive will meet the criterion while operating in the respective conditions as described below.

No errors: 2.17 G RMS, 5-700 Hz.

11.3 Non-operating Vibrations

The drive will not sustain permanent damage or loss of recorded data after being subjected to the environments as described below.

11.3.1 Random Vibration

The test consists of a random vibration applied for each of the three mutually perpendicular axes. A time duration of ten minutes per axis.

3.13 G RMS, 5-800 Hz, flat PSD profile.

11.3.2 Swept Sine Vibration

The test consists of a swept sine vibration applied for each of the three mutually perpendicular axes.

3.13 G RMS, 10-800 Hz

11.4 Operating shock

The drive will meet the criterion while operating in the respective conditions as described below.

No data loss: 1000G, @0.5 ms duration, half sinewave shock pulse

500G, @ 2 ms duration, half sinewave shock pulse

The shock pulses of each level are applied to the drive, ten pulses for each direction and for all three mutually perpendicular axes. There must be a minimum of thirty seconds delay between shock pulses. The input level is applied to a base plate where the drive is attached using four mounting screws.

11.5 Non-operating shock

The drive will not sustain permanent damage or loss of recorded data after being subjected to the environments as described below.

11.5.1 Half sinewave shock pulse

100 G, 11 ms duration, half sinewave pulse

500 G, 2 ms duration, half sine wave pulse

1000 G, 0.5 ms duration, half sinewave pulse

The shocks are applied in each direction of the drive for the three mutually perpendicular axes, one axis at a time. The input level is applied to a base plate where the drive is attached using four mounting screws.

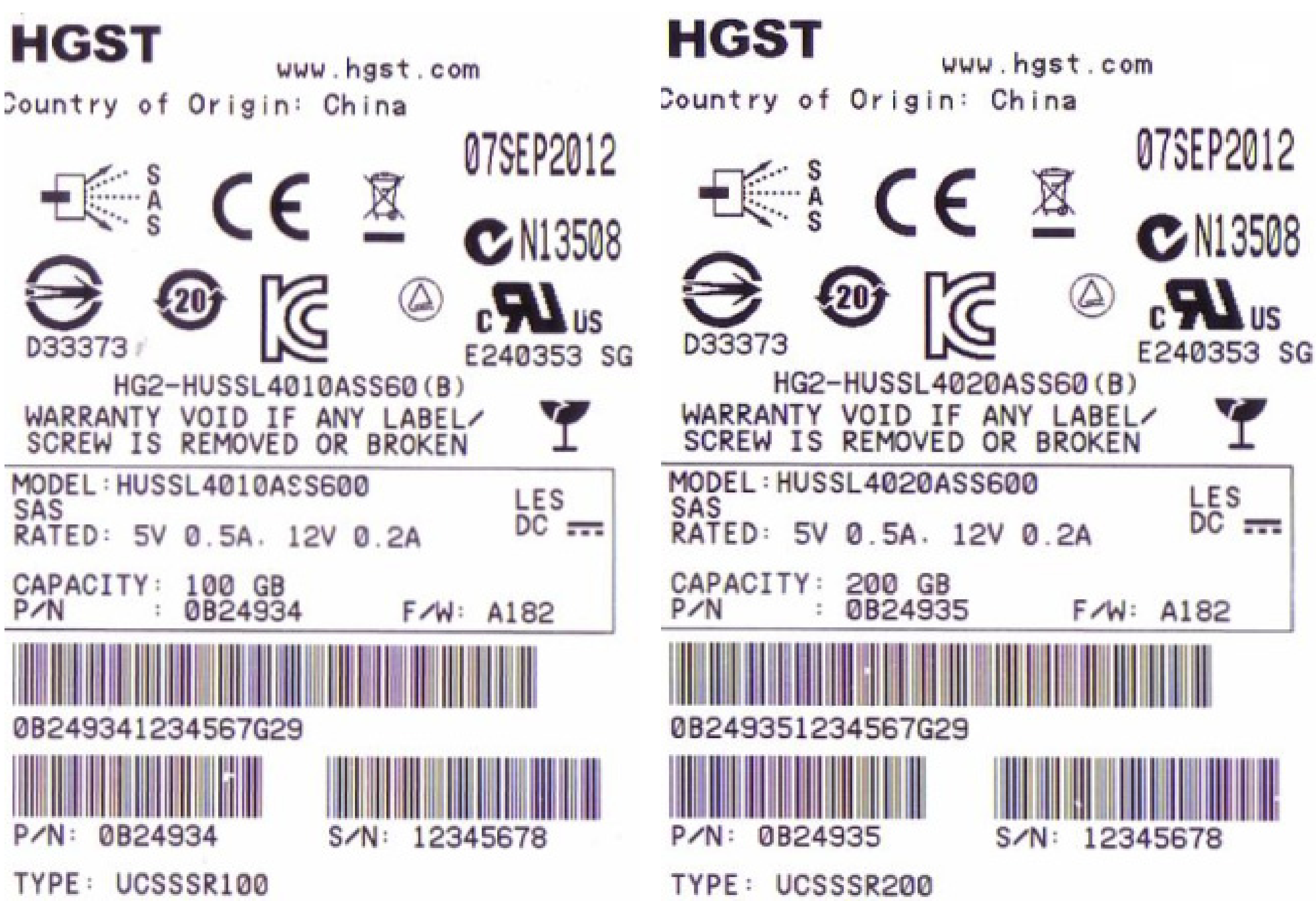
12.0 Identification

12.1 Labels

The following labels are affixed to every drive shipped from the drive manufacturing location in accordance with appropriate drive assembly drawing:

- A label containing HGST, a Western Digital Company logo, HGST part number and the statement “Made by HGST,” or HGST approved equivalent.
- A label containing drive model number, manufacturing date, formatted capacity, country of origin or HGST approved equivalent and UL, C-UL, TUV, CE, MIC, BSMI,CTICK, RoHS and Recycle logos.
- A bar code label containing the drive serial number.
- A user designed label, per agreement
- Interface definition mark, SAS-2 Model

The labels may be integrated with other labels.

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SCREW IS REMOVED OR BROKEN
MODEL:HUSSL4040ASS600
SAS
RATED: 5V 0.5A. 12V 0.2A
LES
DC
CAPACITY: 400 GB
P/N : 0B24936
F/W: A182
0B249361234567G29
P/N: 0B24936
S/N: 12345678
TYPE: UCSSSR400

13.0 Electromagnetic Compatibility

The drive, when installed in a suitable enclosure and exercised with a random accessing routine at a maximum data rate will comply with the worldwide EMC requirements listed below.
The drive is designed for system integration and installation into a suitable enclosure for use. As such, the drive is supplied as a subassembly and is not subject to Subpart B of Part 15 of the FCC Rules and Regulations.

The design of the drive serves to minimize radiated emissions when installed in an enclosure that provides reasonable shielding. As such, the drive is capable of meeting FCC Class B limits. However, it is the users responsibility to assure that the drive meets the appropriate EMC requirements in their system. Shielded I/O cables may be required if the enclosure does not provide adequate shielding, with the shields grounded to the enclosure and to the host computer.

Radiated and Conducted EMI

CISPR22	Class B
AS/NZS CISPR22	Class B
CNS13438 (Taiwan)	Class B
EN55022 (EU)	Class B
FCC Title47 Part 15 (USA)	Class B
GB9254 (China)	Class B
ICES-003, Issue 4	Class B
VCCI (Japan)	Class B

ITE Immunity

EN55024

Power Line Harmonics

EN61000-3-2 (EU)

GB17625.1 (China)

Voltage Fluctuations and Flicker

EN61000-3-3 (EU)

GB17625.2 (China)

13.1 Class B Regulatory Notices

European Union

This product is in conformity with the protection requirements of EU Council Directive 2004/108/EC on the approximation of the laws of the Member States relating to electromagnetic compatibility. Conformity is based on compliance to the following harmonized standards:

- EN 55022: 2006 + A1:2007 (Class B)
- EN 55024: 1998 +A1:2001 +A2:2003
- EN 61000-3-2: 2006
- EN 61000-3-3:1995 + Al:2001 + A2:2005

This product is also in conformity with the protection requirements of EU Council Directive 2006/95/EC on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits. Conformity is based on compliance to the following harmonized standards:

- EN 60950-1:2006 with Am. 11, Second Edition

- IEC 60950-1:2005, Second Edition
- UL 60950-1, Second Edition, 2007-03-27
- CSA C22.2 No. 60950-1-07, Second Edition, 2007-03

HGST cannot accept responsibility for any failure to satisfy the protection requirements resulting from a non-recommended modification of the product, including the fitting of non-HGST option cards.
This product has been tested and found to comply with the limits for Class B Information Technology Equipment according to European Standard EN 55022. The limits for Class B equipment were derived for typical residential environments to provide reasonable protection against interference with licensed communication devices.

Canada
This Class B digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

Germany
Deutschsprachiger EU Hinweis:
Hinweis für Geräte der Klasse B EU-Richtlinie zur Elektromagnetischen Verträglichkeit Dieses Produkt entspricht den Schutzanforderungen der EU-Richtlinie 89/336/EWG zur Angleichung der Rechtsvorschriften über die elektromagnetische Verträglichkeit in den EU-Mitgliedsstaaten. und hält die Grenzwerte der EN 55022 Klasse B ein. Um dieses sicherzustellen, sind die Geräte wie in den Handbüchern beschrieben zu installieren und zu betreiben. Des Weiteren dürfen auch nur von der HGST empfohlene Kabel angeschlossen werden. HGST übernimmt keine Verantwortung für die Einhaltung der Schutzanforderungen, wenn das Produkt ohne Zustimmung der HGST verändert bzw. wenn Erweiterungskomponenten von Fremdherstellern ohne Empfehlung der HGST gesteckt/eingebaut werden.

Deutschland: Einhaltung des Gesetzes über die elektromagnetische Verträglichkeit von Geräten
Dieses Produkt entspricht dem "Gesetz über die elektromagnetische Verträglichkeit von Geräten (EMVG)". Dies ist die Umsetzung der EU-Richtlinie 89/336/EWG in der Bundesrepublik Deutschland.
Zulassungsbescheinigung laut dem Deutschen Gesetz über die elektromagneti-sche Verträglichkeit von Geräten (EMVG) vom 18. September 1998 (bzw. der EMC EG Richtlinie 89/336) für Geräte der Klasse B Dieses Gerät ist berechtigt, in Übereinstimmung mit dem Deutschen EMVG das EG-Konformitätszeichen - CE - zu führen. Verantwortlich für die Konformitätserklärung nach Paragraf 5 des EMVG ist die HGST, a Western Digital Company, 3403 Yerba Buena Road
San Jose, CA 95135. Informational in Hinsicht EMVG Paragraf 4 Abs. (1) 4:
Das Gerät erfüllt die Schutzanforderungen nach EN 55024 und EN 55022 Klasse B.

Korea (MIC)

이 기기는 가정용으로 전자파적합등록을 한 기기로서 주거 지역에서는 물론 모든 지역에서 사용할 수 있습니다.

Taiwan (BSMI)

新加坡商日立環球儲存科技股份有限公司台灣分公司
台北市敦化北路 167 號 5 樓 (宏國大樓)

14.0 Standards

The following shows the safety standards for different countries.

14.1 UL and C-UL Standard Conformity

The drive is certified under the following safety standards for use in Information Technology Equipment, including Electrical Business Equipment:
EN 60950-1:2006 with Am. 11, Second Edition, Europe
IEC 60950-1:2005, Second Edition, International
UL 60950-1, Second Edition, 2007-03-27, USA
CSA C22.2 No. 60950-1-07, Second Edition, 2007-03, Canada

The UL recognition, or the C-UL certification, is maintained for the duration of the product manufacturing life cycle. The UL and C-UL recognition marks appear on the drive label.

14.2 European Standards Compliance

This product is certified to the EN 60950-1:2006 with Am. 11, Second Edition safety standard for Europe.

14.3 German Safety Mark

The product is certified by TUV to meet EN 60950-1:2006 with Am. 11, Second Edition safety standard under the Bauart Mark.

14.4 Flammability

The printed wiring boards, and connectors used in this drive meet or exceed the UL minimum flammability classifications listed in the table below.

The flammability ratings are marked on the printed wiring boards and flex cables.

Component	**Flammability Rating**
Rigid Printed Wiring Board	**Min. V-1**
2.5" SAS Connector	**Min. V-2**

15.0 SAS Attachment

This section defines some basic terminology and describes the behavior of the drive when attached to a ***S***erial ***A***ttached ***S***csi (i.e. SAS) domain.

15.1 General

This section introduces some of the terminology that is used in describing ***S***erial ***A***ttached ***S***CSI (i.e. SAS).

SAS is logically a bi-directional, point to point serial data channel that leverages the SCSI protocol set. Nodes are physically connected via a Port.

Ports may be connected point-to-point via SAS expanders, to form a complex switching network, referred to as a SAS domain.

SAS is defined in terms of a hierarchy of functions or 'protocol layers'. This discussion will focus in on the aspects of SAS that are relevant to this product.

- SCSI Application Layer - Clause 10
- SSP Transport Layer (***S***erial ***S***CSI ***P***rotocol) - Clause 9
- SAS Port Layer - Clause 8
- SSP Link Layer - Clause 7
- SAS PHY Layer - Clause 6
- SAS Physical Layer - Clause 5

All layers are defined in the following ANSI standard.

- "Serial Attached SCSI - 2 (SAS-2)"

In addition, this drive claims compliance with the following ANSI standards.

- SCSI Architecture Model (SAM-3)
- SCSI Block Commands (SBC2)

15.2 SAS Features

The following SAS features are supported by the Drive.

- SAS Compliance
  - "Serial Attached SCSI - 2 (SAS-2)"
- SAS Protocol
  - This drive supports ***S***erial ***S***csi ***P***rotocol (SSP).
  - STP (Tunneled SATA) and SMP (Management protocol) protocols are NOT supported.
- SAS Dual Ported Operation
  - single PHY ports (i.e. Narrow port. Wide Port NOT supported)
  - ports function independently with separate firmware controls
  - Multiple DMA engines capable of accessing either port
  - full duplex and dual port DMA data/data operations
  - Maximum outstanding credit of *four* per port

• Physical Link Rates
 - G1 (1.5 Gbps), G2 (3.0 Gbps), and G3 (6.0 Gbps) supported
 - Largely Automated OOB and speed negotiation sequences
 - Optional Support for the hot-plug timeout in hardware

• Partial support for Disconnect/Reconnect Mode Page (0x02)
 - Maximum Connect Time Limit - *SUPPORTED*
 - Bus Inactivity Time Limit - *NOT SUPPORTED*
 - Maximum Burst Size - SUPPORTED
 - First Burst Size - *NOT SUPPORTED*

•Others...
 - Connection Rate Matching
 - Hard Reset primitive sequence detection and validation in hardware
 - Support for NOTIFY (Enable Spin-up) and NOTIFY (Power Loss Expected)
 - Hashed WWN validation in hardware
 - extended CDB support

15.3 SAS Names and Identifiers

In SAS, device and port names are worldwide unique names within a transport protocol. Port identifiers are the values by which ports are identified within a domain, and are used as SAS addresses. Phy identifiers are unique within a device.

Table 16: Names and identifiers

Object	SAS Implementation
Port Identifier	SAS address
Port Name	Not defined
Device Name	SAS address
Phy Identifier	Phy identifier

Where the SAS Address format is defined by ANSI as follows:

<table>
<tr><th>Byte/Bit</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="4">NAA (5h)</td><td colspan="4">(MSB)</td></tr>
<tr><td>1</td><td colspan="8">IEEE Company ID</td></tr>
<tr><td>2</td><td colspan="8"></td></tr>
<tr><td>3</td><td colspan="4">(LSB)</td><td colspan="4">(MSB)</td></tr>
<tr><td>4</td><td colspan="8"></td></tr>
<tr><td>5</td><td colspan="8"></td></tr>
<tr><td>6</td><td colspan="8">Vendor Specific Identifier</td></tr>
<tr><td>7</td><td colspan="8">(LSB)</td></tr>
</table>

The SAS Device Name is a unique SAS address world wide name. This device name is reported through the SCSI Vital Products Data.

Each of the two SAS ports also has a unique SAS address world wide name. These port identifiers are reported in the IDENTIFY Address frame and are used as source and destination addresses in the OPEN address frame. They are also reported through the SCSI Vital Products Data.

Since this drive is one device with two ports it has three SAS addresses. All SAS Addresses are in 64-bit IEEE Registered Name format, as illustrated in Table 17.

Table 17: IEEE Registered Name format

Bit				
63-60	**59-36**	**35-24**	**23-2**	**1-0**
0101	**OUI in Canonical Form**	**Block Assignment**	**S/N**	**Object**

The Name Address Authority field (5h) specifies the format used for the rest of the name as follows:

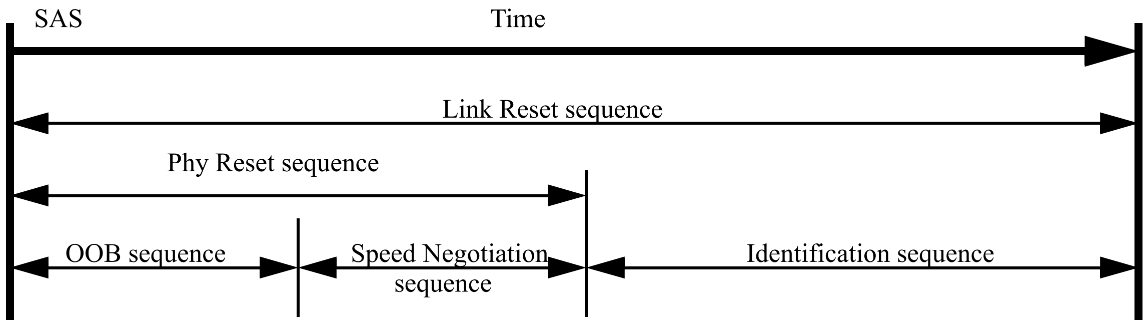
Field	Description
OUI	Organizationally Unique Identifier (24 bits). Canonical form means that each byte is stored in “bit reversed” order.
Block Assignment	Block assignment within HGST, a Western Digital Company
Object	Device Name/Port Identifier 00b Device 01b Port 1 10b Port 2 11b Not assigned
S/N	Sequentially increasing drive serial number assigned at manufacturing.

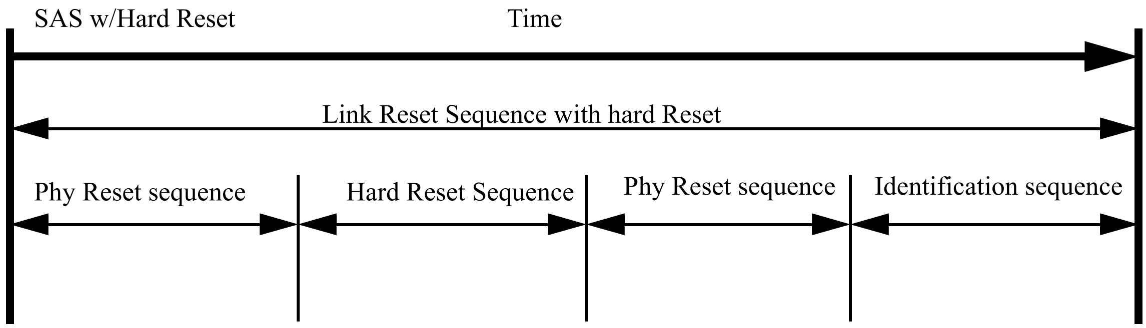
15.4 PHY Layer

The Phy layer defines 8b10b coding and OOB signals. The Phy layer is the interface between the link layer and the physical layer. This section describes Phy Layer behaviors of the Drive. For a complete description of SAS Phy Layer, please see the ANSI specification, SAS 1.1.

15.4.1 Link Reset Sequence

The Link Reset Sequences for SAS are defined in the SAS 2 2ANSI specification and shown below. As show in the diagram, a Phy Reset sequence, consists of an OOB sequence, followed by speed negotiations. Link Reset Sequences will always include a PHY Reset Sequence, followed by an Identification Sequence. Inclusion of a Hard reset sequence is optional. If Hard Reset is performed, it will be preceded by a Phy Reset sequence, and will be followed by Phy Reset/Identification sequences.





15.4.2 Hard Reset

A Hard Reset sequence on a port will not affect the other port, but the outstanding commands on the other port will be aborted due to the LUN reset associated with the Hard Reset. The effect of a Hard Reset will be similar to a Power on Reset, and will result in the re-initialization of all Drive resources. The first command issued from every initiator on the port that received the Hard Reset will result in a CHECK CONDITION with a sense key of UNIT ATTENTION and an additional sense code of SCSI BUS RESET OCCURRED. The first command issued from every initiator on the other port will result in a CHECK CONDITION and an additional sense code of BUS DEVICE RESET OCCURRED.

A Hard Reset Sequence will never be issued by the Drive. A link reset will be initiated by the drive on the affected port upon completion of Hard Reset processing.

15.4.3 SAS OOB (Out of Band)

Out of band (OOB) signals are low-speed signal patterns detected by the Phy that do not appear in normal data streams. They consist of defined amounts of idle time followed by defined amounts of burst time. During the idle time, D.C. idle is transmitted. During the burst time, ALIGN (0) primitives are transmitted repeatedly. The signals are differentiated by the length of idle time between the burst times.

As a SAS compliant device, the Drive uses three OOB signals: COMINIT/COMRESET and COMWAKE and COMSAS.OOB operations are beyond the scope of this specification. Please refer to the ANSI SAS 2 specification for more details.

The drive will initiate OOB by sending COMINITs, under the following conditions:

- POR
- loss of sync
- Identify timeout

15.4.4 SAS Speed Negotiation

The Drive supports G1 (1.5 Gbps), G2 (3.0 Gbps), and G3 (6.0 Gbps) negotiation speeds. The default maximum negotiation rate is G3 speed (per byte 32 in the Phy Control and Discover Mode Page 19 subpage 1). Drive is SAS2 device and supports SNW-1, SNW-2, SNW-3 speed negotiation with Phy capabilities exchange, and training (Train-SNW). Phy capabilities is defined in table below:

Phy Capabilities:

Byte /Bit	7	6	5	4	3	2	1	0
0	Start=1b	TX SSC Type = 0b	Reserved		Requested Logical Link Rate = 0h			
1	G1 Without SSC=1b	G1 With SSC=1b	G2 Without SSC=1b	G2 With SSC=1b	G3 Without SSC=1b	G3 With SSC=1b	Reserved	
2	Reserved							
3	Reserved							Parity

- Start bit is 1 to indicate the beginning of the Phy capabilities
- TX SSC Type bit is set to 1 to indicate that Phy's transmitter uses center-spreading SSC when SSC is enabled. A TX SSC TYPE bit set to 0 indicates that Phy's transmitter uses down-spreading SSC when SSC is enabled.
- Request Logical Link Rate field is 0 to indicate that drive does not support multiplexing
- G1 Without SSC bit set to 1 indicates that drive supports G1(1.5 Gbps) without SSC
- G2 Without SSC bit set to 1 indicates that drive supports G2(3.0 Gbps) without SSC
- G3 Without SSC bit set to 1 indicates that drive supports G3(6.0 Gbps) without SSC
- G1 With SSC bit set to 1 indicates that drive supports G1(1.5 Gbps) with SSC
- G2 With SSC bit set to 1 indicates that drive supports G2(3.0 Gbps) with SSC
- G3 With SSC bit set to 1 indicates that drive supports G3(6.0 Gbps) with SSC
- Parity bit is set to 1 for even parity of the total number of SNW-3 phy capabilities, including Start bit.

Training is based on the highest untried commonly supported settings on the exchanged SNW-3 supported settings bits. If a Train-SNW is invalid and there are additional, untried, commonly supported settings exchanged during SNW-3, then a new Train-SNW will be performed based on the next highest untried, commonly supported settings. Table 18 defines the priority of the supported settings bits.

Table 18: Supported Settings Bit Priorities

Priority	Bit
Highest	G3 With SSC bit
...	G3 Without SSC bit
...	G2 With SSC bit
...	G2 Without SSC bit
...	G1 With SSC bit
Lowest	G3 Without SSC bit

15.4.5 PHY Error Handling

This section defines the PHY layer error handling of the drive.

Error	Error Handling Procedure
Link Reset	After POR or Hard Reset, the drive initiates link reset by transmitting exactly 1 COMINIT. For other resets, the drive does not initiate Link Reset.
COMINIT Timeout	If COMINIT or COMSAS is not received before the “Hot Plug Timeout” period expires, the drive continues to transmit DC zero and wait for COMINIT/ COMSAS. Firmware is notified. This is not considered an error.
COMSAS Timeout	If COMINIT is detected, COMSAS is transmitted, and COMSAS is not received before the COMSAS Detect Timeout timer expires, firmware is notified and the drive continues to transmit DC zero and wait for COMINIT.
Speed Negotiation Errors	If speed negotiation fails with no match, or if the drive fails retrying the matched link rate, firmware is notified and the drive continues to transmit DC zero and wait for COMINIT. If the match link rate retry fails, the Phy Reset Problem counter is incremented (Log Page 0x18).
Loss of Sync	If the drive loses DWORD sync long enough for the loss of sync timer to expire, firmware is notified and the drive transmits a COMINIT to initiate a new link reset. The Loss of DWORD sync counter is incremented (Log Page 0x18).
Disparity/Invalid DWORD Error	If a disparity error or an invalid DWORD is detected by the drive, the Invalid DWORD Count is incremented (Log Page 0x18). The Running Disparity Error Count in Log Page 0x18 is not used

15.5 Link Layer

The SAS link layer defines primitives, address frames, and connections. The Link layer is the interface between the Port layer and the Phy layer. This section describes Link Layer behaviors of the Drive. For a complete description of SAS Link Layer, please see the ANSI specification, SAS 1.1.

15.5.1 Address Frames

Address frames are used for the identification sequence and for connection requests and are only sent outside connections. The Address Frame format is defined below:

Table 19: Address Frame Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Rsvd	Device Type			Address Frame Type			
1-27	Frame Type Dependent bytes							
28-31	CRC							

•The ADDRESS FRAME TYPE field indicates the type of address frame and is defined in table 20. This field determines the definition of the frame type dependent bytes.

Table 20: Frame type:

Value	Address Frame Type Description
0000b	IDENTIFY: Identification Sequence
0001b	OPEN: Connection Request
Others	RESERVED

15.5.1.1 Identify Address Frame

The IDENTIFY address frame format is used for the identification sequence. The IDENTIFY address frame is sent after the phy reset sequence completes. The Idenfity Address Frame format is defined as follows:

Table 21: Identify Address Frame

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Rsvd	Device Type = 1			Address Frame Type = 0			
1	Reserved				Reason			
2	Reserved				SSP Initiator Port=0b	STP Initiator Port=0b	SMP Initiator Port=0b	Rsvd
3	Reserved				SSP Target Port=1b	STP Target Port=0b	SMP Target Port=0b	Rsvd
4-11	Device Name							
12-19	SAS Address							
20	PHY Identifier							
21	Reserved					Inside ZPSDS Persistent=0b	Requested Inside ZPSDS=0b	Break_Reply Capable=1b
22-27	Reserved							
28-31	CRC							

- **Device Type**: set to 001b to indicate that this drive is an “End Device”.
- **Address Frame Type**: set to 00b to indicate that this is an IDENTIFY.
- **Reason**: field indicates the reason for link reset sequence as defined in Table 22 on page 46
- **Initiator Port bits:** set to 000b since this device is a target device only
- **Target Port bits:** set to 100b since this device is a SSP target device only
- **Device Name:** field contains Target Device Identifier
- **SAS ADDRESS:** field contains the port identifier of the SAS port transmitting this frame.
- **PHY Identifier:** field contains the PHY identifier of the PHY transmitting this frame.
- **Break_Reply Capable**: set to 1b to indicate that this port is capable of sending BREAK_REPLY primitive sequence in responding of receiving BREAK primitive sequences

- **Requested Inside ZPSDS**: set to 0b since this is an “End Device”
- **Inside ZPSDS Persistent**: set to 0b since this is an “End Device”

Table 22: Reason field

Value	Address Frame Type Description
00b	Power on
01b	OPEN: Connection Request
02b	Hard Reset (received a Hard Reset during hard reset sequence)
04b	Loss of dword synchronization
07b	Break timeout timer expired
08b	Phy test function stopped
Others	RESERVED

15.5.1.2 OPEN Address Frame

The OPEN address frame format is used for the identification sequence. The OPEN address frame is sent after the phy reset sequence completes. The OPEN Address Frame format is defined as follows:

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Initiator Port=0	Protocol = 1			Address Frame Type = 1			
1	Features = 0				Connection Rate = 8h or 9h or Ah			
2-3	Initiator Connection Tag							
4-11	Destination SAS Address							
12-19	Source SAS Address							
20	Source Zone Group							
21	Pathway Blocked Count							
22-23	Arbitration Wait Time							
24-27	More Compatible Features							
28-31	CRC							

- **Initiator Port**: This bit is set to zero when the Drive is the source port acting as a SAS target.
- **Protocol**: this field is set to 001b to indicate SSP Protocol.
- **Features**: this field is set to zero and ignored by the Drive per SAS 1.1.
- **Connection Rate**: field should be set to 8h (1.5Gbps) or 9h (3Gbps) or Ah (6Gbps), depending on requested link rate. Rate matching is supported by the Drive, therefore if the Link to the drive is 3.0Gbps, and the Connection Rate is 1.5Gbps, the Drive will insert ALIGNs between DWords, to match the Connection Rate.
- **Initiator Connection Tag**: The Drive will set this value to the last value received from this Initiator.
- **Destination SAS Address:** field contains the port identifier of the SAS port to which a connection is being requested.
- **Source SAS Address**: field contains the port identifier on the port that originated this frame (i.e. the drive’s port address).
- **Source Zone Group:** This field is set to zero and ignored by the Drive per SAS 2.

- **Pathway Blocked Count:** this field indicates the number of times the port has retried this connection request due to receiving OPEN_REJECT (PATHWAY BLOCKED). The Drive willl not increment the PATHWAY BLOCKED COUNT value past FFh.
- **Arbitration Wait Time:** this field indicates how long the port transmitting the OPEN address frame has been waiting for a connection request to be accepted. For values from 0000h to 7FFFh, the Arbitration Wait Time timer increments in one microsecond steps. For values from 8000h to FFFFh, the Arbitration Wait Time timer increments in one millisecond step.
- **More Compatible Features**: this field is set to zero and ignored by the Drive per SAS 1.1.

15.5.2 Link Layer Error Handling

This section defines the Link layer error handling of the drive.

Error	Error Handling Procedure
IDENTIFY Timeout	If IDENTIFY is not received before the IDENTIFY timer expires (1ms), firmware is notified and the drive transmits a COMINIT to initiate a new link reset.
BREAK Received	If BREAK is received while the drive has ACK/NAK balance, BREAK or BREAK_REPLY is transmitted and a new connection may be opened if the drive still has frames to transmit. Firmware is not notified. If BREAK is received while the drive does NOT have ACK/NAK balance, BREAK or BREAK_REPLY is transmitted and the current command is aborted and will return Check Condition status with sense data indicating an ACK/NAK timeout.
NAK and ACK/NAK Timeout	If a NAK is received on a RESPONSE frame, the RESPONSE frame is retransmitted with the RETRANSMIT bit set to zero. If an ACK or NAK is not received for a RESPONSE frame within 1ms, the RESPONSE frame will be retransmitted with the RETRANSMIT bit set to one. The drive will retry sending a RESPONSE frame once.
Bad Frame CRC	If a frame fails the CRC check, the frame is NAKed by the drive and discarded. This is a link layer function. The command associated with a NAKed DATA or XFER_RDY frame is aborted with check condition status and sense data corresponding to DATA_PHASE_ERROR is returned. COMMAND frames that fail the CRC check are NAKed and discarded.
OPEN_REJECT	OPEN_REJECT – Retryable Variations • OPEN_REJECT(RETRY) - Will be retried indefinitely by the drive. This case is considered to be occur when the initiator is temporarily not available to accept connections (for example when it is not able to extend R-Rdy credit at this time due to lack of buffers...), so the initiator will ask us to keep “RETRY”-ing, until it becomes available at a later time. Thus, we don't consider this an error condition, but part of normal behavior for the initiator. • OPEN_REJECT(RATE_NOT_SUPPORTED) – If this occurs, it must mean that a link between the drive and initiator renegotiated to a lower link rate after the command was received. In this case, we retry in a new connection at 1.5Gbps. If this error is received for a 1.5Gbps connection, the command is internally aborted. OPEN_REJECT – (PATHWAY_BLOCKED) • OPEN_REJECT(BAD_DESTINATION), OPEN_REJECT(WRONG_DESTINATION), OPEN_REJECT(PROTOCOL_NOT_SUPPORTED) – If these OPEN_REJECTs are received, we internally abort the command.

Credit Timeout	If credit is not received before the credit timer expires, DONE(CREDIT_TIMEOUT) is sent to the Initiator.
DONE Timeout	If credit is extended and the DONE timer expires, BREAK is sent by hardware to tear down the connection.
CREDIT_BLOCKED	If CREDIT BLOCKED is received and the drive has frames to send in the current connection, DONE(CREDIT_TIMEOUT) is returned. Otherwise, DONE(NORMAL) is returned.
OPEN Frame Checking	Reserved fields in the OPEN frame are not checked. • The Dest Address field is checked, and if it doesn't match OPEN_REJECT(WRONG_DESTINATION) is returned. • The Protocol field is checked and if it isn't set to SSP OPEN_REJECT(PROTOCOL_NOT_SUPPORTED) is returned. • If the Link Rate exceeds the physical link rate on that port, OPEN_REJECT(LINK_RATE_NOT_SUPPORTED) is returned. • The Initiator bit is not checked.
OPEN Response Timeout	If AIP or OPEN_ACCEPT is not received before the OPEN Response timer expires, the hardware transmits BREAK.
CLOSE Timeout	If CLOSE is not received before the CLOSE timer expires, the hardware transmits BREAK.
Phy Not Ready	If Link Reset occurs outside of a connection, commands can execute normally across the link reset. If a link reset occurs inside of a connection, the behavior is similar to BREAK in that it is treated as an abruptly closed connection. In cases where the command cannot be continued normally (e.g. a frame is corrupted by OOB signals, or we do not have ACK/NAK balance), the command is terminated with CHECK CONDITION status with sense data corresponding to ACK/NAK TIMEOUT.

15.6 Transport Layer

The Transport layer defines frame formats. The Transport layer is the interface between the application layer and port layer. It is responsible for constructing and parsing frame contents. For SSP, the transport layer only receives frames from the port layer that are going to be ACKed by the link layer. This section describes Transport Layer behaviors of the Drive. For a complete description of SAS Transport Layer, please see the ANSI specification, SAS 1.1.

The transport layer defines the frame format as follows.

Table 23: SAS Frame Format

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Frame Type							
1-3	Hashed Destination Address							
4	Reserved							
5-7	Hashed Source Address							
8-9	Reserved							
10	Reserved			TLR Control = 00b		Retry Data Frames =0b	Retransmit	Rsvd
11	Reserved						# of fill bytes	
12-15	Reserved							
16-17	Tag							
18-19	Target Port Transfer Tag							
20-23	Data Offset							
24-m	Information Unit							
	Fill Bytes (if Needed)							
(n-3)-n	CRC							

- **FRAME TYPE** field, which defines the format of the INFORMATION UNIT field as follows:

Code	Name of Frame	Information Unit	Originator	IU Size (bytes)
01h	DATA	Data	Initiator or Target	1-1024
05h	XFER_RDY	Data Transfer Ready	Target	12
06h	COMMAND	Command	Initiator	28-284
07h	RESPONSE	Response	Target	24-1024
16h	TASK	Task Management Function	Initiator	28
f0-ffh	vendor specific			
all others	reserved			

• The **HASHED DESTINATION SAS ADDRESS** field contains the hashed value of the destination SAS address.

• The **HASHED SOURCE SAS ADDRESS** field contains the hashed value of the source SAS address.

•The **TLR CONTROL** field is not supported

•The **RETRY DATA FRAMES** is not supported

•The **CHANGING DATA POINTER** is not supported

• The **NUMBER OF FILL BYTES** field indicates the number of fill bytes between the INFORMATION UNIT field and the CRC field. The **RETRANSMIT** bit is set to one for RESPONSE frames when attempting to retransmit this frame due to receiving an error during the initial transmission. It shall be set to zero for all other frame types. The **NUMBER OF FILL BYTES** field shall be set to zero for all frame types except DATA frames

•. The **TAG** field contains a value that allows the SSP port to establish a context for commands and task management functions.

• The **TARGET PORT TRANSFER TAG** field is set and used by the drive. The initiator should echo this field in outbound data IU.

• The **INFORMATION UNIT** field contains the information unit, the format of which is defined by the FRAME TYPE field.

• **Fill bytes** shall be included after the INFORMATION UNIT field so the CRC field is aligned on a four byte boundary.

15.6.1 Command Information Unit

The COMMAND frame is sent by an SSP initiator port to request that a command be processed by the drive.

Table 24: COMMAND Information Unit

Byte	Bit							
	7	6	5	4	3	2	1	0
0-7	Logical Unit Number							
8	Reserved							
9	Disable first burst=0	Reserved				Task Attribute		
10	Reserved							
11	Additional CDB Length (in Dwords)						Rsvd	
12-27	CDB							
28-n	Additional CDB Bytes							

• The **LOGICAL UNIT NUMBER** field contains the address of the logical unit. The drive only supports a LUN of 0's.

• A **DISABLE FIRST BURST** bit is not supported by the drive

• The **TASK ATTRIBUTE** field is defined as follows:

Value	Attribute
000b	Simple_Q
001b	Head_of_Q

010b	**Ordered_Q**
100b	**ACA_Q (not supported)**
101b	**Reserved**

- The **ADDITIONAL CDB LENGTH** field contains the length in dwords (four bytes) of the ADDITIONAL CDB field.
- The **CDB** and **ADDITIONAL CDB BYTES** fields together contain the CDB.

15.6.2 TASK Information Units

Table 25: TASK Information Unit

Byte	Bit							
	7	6	5	4	3	2	1	0
0-7	Logical Unit Number							
8-9	Reserved							
10	Task Management Function							
11	Reserved							
12-13	Tag of Task to be Managed							
14-27	Reserved							

- The **LOGICAL UNIT NUMBER** field contains the address of the logical unit. The drive only supports a LUN of 0's.
- The **TASK MANAGEMENT FUNCTION** field is defined as follows:

Value	Function
01h	ABORT TASK: The Drive shall perform the ABORT TASK associated with the value of the TAG OF TASK TO BE MANAGED field
02h	ABORT TASK SET: The Drive shall perform the ABORT TASK SET by aborting all outstanding tasks for the Initiator that sent the TMF.
04h	CLEAR TASK SET: This TMF causes the Drive to abort all tasks in the task set. The action is equivalent to receiving a series of Abort Task requests from all Initiators. A unit attention condition shall be generated for all other Initiators with tasks in the task set. The Additional Sense Code shall be Commands cleared by another Initiator.
08h	LUN RESET: The LUN RESET causes the Target to execute a hard reset. This means: 1. Abort all tasks for all Initiators on either both ports. 2. Release any device reservation on either port. 3. Set a Unit Attention condition for all Initiators.
40h	CLEAR ACA (not supported)
80h	QUERY TASK: The drive shall return a response of FUNCTION SUCCEEDED if the specified task exists, or FUNCTION COMPLETE if the specified task does not exist.
81h	QUERY TASK SET: The drive shall return a response of FUNCTION SUCCEEDED if there is any task exist, or FUNCTION COMPLETE if there is no task exist.

82h	QUERY ASYNCHRONOUS EVENT (formerly QUERY UNIT ATTENTION): The drive shall return a response of FUNCTION SUCCEEDED if there is a unit attention or a deferred error pending, or FUNCTION COMPLETE if there is no unit attention or no deferred error pending.
others	RESERVED: The Drive will return a RESPONSE frame with the DATAPRES field set to RESPONSE_DATA and its RESPONSE CODE field set to TASK MANAGEMENT FUNCTION NOT SUPPORTED.

• If TMF is set to ABORT TASK or QUERY TASK, the **TAG OF TASK TO BE MANAGED** field specifies the **TAG** value from the COMMAND frame that contained the task to be aborted or checked. For all other TMF's, this field is ignored.

•If TMF is set to QUERY ASYNCHRONOUS EVENT, the Additional Response Information argument is set to 000000h for the response of FUNCTION COMPLETE. If the response is FUNCTION SUCCEED, the Additional Response Information argument is set as defined in table 26.

Table 26: Additional Response Information argument for Query Async Event

Byte	Bit							
	7	6	5	4	3	2	1	0
0	RESERVED		UADE DEPTH		SENSE KEY			
1	ADDITIONAL SENSE CODE							
2	ADDITIONAL SENSE CODE QUALIFIER							

The UADE DEPTH is the number of pending unit attention conditions or deferred errors. It is defined as in table Table 27:

The SENSE KEY field is the value of the SENSE KEY field in the highest-priority pending unit attention condition or deferred error.

The ADDITIONAL SENSE CODE field is the value of the ADDITIONAL SENSE CODE field in the highest-priority pending unit attention condition or deferred error.

The ADDITIONAL SENSE CODE QUALIFIER field is the value of the ADDITIONAL SENSE CODE QUALIFIER field in the highest-priority pending unit attention condition or deferred error

Table 27: UADE DEPTH field

Code	Description
00b	The combined number of unit attention conditions and deferred errors is unknown
01b	The combined number of unit attention conditions and deferred errors is one
10b	The combined number of unit attention conditions and deferred errors is greater than one
11b	Reserved

15.6.3 XFER_RDY Information Units

The XFER_RDY frame is sent by the Drive to request write data (i.e. out bound data) from the initiator.

Table 28: XFER_RDY Information Unit

Byte	Bit							
	7	6	5	4	3	2	1	0
0 - 3	REQUESTED OFFSET							
4 - 7	WRITE DATA LENGTH							
8 - 11	RESERVED							

- The **REQUESTED OFFSET** field contains the buffer offset of the segment of write data the Initiator may transmit to the Drive (using DATA frames). The requested offset shall be a multiple of four.
- The **WRITE DATA LENGTH** field contains the number of bytes of write data the Initiator may transmit to the Drive (using DATA frames) from the requested offset.

15.6.4 DATA Information Units

The DATA frame is sent by the Drive to the Initiator (in bound data) or by the Initiator to the Drive (out bound data).

Table 29: DATA Information Unit

Byte	Bit							
	7	6	5	4	3	2	1	0
0 - (n-1)	DATA							

15.6.5 RESPONSE Information Units

The RESPONSE frame is sent by the Drive to the Initiator (in bound data) or by the Initiator to the Drive (out bound data).

Table 30: Response Information Unit

Byte	Bit							
	7	6	5	4	3	2	1	0
0-7	RESERVED							
8-9	MSB	RETRY DELAY TIMER						LSB
10	RESERVED						DataPres	
11	STATUS							
12 - 15	Reserved							
16 - 19	SENSE DATA LENGTH (n bytes)							
20 - 23	RESPONSE DATA LENGTH (m bytes)							
24 - (24+m)	RESPONSE DATA							
(24+m) - (23+m+n)	SENSE DATA							

•The **RETRY DELAY TIMER** field contains the retry delay timer code which is defined as follows:

Status Code	Retry Delay Timer Code	Description
BUSY	**0000h**	**Same as normal busy**
	0001h-FFEFh	**The number of 100 milliseconds increments which Initiator should wait before sending another command to Drive**
	FFF0h-FFFDh	**RESERVED**
	FFEFh	**Initiator should stop sending commands to Drive**
	FFFFh	**Drive is not able to accept the command**
	0000h	**Same as normal busy**
QUEUE FULL	**0001h-FFEFh**	**Initiator should wait before sending another command to the Drive until:** **a) At least the number of 100 milliseconds increments indicated in the RETRY DELAY TIMER CODE field have elapse; or** **b) A command addressed to the Drive completes.**
	FFF0h-FFFFh	**RESERVED**
GOOD	**0000h-FFFFh**	**RESERVED**
CHECKCONDITION	**0000h-FFFFh**	**RESERVED**
CONDITION MET	**0000h-FFFFh**	**RESERVED**
RESERVATIONCONFLICT	**0000h-FFFFh**	**RESERVED**
ACA ACTIVE	**0000h-FFFFh**	**RESERVED**
TASK ABORT	**0000h-FFFFh**	**RESERVED**

•The **DATAPRES** field, which indicates the format and content of the STATUS field, SENSE DATA LENGTH field, RESPONSE DATA LENGTH field, RESPONSE DATA field, and SENSE DATA field.

Value	DATAPRES Description
00b	**NO DATA: no data present**
01b	**RESPONSE_DATA: response data present**
10b	**SENSE_DATA:** sense data present
11b	**RESERVED**

Table 31: RESPONSE DATA

Byte	Bit							
	7	6	5	4	3	2	1	0
0 - 2	RESERVED							
3	RESPONSE CODE							

• **RESPONSE CODES** are defined as follows:

Value	RESPONSE Code Description
00b	Task Management Function complete
02b	Invalid Frame
04b	Task Management Function not supported
05b	Task Management Function failed
08b	Task Management Function succeeded
09b	Invalid LUN
others	RESERVED

15.6.6 Sequences of SSP Information Units

SSP Information Units are used in conjunction with one another to execute SCSI commands. This section provides a brief overview of SAS SSP Information Unit sequences, that would be required to complete a SCSI command.

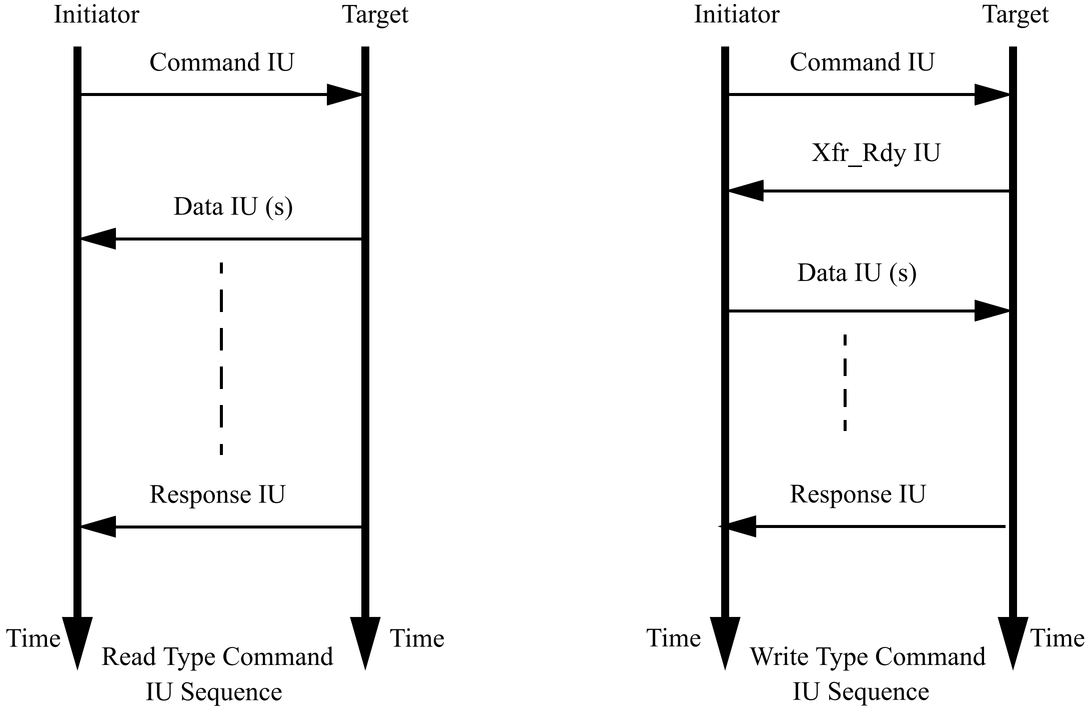


Figure 1: SSP Information Unit Sequences

15.6.7 Transport Layer Error Handling

This section defines the Transport layer error handling by the drive.

