Hard disk drive specifications

HGST Ultrastar Archive Ha10

3.5 inch Serial ATA hard disk drive

Models: HMH7210A0ALE600/1/4
              HMH7210A0ALN600/1/4

Revision 2.1   31 March 2016

HGST Hard Disk Drive OEM Specification

Revision 1.0 (9 June 2015)
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31 March 2016

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1 General

1.1 Introduction

This document describes the specifications of the Ultrastar Archive Ha10 an HGST 3.5-inch 7200-rpm serial ATA interface hard disk drive with the following model numbers:

Table 1   Type and Model#

Capacity	Type	Interface	Model#	Description
10TB	US7SAJ100	Serial ATA 512 Emulation	HMH7210A0ALE600	Instant Secure Erase, BDE off
			HMH7210A0ALE601	BDE(Bulk Data Encryption)
			HMH7210A0ALE604	Secure Erase (Overwrite only)
		Serial ATA 4K Native	HMH7210A0ALN600	Instant Secure Erase, BDE off
			HMH7210A0ALN601	BDE(Bulk Data Encryption)
			HMH7210A0ALN604	Secure Erase (Overwrite only)

1.2 Glossary

ESD	Electrostatic Discharge
Kbpi	1,000 bits per inch
Ktpi	1,000 tracks per inch
Gbps	1,000,000,000 bits per second
Mbps	1,000,000 bits per second
MB/s	1,000,000 bytes per second
TB	1,000,000,000,000 bytes (for Drive Capacity)
GB	1,000,000,000 bytes (for Drive Capacity)
MB	1,048,576 bytes (for Memory Size)
KB	1,024 bytes (for Memory Size)
S.M.A.R.T.	Self-Monitoring Analysis and Reporting Technology
DFT	Drive Fitness Test
ADM	Automatic Drive Maintenance

1.3 General caution

The drive can be damaged by shock or ESD (Electrostatic Discharge).   Any damage sustained by the drive after removal from the shipping package and opening the ESD protective bag are the responsibility of the user.

1.4 References

- Serial ATA II: Extensions to Serial ATA 1.0
- Serial ATA International Organization: Serial ATA Revision 3.2
- supports ZAC r04b (di537r4b-Zoned-device_ATA_Command_Set_ZAC)

2 General features

- Host Managed SMR (Shingled Magnetic Recording)
- Data capacities of 10.0TB
- Spindle speeds of 7200 RPM
- Fluid Dynamic Bearing motor
- Dual Stage Actuator
- Closed-loop actuator servo
- Automatic Actuator lock
- Write Cache
- Advanced Power Management (APM)
- S.M.A.R.T. (Self Monitoring and Analysis Reporting Technology)
- Adaptive zone formatting
- RVS(Rotational Vibration Safeguard)
- 256MB Memory
- Seek time of 8.5 ms in read operation (without Command Overhead)
- Conventional Zone 1% of Total Capacity
- Sequential Write Required Zone size of 256MB
- UnRestricted Sequential Write Required Zone supported (URSWRZ =1)
- Write Verify for Cold Storage Technology
- Segmented buffer implementation
- Automatic Error Recovery procedures for read and write commands
- Automatic defect reallocation
- Sector format of 512/4096   bytes/sector
- Native command queuing support
- Self Diagnostics at Power on and resident diagnostics
- Serial ATA Data Transfer   6/3/1.5Gbps
- Support security feature
- 48 bit addressing feature
- SATA-3.2 compliant
- Support Bulk Data Encryption (specific model only)
- ZAC r04b (di537r4b-Zoned-device_ATA_Command_Set_ZAC) compliant

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Part 1. Functional Specification

3   Fixed disk subsystem description

3.1   Control Electronics

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

- Controls and interprets all interface signals between the host controller and the drive.
- Controls read write accessing of the disk media, including defect management and error recovery.
- Controls starting, stopping, and monitoring of the spindle.
- Conducts a power-up sequence and calibrates the servo.
- Analyzes servo signals to provide closed loop control. These include position error signal and estimated velocity.
- Monitors the actuator position and determines the target track for a seek operation.
- Controls the voice coil motor driver to align the actuator in a desired position.
- Constantly monitors error conditions of the servo and takes corresponding action if an error occurs.
- Monitors various timers such as head settle and servo failure.
- Performs self-checkout (diagnostics).

3.2   Head disk assembly

The head disk assembly (HDA) is assembled in a clean room environment and contains the disks and actuator assembly. Helium is constantly circulated and filtered when the drive is operational. No venting of the HDA is accomplished, as HDA is hermetically sealed.

The spindle is driven directly by an in-hub, brushless, sensorless DC drive motor. Dynamic braking is used to quickly stop the spindle.

3.3   Actuator

The read/write heads are mounted in the actuator. The actuator is a swing-arm assembly driven by a voice coil motor. A closed-loop positioning servo controls the movement of the actuator. An embedded servo pattern supplies feedback to the positioning servo to keep the read/write heads centered over the desired track.

The actuator assembly is balanced to allow vertical or horizontal mounting without adjustment.

When the drive is powered off, the actuator automatically moves the head to the actuator ramp outside of the disk where it parks.

4 Drive characteristics

This section describes the characteristics of the drive.

4.1 Default logical drive parameters

Table 2 Formatted capacity

The default of the logical drive parameters in Identify Device data is as shown below.

Description	10TB model	
Physical Layout		
Label capacity	10TB	10TB
Bytes per Sector	4096	4096
Bytes per Sector	14	14
Number of Heads	7	7
Logical Layout[2]		
Number of Heads	16	16
Bytes per Sector	512e	4096
Number of Sectors/ Track	63	63
Number of Cylinders[1]	16,383	16,383
Number of Sectors	19,532,873,728	2,441,609,216
Total Logical Data Bytes	10,000,831,348,736	10,000,831,348,736

Notes:

[1] Number of cylinders: For drives with capacities greater an 8.45 GB the IDENTIFY DEVICE information word   01 limits the number of cylinders to 16,383 per the ATA specification.

[2] Logical layout: Logical layout is an imaginary drive parameter (that is, the number of heads) which is used to access the drive from the system interface. The Logical layout to Physical layout (that is, the actual Head and Sectors) translation is done automatically in the drive. The default setting can be obtained by issuing an IDENTIFY DEVICE command

4.2 Data sheet

Table 3 Data Sheet

Description	10TB Model
Max Data transfer rate (Mbps)	1900
Interface transfer rate (MB/s)	600
Typ Sustained transfer rate Read/Write (MB/s) *[1]	157.3 / 68.2
Memory size (MB)	256
Rotational speed (RPM)	7,200
Configurable number of buffer segment Number	2048max
Recording density- max (Kbpi)	1660
Track density (Ktpi)	500
Areal density - max (Gbits/in^2)	830

*[1]   Sequential Write Required Zone

4.3 World Wide Name Assignment

Table 4   World Wide Name Assignment

Description	WWN
Organizationally Unique Identifier (OUI)	000CCAh (HGST)
Block Assignment	24Fh (Thailand)

4.4 Drive organization

4.4.1 Drive Format

Upon shipment from HGST manufacturing the drive satisfies the sector continuity in the physical format by means of the defect flagging strategy described in Section 5 in order to provide the maximum performance to users.

4.4.2 Cylinder allocation

Physical cylinder is calculated from the starting data track of 0. It is not relevant to logical CHS. Depending on the capacity some of the inner zone cylinders are not allocated.

Data cylinder
This cylinder contains the user data which can be sent and retrieved via read/write commands and a spare area for reassigned data.

Spare cylinder
The spare cylinder is used by HGST manufacturing and includes data sent from a defect location.

4.4.3   Zone Layout

The LBAs are divided into ranges called zones.
The entire capacity of a zoned block device is organized into a set of contiguous, non-overlapping zones.