Error	Error Handling Procedure
SSP Header Field Checking	Reserved fields in SSP frames are not checked.
Data Offset Error	If a DATA frame with an invalid Data Offset is received, the command associated with the DATA frame is aborted with Check Condition status and sense data corresponding to a DATA OFFSET ERROR is returned
I_T NEXUS Loss Timeout	If a connection cannot be established to an initiator before the I_T NEXUS LOSS timer expires (Mode Page 0x19), all commands from the initiator are internally aborted. The first new command received from the affected Initiator results in a CHECK CONDITION with sense data corresponding to I_T NEXUS LOSS OCCURRED.
Initiator Response Timeout	If DATA frames corresponding to an outstanding XFER_RDY frame are not received before the Initiator Response timer expires (Mode Page 0x19), the command is aborted with CHECK CONDITION status and sense data corresponding to INITIATOR RESPONSE TIMEOUT is returned for the affected command.

Data Overflow	If more data is received than requested via an XFER_RDY frame, the affected command is aborted with CHECK CONDITION status with sense data corresponding to TOO MUCH WRITE DATA is returned.
Invalid Target Port Transfer Tag	If a DATA frame is received and the TPTT is not set to the value used in the corresponding XFER_RDY frame, the frame is discarded. If a COMMAND or TASK frame is received with the TPTT set to a value other than 0xFFFF, a RESPONSE frame with RESPONSE_DATA set to INVALID FRAME is returned.
Invalid Frame Length	If a DATA frame is received with zero bytes of payload data, the frame is discarded. This is not considered an error. If a COMMAND/TASK frame that is too short is received, RESPONSE data corresponding to INVALID FRAME is returned. The additional CDB length field of a COMMAND frame is not checked for correctness. If a DATA frame is received with a payload greater than 1024 bytes, the frame is discarded and the command is aborted with CHECK CONDITION status and sense data corresponding to DATA_PHASE_ERROR is returned.

16.0 SCSI Command Set

Summaries of the SCSI commands supported by the drive are listed below. O = optional, M = mandatory

Table 32: SCSI Commands Supported

Type	Code	Description
M	04h	FORMAT UNIT (04), page 62
M	12h	INQUIRY (12), page 65
O	4Ch	LOG SELECT (4C), page 80
O	4Dh	LOG SENSE (4D), page 83
O	15h	MODE SELECT (15), page 112
O	55h	MODE SELECT (55), page 113
O	1Ah	MODE SENSE (1A), page 114
O	5Ah	MODE SENSE (5A), page 143
O	5Eh	PERSISTENT RESERVE IN (5E), page 145
O	5Fh	PERSISTENT RESERVE OUT (5F), page 148
O	34h	PRE-FETCH (34), page 153
M	08h	READ (6) - (08), page 154
M	28h	READ (10) - (28), page 155
O	A8h	READ (12) - (A8), page 157
O	88h	READ (16) - (88), page 158
O	7Fh/09h	READ (32) - (7F/09), page 159
O	3Ch	READ BUFFER (3C), page 161
M	25h	READ CAPACITY (10) - (25), page 165
O	9Eh/10h	READ CAPACITY (16) (9E/10), page 167
O	37h	READ DEFECT DATA (37), page 169
O	B7h	READ DEFECT DATA (B7), page 172
O	3Eh	READ LONG (3E), page 174
O	07h	REASSIGN BLOCKS (07), page 175
O	1Ch	RECEIVE DIAGNOSTICS RESULTS (1C), page 177
M	17h	RELEASE (17), page 180
O	57h	RELEASE (57), page 181
O	A3h/05h	REPORT DEVICE IDENTIFIER (A3/05), page 182
O	A0h	REPORT LUNS (A0), page 184
O	A3h/0Ch	REPORT SUPPORTED OPERATION CODES (A3/0C), page 185
O	A3h/0Dh	REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS (A3/0D), page 190
M	03h	REQUEST SENSE (03), page 192
M	16h	RESERVE (16), page 193
O	56h	RESERVE (56), page 194
O	01h	REZERO UNIT (01), page 195
M	1Dh	SEND DIAGNOSTIC (1D), page 197
O	A4h/06h	SET DEVICE IDENTIFIER (A4/06), page 204
O	1Bh	START STOP UNIT (1B), page 205
O	35h	SYNCHRONIZE CACHE (10) - (35), page 206
O	91h	SYNCHRONIZE CACHE (16) - (91), page 207

M	00h	TEST UNIT READY (00), page 208
O	2Fh	VERIFY (2F), page 211
O	AFh	VERIFY (12) - (AF), page 213
O	AFh	VERIFY (16) - (8F), page 214
O	7Fh/0Ah	WRITE (6) - (0A), page 217
M	0Ah	WRITE (6) - (0A), page 217
M	2Ah	WRITE (10) - (2A), page 218
O	AAh	WRITE (12) - (AA), page 220
O	8Ah	WRITE (16) - (8A), page 221
O	7Fh/0Bh	WRITE (32) - (7F/0B), page 222
O	2Eh	WRITE AND VERIFY (10) - (2E), page 224
O	AEh	WRITE AND VERIFY (12) - (AE), page 225
O	8Eh	WRITE AND VERIFY (16) - (8E), page 226
O	7Fh/0Ch	WRITE AND VERIFY (32) - (7F/0C), page 227
O	3Bh	WRITE BUFFER (3B), page 228
O	3Fh	WRITE LONG (3F), page 231
O	41h	WRITE SAME (41), page 233
O	93h	WRITE SAME (16) - (93), page 234
O	7Fh/0Dh	WRITE SAME (32) - (7F/0D), page 235
O	42h	UNMAP (42h), page 209

16.1 SCSI Control Byte

The Control Byte is the last byte of every CDB. The format of this byte is shown below.

Table 33: SCSI Control Byte

BIT							
7	6	5	4	3	2	1	0
VU = 0		Reserved = 0				FLAG	LINK

VU

VU stands for Vendor Unique.

FLAG**

If Link is zero, Flag must also be zero. If Link is one, Flag may also be one. Typically this bit is used to cause an interrupt in the Initiator between linked commands.

LINK**

This bit is set to one to indicate that the Initiator desires an automatic link to the next command upon successful completion of the current command.

Note: * - The drive ignores the link bit and flag bit in the CDB.

16.2 Abbreviations

These abbreviations are used throughout the following sections:

LUN Logical Unit Number. An encoded three bit identifier for the logical unit.

VU Vendor Unique bits

LBA Logical Block Address

RSVD Reserved

MSB Most Significant Byte

LSB Least Significant Byte

16.3 Byte ordering conventions

In this specification, where it is not explicitly stated, all multi-byte values are stored with the most significant byte first. For example, in a 4 byte field, byte 0 will contain the MSB and byte 3 the LSB.

16.4 FORMAT UNIT (04)

Table 34: FORMAT UNIT (04)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Command Code = 04h							
1	FMTPINFO		LONG LIST=0	FMTDATA	CMPLIST	Defect List Format		
2	VU = 0							
3-4	Obsolete = 0							
5	VU = 0		Reserved = 0				FLAG	LINK

- **FMTPINFO (Format Protection Information**) in combination with the Protection Field Usage field in the Parameter List Header specifies whether or not the drive enables or disables the use of protection information (see table defined in the Parameter List Header section).
- **FmtData** set to one specifies that a Data Out phase follows the Command phase. The Data Out phase consists of a Parameter List header, optionally followed by an Initialization Pattern Descriptor, optionally followed by a Defect List. If FmtData=0, the following defaults are assumed: DPRY=0, DCRT=1, STPF=1, IP=0, DSP=0, Immed=0.
- **CmpLst** is ignored.
- **Defect List Format** is ignored.
- **Notes:**It is recommended that the MODE SELECT command be issued prior to the FORMAT UNIT command to specify parameters that affect the formatting process.

The Block Length parameter of the Mode Select Parameter List's Block Descriptor is used during formatting and is saved following a successful format operation. If a MODE SELECT command has not been issued since the last reset or start-up (bring-up) sequence, then the Block Length from the previous format operation is used.

Subsequent to receiving a FORMAT UNIT command, the Target responds to commands as follows:

- All commands except REQUEST SENSE and INQUIRY return *Check Condition* status*,* while the format operation is an active I/O process.
- When tagged queuing is enabled (DQue = 0), all commands except REQUEST SENSE and INQUIRY return *Queue Full* status*,* while the FORMAT UNIT command is a queued I/O process.
- When tagged queuing is disabled (DQue = 1), all commands except REQUEST SENSE and INQUIRY return *Busy* status*,* while the FORMAT UNIT command is a queued I/O process
- If a REQUEST SENSE command is received while a format operation is an active I/O process, the Target returns *Good* status. The sense key is set to *Not ready* and the additional sense code and qualifier is set to *Format In Progress*.
- If an INQUIRY command is received while a format operation is an active I/O process, the Target returns *Good* status and Inquiry data as requested.

The format operation must complete successfully for the Drive to be usable. If the command is interrupted by a reset, power down, or an unrecoverable error, the Drive enters a degraded mode of operation in which reading and writing are prohibited. To exit the degraded mode, another FORMAT UNIT command must be sent by the Initiator and completed successfully by the Target.

The FORMAT UNIT command sets the *Unit Attention Condition* for all Initiators except the one that issued the FORMAT UNIT command.

16.4.1 Parameter List Header

Following is the format of the Parameter List Header sent during the data out phase when FmtData is set to one.

Table 35: Format of the Parameter List Header

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Reserved = 0					Protection Field Usage		
1	FOV	DPRY	DCRT	STPF = 1	IP	Obsolete	Immed	Vendor-specific
2 -3	(MSB)			Defect List Length				(LSB)
4-n	Initialization Pattern Descriptor							
(n+1) - m	Defect Descriptor							

- **Protection Field Usage:** in combination with the format protection information (FMTPINFO) field in the CDB specifies whether or not the drive enables or disables the use of protection information:

FMTPINFO	Protection Field Usage	Description
00h	000h	The drive will be formatted to type 0 protection
01h	xxxh	Check Condition status will be returned with the sense key set to Illegal Request and the additional sense code set to Invalid Field in the CDB.
10h	000h	The drive will be formatted to type 1 protection
11h	000h	The drive will be formatted to type 2 protection
11h	001h	Type 3 protection is not supported - Check Condition status will be returned with the sense key set to Illegal Request and the additional sense code set to Invalid Field in the Parameter List

All other combinations of FMTPINFO and Protection Field Usage will result in Check Condition status to be returned with the sense key set to Illegal Request and the additional sense code set to Invalid Field in the Parameter List.

Type 0 protection specifies that the drive shall disable the use of protection information and format to the block size specified. Following a successful format, the PROT_EN bit in the READ CAPACITY (16) parameter data will indicate that protection information is disabled.

Type 1 and type 2 protection specifies that the drive shall enable the use of protection information and format to the block size specified + 8 (e.g., if the block length is 512, then the formatted block length is 520). See format of data below. When protection information is written during a FORMAT UNIT command, protection information shall be written with a default value of all 0xFF's. Following a successful format, the PROT_EN bit in the READ CAPACITY (16) parameter data will indicate that protection information is enabled and the P_TYPE field in the READ CAPACITY (16) parameter data will indicate the protection type.

Byte	BIT							
	7	6	5	4	3	2	1	0
0... n	User Data							
n... n+1	Logical Block Guard							
n+2... n+3	Logical Block Application Tag							
n+4... n+7	Logical Block Reference Tag							

- **The Logical Block Guard field** contains a CRC that covers the preceding user data. This field is generated/checked per the SBC standard.
- **The Logical Block Application Tag field** may be modified by the initiator if the ATO bit is set to zero in mode page 0x0A. If the ATO bit is set to one, then the initiator shall not modify the Logical Block Application Tag field. This field is generated / checked per the SBC standard. The Logical Block Guard field contains a CRC that covers the pre-

ceding user data. This field is generated/checked per the SBC standard.

- **The Logical Block Reference Tag field** is generated/checked depending on protection types. With Type 1 protection, the Logical Block Reference Tag in the first logical block of the data transfer shall contain the least significant four bytes of the LBA contained in the Logical Block Address field of the command. Subsequent blocks shall contain the previous logical block reference tag plus one. With Type 2 protection, the Logical Block Reference Tag in the first logical block of the data transfer shall contain the value in the Expected Initial Logical Block Reference Tag field of the command. Subsequent blocks shall contain the previous logical block reference tag plus one.
- **FOV** (Format Options Valid) bit set to zero indicates that the Target should use its default settings for the DPRY (0), DCRT (1), STPF (1), IP (0), and DSP (1) bits. These bits must all be set to zero in the Parameter List Header when FOV=0, or the command will be terminated with Check Condition status, sense key of Illegal Request, and additional sense code of Invalid Field in Parameter List. FOV=1 indicates that the values set in DPRY, DCRT, STPF, IP, and DSP will be defined as specified below.
- **DPRY** (Disable Primary) bit set to zero disables error injection mode. A DPRY bit set to one enables error injection mode.
- **DCRT** (Disable Certification) is ignored, Certification is not supported.
- **STPF** (Stop Format) is ignored.
- **IP** (Initialization Pattern) bit set to zero specifies that an initialization pattern descriptor is not included and all customer data will be initialized to zeroes. An IP bit of one specifies that an Initialization Pattern Descriptor is included in the FORMAT UNIT parameter list following the parameter list header. The Initialization Pattern Descriptor provides a means of enabling the Security Initialize option, which is not enabled by default. If anything in the Initialization Pattern Descriptor is not set as specified below, the command will be immediately terminated with Check Condition status, sense key of Illegal Request, and additional sense code of Invalid Field in Parameter List.

Table 36: Initialization Pattern Descriptor:

Byte	BIT							
	7	6	5	4	3	2	1	0
0	IP Modifier = 0		SI = 1	Reserved = 0				
1	IP Type = 0							
2 -3	Initialization Pattern Length = 0							

- **IP Modifier** must be set to 0, indicating that the drive will not modify the initialization pattern.
- **SI (Security Initialize)** bit must be set to one when an Initialization Pattern Descriptor is sent. This specifies that the drive shall attempt to erase all locations that may contain customer data, including known defects.
- **Initialization Pattern Type** must be zero, indicating that the drive will use the default initialization pattern. All customer data will be initialized to zeroes.
- **Initialization Pattern Length** must be zero, as user-specified initialization patterns are not supported.
- **DSP** (Disable Saving Parameters) bit when zero indicates the target is to save all the current MODE SELECT saveable parameters during the format operation. When the bit is one, the target is not to save the current MODE SELECT saveable parameters.
- **Immed** (Immediate) bit set to zero requests that status be returned at the end of the format operation. An immediate bit set to one requests that status be returned immediately following CDB validation and transfer of data in the Data Out phase. If the format operation, with the immediate bit set to one, terminates in error, DEFERRED ERROR SENSE data is generated.
- **Defect List Length** must be zero. A user-supplied defect list is not supported. Otherwise the command is terminated with Check Condition status with the sense key set to Illegal Request and the additional sense code set to Invalid Field in Parameter List.

16.5 INQUIRY (12)

Table 37: INQUIRY (12)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Operation Code = 12h							
1	Reserved = 0						CmdDT=0	EVPD
2	Page Code							
3 - 4	Allocation Length							
5	VU = 0		Reserved = 0				FLAG	LINK

The INQUIRY command requests the parameters of the Target to be sent to the Initiator.

An **EVPD** An EVPD bit of one specifies that the target return the vital product data page identified by the Page Code field in the CDB The available VPD pages are defined in the addendum provided for each different drive model in the section entitled Inquiry Data Format.

The **Page Code** specifies which page of vital product data information the drive shall return.

Table 38: Page Code descriptions

EVPD	PAGE CODE	Description
0	0	The Target returns the standard INQUIRY data.
0	Non Zero	The drive returns *Check Condition* status with the sense key of *Illegal Request* and the additional sense code of *Invalid Field in CDB*.
1	Non Zero	The drive returns the vital product data of page code requested.

Allocation Length specifies the number of bytes that the Initiator has allocated for INQUIRY data to be returned. An allocation length of zero implies that no data is to be returned. The Target will terminate the DATA IN phase when all available INQUIRY data has been transferred or when allocation length bytes have been transferred, whichever is less.

Note: If an INQUIRY command is received from an Initiator with a pending unit attention condition (before the target reports *Check Condition* status), the Target processes the INQUIRY command. The unit attention condition is not cleared by this action.

Note: The INQUIRY command is a Priority command and is not queued.

Note: The inquiry data is set at the time of manufacture and will not change (without a FRU change), with the following exceptions:

- Product Revision Level (EVPD=0) can be changed when microcode is downloaded with the Write Buffer command.
- The information returned for EVPD=1, Page Code = 3 is not fixed.

Note: The inquiry data returned when media is not available will not be complete.

Byte 0 of the returned data on an INQUIRY command is the same no matter which page(s) is(are) returned. This description is to be used for all the following page definitions.

The Peripheral Qualifier field of zero (0) indicates that the peripheral device is currently connected to this logical unit. A Peripheral Device Type field of zero (0) indicates that this device is a Direct Access Storage Device (DASD).

16.5.1 Inquiry Data

Fields with a value shown inside quotes (e.g. Value ='xyz') are character fields. A value not in quotes is a numeric value. Character fields are alphanumeric and represented in ASCII.

16.5.1.1 Inquiry Data Format - EVPD = 0, Page Code = 0

Table 39: Inquiry Data- EVPD = 0

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	RMB = 0	Reserved=0						
2	Version = 6							
3	Obsolete	Obsolete	Norm ACA=0	HiSup = 1	Response Data Format = 2			
4	Additional Length = 159 (9Fh)							
5	SCCS=0	ACC=0	TPGS=00b		3PC=0	Reserved = 0		Protect=1
6	Obsolete	EncSer = 1	Port	MultiP=1	Obsolete			RSVD = 0
7	Obsolete	Obsolete	RSVD = 0	RSVD = 0	Obsolete	Obsolete	CmdQue= 1	RSVD = 0
8-15	Vendor ID = "HGST "(ASCII)							
16-31	Product ID (ASCII)							
32-35	Product Revision Level (ASCII)							
36-43	Unit Serial Number (ASCII)							
44-95	Reserved = 0							
96-145	Copyright Notice (ASCII)							
146-163	Reserved=0							

- **Qualifier** is set to zero to indicate that the LUN specified is currently supported. Qualifier is set to 011b when the LUN specified is not present [1]
- **Peripheral Device Type** is set to zero to indicate that the device is a Direct-Access Peripheral Device.
- **Removal Media Bit (RMB)** is always set to zero to indicate no removal media exists.
- **Version** indicates the level of the ANSI standard that the product supports. The drive supports ANSI SPC-4.
- **NormACA** (Normal ACA) field of 0 indicates the device server does not support setting the NACA bit to one in the Control Byte of the CDB as defined in the SAM.
- **HiSup** bit of 1 indicates that the drive uses the hierarchical addressing model to assign LUNs to logical units.
- **Response Data Format** is set to two to indicate that the INQUIRY Data Format as specified in the ANSI SCSI version 2 is supported by the Target.
- **Additional Length** indicates the number of bytes of INQUIRY information that follows.

1.If an INVALID LUN is specified, a *Check Condition* status will be returned for all commands except INQUIRY and REQUEST SENSE.

•**SCCS** bit of zero indicates that the device does not contain an embedded storage array controller component.
- **ACC** bit of zero indicates that no access controls coordinator may be addressed through this logical unit.
- **TGPS** field of zero indicates that the device does not support asymmetric logical unit access.
- **3PC** bit of zero indicates that the device does not support third-party copy commands.
- **Protect** bit of one indicates that the drive supports protection information
- **EncSer**(Enclosure Services) bit of 0 indicates that the Target does not contain an embedded enclosure services component.

•**Port** bit of 0 indicates that the drive received the Inquiry command on port A, while a Port bit of 1 indicates that the drive received the Inquiry command on port B.
- **MultiP** (MultiPort) bit of 1 indicates that the Target has multiple ports and implements multi-port requirements.
- **CmdQue** is set to one to indicate that the drive supports command queuing.
- **Vendor ID** is HGST padded with ASCII blanks.
- **Product ID** is specified in Section 4.3.1
- **Product Revision Level** indicates the level of microcode.
- **Unit Serial Number** contains the drive serial number.

16.5.1.2 Inquiry Data Format - EVPD = 1 - Page Code = 00h

Table 40: Inquiry Data - EVPD = 1 (Page Code = 00h)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = 00h							
2	Reserved = 0							
3	Page Length = 0Bh							
4	Supported Page Code = 00h							
5	Supported Page Code = 03h							
6	Supported Page Code = 80h							
7	Supported Page Code = 83h							
8	Supported Page Code = 86h							
9	Supported Page Code = 87h							
10	Supported Page Code = 88h							
11	Supported Page Code = 8Ah							
12	Supported Page Code = 90h							
13	Supported Page Code =B1h							
14	Supported Page Code = D2h							

- **Qualifier** is set to zero to indicate that the LUN specified in the Command Block is currently supported.
- **Peripheral Device Type** is set to zero to indicate that the device is Direct Access.

- **Page Code** is set to 0, and this field contains the same value as in the page code field of the INQUIRY command descriptor block.
- **Page length** specifies the length of the following page data.
- **Supported Page Code** field contains the Page Codes supported by the Target. The list is in ascending order.

16.5.1.3 Inquiry Data Format - EVPD = 1, Page Code - 03h

Table 41: Inquiry Data - EVPD = 1 (Page Code = 03h)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = 03h							
2	Reserved = 0							
3	Page Length = 204 (CCh)							
4	ASCII Fields Length = 00h							
5-7	Reserved = 0							
8-23	Reserved = 0							
24-35	ASCII uCode Identifier							
36-39	Reserved = 0							
40-41	Major Version							
42-43	Minor Version							
44-47	User Count							
48-51	Build Number							
52-79	Build Date String							
80-81	Code ID							
82-83	Compatibility ID							
84-91	Product ID							
92-99	Interface ID							
100-107	Code Type							
108-119	User Name							
120-135	Machine Name							
136-167	Directory Name							
168-171	Operating State							
172-175	Functional Mode							
176-179	Degraded Reason							
180-183	Broken Reason							
184-187	Code Mode							
188-195	ASCII uCode revision							
196-199	Context failure reason							
200-203	South Assert Address							
204-205	North Assert Code							
206-207	Reserved							

- **Qualifier** is set to zero to indicate that the LUN specified in the Command Block is currently supported.
- **Peripheral Device Type** is set to zero to indicate that the device is Direct Access.
- **Page Code** is set to the value of the page code field in the CDB.
- **Page Length** field specifies the length (in bytes) of the vendor unique VPD information (bytes 4 - 163). If the allocation length of the CDB is too small to transfer all the data, the Page Length field is not adjusted to reflect the truncation.
- **ASCII uCode Identifier** contains the drive’s microcode identifier. The field is alphanumeric (ASCII), left aligned, and the unused bytes are ASCII spaces (20h).
- **Major Version** and **Minor Version** are version numbers of the code loaded on the drive.
- **User Count** is the number of times the code has been built since the master build.

- **Build Number** is the master build version number.
- **Build Date String** is the date the code on the drive was built, in an extended string format.
- **Code ID** is a binary value for firmware development tracking.
- **Compatibility ID** is a binary value for firmware development tracking.
- **Product ID** is the name of the product this code is for.
- **Interface ID** is the interface type and serial interface speed (e.g. SCSI or FCAL 4Gb) of the code.
- **Code Type** is the intended use of the this code. (e.g. local, released, test)
- **User Name** is the username of the person who built this version of the code.
- **Machine Name** is the workstation on which this version of the code was built.
- **Directory Name** is the last 32 characters of the directory from where this code was built.
- **Operating State** is the drive operating state. The least significant bit contains the following:

0 = OM_BROKEN	We have detected a hardware failure or there was an error loading context.
1 = OM_DEGRADED	We have a soft failure; i.e., incomplete format.
2 = OM_INACCESSIBLE	Drive is good.
3 = OM_STARTING	Loading context.
5 = OM_NORMAL	Context is loaded and ready to read/write.
7 = OM_STOPPED	Drive has come ready but now has been stopped.
8 = OM_Notify	Drive is good but NOTIFY has not arrived (SAS).

- **Functional Mode** is the drive functional mode. The least significant byte (0x0000000n) contains the following:

0 = OM_NORMAL_MODE	Not in special or recovery mode.
1 = OM_SPECIAL_CMD	Special command mode on.
3 = OM_SPC_RSV_ACCESS	Special cmd mode and access to reserved area allowed.
5 = OM_SPC_SDWNLOAD	Special cmd mode and special download allowed.
7 = OM_SPC _ RACCESS_SDWNLD	Special cmd, access to reserved area, and special download allowed.

The second byte (0x000n0000) contains the following:
0 = Idle functions are not enabled.
1 = Idle functions are enabled.

- **Degraded Reason** (UECType) is why the file is in a degraded mode; i.e., how to exit this mode.
- **Broken Reason** (UECType) is why the drive believes the hardware is broken.
- **Code Mode** is the type of code the drive is running. The least significant bit contains the following:

- 0 = OM_FLASH	Drive is running flash code
- 1 = OM_FLASH_OVERLAY	Drive is running flash overlay code
- 2 = OM_DISK	Drive is running code that has been loaded from NAND.
- 3 = OM_TRANSIENT	Drive is running code that has been downloaded but not saved.

- **ASCII uCode revision** is the revision level of the media access firmware. This field is alphanumeric.
- **Context failure reason** is a qualifier when the broken reason indicates a damaged context.
- **South Assert Address** is used for debug of firmware asserts.
- **North Assert Code** is used for debug of firmware asserts.

16.5.1.4 Inquiry Data Format - EVPD = 1, Page Code - 80h

Table 42: Inquiry Data - EVPD = 1 (Page Code = 80h)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = 80h							
2	Reserved = 0							
3	Page Length = 16 (10h)							
4-19	Serial Number (ASCII)							

- **Qualifier** is set to zero to indicate that the LUN specified in the Command Block is currently supported.
- **Peripheral Device Type** is set to zero to indicate that the device is Direct Access.
- **Page Code** is set to the value of the page code field in the CDB.
- **Page Length** is set to 16, and this field specifies the length of the following page data.
- **Serial Number** gives the drive serial number, right aligned.

16.5.1.5 Inquiry Data - EVPD = 1 (Page Code = 83h)

Table 43: Inquiry Data Format - EVPD = 1, (Page Code - 83h)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">BIT</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="3">Qualifier = 0</td><td colspan="5">Peripheral Device Type = 0</td></tr>
<tr><td>1</td><td colspan="8">Page Code = 83h</td></tr>
<tr><td>2</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>3</td><td colspan="8">Page Length = 72 (48h)</td></tr>
<tr><td>4</td><td colspan="4">Protocol Identifier = 0</td><td colspan="4">Code Set = 1</td></tr>
<tr><td>5</td><td>PIV=0</td><td>RSVD</td><td colspan="2">Association=0</td><td colspan="4">Identifier Type = 3</td></tr>
<tr><td>6</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>7</td><td colspan="8">Identifier Length = 8</td></tr>
<tr><td>8-15</td><td colspan="8">(MSB) LUN (World Wide ID) (LSB)</td></tr>
<tr><td>16</td><td colspan="4">Protocol Identifier</td><td colspan="4">Code Set = 1</td></tr>
<tr><td>17</td><td>PIV=1</td><td>RSVD</td><td colspan="2">Association = 1</td><td colspan="4">Identifier Type = 3</td></tr>
<tr><td>18</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>19</td><td colspan="8">Identifier Length = 8</td></tr>
<tr><td>20-27</td><td colspan="8">(MSB)
Target Port Identifier (World Wide ID)
(LSB)</td></tr>
<tr><td>28</td><td colspan="4">Protocol Identifier</td><td colspan="4">Code Set = 1</td></tr>
<tr><td>29</td><td>PIV=1</td><td>RSVD</td><td colspan="2">Association = 1</td><td colspan="4">Identifier Type = 4</td></tr>
<tr><td>30</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>31</td><td colspan="8">Identifier Length = 4</td></tr>
<tr><td>32-35</td><td colspan="8">(MSB)
Relative Port Identifier
(LSB)</td></tr>
<tr><td>36</td><td colspan="4">Protocol Identifier = 0</td><td colspan="4">Code Set = 1</td></tr>
<tr><td>37</td><td>PIV=1</td><td>RSVD</td><td colspan="2">Association = 2</td><td colspan="4">Identifier Type = 3</td></tr>
<tr><td>38</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>39</td><td colspan="8">Identifier Length = 8</td></tr>
<tr><td>40-47</td><td colspan="8">(MSB)
Target Device Name Identifier (World Wide ID)
(LSB)</td></tr>
<tr><td>48</td><td colspan="4">Protocol Identifier = 0</td><td colspan="4">Code Set = 3</td></tr>
</table>

- **Protocol Identifier** is valid only when PIV=1. Protocol Identifier = 0 indicates Fibre Channel devices. Protocol Identifier = 6 specifies SAS devices
- **Code Set** specifies the data type for the identifier field. Code Set = 1 indicates binary data, Code Set = 3 indicates ASCII.
- **PIV (Protocol Identifier Valid)** set to zero indicates that the Protocol Identifier field should be ignored. PIV set to one indicates that the Protocol Identifier field contains a valid value.
- **Association** specifies the entity with which the Identifier field is associated: 0h for LUN, 1h for Target or Relative Port, or 2h for Target Device.
- **Identifier Type** specifies the format and assignment authority for the identifier: 3h indicates NAA format of the WWID for LUN, Target Port and Target Device; 4h indicates Relative Port; 8h indicates SCSI name string.
- **Identifier** fields contain the actual Identifier Descriptor:
  - The LUN, Target Port and Target Device Name Identifiers are defined in the NAA IEE WWID format where: Worldwide ID is a 64-bit unique identification for each drive. The format is: 5000CCAh xxxh yyb n where:
    - **xxx** is the 12-bit block assignment defined for each model and manufacturing site
    - **n** is the 22-bit drive unique serial number
    - **yy** is the 2-bit port/node ID select
    - The **Relative Port Identifier** indicates the port which received the Inquiry command: 0000 0001h for the Primary Port, or 0000 0002h for the Secondary Port.

16.5.1.6 Inquiry Data Format - EVPD = 1, Page Code - 86h

Table 44: Inquiry Data Format - EVPD = 1, (Page Code - 86h)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = 86h							
2	Reserved = 0							
3	Page Length = 60 (3Ch)							
4	Reserved = 0		SPT			GRD_CHK	APP_CHK	REF_CHK
5	Reserved = 0			Group_Sup	Prior_Sup	HEADSUP	ORDSUP	SIMPSUP
6	Reserved=0						NV_SUP	V_SUP
7-63	Reserved = 0							

- **SPT** (Supported Protection Type) field is set to 001b to indicate that the drive supports type 1 and type 2 protection.
- **GRD_CHK (Guard Check)** is set to 1 to indicate that the drive checks the Logical Block Guard Tag field in the protection information, if any.
- **APP_CHK (Application Tag Check)** bit is set to 1 to indicate that the drive checks the Logical Block Application Tag field in the protection information, if any.
- **REF_CHK (Reference Tag Check)** bit is set to 1 to indicate that the drive checks the Logical Block Reference Tag field in the protection information, if any.
- **GROUP_SUP (Group Supported)** bit is set to 0 to indicate that the grouping function is not supported.
- **PRIOR_SUP (Priority Supported)** bit is set to 0 to indicate that task priority is not supported.
- **HEADSUP (Head of Queue Supported)** bit is set to 0 to indicate that Head of Queue is not supported.
- **ORDSUP (Ordered Supported)** bit is set to 0 to indicate that Ordered task is not supported.
- **SIMPSUP (Simple Supported)** is set to 1 to indicate support for Simple task attributes.
- **NV_SUP (Non-volatile Supported)** is set to 0 to indicated that non-volatile cache features are not supported.
- **V_SUP (Volatile Supported)** is set to 1 to indicated support of a volatile cache.

16.5.1.7 Inquiry Data Format - EVPD = 1, Page Code - 87h

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = 87h							
2-3	Page Length = 0004h							
4	Reserved=0		Policy Page Code = 3Fh					
5	Policy Subpage Code = FFh							
6	MLUS=1	Reserved = 0					Mode PagePolicy = 0	
7	Reserved = 0							

- **Policy Page Code** set to 3Fh and Policy Subpage Code set to FFh indicate that the descriptor applies to all mode pages and subpages
- **MLUS (Multiple Logical Units Share)** set to 1 indicates the policy is shared by multiple logical units.
- **Mode Page Policy** set to 00b indicates that all mode pages and subpages are shared.

16.5.1.8 Inquiry Data Format - EVPD = 1, Page Code - 88h

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = 88h							
2-3	Page Length = 48 (0030h)							
4-5	Reserved=0							
6-7	Primary Relative Port = 0001h							
8-9	Reserved = 0							
10-11	Initiator Port Transport ID Length = 0							
12-13	Reserved = 0							
14-15	Primary Target Port Descriptors Length = 0Ch							
16	Protocol Identifier				Code Set = 1			
17	PIV=1	RSVD	Association = 1		Identifier Type = 3			
18	Reserved = 0							
19	Identifier Length = 8							
20-27	(MSB) Primary Target Port Identifier (World Wide ID) (LSB)							

<table>
<tr><td>28-29</td><td colspan="5">Reserved = 0</td></tr>
<tr><td>30-31</td><td colspan="5">Secondary Relative Port = 0002h</td></tr>
<tr><td>32-33</td><td colspan="5">Reserved = 0</td></tr>
<tr><td>34-35</td><td colspan="5">Initiator Port Transport ID Length = 0</td></tr>
<tr><td>36-37</td><td colspan="5">Reserved = 0</td></tr>
<tr><td>38-39</td><td colspan="5">Secondary Target Port Descriptors Length = 0Ch</td></tr>
<tr><td>40</td><td colspan="3">Protocol Identifier</td><td colspan="2">Code Set = 1</td></tr>
<tr><td>41</td><td>PIV=1</td><td>RSVD</td><td colspan="2">Association = 1</td><td>Identifier Type = 3</td></tr>
<tr><td>42</td><td colspan="5">Reserved = 0</td></tr>
<tr><td>43</td><td colspan="5">Identifier Length = 8</td></tr>
<tr><td>44-51</td><td colspan="5">(MSB)
Secondary Target Port Identifier (World Wide ID)
(LSB)</td></tr>
</table>

- **Protocol Identifier** is valid only when PIV=1. Protocol Identifier = 0 indicates Fibre Channel devices. Protocol Identifier = 6 indicates SAS devices
- **Code Set** specifies the data type for the identifier field. Code Set = 1 indicates binary data
- **PIV (Protocol Identifier Valid)** set to one indicates that the Protocol Identifier field contains a valid value.
- **Association** specifies the entity with which the Identifier field is associated: 1h for Target or Relative Port.
- **Identifier Type** specifies the format and assignment authority for the identifier: 3h indicates NAA format of the WWID for Target Port.
- **Identifier** fields contain the actual Identifier Descriptor.
  - The Target Port Identifiers are defined in the NAA IEEE WWID format where:

    World Wide ID is a 64-bit unique identification for each drive. The format is: 5000CCAh xxxh yyb n wherexxx is the 12-bit block assignment defined for each model and manufacturing site yy is the 2-bit port/node ID select n is the 22-bit drive unique serial number.

16.5.1.9 Inquiry Data Format - EVPD = 1, Page Code - 8Ah

Table 45: Inquiry Data Format - EVPD = 1, (Page Code - 8Ah)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = 8Ah							
2-3	Page Length = 14 (000Eh)							
4	Reserved=0						STANDBY_Y	STANDBY_Z
5	Reserved=0					IDLE_C	IDLE_B	IDLE_A
6-7	Stopped Condition Recovery Time							
8-9	Standby_Z Condition Recovery Time							
10-11	Standby_Y Condition Recovery Time							
12-13	Idle_A Condition Recovery Time							
14-15	Idle_B Condition Recovery Time							
16-17	Idle_C Condition Recovery Time							

- **Qualifier** field is set to zero to indicate that the LUN specified in the Command Block is currently supported.
- **Peripheral Device Type** is set to zero to indicate that the device is Direct Access.
- **Page Code** is set to the value of the page code field in the CDB.
- **Page Length** is set to 14, and this field specifies the length of the following page data.
- If set to one, a power condition support bit **(STANDBY_Y, STANDBY_Z, IDLE_C, IDLE_B, IDLE_A**) indicates that the associated power condition may be entered with START STOP UNIT command and the associated power condition may be entered with a power condition timer if the timer is supported and enabled.
- **The recovery time fields** indicate the time, in one millisecond increments, that the logical unit takes to transition from the associated power condition to the active power condition. This time does not include the processing time for the command that caused this transition to occur. A value of zero indicates that the recovery time is not specified. A value of FFFFh indicates that the recovery time is more than 65.534 seconds.

16.5.1.10 Inquiry Data - EVPD = 1, Page Code - 90h

Table 46: Inquiry Data - EVPD = 1 (Page Code = 90h)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = 90h							
2-3	Page Length = 24 (0018h)							
4-15	Protocol-specific logical unit information descriptor 0.							
16-27	Protocol-specific logical unit information descriptor 1.							

- **Qualifier** field is set to zero to indicate that the LUN specified in the Command Block is currently supported.
- **Peripheral Device Type** is set to zero to indicate that the device is Direct Access.
- **Page Code** is set to the value of the page code field in the CDB.
- **Page Length** is set to 24, and this field specifies the length of the following page data.
- **Protocol-specific logical unit information descriptor 0** field is defined in Table 47
- **Protocol-specific logical unit information descriptor 1** field is defined in Table 47

Table 47: Protocol-specific logical unit information descriptor

Byte	BIT							
	7	6	5	4	3	2	1	0
0-1	Relative Port Identifier							
2	Reserved				Protocol Identifier = 6h			
3-5	Reserved							
6-7	Descriptor Length (0004h)							
8	Reserved							TLR CONTROL SUPPORTED = 0h
9-11	Reserved							

- **Relative Port Identifier** is set to 1 for Port A (Primary Port) or 2 for Port B (Secondary Port).
- **Protocol Identifier** is set to 6 to specify that this is a SAS SSP Descriptor.
- **TLR Control Supported** field specifies support of the TLR CONTROL field in the SAS SSP frame header. This field is set to zero to indicate that the drive does not support Transport Layer Retries

16.5.1.11 Inquiry Data Format - EVPD = 1, Page Code - B1h

Table 48: Inquiry Data - EVPD = 1 (Page Code = B1h)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = B1h							
2-3	Page Length = 60 (003Ch)							
4-5	Medium Rotation Rate= 1 (1h)							
6	Reserved							
7	Reserved				Nominal Form Factor = 3h			
8-63	Reserved							

- **Qualifier** field is set to zero to indicate that the LUN specified in the Command Block is currently supported.
- **Peripheral Device Type** is set to zero to indicate that the device is Direct Access.
- **Page Code** is set to the value of the page code field in the CDB.
- **Page Length** is set to 60, and this field specifies the length of the following page data.
- **Medium Rotation Rate** field is set to 1, which indicates the drive is an SSD.
- **Nominal Form Factor** field is set to 3h.

16.5.1.12 Inquiry Data Format - EVPD = 1, Page Code - D2h

Table 49: Inquiry Data - EVPD = 1 (Page Code = D2h)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Qualifier = 0			Peripheral Device Type = 0				
1	Page Code = D2h							
2	Reserved = 0							
3	Page Length = 120 (78h)							
4	HDC Version Length = 19 (13h)							
5 - 23	ASCII HDC Version							
24	Card Serial Number Length = 19 (13h)							
25 - 43	ASCII Card Serial Number							
44	NAND FLASH Version Length = 19 (13h)							
45 - 63	ASCII NAND FLASH Version							
64	Card Assembly Part Number Length = 19 (13h)							
65 - 83	ASCII Card Assembly Part Number							
84	Second Card Serial Number Length = 19 (13h)							
85 - 103	ASCII Second Card Serial Number							
104	Second Card Assembly Part Number Length= 19 (13h)							
105 - 123	ASCII Second Card Assembly Part Number							

- **Qualifier** is set to zero to indicate that the LUN specified in the Command Block is currently supported.
- **Peripheral Device Type** is set to zero to indicate that the device is Direct Access.
- **Page Code** is set to the value of the page code field in the CDB.
- **Page Length** is set to 100, and this field specifies the length of the following page data.

Note: If the media is not available, bytes 0 through 3 are valid. All the other fields are ASCII blanks (20h) with a null terminator (00h).

Note: All ASCII fields are alphanumeric, left aligned, and padded on the right with ASCII blanks (20h) with a null terminator (00h).

16.6 LOG SELECT (4C)

Table 50: Log Select (4C)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 4Ch							
1	Reserved = 0			Reserved = 0			PCR	SP
2	PC		Page Code					
3	SubPage Code= 0							
4-6	Reserved = 0							
7 8	(MSB) Parameter List Length = 0 (LSB)							
9	Reserved = 0						FLAG	LINK

The LOG SELECT command provides a means for the Initiator to clear statistical information maintained by the drive and reported via the LOG SENSE command.

- **PCR** The Parameter Code Reset determines whether the Log Sense parameters will be cleared and unit attention posted for all other Initiators. A value of 1 indicates that the parameters be cleared, while a value of zero (except when PC = 11b) indicates that the parameters not be cleared. Parameter list length must be zero when PCR is 1. The PC field is ignored for list parameters, i.e. when the Format and Linking (F&L) field contains 01b or 11b.
- **SP** The Save Parameters bit value of zero indicates that the page parameters not be saved. A value of 1 indicates that the page parameters that are savable be saved after they have been changed. SP bit MUST be 1 if parameter list length is greater than zero. Otherwise it will result in a *Check Condition* status being returned. The sense key shall be set to *Illegal Request* and additional sense code of *Invalid Field in CDB*.
- **PC** The Page Control field defines the type of parameters to be selected. The PC field set to 11b (and PCR is then a don't care) indicates that the Default Cumulative values are set to their default values of 0. If the PC field is set to 01b and PCR is set to 1, the Current Cumulative values are also set to their default values of 0.

  Parameter List Length MUST be zero when PC = 11b. Otherwise the command is terminated and a *Check Condition* status is returned. The sense key shall be set to *Illegal Request* and additional sense code of *Invalid Field in CDB*.
- **Page Code** field identifies which page is being selected. This field must be set to the values indicated in Page 0. If the Page Code value is invalid a Check Condition status is returned with a sense key of Illegal Request and additional sense code of Invalid Field in CDB.
  - If page code field is set to zero, then the selection applies to all log parameters in all valid log pages.
  - If page code field is set to a non zero, then the selection applies to all log parameters specified by this field.
- **SubPage Code** This field specifies the subpage to select. This field is not supported and must be set to 0.
- **Parameter List Length** The Parameter List Length field specifies the length in bytes of the parameter list that shall be located in the DATA OUT buffer. A parameter list length zero indicates that no pages shall be transferred.
  - If the PARAMETER LIST LENGTH field is set to zero, then the PCR bit, the SP bit, and the PC fields apply to the page (pages) addressed by the page code field.
  - If The PARAMETER LIST LENGTH field is set to non zero, and the if PAGE CODE field is non-zero or the SUBPAGE CODE field is non-zero, then the command shall be terminated with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN CDB.

•

Note: A specified length greater than 0x00FF will result in a *Check Condition* status being returned. A length that results in log data being truncated will generate a *Check Condition* status.

Note: For page 0Fh, the maximum parameter list length supported is 4004h (4 bytes for the header and 100h bytes for each of the 40h parameters that are supported). The Parameter List Length must be an integral of the number of parameters plus the 4 byte header. (Ex: Parameter length =104h for one parameter, 204h for 2 parameters,... 4004h for all 40h parameters).

The drive allows updates to the current cumulative values only. A value of zero is acceptable and is not considered an error. The drive updates only pages 0Eh, the Start/Stop Cycle page and 0Fh, the Application Client page. For other pages the parameters are ignored. If the data out buffer contains multiple pages then the application client should send the pages in ascending order. If the data out buffer contains multiple log parameters within a page, all log parameters within the page should be sent and they should be sent in ascending order by parameter code value. The drive shall return Check Condition status if the application client sends pages out of order, parameter codes out of order or missing parameter code. The sense key shall be set to Illegal Request and additional sense code set to Invalid Field in Parameter List. If one or more fields of the CDB are not set correctly the command will be terminated with a *Check Condition* status. The sense key shall be set to *Illegal Request* and additional sense code of *Invalid Field in CDB*. To indicate that parameters have changed, the Target generates a unit attention condition for all Initiators except the one that issued the LOG SELECT command.

The following list contains all individual page parameters (counters) that are set to their default value of zero by the LOG SELECT command (when PCR=1).

- Page **02h** parameters: (Counters for write errors)
  - Write errors recovered without delay
  - Write errors recovered with possible delays
  - LBAs with write fault error
  - Total errors recovered
  - Number of times recovery invoked
  - Total write byte count
  - LBAs with hard error
- Page **03h** parameters: (Counters for read errors)
  - Read errors recovered without delay
  - Read errors recovered with possible delays
  - LBAs with ECC detected error
  - Total errors recovered
  - Number of times recovery invoked
  - Total read byte count
  - LBAs with hard error.
- Page **05h** parameters: (Counters for Verify Errors)
  - Errors recovered without delay
  - Errors recovered with possible delays
  - LBAs with ECC detected error
  - Total errors recovered
  - Number of times recovery invoked
  - Total bytes verified

- LBAs with hard error.

- Page **06h** parameters: (Counters for non medium errors, seek and other hardware type failures)
  - Non-Medium Error Counter
- Page **15h** parameters: (Background Medium Scan information)
  - BMS Status parameter
  - all Medium Scan parameters
- Page **18h** parameters (SAS PHY Error counts - only cleared for the port which receives the Log Select)
  - Invalid DWORD Count
  - Running Disparity Error Count
  - Loss of DWORD Synchronization Count
  - PHY Reset Problem Count
- Page **30h** parameters:
  - Overrun Counter
  - Under run Counter
  - Device Cache Full Read Hits
  - Device Cache Partial Read Hits
  - Device Cache Write Hits
  - Device Cache Fast Writes
  - Device Cache Misses on Reads
- Page **37h** parameters:
  - Media Exception
  - Hardware Exception
  - Total Read Commands
  - Total Write Commands

16.7 LOG SENSE (4D)

Table 51: Log Sense (4D)

Byte	Bit 7	6	5	4	3	2	1	0
0	Command Code = 4Dh							
1	Reserved = 0			Reserved = 0			PPC=0	SP
2	PC		Page Code					
3	Subpage Code = 0							
4	Reserved = 0							
5 6	(MSB) Parameter Pointer = 0 (LSB)							
7 8	(MSB) Allocation Length (LSB)							
9	Reserved = 0						FLAG	LINK

The LOG SENSE command allows the Initiator to retrieve the statistical data regarding the drive.

- **PPC** (Parameter Pointer Control) bit must be set to zero. This specifies that the drive start transferring data starting from the field specified in the parameter pointer field for the number of bytes specified by the allocation length. If the PPC bit is set to 1, *Check Condition* status is returned with a sense key of *Illegal Request* and additional sense code of *Invalid Field in CDB*.
- **SP** (Save Parameters) bit set to 0 specifies that the drive does not save any log parameters. If it is set to 1, all page parameters that are savable (those pages denoted by a DS = 0 in the parameter header control byte) are saved.
- **PC** (Page Control) field defines the type of parameters to be selected. This field must be set to 01b to specify the current cumulative values. Any other value in this field will cause the command to end with a *Check Condition* status with a sense key of *Illegal Request* and an additional sense code of *Invalid Field in CDB*.
- **Page Code** field identifies which page is being requested. This field must be set to the values indicated in Page 0. If the Page Code value is invalid a *Check Condition* status is returned with a sense key of *Illegal Request* and additional sense code of *Invalid Field in CDB*
- **SubPage Code** This field specifies the subpage to select. This field is not supported and must be set to 0.
- **Parameter Pointer Field** specifies the beginning field for the transfer. This field must be set to 0000h. If the Parameter Pointer Field is not zero a *Check Condition* status is returned with a sense key of *Illegal Request* and additional sense code of *Invalid Field in CDB*.
- **Allocation Length** field specifies the maximum number of bytes the Initiator has allocated for returned Log Sense Data. No bytes are transferred if the length is zero. This condition is not considered an error. The Target terminates the Data In phase when all available Log Sense data has been transferred or when the number of bytes equals the allocation length, whichever is less.