Zone size 256MB
Conventional Zone 1% of Total Capacity
Sequential write required zone 99% of Total Capacity

Table 5   Zone Layout

Description	10TB model	
Logical Layout		
Bytes per Sector	512e	4096
Number of Conventional Zone	378	378
Start LBA	0	0
End LBA	198,180,863	24,772,607
Number of Sequential write required zone	36,878	36878
Start LBA	198,180,864	24,772,608
End LBA	19,532,873,727	2,441,609,215
Number of Sectors	19,532,873,728	2,441,609,216

Conventional zone

↓ LBA 0   LBA 24,772,607 ↓

Zone 0	Zone 1	Zone 2	…	Zone 377

Sequential write required zone

↓ LBA 24,772,608   LBA 2,441,609,215 ↓

Zone 378	Zone 379	Zone 380	…	Zone 37255

Figure 1   Logical Layout example: Number of Block pre Sector 4096

4.5   Performance characteristics

Drive performance is characterized by the following parameters:

- Command overhead
- Mechanical positioning
  - Seek time
  - Latency
- Data transfer speed
- Buffering operation (Look ahead/Write cache)

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

4.5.1   Command overhead

Command overhead is defined as the time required

From the time

  H->D Reg FIS w/ command bit is sent by host
  is sent by host

To the time
  - PIO Set Up FIS is sent by device (PIO Read/Write)
  - DATA FIS is sent by device (DMA Read)
  - DMA Activate FIS is sent by device (DMA Write)
  - DMA Set Up FIS is sent by device (NCQ Read/Write)
  - Seek Start (Read cache not hit or Seek)

The table below gives average command overhead.

Table 6   Command overhead

Command type (Drive is in quiescent state)	Typical time (ms)
Read (Cache not hit)	0.2
Read (Cache hit)	0.2
Write	0.5
Seek	0.2

4.5.2　Mechanical positioning

4.5.2.1　Average seek time (without command overhead, including settling)

Table 7　Average seek time

Command Type	Typical (ms)	Max (ms)
Read	8.5	10.0
Write	5.5	6.0

The terms "Typical" and "Max" are used throughout this specification with the following meanings:

Typical.　The average of the drive population tested at nominal environmental and voltage conditions.

Max.　The maximum value measured on any one drive over the full range of the environmental and voltage conditions. (See Section 6.2, "Environment" and Section 6.3, "DC power requirements")

Read: Full span.
Write: Conventional zone, not applicable within sequential write required zone as random access is not allowed

4.5.2.2　Single track seek time (without command overhead, including settling)

Table 8　Single Track Seek Time

Function	Typical (ms)	Max (ms)
Read	0.25	0.35
Write	0.35	0.45

4.5.2.3　Average latency

Table 9　Latency Time

Rotational speed	Time for a revolution (ms)	Average latency (ms)
7200 RPM	8.3	4.16

4.5.3　Drive ready time

Table 10　Drive ready time

Power on to ready	Typical (sec)	Maximum (sec)
	20	30

Ready　The condition in which the drive is able to perform a media access command (such as read, write) immediately

Power on　This includes the time required for the internal self diagnostics.

4.5.4　Operating modes

4.5.4.1　Operating mode descriptions

Operating mode	Description
Spin-up	Start up time period from spindle stop or power down
Seek	Seek operation mode
Write	Write operation mode
Read	Read operation mode
Idle_0	Drive ready, but not performing I/O
Idle_A	Spindle motor is working normally. Servo system is sleeping or waking up. Commands can be received and processed immediately
Idle_B	Spindle rotation at 7200 RPM with heads unloaded
Idle_C/Standby_Y	Spindle rotation at Low RPM with heads unloaded
Standby_Z	Actuator is unloaded and spindle motor is stopped.　Commands can be received immediately
Sleep	Actuator is unloaded and spindle motor is stopped.　Only soft reset or hard reset can change the mode to standby_z

Note: Upon power down or spindle stop a head locking mechanism will secure the heads in the OD parking position.

4.5.4.2　Mode transition times

Mode transition times are shown below.

Table 11　Mode transition times

From	To	RPM	Typical Transition time (sec)	Max Transition time (sec)
Standby Z	Idle A	0 -> 7200	15	30
Idle A	Standby Z	7200 -> 0	Immediately	Immediately
Idle B	Idle A	7200	1.5	30
Idle A	Idle B	7200	0.7	30
Idle C	Idle A	6300 -> 7200	4	30

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5 Defect flagging strategy

Media defects are remapped to the next available sector during the Format Process in manufacturing. The mapping from LBA to the physical locations is calculated by an internally maintained table.

5.1 Shipped format

- Data areas are optimally used.
- No extra sector is wasted as a spare throughout user data areas.
- All pushes generated by defects are absorbed by the spare tracks of the inner zone.
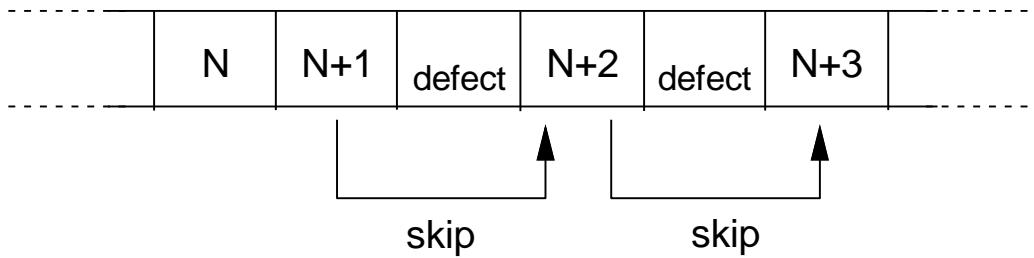
Figure 2   PList physical format

Defects are skipped without any constraint, such as track or cylinder boundary.   The calculation from LBA to physical is done automatically by internal table.

6   Specification

6.1   Electrical interface

6.1.1   Connector location

Refer to the following illustration to see the location of the connectors.
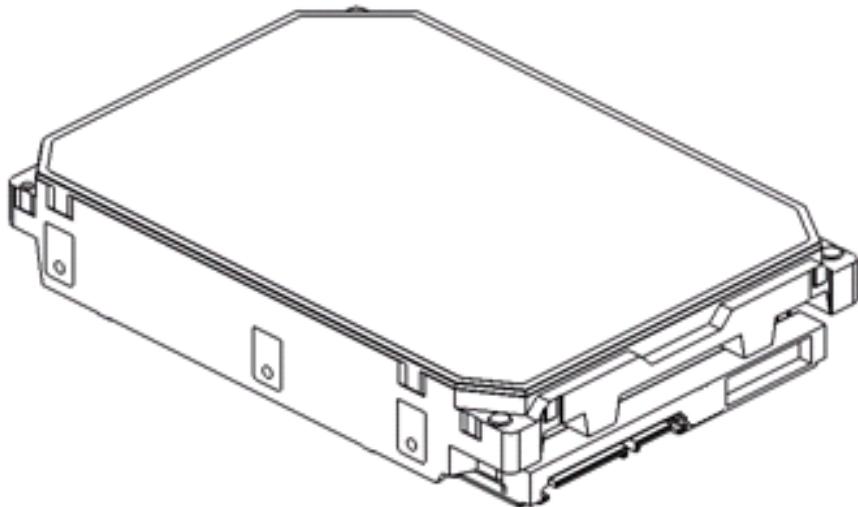
Figure 3   Connector location

6.1.1.1   Signal connector

The SATA signal connector is a 7-pin connector. Power connector is a 15-pin connector.

6.1.2　Signal definition

SATA has receivers and drivers to be connected to Tx+/- and Rx +/- Serial data signal.
Defines the signal names of I/O connector pin and signal name.