16.7.1 Log Page parameters

Each log page begins with a 4-byte page header followed by zero or more variable-length log parameters.

Page header

Page Code field identifies which log page is being transferred.
The Page Length field specifies the length in bytes of the following log parameters.

Log parameters

Each log parameter begins with a 4-byte parameter header followed by one or more bytes of parameter value data.
The Parameter Code field identifies which log parameter is being transferred for that log page.
The Parameter Control field, the 3rd byte of each parameter header, contains several fields.

- **DU** The Disable Update bit is set to 0 to indicate that the drive updates the log parameter value to reflect events that should be noted by that parameter.
- **TSD** The Target Save Disable bit is set to zero to indicate that the drive provides a Target defined method for saving log parameters.
- **ETC** The Enable Threshold Comparison bit is set to 0 to indicate the drive does not perform comparisons between cumulative and any threshold values.
- **TMC** The Threshold Met Criteria field is not valid because this drive does not perform threshold comparisons. This field is set to 0.
- **Format and Linking** The F & L field indicates the type of log parameter and how parameters that reach their maximum value are handled.
  - 00b: Data counter: If any other parameter in this log page reaches its maximum value, then this parameter shall stop incrementing until reinitialized by a Log Select command.
  - 01b: List format ASCII data: No maximum values to handle
  - 10b: Data counter: If another parameter reported in this log page reaches its maximum value, then this parameter shall not stop incrementing. This parameter may be reinitialized by a Log Select command.
  - 11b: List format binary data: No maximum values to handle.

16.7.2 Log Sense Page 0

Page 0 indicates the supported log sense pages. This page is used to determine which additional pages an Initiator can request.

Table 52: Log Sense Page 0

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 0					
1	Reserved							
2-3	Page Length = 0010h (Number of Pages Supported)							
4	First supported page 00h							
5	Second supported page 02h							
6	Third supported page 03h							
7	Fourth supported page 05h							
8	Fifth supported page 06h							
9	Sixth supported page 0Dh							
10	Seventh supported page 0Eh							
11	Eighth supported page 0Fh							
12	Ninth supported page 10h							
13	Tenth supported page 11h							
14	Eleventh supported page 15h							
15	Twelfth supported page 18h							
16	Thirteenth supported page 1Ah							
17	Fourteenth supported Page Code =2Fh							
18	Fifteenth supported Page Code = 30h							
19	Sixteenth supported Page Code = 37h							

16.7.3 Log Sense Page 2

This page contains counters for write errors.

Table 53: Log Sense Page 2 (part 1 of 2)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 02h					
1	Reserved							
2-3	PageLength = 54h							
4-5	Parameter Code = 0000h							
6	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
7	Parameter Length = 08h							
8-15	Errors recovered without delay							
16-17	Parameter Code = 0001h							
18	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
19	Parameter Length = 08h							
20-27	Errors recovered with possible delays							
28-29	Parameter Code = 0002h							
30	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
31	Parameter Length = 08h							
32-39	Reserved = 0							
40-41	Parameter Code = 0003h							
42	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
43	Parameter Length = 08h							
44-51	Total errors recovered							
52-53	Parameter Code = 0004h							
54	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
55	Parameter Length = 08h							
56-63	Times recovery invoked							

Table 54: Log Sense Page 2 (part 2 of 2)

Byte	Bit							
	7	6	5	4	3	2	1	0
64-65	Parameter Code = 0005h							

66	**DU = 0**	**DS = 0**	**TSD = 0**	**ETC = 0**	**TMC = 0**	**F&L = 00b**
67	**Parameter Length = 08h**					
68-75	**Total bytes written**					
76-77	**Parameter Code = 0006h**					
78	**DU = 0**	**DS = 0**	**TSD = 0**	**ETC = 0**	**TMC = 0**	**F&L = 00b**
79	**Parameter Length = 08h**					
80-87	**Count of hard errors**					

All parameter counts indicate the number of sectors with the specified types of errors, except Times Recovery Invoked, which is a cumulative count of all recovery steps attempted on all sectors written.

16.7.4 Log Sense Page 3

This page contains counters for read errors.

Table 55: Log Sense Page 3 (part 1 of 2)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 03h					
1	Reserved							
2-3	PageLength = 54h							
4-5	Parameter Code = 0000h							
6	DU = 0	DS = 0	TSD=0	ETC = 0	TMC = 0		F&L = 00b	
7	Parameter Length = 08h							
8-15	Errors recovered without delay							
16-17	Parameter Code = 0001h							
18	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
19	Parameter Length = 08h							
20-27	Errors recovered with possible delays							
28-29	Parameter Code = 0002h							
30	DU = 0	DS = 0	TSD=0	ETC = 0	TMC = 0		F&L = 00b	
31	Parameter Length = 08h							
32-39	Reserved = 0							
40-41	Parameter Code = 0003h							
42	DU = 0	DS = 0	TSD=0	ETC = 0	TMC = 0		F&L = 00b	
43	Parameter Length = 08h							
44-51	Total errors recovered							
52-53	Parameter Code = 0004h							
54	DU = 0	DS = 0	TSD=0	ETC = 0	TMC = 0		F&L = 00b	
55	Parameter Length = 08h							
56-63	Times recovery invoked							
64-65	Parameter Code = 0005h							

Table 56: Log Sense Page 3 (part 2 of 2)

Byte	Bit							
	7	6	5	4	3	2	1	0

66	**DU = 0**	**DS = 0**	**TSD = 0**	**ETC = 0**	**TMC = 0**	**F&L = 00b**
67	**Parameter Length = 08h**					
68-75	**Total bytes read**					
76-77	**Parameter Code = 0006h**					
78	**DU = 0**	**DS = 0**	**TSD = 0**	**ETC = 0**	**TMC = 0**	**F&L = 00b**
79	**Parameter Length = 08h**					
80-87	**Count of hard errors**					

All parameter counts indicate the number of sectors with the specified types of errors, except Times Recovery Invoked, which is a cumulative count of all recovery steps attempted on all sectors read. ECC-on-the-fly correction is not included in any counters.

16.7.5 Log Sense Page 5

This page contains counters for verify errors.

Table 57: **Log Sense Page 5 (part 1 of 2)**

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 05h					
1	Reserved							
2-3	PageLength = 54h							
4-5	Parameter Code = 0000h							
6	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
7	Parameter Length = 08h							
8-15	Errors recovered without delay							
16-17	Parameter Code = 0001h							
18	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
19	Parameter Length = 08h							
20-27	Errors recovered with possible delays							
28-29	Parameter Code = 0002h							
30	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
31	Parameter Length = 08h							
32-39	Reserved = 0							
40-41	Parameter Code = 0003h							
42	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
43	Parameter Length = 08h							
44-51	Total errors recovered							
52-53	Parameter Code = 0004h							
54	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
55.	Parameter Length = 08h							
56-63	Times recovery invoked							
64-65	Parameter Code = 0005h							

Table 58: Log Sense Page 5 (part 2 of 2)

Byte	Bit							
	7	6	5	4	3	2	1	0
66	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
67	Parameter Length = 08h							
68-75	Total Bytes Verified							
76-77	Parameter Code = 0006h							
78	DU = 0	DS = 0		TSD = 0	TMC = 0		F&L = 00b	
79	Parameter Length = 08h							
80-87	Count of hard errors							

All parameter counts indicate the number of sectors with the specified types of errors, except Times Recovery Invoked, which is a cumulative count of all recovery steps attempted on all sectors verified. ECC-on-the-fly correction is not included in any counters.

16.7.6 Log Sense Page 6

This page contains counters for non-medium errors. This includes seek errors and other hardware type failures.

Table 59: Log Sense Page 6

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 06h					
1	Reserved							
2-3	PageLength = 0Ch							
4-5	Parameter Code = 00h							
6	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
7	Parameter Length = 08h							
8-15	Error count							

16.7.7 Log Sense Page D

This page contains temperature information.

Table 60: Log Sense Page D

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="2">Reserved</td><td colspan="6">Page code = 0Dh</td></tr>
<tr><td>1</td><td colspan="8">Reserved</td></tr>
<tr><td>2-3</td><td colspan="8">PageLength = 0Ch</td></tr>
<tr><td>4-5</td><td colspan="8">Parameter Code = 0000h</td></tr>
<tr><td>6</td><td>DU = 0</td><td>DS = 1</td><td>TSD = 0</td><td>ETC = 0</td><td colspan="2">TMC = 0</td><td colspan="2">F&L = 00b</td></tr>
<tr><td>7</td><td colspan="8">Parameter Length = 02h</td></tr>
<tr><td>8</td><td colspan="8">Reserved</td></tr>
<tr><td>9</td><td colspan="8">Temperature (degrees Celsius)</td></tr>
<tr><td>10-11</td><td colspan="8">Parameter Code 0001h</td></tr>
<tr><td>12</td><td>DU = 0</td><td>DS = 1</td><td>TSD = 0</td><td>ETC = 0</td><td colspan="2">TMC = 0</td><td colspan="2">F&L = 00b</td></tr>
<tr><td>13</td><td colspan="8">Parameter Length = 02h</td></tr>
<tr><td>14</td><td colspan="8">Reserved</td></tr>
<tr><td>15</td><td colspan="8">Reference Temperature (degrees Celsius)</td></tr>
</table>

16.7.8 Log Sense Page E

This page contains manufacturing date information.

Table 61: Log Sense Page E

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 0Eh					
1	Reserved = 0							
2-3	PageLength = 34h							
4-5	Parameter Code = 0001h							
6	DU=0	DS=1	TSD=0	ETC=0	TMC = 0		F&L = 00b	
7	Parameter Length = 06h							
8-11	Year of Manufacture (4 ASCII characters)							
12-13	Week of Manufacture (2 ASCII characters)							
14-15	Parameter Code 0002h							
16	DU=0	DS=0	TSD=0	ETC=0	TMC = 0		F&L = 00b	
17	Parameter Length = 06h							
18-21	Accounting Date Year (4 ASCII characters)							
22-23	Accounting Date Week (2 ASCII characters)							
24-25	Parameter Code 0003h							
26	DU=0	DS=1	TSD=0	ETC=0	TMC = 0		F&L = 00b	
27	Parameter Length = 04h							
28-31	Reserved = 0							
32-33	Parameter Code 0004h							
34	DU=0	DS=1	TSD=0	ETC=0	TMC = 0		F&L = 00b	
35	Parameter Length = 04h							
36-39	Reserved = 0							
40-41	Parameter Code 0005h							
42	DU=0	DS=1	TSD=0	ETC=0	TMC = 0		F&L = 00b	
43	Parameter Length = 04h							
44-47	Reserved = 0							
48-49	Parameter Code 0006h							

50	**DU=0**	**DS=1**	**TSD=0**	**ETC=0**	**TMC = 0**	**F&L = 00b**
51	**Parameter Length = 04h**					
52-55	**Reserved = 0**					

The week and year that the device was manufactured shall be set in the parameter field defined by parameter code 0001h. The date of manufacture cannot be saved using the LOG SELECT command. The data is expected in numeric ASCII characters (30-39h) in the form YYYYWW. The accounting date specified by parameter code 0002h is a parameter that can be saved using the LOG SELECT command.

16.7.9 Log Sense Page F

This page contains the Application Client Log.

Table 62: Log Sense Page F

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 0Fh					
1	Reserved							
2-3	Page length = 4000h							
	Application client log parameter							
4-259	1st application client log parameter							
16132-16387	64th application client log parameter							

The following table describes the application client log parameter structure.

Table 63: Log Sense Page F, Application Client Log

Byte	Bit							
	7	6	5	4	3	2	1	0
0-1	Parameter code							
2	DU = 1	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
3	Parameter length = FCh							
4-	First parameter byte							
255	Last parameter byte							

Parameter code 0000h through 003Fh are supported.

The values stored in the parameter bytes represent data sent to the device in a previous LOG SELECT command.

16.7.10 Log Sense Page 10

This page contains self-test results. The results of the 20 most recent self-tests are stored in this Log page.

Table 64: **Log Sense Page 10**

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 10h					
1	Reserved							
2-3	PageLength = 190h							
4-23	1st self-test results log parameter							
384- 403	20th self-test results log parameter							

The following table describes the self-test results log parameter structure

Table 65: Log Sense Page 10, self-test results

Byte	Bit							
	7	6	5	4	3	2	1	0
0-1	Parameter code							
2	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 11b	
3	Parameter Length = 10h							
4	Function Code			RSVD	Self-Test Results Value			
5	Extended Segment Number							
6-7	Timestamp							
8-15	LBA of First Failure							
16	Reserved				Sense Key			
17	Additional Sense Code							
18	Additional Sense Code Qualifier							
19	Vendor specific							

- **Parameter Code** identifies the log parameter for the log page. The parameter code field for the results of the most recent test will be 0001h. The parameter for the next most recent will be 0002h.
- **Function Code** contains the content of the Function Code field in the SEND DIAGNOSTIC command that initiated this self-test.
- **Self-Test Results Value** is described in the table below.

Table 66: Log Sense Page 10, self-test results

Value	Description
0h	The self-test routine completed without error.
1h	The background self-test routine was aborted by the initiator using a SEND DIAGNOSTIC command with the Abort Background self-test function.
2h	The self-test routine was aborted by the application client by a Task Management function or a reset.
3h	An unknown error occurred while the Target was executing the self-test routine and the Target was unable to complete the self-test routine.
4h	The self-test completed with a test element that failed and it is not known which test element failed.
5h	The first segment of the self-test failed.
6h	The second segment of the self-test failed.
7h	The third or greater segment of the self-test failed (see the Extended segment number field).
8h-Eh	Reserved.
Fh	The self-test is in progress.

- **Extended Segment Number** This field identifies the number of the segment that failed during self-test. If no segment failed, this field will be 00h.

Table 67: Log Sense Page 10, Extended Segment Number

Extended Segment Number	Short Self-Test	Extended Self-Test
1h	Drive Ready Test	
2h	Drive Diagnostics	
3h	SMART	
4h	Low Level Format check	
5h	PLI Capacitor Self-Test	
6h	Random Verify	
7h	- Verify First 300 MB - Verify Last 100 MB	Verify all LBAs
8h	Recheck SMART	

- **Timestamp** This field contains the total accumulated power-on hours of the Target at the time the self-test completed.
- **LBA of first failure** This field contains the LBA of the first logical block address where a self-test error occurred. If no errors occurred during the self-test or the error is not related to a LBA then the field will be FFFFFFFFFFFFFFFFh.
- **Sense Key, Additional Sense Code and Additional Sense Code Qualifier** These fields will contain the additional information relating to the error or exception conditions during self-test.

See Section 16.40 “SEND DIAGNOSTIC (1D)” on page 197, for detailed listing of operations carried out by SEND DIAGNOSTIC command and Power on Diagnostics.

16.7.11 Solid State Media log page (Page 11)

The Solid State Media log page indicates parameters that are specific to SCSI target devices that contain solid state media. A device server that implements the Solid State Media log page shall implement one or more of the defined parameters.

Table 68: Solid State Media log page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	DS	SPF (0)	Page code = 11h					
1	Reserved							
2-3	Page Length = (n -3)							
	Solid State Media log parameters							
4	Solid State Media parameter (first) see Table 69:							
....	First Medium Scan Parameter							
....	...							
n	Solid State Media parameter (last) see Table 69:							

The disable save (DS) bit, the subpage format (SPF) bit, the PAGE CODE field, the SUBPAGE CODE field, and the PAGE LENGTH field are described in SPC-4.

Table 69: Solid State Media log page parameter codes

Parameter Code	Description
0001h	Percentage Used Endurance Indicator
All others values	Reserved

Table 70: Percentage Used Endurance Indicator parameter format

Byte	Bit							
	7	6	5	4	3	2	1	0
0-1	PARAMETER CODE (0001h)							
2	DU	Obsolete	TSD	ETC	TMC		Formant and Linking (11b)	
3	PARAMETER LENGTH (04h)							
4 -6	Reserved							
7	PERCENTAGE USED ENDURANCE INDICATOR							

The FORMAT AND LINKING field shall be set to 11b, indicating that this parameter is a binary format list parameter. The values for the other bits and fields in the parameter control byte for a binary format list parameter are defined in SPC-4.

The PARAMETER LENGTH field indicates the number of bytes to follow in the log parameter.

The PERCENTAGE USED ENDURANCE INDICATOR field indicates an estimate of the percentage of device life that has been used. The value in the field shall be set to zero at the time of manufacture. A value of 100 indicates that the estimated endurance of the device has been consumed, but may not indicate a device failure (e.g., minimum power-off data retention capability reached for devices using flash technology). The value is allowed to exceed 100. Values greater than 254 shall be reported as 255. The device server shall update the value at least once per power-on hour

16.7.12 Log Sense Page 15

This page contains information about Background Medium Scan operations.

Table 71: Log Sense Page 15

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page code = 15h					
1	Reserved							
2-3	Page Length = (19 + 24N -3)							
	Background Medium Scan parameters							
4-19	BMS Status Parameter							
20-43	First Medium Scan Parameter							
	...							
19+24N	Last Medium Scan Parameter							

The following table describes the BMS Status Parameter structure.

Byte	Bit 7	6	5	4	3	2	1	0
0-1	Parameter Code = 0000h							
2	DU=0	DS=0	TSD=0	ETC=0	TMC=0		F&L = 11b	
3	Page Length = 0Ch							
4-7	Power On Minutes							
8	Reserved = 0							
9	BMS Status							
10-11	Number of Scans Performed							
12-13	Medium Scan Progress							
14-15	Reserved = 0							

- **Power On Minutes** indicates the total power on minutes at the time the log page is requested
- **BMS Status** is described in the following table

BMS Status	Description
00h	No scans active
01h	Background medium scan is active
02h	Background pre-scan is active

BMS Status	Description
03h-04h	Not supported
05h	Background scan halted due to medium formatted without P-List
06h	Background scan halted due to a vendor-specific cause
07h	Background scan halted due to temperature out of range
08h	Scan suspended until BMS Interval Timer expires
09h - FFh	Reserved

- Number of Scans Performed indicates the number of background scans that have been performed over the life of the-drive.
- Medium Scan Progress is a percent complete indication of the medium scan. The returned value is a numerator that has 65,536 (1 00 00h) as its denominator.

The following table describes the Medium Scan Parameter structure.

Byte	Bit							
	7	6	5	4	3	2	1	0
0-1	Parameter Code = 0001h - 0800h							
2	DU=0	DS=0	TSD=0	ETC=0	TMC=0		F&L = 11b	
3	Page Length = 14h							
4-7	Power On Minutes							
8	Reassign Status = 0				Sense Key			
9	Additional Sense Code							
10	Additional Sense Code Qualifier							
11-15	Reserved = 0							
16-23	LBA							

- **Power On Minutes** indicates the total power on minutes at the time the error was detected.
- **Reassign Status** is set to 0h. Auto-reallocation is automatic and no action needs to be taken by the Initiator

16.7.13 Log Sense Page 18

This page contains protocol-specific log parameters.

Table 72: Log Sense Page 18

Byte	Bit 7	6	5	4	3	2	1	0
0	Page code = 18h							
1	SubPage Code (00h)							
2-3	(MSB) Page Length (D8h) (LSB)							
Protocol-specific log parameters								
4-111	First Protocol-specific log parameter - Primary Port							
112-219	Last Protocol-specific log parameters - Secondary Port							

Table 73: SAS Log Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0-1	(MSB) Parameter Code (0001h for primary port; 0002h for secondary) (LSB)							
2	DU (=0)	Obsolete	TSD (=0)	ETC (=0)	TMC (00b)		Format and Linking	
3	Parameter Length (68h)							
4	Reserved				Protocol IDENTIFIER (6h)			
5	Reserved							
6	Generation Code							
7	Number of Phys (01h)							
8	Reserved							
9	PHY IDENTIFIER (00h)							
10	Reserved							
11	SAS Phy Log Descriptor Length (60h)							
12	Reserved	Attached Device Type			Attached Reason			
13	Reason				Negotiated Physical Link Rate			
14	Reserved				Attached SSP Initiator Port	Attached STP Initiator Port	Attached SMP Initiator Port	Reserved
15	Reserved				Attached SSP Target Port	Attached STP Target Port	Attached SMP Target Port	Reserved

16-23	(MSB) SAS Address (the address of the target port) (LSB)
24-31	(MSB) ATTACHED SAS ADDRESS (the address received in the incoming IDENTIFY) (LSB)
32	ATTACHED PHY IDENTIFIER (the phy identifier received in the incoming IDENTIFY)
33-39	Reserved
40-43	(MSB) INVALID DWORD COUNT (LSB)
44-47	(MSB) RUNNING DISPARITY ERROR COUNT (LSB)
48-51	(MSB) LOSS OF DWORD SYNCHRONIZATION (LSB)
52-55	(MSB) PHY RESET PROBLEM (LSB)
56-57	Reserved
58	Phy event Descriptor Length (0Ch)
59	Number of Event Descriptors (04h)
60-62	Reserved
63	Phy Event Source (01h) (Invalid DWORD Count)
64-67	(MSB) Phy Event (LSB)
68-71	(MSB) Peak Value Detector Threshold (00h) (LSB)
72-74	Reserved
75	Phy Event Source (02h) (Running Disparity Error Count)
76-79	(MSB) Phy Event (LSB)

80-83	**(MSB)** **Peak Value Detector Threshold (00h)** **(LSB)**
84-86	**Reserved**
87	**Phy Event Source (03h) (Loss of DWORD Sync)**
88-91	**(MSB)** **Phy Event** **(LSB)**
92-95	**(MSB)** **Peak Value Detector Threshold (00h)** **(LSB)**
96-98	**Reserved**
99	**Phy Event Source (04h) (PHY Reset problen)**
100-103	**(MSB)** **Phy Event** **(LSB)**
104-107	**(MSB)** **Peak Value Detector Threshold (00h)** **(LSB)**

- **Attached Device Type**: set to the value received by this PHY during an Identify Sequence.
- **Attached Reason:** If the phy is a physical phy and a SAS phy or expander phy is attached, then the ATTACHED REASON field indicates the value of the REASON field in the last received IDENTIFY address frame (see Table 22 on page 46) during the identification sequence. If the phy is a physical phy and a SATA phy is attached, then the ATTACHED REASON field shall be set to 0h after the initial Register - Device to Host FIS has been received. If the phy is a virtual phy, then the ATTACHED REASON field shall be set to 0h.
- **Reason:** The REASON field indicates the reason for the last link reset sequence as reported in the last transmitted IDENTIFY address frame. (see Table 22 on page 46). If the phy is a physical phy and a SATA phy is attached, then the REASON field indicates the reason for the link reset sequence. For Reason field, refer Table 22 on page 46.
- **Negotiated PHY Link Rate**: set to the link rate negotiated during last Link Reset Sequence.
  - set to 8h when the PHY is enabled and the negotiated speed is 1.5G
  - set to 9h when the PHY is enabled and the negotiated speed is 3.0G
  - set to Ah when the PHY is enabled and the negotiated speed is 6.0G
- **The GENERATION CODE** field is a one-byte counter that shall be incremented by one by the device server every time the values in this mode page or the SAS-2 Phy mode page (see section 10.2.7.7) field values are changed. A GENERATION CODE field set to 00h indicates the generation code is unknown. The device server shall wrap this field to 01h as the next increment after reaching its maximum value (i.e., FFh). The GENERATION CODE field is also contained in the Protocol-Specific Port log page and may be used to correlate phy settings across mode page and log page accesses.
- **Attached Reason:** indicates the value of the REASON field received in the IDENTIFY address frame.
- **Attached Initiator Port bits:** set to the value received by this PHY during an Identify Sequence.
- **Attached Target Port:** set to the value received by this PHY during an Identify Sequence.
- **SAS ADDRESS:** field contains the SAS address *transmitted* by this PHY during an Identify Sequence.
- **Attached SAS ADDRESS:** field contains the SAS address *received* by this PHY during an Identify Sequence.
- **Attached PHY Identifier:** field contains the SAS PHY Identifier *received* by this PHY during an Identify Sequence.

- **INVALID DWORD COUNT:** indicates the number of invalid dwords that have been received outside of phy reset sequences. The count wraps at the maximum value.
- **RUNNING DISPARITY ERROR COUNT:** RUNNING DISPARITY ERROR COUNT increments by one when the port has acquired dword synchronization and detects a transmission word containing a running disparity error at the receiver. When the port has lost dword synchronization, the Running Disparity Error Count is not incremented. The count stops at the maximum value.
- **LOSS OF DWORD SYNCRONIZATION:** indicates the number of times the phy has lost dword synchronization and restarted the link reset sequence of phy reset sequences. The count wraps at the maximum value.
- **PHY RESET PROBLEM:** indicates the number of times the phy reset sequence has failed due to a failure to gain dword sync in the retry speed match speed negotiation. The count wraps at the maximum value.

16.7.14 Log Sense Page 1A

Table 74: Log Sense Page 1A

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 1Ah					
1	SubPage Code (00h)							
2-3	Page Length (30h)							
4-5	Parameter Code 0001h							
6	DU	Obsolete	TSD	ETC	TMC	TMC	FMT & Linking	FMT & Linking
7	Parameter Length = 4							
8-11	Accumulated Transitions to Active State							
12-13	Parameter Code 0002h							
14	DU	Obsolete	TSD	ETC	TMC	TMC	FMT & Linking	FMT & Linking
15	Parameter Length = 4							
16-19	Accumulated Transitions to Idle_A							
20-21	Parameter Code 0003h							
22	DU	Obsolete	TSD	ETC	TMC	TMC	FMT & Linking	FMT & Linking
23	Parameter Length = 4							
24-27	Accumulated Transitions to Idle_B							
28-29	Parameter Code 0004h							
30	DU	Obsolete	TSD	ETC	TMC	TMC	FMT & Linking	FMT & Linking
31	Parameter Length = 4							
32-35	Accumulated Transitions to Idle_C							
36-37	Parameter Code 0008h							
38	DU	Obsolete	TSD	ETC	TMC	TMC	FMT & Linking	FMT & Linking
39	Parameter Length = 4							
40-43	Accumulated Transitions to Standby_Z							
44-45	Parameter Code 0009h							
46	DU	Obsolete	TSD	ETC	TMC	TMC	FMT & Linking	FMT & Linking
47	Parameter Length = 4							
48-51	Accumulated Transitions to Standby_Y							

16.7.15 Log Sense Page 2F

This page contains SMART Status and Temperature Reading.

Table 75: Log Sense Page 2F

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 2Fh					
1	Reserved							
2-3	PageLength = 2Ch							
4-5	Parameter Code = 0000h							
6	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 11b	
7	Parameter Length = 04h							
8	SMART Sense Code Byte							
9	SMART Sense Qualifier							
10	Most Recent Temperature Reading							
11	Vendor Temperature Trip Point							
12	Vendor Unique Maximum Temperature							
13-15	Vendor Unique Reserved = 000000h							
16-47	Vendor Unique Parameters (see Table 76:)							

Table 76: Vendor Unique parameter Code = 0000

Byte	Bit							
	7	6	5	4	3	2	1	0
0-1	Parameter code =0000h							
1	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 11b	
2-3	PageLength = O4h							
4-5	SMART Parameter Sense Code Byte							
6	SMART Parameter Sense Qualifier							
7	SMART Attribute Percentage of Threshold							
8	SMART Attribute Trip							

SMART PARAMETER SENSE CODE is the one-byte value indicating the severity of this particular parameter when host notification for SMART trip is made. For example, 0x5D indicates pre-fail attribute and 0x0B indicates warning attribute.
SMART PARAMETER SENSE QUALIFIER is the one-byte value that uniquely identifies each particular parameter when host notification for SMART trip is made.
SMART ATTRIBUTE PERCENTAGE OF THRESHOLD indicates an estimate of the percentage of threshold reached for the vendor unique SMART attributes. The value in the field is set to zero at the time of manufacture. A value of 100 indicates that the threshold has been reached and SMART trip will be reported to the host if enabled. See Mode Page 0x1C (Information Exceptions Control). The value is allowed to exceed 100. Values greater than 254 are reported as 255. The device server shall update the value at least once per power-on hour. Note that the Volatile memory backup attribute is a pass/fail indicator so it will always read 0 unless the capacitor self test fails, and in that case it would report 100.
SMART ATTRIBUTE TRIP is set to 1b if the threshold for that SMART attribute has ever been exceeded. It is set to 0b if the threshold has never been exceeded.

For the vendor unique parameters codes > 0000h:

Parameter code = 0001h Remaining Reserve 1
Parameter code = 0002h Remaining Reserve 2
Parameter code = 0003h Volatile Memory Backup Failure
Parameter code = 0004h Wear Indicator
Parameter code > 0004h Reserved

16.7.16 Log Sense Page 30

Table 77: Log Sense Page 30

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved		Page code = 30h					
1	Reserved = 0							
2-3	Page Length = 0030h							
4-5	Parameter Code = 0000h							
6	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		F&L = 00b	
7	Parameter Length = 2Ch							
8-51	Reserved = 0							

16.7.17 Log Sense Page 37

This page contains a series of miscellaneous data counters including information about predictive failure analysis occurrences.

Table 78: Log Sense Page 37

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page code = 37h					
1	Reserved							
2-3	Page Length = 0030h (48)							
4-5	Parameter Code = 0000h							
6	DU=0	DS=0	TSD=0	ETC=0	TMC = 0		F&L = 00b	
7	Parameter Length = 2Ch							
8 - 11	(MSB) Power on Hours (hours only) (LSB)							
12 - 19	(MSB) Total Bytes Read (LSB)							
20 - 27	(MSB) Total Bytes Written (LSB)							
28	Max Drive Temp (degrees Celsius)							
29 - 30	(MSB) Reserved = 0 (LSB)							
31	Number of Information Exceptions							
32	MED EXC	HDW EXC	Reserved = 0					
33 - 40	Total Read Commands							
41 - 48	Total Write Commands							
49	Reserved = 0							
50-51	Flash Correction Count							

The **Power on Hours** field specifies the total time the drive has been powered on in hours only.

The **Max. Drive Temperature** field specifies the maximum temperature, in degrees Celsius, the drive has ever reached.

The Number of Information Exceptions field gives the number of Information Exceptions during the life of the drive and not the number of Information Exceptions that have been reported. The number of reported Information Exceptions may be less due to the settings of Mode Page 0x1C. NOTE: This field does not include occurrences of any Information Exception Warnings.

If set, the **Media Exception and Hardware Exception** bits indicate that an Information Exception has occurred during the life of the drive. These flags are set during an Information Exception that may or may not coincide with the reporting of an Information Exceptions as mentioned above.

Total Read Commands counter is incremented for each Read (6) and Read (10) command received.

Total Write Commands counter is incremented for each Write (6), Write (10), Write Verify and Write Verify (16) command received.

Flash Correction Count is incremented each time ECC correction is applied to data stored in Flash ROM.

16.8 MODE SELECT (15)

Table 79: Mode Select (15)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Command Code = 15h</td></tr>
<tr><td>1</td><td colspan="3">Reserved = 0</td><td>PF=1</td><td colspan="3">Reserved = 0</td><td>SP</td></tr>
<tr><td>2
3</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>4</td><td colspan="8">Parameter List Length</td></tr>
<tr><td>5</td><td colspan="2">VU = 0</td><td colspan="4">Reserved = 0</td><td>FLAG</td><td>LINK</td></tr>
</table>

The MODE SELECT (15) command provides a means for the Initiator to specify LUN or device parameters to the Target. It also allows an Initiator to specify options the Target uses in error recovery, caching, and formatting.

There is a single set of Mode Page parameters shared by all Initiators.

- **PF** A PF (Page Format) bit value of one indicates that the data sent by the Initiator after the Mode Select Header and the Block Descriptor, if any, complies to the Page Format. The Target ignores this field since it only accepts mode parameters in the Page Format.
- **SP** Save Pages. This indicates

0 The drive shall not save the pages sent during the Data Out phase but will use them for all following commands until the power is removed, a reset is received, or a new MODE SELECT command is received.

1 The drive will save the data in the reserved area of the media. It will be used for all the following commands until another MODE SELECT command is issued. This information is maintained over a power cycle or reset of the drive.

- **Parameter List Length** This specifies the number of bytes to be sent from the Initiator. A parameter list length of zero suppresses data transfer and is not considered an error.

The MODE SELECT parameter list contains a 4-byte header followed by zero or one block descriptor followed by zero or more pages. The pages that are valid with this command are defined in the addendum under the heading **Mode Select Data**, as they vary with the drive model.

Application Note

The Initiator should issue a MODE SENSE command requesting all Changeable values (see PCF field in byte two of the CDB) prior to issuing a MODE SELECT command. This is necessary to find out which pages are implemented by the drive and the length of those pages. In the Pages of the MODE SENSE command the drive will return the number of bytes supported for each Page. The Page Length set by the Initiator in the MODE SELECT command must be the same value as returned by the drive in MODE SENSE Page Length. If not, the drive will return *Check Condition* status with sense key of *Illegal Request*.

Note: If an Initiator sends a MODE SELECT command that changes any parameters that apply to other Initiators, the drive shall generate an unit attention condition for all Initiators except for the one that issued the MODE SELECT command. The drive shall set the additional sense code to *Parameters Changed* (2Ah).

16.9 MODE SELECT (55)

Table 80: Mode Select (55)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 55h							
1	Reserved = 0			PF=1	Reserved = 0			SP
2-6	Reserved = 0							
7-8	(MSB) Parameter List Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The MODE SELECT (55) command provides a means for the Initiator to specify LUN or device parameters to the Target. See the MODE SELECT (15) command for a description of the fields in this command.

16.10 MODE SENSE (1A)

Table 81: Mode Sense (1A)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 1Ah							
1	Reserved			RSVD	DBD	Reserved = 0		
2	PCF		Page Code					
3	Subpage Code							
4	Allocation Length							
5	VU = 0		Reserved = 0				FLAG	LINK

The MODE SENSE (1A) command provides a means for the drive to report various device parameters to the Initiator. It is the complement to the MODE SELECT command.

If the **DBD** (Disable Block Descriptor) bit is zero, the Target will return the Block Descriptor. If the DBD bit is set to 1, the Target will not return the Block Descriptor.

Allocation Length indicates the maximum number of bytes that the Initiator has set aside for the DATA IN phase. A value of zero is not considered an error. If the allocation length is smaller than the amount available, that portion of the data up to the allocation length will be sent. This may result in only a portion of a multi-byte field being sent.

Page Control Field: PCF (Page Control Field) defines the type of Page Parameter values to be returned.

PCF Meaning

0 0 **Report current values.** The drive returns the current values under which the logical unit is presently configured for the page code specified. The current values returned are

1. Initially following power-up but before the media is accessed, the default values become current. Once the media can be accessed, the saved values are read from the Reserved Area and become current.
2. The parameters set in the last successful MODE SELECT command.
3. The saved values if a MODE SELECT command has not been executed since the last power-on, hard RESET condition, or TARGET RESET message.

Following the completion of start-up, execution of the MODE SELECT command can modify the current values.

Note: Those parameters associated with format are not considered current and are not saved until the successful completion of a FORMAT UNIT command.
In addition, the current values take on the saved values after a reset if the parameters were saved. If the Page Code is 3Fh, then all pages implemented by the Target are returned to the Initiator with fields and bit values set to current values.
If the Page Code is not 3Fh, the page defined by the Page Code, if supported by the Target, is returned with fields and bits set to current values.

Note: The drive will not process the MODE SELECT command until the completion of spin-up. Therefore, the Initiator cannot modify the current values prior to the saved values being read in.

0 1 **Report changeable value.** The drive returns the changeable values for the page code specified. The page requested is returned containing information that indicates which fields are changeable. All bits of parameters that are changeable shall be set to one. Parameters that are *defined by the drive* shall be set to zero. If any part of a field is changeable, all bits in that field shall be set to one.

Note: For a value field such as the buffer ratios of page 2 the bit field will not indicate the range of supported values but rather that the field is supported.

1 0 **Report default value.** The drive returns the default values for the page code specified. The parameters not supported by the drive are set to zero.

1 1 **Report saved value.** The drive returns the saved value for the page code specified.

Saved values are one of the following:

- the values saved as a result of MODE SELECT command
- identical to the default values
- zero when the parameters are not supported

The Page Length byte value of each page returned by the drive indicates up to which fields are supported on that page.

Page Code: This field specifies which page or pages to return. Page code usage is defined in the figure below.

Table 82: Page Code Usage

Page Code	Description
00h - 1Ch	**Return specific page, if supported.**
3Fh	**Return all supported pages.**

If a Page Code of 3Fh is used, MODE SENSE returns the pages in ascending order with one exception. Page 0 is always returned last in response to a MODE SENSE command.

If an unsupported page is selected, the command is terminated with a CHECK CONDITION status and available sense of ILLEGAL REQUEST/INVALID FIELD IN CDB.

Subpage Code: This field specifies the subpage to return, and may be set to a specific page, or to FFh for all supported sub-pages.

16.10.1 Mode Parameter List

The mode parameter list contains a header followed by zero or more block descriptors followed by zero or more variable length pages.

16.10.1.1 Header

The header used for the 6-byte CDB is defined below.

Table 83: Mode parameter header (6)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Mode Data Length							
1	Medium Type = 0							
2	WP=0	Reserved=0		DPOFUA =1	Reserved = 0			
3	Block Descriptor Length (= 0 or 8)							

The header used for the 10-byte CDB is defined below.

Table 84: Mode parameter header (10)

Byte	Bit							
	7	6	5	4	3	2	1	0
0 1	(MSB) Mode Data Length (LSB)							
2	Medium Type = 0							
3	WP=0	Reserved=0		DPOFUA =1	Reserved = 0			
4 5	Reserved = 0							
6 7	(MSB) Block Descriptor Length (= 0 or 8) (LSB)							

- **Mode Data Length**. When using the MODE SENSE command, the mode data length field specifies the length in bytes of the following data that is available to be transferred. The mode data length does not include the length byte itself. When using the MODE SELECT command, this field is reserved.
- **Medium Type** field is always set to zero in the drive (Default Medium Type).
- **WP**. When used with the MODE SELECT command, the Write Protect (WP) bit is reserved.
  When used with the MODE SENSE command, a Write Protect (WP) bit of zero indicates that the medium is write enabled.
- **DPOFUA** bit value of 1 indicates that the Target supports the FUA and DPO bits in the Read and Write Commands.
- **Block Descriptor Length** specifies the length in bytes of the block descriptors. When used with the MODE SELECT command, zero or eight is supported by the drive. When used with the MODE SENSE command, the drive returns eight to indicate that only a single block descriptor is available.

Note: DPOFUA is ignored during Mode Select command processing although the SCSI Standard states that it is reserved during Mode Select. Ignoring it allows the Mode Sense Parameter List for the byte containing this bit to be re-used as a Mode Select Parameter List.

16.10.1.2 Block Descriptor

Table 85: Mode Parameter Block Descriptor

Byte 0 **Byte 1** **Byte 2** **Byte 3**	**(MSB)** **Number of Blocks** **(LSB)**
Byte 4	**Density code = 0**
Byte 5 **Byte 6** **Byte 7**	**(MSB)** **Block Length** **(LSB)**

The Block descriptor provides formatting information about the Number of Blocks (user addressable) to format at the specified Block Length.

- Number of Blocks

  When used with the MODE SELECT command, the **Number of Blocks** field must be

  - Zero to indicate not to change available blocks
  - 0xFFFFFFFF to indicate all available blocks
  - The exact number of blocks in the data area of the drive, which can be obtained with the MODE SENSE
  - The number of blocks less than exact one, in order to **CLIP** the number of blocks

  Any other value is invalid and causes the command to fail with *Check Condition* status.

  When used with the MODE SENSE command, the field contains the exact number of blocks.

- Density Code
  - Always 0 for direct access devices.
- Block Length

  The Block Length field reflects the number of bytes of user data per sector (not including any protection information). When used with the MODE SELECT command, the **Block length** field must contain the value from 512 to 528 (8 bytes step) or zero. Otherwise the drive will terminate the command with *Check Condition* status.

  A FORMAT UNIT command is required to cause these parameters to become current only if the block length parameter is different from the current block length.

  When used with the MODE SENSE command, the field is dependent on how the media is currently formatted.

16.10.1.3 Page Descriptor

Table 86: Mode Parameter Page Format

Byte 0	**PS**	**SPF**	**Page Code**
Byte 1	**Page Length**		
Byte 2-n	**Mode Parameters**		

Each mode page contains a page code, a page length, and a set of mode parameters.

When using the MODE SENSE command, a Parameter Savable (PS) bit of one indicates that the mode page can be saved by the drive in the reserved area of the drive. A PS bit of zero indicates that the supported parameters cannot be saved. When using the MODE SELECT command, the PS bit is reserved (zero).

SPF (Sub-Page Format) is set to zero to indicate the short page format is used. The bit is set to one to indicate the long format is used, supporting sub-pages. The drive supports the following mode page codes:

Table 87: Mode Parameter Page Format

Page	Description	PS
00	Vendor Unique Parameters	1
01	Read-Write Error Recovery Parameters	1
02	Disconnect/Reconnect Control Parameters	1
03	Format Device Parameters	0
04	Rigid Disk Geometry Parameters	0
07	Verify Error Recovery Parameters	1
08	Caching Parameters	1
0A	Control Mode Page	1
0C	Notch Parameters	1
19	Port Control Page	1
1A	Power Control Parameters	1
1C	Informational Exceptions Control	1

The page length field specifies the length in bytes of the mode parameters that follow. If the Initiator does not set this value to the value that is returned for the page by the MODE SENSE command, the drive will terminate the command with *Check Condition* status.

16.10.2 Mode Page 00 (Vendor Unique Parameters)

Table 88: Vendor Unique Parameters - Page 00

Byte	Bit								Default
	7	6	5	4	3	2	1	0	
0	PS	0	Page Code = 00h						80h
1	Page Length = 0Eh								0Eh
2	Ignored								00h
3	Ignored								00h
4	Ignored								00h
5	Ignored			FDD	Ignored		CAEN	Ignored	02h
6	Ignored				OCT (high nibble)				00h
7	Overall Command Timer (low byte)								00h
8	Ignored								00h
9	Temperature Threshold								00h
10	Command Aging Limit (Hi byte)								00h
11	Command Aging Limit (Low byte)								30h
12	Error Injection	Read Reporting Threshold							16h
13-14	Ignored								00h
15	Ignored		FCERT	Ignored				Reserved = 0	00h

Fields marked in the table as 'Ignored' are not used or checked by the drive. They will be initialized to zero but can be set as desired for compatibility with older drives.

- **FDD** (Format Degraded Disable) controls the reporting of Format Degraded sense data for Test Unit Ready commands when the drive is in a format degraded state. When the FDD bit is one, Format Degraded sense data will not be reported for a Test Unit Ready command. When the FDD bit is zero, Format Degraded sense data will be reported for Test Unit Ready commands when the drive is in a format degraded state. This bit does not affect the reporting of Format Degraded conditions for any media access commands.
- **CAEN** (Command Aging Enable) When set this bit causes the Command Age Limit timer to be used to avoid commands waiting in the command queue for an indefinite period. When commands have been in the queue for a period of time greater than the timer limit they will be reordered to be executed on a first come first served basis. When this bit is reset, commands are always executed based on the queue reordering rules.
- **OCT** (Overall Command Timer) controls the maximum command execution time, from receipt by the drive until status is returned. If the command is unable to complete in the specified amount of time, it will be aborted with Check Condition status, Aborted Command sense key. The Overall Command Timer does not alter the behavior of the Command Aging Limit or Recovery Time Limit. Each unit of this timer is 50 milliseconds. Setting the value to zero disabled the feature.
- **Temperature Threshold** Temperature Threshold specifies the threshold value in degrees Celsius for the thermal sensor Information Exception Warning; the reporting of which is controlled by Mode Page 0x1C. A value of 0 selects the default value (70 degrees Celsius).

- **Command Aging Limit** This value controls the maximum time a command should wait in the command queue when the CAEN bit is set. Each unit of this timer is 50 ms.
- **Error Injection** bit indicates whether internal error injection is currently enabled or disabled. This bit is read only. A value of 1 indicates that error injection mode is currently enabled. A value of 0 indicates that error injection mode is currently disabled. Error injection mode is a drive feature that randomly injects pseudo errors during read commands. It is controlled by the DPRY bit of the Format command. This mode should only be used in a drive test mode to validate drive and system error reporting and handling functionality.'.
- **Read Reporting Threshold** specifies the bits-in-error threshold at which recovered errors will be reported when PER in Mode Page 0x01 is set to 1. The bit error on the media needs to exceed this threshold before it will be reporting. Valid values for this field range from 3 to 23 bits in error.
- **FCERT** (Format Certification) bit determines whether the certification step will be performed during a Format Unit command. FCERT bit set to 0 disables certification. FCERT bit set to 1 enables the certification step.

16.10.3 Mode Page 01 (Read/Write Error Recovery Parameters)

Table 89: Mode Page 01 (Vendor Unique Parameters)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th><th></th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th><th>Default</th></tr>
<tr><td>0</td><td>PS</td><td>0</td><td colspan="6">Page Code = 01h</td><td>81h</td></tr>
<tr><td>1</td><td colspan="8">Page Length = 0Ah</td><td>0Ah</td></tr>
<tr><td>2</td><td>AWRE</td><td>ARRE</td><td>TB</td><td>RC</td><td>EER=0</td><td>PER</td><td>DTE</td><td>DCR</td><td>C0h</td></tr>
<tr><td>3</td><td colspan="8">Read Retry Count</td><td>01h</td></tr>
<tr><td>4</td><td colspan="8">Obsolete = 0</td><td>00h</td></tr>
<tr><td>5</td><td colspan="8">Obsolete = 0</td><td>00h</td></tr>
<tr><td>6</td><td colspan="8">Obsolete = 0</td><td>00h</td></tr>
<tr><td>7</td><td colspan="8">Reserved</td><td>00h</td></tr>
<tr><td>8</td><td colspan="8">Write Retry Count</td><td>00h</td></tr>
<tr><td>9</td><td colspan="8">Reserved</td><td>00h</td></tr>
<tr><td>10
11</td><td colspan="8">(MSB) Recovery Time Limit
(LSB)</td><td>00h</td></tr>
</table>

The Read-Write recovery parameters that will be used during any command that performs a read or write operation to the medium are as follows:

- **AWRE** Automatic Write Reallocation Enabled bit, is ignored. Automatic Write Reallocation is always performed
- **ARRE** Automatic Read Reallocation Enabled bit is ignored. Automatic Read Reallocation is always performed.
- **TB** (Transfer Block bit) is ignored.
- **RC** (Read Continuous) bit, is ignored.
- **EER** (Enable Early Recovery) bit is ignored.
- **PER** (Post Error) bit specifies whether or not recovered errors are reported. It is used in conjunction with the Read Reporting Threshold in Mode Page 0x00. Setting this bit to 1 enables recovered error reporting of media bit errors that exceed the Read Reporting Threshold in Page 0x00. Setting this bit to 0 disables recovered error reporting of media errors.
- **DTE** (Data Terminate on Error) is ignored.
- **DCR** (Disable Correction) bit, is ignored.
- **Read Retry Count** ignored. Read recovery is always performed.
- **Write Retry Count** is ignored.
- **Recovery Time Limit** is ignored.