Table 12　Interface connector pins and I/O signals

	No.		Plug Connector pin definition	Signal	I/O
Signal	S1	GND	2nd mate	Gnd	
	S2	A+	Differential signal A from Phy	RX+	Input
	S3	A-		RX-	Input
	S4	Gnd	2nd mate	Gnd	
	S5	B-	Differential signal B from Phy	TX-	Output
	S6	B+		TX+	Output
	S7	Gnd	2nd mate	Gnd	
Key and spacing separate signal and power segments					
Power	P1	V33	3.3V power	3.3V	
	P2	V33	3.3V power	3.3V	
	P3	V33	3.3V power, pre-charge, 2nd Mate	3.3V	
	P4	Gnd	1st mate	Gnd	
	P5	Gnd	2nd mate	Gnd	
	P6	Gnd	2nd mate	Gnd	
	P7	V5	5V power,pre-charge,2nd Mate	5V	
	P8	V5	5V power	5V	
	P9	V5	5V power	5V	
	P10	Gnd	2nd mate	Gnd	
	P11	Reserved	Support staggered spin-up and LED activity	Reserve	
	P12	Gnd	1st mate	Gnd	
	P13	V12	12V power,pre-chage,2nd mate	V12	
	P14	V12	12V power	V12	
	P15	V12	12V power	V12	

6.1.2.1　TX+ / TX-

These signals are the outbound high-speed differential signals that are connected to the serial ATA cable

6.1.2.2　RX+ / RX-

These signals are the inbound high-speed differential signals that are connected to the serial ATA cable.

6.1.2.3　5V PRECHARGE

+5 Vdc power that is available on the extended pins. This is used for pre-charging the I/O module.
The enclosure shall provide for a current limit of 4.5 A peak on each 5V pre-charge pin (R=1.1 Ohms).These signals are the inbound high-speed differential signals that are connected to the serial ATA cable.

6.1.2.4　12V PRECHARGE

+12 Vdc power that is available on the extended pins. This is used for pre-charging the 12V circuitry in the I/O Option slot module.
The enclosure shall be capable of supplying 2.4 A peak on each 12 V pre-charge pin (R=5 Ohms). These signals are the inbound high-speed differential signals that are connected to the serial ATA cable.

6.1.3 Out of band signaling
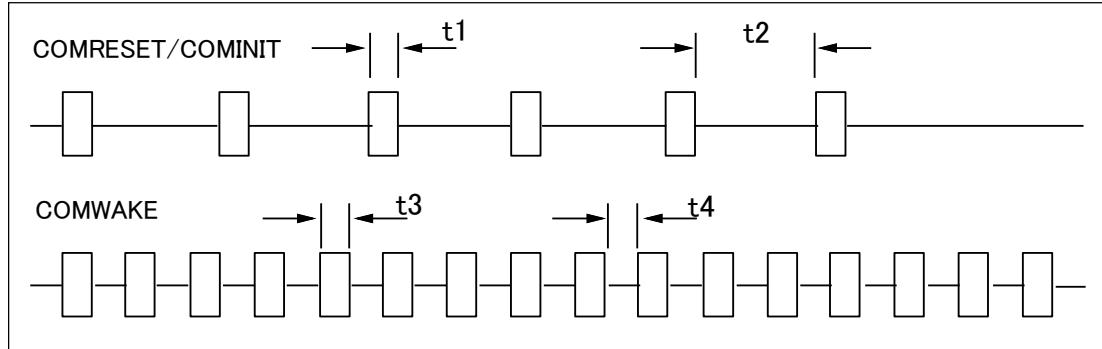
Figure 4   The timing of COMRESET, COMINIT and COMWAKE

Table 13   Parameter descriptions

	PARAMETER DESCRIPTION	Nominal (ns)
t1	ALIGN primitives	106.7
t2	Spacing	320
t3	ALIGN primitives	106.7
t4	Spacing	106.7

6.2 Environment

6.2.1 Temperature and humidity

Table 14   Temperature and humidity

Operating conditions	
Temperature	10 to 60°C
Relative humidity	5 to 90% non-condensing
Maximum wet bulb temperature	29.4°C non-condensing
Maximum temperature gradient	20°C/Hour
Altitude	–300 to 3,048 m
Non-Op conditions	
Temperature	-40 to 70°C (Storage 0 to 70°C)
Relative humidity	5 to 95% non-condensing
Maximum wet bulb temperature	35°C non-condensing
Maximum temperature gradient	30°C/Hour
Altitude	–300 to 12,000 m (Inside dashed-dotted line of Figure 5)

Notes:
- *The system is responsible for providing sufficient ventilation to maintain a surface temperature below 65°C at the center of the top cover of the drive.*
- *Non condensing conditions should be maintained at any time.*
- *Maximum storage period within shipping package is one year.*
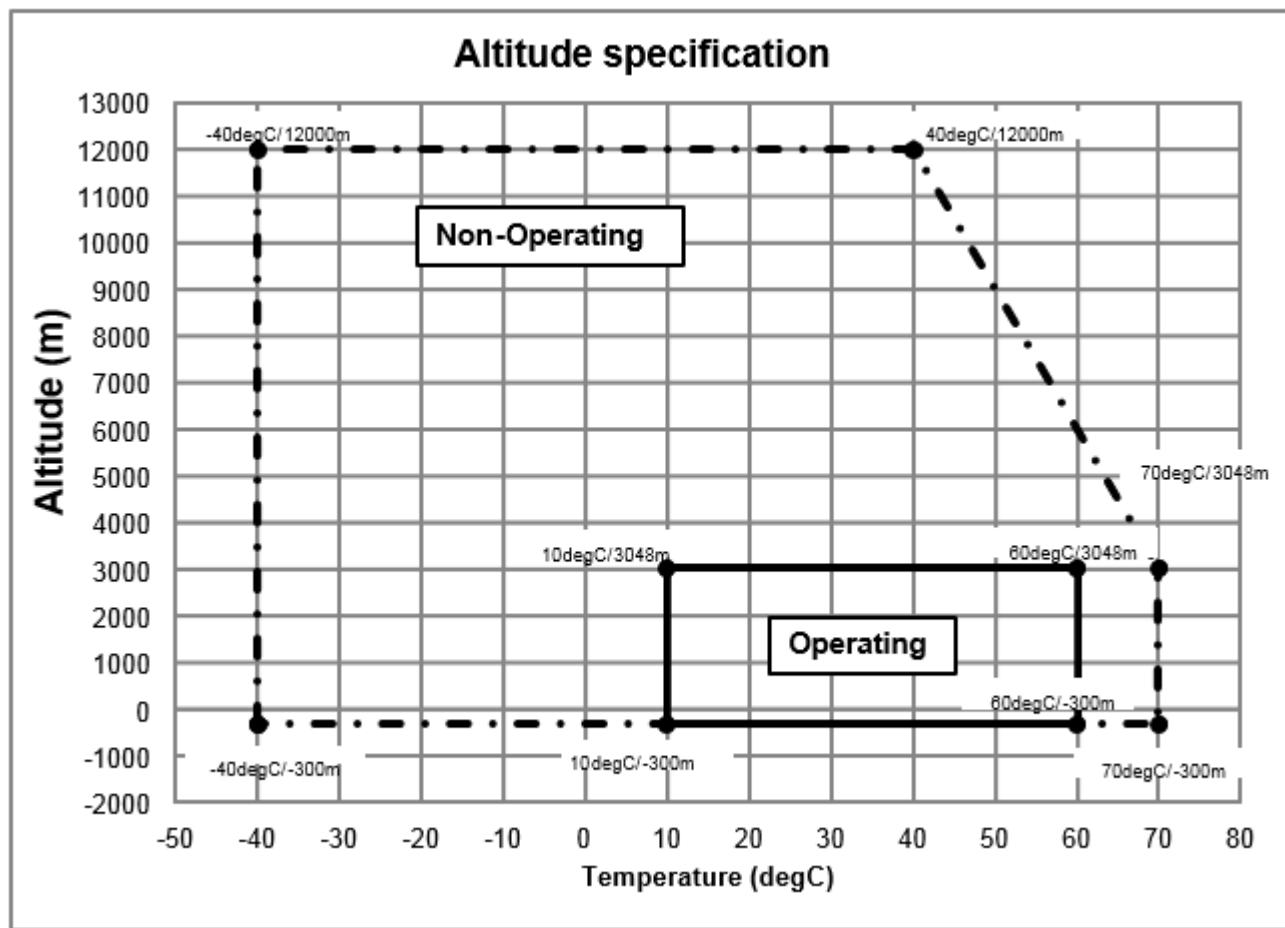
Figure 5   Limits of temperature and altitude
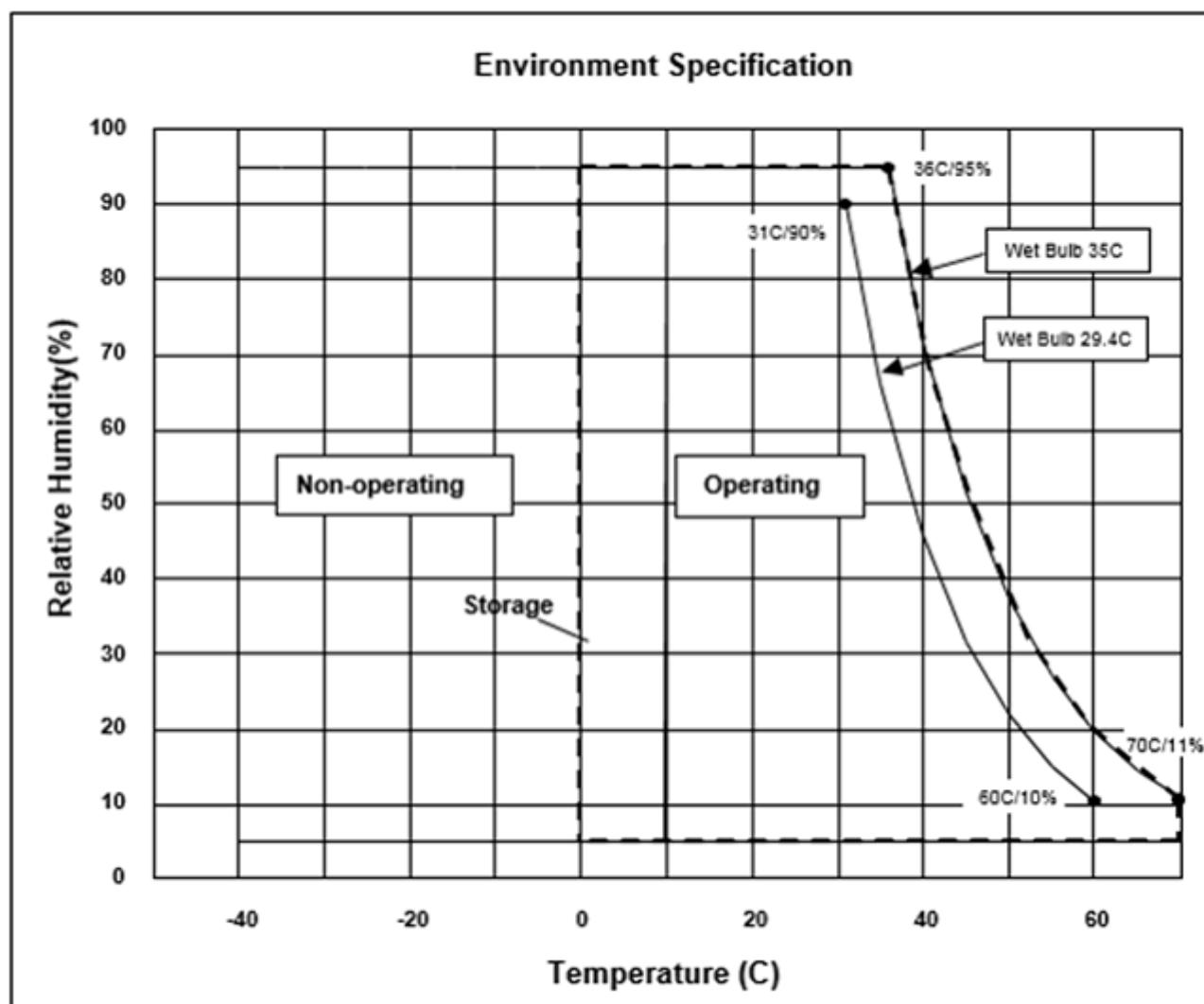
Figure 6   Limits of temperature and humidity