16.10.4 Mode Page 02 (Disconnect/Reconnect Parameters)

Table 90: Mode Page 02 (Disconnect/Reconnect Parameters)

Byte	Bit								
	7	6	5	4	3	2	1	0	Default
0	PS	0	Page Code = 02h						82h
1	Page Length = 0Eh								0Eh
2	Read Buffer Full Ratio								00h
3	Write Buffer Empty Ratio								00h
4-5	(MSB) Bus Inactivity Time Limit (LSB)								00h
6-7	Disconnect Time Limit = 0								00h
8-9	(MSB) Maximum Connect Time Limit (LSB)								00h
10-11	(MSB) Maximum Burst Size (LSB)								00h
12-13	Reserved = 0								00h
14-15	First Burst Size = 0								00h

The disconnect/reconnect page provides the Initiator with the means to tune the performance of the SAS Link.

The drive uses the disconnect/reconnect parameters to control when it attempts to regain control of the link during READ (operation code 08h and 28h) and WRITE (0Ah, 2Ah and 2E).

- **Read Buffer Full Ratio** is ignored.
- **Bus Inactivity Time Limit** specifies the maximum time that the SAS target port is permitted to maintain a connection without transferring a frame to the initiator port, specified in 100 microsecond increments. When this value is exceeded, the target port will prepare to close the connection by transmitting DONE. A value of zero indicates that there is no bus inactivity time limit.
- **Disconnect Time Limit** is not supported.
- **Write Buffer Empty Ratio** is ignored.

Both the Read Buffer Full Ratio and the Write Buffer Empty Ratio pertain to the current active notch. For each active notch as defined in page 0Ch there are separate Read Buffer Full Ratios and Write Buffer Empty Ratios. When the active notch is set to zero, the values are applied in mode page 0Ch across all notches.

- **Maximum Connect Time Limit** specifies the maximum amount of time the drive will keep a SAS connection open. The time is specified in 100 microsecond increments. The default value of zero, indicates no time limit. A maximum value of FFFFh, specifies a connection time limit of 6.55 seconds. When this time expires, the drive will prepare to close the connection.

16.10.5 Mode Page 03 (Format Device Parameters)

Table 91: Mode Page 03 (Format Device Parameters)

Byte	Bit 7	6	5	4	3	2	1	0	Default
0	PS	0	Page Code = 03h						03h
1	Page Length = 16h								16h
2-3	(MSB) Tracks per Zone								00h
								(LSB)	00h
4-5	(MSB) Alternate Sectors per Zone = 0								00h
								(LSB)	00h
6-7	(MSB) Alternate Tracks per Zone = 0								00h
								(LSB)	00h
8-9	(MSB) Alternate Tracks per Logical Unit = 0								00h
								(LSB)	00h
10-11	(MSB) Sectors Per Track								xxh
								(LSB)	00h
12-13	(MSB) Data Bytes per Physical Sector								00h
								(LSB)	00h
14-15	(MSB) Interleave = 0001h or 0000h								00h
								(LSB)	01h
16-17	(MSB) Track Skew Factor								00h
								(LSB)	00h
18-19	(MSB) Cylinder Skew Factor								00h
								(LSB)	00h
20	SSEC	HSEC	RMB	SURF	RESERVED = 0				40h
21-23	Reserved = 0								00h

The format device page contains parameters that specify the medium format. This page contains no changeable parameters.

- **Tracks per Zone** is obsolete for SSDs.
- **Sectors per Track** is obsolete for SSDs.
- **Data Bytes per Physical Sector** specifies the number of user data bytes per physical sector. The value depends upon the current formatted Block Length.
- **Interleave** value of 1 or 0 is valid. However, the drive will ignore this.
- **Track Skew Factor** is obsolete for SSDs.
- **Cylinder Skew Factor** is obsolete for SSDs.
- **SSEC** = Zero indicates that the drive does not support soft sector formatting.
- **HSEC** = One indicates that the drive supports hard sector formatting.
- **RMB** = Zero indicates that the media does not support removable Fixed Disk.
- **SURF** = Zero indicates that progressive addresses are assigned to all logical blocks in a cylinder prior to allocating addresses within the next cylinder.

16.10.6 Mode Page 04 (Rigid Disk Drive Geometry Parameters)

Table 92: Mode Page 04 (Rigid Disk Drive Geometry Parameters)

Byte	Bit 7	6	5	4	3	2	1	0	Default
0	PS	0	Page Code = 04h						04h
1	Page Length = 16h								16h
2-4	(MSB) Number of Cylinders (LSB)								00h 00h
5	Number of heads								00h
6-8	(MSB) Starting Cylinder - Write Precompensation = 0 (LSB)								00h 00h
9-11	(MSB) Starting Cylinder - Reduced Write Current = 0 LSB)								00h 00h
12-13	(MSB) Drive Step Rate = 0 (Not used) (LSB)								00h 00h
14-16	(MSB) Landing Zone Cylinder = 0 (Not used) (LSB)								00h 00h
17	RESERVED = 0						RPL = 0		00h
18	Rotational Offset = 0 (Not used)								00h
19	RESERVED = 0								00h
20-21	(MSB) Medium Rotation Rate (LSB)								00h 01h
22-23	Reserved = 0								00h

The rigid disk drive geometric page specifies various parameters for the drive.

- Medium Rotation Rate = 1 indicates the drive is an SSD.

16.10.7 Mode Page 07 (Verify Error Recovery Parameters)

Table 93: Mode Page 07 (Verify Error Recovery Parameters)

Byte	Bit								
	7	6	5	4	3	2	1	0	Default
0	PS	0	Page Code = 07h						87h
1	Page Length = 0Ah								0Ah
2	Reserved = 0				EER=0	PER	DTE	DCR	00h
3	Verify Retry Count								01h
4	Obsolete =0								00h
5 - 9	Reserved = 0								00h
10-11	(MSB) Verify Recovery Time Limit (LSB)								00h

The Verify recovery parameters are used by the Target when recovering from and reporting errors associated with the verification of the Initiator's Data for the following commands:

- **VERIFY**
- **WRITE AND VERIFY** - the verify portion of the command only.
- **EER**. is ignored.
- **PER**. is ignored. The PER setting in Mode Page 01h is used for Verify commands.
- **DTE**. is ignored.
- **DCR**. is ignored.
- **Verify Recovery Time Limit** is ignored.

16.10.8 Mode Page 08 (Caching Parameters)

Table 94: Page 08 (Caching Parameters)

Byte	Bit 7	6	5	4	3	2	1	0	Default
0	PS	0	Page Code = 08h						88h
1	Page Length = 12h								12h
2	IC	ABPF	CAP	DISC	SIZE	WCE	MF	RCD	04h
3	Demand Read Retention Priority				Write Retention Priority				00h
4-5	(MSB) Disable Pre-fetch Transfer Length (LSB)								FFh
6-7	(MSB) Minimum Pre-fetch (LSB)								00h
8-9	(MSB) Maximum Pre-fetch (LSB)								FFh
10-11	Maximum Pre-fetch Ceiling								FFh
12	FSW	LBCSS	DRA	Reserved = 0					00h
13	Number of Cache Segments								00h
14-15	(MSB) Cache Segment Size (LSB)								00h
16	Reserved = 0								00h
17-19	(MSB) Non Cache Segment Size (LSB)								00h

The caching parameters page defines parameters that affect the use of the cache.

- **IC** (Initiator Control) bit is ignored.
- **ABPF** (Abort Pre-fetch) bit is ignored.
- **CAP** (Caching Analysis Permitted) is not supported and is ignored.
- **DISC** (Discontinuity) is not supported and is ignored.
- **SIZE** (Size Enable) bit is ignored.
- **WCE** (Write Cache Enable) bit is ignored. A fail-safe write caching is always enabled.
- **MF** (Multiplication Factor) bit is ignored.
- **RCD** (Read Cache Disable) bit is ignored.
- **Demand Read Retention Priority** is not supported.
- **Write Retention Priority** is not supported.
- **Disable Pre-fetch Transfer Length** is ignored.
- **Minimum Pre-fetch** is ignored.
- **Maximum Pre-fetch** is ignored.
- **Maximum Pre-fetch Ceiling** is ignored.
- **FSW** (Force Sequential Write) is not supported and is ignored. All logical blocks will be written in sequential order.
- **LBCSS** (Logical Block Cache Segment Size) bit is ignored
- **DRA** (Disable Read Ahead) is ignored.

- **Number of Cache Segments** field is ignored.
- **Cache Segment Size** field is ignored.
- **Non Cache Segment Size** is not supported and is ignored.

16.10.9 Mode Page 0A (Control Mode Page Parameters)

Table 95: Page 0A (Control Mode Page Parameters)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th><th>Default</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th><th></th></tr>
<tr><td>0</td><td>PS</td><td>0</td><td colspan="6">Page Code = 0Ah</td><td>8Ah</td></tr>
<tr><td>1</td><td colspan="8">Page Length = 0Ah</td><td>0Ah</td></tr>
<tr><td>2</td><td colspan="3">TST=0</td><td>TMFonly=0</td><td>RSVD=0</td><td>D_Sense=0</td><td>GLTSD=0</td><td>RLEC=0</td><td>00h</td></tr>
<tr><td>3</td><td colspan="4">Queue Algorithm Modifier</td><td>Rsvd=0</td><td colspan="2">QErr</td><td>DQue</td><td>00h</td></tr>
<tr><td>4</td><td>RSVD=0</td><td>RAC=0</td><td colspan="2">UA_INTLCK_CTRL=0</td><td>SWP=0</td><td colspan="3">Obsolete</td><td>00h</td></tr>
<tr><td>5</td><td>ATO</td><td>TAS=0</td><td colspan="6">Reserved=0</td><td>00h</td></tr>
<tr><td>6-7</td><td colspan="8">Obsolete=0</td><td>00h</td></tr>
<tr><td>8-9</td><td colspan="8">(MSB) Busy Timeout Period (LSB)</td><td>00h</td></tr>
<tr><td>10-11</td><td colspan="8">(MSB) Extended Self-test Routine Completion Time (LSB)</td><td>XXh</td></tr>
</table>

Following are parameter options for Page 0A.

- **Queue algorithm modifier** specifies restrictions on the algorithm used for reordering commands that are tagged with the SIMPLE message.
  0h: Restricted reordering. The Target shall reorder the actual execution sequence of the queued commands from each Initiator such that data integrity is maintained for that Initiator.

  1h: Unrestricted reordering allowed. The Target may reorder the actual execution sequence of the queued commands in any manner it selects. Any data integrity exposures related to command sequence order are explicitly handled by the Initiator through the selection of appropriate commands and queue tag messages.

  2h-7h: RESERVED.

  8: Command reordering is disabled

  9-Fh: RESERVED
- **QErr** (Queue Error Management) The queue error management (QERR) field specifies how the device server shall handle blocked tasks when another task receives a *Check Condition* status.

QERR value	Description
00b	**Specifies that all tasks from all Initiators are blocked from execution when a Contintent Allegiance (CA condition) is pending. Those blocked tasks are allowed to resume execution in a normal fashion after the CA condition is cleared.**
01b	**Specifies that all tasks from all Initiators are aborted when the Target returns *Check Condition* status. A unit attention condition will be generated for each Initiator that had commands in the queue except for the Initiator that received the *Check Condition* status. The sense key will be set to *Unit Attention* and the additional sense code will be set to *Commands Cleared by Another Initiator.***

10b	**Reserved**
11b	**Blocked tasks in the task set belonging to the Initiator to which a *Check Condition* status is sent shall be aborted when the status is sent.**

- **DQue** (Disable Queuing) bit set at zero specifies that tagged queuing shall be enabled if the Target supports tagged queuing. A DQue bit set at one specifies that tagged queuing shall be disabled. Command queuing is always enabled on the drive, therefore this bit is ignored.
- **ATO** (Application Tag Owner) bit set to one specifies that the contents of the Logical Block Application Tag field in the protection information, if any, shall not be modified by the drive. An ATO bit set to zero specifies that the contents of the Logical Block Application Tag field in the protection information, if any, may be modified by the drive. If the ATO bit is set to zero, the drive will ignore the contents of the Logical Block Application Tag field in the protection information.
- **Busy Timeout Period** is not supported and is ignored.
- **Extended Self-test Routine Completion Time** is an advisory parameter that an Initiator may use to determine the time in seconds that the Target requires to complete self-test routine when the Target is not interrupted by an Initiator and no errors occur during execution of the self-test routine.

16.10.9.1 Control Extension Subpage

Table 96: Control Extension Subpage

CByte	Bit								Default
	7	6	5	4	3	2	1	0	
0	PS	SPF=1	Page Code = 0Ah						4Ah
1	Subpage Code = 1								01h
2-3	Page Length = 001Ch								001Ch
4	Reserved = 0					TCMOS	SCSIP	IALUAE	00h
5	Reserved = 0				Initial Priority				00h
6-31	Reserved = 0								00h

No fields in the Control Extension subpage are currently changeable. The page is supported for compatibility only.

16.10.10 Mode Page 0C (Notch Parameters)

Table 97: Page 0C (Notch Parameters)

Byte	Bit 7	6	5	4	3	2	1	0	Default
0	PS	0	Page Code = 0Ch						8Ch
1	Page Length = 16h								16h
2	ND=1	LPN=0	Reserved = 0						80h
3	Reserved = 0								00h
4-5	(MSB) Maximum Number of Notches (LSB)								00h 00h
6-7	(MSB) Active Notch (LSB)								00h 00h
8-11	(MSB) Starting Boundary (LSB)								00h 00h
12-15	(MSB) Ending Boundary (LSB)								00h 00h
16-23	(MSB) Pages Notched (LSB)								0000h 0000h 0000h 0000h

The notch page is obsolete for SSDs.

16.10.11 Mode Page 18h

(SAS only)

Table 98: Page 18h (Protocol-Specific Logical Unit mode page)

Byte	Bit 7	6	5	4	3	2	1	0	Default
0	PS=0	SPF=0	Page Code = 18h						18h
1	Page Length = 6h								6h
2	Reserved		Transport Layer Retries=0			Protocol Identifier = 6h			6h
3	Reserved = 0								00h
4-7	Reserved								00h

This page defined protocol-specific parameters that affect the logical unit.

- Transport Layer Retries is unchangeable and set to zero. The drive does not support Transport Layer Retries as defined in SAS 1.1.

16.10.12 Mode Page 19h (Port Control Parameters)

The Protocol-Specific Port mode page contains parameters that affect SSP target port operation. There is one copy of the mode page shared by all SSP initiator ports.

16.10.12.1 Short Format of Port Control Page

Table 99: Short (Port Control Parameters) Short Format

Byte	Bit 7	6	5	4	3	2	1	0	Default
0	PS	SPF=0	Page Code = 19h						99h
1	Page Length = 0Eh								0Eh
2	Reserved	Con-tinue AWT = 0	Broadcast Asynchronous Event	Ready LED Meaning	Protocol Identifier = 6h				06h
3	Reserved								00h
4-5|	(MSB) I_T NEXUS LOSS TIMER (LSB)								07h-D0h
6-7	(MSB) INITIATOR RESPONSE TIMEOUT (LSB)								07h-D0h
8-9|	(MSB) REJECT TO OPEN LIMIT = 0000h (LSB)								0000h
10-15	Reserved								00h

- The Parameters Savable (PS) bit is set to one, indicating the parameters are saveable.
- The **SPF** field shall be set to zero for access to the short format mode page.
- **Protocol Identifier** has a value of 6h indicating this is a SAS SSP specific mode page.
- **A CONTINUE AWT** bit set to one specifies that the SAS port shall not stop the Arbitration Wait Time timer and set the Arbitration Wait Time timer to zero when the SAS port receives an OPEN_REJECT (RETRY). A CONTINUE AWT bit set to zero specifies that the SAS port shall stop the Arbitration Wait Time timer and set the Arbitration Wait Time timer to zero when it receives an OPEN_REJECT (RETRY).
- **A BROADCAST ASYNCHRONOUS EVENT** bit set to one specifies that the device server shall enable origination of Broadcast (Asynchronous Event). A BROADCAST ASYNCHRONOUS EVENT bit set to zero specifies that the device server shall disable origination of Broadcast (Asynchronous Event).

Ready LED Meaning specifies the READY LED signal behavior. In general, when the bit is 0, and the drive is in a ready state, the LED is usually on, but flashes on and off when commands are processed. When the bit is 1, the LED is usually off, but flashes on and off when commands are processed. For additional implementation specifics, see the SAS 2 draft standard

- The **I_T NEXUS LOSS TIME** field contains the time (in milliseconds) that our SSP target port shall retry connection requests to an SSP initiator port that are rejected with responses indicating the SSP initiator port may no longer be present before recognizing an I_T nexus loss. A value of 0 indicates a vendor specific amount of time and defaults to a 2 second time period. A value of FFFFh indicates an unlimited period. The default value of 7D0h, specifies a 2 second time period.

- **INITIATOR RESPONSE TIMEOUT** field contains the time in milliseconds that the SSP target port shall wait for the receipt of a Data frame after sending the XFER_RDY frame requesting data. When the INITIATOR RESPONSE TIMEOUT expires, the associated will be aborted. An INITIATOR RESPONSE TIMEOUT field value of zero indicates that the SSP target port shall disable the timer. This value is enforced by the transport layer. The default value of 7D0h, specifies a 2 second time period.

- **The REJECT TO OPEN LIMIT** field contains the minimum time in 10 µs increments that the target port shall wait to establish a connection request with an initiator port on an I_T nexus after receiving an OPEN_REJECT (RETRY), OPEN_REJECT (CONTINUE 0), or OPEN_REJECT (CONTINUE 1). This value may be rounded as defined in SPC-4. A REJECT TO OPEN LIMIT field set to 0000h indicates that the minimum time is vendor specific. This minimum time is enforced by the transport layer.

16.10.12.2 Long Format of Port Control Page

Table 100: Long Format of Port Control Page

Byte	Bit								Default
	7	6	5	4	3	2	1	0	
0	PS	SPF=1	Page Code = 19h						D9h
1	Subpage Code								...
2-3	Page Length (n-3)								0000h
4	RSVD								00h
5	RSVD				Protocol Identifier = 6h				06h
6	Protocol Specific Mode Parameters								...
n									...

The drive maintains an independent set of port control mode page parameters for each SAS initiator port.

- The **SPF** field shall be set to one for access to the long format mode page.

- **Subpage Code** indicates which subpage is being accessed. The drive support the following subpage codes. If the Subpage Code is not supported, the drive returns a CHECK CONDITION status, the sense key is set to ILLEGAL REQUEST and the additional sense code set to ILLEGAL FIELD IN PARAMETER LIST.
  - 01h: PHY Control and Discover Subpage
  - 02h: Shared Port Control subpage
  - FFh: All supported subpages.

- **Page Length** specifies the length in bytes of the subpage parameters after the Page Length.

- **Protocol Identifier** has a value of 6h indicating this is a SAS SSP specific mode page.

16.10.12.3 PHY Control and Discover (Subpage 1)

Table 101: PHY Control and Discover (Subpage 1)

Byte	Bit								Default
	7	6	5	4	3	2	1	0	
0	PS	SPF=1	Page Code = 19h						D9h
1	Subpage Code = 1								01h
2-3	Page Length = 0064h								0064h
4	Reserved								00h
5	Reserved				Protocol Identifier = 6h				06h
6	Generation Code								00h
7	Number of PHYS = 2								02h
8-55	SAS PHY Mode Descriptor 0								...
56-103	SAS PHY Mode Descriptor 1								...

The Phy Control And Discover subpage contains phy-specific parameters. MODE SENSE command returns the current settings for the initiator.

- **Protocol Identifier** has a value of 6h indicating this is a SAS SSP specific mode page.
- **The GENERATION CODE field** is a one-byte counter that shall be incremented by one by the device server every time the values in this mode page or the SAS-2 Phy mode page (see section 16.10.12.5) field values are changed. A GENERATION CODE field set to 00h indicates the generation code is unknown. The device server shall wrap this field to 01h as the next increment after reaching its maximum value (i.e., FFh). The GENERATION CODE field is also contained in the Protocol-Specific Port log page and may be used to correlate phy settings across mode page and log page accesses.
- **Number of PHYS** field is set to 2, to represent the dual ported drive (one PHY per port)
- The **SAS PHY Mode Descriptor** Fields are defined in Table 102 on page 136. There are two SAS PHY Mode Descriptor fields, one per port.

Table 102: SAS PHY Mode Descriptor

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Reserved</td></tr>
<tr><td>1</td><td colspan="8">PHY IDENTIFIER</td></tr>
<tr><td>2-3</td><td colspan="8">(MSB)
Reserved
(LSB)</td></tr>
<tr><td>4</td><td>Reserved</td><td colspan="3">ATTCHED DEVICE TYPE</td><td colspan="4">ATTCHED REASON</td></tr>
<tr><td>5</td><td colspan="4">Reason</td><td colspan="4">Negotiated Logical Link Rate</td></tr>
<tr><td>6</td><td colspan="4">Reserved</td><td>ATTACHED SSP INITIATOR PORT</td><td>ATTACHED STP INITIATOR PORT</td><td>ATTACHED SMP INITIATOR PORT</td><td>Reserved</td></tr>
<tr><td>7</td><td colspan="4">Reserved</td><td>ATTACHED SSP TARGET PORT</td><td>ATTACHED STP TARGET PORT</td><td>ATTACHED STP TARGET PORT</td><td>Reserved</td></tr>
<tr><td>8-15</td><td colspan="8">(MSB) SAS ADDRESS (LSB)</td></tr>
<tr><td>16-23</td><td colspan="8">(MSB) ATTACHED SAS ADDRESS (LSB)</td></tr>
<tr><td>24</td><td colspan="8">ATTACHED PHY IDENTIFIER</td></tr>
<tr><td>25-31</td><td colspan="8">(MSB) Reserved (LSB)</td></tr>
<tr><td>32</td><td colspan="4">PROGRAMMED MINIMUM PHYSICAL LINK RATE</td><td colspan="4">HARDWARE MINIMUM PHYSICAL LINK RATE</td></tr>
<tr><td>33</td><td colspan="4">PROGRAMMED MAXIMUM PHYSICAL LINK RATE</td><td colspan="4">HARDWARE MAXIMUM PHYSICAL LINK RATE</td></tr>
<tr><td>34-41</td><td colspan="8">(MSB) Reserved (LSB)</td></tr>
<tr><td>42-43</td><td colspan="8">(MSB) Vendor specific (LSB)</td></tr>
<tr><td>44-47</td><td colspan="8">(MSB) Reserved (LSB)</td></tr>
</table>

- **PHY Identifier:** Unique PHY Identifier for the PHY associated with the other data in this SAS PHY Mode Descriptor Page.
- **Attached Reason:** indicates the value of the REASON field in the last received IDENTIFY address frame associated with the PHY Identifier list in this SAS PHY Mode Descriptor. See Table 22 on page 46.
- **Attached Device Type:** indicated the value of the DEVICE TYPE field in the last received IDENTIFY address frame associated with the PHY Identifier listed in this SAS PHY Mode Descriptor.See Table 21 on page 45.
- **Attached SAS Address:** indicates the value of the attached SAS address in the last received IDENTIFY address frame associated with the PHY Identifier list in this SAS PHY Mode Descriptor. See Table 21 on page 45.
- **Attached PHY Identifier:** indicated the value of the attached PHY Identifier field in the last received IDENTIFY address frame associated with the PHY Identifier listed in this SAS PHY Mode Descriptor.See Table 21 on page 45.

- **SAS Address:** Unique Port Identifier for the Port associated with the PHY Identifier listed in this SAS PHY Mode Descriptor
- **Hardware Minimum Physical Link Rate:** Minimum link rate supported by the Port associated with the PHY Identifier listed in this SAS PHY Mode Descriptor.
- **Hardware Maximum Physical Link Rate:** Maximum link rate supported by the Port associated with the PHY Identifier listed in this SAS PHY Mode Descriptor.
- **Programmed Minimum Physical Link Rate:** Current minimum link rate used during speed negotiation by the Port associated with the PHY Identifier listed in this SAS PHY Mode Descriptor.
- **Programmed Maximum Physical Link Rate:** Current maximum link rate used during speed negotiation by the Port associated with the PHY Identifier listed in this SAS PHY Mode Descriptor.

16.10.12.4 Shared Port Control (Subpage 2)

Table 103: Shared Port Control (Subpage 2)

Byte	Bit								Default
	7	6	5	4	3	2	1	0	
0	PS	SPF=1	Page Code = 19h						D9h
1	Subpage Code = 2								02h
2 - 3	Page Length = 000Ch								000Ch
4	Reserved = 0								00h
5	Reserved = 0				Protocol Identifier = 6				06h
6 - 7	Power Loss Timeout								0000h
8 - 15	Reserved = 0								00h

- **Power Loss Timeout** is the maximum time, in one millisecond increments, that the drive port will respond to connection requests with OPEN_REJECT(RETRY) after receiving NOTIFY(POWER LOSS EXPECTED). The Power Loss Time-out will be restarted after each NOTIFY(POWER LOSS EXPECTED) that is received. A POWER LOSS TIMEOUT field set to 0000h specifies that the maximum time is vendor-specific and automatically defaults to 2 seconds.

16.10.12.5 SAS-2 Phy Mode Page (Subpage 3)

Table 104: Subpage 3

Byte	Bit								
	7	6	5	4	3	2	1	0	Default
0	PS	SPF=1	Page Code 19h						D9h
1	Subpage Code = 3								03h
2-3	Page Length = 002Ch								002Ch
4	Reserved = 00h								00h
5	Reserved = 0				Protocol Identifier = 6				06h
6	Generation Code								00h
7	Number of Phys = 02h								02h
8-27	SAS-2 PHY Mode Descriptor 0								--
28-47	SAS-2 PHY Mode Descriptor 1								--

- **The GENERATION CODE field** is a one-byte counter that shall be incremented by one by the device server every time the values in this mode page or the SAS-2 Phy mode page (see section 16.10.12.5) field values are changed. A GENERATION CODE field set to 00h indicates the generation code is unknown. The device server shall wrap this field to 01h as the next increment after reaching its maximum value (i.e., FFh). The GENERATION CODE field is also contained in the Protocol-Specific Port log page and may be used to correlate phy settings across mode page and log page accesses.

Table 105: PHY Mode Descriptor (0 and 1)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved							
1	PHY Identifier							
2-3	Descriptor Length (0010h)							
4-7	Programmed PHY Capabilities							
8-11	Current PHY Capabilities							
12-15	Attached PHY Capabilities							
16-17	Reserved							
18	Reserved			Negotiated SSC	Negotiated Physical Link Rate			
19	Reserved							Hardware Muxing Supported='0'

- **Phy Capabilities are defined under the "SAS Speed Negotiation" on page 43**

16.10.13 Mode Page 1A (Power Control)

Table 106: Page 1A (Power Control)

Byte	Bit								
	7	6	5	4	3	2	1	0	Default
0	PS	0	Page Code = 1Ah						9Ah
1	Page Length = 26h								26h
2	Reserved = 00h							Standby_Y	00h
3	Reserved = 0				Idle_C	Idle_B	Idle_A	Standby_Z	00h
4-7	Idle_A Condition Timer								00h
8-11	Standby_Z Condition Timer								00h
12-15	Idle_B Condition Timer								00h
16-19	Idle_C Condition Timer								00h
20-23	Standby_Y Condition Timer								00h
24-39	Reserved								00h

- **If the STANDBY_Y bit** is set to one, then the standby_y condition timer is enabled. If the STANDBY_Y bit is set to zero, then the device shall ignore the standby_y condition timer.
- **If the IDLE_C bit** is set to one, then the idle_c condition timer is enabled. If the IDLE_C bit is set to zero, then the device shall ignore the idle_c condition timer.
- **If the IDLE_B bit** is set to one, then the idle_b condition timer is enabled. If the IDLE_B bit is set to zero, then the device shall ignore the idle_b condition timer.
- **If the IDLE_A bit** is set to one, then the idle_a condition timer is enabled. If the IDLE_A bit is set to zero, then the device shall ignore the idle_c condition timer.
- **If the STANDBY_Z bit** is set to one, then the standby_z condition timer is enabled. If the STANDBY_Z bit is set to zero, then the device shall ignore the standby_z condition timer.
- **The IDLE_A Condition Timer** field specifies the initial value, in 100 millisecond increments, for the idle_a power condition timer. The minimum allowable inactivity time for idle_a is 1 second. Any value less than this is accepted, but will automatically default to 1 second.
- **The STANDBY_Z Condition Timer** field specifies the initial value, in 100 millisecond increments, for the standby_z power condition timer. The minimum allowable inactivity time for standby_z is 2 minutes. Any value less than this is accepted, but will automatically default to two minutes. In addition, a limit of 60 timer initiated head unloads per 24 hour period is enforced.
- **The IDLE_B Condition Timer** field specifies the initial value, in 100 millisecond increments, for the idle_b power condition timer. The minimum allowable inactivity time for idle_b is 2 minutes. Any value less than this is accepted, but will automatically default to two minutes. In addition, a limit 60 timer initiated head unloads per 24 hour period is enforced.
- **The IDLE_C Condition** Timer field specifies the initial value, in 100 millisecond increments, for the idle_c power condition timer. The minimum allowable inactivity time for idle_c is 2 minutes. Any value less than this is accepted, but will automatically default to two minutes. In addition, a limit of 60 timer initiated head unloads per 24 hour period is enforced.
- **The STANDBY_Y Condition Timer** field specifies the initial value, in 100 millisecond increments, for the standby_y power condition timer. The minimum allowable inactivity time for standby_y is 2 minutes. Any value less than this is accepted, but will automatically default to two minutes. In addition, a limit 60 timer initiated head unloads per 24 hour period is enforced.

16.10.14 Mode Page 1C (Informational Exceptions Control)

Table 107: Page 1C (Informational Exceptions Control)

Byte	BIT								
	7	6	5	4	3	2	1	0	Default
0	PS	0	Page Code = 1Ch						9Ch
1	Page Length = 0Ah								0Ah
2	PERF	RSVD	EBF	EWASC	DEXCPT	TEST	EBACK-ERR	LOGERR	10h
3	Reserved = 0				Method of Reporting				03h
4-7	(MSB) Interval Timer (LSB)								00h 00h 00h 00h
8-11	(MSB) Report Count (LSB)								00h

- **PERF** (Performance) bit is not supported and is ignored. Informational Exception operations will not cause performance delays.
- **EBF** (Enable Background Function) bit is not supported and is ignored. Background functions are always enabled.
- **EWASC** (Enable Warning ASC) bit of zero indicates that Temperature Warnings will not be reported. An EWASC bit of one allows Temperature Warnings to be reported, if the temperature inside the SSD enclosure exceeds the threshold set in Mode Page 00h. The Method of Reporting field controls the reporting method. EWASC is independent of DEXCPT.
- **DEXCPT** (Disable Exception Control) bit of zero indicates information exception operations are enabled. The reporting of information exception conditions when the DEXCPT bit is set to zero is determined from the Method of Reporting field. A DEXCPT bit of one indicates the Target disabled all information exception operations.
- **TEST** bit of one instructs the drive to generate false drive notifications at the next interval time, (as determined by the INTERVAL TIMER field), if the DEXCPT is zero. The Method of Reporting and Report Count would apply. The false drive failure is reported as sense qualifier 5DFFh. The TEST bit of zero instructs the drive to stop generating any false drive notifications.
- **Enable Background Error (EBACKERR)** bit of zero disables reporting of background self-test errors and background scan errors via Information Exceptions Control. An EBACKERR bit of one enables reporting of these background errors as Information Exception Warnings. The method of reporting these errors is determined from the MRIE field.
- **LOGERR** (Log Errors) is not used and ignored internally by the Target.

- **Method of Reporting** Informational Exceptions indicates the methods used by the Target to report informational exception conditions.

Code	Description
0h	**No reporting of informational exception condition:** This method instructs the Target to not report informational exception condition.
1h	**Asynchronous event reporting:** Not supported.
2h	**Generate unit attention:** This method instructs the Target to report informational exception conditions by returning a *Check Condition* status on any command. The sense key is set to *Unit Attention* and the additional sense code indicates the cause of the informational exception condition. The command that has the *Check Condition* is not executed before the informational exception condition is reported.
3h	**Conditionally generate recovered error:** This method instructs the Target to report informational exception conditions, dependent on the value of the PER bit of the error recovery parameters mode page, by returning a *Check Condition* status on any command. The sense key is set to *Recovered Error* and the additional sense code indicates the cause of the informational exception condition. The command that has the *Check Condition* completes without error before any informational exception condition is reported.
4h	**Unconditionally generate recovered error:** This method instructs the Target to report informational exception conditions, regardless of the value of the PER bit of the error recovery parameters mode page, by returning a *Check Condition* status on any command. The sense key is set to *Recovered Error* and the additional sense code indicates the cause of the informational exception condition. The command that has the *Check Condition* completes without error before any informational exception condition is reported.
5h	**Generate no sense:** This method instructs the Target to report informational exception conditions by returning a *Check Condition* status on any command. The sense key is set to *No Sense* and the additional sense code indicates the cause of the informational exception condition. The command that has the *Check Condition* completes without error before any informational exception condition is reported.
6h	**Only report informational exception condition on request:** This method instructs the Target to preserve the informational exception(s) information. To find out about information exception conditions the Application Client polls the Target by issuing an unsolicited *Request Sense* command. The sense key is set to *No Sense* and the additional sense code indicates the cause of the informational exception condition.
7h-Fh	Reserved.

- **Interval Timer** field indicates the period in 100 millisecond increments for reporting that an informational exception condition has occurred. The target shall not report informational exception conditions more frequently than the time specified by the Interval Timer field and as soon as possible after the time interval has elapsed. After the informational exception condition has been reported the interval timer is restarted. A value of zero or 0xFFFFFFFF in the Interval Timer field indicates that the target only reports the informational exception condition one time and will override the value set in the Report Count field.
- **Report Count** field indicates the number of times the Target reports an informational exception condition. The Report Count of ZERO indicates no limits on the number of times the Target reports an informational exception condition.

16.10.14.1 Background Control (Subpage 01h)

Table 108: Background Control (Subpage 01h)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">BIT</th><th></th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th><th>Default</th></tr>
<tr><td>0</td><td>PS</td><td>SPF=1</td><td colspan="6">Page Code = 1Ch</td><td>DCh</td></tr>
<tr><td>1</td><td colspan="8">Subpage Code = 01h</td><td>01h</td></tr>
<tr><td>2-3</td><td colspan="8">Page Length = 0Ch</td><td>000Ch</td></tr>
<tr><td>4</td><td colspan="5">Reserved = 0</td><td>S_L_Full</td><td>LOWIR</td><td>EN_BMS</td><td>00h</td></tr>
<tr><td>5</td><td colspan="7">Reserved = 0</td><td>EN_PS</td><td>00h</td></tr>
<tr><td>6-7</td><td colspan="8">Background Medium Scan Interval Time</td><td>00A8h</td></tr>
<tr><td>8-9</td><td colspan="8">Background Pre-Scan Time Limit</td><td>0000h</td></tr>
<tr><td>10-11</td><td colspan="8">Minimum Idle Time Before Background Scan</td><td>0000h</td></tr>
<tr><td>12-13</td><td colspan="8">Maximum Time To Suspend Background Scan (Ignored)</td><td>0000h</td></tr>
<tr><td>14-15</td><td colspan="8">Reserved = 0</td><td>0000h</td></tr>
</table>

- **Suspend On Log Full (S_L_FULL)** bit set to zero allows background scans to continue if the results log (Log Sense Page 15h) is full. S_L_FULL bit set to one will cause background scans to suspend when the log is full.
- **Log Only When Intervention Required (LOWIR)** bit set to zero allows logging of all medium errors in the results log (Log Sense Page 15h). When the LOWIR bit is set to one, only unrecovered medium errors will be logged.
- **EN_BMS (Enable Background Medium Scan)** bit set to zero specifies that the background medium scan is disabled. EN_BMS bit set to one specifies that background medium scan operations are enabled. If a background medium scan is in progress when the EN_BMS bit is changed from one to zero, then the medium scan shall be suspended until the EN_BMS bit is set to one, at which time the medium scan shall resume from the suspended location.
- **EN_PS (Enable Pre-Scan)** bit set to zero specifies that the pre-scan is disabled. If a pre-scan operation is in progress when EN_PS is changed from a one to a zero, then pre-scan is halted. An EN_PS bit set to one specifies that a pre-scan operation is started after the next power-on cycle. Once this pre-scan has completed, another pre-scan shall not occur unless the EN_PS bit is set to zero, then set to one, and another power-on cycle occurs.
- **Background Medium Scan Interval Time** specifies the minimum time, in hours, between the start of one background medium scan operation and the start of the next background medium scan operation.
- **Background Pre-Scan Time Limit** specifies the maximum time, in hours, for a pre-scan operation to complete. If the pre-scan operation does not complete within the specified time, then it is halted. A value of zero specifies an unlimited time limit.
- **Minimum Idle Time Before Background Scan** specifies the minimum time, in milliseconds, that the drive must be idle before resuming a background media scan or pre-scan. A value of zero will be treated as the default value of 1.0 second. Any value less than 100 milliseconds will be treated as 100 milliseconds. The internal timer granularity is 50 milliseconds.
- **Maximum Time To Suspend Background Scan** (Ignored).

16.11 MODE SENSE (5A)

Table 109: Mode Sense (5A)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Command Code = 5Ah</td></tr>
<tr><td>1</td><td colspan="4">Reserved = 0</td><td>DBD</td><td colspan="3">Reserved = 0</td></tr>
<tr><td>2.</td><td colspan="2">PCF</td><td colspan="6">Page Code</td></tr>
<tr><td>3-6</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>7-8</td><td colspan="8">(MSB) Allocation Length (LSB)</td></tr>
<tr><td>9</td><td colspan="2">VU = 0</td><td colspan="4">Reserved = 0</td><td>FLAG</td><td>LINK</td></tr>
</table>

The MODE SENSE (5A) command provides a means for the drive to report various device parameters to the initiator. See the MODE SENSE (1A) command for a description of the fields in this command.

16.12 PERSISTENT RESERVE IN (5E)

Table 110: Persistent Reserve In (5E)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 5Eh							
1	Reserved = 0			Service Action				
2-6	Reserved = 0							
7-8	(MSB) Allocation Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The PERSISTENT RESERVE IN command is used to obtain information about persistent reservations and reservation keys that are active within the controller. This command is used in conjunction with the PERSISTENT RESERVE OUT command PERSISTENT RESERVE OUT (5F).

The **Allocation Length** indicates how much space has been allocated for the returned parameter data. If the length is not sufficient to contain all parameter data, the first portion of the data will be returned. If the remainder of the data is required, the initiator should send a new PERSISTENT RESERVE IN command and an Allocation Length large enough to contain all data.

16.12.1 Service Action

The following service action codes are implemented. If a reserved service action code is specified, the drive returns a **Check Condition** status. The sense key is set to *Illegal Request* and the additional sense data is set to *Invalid Field in CDB*.

Table 111: PERSISTENT RESERVE IN, Service Action Codes

Code	Name	Descriptions
00h	Read Keys	Reads all registered Reservation Keys
01h	Read Reservations	Reads all current persistent reservations
02h	Report Capabilities	Returns capability information
03h	Read Full Status	Reads complete information about all registrations and the persistent reservation, if any
04h-1Fh	Reserved	Reserved

16.12.2 Parameter data for Read Keys

Table 112: PERSISTENT RESERVE IN, parameter data for Read Keys

Byte	Bit							
	7	6	5	4	3	2	1	0
0-3	(MSB) Generation (LSB)							
4-7	(MSB) Additional length (n-7) (LSB)							
8-15	(MSB) First reservation key (LSB)							
	:							
(n-7) - n	(MSB) Last reservation key (LSB)							

Generation is a counter that increments when PERSISTENT RESERVE OUT command with “Register” or “Preempt and Clear” completes successfully. Generation is set to 0 as part of the power on reset process and hard reset process.

The **Generation** field contains a 32-bit counter that the Target shall increment every time a PERSISTENT RESERVE OUT command requests a Register, a Clear, a Preempt, or a Preempt and Abort service action. The counter shall not be incremented by a PERSISTENT RESERVE IN command, by a PERSISTENT RESERVE OUT command that performs a Reserve or Release service action, or by a PERSISTENT RESERVE OUT command that is not performed due to an error or reservation conflict. Regardless of the APTPL value the generation value shall be set to 0 as part of the power on reset process.

The **Additional Length** field contains a count of the number of bytes in the reservation key list. If the allocation length specified by the PERSISTENT RESERVE IN command is not sufficient to contain the entire parameter list, then only the bytes from 0 to the maximum allowed allocation length shall be sent to the Initiator. The incremental remaining bytes shall be truncated, although the Additional Length field shall still contain the actual number of bytes in the reservation key list without consideration of any truncation resulting from an insufficient allocation length. This shall not be considered an error.

The **Reservation Key** list contains the 8-byte reservation keys for all Initiators that have registered through all ports with the Target.

16.12.3 Parameter Data for Read Reservations

Table 113: PERSISTENT RESERVE IN, parameter data for Read Reservations

Byte	Bit							
	7	6	5	4	3	2	1	0
0-3	(MSB) Generation (LSB)							
4-7	(MSB) Additional length (n-7) (LSB)							
8-n	(MSB) Reservation descriptors (LSB)							

The **Generation** field shall be as defined for the Persistent Reserve In Read Keys parameter data. The Additional Length field contains a count of the number of bytes to follow in the Reservation Descriptor(s).

If the **Allocation length** specified by the PERSISTENT RESERVE IN command is not sufficient to contain the entire parameter list, then only the bytes from 0 to the maximum allowed allocation length shall be sent to the Initiator. The remaining bytes shall be truncated, although the Additional Length field shall still contain the actual number of bytes of the Reservation Descriptor(s) and shall not be affected by the truncation. This shall not be considered an error.

The format of the **Reservation Descriptors** is defined in the Persistent Reserve In Reservation Descriptor table. There shall be a Reservation Descriptor for the persistent reservation, if any, present in the Target having a persistent reservation.

Table 114: PERSISTENT RESERVE IN, Read Reservation Descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0-7	(MSB) Reservation key (LSB)							
8-11	(MSB) Scope-specific address (LSB)							
12	Reserved							
13	Scope=0				Type			
14-15	(MSB) Extent Length=0 (LSB)							

.The **Scope** of each persistent reservation created by a PERSISTENT RESERVE OUT command will be returned. See the PERSISTENT RESERVE OUT command section for details.

16.13 PERSISTENT RESERVE OUT (5F)

Table 115: PERSISTENT RESERVE OUT (5F)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 5Fh							
1	Reserved = 0			Service Action				
2	Scope=0				Type			
3-6	Reserved = 0							
7-8	Parameter List Length = 18h							
11	VU = 0		Reserved = 0				FLAG	LINK

The PERSISTENT RESERVE OUT command is used to request service actions that reserve the drive for the exclusive or shared use of the initiator. The command uses other service actions to manage and remove such reservations. This command is used in conjunction with the PERSISTENT RESERVE IN command, and should not be used with the RESERVE and RELEASE commands.

Note: If a PERSISTENT RESERVE OUT command is received when a RESERVE is active for the drive, the command will be rejected with **Reservation Conflict** status.

Parameter List Length must be 18h. If not, Check Condition status will be returned, with sense key of Illegal Request and additional sense code of Parameter List Length Error.

.

16.13.1 Service Action

The following service action codes are supported.

Table 116: PERSISTENT RESERVE OUT, Service Action Code

Code	Name	Description
00h	**Register**	Register a reservation key
01h	**Reserve**	Create a persistent reservation using a reservation key
02h	**Release**	Release a persistent reservation
03h	**Clear**	Clear all reservation keys and all persistent reservations
04h	**Preempt**	Preempt persistent reservations from another Initiator
05h	**Preempt and Abort**	Preempt persistent reservations from another Initiator and clear the task set for the preempted Initiator
06h	**Register and Ignore existing key**	Register a reservation key
07h-1Fh	**Reserved**	Reserved

16.13.2 Type

The **Type** field specifies the characteristics of the persistent reservation being established for all customer data sectors. The table below describes the supported types and how read and write commands are handled for each reservation type.

Table 117: PERSISTENT RESERVE OUT, Type Code

Code	Name	Description
0h	Reserved	Reserved
1h	Write Exclusive	Reads Shared: Any initiator may execute commands that transfer from the media. Writes Exclusive: Only the initiator with the reservation may execute commands that transfer data to the media; Reservation Conflict status will be returned to other initiators.
2h	Reserved	Reserved
3h	Exclusive Access	Reads Exclusive: Only the initiator with the reservation may execute commands that transfer data from the media; Reservation Conflict status will be returned to other initiators. Writes Exclusive: Only the initiator with the reservation may execute commands that transfer data to the media; Reservation Conflict status will be returned to other initiators.

4h	Reserved	Reserved
5h	Write Exclusive Registrants Only	Reads Shard: Any initiator may execute commands that transfer from media. Writes Exclusive: Only registered initiators may execute commands that transfer data to the media; Reservation Conflict status will be returned to other initiators.
6h	Exclusive Access Registrants Only	Reads Exclusive: Only registered initiators may execute commands that transfer data from the media; Reservation Conflict status will be returned to other initiators. Writes Exclusive: Only registered initiators may execute commands that transfer data to the media; Reservation Conflict status will be returned to other initiators.
7h-Fh	Reserved	Reserved

16.13.3 Parameter list

The **Parameter List** required to perform the PERSISTENT RERSERVE OUT command is defined in the table below. All fields must be sent on all PERSISTENT RESERVE OUT commands, even if the field is not required for the specified service action.

Table 118: Parameter List

Byte	**Bit**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0-7	**(MSB)**			**Reservation Key**				**(LSB)**
8-15	**(MSB)**			**Service Action Reservation Key**				**(LSB)**
16-19	**(MSB)**			**Reserved = 0**				**(LSB)**
20	**Reserved = 0**				**SPEC_I_P**	**ALL_TG_PT**	**Reserved = 0**	**APTPL**
21-23	**Reserved = 0**							

Reservation Key contains an 8-byte value provided by the initiator, and identifies the initiator that issued the PERSISTENT RESERVE OUT command. The Reservation Key must match the registered reservation key for the initiator for all service actions except REGISTER and REGISTER AND IGNORE EXISTING KEY.

Service Action Reservation Key contents vary based on the service action. For REGISTER and REGISTER AND IGNORE EXISTING KEY, the Service Action Reservation Key must contain the new reservation key to be registered. For PREEMPT and PREEMPT AND ABORT, the field contains the reservation key of the persistent reservation that is being preempted. This field is ignored for all other service actions.

If the Specify Initiator Ports (**SPEC_I_PT**) bit is set to zero, the device server shall apply the registration only to the I_T nexus that sent the PERSISTENT RESERVE OUT command. If the SPEC_I_PT bit is set to one for any service action except the REGISTER service action, then the command shall be terminated with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER LIST. If the SPEC_I_PT bit is set to one for the REGISTER service action, the additional parameter data (see table XXX) shall include a list of transport IDs and the device server shall also apply the registration to the I_T nexus for each initiator port specified by a TransportID. If a registration fails for any initiator port (e.g., if the logical unit does not have enough resources available to hold the registration information), no registrations shall be made, and the command shall be terminated with CHECK CONDITION status.

For Transport IDs, please refer to Table 179 on page 306 of Spc4r27.

The All Target Ports (**ALL_TG_PT**) bit is valid only for the REGISTER service action and the REGISTER AND IGNORE EXISTING KEY service action, and shall be ignored for all other service actions. Support for the ALL_TG_PT bit is optional. If the device server receives a REGISTER service action or a REGISTER AND IGNORE EXISTING KEY service action with the ALL_TG_PT bit set to one, it shall create the specified registration on all target ports in the SCSI target device known to the device server (i.e., as if the same registration request had been received individually through each target port). If the device server receives a REGISTER service action or a REGISTER AND IGNORE EXISTING KEY service action with the ALL_TG_PT bit set to zero, it shall apply the registration only to the target port through which the PERSISTENT RESERVE OUT command was received.