6.2.2   Corrosion test

The drive shows no sign of corrosion inside and outside of the hard disk assembly and is functional after being subjected to seven days at 50°C with 90% relative humidity.

6.2.3   Atmospheric condition

Environments that contain elevated levels of corrosives (e.g. hydrogen sulfide, sulfur oxides, or hydrochloric acid) should be avoided. Care must be taken to avoid using any compound/material in a way that creates an elevated level of corrosive materials in the atmosphere surrounding the disk drive. Care must also be taken to avoid use of any organometallic (e.g. organosilicon or organotin) compound/material in a way that creates elevated vapor levels of these compounds/materials in the atmosphere surrounding the disk drive.

6.3   DC power requirements

Damage to the drive electronics may result if the power supply cable is connected or disconnected to the legacy Power connector while power is being applied to the drive (no hot plug/unplug is allowed). If SATA power supply cable is connected or disconnected to the SATA power connector, hot plug/unplug is allowed.

6.3.1   Input voltage

Table 15   Input voltage

Input voltage	During run and spin up	Absolute max spike voltage	Supply rise time
+5 Volts Supply	5V ± 5%	–0.3 to 5.5V	0 to 200ms
+12 Volts Supply	12V ± 5%	–0.3 to 15.0V	0 to 400ms

Caution: To avoid damage to the drive electronics, power supply voltage spikes must not exceed specifications.

6.3.2 Power supply current (typical[1])

Table 16 Power supply current

Serial ATA @6Gb/sec 10TB Model

	IO/Sec	Current +5V Amp	Current +12V Amp	Power Watts	
Start up Peak DC [1]			1.46		
Start up Peak AC		0.86	2.00		
Idle_0 Ave.		0.28	0.32	5.2	
Idle Ripple [2]		0.25	0.31		
Random RW 8KB Qd=1 Peak		0.91	1.87		
Random RW 8KB Qd=1 Ave.	40	0.43	0.45	7.6	[4]
Random RW 4KB Qd=1 Peak		0.95	1.87		
Random RW 4KB Qd=1 Ave.	46	0.42	0.47	7.8	[4]
Sequential Read Peak		0.79			Conventional zone
Sequential Read Ave. [3]		0.62	0.34	7.2	Conventional zone
Sequential Write Peak		0.61			Conventional zone
Sequential Write Ave. [3]		0.46	0.37	6.7	Conventional zone
Sequential Read Peak		0.81			SMR zone
Sequential Read Ave. [3]		0.60	0.33	7.0	SMR zone
Sequential Write Peak		0.77			SMR zone
Sequential Write Ave. [3]		0.50	0.35	6.6	SMR zone
BMS Peak		0.77			
BMS Ave.		0.59	0.33	7.0	

Power Save Mode (PHY state: Active)	Current +5V Amp	Current +12V Amp	Power Watts	Watts Saved [5]	Recovery [1] 12V DC peak	Recovery [1] 12V AC peak
Idle_A	0.27	0.32	5.1	0.1		
Idle_B	0.20	0.22	3.7	1.5		
Idle_C	0.20	0.18	3.2	2.0	0.99	1.88
Standby_Y	0.20	0.18	3.2	2.0	0.99	1.88
Standby_Z	0.20	0.003	1.0	4.2	1.47	1.89
Sleep	0.20	0.003	1.0	4.2	1.47	1.89

PHY power condition	Port A Watts Saved
Partial	0.37
Slumber	0.37

Notes

Reference data, sample number = 10HDDs, DE temp. = 40degC (25degC for Start up), WCE=1

[1] 200mS windowed average
[2] Pk to Pk BWL @20MHz
[3] Max transfer rate
[4] Random zone Read and Write in partially selected zone
[5] Saved watts compared to Idle_0

6.3.3 Power supply generated ripple at drive power connector

Table 17   Power supply generated ripple at drive power connector

	Maximum (mV pp)	**MHz**
+5V DC	200	0-10
+12V DC	250	0-10

During drive start up and seeking 12-volt ripple is generated by the drive (referred to as dynamic loading). If the power of several drives is daisy chained together, the power supply ripple plus the dynamic loading of the other drives must remain within the above regulation tolerance. 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 performance of the drive, the drive must be held by four screws in a user system frame which has no electrical level difference at the four screws position and has less than ±300 millivolts peak to peak level difference to the ground of the drive power connector.