APTPL (Activate Persist Through Power Loss) bit is valid only for REGISTER and REGISTER AND IGNORE EXISTING KEY, and is ignored for all other service actions. If the last valid APTPL bit value received is zero, power loss will cause all persistent reservations to be released, and all reservation keys to be removed. If the last valid APTPL bit value received is one, any persistent reservation and all reservation keys for all initiators will be retained across power cycles.

16.13.4 Summary

Table 119: PERSISTENT RESERVE OUT, Service Action, Parameters

Service Action	Parameters						Generation counter
	Scope Type	Rsv Key	SvcAct RsvKey	S-spec addr	Extent length	APTPL	
(0) Register	ignore	verify	save	ignore	ignore	apply	+ 1
(1) Reserve	apply	verify	ignore	ignore	ignore	ignore	---
(2) Release	apply	verify	ignore	ignore	ignore	ignore	---
(5) Preempt and Abort	apply	verify	save	ignore	ignore	ignore	+ 1

16.13.4.1 Scope, Type

The Scope and the Type are applied in the process for the Reserve, Release, and Preempted and Clear service action but they are ignored in the process for the Register service action because they are not used.

16.13.4.2 Reservation Key

The Reservation Key is verified in each service action process. If the Initiator that registered a key is different from the Initiator requesting PERSISTENT RESERVE OUT command, the drive returns a **Reservation Conflict** status.

16.13.4.3 Service Action Reservation Key

On Register service action, the drive saves the key specified in the Service Action Reservation Key field as a key of Initiator requesting PERSISTENT RESERVE OUT command.

On Preempt and Clear service action, the reservation that has a key specified in the Service Action Reservation Key field is preempted.

On other service actions, this field is ignored.

16.13.4.4 APTPL

The APTPL (Active Persist Through Power Loss) is valid only for the Register service action. The drive ignores the APTPL in other service actions.

The following table shows the relationship between the last valid APTPL value and information held by the drive.

Table 120: APTPL and information held by a drive

Information held by the drive	The last valid APTPL value	
	0	1
Registration	all keys are set to 0	retained
Persistent Reservation	all are removed	retained
Generation counter	set to 0	set to 0

16.13.4.5 Generation counter

The drive increments the Generation counter when Register service action or Preempt and Clear service action complete successfully.

16.14 PRE-FETCH (34)

Table 121: PRE-FETCH (34)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 34h							
1	Reserved = 0			Reserved = 0			Immed = 0	Obso-lete
2-5	(MSB) Logical Block Address (LSB)							
6	Reserved = 0							
7-8	(MSB) Transfer Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The PRE-FETCH command requests the drive to transfer data to the cache. This command is implemented as a no-op and returns good status on the SSD.

16.15 READ (6) - (08)

Table 122: READ (6) - (08)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Command Code = 08h</td></tr>
<tr><td>1</td><td colspan="3">Reserved = 0</td><td colspan="5">(MSB) LBA</td></tr>
<tr><td>2-3</td><td colspan="8">Logical Block Address
(LSB)</td></tr>
<tr><td>4</td><td colspan="8">Transfer Length</td></tr>
<tr><td>5</td><td colspan="2">VU = 0</td><td colspan="4">Reserved = 0</td><td>FLAG</td><td>LINK</td></tr>
</table>

The READ command requests the drive to transfer from the medium to the initiator the specified number of blocks (Transfer Length) starting at the specified Logical Block Address (LBA).

- **Logical block address** field specifies the logical unit at which the READ operation shall begin.
- **Transfer length** field specifies the number of blocks to be transferred. A value of zero implies 256 blocks are to be transferred.

16.16 READ (10) - (28)

Table 123: READ (10) - (28)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 28h							
1	RDPROTECT			DPO	FUA	Rsvd= 0	FUA_ NV	Obso- lete
2-5	(MSB) Logical Block Address (LSB)							
6	Reserved = 0							
7-8	(MSB) Transfer Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The READ (10) command requests the drive to transfer data to the Initiator. The larger LBA and Transfer Length fields permit greater quantities of data to be requested per command than with the READ command and are required to access the full LBA range of the larger capacity drives.

- **FUA_NV** (Force Unit Access Non-Volatile Cache) may be set to 0 or 1, but is ignored since NV_SUP=0 in Inquiry Page 86h.
- **Transfer length** The number of contiguous blocks to be transferred. If the transfer length is zero, the seek occurs, but no data is transferred. This condition is not considered an error. If read ahead is enabled, a read ahead is started after the seek completes.
- **DPO** (Disable Page Out) bit is ignored.
- **FUA** (Force Unit Access) bit is ignored.
- **RDPROTECT** defines the manner in which protection information read from drive shall be checked during processing of the command. Protection information is stored on drive, and may be transmitted to the drive's internal data buffer and to the initiator with the user data. If the drive is not formatted with protection information, RDPROTECT must be set to 000b, else **Check Condition** status will be returned with sense key of Illegal Request and additional sense code of Invalid Field in CDB.

- RDPROTECT=000b

Protection information is not transmitted to the initiator and is not checked.

RDPROTECT=001b

- Protection information is transmitted to the initiator with the user data
- Logical Block Guard is checked
- Logical Block Application Tag is checked (applies to READ(32) command only)
- Logical Block Reference Tag is checked

RDPROTECT=010b

- Protection information is transmitted to the initiator with the user data
- Logical Block Guard is not checked
- Logical Block Application Tag is checked (applies to READ(32) command only)
- Logical Block Reference Tag is checked

RDPROTECT=011b

- Protection information is transmitted to the initiator with the user data
- Logical Block Guard is not checked
- Logical Block Application Tag is not checked
- Logical Block Reference Tag is not checked

RDPROTECT=100b

- Protection information is transmitted to the initiator with the user data
- Logical Block Guard is checked
- Logical Block Application Tag is not checked
- Logical Block Reference Tag is not checked

RDPROTECT=101b, 110b, 111b
These values are reserved. **Check Condition** status will be returned with sense key of Illegal Request and additional sense code of Invalid Field in CDB.

If a check of the protection information fails, **Check Condition** status will be returned with sense key of Aborted Command and additional sense code indicating which protection field check failed.

Refer to the ANSI T10 standards for additional details of protection information.

If the transfer length is zero, no data is transferred. The CDB is validated and protocol checked and, if no problems are found, **Good** status is returned immediately. This condition is not considered an error.

16.17 READ (12) - (A8)

Table 124: Read (12) - (A8)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = A8h							
1	RDPROTECT			DPO	FUA	Rsvd = 0	FUA_NV	Rsvd = 0
2 - 5	(MSB) Logical Block Address (LSB)							
6 - 9	(MSB) Transfer Length (LSB)							
10	Reserved = 0							
11	VU = 0		Reserved = 0				FLAG	LINK

The READ(12) command causes the drive to transfer data to the initiator. See the READ(10) description for the definitions of the fields in this command.

16.18 READ (16) - (88)

Table 125: READ (16) - (88)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 88h							
1	RDPROTECT			DPO	FUA	Rsvd=0	FUA_NV	Rsvd=0
2 - 9	(MSB) Logical Block Address (LSB)							
10-13	(MSB) Transfer Length (LSB)							
14	Restricted For MMC-4	Reserved = 0		GROUP NUMBER				
15	VU = 0		Reserved = 0				FLAG	LINK

The READ(16) command causes the drive to transfer data to the initiator. See the READ(10) description for the definitions of the fields in this command.

16.19 READ (32) - (7F/09)

Table 126: READ (32) - (7F/09)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Command Code = 7Fh</td></tr>
<tr><td>1</td><td colspan="2">VU = 0</td><td colspan="4">Reserved = 0</td><td>FLAG</td><td>LINK</td></tr>
<tr><td>2-5</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>6</td><td colspan="3">Reserved = 0</td><td colspan="5">Group Number = 0</td></tr>
<tr><td>7</td><td colspan="8">Additional CDB Length = 18h</td></tr>
<tr><td>8 - 9</td><td colspan="8">Service Action = 0009h</td></tr>
<tr><td>10</td><td colspan="3">RDPROTECT</td><td>DPO</td><td>FUA</td><td>Rsvd=
0</td><td>FUA_
NV</td><td>Rsvd=0</td></tr>
<tr><td>11</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>12 -19</td><td colspan="8">(MSB)
Logical Block Address
(LSB)</td></tr>
<tr><td>20 - 23</td><td colspan="8">(MSB)
Expected Initial Logical Block Reference Tag
(LSB)</td></tr>
<tr><td>24 - 25</td><td colspan="8">(MSB)
Logical Block Application Tag
(LSB)</td></tr>
<tr><td>26-27</td><td colspan="8">(MSB)
Logical Block Application Tag Mask
(LSB)</td></tr>
<tr><td>28 - 31</td><td colspan="8">(MSB)
Transfer Length
(LSB)</td></tr>
</table>

The READ command requests that the drive transfer data from drive to the initiator. Each logical block transferred includes user data and may include protection information, based on the RDPROTECT field and the drive format.

If the drive is formatted with type 2 protection (PROT_EN=1 and P_TYPE=001b in the READ CAPACITY (16) parameter data), then this command will be processed normally. Any other protection types will result in Check Condition status to be returned with sense key of Illegal Request and additional sense code of Invalid Command Operation Code

The Expected Initial Logical Block Reference Tag field contains the value of the Logical Block Reference Tag field expected in the protection information of the first logical block accessed by the command.

If the ATO bit is set to one in Mode Page 0Ah, the Logical Block Application Tag Mask field contains a value that is a bit mask for enabling the checking of the Logical Block Application Tag field in the protection information for each logical block accessed by the command. A Logical Block Application Tag Mask bit set to one enables the checking of the corresponding bit of the Expected Logical Block Application Tag field with the corresponding bit of the Logical Block Application Tag field in the protection information.

If the ATO bit is set to zero, the Logical Block Application Tag Mask field and the Expected Logical Block Application Tag field are ignored

16.20 READ BUFFER (3C)

Table 127: READ BUFFER (3C)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Command Code = 3Ch</td></tr>
<tr><td>1</td><td colspan="3">Reserved = 0</td><td colspan="5">Mode</td></tr>
<tr><td>2</td><td colspan="8">Buffer ID = 0</td></tr>
<tr><td>3-5</td><td colspan="8">(MSB)
Buffer Offset
(LSB)</td></tr>
<tr><td>6-8</td><td colspan="8">(MSB) Allocation Length
(LSB)</td></tr>
<tr><td>9</td><td colspan="2">VU = 0</td><td colspan="4">Reserved = 0</td><td>FLAG</td><td>LINK</td></tr>
</table>

The READ BUFFER command is used in conjunction with the WRITE BUFFER command as a diagnostic function for testing the memory of the drive and the SCSI bus integrity. This command does not alter the medium.

The function of this command and the meaning of fields within the command descriptor block depend on the contents of the mode field.

MODE	Description
00000	Read Combined Header and Data
00010	Read Data
00011	Descriptor
01010	Read Data from Echo Buffer
01011	Echo Buffer Descriptor
11010	Enable Expander Communications Protocol and Echo Buffer
All others	Not supported

16.20.1 Combined Header And Data (Mode 00000b)

In this mode a 4-byte header followed by data bytes is returned to the Initiator during the DATA IN phase. The Buffer ID and the buffer offset field are reserved.

The drive terminates the DATA IN phase when allocation length bytes of header plus data have been transferred or when the header and all available data have been transferred to the Initiator, whichever is less.

The 4-byte READ BUFFER header (see figure below) is followed by data bytes from the data buffer of the drive.

Table 128: Read Buffer Header

Byte	Bit						
	7	6	5	4	3	2	1
0	RSVD = 0						
1-3	(MSB) Buffer Capacity (LSB)						

The buffer capacity specifies the total number of data bytes that are available in the data buffer of the drive. This number is not reduced to reflect the allocation length nor is it reduced to reflect the actual number of bytes written using the WRITE BUFFER command.

Following the READ BUFFER header the drive will transfer data from its data buffer.

16.20.2 Read Data (Mode 00010b)

In this mode, the DATA IN phase contains buffer data.

- **Buffer ID** field must be set to zero, indicating the data transfer buffer. If another value is specified, the command is terminated with **Check Condition** status. The drive shall set sense key to *Illegal Request* and additional sense code to *Illegal Field in CDB*.
- **Buffer Offset** specifies the offset of the memory space specified by the Buffer ID. The Initiator should conform to the offset boundary requirements returned in the READ BUFFER descriptor. If the value exceeds the buffer specified, the command is terminated with **Check Condition** status. The drive shall set sense key to *Illegal Request* and additional sense code to *Illegal Field in CDB*.
- **Allocation Length** The drive terminates the DATA IN phase when allocation length bytes of data have been transferred or when the header and all available data have been transferred to the Initiator, whichever is less.

16.20.3 Descriptor (Mode 00011b)

In this mode, a maximum of four bytes of READ BUFFER descriptor information are returned. The drive returns the descriptor information for the buffer specified by the Buffer ID.

- **Buffer ID** field should normally be set to zero, indicating the drive data transfer buffer. If any other value is specified, the drive returns all zeros in the READ BUFFER descriptor.
- **Buffer Offset** field is reserved.
- **Allocation Length** should be set to four or greater. The drive transfers the allocation length or four bytes of READ BUFFER descriptor, whichever is less. The allocation length of zero indicates no data is transfered.The allocation length of greater than zero and less than four (size of the Descriptor) is an invalid request and will cause the command to be terminated with **Check Condition** status. The drive shall set sense key to *Illegal Request* and additional sense code to *Illegal Field in CDB*.

The READ BUFFER descriptor is defined in the figure below.

Table 129: Read Buffer Description

Byte	Bit						
	7	6	5	4	3	2	1
0	Offset Boundary = 0x09						
1-3	(MSB) Buffer Capacity (LSB)						

The value contained in the Buffer Offset field of subsequent WRITE BUFFER and READ BUFFER commands should be a multiple of two to the power of the offset boundary. The offset boundary is always set to nine, which indicates Sector Boundaries.

16.20.4 Read Data from Echo Buffer (Mode 01010b)

In this mode the drive transfers data from the echo buffer. The echo buffer will transfer the same data as when the WRITE BUFFER command was issued with the mode field set to echo buffer.

WRITE BUFFER command with the mode field set to echo buffer should be sent prior to the READ BUFFER command; otherwise the READ BUFFER command will be terminated with **Check Condition** status and *Illegal Request*.

In this mode Read Buffer transfers the specified amount of data or the amount previously written with a Write Buffer using mode 1010b from the echo buffer, whichever is less.

Issuing a Read Buffer mode 1010b before a Write Buffer mode 1010b will cause indeterminate data to be returned.

The most significant two bytes of the Allocation Length are ignored. The specified amount of data transferred should not be larger than the echo buffer capacity. The echo buffer capacity may be determined by using Read Buffer mode 1011b. Any additional data transferred over and above the echo buffer capacity is regarded as indeterminate.

The Buffer ID and Buffer Offset fields are ignored in this mode.

Note: The echo buffer is a separate buffer from the data buffer used with other read buffer modes. It is intended to be used for domain validation purposes.

16.20.5 Echo Buffer Descriptor (Mode 01011b)

In this mode, a maximum of four bytes of Read Buffer Descriptor information is returned. The drive returns the descriptor information for the echo buffer. The Buffer Offset field is reserved in this mode and must be zero. The drive transfers the lesser of the allocation length or four bytes of following Echo Buffer Descriptor.

Table 130: Echo Buffer Descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved = 0							EBOS=0
1	Reserved = 0							
2	Reserved = 0				(MSB) Buffer Capacity			
3	Buffer Capacity (LSB)							

- **EBOS** (Echo Buffer Overwritten Supported) bit of zero indicates that the echo buffer is shared by all Initiators.
- **Buffer Capacity** field returns the size of the echo buffer in byte aligned to a 4-byte boundary.

16.20.6 Expander Communications and Echo Buffer (Mode 11010b)

Receipt of a READ BUFFER command with this mode (11010b) causes a communicative expander to enter the expanded communication protocol mode. SCSI target devices that receive a READ BUFFER command with this mode shall process it as if it were a READ BUFFER command with mode 01010b (see 17.17.4 Read Data from Echo Buffer).

16.21 READ CAPACITY (10) - (25)

Table 131: READ CAPACITY (10) - (25)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 25h							
1	Reserved = 0			Reserved = 0				Obso-lete
2-5	(MSB) Logical Block Address (LSB)							
6-7	Reserved = 0							
8	Reserved = 0							PMI
9	VU = 0		Reserved = 0				FLAG	LINK

The READ CAPACITY command returns information regarding the capacity of the drive.

- **Logical Block Address** is used in conjunction with the PMI bit.
- **PMI** (Partial Medium Indicator) indicates:

PMI	Description
0	The drive returns the last LBA of the drive. If the LBA field is not 0, the command to be terminated with Check Condition status. The drive shall set sense key to Illegal Request and additional sense code to Illegal Field in CDB.
1	The drive returns the last LBA and block length in bytes are that of the LBA after which a substantial delay in data transfer will be encountered. On SSDs, this returned LBA is the last LBA of the drive. If the LBA field is greater than the last LBA of the drive, the command to be terminated with Check Condition status. The drive shall set sense key to Illegal Request and additional sense code to Illegal Field in CDB

16.21.0.1 Returned Data Format

The data returned to the Initiator in response to the READ CAPACITY command is described here. The data is returned in the DATA IN phase.

Table 132: Format of READ CAPACITY command reply

Byte	Bit							
	6	7	5	4	3	2	1	0
0-3	(MSB) Maximum Logical Block Address (LSB)							
4-7	(MSB) Block Length (LSB)							

- **Block Length** specifies the length in bytes of each block of user data (not including protection information).

16.22 READ CAPACITY (16) (9E/10)

Table 133: Read Capacity (16) (9E/10)

Byte	Bit							
	6	7	5	4	3	2	1	0
0	Command Code = 9Eh							
1	Reserved = 0			Service Action = 10h				
2-9	(MSB) Logical Block Address (LSB)							
10-13	(MSB) Allocation Length (LSB)							
14	Reserved = 0							PMI
15	CONTROL							

The READ CAPACITY (16) (9E/10) command returns information regarding the capacity of the drive.
This command is processed like the standard READ CAPACITY (25) command.
The contents of the CONTROL byte are defined in SAM-4.

16.22.1 Returned Data Format

Table 134: Returned Data Format

Byte	Bit							
	6	7	5	4	3	2	1	0
0 - 7	(MSB) Returned Logical Block Address (LSB)							
8 - 11	(MSB) Logical Block Length in Bytes (LSB)							
12	Reserved = 0				P_Type			Prot_En
13	P_I_Exponent				Logical Block Per Physical Block Exponent			
14	TPE	TPRZ	(MSB) Lowest Aligned Logical Block Address					
15	Lowest Aligned Logical Block Address (LSB)							
16 - 31	Reserved							

The RETURNED **LOGICAL** BLOCK **ADDRESS** field and LOGICAL **BLOCK LENGTH** IN BYTES field of the READ CAPACITY (16) parameter data are the same as the in the READ CAPACITY (10) parameter data.

The maximum value that shall be returned in the RETURNED LOGICAL BLOCK ADDRESS field is FFFF_FFFF_FFFF_FFFEh.

The protection type (P_TYPE) field and the protection enable (PROT_EN) bit indicate the logical unit's current type of protection. See table below:

Table 135: P_TYPE field and PROT_EN bit

PROT_EN	P_TYPE	Description
0	xxxb	The logical unit is formatted to type 0 protection
1	000b	The logical unit is formatted to type 1 protection
1	001b	The logical unit is formatted to type 2 protection
1	010b	The logical unit is formatted to type 3 protection
1	011b to 111b	Reserved

The **P_I_EXPONENT** field may be used to determine the number of protection information intervals placed within each logical block.
The number of protection information intervals is calculated as follows:

number of protection information intervals = 2***(p_iexponent)**

where:

p_i exponent is the contents of the P_I EXPONENT field

The **Logical Block Per Physical Block Exponent** field is defined below:

Table 136: LOGICAL BLOCKS PER PHYSICAL BLOCK EXPONENT field

Code	Description
0	One or more physical blocks per logical block (a)
n > 0	2^n logical blocks per physical block Equation
1	The logical unit is formatted to type 2 protection
(a) The number of physical blocks per logical block is not reported.	

If the thin provisioning enabled **(TPE)** bit is set to one, then the logical unit implements thin provisioning
If the TPE bit is set to zero, then the logical unit implements full provisioning

If the thin provisioning read zeros (**TPRZ**) bit is set to one, then, for an unmapped LBA specified by a read operation, the device server shall send user data with all bits set to zero to the data-in buffer. If the TPRZ bit is set to zero, then, for an unmapped LBA specified by a read operation, the device server shall send user data with all bits set to any value to the data-in buffer.

The LOWEST ALIGNED LOGICAL BLOCK ADDRESS field indicates the LBA of the first logical block that is located at the beginning of a physical block.

NOTE: The highest LBA that the lowest aligned logical block address field supports is 3FFFh (i.e, 16,383).

16.23 READ DEFECT DATA (37)

Table 137: READ DEFECT DATA (37)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 37h							
1	Reserved = 0			Reserved = 0				0
2	Reserved = 0			Plist	Glist	Defect List Format		
3-6	Reserved = 0							
7-8	(MSB) Allocation Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The READ DEFECT DATA command requests that the Target transfer the medium defect data to the Initiator.

If the Target is unable to access any medium defect data it will return a **Check Condition** status with the appropriate sense key. The sense key will be set to either *Medium Error* (03h) if a medium error occurred or *No Sense* (00h) if the list does not exist and the additional sense code will be set to *Defect List Error* (19h).

- **Plist** bit set to one indicates that the Target returns the Plist. A Plist bit of zero indicates that the Target shall not return the Plist of defects.
- **Glist** bit set to one indicates that the Target returns the Glist. A Glist bit of zero indicates that the Target shall not return the Glist.

  Note: With both bits set to one Plist and Glist the Target will return both the primary and grown defect lists. With both bits set to zero, the Target will return only a 4-byte Defect List Header.
- **Defect List format** field is used by the Initiator to indicate the preferred format for the defect list.

  The Defect List Format of '101 (Physical Sector Format)' is supported. If the requested format is not supported by the drive, it will return the defect list in its default format '101' and then terminate the command with **Check Condition** status. The sense key will be set to *Recovered Error* (01h) and the additional sense code will be set to *Defect List Not Found* (1Ch).

The drive sends defect list (Defect Descriptors) in a 8-byte Absolute Block Address (ABA) format that follows a four byte Defect List Header.

The Target will transfer all of the Read Defect Data up to the number of bytes allocated by the Initiator.

Table 138: Defect List Format

Preferred Defect List Format	Returned Defect List Format
Block (000b)	Physical Sector
Bytes from Index (100b)	Physical Sector
Physical Sector (101b)	Physical Sector
Vendor Unique (110b)	Physical Sector
Reserved (001b)	
Reserved (010b)	
Reserved (011b)	
Reserved (111b)	

Note: The drive will terminate the Data In phase when the Allocation Length has been transferred or when all available Defect Data has been transferred to the Initiator, whichever is less.

The Read Defect Data contains a 4-byte header followed by zero or more defect descriptors.

16.23.1 Defect List Header

Table 139: Defect List Header

Byte	Bit							
	7	6	5	4	3	2	1	0
	Defect List Header							
0	Reserved = 0							
1	Reserved = 0			Plist	Glist	Defect List Format		
2-3	(MSB) Defect List length (LSB)							

16.23.2 Defect List Descriptor

Table 140: Defect List Descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
	Defect List Descriptor							
0-7	Defect Descriptor 0							
.								
8n - (8n+7)	Defect Descriptor n							

16.23.3 Physical Sector Format (101b)

Table 141: Defect Descriptors of Physical Sector Format

Byte	Defect Descriptors
3-0	(MSB) Die of Defect (LSB)
7-4	(MSB) Erase Block of Defect (LSB)

The Defect List Format field specifies the format of the defect list data returned by the Target.

The Defect List Length field specifies the length in bytes of the defect descriptors that follow. The Defect List Length is equal to eight times the number of defect descriptors.

Normally the Target will set the Defect List Length field to the amount of space needed to contain the entire defect list. However, the Target is capable of building a defect list with a length such that the entire list cannot be transferred using the maximum allocation length. If the defect list grows beyond 8191 entries, the defect data cannot be transferred with an allocation length of 0FFFFh. The Target will transfer a partial defect list and return **Check Condition** status with the sense key set to *Recovered Error* and the additional sense code set to *Partial Defect List Transferred*. The defect list length will be set to 0FFF8h, indicating the maximum number of defect descriptors that can be transferred. Defects beyond this number cannot be read by the Initiator.

16.24 READ DEFECT DATA (B7)

Table 142: READ DEFECT DATA (B7)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = B7h							
1	Reserved = 0			Plist	Glist	Defect List Format		
2-5	Reserved = 0							
6-9	(MSB) Allocation Length (LSB)							
10	Reserved = 0							
11	VU = 0		Reserved = 0				FLAG	LINK

(See Section 16.23 READ DEFECT DATA (37)” on page 169.)

16.24.1 Defect List Header

Table 143: Defect List Header

Byte	Bit							
	7	6	5	4	3	2	1	0
	Defect List Header							
0	Reserved = 0							
1	Reserved = 0			Plist	Glist	Defect List Format		
2-3	Reserved = 0							
4-7	(MSB) Defect List length (LSB)							

(See Defect List Header for Read Defect Data (37) in Section Table 16.23.1, “Defect List Header,” on page 171.)

16.24.2 Defect List Descriptor

Table 144: Defect List Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
	Defect List Descriptor							
0-7	Defect Descriptor 0							
.								
8n - (8n+7)	Defect Descriptor n							

(See Defect List Descriptor for Read Defect Data (37) in Section 16.23.2 Defect List Descriptor" on page 171.)

16.24.3 Physical Sector Format (101b)

Table 145: Defect Descriptors of Physical Sector Format

Byte	Defect Descriptors
0-3	(MSB) Die of Defect (LSB)
4-7	(MSB) Erase Block of Defect (LSB)

16.25 READ LONG (3E)

Table 146: READ LONG (3E)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 3Eh							
1	Reserved = 0			Reserved = 0			Correct = 0	Obsolete
2-5	(MSB) Logical Block Address (LSB)							
6	Reserved = 0							
7-8	(MSB) Byte Transfer Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The READ LONG command requests the drive to transfer one block of data to the Initiator. The transfer data includes data and ECC field data.

- **Correct** bit is ignored. ECC correction is always performed. If ECC correction fails, the Target terminates the command with **Check Condition** status, the sense key is set to Medium Error, and an additional sense code set to Unrecovered Read Error.
- **Logical Block Address** field specifies the logical block at which the read operation shall occur.
- **Byte Transfer Length** field must specify exactly the number of bytes of data that are available for transfer. If a non-zero byte transfer length does not match the available data length, the Target terminates the command with **Check Condition** status, the sense key is set to *Illegal Request*, and an additional sense code set to *Invalid Field in CDB*. The valid and ILI bits are set to one and the information field is set to the difference of the requested length minus the actual length in bytes. Negative values are indicated by two's complement notation.

  The transfer length is calculated as follows:

  transfer length = logical block size + 4

The data read by this command is neither read from nor retained in the cache.

16.26 REASSIGN BLOCKS (07)

Table 147: REASSIGN BLOCKS (07)

Byte	Bit 7	6	5	4	3	2	1	0
0	Command Code = 07h							
1	Reserved = 0				Reserved = 0			
2 3 4	Reserved = 0							
5	VU = 0		Reserved = 0				FLAG	LINK

The REASSIGN BLOCKS command is implemented as a no-op on the SSD. To maintain compatibility, the SSD performs protocol checking on the CDB and a range check of the LBA(s) transferred to the drive during the DATA OUT phase.

The REASSIGN BLOCKS command will not modify the specified LBAs or attempt to recover or reallocate them. An unreadable LBA will remain unreadable after execution of a REASSIGN BLOCKS command.

Following is the format of the data sent by the Initiator during the DATA OUT phase.

Table 148: Format of Reassign Blocks data

Byte	**Bit**						
	7	**6**	**5**	**4**	**3**	**2**	**1**
0	**Reserved = 0**						
1	**Reserved = 0**						
2-3	**(MSB)**			**Defect List Length = 4/8/12/16**			**(LSB)**
4-7	**(MSB)**			**Defect Logical Block Address 1**			**(LSB)**
8-11	**(MSB)**			**Defect Logical Block Address 2**			**(LSB)**
12-15	**(MSB)**			**Defect Logical Block Address 3**			**(LSB)**
16-19	**(MSB)**			**Defect Logical Block Address 4**			**(LSB)**

- **Defect List Length** must be 4, 8, 12, or 16. Otherwise, the drive returns *Check Condition* with a sense key of *Illegal Request*.
- **Defective Logical Block Address** is four bytes in length. The Initiator can specify from 1 to 4 Defective Logical Block Addresses according to the Defect List Length from 4 to 16, respectively. LBAs are not required to be in ascending order. If the Defective Logical Block Address is greater than the maximum LBA of the drive, the command will be terminated with Check Condition with a sense key of Illegal Request.

16.27 RECEIVE DIAGNOSTICS RESULTS (1C)

Table 149: RECEIVE DIAGNOSTIC RESULTS (1C)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 1Ch							
1	Reserved = 0			Reserved = 0				PCV
2	Page Code							
3 4	(MSB) Allocation Length (LSB)							
5	VU = 0		Reserved = 0				FLAG	LINK

The RECEIVE DIAGNOSTIC RESULTS command requests that analysis data requested by a SEND DIAGNOSTIC command be sent to the Initiator.

- **PCV** (Page Code Valid) bit of zero indicates that the most recent SEND DIAGNOSTIC command shall define the data returned by this command. PCV bit of one indicates that the contents of the Page Code field shall define the data returned by this command.
- **Allocation Length** specifies the amount of data to be returned to the Initiator. This value may be zero and this is not considered an error. The Target terminates the Data In phase when all available data has been transferred or when the number of bytes transferred equals the Parameter List Length.

16.27.1 Receive Diagnostic Results Page 0

This page contains a list of supported pages.

Table 150: Receive Diagnostic Results page 0

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Page Code = 0							
1	Reserved = 0							
2-3	Page Length = 03h							
4	(Supported Pages) Page = 0h							
5	CJTPAT page = 3Fh							
6	Translate address page = 40h							

The supported diagnostic page returns a list of supported pages in ascending order.

16.27.2 Receive Diagnostic Results Page 40

Using the SEND DIAGNOSTIC command, an address in either physical or logical format is supplied to the drive. This page is then used to retrieve the address translated into the other format. Note that this address translation functionality is only supported by the SSD for HDD compatibility. The physical address does not represent a true physical address on the SSD's media.

Table 151: Receive Diagnostic Results Page 40

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Page Code = 40h							
1	Reserved = 0							
2-3	Page Length							
4	Reserved = 0					Supplied format		
5	RA	Reserved=0				Translate format		
6-n	Translated Address							

- **Page Length** is set to 02h if the address is in a Reserved Area (RA =1). Otherwise, Page Length is set to 06h if the Translate Format is Block format, or 0Ah if the Translate Format is Bytes From Index format or Physical Sector format.
- **Supplied Format** is the value supplied by the SEND DIAGNOSTIC command; it may be one of the three following values:
  - **000b** Block format
  - **100b** Bytes From Index format
  - **101b** Physical Sector format
- **Translate Format** is the value supplied by the SEND DIAGNOSTIC command and specifies the format in which the address has been translated into List. If the supplied format is the Block format, the Translate format must be either Bytes from Index or Physical Sector format. If the supplied format is the Bytes from Index or Physical Sector format, the Translate format must be Block format. Otherwise the Target will terminate the command with **Check Condition** status.
- **RA (Reserved Area)** is set to on if the translated block is an inaccessible sector, which reflects a defect, an unused sector on a spare cylinder, or a sector beyond the Maximum Customer LBA.
- **Translated Address** contains the address in the translate format. If it is an LBA, it is contained within the first four bytes of the field (bytes 6 to 9) of the page data. For a physical format it is as follows:

Table 152: Translated address

Byte	Bit							
	7	6	5	4	3	2	1	0
6-13	Physical Address							

16.28 RELEASE (17)

Table 153: RELEASE (17)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 17h							
1	Reserved = 0			3rdPty=0	3rd Party ID			Ext=0
2	Reservation Identification							
3-4	Reserved = 0							
5	VU = 0		Reserved = 0				FLAG	LINK

The RELEASE command is used to release a LUN previously reserved. It is not an error for an Initiator to release a LUN that is not currently active. The drive returns **Good** status without altering the reservation.

- **3rdPty** must be 0. Third Party reservations are not supported. If the 3rdPty bit is not zero, Check Condition status is returned with a sense key of Illegal Request and additional sense code of Invalid Field in CDB.
- **3rd Party ID** is ignored.
- **Ext**ents must be 0. Extension is not supported by the drive.
- **Reservation Identification** field is ignored.

16.29 RELEASE (57)

Table 154: RELEASE (57)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 57h							
1	Reserved = 0			3rdPty=0	Reserved = 0			Ext = 0
2	Reservation Identification							
3	3rd Party Device ID							
4-8	Reserved = 0							
9	VU = 0		Reserved = 0				FLAG	LINK

The RELEASE command is used to release a LUN previously reserved. It is not an error for an Initiator to release a LUN that is not currently active. The drive returns **Good** status without altering the reservation.

- **3rdPty** must be 0. Third Party reservations are not supported. If the 3rdPty bit is not zero, Check Condition status is returned with a sense key of Illegal Request and additional sense code of Invalid Field in CDB.
- **3rd Party ID** is ignored.
- **Extent** must be 0. Extension is not supported by the drive.
- **Reservation Identification** field is ignored.

16.30 REPORT DEVICE IDENTIFIER (A3/05)

Table 155: REPORT DEVICE IDENTIFIER (A3/05)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = A3h							
1	Reserved = 0				Service Action = 05h			
2	Reserved = 0							
3	Reserved = 0							
4-5	(MSB) LUN=0 (LSB)							
6-9	(MSB) Allocation Length (LSB)							
10	Reserved = 0							
11	VU = 0		Reserved = 0				FLAG	LINK

The **REPORT DEVICE IDENTIFIER** command requests that the device server send device identification information to the application client.

The **LUN** contains the logical unit number parameter. This parameter is expected to be zero. Other value for this parameter will cause the command to terminate with a CHECK CONDITION status. The sense key is set to ILLEGAL REQUEST, and the additional sense code is set to INVALID FIELD IN CDB.

The **ALLOCATION LENGTH** field indicates how much space has been reserved for the returned parameter data. If the length is not sufficient to contain all the parameter data, the first portion of the data is returned. This is not considered an error. The actual length of the parameter data is available in the IDENTIFIER LENGTH field in the parameter data. If the remainder of the parameter data is required, the application client should send a new REPORT DEVICE IDENTIFIER command with an ALLOCATION LENGTH field large enough to contain all the data.

The REPORT DEVICE IDENTIFIER parameter list contains a 4-byte field that contains the length in bytes of the parameter list and the logical unit's identifier.

Table 156: Report Device Identifier parameter list

Byte	Bit							
	7	6	5	4	3	2	1	0
0-3	(MSB) Identifier Length = n - 3 (LSB)							
4-n	Identifier							

The IDENTIFIER LENGTH field specifies the length in bytes of the IDENTIFIER field. If the ALLOCATION LENGTH field in the CDB is too small to transfer all of the identifier, the length is not adjusted to reflect the truncation. The identifier length initially equals zero and is changed only by a successful SET DEVICE IDENTIFIER command.

The IDENTIFIER field contains a vendor specific value. The value reported is the last value written by a successful SET DEVICE IDENTIFIER command. The value of the identifier is changed only by a SET DEVICE IDENTIFIER command. The identifier value persist through resets, power cycles, media format operations.

The Target return the same Identifier to all Initiators on all ports.

The execution of a REPORT DEVICE IDENTIFIER requires the enabling of a nonvolatile memory within the logical unit. If the nonvolatile memory is not ready, the device server returns **Check Condition** status rather than wait for the device to become ready. The sense key is set to *Not Ready* and the additional sense data is set as described in the TEST UNIT READY command. This information should allow the application client to determine the action required to cause the device server to become ready.

16.31 REPORT LUNS (A0)

Table 157: REPORT LUNS (A0)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = A0h							
1-5	Reserved							
6-9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	VU = 0		Reserved = 0				FLAG	LINK

The REPORT LUNS command requests that the Target return the known LUN to the Initiator. The REPORT LUNS command should always be available and is unaffected by any reservations.

The Allocation Length must be at least 16 bytes. If the Allocation Length is less than 16 bytes, the Target will return a **Check Condition** status with sense key of *Illegal Request* and additional sense code of *Invalid Field in CDB*. If the Allocation Length is not sufficient to contain the LUN values for all configured logical units, the Target shall report as many LUN values as will fit in the specified Allocation Length. This is not considered an error.

The REPORT LUNS command will send the LUN list in the subsequent Data Out Phase. The format of the LUN list is shown in the following table.

Table 158: LUN Reporting parameter list format

Byte	Bit							
	7	6	5	4	3	2	1	0
0-3	(MSB) LUN List Length = 8 (LSB)							
4-7	Reserved							
8-15	(MSB) LUN = 0 (LSB)							

The LUN list length shall contain the length in bytes of the LUN list that is available to be transferred. This product only supports one LUN. Therefore, the LUN list length must be set to 8. The only supported LUN is zero.

16.32 REPORT SUPPORTED OPERATION CODES (A3/0C)

Table 159: REPORT SUPPORTED OPERATION CODES (A3/0C)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Command Code = A3h</td></tr>
<tr><td>1</td><td colspan="4">Reserved = 0</td><td colspan="4">Service Action = 0Ch</td></tr>
<tr><td>2</td><td>RCTD</td><td colspan="4">Reserved = 0</td><td colspan="3">Reporting Options</td></tr>
<tr><td>3</td><td colspan="8">Requested Operation Code</td></tr>
<tr><td>4-5</td><td colspan="8">Requested Service Action</td></tr>
<tr><td>6-9</td><td colspan="8">Allocation Length</td></tr>
<tr><td>10</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>11</td><td colspan="2">VU = 0</td><td colspan="4">Reserved</td><td>FLAG</td><td>LINK</td></tr>
</table>

The REPORT SUPPORTED OPERATION CODES command requests information on commands that the drive supports. The initiator may request a list of all operation codes and service actions supported, or the command support data for a specific command.

RCTD: A return command timeouts descriptor (RCTD) bit set to one specifies that the command timeouts descriptor shall be included in each command descriptor (see section 16.32.1) that is returned or in the one_command parameter data (see section 16.32.2) that is returned. A RCTD bit set to zero specifies that the command timeouts descriptor shall not be included in any parameter data returned.

Reporting Options specifies the information to be returned in the parameter data.

Table 160: Reporting Options

Reporting Options	Description
000b	A list of all operation codes and service actions supported by the drive will be returned in the all_commands parameter data format. The Requested Operation Code field and Requested Service Action field will be ignored.
001b	The command support data for the operation code specified in the Requested Operation Code field will be returned in the one_command parameter data format. The Requested Service Action field will be ignored. If the Requested Operation Code field specifies an operation code that has service actions, Check Condition status will be reported with a sense key of Illegal Request and additional sense code of Invalid Field in CDB.
010b	The command support data for the operation code and service action specified in the Requested Operation Code field and Requested Service Action field will be returned in the one_command parameter data format. If the Requested Operation Code field specifies an operation code that does not have service actions, Check Condition status will be reported with a sense key of Illegal Request and additional sense code of Invalid Field in CDB.
011b-111b	**Reserved**

Requested Operation Code specifies the operation code of the command to be returned in the one_command parameter data format.

Requested Service Action specifies the service action of the command to be returned in the one_command parameter data format.

Allocation Length specifies the number of bytes that have been allocated for the returned parameter data. If the length is not sufficient to contain all the parameter data, the first portion of the data shall be returned. The actual length of the parameter data may be determined from the Additional Length field in the parameter data.

16.32.1 All_commands parameter data format

The Report Supported Operation Codes all_command parameter data format begins with a four-byte header that contains the length in bytes of the parameter data, followed by a list of supported commands. Each command descriptor contains information about a single supported command CDB (i.e. one operation code and service action combination, or one non-service action
operation code).

Table 161: All_command parameter data format

Byte	Bit							
	7	6	5	4	3	2	1	0
0-3	Command Data Length (n-3)							
4	Command Descriptor 0							
N	Command Descriptor X							

Each **Command Descriptor** contains information about a single supported command CDB.

Table 162: Command Descriptor format

Byte	Bit							
	7	6	5	4	3	2	1	0
0-3	Operation Code							
1	Reserved = 0							
2-3	Service Action							
4	Reserved = 0							
5	Reserved = 0						CTDP	Serva-ctv
6-7	CDB Length							
8-19	Command Timeouts Descriptor, if any (see 16.32.3)							

Operation Code contains the operation code of a supported command.

Service Action contains a supported service action of the supported operation. If the operation code does not have a service

action, the Service Action field will be set to zero.
CTDP: A command timeouts descriptor present bit set to one indicates that the command timeouts descriptor (see 18.32.3) is included in this command descriptor. A CTDP bit set to zero indicates that the command timeouts descriptor is not included in this command descriptor.

Servactv set to zero indicates the operation code does not have service actions and the Service Action field should be ignored. SERVACTV set to one indicates the operation code field has service actions and the contents of the Service Action field are valid.
CDB Length contains the length of the command CDB in bytes.

16.32.2 One_command parameter data format

The Report Supported Operation Codes one_command parameter data format contains information about the CDB and a usage map for bits in the CDB for the command specified by the Reporting Options, Requested Operation Code, and Requested Service Action fields in the Reported Supported Operation Codes CDB.

Table 163: One_command parameter data format

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved = 0							
1	CTDP	Reserved = 0				Support		
2-3	CDB Size (n-3)							
4-n	CDB Usage Data							
n+1 - n+12	Command Timeouts Descriptor, if any (see 16.32.3)							

CTDP: A command timeouts descriptor present bit set to one indicates that the command timeouts descriptor is included in this command descriptor. (see section 16.32.3) A CTDP bit set to zero indicates that the command timeouts descriptor is not included in this command descriptor.

The Support field is defined in the table below.

Table 164: One_command parameter support field

Recording Option	Description
000b	Data about the requested command is not currently available. All data after byte 1 is not valid. A subsequent request for command support data may be successful.
001b	The requested command is not supported. All data after byte 1 is not valid.
010b	Reserved.
011b	The requested command is supported in conformance with the standard.
100b	Reserved
101b	The requested command is supported in a vendor specific manner.
110b-111b	Reserved.

CDB Size contains the size of the CDB Usage Data field in the parameter data, and the number of bytes in the CDB for the command requested.
CDB Usage Data contains information about the CDB for the command requested. The first byte of the CDB Usage Data field contains the operation code for the command. If the command contains a service action, then that service action code is returned in the same location as the Service Action field of the command CDB. All other bytes of the CDB Usage Data field contain a usage map for bits in the CDB for the command requested.

The bits in the usage map have a one-for-one correspondence to the CDB for the command requested. If the drive evaluates a bit in the CDB, the usage map will contain a one in the corresponding bit position. The usage map will contain a zero in the corresponding bit position for any field treated as ignored or reserved.

16.32.3 Command timeouts descriptor format

16.32.3.1 Overview

The command timeouts descriptor (see Table 165:) returns time-out information for commands supported by the logical unit based on the time from the start of processing for the command to its reported completion. Values returned in the command timeouts descriptor do not include times that are outside the control of the device server (e.g., prior commands with the IMMED bit set to one in the CDB, concurrent commands from the same or different I_T nexuses, manual unloads, power-on self tests, prior aborted commands, commands that force cache synchronization, delays in the service delivery subsystem).
For commands that cause a change in power condition (Idle/Standby Powersave Modes), values returned in the command timeouts descriptor do not include the power condition transition time (e.g., the time to spinup rotating media).
Values returned in the command timeouts descriptor should not be used to compare products.

Table 165: Command timeouts descriptor format

Byte	7	6	5	4	3	2	1	0
0 - 1	Descriptor Length (0Ah)							
2	Reserved = 0							
3	Command Specific							
4- 7	Nominal Command Processing Time-out							
8 - 11	Recommended Command Time-out							

The DESCRIPTOR LENGTH field indicates the number of bytes that follow in the command timeouts descriptor.
The COMMAND SPECIFIC field contains time-out information (see Table 166:) that is specific to one or more commands. If no command specific time-out information is defined by this or the applicable command standard, the COMMAND SPECIFIC field is reserved.

Table 166: Command timeouts descriptor Command Specific Field usage

Command	Reference
WRITE BUFFER	See Section 16.32.3.2

16.32.3.2 WRITE BUFFER: command timeouts descriptor COMMAND SPECIFIC field usage

For the WRITE BUFFER command, the COMMAND SPECIFIC field usage is reserved for all modes except the following:

- Download microcode mode (04h);
- Download microcode and save mode (05h);
- Download microcode with offsets mode (06h);
- Download microcode with offsets and save mode (07h);
- Download microcode with offsets and defer activation mode (0Eh) only if the microcode is activated by an event other than an activate deferred microcode mode; and
- Activate deferred microcode mode (0Fh).

If the command timeouts descriptor describes one of the WRITE BUFFER modes listed in this subclause, then the COMMAND SPECIFIC field indicates the maximum time, in one second increments, that access to the SCSI device is limited or not possible through any SCSI ports associated with a logical unit that processes a WRITE BUFFER command that specifies one of the named modes. A value of zero in the COMMAND SPECIFIC field indicates that the no maximum time is indicated.

16.33 REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS (A3/0D)

Table 167: Report Supported Task Management Functions (A3/0D)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = A3h							
1	Reserved = 0			Service Action = 0Dh				
2-5	Reserved = 0							
6-9	Allocation Length							
10	Reserved = 0							
11	VU = 0		Reserved = 0				Flag	Link

The REPORT SUPPORTED TASK MANAGEMENT FUNCTIONS command requests information on task management functions supported by the drive.

Allocation Length specifies the number of bytes that have been allocated for the returned parameter data. The allocation length must be at least four. If the allocation length is less than four, Check Condition Status will be returned with sense key of Illegal Request and additional sense code of Invalid Field in CDB.

The format of the returned parameter data is shown below.

Byte	Bit							
	7	6	5	4	3	2	1	0
0	ATS	ATSS	CACAS	CTSS	LURS	QTS	TRS	WAKES
1	Reserved					QUAS	QTSS	ITNRS
2	Reserved							
3	Reserved							

ATS (Abort Task) bit set to one indicates that ABORT TASK is supported. An ATS bit of zero indicates that ABORT TASK is not supported.

ATSS (Abort Task Set) bit set to one indicates that ABORT TASK SET is supported. An ATSS bit of zero indicates that ABORT TASK SET is not supported.

CACAS (Clear ACA) bit set to one indicates that CLEAR ACA is supported. A CACAS bit of zero indicates that CLEAR ACA is not supported.

CTSS (Clear Task Set) bit set to one indicates that CLEAR TASK SET is supported. A CTSS bit of zero indicates that CLEAR TASK SET is not supported.

LURS (Logical Unit Reset) bit set to one indicates that LOGICAL UNIT RESET is supported. An LUR bit of zero indicates that LOGICAL UNIT RESET is not supported.

QTS (Query Task) bit set to one indicates that QUERY TASK is supported. A QTS bit of zero indicates that QUERY TASK is not supported.

TRS (Target Reset) bit set to one indicates that TARGET RESET is supported. A TRS bit of zero indicates that TARGET RESET is not supported.

WAKES (Wakeup) bit set to one indicates that WAKEUP is supported. A WAKES bit of zero indicates that WAKEUP is not supported.

A QUERY UNIT ATTENTION supported (QUAS) bit set to one indicates the QUERY UNIT ATTENTION task management function (see SAM-4) is supported by the logical unit. A QUAS bit set to zero indicates the QUERY UNIT ATTENTION task management function is not supported.

A QUERY TASK SET supported (QTSS) bit set to one indicates the QUERY TASK SET task management function (see SAM-4) is supported by the logical unit. A QTSS bit set to zero indicates the QUERY TASK SET task management function is not supported.

An I_T NEXUS RESET supported (ITNRS) bit set to one indicates the I_T NEXUS RESET task management function (see SAM-4) is supported by the logical unit. An ITNRS bit set to zero indicates the I_T NEXUS RESET task management function is not supported.

16.34 REQUEST SENSE (03)

Table 168: REQUEST SENSE (03)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 03h							
1	Reserved = 0			Reserved = 0				
2-3	Reserved = 0							
4	Allocation Length							
5	VU = 0		Reserved = 0				FLAG	LINK

The REQUEST SENSE command requests the drive to transfer sense data.

If REQUEST SENSE command with an invalid LUN is received, the drive returns **Good** status and reports a sense key of *Illegal Request* and an additional sense code of *Logical Unit Not Supported*.

If the drive has no sense data available to return, it shall return a sense key of *No Sense* and an additional sense code of *No Additional Sense Information*.

Separate sense data is maintained by the device for each Initiator. Therefore, there is no requirement for an Initiator to expeditiously clear a *Check Condition* as this will not affect other initiators in a multi-Initiator system.

The drive will return the number of bytes in the allocation length or 32 bytes, whichever is less.

16.35 RESERVE (16)

Table 169: RESERVE (16)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 16h							
1	Reserved = 0			3rdPty=0	3rd Party ID			Ext=0
2	Reservation Identification							
3-4	(MSB) Extent List Length = 0 (LSB)							
5	VU = 0		Reserved = 0				FLAG	LINK

The RESERVE command is used to reserve a LUN for an Initiator. This reservation can be either for the Initiator sending the command or for a third party as specified by the Initiator.

Extents are not supported by the drive. The Ext bit must be zero. If Ext bit is set to one, **Check Condition** status is returned with a sense key of *Illegal Request* and additional sense code of *Invalid Field in CDB*. The Reservation Identification and Extent List Length fields are ignored.

The Reserve command requests that the entire LUN be reserved for the Initiator until

- the reservation is superseded by another valid Reserve command from the Initiator that made the reservation.
- the reservation is released by a RELEASE command from the same Initiator.
- a hard Reset condition occurs.
- a Target Reset message is received from any Initiator.
- a power off/on cycle occurs.

3rdPty must be 0. Third Party reservations are not supported. If the 3rdPty bit is not zero, Check Condition status is returned with a sense key of Illegal Request and additional sense code of Invalid Field in CDB.

3rd Party ID is ignored.

Only the Initiator that issued the Reserve command for a LUN may release the LUN, regardless of the 3rdPty option. This Initiator may also release the LUN by issuing another RESERVE command. This superseding RESERVE command releases the previous reservation when the new reservation is granted.

Reservation queuing is not supported by the drive. If a LUN is reserved and a RESERVE command is issued from a different Initiator, the Target responds with a RESERVATION CONFLICT.

16.36 RESERVE (56)

Table 170: RESERVE (56)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 56h							
1	Reserved = 0			3rdPty=0	Reserved			Ext=0
2	Reservation Identification							
3	Third Pay Device ID							
4-6	Reserved = 0							
7-8	(MSB) Extent List Length = 0 (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The RESERVE command is used to reserve a LUN for an Initiator. This reservation can be either for the Initiator sending the command or for a third party as specified by the Initiator.

Extents are not supported by the drive. The Ext bit must be zero. If Ext bit is set to one, **Check Condition** status is returned with a sense key of *Illegal Request* and additional sense code of *Invalid Field in CDB*. The Reservation Identification and Extent List Length fields are ignored.

The Reserve command requests that the entire LUN be reserved for the Initiator until

- the reservation is superseded by another valid Reserve command from the Initiator that made the reservation.
- the reservation is released by a RELEASE command from the same Initiator.
- a hard Reset condition occurs.
- a Target Reset message is received from any Initiator.
- a power off/on cycle occurs.

3rdPty must be 0. Third Party reservations are not supported. If the 3rdPty bit is not zero, Check Condition status is returned with a sense key of Illegal Request and additional sense code of Invalid Field in CDB.

3rd Party ID is ignored.

Only the Initiator that issued the Reserve command for a LUN may release the LUN, regardless of the 3rdPty option. This Initiator may also release the LUN by issuing another RESERVE command. This superseding RESERVE command releases the previous reservation when the new reservation is granted.

Reservation queuing is not supported by the drive. If a LUN is reserved and a RESERVE command is issued from a different Initiator, the Target responds with a RESERVATION CONFLICT.

16.37 REZERO UNIT (01)

Table 171: REZERO UNIT (01)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 01h							
1	Reserved = 0			Reserved = 0				
2-4	Reserved = 0							
5	VU = 0		Reserved = 0				FLAG	LINK

The REZERO UNIT command is implemented as a no-op on the SSD.

16.38 SEEK (6) - (0B)

Table 172: SEEK (6) - (0B)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 0Bh							
1	Reserved = 0			(MSB) LBA				
2 3	Logical Block Address (LSB)							
4	Reserved = 0							
5	VU = 0		Reserved = 0				FLAG	LINK

The SEEK (6) command is implemented as a no-op on the SSD. No checking is performed on the LBA in the CDB.

16.39 SEEK (10) - (2B)

Table 173: SEEK (10) - (2B)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 2Bh							
1	Reserved = 0			Reserved = 0				0
2-5	(MSB) Logical Block Address (LSB)							
6-8	Reserved = 0							
9	VU = 0		Reserved = 0				FLAG	LINK

The SEEK (10) command is implemented as a no-op on the SSD. No checking is performed on the LBA in the CDB.

16.40 SEND DIAGNOSTIC (1D)

Table 174: SEND DIAGNOSTIC (1D)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 1Dh							
1	Function Code			PF	RSVD =0	SlfTst	Dev0fl	Unt0fl
2	Reserved = 0							
3-4	(MSB) Parameter List Length (LSB)							
5	VU = 0		Reserved = 0				FLAG	LINK

The SEND DIAGNOSTIC command requests the drive to perform its self-diagnostic test or to perform a function based on a page of information sent in a Data Out phase during the command.

- **PF (Page Format)** bit set to one indicates the data sent by the Initiator conform to the page structure as specified in SCSI standard. This bit is ignored by the Target if the SlfTst bit is set.
- **SlfTst** set to one indicates that the device performs its default self-test. If SlfTst is one, the Function code field is ignored. If SlfTst is set to zero, the action to perform is specified in Function code field.

Table 175: SEND DIAGNOSTIC Function Code (1D)

Value	Function name	Descrition
000b	NA	Value to be used when the SlfTst bit is set to one or if the SEND DIAGNOSTIC command is not invoking one of the other self-test function codes.
001b	Background Short self-test	The device server starts its short self-test routine in background mode.
010b	Background extended self-test	The device server starts its extended self-test routine in background mode.
011b	NA	Reserved.
100b	Abort background self-test	Abort the current self-test in the background mode. This value is only valid if a previous SEND DIAGNOSTIC command specified a background self-test function and that function has not been completed.
101b	Foreground short self-test	The device server starts its short self-test routine in the foreground mode. This self-test will complete in two minutes or less.
110b	Foreground extended self-test	The device server starts its extended self-test routine in the foreground mode.The completion time for this test is reported in Mode Page 0Ah (refer to section 17.11.9 "Mode Page 0A).
111b		Reserved.

- **DevOfl** is ignored by the Target for compatibility.
- **UntOfl** is ignored by the Target for compatibility.
- **Parameter List Length** must be 0 when the SlfTst bit is one. Otherwise, **Check Condition** status will be generated with a sense key of *Illegal Request* and additional sense of *Invalid Field in CDB*. If the SlfTst bit is zero, it should be set to the length of the page to be transferred in the DATA OUT phase of the command. If it does not match the expected length of the page a **Check Condition** status will be also generated with a sense key of *Illegal Request* and additional sense of *Invalid Field in CDB*.

If a fault is detected during the default or foreground self-test, a **Check Condition** is reported as an end status. If a fault is detected during the background self-test, it is logged in the log page for later retrieval by a LOG SENSE command.

See Diagnostics, page 253 for a detailed listing of operations carried out by the SEND DIAGNOSTIC command and Power on Diagnostics.

16.40.1 Send Diagnostic Page 0

This page requests that the drive return a list of supported pages on the next RECEIVE DIAGNOSTICS command.

Table 176: Diagnostic Page 0

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Page Code = 0</td></tr>
<tr><td>1</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>2 - 3</td><td colspan="8">Page Length = 0</td></tr>
</table>

16.40.2 Send Diagnostic Page 3F

Table 177: Diagnostic Page 3F

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Page Code = 3F</td></tr>
<tr><td>1</td><td colspan="4">Reserved = 0</td><td colspan="4">Protocol Identifier = 6</td></tr>
<tr><td>2 - 3</td><td colspan="8">Page Length = 1Ch</td></tr>
<tr><td>4</td><td colspan="8">Phy Identifier</td></tr>
<tr><td>5</td><td colspan="8">Phy Test Function</td></tr>
<tr><td>6</td><td colspan="8">Phy Test Pattern</td></tr>
<tr><td>7</td><td>Rsvd=0</td><td>Phy Test Pattern SATA = 0</td><td colspan="2">Phy Test Pattern SSC</td><td colspan="4">Phy Test Pattern Physical Link Rate</td></tr>
<tr><td>8 - 10</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>11</td><td colspan="8">Phy Test Pattern Dwords Control</td></tr>
<tr><td>12 - 19</td><td colspan="8">Phy Test Pattern Dwords</td></tr>
<tr><td>20 - 31</td><td colspan="8">Reserved = 0</td></tr>
</table>

- Phy Identifier specifies the selected phy that is to perform or to stop performing a phy test function. If the phy does not exist, Check Condition status will be returned with a sense key of Illegal Request and additional sense of Invalid Field in Parameter List.
- Phy Test Function specifies the phy test function to be performed. If an unsupported function is requested, Check Condition status will be returned with a sense key of Illegal Request and additional sense of Invalid Field in Parameter List.

Phy Test Function	Description
00h	If the selected phy is performing a phy-test function, then the selected phy stop performing the phy test function and originate a link reset sequence. If the selected phy is not performing a phy test function, then this function as no effect on the selected phy.
01h	If the selected phy is not performing a phy test function, the selected phy will be set to transmit the phy test pattern specified by the Phy Test Pattern field at the physical link rate specified by the Phy Test Pattern Physical
02h-FDh	Unsupported
FEh	Analog Loopback - If the selected phy is not performing a phy test function, the selected phy will be set to retransmit the data pattern received by the phy receiver without retime
FFh	Retime Loopback- If the selected phy is not performing a phy test function, the selected phy will be set to retransmit the retimed data pattern received by the phy receiver

- **Phy Test Pattern** specifies the phy test pattern to be transmitted when the Phy Test Function is set to 01h. If an unsupported value is specified, Check Condition status will be returned with a sense key of Illegal Request and additional sense of Invalid Field in Parameter List.

Phy Test Pattern	Description
00h	Reserved
01h	JTPAT
02h	CJTPAT
03h-0Fh	Reserved
10h	TRAIN (Not Supported)
11h	TRAIN_DONE (Not Supported)
12h	IDLE
13h	SCRAMBLE_0
14h - 3Fh	Reserved
40h	TWO_DWORDS
41h - EFh	Reserved
F0h	PRBS7 (DcC un-balanced version)
F0h-FFh	Reserved

- **Phy Test Pattern Physical Link Rate** specifies the physical link rate at which the phy test pattern shall be transmitted. Supported values are 8h for 1.5 Gbps, 9h for 3.0 Gbps, and Ah for 6.0 Gbps. If an unsupported value is specified, Check Condition status will be returned with a sense key of Illegal Request and additional sense of Invalid Field in Parameter List.
- **Phy Test Pattern SATA** bit set to 0 indicates that the phy transmits the phy test pattern as a SAS phy. If this bit is set to 1, Check Condition status will be returned with a sense key of Illegal Request and additional sense of Invalid Field in Parameter List
- **Phy Test Pattern SSC** field specifies the SSC modulation type which the phy test pattern will be transmitted. If an unsupported SSC modulation type is specified, Check Condition status will be returned with a sense key of Illegal Request and additional sense of Invalid Field in Parameter List.

Note: The drive's SSC hardware is shared between both ports. In order for the drive to transmit SSC, both ports must be configured with SSC enabled. When Phy Test Pattern SSC is specified, drive will apply the SSC modulation type to both ports in order for spreading to occur. This could cause link disruption if the connected HBA is unable to receive a SSC signal.

Phy Test Pattern SSC Code	Description
00h	No SSC
01h	Center-spreading SSC (Not supported)

10h	Down-spreading SSC
11h	Reserved

- **Phy Test Pattern Dwords Control** controls whether the bytes in the Phy Test Pattern Dwords field are sent as control characters or data characters.

Phy Test Pattern Dwords Control	Description
00h	Each byte is sent as a data character
08h	Not supported
80h	Not supported
88h	The first and fifth bytes are sent as control characters, other bytes are sent as data characters. Note: the value of the two Dwords must be the same.

- **Phy Test Pattern Dwords** contains the two Dwords that are sent during a TWO_DWORDS test pattern.

16.40.3 Send Diagnostic Page 40

This allows the Initiator to translate a LBA or physical sector address to the other format. The address to be translated is passed to the Target with the SEND DIAGNOSTIC command and the results are returned to the Initiator by the RECEIVE DIAGNOSTICS command.

The Target will read the parameter list from the Initiator, and, if no errors are detected in the parameter list, **Good** status will be returned. The data translation will be performed upon receipt of the RECEIVE DIAGNOSTICS command.

Table 178: Diagnostic Page 40

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Page Code = 40h							
1	Reserved = 0							
2-3	Page Length = 0Ah							
4	Reserved = 0					Supplied format		
5	Reserved = 0					Translate format		
6-13	Address to Translate							

Supplied Format may take one of the following three values:

- **000b** Block format
- **100b** Bytes From Index format
- **101b** Physical Sector format

It specifies the format in which the address has been supplied.

- **Translate Format** specifies the format that the address should be translated into. If the supplied format is the Block format, the Translate format must be either Bytes from Index or Physical Sector format. If the supplied format is the Bytes from Index or Physical Sector format, the Translate format must be Block format. If either of the format fields is invalid or they specify the same format, the command will terminate with **Check Condition** status with a sense code of *Illegal Request* and *Illegal Field in Parameter List*.
- **Address to Translate** contains the address to translate. If the logical block format is specified, the first four bytes of the field (bytes 6 to 9) contain the LBA and the remainder must be zero. For the physical format the address must be specified as follows.

Table 179: Address to translate

Byte	Bit							
	7	6	5	4	3	2	1	0
6-13	Physical Address							

16.41 SET DEVICE IDENTIFIER (A4/06)

Table 180: SET DEVICE IDENTIFIER (A4/06)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = A4h							
1	Reserved = 0				Service Action = 06h			
2	Reserved = 0							
3	Reserved = 0							
4-5	Restricted = 0							
6-9	(MSB) Parameter List Length (LSB)							
10	Reserved = 0							
11	VU = 0		Reserved = 0				FLAG	LINK

The SET DEVICE IDENTIFIER command requests that the device identifier information be set to the value received in the SET DEVICE IDENTIFIER parameter list.

On successful completion of a SET DEVICE IDENTIFIER command a unit attention is generated for all Initiators except the one that issued the service action. When reporting the unit attention condition the additional sense code is set to *Device Identifier Changed*.

- **Parameter List Length** field specifies the length in bytes of the Identifier that is transferred from the host system to the Target. The maximum value for this field is 512 bytes. A parameter list length of zero indicates that no data is transferred, and that subsequent REPORT DEVICE IDENTIFIER commands return an Identifier length of zero.

The SET DEVICE IDENTIFIER parameter list contains the identifier to be set by the addressed logical unit.

Table 181: SET DEVICE IDENTIFIER, Parameter List

Byte	Bit							
	7	6	5	4	3	2	1	0
0-n	Identifier							

The IDENTIFIER field is a vendor specific value, to be returned in subsequent REPORT DEVICE IDENTIFIER commands.

16.42 START STOP UNIT (1B)

Table 182: START STOP UNIT (1B)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 1Bh							
1	Reserved = 0							Immed
2	Reserved = 0							
3	Reserved = 0				Power Condition Modifier			
4	Power Condition				Reserved=0		LoEj = 0	Start
5	VU = 0		Reserved = 0				FLAG	LINK

The START STOP UNIT command is used to make the media accessible or inaccessible. At power-on, the SSD automatically makes the media accessible, but START STOP UNIT emulates HDD behaviors by making the drive ready or not ready.

- **Immed** bit is to specify
  0 status is to be returned at the end of the operation.
  1 **Good** status shall always be returned immediately after command has been received. The TEST UNIT READY command may be used to determine when the drive becomes ready.
- **Power Conditions and Power Condition Modifier fields** are ignored. Power save modes are not supported.
- **Start bit is to specify:**
  0 make the media inaccessible
  1 make the media accessible

START STOP UNIT with Start = 0 causes the firmware to save critical data to the media and make the SSD safe for power removal. Removing power without issuing START STOP UNIT with Start = 0 causes a longer time to ready on the subsequent power on.

Note: NOTIFY(ENABLE_SPINUP) is not required for the SSD to come ready after power on. Once the drive has become ready, the START STOP UNIT command can be used without any errors regardless of the current state. Note that NOTIFY(ENABLE_SPINUP) is required to transition from the Stopped state to the Ready state

16.43 SYNCHRONIZE CACHE (10) - (35)

Table 183: SYNCHRONIZE CACHE (10) - (35)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Command Code = 35h							
1	Reserved = 0			Reserved = 0			Immed = 0	Obso-lete
2-5	(MSB) Logical Block Address (LSB)							
6	Reserved = 0							
7-8	(MSB) Number of Blocks (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The SYNCHRONIZE CACHE command ensures that logical blocks in the cache have their most recent data value recorded on the media.

- **Logical Block Address** is to specify where the operation is to begin.
- **Immed** (immediate) must be zero. An immediate bit of zero indicates that the status shall not be returned until the operation has completed. If the Immed bit is set to one, the drive returns a **Check Condition** status. The sense key shall be set to *Illegal Request* and the additional sense code shall be set to *Invalid Field in CDB*.
- **Number of Blocks** specifies the total number of contiguous logical blocks within the range. Number of Blocks of zero indicates that all remaining logical blocks on the logical unit shall be within the range.

16.44 SYNCHRONIZE CACHE (16) - (91)

Table 184: Synchronize Cache (16) - (91)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Command Code = 91h							
1	Reserved = 0						Immed = 0	Rsvd= 0
2-9	Logical Block Address							
10-13	Number of Blocks							
14	Reserved = 0							
15	VU = 0		Reserved = 0				FLAG	LINK

The SYNCHRONIZE CACHE command ensures that logical blocks in the cache have their most recent data value recorded on the media. See the SYNCHRONIZE CACHE (10) description for definitions of the fields in this command.

16.45 TEST UNIT READY (00)

Table 185: TEST UNIT READY (00)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 00h							
1	Reserved = 0			Reserved = 0				
2-4	Reserved = 0							
5	VU = 0		Reserved = 0				FLAG	LINK

The TEST UNIT READY command allows the Initiator to check if the drive is READY. The SCSI specification defines READY as the condition where the device will accept a media-access command without returning **Check Condition** status.

The drive will verify that the media is accessible. If the media is not accessible, **Check Condition** status is returned with sense key of Not Ready. If the media is accessible, the drive returns good status and will execute media access commands.

The TEST UNIT READY command is not intended as a diagnostic. No self diagnostic is performed by the device as a result of this command.

The TEST UNIT READY command has special significance for power sequencing using the UNIT START command with an Immediate bit of one. In this mode the UNIT START command returns **Task Complete** status immediately and expects the Initiator to issue TEST UNIT READY commands to determine when the media is accessible.

Note: The Power On sequence automatically transitions the drive to the Ready state. The drive does not execute any commands other than TEST UNIT READY, INQUIRY, or REQUEST SENSE command until the Power On sequence is complete. The drive will return **Check Condition** status with Not Ready sense key and In Process of Becoming Ready sense code for all other commands during the Power On period.

16.46 UNMAP (42h)

Table 186: UNMAP (42h)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 42h							
1	Reserved = 0							ANCHOR
2-5	Reserved = 0							
6	Reserved = 0			GROUP NUMBER				
7-8	Parameter List Length							
5	Control							

The OPERATION CODE field is defined in SPC-4 and shall be set to the value defined in Table 189:

An ANCHOR bit set to zero specifies that the LBAs on which unmap operations are performed, if any, shall become deallocated. An ANCHOR bit set to one specifies that the LBAs on which unmap operations are performed, if any, shall become anchored.

If the ANCHOR bit is set to one, and the ANC_SUP field in the Thin Provisioning VPD page is set to 000b, then 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 CDB.

See the PRE-FETCH (10) command for the definition of the GROUP NUMBER field.

The PARAMETER LIST LENGTH field specifies the length in bytes of the UNMAP parameter data that shall be sent from the application client to the device server. A PARAMETER LIST LENGTH set to zero specifies that no data shall be sent.

The contents of the CONTROL byte are defined in SAM-4.

16.46.1 UNMAP parameter list

The UNMAP parameter list contains the data sent by an application client along with an UNMAP command. Included in the data are an UNMAP parameter list header and block descriptors for LBA extents to be processed by the device server for the UNMAP command. The LBAs specified in the block descriptors may contain overlapping extents, and may be in any order.

If the ANCHOR bit in the CDB is set to zero, then each specified LBA should become deallocated and may become anchored.

If the ANCHOR bit in the CDB is set to one, and the ANC_SUP field in the Thin Provisioning VPD page is set to 001b, then for each specified LBA:

a. If the LBA is mapped, then that LBA should become anchored, and the LBA shall not become deallocated;
b. If the LBA is deallocated, then that LBA shall become anchored.If a lack of LBA mapping resources prevents the LBA from becoming anchored, then the command shall be terminated or
c. If the LBA is anchored, then that LBA shall remain anchored.

Table 187: UNMAP parameter list

Byte	Bit							
	7	6	5	4	3	2	1	0
0-1	UNMAP DATA LENGTH (n-1)							
2-3	UNMAP BLOCK DESCRIPTOR DATA LENGTH (n-7)							
4-7	Reserved = 0							
8-23	UNMAP block descriptor (first)							
...	....							
(n-15) -n	UNMAP block descriptor (last)							

The UNMAP DATA LENGTH field specifies the length in bytes of the following data that is available to be transferred from the data-out buffer. The unmap data length does not include the number of bytes in the UNMAP DATA LENGTH field.

The UNMAP BLOCK DESCRIPTOR DATA LENGTH field specifies the length in bytes of the UNMAP block descriptors that are available to be transferred from the data-out buffer. The unmap block descriptor data length should be a multiple of 16. If the unmap block descriptor data length is not a multiple of 16, then the last unmap block descriptor is incomplete and shall be ignored. If the UNMAP BLOCK DESCRIPTOR DATA LENGTH is set to zero, then no unmap block descriptors are included in the UNMAP parameter data. This condition shall not be considered an error.

Table 188: UNMAP block descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0-7	UNMAP LOGICAL BLOCK ADDRESS							
8-11	NUMBER OF LOGICAL BLOCKS							
12-15	Reserved = 0							

The UNMAP LOGICAL BLOCK ADDRESS field contains the first LBA of the UNMAP block descriptor to be unmapped.
The NUMBER OF LOGICAL BLOCKS field contains the number of LBAs to be unmapped beginning with the LBA specified by the UNMAP LOGICAL BLOCK ADDRESS field.

If the NUMBER OF LOGICAL BLOCKS is set to zero, then no LBAs shall be unmapped for this UNMAP block descriptor. This condition shall not be considered an error.
If the LBA specified by the UNMAP LOGICAL BLOCK ADDRESS field plus the number of logical blocks exceeds the capacity of the medium, then 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 LOGICAL BLOCK ADDRESS OUT OF RANGE.

If the total number of logical blocks specified in the UNMAP block descriptor data exceeds the value indicated in the MAXIMUM UNMAP LBA COUNT field in the Block Limits VPD page, or if the number of UNMAP block descriptors exceeds the value of the MAXIMUM UNMAP BLOCK DESCRIPTOR COUNT field in the Block Limits VPD page, then the device server shall terminate the command with CHECK CONDITION status with thesense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

16.47 VERIFY (2F)

Table 189: VERIFY (2F)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Command Code = 2Fh							
1	VRPROTECT			DPO	Reserved = 0		Byte Chk	RSVD = 0
2-5	(MSB) Logical Block Address (LSB)							
6	Reserved = 0							
7-8	(MSB) Verification Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The VERIFY command requests that the drive verify the data written on the media. A verification length of zero indicates that no data will be transferred. This condition is not considered an error.

- **ByteChk** bit set to zero indicates that the data is read from the drive and verified using ECC.If an ECC error is detected in the verify process, **Check Condition** status is returned with sense key set to *Medium Error*. ByteChk bit set to one indicates that byte-by-byte comparison is performed between the data on the drive and data transferred from the initiator during the data-out phase.

  If the comparison is unsuccessful, the command is terminated with **Check Condition** status and the sense key is set to *Miscompare*.
- **DPO** (Disable Page Out) bit is ignored.
- The command implies FUA.

The command stops on *Check Condition* and reports the LBA in error. The command must be reissued, starting with the next LBA, to verify the remainder of the Drive.

The Verification Length is the number of blocks to check.

The data (if any) from the data-out phase and the data from the media are not retained in the cache. Therefore, the DPO bit has no effect on this command and is ignored.

VRPROTECT defines the manner in which protection information read from drive shall be checked during processing of the command. Protection information is stored on drive, and may be validated using the drive's internal checking algorithms, and also byte-by-byte compared using data from the initiator when ByteChk=1.

If the drive is not formatted with protection information, VRPROTECT must be set to 000b, else Check Condition status will be returned with sense key of Illegal Request and additional sense code of Invalid Field in CDB.

VRPROTECT=000b

If the drive is not formatted with protection information, only user data is verified.

If the drive is formatted with protection information:

- Logical Block Guard is checked
- Logical Block Application Tag is checked (applies to VERIFY(32) command only)
- Logical Block Reference Tag is checked

VRPROTECT=001b

- Logical Block Guard is checked
- Logical Block Application Tag is checked (applies to VERIFY(32) command only)
- Logical Block Reference Tag is checked

VRPROTECT=010b

- Logical Block Guard is not checked
- Logical Block Application Tag is checked (applies to VERIFY(32) command only)
- Logical Block Reference Tag is checked

VRPROTECT=011b

- Logical Block Guard is not checked
- Logical Block Application Tag is not checked
- Logical Block Reference Tag is not checked

VRPROTECT=100b

- Logical Block Guard is checked
- Logical Block Application Tag is not checked
- Logical Block Reference Tag is not checked

VRPROTECT=101b, 110b, 111b

These values are reserved. Check Condition status will be returned with sense key of Illegal Request and additional sense code of Invalid Field in CDB.

If a check of the protection information fails, Check Condition status will be returned with sense key of Aborted Command and additional sense code indicating which protection field check failed.

If ByteChk=1, the drive's internal checking of protection information is done only when VRPROTECT=000b and the drive is formatted with protection information

If ByteChk=1, and VRPROTECT is not set to 000b, checking of protection information is performed on the fields described above as a byte-by-byte comparison against the data transferred to the drive by the initiator during the Data Out phase.

Refer to the ANSI T10 standards for additional details of protection information.

16.48 VERIFY (12) - (AF)

Table 190: Verify (12) - (AF)

Byte	BIT							
	7	6	5	4	3	2	1	0
0	Command Code = AFh							
1	VRPROTECT			DPO	FUA	Reserved=0	Byte Chk	Reserved = 0
2-5	(MSB) Logical Block Address (LSB)							
6 - 9	(MSB) Verification Length (LSB)							
10	Reserved = 0							
11	VU = 0		Reserved = 0				FLAG	LINK

The VERIFY(12) command causes the drive to verify data written on the media. See the VERIFY(10) description for the definitions of the fields in this command.

16.49 VERIFY (16) - (8F)

Table 191: Verify (16) - (8F)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 08Fh							
1	VRPROTECT			DPO	Reserved = 0		Byte Chk	Rsvd = 0
2-9	(MSB) Logical Block Address (LSB)							
10-13	(MSB) Verification Length (LSB)							
14	Reserved = 0							
15	VU = 0		Reserved = 0				FLAG	LINK

The VERIFY command requests that the drive verify the data written on the media. See the VERIFY (10) description for the definitions of the fields in this command.

16.50 VERIFY (32) - (7F/0A)

Table 192: Verify (32) - 7F/0A)

Byte	Bit 7	6	5	4	3	2	1	0
0	Command Code = 07Fh							
1	VU = 0		Reserved = 0				FLAG	LINK
2-5	Reserved = 0							
6	Reserved = 0			Group Number = 0				
7	Additional CDB Length = 18h							
8 - 9	Service Action = 000Ah							
10	RDPROTECT			DPO	Reserved = 0		ByteChk	Reserved=0
11	Reserved = 0							
12 - 19	(MSB) Logical Block Address (LSB)							
20 - 23	(MSB) Expected Initial Logical Block Reference Tag (LSB)							
24 - 25	(MSB) Expected Logical Block Application Tag (LSB)							
26 - 27	(MSB) Logical Block Application Tag Mask (LSB)							
28 - 31	(MSB) Verification Length (LSB)							

The VERIFY command requests that the verify the data written on the media. Each logical block includes user data and may include protection information, based on the VPROTECT field and the drive format.

If the drive is formatted with type 2 protection (PROT_EN=1 and P_TYPE=001b in the READ CAPACITY (16) parameter data), then this command will be processed normally. Any other protection types will result in Check Condition status to be returned with sense key of Illegal Request and additional sense code of Invalid Command Operation Code

The Expected Initial Logical Block Reference Tag field contains the value of the Logical Block Reference Tag field expected in the protection information of the first logical block accessed by the command.

If the ATO bit is set to one in Mode Page 0Ah, the Logical Block Application Tag Mask field contains a value that is a bit mask for enabling the checking of the Logical Block Application Tag field in the protection information for each logical block accessed by the command. A Logical Block Application Tag Mask bit set to one enables the checking of the corresponding bit of the Expected Logical Block Application Tag field with the corresponding bit of the Logical Block Application Tag field in the protection information.

If the ATO bit is set to zero, the Logical Block Application Tag Mask field and the Expected Logical Block Application Tag field are ignored.

16.51 WRITE (6) - (0A)

Table 193: WRITE (6) - (0A)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 0Ah							
1	Reserved = 0			(MSB) LBA				
2-3	Logical Block Address (LSB)							
4	Transfer Length							
5	VU = 0		Reserved = 0				FLAG	LINK

The WRITE command requests the drive to write the specified number of blocks of data (**Transfer Length**) from the Initiator to the medium starting at the specified **Logical Block Address** (**LBA**).

See Section 16.15 READ (6) - (08)” on page 154 for the parameters.

16.52 WRITE (10) - (2A)

Table 194: WRITE (10) - (2A)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 2Ah							
1	WRPROTECT			DPO	FUA	Rsvd=0	FUA_NV	Obsolete
2-5	(MSB) Logical Block Address (LSB)							
6	Reserved = 0							
7-8	(MSB Transfer Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The WRITE (10) command requests that the drive write the data transferred from the Initiator. This command is processed like the standard WRITE (6) - (0A) command except for the longer transfer length.

- **Transfer Length** is the number of contiguous blocks to be transferred. If the transfer length is zero, the seek occurs, but no data is transferred. This condition is not considered an error.
- **DPO** (Disable Page Out) bit is ignored.
- **FUA** (bit is ignored.
- **FUA_NV** (Force Unit Access Non-Volatile Cache) may be set to 0 or 1, but is ignored since NV_SUP=0 in Inquiry Page 86h.

If a WRITE(6) command is received after protection information is enabled, the drive will set the protection information as follows as it writes each block to drive:

- the Logical Block Guard field is set to a properly generated CRC
- the Logical Block Reference Tag field is set to:
  - the least significant four bytes of the LBA, if the drive is formatted with type 1 protection (PROT_EN=1 and P_TYPE=000b in the READ CAPACITY (16) parameter data); or
  - FFFFFFFFh, if the drive is formatted with type 2 protection (PROT_EN=1 and P_TYPE=001b in the READ CAPACITY (16) parameter data)
- the Logical Block Application Tag field is set to
  - FFFFh, if the ATO bit is set to one in Mode Page 0Ah; or
  - Any value, if the ATO bit is set to zero

WRPROTECT defines the manner in which protection information written to drive shall be checked during processing of the command. Protection information may be transmitted to the drive with the user data, based on the WRPROTECT bit and the drive format.

If the drive is not formatted with protection information, WRPROTECT must be set to 000b, else Check Condition status will be returned with sense key of Illegal Request and additional sense code of Invalid Field in CDB.

WRPROTECT=000b

Protection information is not transmitted to the drive.

If the drive is formatted with protection information, the drive will write protection information to drive based on its internal algorithms.

WRPROTECT=001b

- Protection information is transmitted to the drive with the user data
- Logical Block Guard is checked
- Logical Block Application Tag is checked (applies to WRITE (32) command only)
- Logical Block Reference Tag is checked

WRPROTECT=010b

- Protection information is transmitted to the drive with the user data
- Logical Block Guard is not checked
- Logical Block Application Tag is checked (applies to WRITE(32) command only)
- Logical Block Reference Tag is checked

WRPROTECT=011b

- Protection information is transmitted to the drive with the user data
- Logical Block Guard is not checked
- Logical Block Application Tag is not checked
- Logical Block Reference Tag is not checked

WRPROTECT=100b

- Protection information is transmitted to the drive with the user data
- Logical Block Guard is checked
- Logical Block Application Tag is not checked
- Logical Block Reference Tag is not checked

WRPROTECT=101b, 110b, 111b

These values are reserved. Check Condition status will be returned with sense key of Illegal Request and additional sense code of Invalid Field in CDB.

If a check of the protection information fails, Check Condition status will be returned with sense key of Aborted Command and additional sense code indicating which protection field check failed.

Refer to the ANSI T10 standards for additional details of protection information.

16.53 WRITE (12) - (AA)

Table 195: Write (12) - (AA)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = AAh							
1	WRPROTECT			DPO	FUA	Rsvd=0	FUA_NV	Rsvd=0
2-5	(MSB) Logical Block Address (LSB)							
6-9	(MSB) Transfer Length (LSB)							
10	Reserved=0							
11	VU = 0		Reserved = 0				FLAG	LINK

The WRITE(12) command causes the drive to write data from the initiator to the media. See the WRITE(10) description for the definitions of the fields in this command.

16.54 WRITE (16) - (8A)

Table 196: Write (16) - (8A)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 8Ah							
1	WRPROTECT			DPO	FUA	Rsvd=0	FUA_NV	Rsvd=0
2-9	(MSB) Logical Block Address (LSB)							
10-13	(MSB) Transfer Length (LSB)							
14	Reserved = 0							
15	VU = 0		Reserved = 0				FLAG	LINK

The WRITE(16) command causes the drive to write data from the initiator to the media. See the WRITE(10) description for the definitions of the fields in this command.

16.55 WRITE (32) - (7F/0B)

Table 197: Write (32) - (7F/0B)

Byte	Bit 7	6	5	4	3	2	1	0
0	Command Code = 7Fh							
1	VU = 0		Reserved = 0				FLAG	LINK
2-5	Reserved = 0							
6	Reserved = 0			Group Number = 0				
7	Additional CDB Length = 18h							
8-9	Service Action = 000Bh							
10	WRPROTECT			DPO	FUA	Rsvd=0	FUA_NV	Rsvd=0
11	Reserved = 0							
12-19	(MSB) Logical Block Address (LSB)							
20-23	(MSB) Expected Initial Logical Block Reference Tag (LSB)							
24-25	(MSB) Expected Logical Block Application Tag (LSB)							
26-27	(MSB) Logical Block Application Tag Mask (LSB)							
28-31	(MSB) Transfer Length (LSB)							

The WRITE command requests that the drive write data transferred from the initiator to drive. Each logical block transferred includes user data and may include protection information, based on the WRPROTECT field and the drive format. Each logical block written includes user data and, if the drive is formatted with protection information enabled, protection information.

If the drive is formatted with type 2 protection (PROT_EN=1 and P_TYPE=001b in the READ CAPACITY (16) parameter data), then this command will be processed normally. Any other protection types will result in Check Condition status to be returned with sense key of Illegal Request and additional sense code of Invalid Command Operation Code

The Expected Initial Logical Block Reference Tag field contains the value of the Logical Block Reference Tag field expected in the protection information of the first logical block accessed by the command.

If the ATO bit is set to one in Mode Page 0Ah, the Logical Block Application Tag Mask field contains a value that is a bit mask for enabling the checking of the Logical Block Application Tag field in the protection information for each logical block accessed by the command. A Logical Block Application Tag Mask bit set to one enables the checking of the corresponding bit of the Expected Logical Block Application Tag field with the corresponding bit of the Logical Block Application Tag field in the protection information.

If the ATO bit is set to zero, the Logical Block Application Tag Mask field and the Expected Logical Block Application Tag field are ignored.

16.56 WRITE AND VERIFY (10) - (2E)

Table 198: WRITE AND VERIFY (10) - (2E)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 2Eh							
1	WRPROTECT			DPO	Reserved = 0		Byte Chk	Obso-lete
2-5	(MSB) Logical Block Address (LSB)							
6	Reserved = 0							
7-8	(MSB) Transfer Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

WRITE AND VERIFY command requests that the drive writes the data transferred from the Initiator to the medium and then verify that the data is correctly written. An implied FUA (Force Unit Access) and an implied Synchronize Cache are performed before starting the operation. This insures that data from the drive, not the cache, is verified.

- See the WRITE (10) command description for the definition of the WRPROTECT field.
- **Transfer Length** is the number of contiguous blocks to transferred. If the transfer length is zero, the seek occurs, but no data is transferred. This condition is not considered an error.
- **ByteChk** bit set to zero indicates that the data is read back from the drive and verified using ECC after the successful write operation. If an ECC error is detected in the verify process, **Check Condition** status is returned with sense key set to *Medium Error*. ByteChk bit set to one indicates that byte-by-byte comparison is performed between data on the drive starting the block specified in LBA field and data transferred from the Initiator.

  If the comparison is unsuccessful, the command is terminated with **Check Condition** status and the sense key is set to *Miscompare*.
- **DPO** (Disable Page Out) bit is ignored.

16.57 WRITE AND VERIFY (12) - (AE)

Table 199: Write and Verify (12) - (AE)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = AEh							
1	WRPROTECT			DPO	Reserved = 0		ByteChk	Obsolete
2-5	(MSB) Logical Block Address (LSB)							
6-9	(MSB) Transfer Length (LSB)							
10	Reserved = 0							
11	VU = 0		Reserved = 0				FLAG	LINK

The WRITE AND VERIFY command requests that the drive write the data transferred from the Initiator to the medium and then verify that the data is correctly written. See the WRITE AND VERIFY (10) description for the definitions of the fields in this command.

16.58 WRITE AND VERIFY (16) - (8E)

Table 200: Write and Verify (16) - (8E)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 8Eh							
1	WRPROTECT			DPO	Reserved = 0		Byte Chk	Obso-lete
2-9	(MSB) Logical Block Address (LSB)							
10-13	(MSB) Transfer Length (LSB)							
14	Reserved = 0							
15	VU = 0		Reserved = 0				FLAG	LINK

The WRITE AND VERIFY command requests that the drive write the data transferred from the Initiator to the medium and then verify that the data is correctly written.

16.59 WRITE AND VERIFY (32) - (7F/0C)

Table 201: Write and Verify (32) - (7F/0C)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 7Fh							
1	VU = 0		Reserved = 0				FLAG	LINK
2 - 5	Reserved = 0							
6	Reserved = 0			Group Number = 0				
7	Additional CDB Length = 18h							
8 - 9	Service Action = 000Ch							
10	WRPROTECT			DPO	Reserved = 0		ByteChk	Reserved=0
11	Reserved = 0							
12 - 19	Logical Block Address							
20 - 23	Expected Initial Logical Block Reference Tag							
24 - 25	Expected Logical Block Application							
26 - 27	Logical Block Application Tag Mask							
28 - 31	Transfer Length							

The WRITE AND VERIFY command requests that the drive write the data transferred from the initiator to drive and then verify that the data is correctly written.

If the drive is formatted with type 2 protection (PROT_EN=1 and P_TYPE=001b in the READ CAPACITY (16) parameter data), then this command will be processed normally. Any other protection types will result in Check Condition status to be returned with sense key of Illegal Request and additional sense code of Invalid Command Operation Code

The Expected Initial Logical Block Reference Tag field contains the value of the Logical Block Reference Tag field expected in the protection information of the first logical block accessed by the command.

If the ATO bit is set to one in Mode Page 0Ah, the Logical Block Application Tag Mask field contains a value that is a bit mask for enabling the checking of the Logical Block Application Tag field in the protection information for each logical block accessed by the command. A Logical Block Application Tag Mask bit set to one enables the checking of the corresponding bit of the Expected Logical Block Application Tag field with the corresponding bit of the Logical Block Application Tag field in the protection information.

If the ATO bit is set to zero, the Logical Block Application Tag Mask field and the Expected Logical Block Application Tag field are ignored.

16.60 WRITE BUFFER (3B)

Table 202: WRITE BUFFER (3B)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 3Bh							
1	Reserved = 0			Mode				
2	Buffer ID							
3-5	Buffer Offset							
6-8	Parameter List Length							
9	VU = 0		Reserved = 0				FLAG	LINK

The WRITE BUFFER command is used in conjunction with the READ BUFFER command as a diagnostic function for testing the memory of the drive and the SCSI bus integrity. This command does not alter the medium of the drive. Additional modes are provided for downloading microcode and saving microcode.

This command will cause the entire cache to be emptied.

The function of this command and the meaning of fields within the command descriptor block depend on the contents of the mode field.

MODE	Description
00000	Write combined header and data
00010	Data
00100	Download Microcode
00101	Download Microcode and Save - single binary file
00111	Download Microcode and Save - multiple binary files
01010	Write Data to Echo Buffer
11010	Enable expander Communications Protocol
All Others	Not Supported

If any values other than shown above are specified, **Check Condition** status is returned with a sense key of *Illegal Request* and additional sense code of *Invalid Field in CDB*.

16.60.1 Combined Header And Data (Mode 00000b)

In this mode, the data to be transferred is preceded by a four-byte header.

Buffer ID must be zero. If another value is specified, no download function is performed and the command is terminated with **Check Condition** status. And the drive shall set the sense key to *Illegal Request* and additional sense code to *Illegal Field in CDB*.

Buffer Offset must be zero. If another value is specified, no download function is performed and the command is terminated with **Check Condition** status. And the drive shall set the sense key to *Illegal Request* and additional sense code to *Illegal Field in CDB*.

Parameter List Length specifies the number of bytes that shall be transferred during the DATA OUT phase. This number includes four bytes of header, so the data length to be stored in the drive buffer is transfer length minus four. If the length exceeds the buffer size, the command is terminated with **Check Condition** status. And the drive shall set sense key to *Illegal Request* and additional sense code to *Illegal Field in CDB*. A Parameter List Length of less than four (size of header) indicates no data is transferred.

The 4-byte header consists of all reserved bytes.

Table 203: Write Buffer Header

Byte	Bit							
	7	6	5	4	3	2	1	0
0-3	Reserved = 0							

16.60.2 Write Data (Mode 00010b)

In this mode, the DATA OUT phase contains buffer data.

Buffer ID must be zero. If another value is specified, no download function is performed and the command is terminated with Check Condition status. And the drive shall set the sense key to *Illegal Request* and additional sense code to *Illegal Field In CDB.*

Buffer Offset specifies the offset of the memory space specified by the Buffer ID. The initiator should conform to the offset boundary requirements returned in the READ BUFFER descriptor. If the value exceeds the buffer specified, the command is terminated with **Check Condition** status. And the drive shall set the sense key to *Illegal Request* and additional sense code to *Illegal Field In CDB.*

Parameter List Length specifies the Parameter List Length. It must be

- less than the capacity of the buffer size after adding the Buffer Offset value and
- on a sector boundary

A Parameter List Length of zero indicates no data is to be transferred and command status is returned.

If an invalid value is specified, the command is terminated with **Check Condition** status. And the drive shall set the sense key to *Illegal Request* and additional sense code to *Illegal Field In CDB.*

16.60.3 Download Microcode (Mode 00100b)

NOTE: It is not expected that a customer will ever issue this format of the command.

In this mode, the microcode is transferred to the control memory space of the drive. When downloaded, the drive will operate with the newly downloaded code immediately until the next power cycle.

Buffer ID field is used to indicate which portion of the microcode image is being downloaded. The following Buffer IDs are supported by the Target:

- 00h: Main Microprocessor Code
- nnh: ID of Vendor Unique Reserved Area

Any unsupported value for the Buffer ID will cause the command to terminate with **Check Condition** status. And the drive shall set the sense key to *Illegal Request* and additional sense code to *Illegal Field In CDB*.

Buffer Offset must be zero. If an invalid value is specified, the command is terminated with **Check Condition** status. The drive shall set the sense key to *Illegal Request* and additional sense code to *Illegal Field in CDB*.

Parameter List Length must be the size of the data set to be downloaded. It may also be set to 0000h in which case no code is updated and command status is returned. If an invalid value is specified, the command is terminated with **Check Condition** status. And the drive shall set the sense key to *Illegal Request* and additional sense code to *Illegal Field In CDB.*

This process generates a unit attention condition for MICROCODE HAS BEEN CHANGED for all Initiators except the one which sent the WRITE BUFFER command. Upon the completion of the WRITE BUFFER command the new microcode is immediately ready for operation.

Note: The Download Microcode mode described in this specification is to indicate that the drive will accept a command with this mode, though it is not expected that a user will ever issue such a command. To use the write buffer command with this mode, a special microcode version is required from development. If such a microcode is released from development, then it will include appropriate instructions on the function of new microcode and its effect on the drive operations after download.

16.60.4 Download Microcode and Save (Mode 00101b) -Single Binary File

In this mode the data is transferred to the drive to save into the System reserved area on the drive. This is for functional upgrade and configuration change reflecting the user's requirements and the manufacturer's reason or both, and it is stored in the media as a permanent copy. The newly downloaded code becomes effective after the drive issues and completes a self-initiated Power On Reset.

Note: It requires up to 30 seconds to update the microcode including the Flash ROM update.

Note: New code to be downloaded to the drive will be provided by development either by request of a customer for an additional function or as a result of a functional change by development. However please note that not all possible fixes or new functions can be applied to a drive in this manner and that there is a very high dependency on the level of ROM code contained within the drive. If an invalid code or a code not compatible with the ROM code is downloaded, the drive will usually reject this code and will continue normal operation. However there is a small possibility that an invalid code will be accepted. If this occurs, the unit usually becomes inoperable and will have to be returned to the manufacturer for recovery.

Buffer ID field is used to indicate which portion of the microcode image is being downloaded. To download microcode, the buffer ID should be set to 00h. Other values are reserved for HGST development purposes only.

16.60.5 Download Microcode and Save (Mode 00111b) - Multiple Binary Files

In this mode the target receives a segment of the binary microcode file. The Parameter List Length (segment length) of each segment shall be a multiple of 4K bytes. The total length of all segments received shall be equal to the total length of the binary microcode file. All segments must be sent in the proper sequential order.
If an invalid Parameter List Length is specified, **Check Condition** status is returned with sense key of Illegal Request and additional sense code of *Invalid Field in CDB*.