6.3.4 Power Consumption Efficiency

Table 18   Power consumption efficiency

Power Consumption Efficiency at Idle	W/TB	0.51
	W/GB	0.00051

6.4 Reliability

6.4.1 Data integrity

No more than one sector is lost at Power loss condition during the write operation when the write cache option is disabled. If the write cache option is active, the data in write cache will be lost. To prevent the loss of customer data, it is recommended that the last write access before power off be issued after setting the write cache off.

6.4.2 Cable noise interference

To avoid any degradation of performance throughput or error rate when the interface cable is routed on top or comes in contact with the HDA assembly, the drive must be grounded electrically to the system frame by four screws. The common mode noise or voltage level difference between the system frame and power cable ground or AT interface cable ground should be in the allowable level specified in the power requirement section.

6.4.3 Load/Unload

The product supports a minimum of 600,000 normal load/unloads in a 40° C environment.
Load/unload is invoked by transition of the HDD's power mode. (Chapter 4.5.4 Operating modes)
    Idle (Idle_A) <-> unload idle (Idle_B)
    Idle (Idle_A) <-> Low rpm idle (Idle_C)

6.4.4 Start/stop cycles

The drive withstands a minimum of 50,000 start/stop cycles in a 40° C environment and a minimum of 10,000 start/stop cycles in extreme temperature or humidity within the operating range.

6.4.5 Preventive maintenance

None

6.4.6 Data reliability

Probability of not recovering data is 1 in 10^{15} bits read.

LDPC on the fly/ offline data correction

- 600 bit LDPC
- This implementation recovers maximum 330 bits single burst error by on the fly correction and maximum 450 bits single burst error by offline correction

6.4.7 Required Power-Off Sequence

The required BIOS sequence for removing power from the drive is as follows:

Step 1: Issue one of the following commands.
        Standby
        Standby immediate
        Sleep

Note: Do not use the Flush Cache command for the power off sequence because this command does not invoke Unload

Step 2: Wait until the Command Complete status is returned.   In a typical case 350 ms are required for the command to finish completion; however, the BIOS time out value needs to be 30 seconds considering error recovery time.

Step 3: Terminate power to HDD.

6.5   Mechanical specifications

6.5.1   Physical dimensions
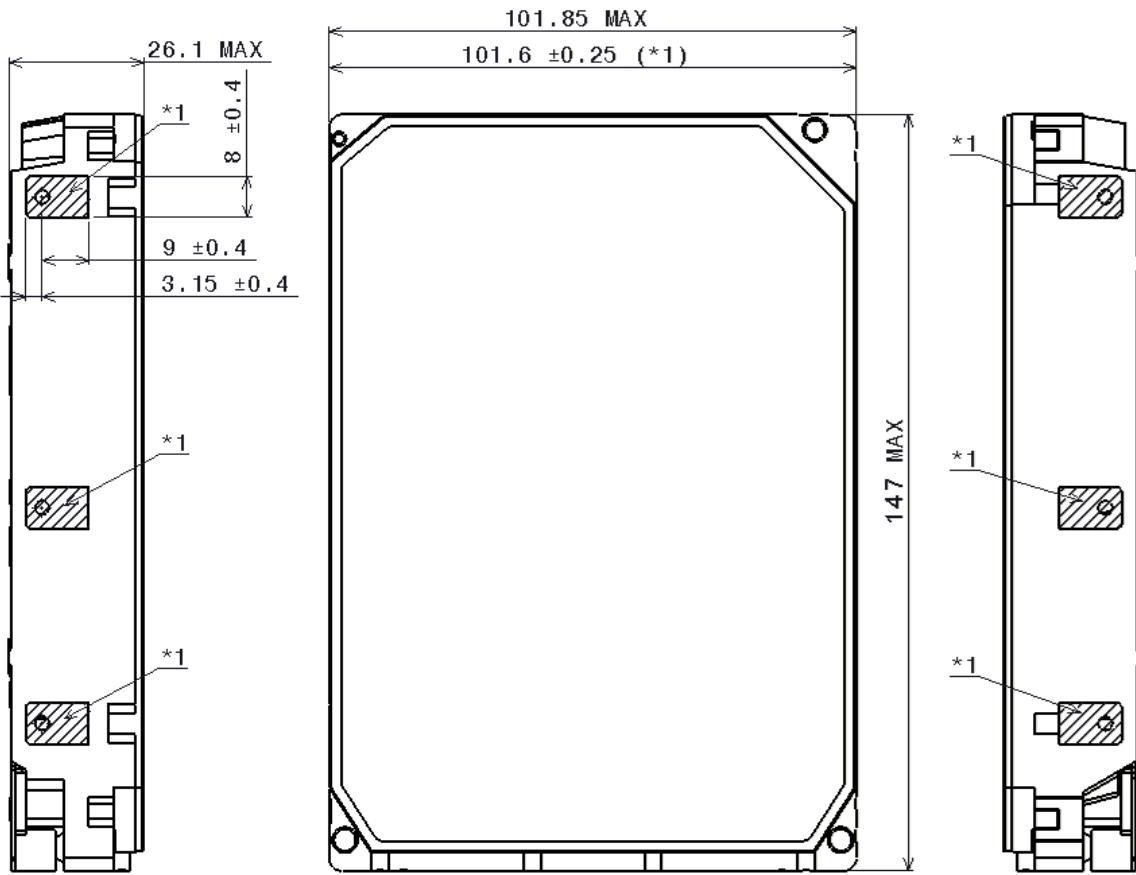
Figure 7   Top and side views and mechanical dimensions

All dimensions are in millimeters.
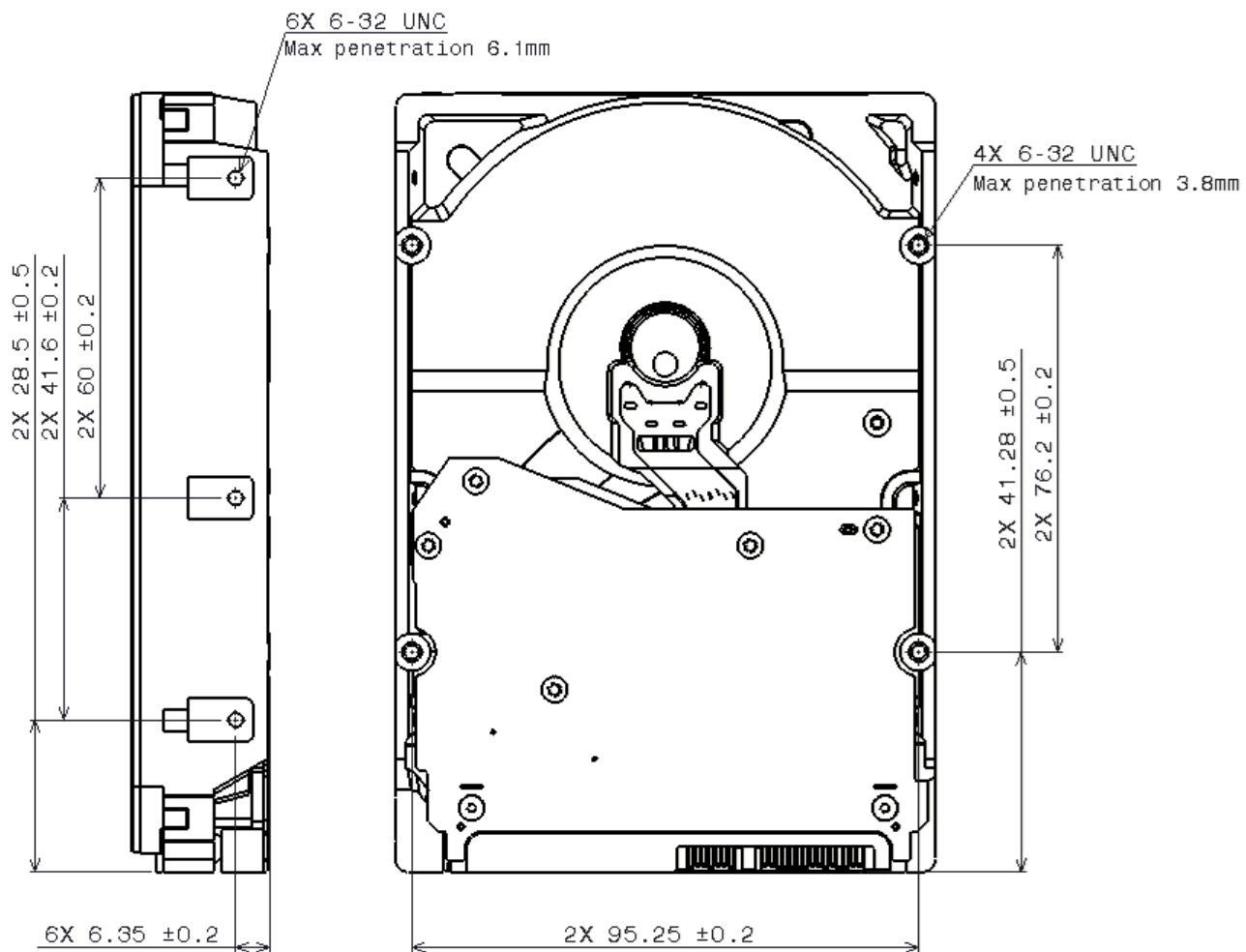
Figure 8   Bottom and side views with mounting hole locations

All dimensions in the above figure are in millimeters.

The following table shows the physical dimensions of the drive.

Table 19   Physical Dimensions

Height (mm)	Width (mm)	Length (mm)	Weight (grams)
26.1 MAX	101.6 ± 0.25	147 MAX	650 MAX

6.5.2   Connector locations
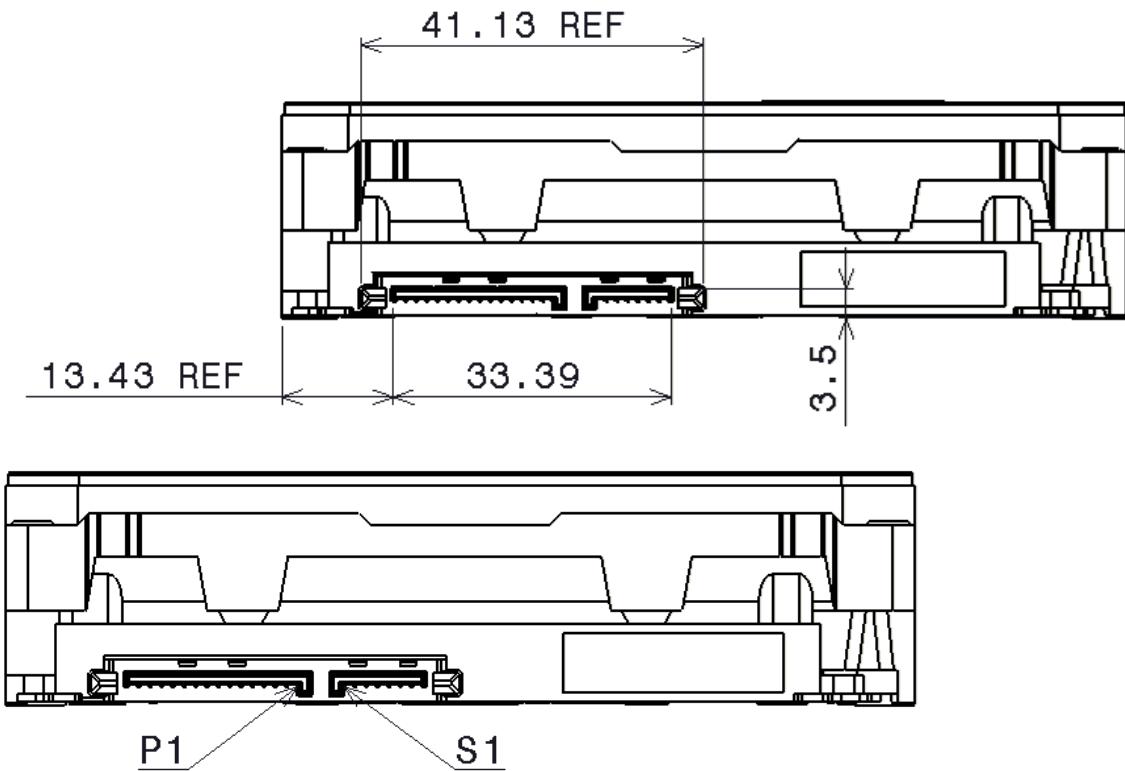
Figure 9   Connector locations

6.5.3   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.

For reliable operation, the drive must be mounted in the system securely enough to prevent excessive motion or vibration of the drive during seek operation or spindle rotation, using appropriate screws or equivalent mounting hardware.

The recommended mounting screw torque is 0.6 - 1.0 Nm (6-10 Kgf.cm).

The recommended mounting screw depth is 3.8mm maximum for bottom and 6.1 mm maximum for horizontal mounting.

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

6.5.4   Heads unload and actuator lock

Heads are moved out from disks (unload) to protect the disk data during shipping, moving, or storage.   Upon power down, the heads are automatically unloaded from disk area and the locking mechanism of the head actuator will secure the heads in unload position.

6.6 Vibration and shock

All vibration and shock measurements recorded in this section are made with a drive that has no mounting attachments for the systems. The input power for the measurements is applied to the normal drive mounting points.

6.6.1 Operating vibration

6.6.1.1 Random vibration (Linear)

The test is 30 minutes of random vibration using the power spectral density (PSD) levels shown below in each of three mutually perpendicular axes. The disk drive will operate without non-recoverable errors when subjected to the below random vibration levels.

Table 20 Random vibration PSD profile break points (operating)

Frequency	5 Hz	17 Hz	45 Hz	48 Hz	62 Hz	65 Hz	150 Hz	200 Hz	500 Hz	RMS (m/sec^2)
[(m/sec^2)^2/Hz]	1.9 x 10E–3	1.1 x 10E–1	1.1 x 10E–1	7.7 x 10E–1	7.7 x 10E–1	9.6 x 10E–2	9.6 x 10E–2	4.8 x 10E–2	4.8 x10E-2	6.57

The overall RMS (root mean square) level is 6.57 m/sec^2 (0.67 G).

6.6.1.2 Swept sine vibration (Linear)

The drive will meet the criteria shown below while operating in the specified conditions:

• No errors occur with 4.9 m/sec^2 (0.5 G) 0 to peak, 5 to 300 to 5 Hz sine wave, 0.5 oct/min sweep rate with 3-minute dwells at two major resonances

• No data loss occurs with 9.8 m/sec^2 (1 G) 0 to peak, 5 to 300 to 5 Hz sine wave, 0.5 oct/min sweep rate with 3-minute dwells at two major resonances

6.6.1.3 Random vibration (Rotational)

The drive will meet the criteria shown below while operating in the specified conditions:

• Less than 20% Performance degradation

• The overall RMS (Root Mean Square) level of vibration is 12.5Rad/sec^2. PSD profile is shown below.

Table 21 Random vibration (Rotational) PSD profile break points

Frequency	20 Hz	100 Hz	200 Hz	800 Hz	1000 Hz	1500 Hz	1700 Hz	2000 Hz	RMS (Rad/s^2)
[(Rad/s^2)^2/Hz]	1.90E-02	1.90E-02	1.87E-01	1.87E-01	5.33E-02	7.70E-03	4.00E-03	4.00E-03	12.5

6.6.2 Nonoperating vibration

The drive does not sustain permanent damage or loss of previously recorded data after being subjected to the environment described below

6.6.2.1 Random vibration

The test consists of a random vibration applied for each of three mutually perpendicular axes with the time duration of 10 minutes per axis. The PSD levels for the test simulate the shipping and relocation environment shown below. The overall RMS (Root Mean Square) level of vibration is 10.2 m/sec^2 (1.04 G).