The first segment sent in this mode indicates, by default, the first segment of the binary microcode file. If a **Check Condition** status is returned in this mode, a **Buffer ID** == 00h in the subsequent Write Buffer command in this mode indicates the first segment of the binary microcode file. Otherwise the **Buffer ID** field is ignored.

The **Buffer Offset** field is ignored.

After all segments of the binary microcode file have been received, the drive behavior is the same as Download Microcode and Save (Mode 00101b) - Single Binary File.

16.60.6 Write Data to Echo Buffer (Mode 01010b)

In this mode the Target transfers data into the echo buffer. The echo buffer is assigned in the same manner by the Target as it would for a WRITE operation. Data will be sent aligned on 4-byte boundaries.

Upon successful completion of a WRITE BUFFER command the data will be preserved in the echo buffer unless there is an intervening command to any logical unit, in which case it may be changed.

16.60.7 Enable Expander Communications Protocol (Mode 11010b)

In this mode the drive behavior is the same as Write Data to Echo Buffer (Mode 0101b).

16.61 WRITE LONG (3F)

Table 204: WRITE LONG (3F)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 3Fh							
1	COR_DIS	WR_UNCOR	PBLOCK =0	Reserved = 0				Obso-lete
2-5	(MSB) Logical Block Address (LSB)							
6	Reserved = 0							
7-8	(MSB) Byte Transfer Length (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The WRITE LONG command requests the drive to write **one block** of data transferred from the Initiator.

The transfer data must include

- User Data
- 4 bytes of CRC data

Parameters are

- **COR_DIS** - correction disabled, bit 7 in byte 1. When this bit is set to one, we mark the LBA as a pseudo unrecovered error with correction disabled. A subsequent read to this LBA would:

  a) Perform no error recovery on the block;

  b) Perform no automatic reallocation of the affected logical blocks, including any automatic reallocation enabled by the Read-Write Error Recovery mode page;

  c) Not consider errors on the affected logical blocks to be informational exception conditions as defined in the Information Exceptions Control mode page (see SPC-4);

  d) not log errors on the affected logical blocks in the Error Counter log pages

  e) On a read to the LBA, return check condition status with the sense key set to Medium Error and the additional sense code set to read error marked bad by client.

- **WR_UNCOR** - write uncorrectable, bit 6 in byte 1. If we receive a Write Long command with the WR_UNCOR bit set to one, we would create a pseudo unrecovered error with correction enabled. On following read commands to the LBA, the drive will:

  a) use our normal recovery procedures (which will end in a hard error);

  b) perform no automatic reallocation of the affected logical blocks, including any automatic reallocation enabled by the Read-Write Error Recovery mode page;

  c) consider errors on the affected logical blocks to be informational exception conditions as defined in the Information

Exceptions Control mode page (see SPC-4);

d) log errors on the affected logical blocks in the Error Counter log pages

e) On a read to the LBA, return check condition status with the sense key set to Medium Error and the additional sense code set to read error marked bad by client.

The error state for LBA written with the COR_DIS or WR_UNCOR bits set, will remain in effect until the LBA is rewritten by a write, write same, format, write long without COR_DIS set, reassign or write verify command.

- **Logical Block Address** field specifies the logical block at which the write operation shall occur.
- **Byte Transfer Length**. This field must specify the exact number of bytes of data available for transfer. If a non-zero byte transfer length does not match the available data length, the Target terminates the command with **Check Condition** status, then the sense key is set to *Illegal Request*, and an additional sense code is set to *Invalid Field in CDB*. The valid and ILI bits are set to one and the information field is set to the difference of the requested length minus the actual length in bytes. Negative values are indicated by two's complement notation.

Note: Since the ECC bytes are not included in the Read Long data, ECC correction capability cannot be tested using Read/ Write Long. In addition to using COR_DIS or WR_UNCOR, a hard error can be emulated by modifying the Read Long data and writing it using Write Long. The CRC returned in the Read Long data transfer is not re-calculated on a Write Long, and a CRC check failure on a subsequent Read will return check condition status with the sense key set to Medium Error and the additional sense code set to UNRECOVERED READ ERROR.th in bytes. Negative values are indicated by two's complement notation.

16.62 WRITE SAME (41)

Table 205: WRITE SAME (41)

Byte	Bit 7	6	5	4	3	2	1	0
0	Command Code = 41h							
1	WRPROTECT			Reserved = 0		PBDA TA=0	LBDA TA=0	Obso-lete
2-5	(MSB) Logical Block Address (LSB)							
6	Reserved = 0							
7-8	(MSB) Number of Blocks (LSB)							
9	VU = 0		Reserved = 0				FLAG	LINK

The WRITE SAME command instructs the Target to write a single block of data transferred to the Target from the Initiator to a number of sequential logical blocks. This command is useful for writing large data areas without sending all of the data over the SCSI bus.

- See the WRITE(10) command description for the definition of the WRPROTECT field.
- **Logical Block Address** specifies the address at which the write begins. The Number of Blocks specifies the number of contiguous blocks to be written. If the number is zero, all of the remaining blocks on the specified Logical Unit are written.
- **Number of Blocks** specifies the number of contiguous blocks to be written. If the number is zero, all of the remaining blocks on the specified logical unit are written.
- **RelAdr** (Relative Block Address) is not supported and must be set to be zero.

The data for this command is not retained in the cache.

16.63 WRITE SAME (16) - (93)

Table 206: Write Same (16) - (93)

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Command Code = 93h							
1	WRPROTECT			ANCHOR	UNMAP	PBDATA =0	LBDATA =0	Obsolete
2-9	(MSB)			Logical Block Address				(LSB)
10-13	(MSB)			Number of Blocks				(LSB)
14	Reserved = 0							
15	VU = 0		Reserved = 0				FLAG	LINK

The Write Same command instructs the Target to write a single block of data transferred to the Target from the Initiator to a number of sequential logical blocks. See the WRITE(10) command description for the definition of the WRPROTECT field.

Table 207: ANCHOR bit, UNMAP Bit, and ANC_SUP bit

UNMAP Bit	ANCHOR Bit	ANC_SUP Field	Action
0b	0b	n/a	Write
	1b	n/a	Error
1b	0b	n/a	Unmap
	1b	000b	Error
		001b	Anchor

For Action:

- **Write:** The device server shall perform the specified write operation on each LBA specified by the command.
- **Error:** The device server shall terminate the command with CHECK CONDITION status with the sense key set to to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.
- **Unmap:** The device server should deallocate each LBA specified by the command but may anchor each LBA specified by the command. If the device server does not deallocate or anchor the LBA, then the device server shall perform the specified write operation.
- **Anchor:** The device server should anchor each LBA specified by the command instead of performing the specified write operation. If the device server does not anchor the LBA, the device server shall perform the specified write operation

The device server shall ignore the UNMAP bit and the ANCHOR bit, or 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 CDB if:

d. The logical unit is fully provisioned (i.e., the TPE bit is set to zero in the READ CAPACITY (16) parameter data and
e. The UNMAP bit is set to one or the ANCHOR bit is set to one.

16.64 WRITE SAME (32) - (7F/0D)

Table 208: Write Same (32) - (7F/0D)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Command Code = 7Fh</td></tr>
<tr><td>1</td><td colspan="2">VU = 0</td><td colspan="4">Reserved = 0</td><td>FLAG</td><td>LINK</td></tr>
<tr><td>2-5</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>6</td><td colspan="3">Reserved = 0</td><td colspan="5">Group Number = 0</td></tr>
<tr><td>7</td><td colspan="8">Additional CDB Length = 18h</td></tr>
<tr><td>8 - 9</td><td colspan="8">Service Action = 000Dh</td></tr>
<tr><td>10</td><td colspan="3">WRPROTECT</td><td>ANCHOR</td><td>UNMAP</td><td>PBDATA =0</td><td>LBDATA =0</td><td>Reserved</td></tr>
<tr><td>11</td><td colspan="8">Reserved = 0</td></tr>
<tr><td>12 - 19</td><td colspan="8">(MSB)
Logical Block Address
(LSB)</td></tr>
<tr><td>20 - 23</td><td colspan="8">(MSB)
Expected Initial Logical Block Reference Tag
(LSB)</td></tr>
<tr><td>24 - 25</td><td colspan="8">(MSB)
Expected Logical Block Application Tag
(LSB)</td></tr>
<tr><td>26 - 27</td><td colspan="8">(MSB)
Logical Block Application Tag Mask
(LSB)</td></tr>
<tr><td>28 - 31</td><td colspan="8">(MSB)
Number of Blocks
(LSB)</td></tr>
</table>

The WRITE SAME command requests that the drive write a single block of data transferred from the initiator to drive for a number of sequential logical blocks. This command is useful for writing large data areas with the same data, without sending all of the data over the interface. Each logical block transferred includes user data and may include protection information, based on the WRPROTECT field and the drive format. Each logical block written includes user data and, if the drive is formatted with protection information enabled, protection information.

If the drive is formatted with type 2 protection (PROT_EN=1 and P_TYPE=001b in the READ CAPACITY (16) parameter data), then this command will be processed normally. Any other protection types will result in Check Condition status to be returned with sense key of Illegal Request and additional sense code of Invalid Command Operation Code

The Expected Initial Logical Block Reference Tag field contains the value of the Logical Block Reference Tag field expected in the protection information of the first logical block accessed by the command.

If the ATO bit is set to one in Mode Page 0Ah, the Logical Block Application Tag Mask field contains a value that is a bit mask for enabling the checking of the Logical Block Application Tag field in the protection information for each logical block accessed by the command. A Logical Block Application Tag Mask bit set to one enables the checking of the corresponding bit of the Expected Logical Block Application Tag field with the corresponding bit of the Logical Block Application Tag field in the protection information.

If the ATO bit is set to zero, the Logical Block Application Tag Mask field and the Expected Logical Block Application Tag field are ignored.

17.0 SCSI Status Byte

Upon the completion of a command a status byte is sent to the initiator. Additional sense information may also be available depending on the contents of the status byte. The following section describes the possible values for the status byte and sense data. All Reserved fields are set to zero.

Table 209: SCSI Status Byte. Format of the SCSI STATUS byte.

Bit							
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Reserved = 0		Status Code					RSVD

STATUS BYTE Description

00h GOOD

The command has been successfully completed.

02h CHECK CONDITION

An error, exception, or abnormal condition has been detected. The sense data is set by the drive. The REQUEST SENSE command should be issued to determine the nature of the condition.

04h CONDITION MET

This status is returned when an unlinked PRE-FETCH command has been successfully completed.

08h BUSY

This condition is returned when disconnect privilege is not granted while the drive is BUSY processing the other command for the other initiator. The normal initiator recovery action is to issue the command at a later time or to reissue the command and grant the disconnect privilege.

10h INTERMEDIATE

Not supported.

14h INTERMEDIATE CONDITION MET

Not supported.

18h RESERVATION CONFLICT

This status is returned whenever an SCSI device attempts to access the drive, but it has been reserved by another initiator.

28h QUEUE FULL

This status indicates that the target's command queue is full. If a tagged command queuing feature is enabled and there is no room on the command queue, this status is returned when the initiator sends a command. For this status, sense data are not valid.

18.0 Additional information

This chapter provides additional information or descriptions of various functions, features, or operating models supported by the Target that are not fully described in previous chapters.

18.1 SCSI Protocol

There are various operating conditions that prevent the Target from executing a SCSI command. This section describes each of these operating conditions and their relative priority.

18.1.1 Priority of SCSI Status Byte Reporting

After establishing the I_T_L nexus or I_T_L_Q nexus the Target must first determine whether command execution is allowed. Execution is deferred until a later time if the command must be added to the command queue. Execution may also be prevented by an internal Target condition that requires the reporting of a Check Condition, Queue Full, Busy, or Reservation Conflict Status. There are several different internal conditions to be active at the same time. The order in which the Target checks for each of these conditions determines their priority (highest priority first) as follows:

1. Check Condition status for invalid Logical Unit Number. (See Section 18.1.2, “Invalid LUN Processing” on page 239)
2. Check Condition status for Incorrect Initiator Connection.
3. Check Condition status for Unit Attention Condition (See Section 18.1.4, “Unit Attention Condition” on page 241
4. Busy Status or Queue Full Status (See 18.1.3, “Command Processing During Execution of Active I/O Process” on page 240
5. Check Condition status for Deferred Error Condition (See Section 18.1.7, “Deferred Error Condition” on page 243)
6. Check Condition status during Startup and Format operations (See Section “18.1.5, “Command Processing During Startup and Format Operations” on page 243)
7. Reservation Conflict status (See Section 18.1.9, “Command Processing while Reserved” on page 250)
8. Check Condition status for invalid command opcode
9. Check Condition status for invalid command descriptor block

The highest priority internal condition that prevents command execution is reported by the Target provided there is no bus error.

For all Check Conditions Sense data is built by the target provided a valid LUN address is known. Sense data is cleared by the Target upon receipt of any subsequent command to the LUN from the initiator receiving the Check Condition.

18.1.2 Invalid LUN Processing

Any value other than zero in the FCP_LUN field of the FCP_CMD IU is invalid.

The target's response to an invalid LUN varies with the command, as follows:

Inquiry: Execute the command, return the INQUIRY data that indicates unknown device type (byte 0 = 7Fh), and return GOOD status. All other bytes are valid (see 16.5, “INQUIRY (12)” on page 65).

Request Sense: Execute the command, return the sense data with the Sense Key set to Illegal Request and the Additional Sense Code and Additional Sense Code Qualifier set to LOGICAL UNIT NOT SUPPORTED, and return GOOD status (see also 16.34, “REQUEST SENSE (03)” on page 192).

All Others: Do not execute the command and return CHECK CONDITION status, along with the auto-sense data with the Sense Key set to Illegal Request and the Additional Sense Code and Additional Sense Code Qualifier set to LOGICAL UNIT NOT SUPPORTED.

In all cases, the target's response to the command for an invalid LUN does not affect the current execution of a command on the valid LUN for this initiator or any other initiator.

18.1.3 Command Processing During Execution of Active I/O Process

When the target is not executing any I/O processes, a new I/O process is permitted to execute (unless execution is prevented by another internal target condition listed in 18.1.1, "Priority of SCSI Status Byte Reporting" on page 239).

If an active I/O process exists when the target receives a new command, then the target determines if:

- the command is permitted to execute
- the command is added to the queue
- Queue Full status is to be returned
- Busy status is to be returned

If an active I/O process exists when the target receives a new command, then the target determines how the new command should be handled based on the following rules:

- Check Condition status is returned with sense key set to Logical Unit Not Ready if:
  - the startup operation or a format operation is active. See 18.1.5, "Command Processing During Startup and Format Operations" on page 243 for the exact conditions which cause this response.

Note: If a Unit Attention is pending when this condition exists, the sense key is set to Unit Attention rather than Logical Unit Not Ready since Unit Attention has a higher reporting priority (see 18.1.1, "Priority of SCSI Status Byte Reporting" on page 239).

- The command is permitted to execute if:
  - the command is a priority command (see 18.2, "Priority Commands" on page 250).
- the conditions to execute concurrently are met (see 18.5, "Concurrent I/O Process" on page 251).
- The command is added to the queue if:
  - any I/O process already exists at the target, and
  - this is not an incorrect initiator connection.
- Queue Full status is returned if:
  - the command would otherwise be added to the queue (according to the rules described above), but all slots in the queue are full, or
  - the command would otherwise be added to the queue (according to the rules described above), but all of the available queue slots not reserved for use by another initiator are full, or
  - a Format Unit command was previously queued but has not yet begun execution, or
  - the target is in a Degraded Mode (see 18.1.8, "Degraded Mode" on page 244) and a Start Unit command was previously queued but has not yet begun execution.
- Busy status is never returned.

18.1.4 Unit Attention Condition

The target generates a unit attention condition when one of the following occurs:

- The target has been reset

  This includes a power-on reset or a reset caused by a Target Reset Task Management function or Reset LIP. In all of these cases, a unit attention condition is generated for each initiator. In addition, a process login (PRLI) will cause a Unit Attention Condition Power-On Reset for that initiator with an Additional Sense Code and Additional Sense Code Qualifier reported as Power-On Reset, Power-On Reset Occurred.

- MODE SELECT command has been executed

  In this case, a unit attention condition is generated for all initiators except the one that issued the MODE SELECT command. The Additional Sense Code and Additional Sense Code Qualifier reported is MODE PARAMETERS CHANGED. The unit attention condition is generated if any of the current page parameters are set by the MODE SELECT command. The target does not check to see that the old parameters are different from the new parameters. For example: If the initiator issues a MODE SENSE command with a page code to report the current values followed by a MODE SELECT command with the same parameter list, a unit attention condition is generated despite the fact that the current parameters were not changed from their previous value. However, if the target detects an illegal parameter or error condition prior to modifying the current parameters, a unit attention condition is not generated since the parameters were not set. The unit attention condition is also not generated if the MODE SELECT command parameter list does not include any pages and only the header or header/block descriptor is present.

- FORMAT UNIT command has been executed

  In this case, a unit attention condition is generated for all initiators except the one that issued the FORMAT UNIT command. The Additional Sense Code and Additional Sense Code Qualifier reported is NOT READY TO READY TRANSITION, (MEDIUM MAY HAVE CHANGED). This indicates that the block descriptor parameters from the last MODE SELECT command have been used and are now considered current values.

- WRITE BUFFER command to download microcode has been executed

  In this case, a unit attention condition is generated for all initiators except the one that issued the WRITE BUFFER command. The Additional Sense Code and Additional Sense Code Qualifier reported is MICROCODE HAS BEEN CHANGED.

- Commands Cleared by another initiator

  This unit attention condition is generated after an initiator sends a Clear Task Set Task Management function. The unit attention condition is generated for all other initiators with I/O processes that were either active or queued for the logical unit. The Additional Sense Code and Additional Sense Code Qualifier reported is COMMANDS CLEARED BY ANOTHER INITIATOR.

- LOG SELECT command with PCR bit has cleared parameters.

  In this case, a unit attention condition is generated for all initiators except the one that issued the LOG SELECT command. The additional sense code and additional sense code qualifier reported is Log Select Parameters Changed.

- The registration or reservation made by a Persistent Reserve Out command was cleared by another initiator.

  In this case, a unit attention condition is generated for the initiator that held the cleared registration or reservation.

- A Predictive Failure Analysis threshold has been reached and the Method of Reporting field of mode page 1Ch is 2h.

The unit attention condition persists for each initiator until that initiator clears the condition from the logical unit as described below. Several commands are handled as special cases during a unit attention condition These cases are also discussed below.

If the target receives a command from an initiator before reporting a CHECK CONDITION status for a pending unit attention condition for that initiator, the target's response varies with the command as follows:

Inquiry Execute the command, return GOOD status, and preserve the unit attention condition.

Report Luns Same as above

Request Sense Execute the command, return any pending sense data, return GOOD status, and preserve the unit attention condition. If there is not any pending sense data, the sense data associated with the highest priority unit attention condition is returned and the highest priority unit attention condition is cleared for this initiator.

All Others Do not execute the command, return a CHECK CONDITION status, clear the highest priority unit attention condition for this initiator and return the associated sense data.

More than one unit attention condition may be generated for an initiator before that initiator clears the unit attention condition.

18.1.5 Command Processing During Startup and Format Operations

If the Target receives a command from an Initiator while the Target is executing a startup or format operation, the response of the Target varies with the command as follows:

INQUIRY The drive sends inquiry data and returns appropriate status.

REQUEST SENSE Executes the command, returns a Sense key of NOT READY and an Additional Sense Code of LOGICAL UNIT NOT READY and returns GOOD STATUS.

The Additional Sense Code Qualifier that is returned depends on type of I/O processes that are active:

For the START/UNIT STOP and the Auto-start operation, the qualifier returned is LOGICAL UNIT IS IN PROCESS OF BECOMING READY. For the FORMAT UNIT command, the qualifier returned is LOGICAL UNIT NOT READY, FORMAT IN PROGRESS, and the Sense key specific bytes are set to return the progress indication.

REPORT LUNS The drive sends REPORT LUNS data and appropriate status.

ALL OTHER The drive terminates the command with CHECK CONDITION status. The Sense data generated is described in Request Sense above.

18.1.6 Internal Error Condition

The Target generates an Internal Error condition for all Initiators when an internally initiated operation ends with an unrecoverable error.

An Internal Error condition causes Sense data to be generated and saved for all Initiators. The Error Code field of the Sense is set for a Current Error (70h) and the Sense Key is set to HARDWARE ERROR. Recovered errors are not reported.

The Internal Error condition persists for each Initiator until that Initiator clears the condition from the logical unit as described below. Several commands are handled as special cases during an Internal Error condition. These cases are also discussed.

If the Target receives a command from an Initiator while an Internal Error condition exists for that Initiator, the response of the Target varies with the command as follows:

INQUIRY The drive executes the command with GOOD status and does not clear the Internal Error condition.

REQUEST SENSE The drive executes the command, returns the sense data generated by the Internal Error condition, returns Good Status, and clears the Internal Error condition for that Initiator.

ALL OTHER The drive terminates the command with a CHECK CONDITION status and clears the Internal Error condition.

18.1.7 Deferred Error Condition

Error code (71h) of sense data indicates that the Check Condition status returned is the result of an error or exception condition that occurred during execution of a previous command for which Good status has already been returned.

The drive creates an Deferred Error condition when

- Execution of a Format Unit command with the immediate bit of one ends with an error.

18.1.8 Degraded Mode

There are certain errors or conditions which may impair the ability of the drive to function normally. Rather than fail hard the drive is designed to be as responsive as possible. Also, in most cases, some action on the part of the initiator may be used to restore normal operation. This mode of limited operation is called Degraded Mode.

There are 3 conditions in the Degraded Mode:

- Media Degraded which is caused by one of the following conditions:
  - Context Load was started (by POR or Unit Start command) and the Target is under Self Configuration
  - Context Load Failure (Disable Logical)
  - Unit Stop command was issued after the Target successfully completed the Self Configuration
- Self Configuration Failure Degraded which is caused by one of the following conditions:
  - RAM Code, Read Failure
  - RAM Code, Revision Mismatch
- Format Command Failure Degraded. This condition is caused when Format Unit command failed or was interrupted abnormally (Mode Page 0, byte 5, bit 4 FDD controls Format Degraded mode)

18.1.8.1 Response to SCSI Command in Degraded Mode - Becoming Ready

Table 210: Media Degraded Mode Becoming ready

Command (w/Option)	**Response**
Request Sense	Executed. The Target may return Sense Key 02h (Not Ready) ASC/ASCQ 0401h (In Process of Becoming Ready)
Inquiry (EVPD=0)	Executed
Inquiry (EVPD=1)	Executed and Check Condition is returned with Sense Key 05h (Illegal Request) ASC/ASCQ 2400h (Invalid Field in CDB)
Test Unit Ready	Executed and Check Condition is returned with Sense Key 02h (Not Ready) ASC/ASCQ 0401h (In Process of Becoming Ready)
Start Stop Unit (Start)	Executed - Success: Good Status is returned. Media Degraded Mode is cleared - Context Load Failure: Check Condition with Sense Key 04h (Hardware Error) ASC/ASCQ 4400h (Internal Target Error) - Self Configuration Failure: Check Condition with Sense Key 04h (Hardware Error) ASC/ASCQ 4080h (Diag Fail- Bring up Fail)
Other Commands	Not Executed. Check Condition Status is returned with Sense Key 02h (Not Ready) ASC/ASCQ 0401h (In Process of Becoming Ready)

18.1.8.2 Response to SCSI Command in Degraded Mode - Context Load

Table 211: Media Degraded Mode - Context Load Failure

Command (w/Option)	Response
Request Sense	Executed. The Target may return Sense Key 04h (Hardware Error) ASC/ASCQ 4400h (Internal Target Failure)
Inquiry (EVPD=0)	Executed
Inquiry (EVPD=1)	Executed and Check Condition is returned with Sense Key 05h (Illegal Request) ASC/ASCQ 2400h (Invalid Field in CDB)
Test Unit Ready	Executed and Check Condition is returned with Sense Key 04h (Hardware Error) ASC/ASCQ 4400h (Internal Target Failure)
Start Stop Unit (Start)	Executed - Success: Good Status is returned. Media Degraded Mode is cleared - Context Load Failure: Check Condition with Sense Key 04h (Hardware Error) ASC/ASCQ 4400h (Internal Target Failure) - Self Configuration Failure: Check Condition with Sense Key 04h (Hardware Error) ASC/ASCQ 4080h (Diag Fail- Bring up Fail)
Start Stop Unit (Stop)	Executed. Good Status is returned. Media Degraded Mode is NOT cleared
Other Commands	Not Executed. Check Condition Status is returned with Sense Key 04h (Hardware Error) ASC/ASCQ 4400h (Internal Target Failure

18.1.8.3 Response to SCSI Command in Degraded Mode - Drive issued received unit stop Command.

Table 212: Media Degraded Mode - Drive issued, received Unit Stop Command

Command (w/Option)	Response
Request Sense	Executed. The Target may return Sense Key 02h (Not Ready) ASC/ASCQ 0402h (Initialize Command Required)
Inquiry (EVPD=0)	Executed
Inquiry (EVPD=1)	Executed
Test Unit Ready	Executed and Check Condition is returned with Sense Key 02h (Not Ready) ASC/ASCQ 0402h (Initialize Command Required)
Start Stop Unit (Start)	Executed - Success: Good Status is returned. Media Degraded Mode is cleared - Context Load Failure: Check Failure: Check Condition with Sense Key 04h (Hardware Error) ASC/ASCQ 4400h (Internal Target Failure) - Self Configuration Failure: Check Condition with Sense Key 04h (Hardware Error) ASC/ASCQ 4080h (Diag Fail- Bring up Fail)
Start Stop Unit (Stop)	Executed. Good Status is returned. Media Degraded Mode is NOT cleared
Other Commands	Not Executed. Check Condition Status is returned with Sense Key 04h (Hardware Error:) ASC/ASCQ 4400h (Internal Target Failure)

18.1.8.4 Self Configuration Failure Degraded Mode

Table 213: Self Configuration Failure Degraded Mode

Command (w/Option)	**Response**
Request Sense	Executed. The Target may return Sense Key 04h (Hardware Error) ASC/ASCQ 4080h (Diag Fail- Bring up Fail)
Inquiry (EVPD=0)	Executed
Inquiry (EVPD=1)	Executed and Check Condition is returned with Sense Key 05h (Illegal Request) ASC/ASCQ 2400h (Invalid Field in CDB)
Test Unit Ready	Executed and Check Condition is returned with Sense Key 04h (Hardware Error) ASC/ASCQ 4080h (Diag Fail- Bring up Fail)
Start Stop Unit (Start)	Executed - Success: Good Status is returned. Media Degraded Mode is cleared - Context Load Failure: Check Condition with Sense Key 04h (Hardware Error) ASC/ASCQ 4400h (Internal Target Failure) - Self Configuration Failure: Check Condition with Sense Key 04h (Hardware Error) ASC/ASCQ 4080h (Diag Fail- Bring up Fail)
Write Buffer (Download and Save)	Executed. - Success: Good Status is returned. Media Degraded Mode is cleared - Self Configuration Failure: Check Condition with Sense Key 04h (Hardware Error) ASC/ASCQ 4080h (Diag Fail- Bring up Fail) Sense Key 02h (Not Ready) ASC/ASCQ 4085h (Diag Fail-RAM code NOT load)
Other Commands	Not Executed. Check Condition Status is returned with Sense Key 04h (Hardware Error) ASC/ASCQ 4080h (Diag Fail- Bring up Fail)

18.1.8.5 Format Command Failure Degraded Mode

Table 214: Format Command Failure Degraded Mode

Command (w/Option)	**Response**
Request Sense	Executed. The Target may return Sense Key 02h (Not Ready) ASC/ASCQ 3100h (Format Corrupted) Sense Key 03h (Medium Error) ASC/ASCQ 3100h (Format Corrupted)
Inquiry (EVPD=0)	Executed
Inquiry (EVPD=1)	Executed
Test Unit Ready	Executed and Check Condition is returned with Sense Key 02h (Not Ready) ASC/ASCQ 3100h (Format Corrupted)
Format Unit	Executed - Success: Good Status is returned. Format Degraded Mode is cleared - Failure: Check Condition Status is returned and Format Degraded Mode is NOT cleared.
Other Commands	Not Executed. Check Condition Status is returned with Sense Key 03h (Medium Error) ASC/ASCQ 3100h (Format Corrupted)

Note: Mode Page 0 byte 5 bit 4 (FDD) = 0

18.1.9 Command Processing while Reserved

A logical unit is reserved after successful execution of the Reserve command. Each time a Reserve command is executed successfully, the Target records the SCSI ID of the Initiator that made the reservation and the SCSI ID of the Initiator that is to receive the reservation. This information is needed to determine whether subsequent commands should be permitted or if the Reservation Conflict Status should be reported. The Initiator that made the reservation is the Initiator that issued the Reserve command. The Initiator to receive the reservation may be either the same or a different Initiator (third-party reservation).

If the logical unit is reserved when a new command is received, the Target examines the command opcode and the SCSI ID of the issuing Initiator to determine whether a Reservation Conflict Status should be returned based on the following rules:

If the issuing Initiator is the one that made the reservation and also the one to receive the reservation, then all commands are permitted.

If the issuing Initiator is neither the one that made the reservation nor the one to receive the reservation, then

- A Request Sense or Inquiry command is permitted.
- A Release command is permitted but is ignored.
- Any other command results in a Reservation Conflict Status.

If the issuing Initiator is the one that made the reservation but is not the one to receive the reservation, then

- An Inquiry, Request Sense, Reserve, or Release command is permitted.
- Any other command results in a Reservation Conflict Status.

If the issuing Initiator is not the one that made the reservation but is the one to receive the reservation, then

- A Reserve command results in a Reservation Conflict Status.
- A Release command is permitted but is ignored.
- Any other command is permitted.

If a Reservation Conflict Status is not reported and the command is permitted, then the Target checks the next highest priority internal condition to determine whether execution is allowed. See Section 18.1.1, “Priority of SCSI Status Byte Reporting” on page 239.

18.2 Priority Commands

Certain SCSI commands always execute without returning a Busy Status or Reservation Conflict Status in response to the command. These commands are

- Inquiry
- Request Sense
- Report LUNs
- Test Unit Ready

These commands are executed prior to attempting to complete the execution of any other pending command in the queue. These commands are never queued.

18.3 Command Queuing

When the initiator specifies that the drive shall disable command queuing, the initiator must send only untagged commands. When the initiator specifies that the target shall enable command queuing, the initiator may send either tagged or untagged command, but shall not use both at the same time.

The following commands are never queued.

- Priority Commands (i.e.: Request Sense and Inquiry)
- Commands for an invalid LUN.

18.3.1 Queue Depth

Any initiator can queue at least one command at any time irrespective of the actions of any other initiators in the system. A single initiator may queue up to 128 commands, if no other initiator has more than one command in the queue, although at times this maximum may be reduced as the drive can reserve command blocks for internal use.

18.3.2 Queue Full Status

The drive will respond with QUEUE FULL status to a SCSI command when all queue slots are utilitzed. The SCSI command is not placed in the command queue under this condition.

18.3.3 Termination of I/O Processes

Normal termination of I/O processes occurs when the target returns SCSI status. I/O processes may also be terminated by the following:

- An ABORT TASK terminates the specified I/O process from the issuing initiator
- An ABORT TASK SET terminates all I/O processes from the issuing initiator
- A CLEAR TASK SET, TARGET RESET or reset terminates all I/O processes from all initiators
- Failure by an initiator to initiate Exchange Authentication within RR_TOV of the completion of Loop Initialization results in an implicit logout and termination of all associated I/O processes (21.8.5 Effects of LIP on Command Queuing on a page 291)

18.4 Command Reordering

Command reordering is supported when enabled by the Queue Algorithm Modifier in mode page 0A (see 16.10.9, “Mode Page 0A (Control Mode Page Parameters)” on page 129.

18.5 Concurrent I/O Process

Concurrent command are always allowed to execute concurrently with non-priority commands. A second priority command received while a priority command is being executed is put at the head of the command queue.

- WRITE commands when another WRITE command is an active I/O process
- READ commands when another READ command is an active I/O process

When a concurrent command ends in CHECK CONDITION status, the QErr bit on the Mode Page 0Ah will determine how other active I/O processes from the same initiator for that drive will be handled.

18.6 Write Cache

If the WCE (Write cache enable) bit is 1, the drive returns Good Status and Task complete message and goes to Bus Free immediately after receiving the data of the last sector before actually writing the data onto the media.

If the drive detects an error after it returns a Good Status, the drive sets a Deferred Error (Error Code of sense data = 71h) and a following command will be returned with Check Condition and the Contingent allegiance condition is established. Under the Contingent allegiance condition all queued processes including commands from other initiators are suspended.

18.7 Automatic Rewrite/Reallocate

The target supports auto reallocation for all media access commands. Auto reallocation cannot be disabled, and the ARRE setting is ignored.

18.8 Segmented Caching

18.8.1 Overview

Segmented Caching divides the data buffer into several smaller buffers. Each buffer is used as Read/ Write/Read-Ahead buffer.

18.8.2 Read Ahead

The Read Ahead function consists of reading data that the Initiator has not yet requested to the drive buffer. This function is intended to improve performance for an initiator that frequently accesses sequential data with successive SCSI read commands.

The drive initiates the Read ahead function when the following conditions exist:

- Read, Verify and Write and Verify is received.
- The consecutive LBA of the requested LBA is not available in the buffer.

Even if an error occurs during the Read ahead, the error will not be reported to the Initiator. The data read before the error occurred will be stored as valid data by the Read Ahead function.

18.9 Multiple Initiator Systems

This section describes how the target behaves in a multiple initiator system. Up to 64 initiators may be supported at any one time.

18.9.1 Sense Data

A separate sense data area is reserved for each initiator. Each area is maintained independently. This allows a command from one initiator to complete with a CHECK CONDITION status and generate sense data without being affected by a subsequent command from a different initiator. There is no requirement for the first initiator to send a REQUEST SENSE command to retrieve the Sense Data prior to the execution of a command from a different initiator.

18.9.2 Mode Pages

A single set of Mode pages is maintained. This includes both current and saved parameters. If a MODE SELECT command is executed that updates the current parameters, a unit attention condition is generated for all initiators except the one that issued the command. See 18.1.4, “Unit Attention Condition” on page 241 for more information.

18.10 Multiple Initiator Environment

18.10.1 Initiator Sense Data

Separate sense data is reserved for each I-T-L. Each sense data is maintained independent of commands from other initiators.

18.10.2 Initiator Mode Select/Mode Sense Parameters

A single shared copy of the Mode Select/Mode Sense parameters is maintained by the drive. This includes both the current and saved parameters.

18.11 Reset

Reset actions will return the drive to a known, initialized state.

This device supports the reset sources discussed below.

18.11.1 Reset Sources

There are four sources of resets detected by the target:

Reset Name	Reset Source
Power-On Reset	This is the signal generated by the hardware at initial power-on
Self-Initiated reset	This is a software-generated reset that occurs when a catastrophic error is detected by the microcode.
00B Reset	This is an 00B Reset Sequence received on the SAS interface.
Target Reset	This is an FCP_CMD IU with the TARGET RESET TMF flag set.
Reset LUN	This is a FCP_CMD IU with the RESET LUN TMF flag set.

18.11.2 Reset Actions

The action taken by the drive following a reset is dependent on the source of the reset.

18.11.2.1 Power-On reset and Self-Initiated reset

These two reset conditions cause the following to be performed in the order shown:

- A power-up sequence
- A startup sequence is necessary to put the drive in a ready state

These reset conditions cause the following actions:

- If the reset occurs during the power-up sequence, the power-up sequence is re-started.
- If a start-up sequence has not yet completed, the start-up sequence is restarted. Note: The power-up sequence is not re-run, since it has already completed.
- If the reset occurs while a physical sector is being written, the WRITE operation is disabled at the end of the current sector. The media is not corrupted.

18.12 Diagnostics

The drive will execute Power on Diagnostics at power on time to assure the correct operation of the drive by validating components (ROM, RAM, Sector Buffer, EEPROM, HDC, PLI Capacitor), checking stored information in the Reserved Area and EEPROM, and verifying fault detects circuits.

Self-test can be invoked by issuing a SEND DIAGNOSTIC command.

18.12.1 Power on Diagnostics

At power on time the following tests are executed:

1. Validation of ROM and EEPROM

2. RAM test for internal RAM
3. Test and Initialize HDC registers
4. RAM test for Sector Buffer
5. PLI selftest
6. Validation of RAM code and data table (RDM, Log, Mode Page) from the Reserved Area

Faults detected before successful completion of the HDC section could prevent the drive from responding to a selection.

Faults detected after the successful completion of the HDC test section will be reported as CHECK CONDITION status to the Initiator on the first command issued after a fault is detected (except for the INQUIRY, REPORT LUNS and REQUEST SENSE commands). The INQUIRY, REPORT LUNS and REQUEST SENSE commands will always be responded with a GOOD status. Detecting a fault during power on will not terminate execution of the tests nor will it terminate the power on process.

18.12.2 Self-test via SEND DIAGNOSTIC Command

18.12.2.1 Default Self-test

The default self-test is invoked by the SlfTst bit in the SEND DIAGNOSTIC command. The response is simply a GOOD status if the test is successful or a CHECK CONDITION status if the test fails.

The following tests are performed by the default self-test (in the order defined):

1. **Logical Enable Check to determine if the media is accessible logically.S**
2. **Write, Read and Compare test** is a drive read/write test. It writes data to a predefined location in the reserved area and then reads it back and validates the content.

18.12.2.2 Short and Extended Self-tests

There are two other types of self-tests that may be invoked using the Function Code field in the SEND DIAGNOSTIC command: a short self-test and an extended self-test. The tests performed in the short and extended self-tests are described later. The time required by a logical unit to complete its extended self- test is specified in the Extended self-test Completion Time field in the Control Mode Page. The results of self-test can be retrieved via the LOG SENSE command for Log Page 10.

18.12.2.3 Self-test Modes

There are two modes for short and extended self-tests: a foreground mode and a background mode. These modes are described in the following clauses.

Foreground mode

When the drive receives a SEND DIAGNOSTIC command specifying a self-test to be performed in the foreground mode, the drive will return status for that command after the self-test has been completed. While performing a self-test in the foreground mode, the drive will respond to all commands except INQUIRY, REPORT LUNS, and REQUEST SENSE with a CHECK CONDITION status, a sense key of NOT READY and an additional sense code of LOGICAL UNIT NOT READY - SELF-TEST IN PROGRESS.

If the drive is performing a self-test in the foreground mode and a test error occurs, the drive will update the self-test results log page and report CHECK CONDITION status with a sense key of HARDWARE ERROR and an additional sense code of LOGICAL UNIT FAILED SELF-TEST. The application client may obtain additional information about the failure by reading the self-test results log page.

An application client may terminate a self-test that is being performed in the foreground mode using an ABORT TASK, ABORT TASK SET, or CLEAR TASK SET task management function. If the drive receives an ABORT TASK, ABORT TASK SET, or CLEAR TASK SET task management function while performing a self-test in the foreground mode, it will abort the self-test and update the self-test results log page.

Background mode

When the drive receives a SEND DIAGNOSTIC command specifying a self-test to be performed in the background mode, the drive will return status for that command as soon as the command descriptor block has been validated. After returning status for the SEND DIAGNOSTIC command specifying a self- test to be performed in the background mode, the drive will initialize the self-test results log page as follows. The Function Code from the SEND DIAGNOSTIC command will be placed in the Function Code field in the log page. The self-test Results field shall be set to 0Fh. After the self-test results log page is initialized, the drive will begin the first self-test segment.

While the device server is performing a self-test in the background mode, it shall terminate with a CHECK CONDITION status any SEND DIAGNOSTIC command it receives that meets one of the following criteria:

a. The SlfTst bit is one
b. The Function Code field contains a value other than 000b or 100b.

When terminating the SEND DIAGNOSTIC command, the sense key shall be set to NOT READY and the additional sense code shall be set to LOGICAL UNIT NOT READY, SELF-TEST in PROGRESS. While performing a self-test in the background mode, the drive will suspend the self- test to service any other command other than SEND DIAGNOSTIC (with Function Code field set to 100b) WRITE BUFFER (with the mode set to any download microcode option), FORMAT UNIT and START UNIT STOP command. Suspension of the self-test to service the command will occur within 2 seconds. If SEND DIAGNOSTIC (with Function Code field set to 100b), WRITE BUFFER (with the mode set to any download microcode option), FORMAT UNIT or START UNIT STOP command is received, the drive will abort the self-test, update the self-test log, and service the command within two seconds after the command descriptor block has been validated.

An application client may terminate a self-test that is being performed in the background mode by issuing a SEND DIAGNOSTIC command with the Function Code field set to 100b (Abort background self-test function).

Elements common to foreground and background self-test modes

The Progress Indication field returned in response to a REQUEST SENSE command may be used by the application client at any time during execution of a self-test to poll the progress of the test. While executing a self-test unless an error has occurred, the drive will respond to a REQUEST SENSE command by returning a sense key of NOT READY and an additional sense code of LOGICAL UNIT NOT READY - SELF-TEST IN PROGRESS with the sense key specific bytes set for progress indication.

The application client may obtain information about the twenty most recently completed self-tests by reading the self-test results log page. This is the only method for an application client to obtain information about self-tests performed in the background mode. The default self-test results are not logged in the log page.

Tests performed in the Short and Extended Self-test

The following table defines the tests performed in the short and extended self test. They are defined by their segment number which is also used to report Self-Test Results, in Log Sense Page 10. Note that the only difference between the Short and the Extended tests, is the sequential verify test in segment 7h. Also note that either of these tests can be run in foreground or background mode as previously described.

Table 215: Short and Extended Self-Test Description

Segment Number	Short Self-Test	Extended Self-Test	Test Description
1h	Drive Ready Test		Internal check to insure drive is “ready”, similar to a Test Unit Ready command.
2h	Drive Diagnostics		This test is comprised of the Default Self Test as defined in Section 18.12.2.1, “Default Self-test” on page 254
3h	PLI Test		Drain and recharge Caps
4h	SMART		Perform SMART testing and check results to ensure that SMART threshold criteria are not exceeded
5h	Low Level Format check		Check to insure that the media is currently not in the MEDIA FORMAT CORRUPTED state.
6h	Reserved Area check		Write/Read test in a predefined location in the drive's Reserved Area of the drive.
7h	- Verify First 300MB - Verify Last 100 MB	Verify all LBA’s	Sequential verify operation. Ensure that no uncorrectable errors occur within the verify range.
8h	Recheck SMART		Same as segment 4h.

18.12.2.4 Background Medium Scan

For a related function, see Mode Page 1C (Informational Exceptions Control), page 140

18.13 Idle Time Function

The drive periodically saves data in logs and S.M.A.R.T. counters in the reserved area of the drives. The information is used by the drive to support various SCSI commands and for the purpose of failure analysis.

18.14 Command Time out Limits

The 'Command Time-out Limits' are defined as the time period from the SCSI Arbitration phase through the SCSI Task complete message, associated with a particular command.

The following times are for environments where Automatic Reallocation is disabled and there are no queued commands.

18.14.1 Reassignment Time

The drive should be allowed a minimum of 5 seconds to complete a “Reassign Blocks” command.

18.14.2 Format Time

Approximately 3 minutes should be allowed to complete a “Format Unit” command.

18.14.3 Start/Stop Unit Time

The drive should be allowed a minimum of 10 seconds to complete a “Start Stop Unit” command (with Immed bit = 0). Initiators should also use this time to allow startup sequences initiated by auto start ups and “Start Stop Unit” commands (with Immed bit = 1) to complete and place the drive in a “ready for use” state.

18.14.4 Medium Access Command Time

The time-out limit for medium access commands that transfer user data or non-user data or both should be a minimum of 30 seconds. These commands are

Pre-Fetch

Read

Read Defect Data

Seek

Send Diagnostic (Function Code = 0)

Read Long

Reassign Blocks

Write

Write and Verify

Write Buffer

Write Long

Write Same

Verify

Note: The 5-second limit assumes the absence of bus contention and data transfers of 64 blocks or less. This time should be adjusted for anticipated bus contention and if longer user data transfers are requested.

18.14.5 Time-out Limits for Other Commands

The drive should be allowed a minimum of 5 seconds to complete these commands:

Inquiry

Log Select

Log Sense

Mode Select

Mode Sense

Persistent Reserve In/Out

Read Buffer

Read Capacity

Release

Request Sense

Reserve

Set/Report Device Identifier

Start/Stop Unit (with Immed bit = 1)

Synchronize Cache

Test Unit Ready

The command time-out for a command that is not located at the head of the command queue should be increased by the sum of command time-outs for all of the commands that are performed before it is.

18.15 Recommended Initiator ERP

The Drive's design points for error reporting to the system assumes certain system action for the error return codes. These assumptions are:

1. SCSI protocol will be the first priority in reporting errors.
2. The system will maintain a log of all reported errors.
3. System architecture should include all error handling recommendations made in this section. Deviations should have mutual agreement between Drive development and system integration.

This section is directed toward documenting the assumptions made by the Drive that the system is expected to implement. The two error classes that the system should be concerned with are DATA and NON-DATA errors.

Data errors are those errors that deal with the handling of data to and from the MEDIA and are identified by the Additional Sense Code contained in the sense data. The Additional Sense Codes for data errors are as follows:

- 11 - Unrecovered read error
- 17 - Recovered read error

Nondata errors are those errors that do not have a direct relationship with transferring data to and from the media. Nondata errors can include data handling if the media is not associated with the error (that is, interface error).

The system action assumed for each class of error is outlined here.

18.15.1 Drive Service Strategy

The Drive service strategy is defined so the customer will be able to use the system as soon after a failure is detected as possible. The first priority is to replace the entire drive to make the system operational with minimal service time. The service representative should:

1. Back up all the customer data on this drive if possible
2. Replace the complete drive
3. Restore the customer data
4. Return the drive to customer service

18.15.2 Recommendations for System Error Log

The system error log should contain information about the Drive error that will allow recovery actions. The system error logs should contain all the error information returned in the sense data. At a minimum, the following information about each error occurrence should be logged.

- Valid bit and error code (Sense byte 0)
- Sense Key (Sense byte 2)
- Information bytes (Sense bytes 3 through 6)
- Command specific information (Sense bytes 8 through 11)
- Additional Sense Code (Sense byte 12)
- Additional Sense Code Qualifier (Sense byte 13)
- Field Replaceable Unit (Sense byte 14)
- Sense Key Specific (Sense bytes 15, 16, and 17)
- Vender Unique error information (Sense bytes 20 through 23)

18.15.3 Data Recovery Procedure

No action can be taken on hard or soft read errors. Block retirement happens automatically based on the block retirement policy in the firmware. LBAs that report a hard read error will become readable after a write. Until a write command is received for the affected LBAs, a hard error will be reported on a read to the affected LBAs.

18.15.4 Nondata Error Recovery Procedure

The Drive will follow a logical recovery procedure for nondata errors. The initiator options for non-data errors are limited to logging the error, retrying the failing command, or replacing the drive.

These recovery procedures assume the initiator practices data back-up and logs errors at the system level for interrogation by service personnel.

18.15.4.1 Drive Busy

The Drive is busy performing an operation. **This is not an error condition.** The initiator can test for completion of the operation by issuing *Test Unit Ready (00)* (or media access) commands.

- If the *Test Unit Ready (00)* (or media access) command completes with *Check Condition Status* then issue a *Request Sense (03)*
  - If the specified recovery procedure for the sense data is for a condition other than drive busy, follow the recovery procedure for the condition reported.
  - If the specified recovery procedure for the sense data is for a drive busy condition, then continue re-issuing the *Test Unit Ready (00)* and *Request Sense* commands for the duration of a media access time-out or until the drive returns *Good Statu*s.
  - If the drive has been busy for longer than the limit specified in Section 18.14, “Command Time out Limits” on page 257, then service the drive using the service guidelines recommended in Section 18.15.1, “Drive Service Strategy” on page 259. Otherwise return to normal processing.
- If the *Test Unit Ready (00)* (or media access) command completes with *Good Statu*s, then return to normal processing.