Table 22 Random vibration PSD profile break points (nonoperating)

Frequency	2 Hz	4 Hz	8 Hz	40 Hz	55 Hz	70 Hz	200 Hz
[(m/sec^2)^2/Hz]	0.096	2.89	2.89	0.289	0.962	0.962	0.096

6.6.2.2 Swept sine vibration

- 19.6 m/sec^2 (2 G) (Zero to peak), 5 to 500 to 5 Hz sine wave
- 0.5 oct/min sweep rate
- 3 minutes dwell at two major resonances

6.6.3 Operating shock

The drive meets the following criteria while operating in the conditions described below. The shock test consists of 10 shock inputs in each axis and direction for total of 60. There must be a delay between shock pulses long enough to allow the drive to complete all necessary error recovery procedures.

- No error occurs with a 98.1 m/sec^2 (10 G) half-sine shock pulse of 11 ms duration.
- No data loss occurs with a 294 m/sec^2 (30 G) half-sine shock pulse of 4 ms duration.
- No data loss occurs with a 686 m/sec^2 (70 G) half-sine shock pulse of 2 ms duration.

6.6.4 Nonoperating shock

The drive will operate without non-recoverable errors after being subjected to shock pulses with the following characteristics.

6.6.4.1 Trapezoidal shock wave

- Approximate square (trapezoidal) pulse shape
- Approximate rise and fall time of pulse is1 ms
- Average acceleration level is 490 m/sec^2 (50 G). (Average response curve value during the time following the 1 ms rise time and before the 1 ms fall with a time "duration of 11 ms")
- Minimum velocity change is 4.23 m/sec

6.6.4.2　Sinusoidal shock wave

The shape is approximately half-sine pulse.　The figure below shows the maximum acceleration level and duration.

Table 23　Sinusoidal shock wave

Acceleration level (m/sec^2)	Duration (ms)
2940(300G)	1
1470(150G)	11

6.6.5　Nonoperating Rotational shock

All shock inputs shall be applied around the actuator pivot axis.

Table 24　Rotational Shock

Duration	Rad/sec^2
1 ms	30,000
2 ms	20,000

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6.7 Acoustics

The upper limit criteria of the octave sound power levels are given in Bels relative to one picowatt and are shown in the following table. The sound power emission levels are measured in accordance with ISO 7779.

Table 25   Sound power levels

Mode	7200rpm (Typical / Max)
Idle	2.0 / 2.5
Operating	3.6 / 4.0

Mode definition:

Idle mode. The drive is powered on, disks spinning, track following, unit ready to receive and respond to interface commands.

Operating mode. Continuous random cylinder selection and seek operation of the actuator with a dwell time at each cylinder.   The seek rate for the drive is to be calculated as shown below:

- Dwell time = 0.5 x 60/RPM
- Seek rate = 0.4 / (Average seek time + Dwell time)

6.8 Identification labels

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

- A label containing the HGST logo, the HGST part number, and the statement "Made by HGST, Ltd." or HGST approved equivalent
- A label containing the drive model number, the manufacturing date code, the formatted capacity, the place of manufacture, UL/CSA/TUV/CE/RCM mark logos and WEEE/China RoHS logos
- A bar code label containing the drive serial number
- A label containing the jumper pin description
- A user designed label per agreement

The above labels may be integrated with other labels.

6.9   Safety

6.9.1   UL and CSA standard conformity

The product is qualified per UL60950-1：Second Edition and CAN/CSA-C22.2 No.60950-1-07 Second Edition, for use in Information Technology Equipment including Electric Business Equipment.

The UL recognition or the CSA certification is maintained for the product life.

The UL and C-UL recognition mark or the CSA monogram for CSA certification appear on the drive.

6.9.2   German Safety Mark

The product is approved by TUV on Test requirement: EN60950-1：2006+A11 but the GS mark is not applicable to internal devices such as this product.

6.9.3   Flammability

The printed circuit boards used in this product are made of material with the UL recognized flammability rating of V-1 or better. The flammability rating is marked or etched on the board. All other parts not considered electrical components are made of material with the UL recognized flammability rating of V-2 minimum basically.

6.9.4   Safe handling

The product is conditioned for safe handling in regards to sharp edges and corners.

6.9.5   Substance restriction requirements

The product complies with the Directive 2002/95/EC of the European Parliament on the restrictions of the use of the certain hazardous substances in electrical and electronic equipment (RoHS) and with Halogen free requirements based on the electronics industry standard, IEC 61249-2-21 (http://www.iec.ch/).

6.9.6   Secondary circuit protection

Spindle/VCM driver module includes 12 V over current protection circuit.

6.10　Electromagnetic compatibility

When installed in a suitable enclosure and exercised with a random accessing routine at maximum data rate, the drive meets the following worldwide EMC requirements:

- United States Federal Communications Commission (FCC) Rules and Regulations (Class B), Part 15. (A 6 dB buffer shall be maintained on the emission requirements).
- European Economic Community (EEC) directive number 76/889 related to the control of radio frequency interference and the Verband Deutscher Elektrotechniker (VDE) requirements of Germany (GOP).Spectrum Management Agency (SMA) EMC requirements of Australia. The SMA has approved RCM Marking for HGST.

6.10.1　CE Mark

The product is declared to be in conformity with requirements of the following EC directives under the sole responsibility of HGST, Ltd:

Council Directive 2004/108/EC on the approximation of laws of the Member States relating to electromagnetic compatibility.

6.10.2　RCM Mark

The product complies with the following Australian EMC standard:

"Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement, EN 55022 : 2010（AS/NZS CISPR 22 : 2009 /　A1 : 2010 Comparable）"

6.10.3　BSMI Mark

The product complies with the Taiwan EMC standard "Limits and methods of measurement of radio disturbance characteristics of information technology equipment, CNS 13438 Class B."

6.10.4　KC Mark

The product complies with the Korea EMC standard.　The regulation for certification of information and communication equipment is based on "Telecommunications Basic Act" and "Radio Waves Act" Korea EMC requirement are based technically on CISPR22 measurement standards and limits.　KC standards are likewise based on IEC standards.

Part 2. Interface Specification

7　General

7.1　Introduction

This specification describes the host interface of HMH7210A0ALE60n(512e), HMH7210A0ALN60n(4Kn)

This product is Host managed device that supports di537r4b-Zoned-device_ATA_Command_Set_ZAC.

The interface conforms to the following working documents of Information technology with certain limitations described in the chapter 7.3 "Deviations from Standard" on page 46

- Serial ATA International Organization: Serial ATA Revision 3.2

7.2　Terminology

Device　　　　　　　　Device indicates HMH7210A0ALE60n(512e), HMH7210A0ALN60n(4Kn)

Host　　　　　　　　　Host indicates the system that the device is attached to.

7.3　Deviations From Standard

The device conforms to the referenced specifications, with deviations described below.

Check Power Mode　　　　If the Extended Power Conditions feature set is disabled and the device is in Idle mode, Check Power Mode command returns FFh by Sector Count Register, instead of returning 80h. Refer to 12.1 "Check Power Mode" for detail.

COMRESET　　　　　　COMRESET response is not the same as that of Power On Reset.　Refer to section 10.1, "Reset Response" for detail.

Download　　　　　　　Both Download Microcode and Download Microcode DMA are aborted when the device is in security locked mode.

COMRESET response time　During 500ms from Power On Reset, COMINIT is not returned within 10ms as a response to COMRESET.

Streaming Commands　　When the device is in standby mode, Streaming Commands can't be completed while waiting for the spindle to reach operating speed even if execution time exceeds specified CCTL (Command Completion Time Limit). The minimum CCTL is 50ms.CCTL is set to 50ms when the specified value is shorter than 50ms.

SCT Error Recovery Control　When the device is in standby mode, any command where error recovery time limit is specified can't be completed while waiting for the spindle to reach operating speed even if execution time exceeds specified recovery time limit. The minimum time limit is 6.5 second. When the specified time limit is shorter than 6.5 second, the issued command is aborted.