18.15.4.2 Unrecovered Drive Error

The initiator should retry the failing command.

5. If the retry of the failing command completes with *Good Status* or recovered Sense Key, follow the recovery procedure in Section 18.15.4.3, "Recovered Drive Error" on page 261.
6. If the retry of the failing command completes with hardware error sense, verify there is no outside cause (e.g., power supply) for the failure, then retry the failing command.
   a. If the retry of the failing command completes with *Good Statu*s, follow the recovery procedure in next Section 18.15.4.3, "Recovered Drive Error" on page 261.
   b. If the retry of the failing command completes with Recovered sense or Hardware error sense, then service the drive using the service guideline recommended in Section 18.15.1, "Drive Service Strategy" on page 259.

18.15.4.3 Recovered Drive Error

The Initiator should log the error as soft with the recovery level.

18.15.4.4 Drive Not Ready

The initiator should do the following:
1. Issue a *Start Stop Unit (1B)* command.
2. Verify that the drive comes ready within the time specified in Section 4.5.3, "SSD Response Time" on page 9.
3. If the drive fails to come ready within the specified time, service the drive using the service guidelines specified in Section 18.15.1, "Drive Service Strategy" on page 259.
4. Retry the failing command.
   a. If the failing command completes with *Good Statu*s, log the error as recovered.
   b. If the failing command completes with Not Ready sense, verify there is no outside cause (for example, the power supply). Then service the drive using the service guidelines specified in Section 18.15.1, "Drive Service Strategy" on page 259.

18.15.4.5 Degraded Mode

Refer to Section 18.1.8, "Degraded Mode" on page 244, for the definition of this state. There are three causes for entering degraded mode. In all cases the Sense Key is *Not Ready*. The causes are the following:
1. Sense Code/Qualifier of *Logical Unit Not Ready*, *initializing command required*. The media is not accessible. This may not be an error condition. The initiator should issue a *Unit start (1B)* command to enable media access. If the Drive fails to come ready in the time specified in Section 18.14, "Command Time out Limits" on page 257, service the drive using the service guideline recommended in Section 18.15.1, "Drive Service Strategy" on page 259.
2. Sense Code/Qualifier of *Diagnostic Failur*e. Failure of a Send Diagnostic self test, a start up sequence, or other internal target failures.

- Failure of a send diagnostic self test or a start up sequence.

This failure is the result of the diagnostics that are executed during power on or when the *Send Diagnostic (1D)* command is executed detecting a failure. As with the RAM code not loaded and the configuration data not loaded, the recovery is either a power cycle or issuing the *Send Diagnostic (1D)* command with the self test bit set active. Recovery for a failed Send Diagnostic (1D) is achieved in one of the following ways:

Executing the Send Diagnostic (1D) command

Power cycling the drive

If the failure repeats, service the drive using the service guideline recommended in Section 18.15.1, "Drive Service Strategy" on page 259.

Recovery for a failed power up sequence is achieved in one of the following ways:

Issuing a Unit start (1B) command

Power cycling the drive.

If the failure repeats, service the drive using the service guideline recommended in Section 18.15.1, "Drive Service Strategy" on page 259.

- Internal target failures

  Recovery of this condition is either a power cycle or successful completion of the Send Diagnostic (1D). Service the drive using the recommended service guidelines specified in Section 18.15.1, “Drive Service Strategy” on page 259, if the power cycle or the Send Diagnostic (1D) command fail to complete successfully.

3. Sense Code/Qualifier of **Format Command Failed** Format Unit (04).

   Recovery from a failed Format Unit (04) is achieved by retrying the command. If the command fails a second time, service the drive following the procedure defined in Section 18.15.1, “Drive Service Strategy” on page 259.

If the above defined recovery procedures fail to clear the degraded mode condition, the Drive should be replaced. Follow the procedure in Section 18.15.1, “Drive Service Strategy” on page 259, when replacing the drive.

18.15.4.6 Interface Protocol

For all interface protocol errors, the initiator should complete the following steps:
1. Correct the parameter that caused the Illegal Request
2. Retry the failing command
3. If the first retry of the failing command completes with
   - *Good Status*, log the error as recovered
   - *Check Condition Status* with sense data for an Illegal Request, verify there is no outside cause (for example, the power supply) for the failure
   - *Other*, follow the recommendations for the error condition reported. Retry the failing command. If this retry of the failing command completes with
     - *Good Status*, log the error as recovered
     - *Check Condition Status* with sense data for an Illegal Request, service the drive using the service guideline recommended in Section 18.15.1, “Drive Service Strategy” on page 259.
     - *Other*, follow the recommendations for the error condition reported.

18.15.4.7 Aborted Command

The initiator should determine the cause from the Additional Sense Code (byte 12):

- Sense Key = B (Aborted Command) with Additional Sense Codes of 1B, 25, 43, 49, and 4E are initiator caused abort conditions. The initiator should correct the condition that caused the abort and retry the failing command.
- Sense Key = B (Aborted Command) with Additional Sense Code of 44 or 48 are drive caused abort conditions. The initiator should:
  1. Retry the failing command.
  2. If the retry of the failing command completes with
     - *Good Statu*s, log the error as recovered.
     - Abort Command Sense, verify there is no outside cause (e.g. power supply) for the failure.
  3. Retry the failing command.
  4. If the retry of the failing command completes with
     - *Good Statu*s, log the error as recovered.
     - Abort command sense, then service the drive using the service guideline recommended in Section 18.15.1, “Drive Service Strategy” on page 259.
- Sense Key = B (Aborted Command) and an Additional Sense Code of 47 can be an initiator or Drive caused abort condition. The initiator should follow the above procedure for initiator caused abort conditions if the Drive detected the SCSI bus parity error. The initiator should follow the above procedure for Drive caused abort conditions if the initiator detected the SCSI bus parity error.

18.15.4.8 Unit Attention Condition

Unit Attention Conditions are not errors. They alert the initiator that the drive had an action that may have changed an initiator controlled state in the drive. These conditions are the following:

Not Ready to Ready Transition

Not ready to ready transition, unit formatted. This *Unit Attention Condition* will not be reported to the initiator that issued the *Format Unit (04*).

Reset

Reset - This means the drive was reset by either a power-on reset, LIP Reset, Target Reset or an internal reset.

Mode Parameters Changed

A *Mode Select (15)* command successfully completed. This means that the mode parameters that are the current value may have changed. The parameters may or may not have changed but the command to change the parameters successfully completed. The Drive does not actually compare the old current and the new current parameters to determine if the parameters changed. This *Unit Attention Condition* will not be reported to the initiator that issued the *Mode Select (15).*

Microcode Has Changed

Write Buffer (3B) to download microcode has successfully completed. This means that the microcode that controls the Drive has been changed. The code may or may not be the same as the code currently being executed. The Drive does not compare old level code with new code.

Commands Cleared by Another Initiator

Tagged commands cleared by a clear queue message. This means that the command queue has been cleared. The *Unit Attention Condition* is not reported to the initiator that issued the clear queue message. *Unit Attention Condition* is reported to all initiators that had commands active or queued.

Reissue any outstanding command.

Log Select Parameters Changed

A Log Select (4C) command successfully completed. This means that the Log Select command cleared statistical information successfully (See Section 16.6, “LOG SELECT (4C)” on page 80). Unit Attention Condition is reported to all initiators excluding the initiator that issued the Log Select command.

Device Identifier Changed

A Set Device Identifier (A4) command successfully completed. This means that the Set Device Identifier information field has been updated. (See 16.41, “SET DEVICE IDENTIFIER (A4/06)” on page 204) A Unit Attention Condition is reported to all initiators excluding the initiator that issued the Set Device Identifier command.

18.15.4.9 Components Mismatch

The compatibility test is performed at a power cycle. The compatibility test verifies the microcode version of the electronics. When the Drive detects the microcode version mismatch, the most likely cause is the result of incorrect parts used during a service action.

If the error reported is Sense Key/code/qualifier 4/40/80, Diagnostic failure, bring-up fail, the initiator should do the following:

1. Retry Power cycle
2. Check the send diagnostic end status. If the status is
   - GOOD, Return to normal processing
   - *Check Condition Status*, issue a *Request Sense (03)* and follow the recommendations for the sense data returned unless the sense data is for a component mismatch. If the sense data is for component mismatch, service the drive using the service guideline recommended in Section 18.15.1, "Drive Service Strategy" on page 259.

18.15.4.10 Self Initiated Reset

The Drive will initiate a self reset when the condition of the Drive cannot be determined. The internal reset will terminate any outstanding commands, release any reserved initiators, and reset the firmware. The initiator can recover by

1. Logging the error
2. Retrying the failing command. If the failing command completes with:
   - *Good Status*, return to normal processing
   - Self initiated reset sense, service the drive according the guidelines recommended in Section 18.15.1, "Drive Service Strategy" on page 259.
   - Other, follow the recommendations for the error reported.

18.15.4.11 Defect List Recovery

This is not an error condition.

The initiator either requested a defect list in a format (block or vendor specific) that the Drive does not support or the requested defect list(s) exceed the maximum list length that can be returned. If the Sense Key/Code/Qualifier are:

1/1F/00, the requested list(s) exceed the maximum length that can be supported. The initiator should request one list at a time. If a single list exceeds the maximum returnable length, this may be an indication of a marginally operational drive. Service the drive following the service guidelines in Section 18.15.1, "Drive Service Strategy" on page 259.

1/1C/01 or 1/1C/02, the requested defect list is not in the format that the Drive supports. The requested defect list is returned in the physical format. This is the default format. There is no initiator action required for this condition.

18.15.4.12 Miscompare Recovery

A miscompare can occur on a *Verify (2F)* command or a *Write and Verify (2E)* with the byte check (ByteChk) bit active. Recovery for a miscompare error is different for the two commands.

Verify Command

The initiator should do the following:

1. Verify that the data sent to the drive is the correct data for the byte-by-byte compare.
2. Read the data from the media with a *Read (08)* or *Read (28)* command and verify that the data from the media is the expected data for the byte-by-byte compare.
   - If all data are correct, this is an indication that the data may have been read from the media incorrectly without an error detected. Service the drive using the procedure specified in Section 18.15.1, “Drive Service Strategy” on page 259.
   - If all data are not correct, this is an indication that the data on the media is not the data the initiator expected. Rewrite the correct data to the media.

Write and Verify Command

The drive uses the same data in the data buffer to write then read and compare. A miscompare error on the *Write and Verify (2E)* command is an indication that the drive cannot reliably write or read the media. Service the drive using the procedures specified in Section 18.15.1, “Drive Service Strategy” on page 259.

18.15.4.13 Microcode Error

The microcode from the interface is validated before the device operates using that microcode. When the validation detects incorrect or incomplete data, the Drive enters degraded mode.

If the initiator attempted to load microcode using the *Write Buffer (3B)* retry the *Write Buffer (3B).* If the command completes with

- *Good Status* - return to normal processing
- *Check Condition Status* - service the drive using the service guidelines recommended in Section 18.15.1, “Drive Service Strategy” on page 259.

If the check sum error occurred during normal processing, the initiator may attempt to load microcode before deciding to service the drive using the service guidelines recommended in Section 18.15.1, “Drive Service Strategy” on page 259.

To load new microcode, the initiator should issue a Write Buffer (3B) command with the download and save option. If the Write Buffer (3B) command completes with

- Good Status, return to normal processing. Retry the failing command. If the task complete with
  - Good Status - Continue normal processing.
  - Check Condition Status for check sum error - Service the drive using the service guidelines recommended in Section 18.15.1, “Drive Service Strategy” on page 259.
  - Check Condition Status for any other error - follow the recommended recovery procedure for the error reported.
- Check Condition Status for Check sum error, service the drive using the service guidelines recommended in Section 18.15.1, “Drive Service Strategy” on page 259.
- Check Condition Status for any other error, follow the recommendations for the returned sense data.

18.15.4.14 Predictive Failure Analysis

The Drive performs error log analysis and will alert the initiator of a potential failure. The initiator should determine if this device is the only device with error activity.

If this drive is the only drive attached to the initiator with error activity, service the drive using the procedures specified in Section 18.15.1, “Drive Service Strategy” on page 259.

Note: Service for this drive can be deferred. The longer service is deferred, the more probable a failure can occur that will require immediate service.

If more than this drive is experiencing error activity, the drive is probably not at fault. Locate and service the outside source causing error activity on this drive.

19.0 SCSI Sense Data

19.1 SCSI Sense Data Format

Format of the sense data returned by the drive in response to the REQUEST SENSE command.

Table 216: Format of Sense Data.

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Valid	Error Code (70h or 71h)						
1	RSVD = 0							
2	0		ILI	0	Sense Key			
3-6	(MSB) Information Bytes (LSB)							
7	Additional Sense Length							
8-11	(MSB) Product Specific Information (LSB)							
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	FRU = 0							
15	SKSV	Sense-Key Specific Bits						
16-17	Sense-Key Specific Bytes							
18-19	Reserved = 0							
20-23	Vendor unique Error information							
24-29	Product Specific Information							
30-31	Reserved = 0							

19.2 Sense Data Description

19.2.1 Valid (Bit 7 of byte 0)

0 The Information Bytes (byte 3 through 6) are not defined.

1 The Information Bytes (byte 3 through 6) contain a valid logical block address.

19.2.2 Error Code (Bit 6 - 0 of byte 0)

70h Current Error. This indicates an error for the current command.

71h Deferred Error. This indicates that the error is for a previous command that has already returned a good status. Such commands are associated with the immediate bit or write caching. Format unit (04h) command is an example of a command that may return a deferred error.

19.2.3 ILI: Incorrect Length Indicator (Bit 5 of byte 2)

The ILI bit is valid for the Read Long (3Eh) command and Write Long (3Fh) command only. ILI set to one and Valid Bit set to one indicates that the requested logical block length does not match the logical block length of the data on the medium for a Read Long or Write Long command. The Information field contains residue information about the error. ILI set to zero indicates there is no incorrect length condition.

0 No Incorrect Length condition.

1 Incorrect Length Indicated.

Valid	ILI	Command = Read Long or Write Long	Description
x	0	x	No incorrect length condition
1	1	yes	Requested Logical block Length does not match the logical block length of the data on the drive

19.2.4 Sense Key (Bit 3 - 0 of byte 2)

The sense key provides generic categories in which error and exception conditions can be reported. Initiators would typically use sense keys for high level error recovery procedures.

0h **No Sense**

There is no sense key information to be reported for the logical unit.

1h **Recovered Error**

The last command completed successfully with some recovery action performed by the drive. More detailed information is available in the Additional Sense Code and Additional Sense Code Qualifier.

2h **Not Ready**

The logical unit addressed cannot be addressed. More detailed information is available in the Additional Sense Code and Additional Sense Code Qualifier.

3h **Medium Error**

The command terminated with an unrecoverable error condition caused by a flaw in the media or an error in the recorded data. More detailed information is contained in the Additional Sense Code and Additional Sense Code Qualifier.

4h **Hardware Error**

The drive detected a unrecoverable hardware error while performing a command or during a diagnostic test. More detailed information is contained in the Additional Sense Code and Additional Sense Code Qualifier.

5h **Illegal Request**

There was an illegal parameter in the command descriptor block or additional parameter supplied as data. If an invalid parameter is found in the CDB, then the command is terminated without altering the medium. If an invalid parameter is found in parameters supplied as data, then the drive might have altered the medium.

6h **Unit Attention**

Indicates that the drive entered in the 'Unit Attention Condition'. (See Section 18.1.4, “Unit Attention Condition” on page 241)

7h **Data Protect**

8h **Not used**

9h **Vendor Specific**

Ah **Not used**

Bh **Aborted command**

The drive aborted the command.

Ch-Dh **Not Implemented**

Eh **Miscompare**

Fh **Reserved**

19.2.5 Information Bytes (Byte 3 through 6)

This field is only valid when Valid Bit is one.

- ILI = 0: This field contains the unsigned LBA associated with the sense key. The LBA reported will be within the LBA range of the command as defined in the CDB.
- ILI = 1: This field contains the difference (residue) of the requested length in bytes. Negative values are indicated by two's complement notation.

Valid	ILI	Description
0	x	0x00000000 - (not used/invalid)
1	0	LBA
1	1	Residue of the requested length in bytes

19.2.6 Additional Sense Length (Byte 7)

Indicates the remaining number of bytes in the sense data. (It is always set to 18h.)

19.2.7 Command Specific Information (Byte 8 through 11)

This field is unused and will be set to zero.

19.2.8 Additional Sense Code/Qualifier (Byte 12 and 13)

The following table shows the description of the combination of Sense Key / Sense Code / Qualifier.

Valid Sense Key, Code, Qualifier Combinations Used by the Drive.			
Key	**Code**	**Qual**	**Description**
			Sense Key = No Sense
0	**00**	**00**	**No Additional Sense Information**
			(00 00) No Error.
			Sense Key = Recovered Error
0	**0B**	**01**	**Temperature Warning Error**
			1A02 Temperature Warning
0	**0B**	**03**	**Background Selftest Failure Warning**
			1A03 Background selftest failure warning
0	**0B**	**04**	**Background Pre-Scan Failure Warning**
			1A04 Background pre-scan failure warning
0	**0B**	**05**	**Background Media Scan Failure Warning**
			1A05 Background media scan failure warning
0	**0B**	**06**	**Wear Warning**
			1A06 Wear Warning
1	**0B**	**01**	**Temperature Warning Error**
			2A02 Temperature Warning
1	**0B**	**03**	**Background Selftest Failure Warning**
			2A03 Background selftest failure warning
1	**0B**	**04**	**Background Pre-Scan Failure Warning**
			2A04 Background pre-scan failure warning
1	**0B**	**05**	**Background Media Scan Failure Warning**
			2A05 Background media scan failure warning
1	**0B**	**06**	**Wear Warning**
			2A06 Wear Warning

1	**5D**	**10**	**Predictive Failure Analysis Threshold Reached**
			xAFE SMART: Extreme over-temperature warning
			xAFF SMART: Test warning
1	**5D**	**53**	**Remaining Reserve 1**
			xA53: Remaining Reserve 1
1	**5D**	**54**	**Remaining Reserve 2**
			xA54: Remaining Reserve 2
1	**10**	**01**	**Recovered Guard check error**
			17BC Recovered Guard check error
1	**10**	**02**	**Recovered Application tag error**
			17BA Recovered Application tag error
1	**10**	**03**	**Recovered Reference tag error**
			17B8 Recovered Reference tag error
1	**17**	**01**	**Recovered Data with Retries**
			172A XOR Rebuild successful
			172B Media Hard Error but XOR Retry recovered
			172C Recovered media error (with ECC)
1	**1F**	**00**	**Partial Defect List Transfer**
			1749 Partial defect list transferred
1	**44**	**00**	**Internal Target Failure**
			F123 Invalid request to enter sleep mode
			F128 DRAM test in progress
			F129 DRAM test complete
			1201 Error in UEC class
			1202 Error in UEC cause
			171C Recovered DRAM CRC error
			F427 HMI: DRD HMT timeout
			17C2 Recovered Read CRC error
			17C4 Recovered DRAM ECC error

			17C6 Recovered DRAM ECC LBA error
1	**0B**	**01**	**Temperature Warning Error**
			2A02 Temperature Warning
1	**0B**	**03**	**Background Selftest Failure Warning**
			2A03 Background selftest failure warning
1	**0B**	**04**	**Background Pre-Scan Failure Warning**
			2A04 Background pre-scan failure warning
1	**0B**	**05**	**Background Media Scan Failure Warning**
			2A05 Background media scan failure warning
1	**0B**	**06**	**Wear Warning**
			2A06 Wear Warning
			Sense Key = Not Ready
2	**04**	**00**	**Logical Unit Not Ready**
			F501 Logical unit not ready
2	**04**	**01**	**Logical Unit Is In The Process of Becoming Ready**
			F502 Logical unit becoming ready
2	**04**	**02**	**Logical Unit Not Ready, initializing command required**
			F124 Bring-up error
			F503 Logical unit not ready - initializing command required
2	**04**	**03**	**Logical Unit Not Ready, Manual Intervention Required**
			F572 Not ready - manual intervention required
2	**04**	**04**	**Logical Unit Not Ready, Format In Progress**
			F504 Not ready - format in progress
2	**04**	**09**	**Not Ready - Self-test In Progress**
			F505 Not ready - self-test in progress
2	**04**	**11**	**Not Ready - Notify (Enable Spin-up) Required**
			F553 Not ready - Notify (Enable Spin-up) required (SAS only)
2	**04**	**F0**	**Vendor Unique - Logical Unit Not Ready**
			F133 BATS error: Vendor ID mismatch
2	**31**	**00**	**Medium Format Corrupted - Reassign Failed**

			F506 Reassign failed
2	**31**	**01**	**Format Command Failed**
			F507 Format failed
3	**10**	**01**	**Unrecovered Guard check error**
			F7BD Unrecovered Guard check error
3	**10**	**02**	**Unrecovered Application tag error**
			F7BB Unrecovered Application tag error
3	**10**	**03**	**Unrecovered Reference tag error**
			F7B9 Unrecovered Reference tag error
3	**11**	**00**	**Unrecovered Read Error**
			F421 HMI: DRD CRC error
			F52D Buffer CRC error on read
			F72D Unrecovered media error
3	**11**	**14**	**Unrecovered LBA write uncorrectable error**
			F7CC: Unrecovered LBA write uncorrectable error
3	**31**	**00**	**Medium Format Corrupted Reassign Failed**
			F701 Format corrupted
4	**35**	**00**	**Enclosure Services Failure**
			F539 ESI: unspecified failure (FC-AL only)
4	**35**	**01**	**Enclosure Services Failure - Unsupported Enclosure Function**
			F53A ESI: unsupported function (FC-AL only)
4	**35**	**02**	**Enclosure Services Failure - Enclosure Services Unavailable**
			F53B ESI: enclosure unavailable (FC-AL only)
4	**35**	**03**	**Enclosure Services Failure - Enclosure Services Transfer Failure**
			F556 ESI: transfer failed - write ack
			F557 ESI: transfer failed - read ack
			F558 ESI: transfer failed - write ready
			F559 ESI: transfer failed - read ready
			F55E ESI: transfer failed - EDV
			F579 ESI: Transfer Checksum Error

			F57A ESI: Transfer Checksum Ready Timeout
4	**35**	**04**	**Enclosure Services Failure - Enclosure Services Refused**
			F55A ESI: transfer refused - write ack
			F55B ESI: transfer refused - read ack
			F55C ESI: transfer refused - write ready
			F55D ESI: transfer refused - read ready
4	**35**	**80**	**Enclosure Services Failure**
			F53C ESI: SES Timeout
4	**3E**	**03**	**Self-test Failed**
			F75D Self-test failed
4	**3E**	**04**	**Media Self-test Failed**
			F762 Media selftest hard cache fail
			F763 Media selftest OTF cache fail
4	**40**	**80**	**Diagnostic Failure**
			F101 BATS error: Reserved Area - Invalid request
			F102 BATS error: Reserved Area - Broken
			F103 BATS error: Reserved Area - Invalid version
			F104 BATS error: Reserved Area - Invalid checksum
			F105 BATS error: Reserved Area - Invalid eyecatcher
			F106 BATS error: Reserved Area - Invalid main header checksum
			F107 BATS error: Reserved Area - Invalid read length
			F108 BATS error: Reserved Area - Address boundary error
			F10E BATS error: Directory broken
			F10F BATS error: Overlay code load error
			F110 BATS error: Overlay code check
			F111 BATS error: RAM code load error
			F112 BATS error: RAM code check
			F113 BATS error: Config invalid
			F114 BATS error: Log manager invalid

			F11D Incorrect drive Code
			F121 BATS error: Code download in progress
			F122 BATS error: Performance data read error
			F125 BATS error: Invalid RID/FID
			F12B BATS error: Reserved area - invalid model
			F12C BATS error: Invalid code size
			F12E Format Reserved: Insufficient DIRS good
			F12F Format Reserved: Insufficient FATS good
			F131 Flash timeout
			F137 Flash ECC error
			F139 Format Reserved: Resize RIDFID error
			F13B SW target broken
			F13C NCDE DRAM Error
			F13C NCDE DRAM Error
4	**40**	**81**	**DRAM Failure**
			F12A DRAM test error
4	**40**	**A0**	**Diagnostic Failure**
			F11B BATS#2 error: CRC test error
			F11C BATS#2 error: XOR test error
			F136 BATS#2 error: End-to-End test error
4	**44**	**00**	**Internal Target Failure**
			F140 Cap charge time exceeded
			F141 Cap discharge time exceeded
			F142 Cap discharge time too short
			F143 Cap charge exit check failed
			F208 Nand missing
			F209 Sanity blocksize error
			F20A Mode page structure mismatch
			F60E Fconfig token update failed after code download

			F401 HMI: HMT error invalid
			F402 HMI: AES side slots overflow
			F403 HMI: HMT side valids overflow
			F404 HMI: FIFO num valid overflow
			F405 HMI: FIFO num available overflow
			F601 South: Boot incomplete
			F602 South: Trapped
			F603 South: Timeout
			F604 South: Command done
			F605 South: Command error
			F606 South: Unknown event
			F607 South: Generic assert
			F608 South: Identify failed
			F609 South: Assert dump invalid
			F60A South: Assert collision
			F60B South: Not ready for asserts
			F60C South: Dump erase but no assert found
			F60D South: Dump read but no assert found
			F60F Fconfig token parsing failed
			F610 South: Nand unsupported
			F611 South: NandID mismatch
			F612 South: No firmware found
			F613 South: Bad firmware checksum
			F620 South: Enable logical
			F621 South: Disable logical no context
			F622 South: Disable logical bad context
			F623 South: Disable logical asserted
			F624 South: Disable logical no defect map
			F625 South: Disable logical no space

			F626 South: Disable logical channel CE conflict
			F627 South: Read only
			F628 South: Log Invalid
			F71D Unrecovered DRAM CRC error
			F7C3 Unrecovered Read CRC error
			F7C5 Unrecovered DRAM ECC error
			F7C7 Unrecovered DRAM ECC LBA error
			FCxx Unable to read RID or FID number xx
4	**81**	**00**	**Vendor Unique - Internal Logic Error**
			F56F Log dump data memory error
5	**15**	**00**	**Phy Test Function in Progress**
			F50D Phy test function in progress
5	**1A**	**00**	**Parameter List Length Error**
			F820 Parameter list length error
5	**20**	**00**	**Invalid Command Operation Code**
			F821 Invalid opcode in CDB
5	**21**	**00**	**Logical Block Address out of Range**
			F822 LBA out of range
5	**24**	**00**	**Invalid Field in CDB**
			F823 Illegal request - invalid field in CDB
5	**25**	**00**	**Logical Unit Not Supported**
			FA24 Invalid LUN
5	**26**	**00**	**Invalid Field in Parameter List**
			F825 Illegal request - invalid field in parameter list
			F826 Unsupported log page
5	**26**	**02**	**Parameter Value Invalid**
			F120 BATS error: Code compatibility failure
			F126 BATS error: Code checksum error
			F127 BATS error: Invalid header

			F130 Incorrect Customer code
5	**26**	**04**	**Invalid Release of Active Persistent Reservation**
			F828 Invalid release of persistent reservation
5	**2C**	**00**	**Illegal Request Sequence error**
			F511 Illegal Request Sequence error
5	**49**	**00**	**Invalid Message Error**
			F512 Invalid message
5	**55**	**04**	**Insufficient Registration Resources**
			F567 Insufficient registration resources
6	**0B**	**01**	**Temperature Warning Error**
			3A02 Temperature Warning
6	**0B**	**03**	**Background Selftest Failure Warning**
			3A03 Background selftest failure warning
6	**0B**	**04**	**Background Pre-Scan Failure Warning**
			3A04 Background pre-scan failure warning
6	**0B**	**05**	**Background Media Scan Failure Warning**
			3A05 Background media scan failure warning
6	**0B**	**06**	**Wear Warning**
			3A06 Wear Warning
6	**28**	**00**	**Not Ready To Ready Transition (Format completed)**
			F514 Not ready to read transition
6	**29**	**00**	**Unit Attention - Login Reset**
			F515 Login reset (FC-AL only)
6	**29**	**01**	**Unit Attention - POR Occurred**
			F516 Power on reset
6	**29**	**02**	**Unit Attention - SCSI Bus Reset Occurred**
			F517 LIP Reset (FC-AL), SAS Hard Reset (SAS)
6	**29**	**03**	**Unit Attention - Bus Device Reset Occurred**
			F518 Target Reset (FC-AL), LUN Reset (SAS)
6	**29**	**04**	**Unit Attention - Self Initiated Reset Occurred**

			F519 Self initiated reset
6	**29**	**05**	**Transceiver Changed to SE**
			F548 Device Control Hard Reset received
6	**29**	**07**	**I_T Nexus Loss Occurred**
			F554 I_T Nexus Loss Occurred (SAS only)
6	**2A**	**01**	**Mode Parameters Changed**
			F51C Mode parameters changed
6	**2A**	**02**	**Log Parameters Changed**
			F51D Log parameters changed
6	**2A**	**03**	**Reservations Preempted**
			F51E Reservations pre-empted
6	**2A**	**04**	**Reservations Released**
			F51F Reservations released
6	**2A**	**05**	**Registrations Released**
			F520 Registrations pre-empted
6	**2F**	**00**	**Commands Cleared by Another Initiator**
			F521 Commands cleared by another initiator
6	**2F**	**01**	**Commands Cleared by Power Loss Notification**
			F573 Commands cleared due to power failure event (SAS)
6	**3F**	**01**	**Microcode has been changed**
			F522 Microcode changed
6	**3F**	**03**	**Inquiry Parameters Changed**
			F523 Inquiry parameters changed
6	**3F**	**05**	**Device Identifier Changed**
			F537 Device identifier changed
B	**0E**	**02**	**Information Unit Too Long**
			F562 Information unit too long.
B	**10**	**00**	**Aborted Command** CRC error
			F417 HMI: DWT CRC error
			F52C Drive CRC error

B	**10**	**01**	**Aborted Command – End-to-End Guard Check**
			F414 HMI: HWT guard check error
			F424 HMI: DRD guard check error
			F529 Drive Guard check error
			F568 End-to-End Data Protection Guard check
B	**10**	**02**	**Aborted Command – End-to-End Application Tag Check**
			F415 HMI: HWT app check error
			F423 HMI: DRD application tag check error
			F52A Drive application tag check error
			F569 End-to-End Data Protection Application Tag check
B	**10**	**03**	**Aborted Command – End-to-End Reference Tag Check**
			F416 HMI: HWT ref check error
			F422 HMI: DRD ref check error
			F52B Drive reference tag check error
			F56A End-to-End Data Reference Tag check
B	**3F**	**0F**	**Aborted Command - Echo Buffer Overwritten**
			F544 Echo buffer overwritten
B	**44**	**00**	**Internal Target Failure**
			F406 HMI: Abort
			F410 HMI: Write SG abort
			F411 HMI: DWT DRAM ECC error
			F412 HMI: HWT sync CRC error
			F413 HMI: HWT sync CRC LBA error
			F418 HMI: DWT HMT error
			F419 HMI: DWT HMT timeout
			F420 HMI: Read SG abort
			F425 HMI: DRD HMI LBA error
			F427 HMI: DRD HMT timeout
			F426 HMI: DRD HMT error

			F526 Drive HMI LBA error
			F527 Drive HMI error
			F528 Drive HMI Timeout
			F52E Internal target failure - Host Interface
			F54A Xfer Ready credit exceeded (FC-AL only)
			F54B Xfer length error (FC-AL only)
			F56B ECC error in DRAM customer data area
			F56C Uncorrectable DRAM ECC error
			F56E Log dump south error
			F570 Host interface CRC error
			F741 Media overall command timeout not dispatched
			F742 Media overall command timeout in recovery
			F743 Media overall command timeout executing
			F57B Host Interface Synchronous CRC LBA Error
			F75C Internal media access timeout
B	**47**	**01**	**Data Phase CRC Error**
			F54E Data Phase CRC Error
B	**4B**	**00**	**Data Phase Error**
			F53E Data phase error
B	**4B**	**01**	**Invalid Target Port Transfer Tag Received**
			F561 Information unit too short (SAS only)
B	**4B**	**02**	**Too Much Write Data**
			F560 Too much write data (SAS only)
B	**4B**	**03**	**ACK/NAK Timeout**
			F551 ACK/NAK Timeout (SAS only) F57D Break Received (SAS only)
B	**4B**	**04**	**NAK Received**
			F550 NAK Received (SAS only)
B	**4B**	**05**	**Data Offset Error**
			F552 Bad parameter offset (SAS only)

B	**4B**	**06**	**Initiator Response Timeout**
			F555 Initiator response timeout (SAS only)
B	**4E**	**00**	**Overlapped Commands Attempted**
			F534 Overlapped command attempted
B	**4F**	**00**	**Command Aborted Due To Loop Initialization**
			F53F Abort by LIP (FC-AL only), Abort by OOB (SAS)
			Sense Key = Miscompare
E	**1D**	**00**	**Miscompare During Verify Operation**
			F535 Miscompare during verify

19.2.9 RU: Field Replaceable Unit (Byte 14)

The FRU (Field Replaceable Unit) field value will always be zero.

19.2.10 Sense Key Specific (Byte 15 through 17)

The definition of this field is determined by the value of the sense key field.

19.2.10.1 Sense Key Specific - Illegal Request (Sense Key = 5h)

Error field pointer is returned.

Table 217: Field Pointer Bytes

Byte	Bit							
	7	6	5	4	3	2	1	0
15	SKSV	C/D	Reserved		BPV	Bit Pointer		
16 17	(MSB) Field Pointer (LSB)							

SKSV Sense-key specific valid

- **0** Sense-key specific field is not valid.
- **1** Sense-key specific field is valid.

C/D Command/Data

- **0** Indicates that the illegal parameter was in the data parameters sent by the initiator during DATA OUT phase
- **1** Indicates that the illegal parameter was in the command descriptor block.

BPV Bit Pointer Valid

- **0** Bit pointer field is not valid.
- **1** Bit pointer field is significant.

Bit Pointer Indicates which bit of the byte number reported in Field Pointer is the bit in error. When a multiple bit field is in error, the pointer points to the most significant bit of the field.

Field Pointer Indicates which bytes of the command descriptor block or of the parameter data were in error. Bytes are numbered starting from zero, as shown in the tables describing the commands and parameters. When a multiple byte field id is in error, the pointer points to the most significant byte of that field.

19.2.10.2 Sense Key Specific - Recovered (Sense Key = 1h) or Medium (Sense Key = 3h) or Hardware (Sense Key = 4h)

Hardware (Sense Key = 4h) or Medium Error (Sense Key = 3h)

Actual Retry Count is reported.

Table 218: Actual Retry Count

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
15	**SKSV**	**Reserved**						
16	**Reserved**							
17	**Actual Retry Count**							

SKSV Sense-key specific valid

0 Actual Retry Count is not valid.

1 Actual Retry Count is valid.

Actual Retry Count Number of retry steps used in attempting to recover from the error condition.

19.2.10.3 Sense Key Specific - Not Ready (Sense key = 2h)

These fields are defined for the Format unit (04h) command with the Immediate bit set to one and the Send Diagnostic (1Dh) command with Background self-test function.

Progress indication is returned.

Table 219: Progress Indication

Byte	Bit 7	6	5	4	3	2	1	0
15	SKSV	Reserved						
16	(MSB)	Progress Indication						
17								(LSB)

SKSV Sense-key specific valid

- **0** Progress Indication is not valid.
- **1** Progress Indication is valid.

Progress Indication Indicates a percent complete in which the returned value is the numerator that has 10000h as its denominator.

19.2.11 Reserved (Byte 18 through 19)

Reserved fields are filled with zero.

19.2.12 Vendor unique error information (Byte 20 through 23)

This field gives detailed information about the error. It contains a unique code which describes where the error was detected and which piece of hardware or microcode detected the error depending on current operation.

19.2.13 Physical Error Record (Byte 24 thru 29)

- ILI = 1 - This field contains zeros.
- ILI = 0 - These bytes contain the physical location of the error.

  If physical location has no relevance for the error, bytes 24 through 29 will all be set to 0FFFFFFFFFFFFh for Valid = 0 and ILI = 0. This Physical Error Record field is valid for Sense Key 1, 3, and 4 only.

Valid	ILI	Description
1	0	Die (bytes 24-25) Channel (byte 26) CE (byte 27) Sector Number (byte 28-29)
1	1	0x000000000000
0	x	0x000000000000 - (not used/invalid)

19.2.14 Reserved (Byte 30 through 31)

Reserved fields are filled with zero.

20.0 Appendix. UEC list

Following is the list of Unit Error Codes and associated descriptions. The Unit Error Codes are returned by the target in sense data bytes 20-21.

The list of Unit Error Codes and descriptions does not have a direct correlation to the error descriptions and Sense Key/Code/ Qualifier descriptions in Section 18.0, “Additional information” on page 239. These codes are used internally by HGST and may change without notice.

How to find a specific UEC

The second hex digit indicates the grouping, e.g. interface, media, servo, etc. types of errors. The table is sorted without regard to the first hex digit; instead, sorting is by the least significant three hex digits.

Table 220: Unit Error Codes

UEC	Description
0000	No error
F101	BATS error: Reserved Area - Invalid request
F102	BATS error: Reserved Area - Broken
F103	BATS error: Reserved Area - Invalid version
F104	BATS error: Reserved Area - Invalid checksum
F105	BATS error: Reserved Area - Invalid eyecatcher
F106	BATS error: Reserved Area - Invalid main header checksum
F107	BATS error: Reserved Area - Invalid read length
F108	BATS error: Reserved Area - Address boundary error
F10E	BATS error: Directory broken
F10F	BATS error: Overlay code load error
F110	BATS error: Overlay code check
F111	BATS error: RAM code load error
F112	BATS error: RAM code check
F113	BATS error: Config invalid
F114	BATS error: Log manager invalid
F119	Bats#2 error: Read Write test error
F11B	BATS#2 error: CRC test error
F11C	BATS#2 error: XOR test error
F11D	Incorrect drive Code
F120	BATS error: Code Compatibility Failure
F121	BATS error: Code download in progress
F122	BATS error: Performance data read error
F123	Invalid request to enter sleep mode
F124	Bring-up error
F125	BATS error: Invalid RID/FID
F126	BATS error: Code checksum error
F127	BATS error: Invalid header
F128	DRAM test in progress

UEC	Description
F129	DRAM test complete
F12A	DRAM test error
F12B	BATS error: Reserved area - invalid model
F12C	BATS error: Invalid code size
F12E	Format Reserved: Insufficient DIRS good
F12F	Format Reserved: Insufficient FATS good
F130	Incorrect Customer Code
F131	Flash time-out
F133	BATS error: Vendor ID mismatch
F136	BATS#2 error: End-To-End Data Protection error
F137	Flash ECC error
F139	Format Reserved: Resize RIDFID error
F13B	SW Target broken
F13C	NCDE DRAM failure
F140	BATS error: Cap charge time exceeded
F141	BATS error: Cap discharge time exceeded
F142	BATS error: Cap discharge time too short
F143	BATS error: Cap charge exit check failed
1201	Error in UEC class
1202	Error in UEC cause
F203	Internal target failure
F207	AHB Access Error
F208	NAND Missing
F209	North/South disagree on block size
F20A	Mode page structure mismatch
F401	HMI: HMT error invalid
F402	HMI: AES side slots overflow
F403	HMI: HMT side valids overflow
F404	HMI: FIFO num valid overflow
F405	HMI: FIFO num available overflow
F406	HMI: Abort
F410	HMI: Write SG abort
F411	HMI: DWT DRAM ECC error
F412	HMI: HWT sync CRC error
F413	HMI: HWT sync CRC LBA error
F414	HMI: HWT guard check error
F415	HMI: HWT app check error
F416	HMI: HWT ref check error

UEC	Description
F417	HMI: DWT CRC error
F418	HMI: DWT HMT error
F419	HMI: DWT HMT time-out
F420	HMI: Read SG abort
F421	HMI: DRD CRC error
F422	HMI: DRD ref check error
F423	HMI: DRD app check error
F424	HMI: DRD guard check error
F425	HMI: DRD HMI LBA error
F426	HMI: DRD HMT error
F427	HMI: DRD HMT time-out
F501	Logical unit not ready
F502	Logical unit becoming ready
F503	Logical unit not ready - initializing command required
F504	Not ready - format in progress
F505	Not ready - self-test in progress
F506	Reassign failed
F507	Format failed
F50D	Phy Test Function in Progress
F511	Illegal request sequence error
F512	Invalid Message
F514	Not ready to ready transition
F515	Login reset (FC-AL only)
F516	Power on reset
F517	LIP reset (FC-AL), SAS Hard Reset (SAS)
F518	Target Reset (FC-AL), LUN Reset (SAS)
F519	Self initiated reset
F51C	Mode parameters changed
F51D	Log parameters changed
F51E	Reservations pre-empted
F51F	Reservations released
F520	Registrations pre-empted
F521	Commands cleared by another initiator
F522	Microcode changed
F523	Inquiry parameters changed
F526	Drive HMI LBA error
F527	Drive HMT error
F528	Drive HMT time-out
F529	Drive guard check error
F52A	Drive application tag error

UEC	Description
F52B	Drive reference tag error
F52C	Drive CRC error
F52D	Buffer CRC error on read
F52E	Internal target failure
F534	Overlapped command attempted
F535	Miscompare during verify
F536	Reservation conflict
F537	Device identifier changed
F539	ESI: unspecified failure (FC-AL only)
F53A	ESI: unsupported function (FC-AL only)
F53B	ESI: enclosure unavailable (FC-AL only)
F53C	ESI: transfer failure (FC-AL only)
F53E	Data phase error
F53F	Abort by LIP (FC-AL), Abort by OOB (SAS)
F544	Echo buffer overwritten
F548	Device Control Hard Reset received
F54A	Xfer Ready credit exceeded (FC-AL only)
F54B	Transfer length error (FC-AL only)
F54E	Data Phase CRC Error
F550	NAK rcvd (SAS)
F551	ACK NAK Time-out (SAS)
F552	Bad parameter offset (SAS)
F553	LUN Not ready, Notify (Enable Spinup) required (SAS)
F554	I_T_Nexus Loss Occurred (SAS)
F555	Initiator Response Time-out (SAS)
F556	ESI transfer failed - write ack (FC-AL)
F557	ESI transfer failed - read ack (FC-AL)
F558	ESI transfer failed - write ready (FC-AL)
F559	ESI transfer failed - read ready (FC-AL)
F55A	ESI transfer refused - write ack (FC-AL)
F55B	ESI transfer refused - read ack (FC-AL)
F55C	ESI transfer refused - write ready (FC-AL)
F55D	ESI transfer refused - read ready (FC-AL)
F55E	ESI transfer failed - EDV (FC-AL)
F560	Too much write data (SAS)
F561	Information unit too short (SAS)
F562	Information unit too long (SAS)
F566	Not ready in HGST DST
F567	Insufficient registration resources
F568	End-to-End Data Protection Guard check
F569	End-to-End Data Protection Application Tag check

UEC	Description
F56A	End-to-End Data Protection Reference Tag check
F56B	ECC error in DRAM customer data area
F56C	Uncorrectable DRAM ECC error
F56E	Log dump south error
F56F	Log dump data memory error
F570	Host interface Synchronous CRC error
F572	LUN not ready; manual intervention required
F573	Commands cleared due to power failure event (SAS)
F574	Unsupported hardware
F579	ESI Transfer Checksum Error (FC-AL)
F57A	ESI Transfer Checksum Ready Time-out (FC-AL
F57B	Host Interface Synchronous CRC LBA Error
F57D	BREAK received
F601	South: Boot incomplete
F602	South: Trapped
F603	South: Time-out
F604	South: Command done
F605	South: Command error
F606	South: Unknown event
F607	South: Generic assert
F608	South: Identify failed
F609	South: Assert dump invalid
F60A	South: Assert collision
F60B	South: Not ready for asserts
F60C	South: Dump erase but no assert found
F60D	South: Dump read but no assert found
F60E	South: Fconfig token update failed after code download
F60F	South: Fconfig token parsing failed
F610	South: Nand unsupported
F611	South: NandID mismatch
F612	South: No firmware found
F613	South: Bad firmware checksum
F614	South: No slots found
F620	South: Enable logical
F621	South: Disable logical no context
F622	South: Disable logical bad context
F623	South: Disable logical asserted
F624	South: Disable logical no defect map
F625	South: Disable logical no space
F626	South: Disable logical channel CE conflict

UEC	Description
F627	South: Read only
F628	South: Log Invalid
F701	Format corrupted
171C	Recovered DRAM CRC error
F71D	Unrecovered DRAM CRC error
172A	XOR Rebuild successful
172B	Media Hard Error but XOR Retry recovered
172C	Recovered media error (with ECC)
F72D	Unrecovered media error
F741	Media overall command time-out not dispatched
F742	Media overall command time-out in recovery
F743	Media overall command time-out executing
1749	Partial defect list transferred
F75C	Internal media access time-out
F75D	Selftest failed
F762	Cache test fail
F763	OTF cache fail
17B8	Recovered Reference tag error
F7B9	Unrecovered Reference tag error
17BA	Recovered Application tag error
F7BB	Unrecovered Application tag error
17BC	Recovered Guard check error
F7BD	Unrecovered Guard check error
17C2	Recovered Read CRC error
F7C3	Unrecovered Read CRC error
17C4	Recovered DRAM ECC error
F7C5	Unrecovered DRAM ECC error
17C6	Recovered DRAM ECC LBA error
F7C7	Unrecovered DRAM ECC LBA error
F7CC	Unrecovered LBA ECC write uncorrectable
F820	Parameter list length error
F821	Invalid opcode in CDB
F822	LBA out of range
F823	Illegal request - invalid field in CDB

UEC	Description
F824	Invalid LUN
F825	Illegal request - invalid field in parameter list
F826	Illegal request - Unsupported Log Page
F828	Illegal request - Invalid Release of Persistent Reservation
1A02	SMART: Temperature warning (no sense)
2A02	SMART: Temperature warning (recovered sense)
3A02	SMART: Temperature warning (unit attn sense)
1A03	SMART: Background selftest warning (no sense)
2A03	SMART: Background selftest warning (recovered sense)
3A03	SMART: Background selftest warning (unit attn sense)
1A04	SMART: Background Pre-Scan warning (no sense)
2A04	SMART: Background Pre-Scan warning (recovered sense)
3A04	SMART: Background Pre-Scan warning (unit attn sense)
1A05	SMART: Background Media Scan warning (no sense)
2A05	SMART: Background Media Scan warning (recovered sense)
3A05	SMART: Background Media Scan warning (unit attn sense)
1A06	SMART: Wear warning (no sense)
2A06	SMART: Wear warning (recovered sense)
3A06	SMART: Wear warning (unit attn sense)
1A28	SMART: Capacitor fail (no sense)
2A28	SMART: Capacitor fail (recovered sense)
3A28	SMART: Capacitor fail (unit attn sense)
1A53	SMART: Remaining Reserve 1 (no sense)
2A53	SMART: Remaining Reserve 1 (recovered sense)
3A53	SMART: Remaining Reserve 1 (unit attn sense)
1A54	SMART: Remaining Reserve 2 (no sense)
2A54	SMART: Remaining Reserve 2 (recovered sense)
3A54	SMART: Remaining Reserve 2 (unit attn sense)
1AFE	SMART: Thermal Sense trip (no sense)
2AFE	SMART: Thermal Sense trip (recovered sense)
3AFE	SMART: Thermal Sense trip (unit attn sense)
1AFF	SMART: Test warning (no sense)
2AFF	SMART: Test warning (recovered sense)
3AFF	SMART: Test warning (unit attn sense)
FCxx	Unable to read RID or FID number xx

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