8 Registers

In Serial ATA, the host adapter contains a set of registers that shadow the contents of the traditional device registers, referred to as the Shadow Register Block.   Shadow Register Block registers are interface registers used for delivering commands to the device or posting status from the device.   About details, please refer to the Serial ATA Specification.

In the following cases, the host adapter sets the BSY bit in its shadow Status Register and transmits a FIS to the device containing the new contents.

• Command register is written in the Shadow Register Block

• Device Control register is written in the Shadow Register Block with a change of state of the SRST bit

• COMRESET is requested

8.1 Alternate Status Register

Table 26   Alternate Status Register

Alternate Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC /SERV	DRQ	COR	IDX	ERR

This register contains the same information as the Status Register. The only difference is that reading this register does not imply interrupt acknowledge or clear a pending interrupt. See 8.11 "Status Register" on the page 51 for the definition of the bits in this register.

8.2 Command register

This register contains the command code being sent to the device. Command execution begins immediately after this register is written. The command set is shown in Table 79 Command Set on page 130.

All other registers required for the command must be set up before writing the Command Register.

8.3 Cylinder High Register

This register contains the high order bits of the starting cylinder address for any disk access. At the end of the command, this register is updated to reflect the current cylinder number.

In LBA Mode this register contains Bits 16-23. At the end of the command, this register is updated to reflect the current LBA Bits 16-23.

The cylinder number may be from zero to the number of cylinders minus one.

When 48-bit addressing commands are used, the "most recently written" content contains LBA Bits 16-23, and the "previous content" contains Bits 40-47. The 48-bit Address feature set is described in 10.12.

8.4   Cylinder Low Register

This register contains the low order bits of the starting cylinder address for any disk access. At the end of the command, this register is updated to reflect the current cylinder number.

In LBA Mode this register contains Bits 8-15. At the end of the command, this register is updated to reflect the current LBA Bits 8-15.

The cylinder number may be from zero to the number of cylinders minus one.

When 48-bit addressing commands are used, the "most recently written" content contains LBA Bits 8-15, and the "previous content" contains Bits 32-39.

8.5   Device Control Register

Table 27   Device Control Register

Device Control Register							
7	6	5	4	3	2	1	0
HOB	-	-	-	1	SRST	-IEN	0

Bit Definitions

HOB   HOB (high order byte) is defined by the 48-bit Address feature set. A write to any Command Register shall clear the HOB bit to zero.

SRST (RST)   Software Reset. The device is held reset when RST=1. Setting RST=0 re-enables the device.

                     The host must set RST=1 and wait for at least 5 microseconds before setting RST=0, to ensure that the device recognizes the reset.

-IEN   Interrupt Enable. When –IEN=0, and the device is selected, device interrupts to the host will be enabled. When –IEN=1, or the device is not selected, device interrupts to the host will be disabled.

8.6   Device/Head Register

Table 28   Device/Head Register

Device/Head Register							
7	6	5	4	3	2	1	0
1	L	1	DRV	HS3	HS2	HS1	HS0

This register contains the device and head numbers.

Bit Definitions

L
Binary encoded address mode select. When L=0, addressing is by CHS mode. When L=1, addressing is by LBA mode.

DRV
Device. This product ignores this bit.

HS3,HS2,HS1,HS0
Head Select. These four bits indicate binary encoded address of the head. HS0 is the least significant bit. At command completion, these bits are updated to reflect the currently selected head.

The head number may be from zero to the number of heads minus one.

In LBA mode, HS3 through HS0 contain bits 24-27 of the LBA. At command completion, these bits are updated to reflect the current LBA bits 24-27.

8.7   Error Register

Table 29   Error Register

Error Register							
7	6	5	4	3	2	1	0
ICRCE	UNC	0	IDNF	0	ABRT	TK0NF	AMNF

This register contains status from the last command executed by the device, or a diagnostic code.

At the completion of any command except Execute Device Diagnostic, the contents of this register are valid always even if ERR=0 in the Status Register.

Following a power on, a reset, or completion of an Execute Device Diagnostic command, this register contains a diagnostic code.

Bit Definitions

ICRCE (CRC)
Interface CRC Error. ICRCE=1 indicates a CRC error occurred during FIS transmission or FIS reception.

UNC
Uncorrectable Data Error. UNC=1 indicates an uncorrectable data error has been encountered.

IDNF (IDN)
ID Not Found. IDN=1 indicates the requested sector's ID field could not be found.

ABRT (ABT)
Aborted Command. ABT=1 indicates the requested command has been aborted due to a device status error or an invalid parameter in an output register.

TK0NF (T0N)
Track 0 Not Found. T0N=1 indicates track 0 was not found during a Recalibrate command.

AMNF (AMN)
Address Mark Not Found. This product does not report this error. This bit is always zero.

8.8   Features Register

This register is command specific. This is used with the Set Features command, SMART Function Set command and Format Unit command.

8.9   Sector Count Register

This register contains the number of sectors of data requested to be transferred on a read or write operation between the host and the device. If the value in the register is set to 0, a count of 256 sectors (in 28-bit addressing) or 65,536 sectors (in 48-bit addressing) is specified.

If the register is zero at command completion, the command was successful. If not successfully completed, the register contains the number of sectors which need to be transferred in order to complete the request.

The contents of the register are defined otherwise on some commands. These definitions are given in the command descriptions.

8.10   Sector Number Register

This register contains the starting sector number for any disk data access for the subsequent command.
The sector number is from one to the maximum number of sectors per track.

In LBA mode, this register contains Bits 0-7. At the end of the command, this register is updated to reflect the current LBA Bits 0-7.

When 48-bit commands are used, the "most recently written" content contains LBA Bits 0-7, and the "previous content" contains Bits 24-31.

8.11 Status Register

Table 30 Status Register

Status Register							
7	6	5	4	3	2	1	0
BSY	DRDY	DF	DSC /SERV	DRQ	CORR	IDX	ERR

This register contains the device status. The contents of this register are updated whenever an error occurs and at the completion of each command.

If the host reads this register when an interrupt is pending, it is considered to be the interrupt acknowledge. Any pending interrupt is cleared whenever this register is read.

If BSY=1, no other bits in the register are valid.

Bit Definitions

BSY
Busy. BSY=1 whenever the device is accessing the registers. The host should not read or write any registers when BSY=1. If the host reads any register when BSY=1, the contents of the Status Register will be returned.

DRDY (RDY)
Device Ready. RDY=1 indicates that the device is capable of responding to a command. RDY will be set to 0 during power on until the device is ready to accept a command. If the device detects an error while processing a command, RDY is set to 0 until the Status Register is read by the host, at which time RDY is set back to 1.

DF
Device Fault.   This product does not support DF bit. DF bit is always zero.

DSC
Device Seek Complete. DSC=1 indicates that a seek has completed and the device head is settled over a track. DSC is set to 0 by the device just before a seek begins. When an error occurs, this bit is not changed until the Status Register is read by the host, at which time the bit again indicates the current seek complete status.

When the device enters into or is in Standby mode or Sleep mode, this bit is set by device in spite of not spinning up.

SERV (SRV)
Service. This product does not support SERV bit.

DRQ
Data Request. DRQ=1 indicates that the device is ready to transfer a word or byte of data between the host and the device. The host should not write the Command register when DRQ=1.

CORR (COR)
Corrected Data. Always 0.

IDX
Index. IDX=1 once per revolution. Since IDX=1 only for a very short time during each revolution, the host may not see it set to 1 even if the host is reading the Status Register continuously. Therefore, the host should not attempt to use IDX for timing purposes.

ERR
Error. ERR=1 indicates that an error occurred during execution of the previous command. The Error Register should be read to determine the error type. The device sets ERR=0 when the next command is received from the host.

9 Normal and Error Output field descriptions

9.1 Overview

9 Normal and Error Output field descriptions describes requirements for all commands. Individual commands may describe additional requirements.

The normal outputs (see ACS-4) and error outputs (see ACS-4) for each command include:

a)   a one byte STATUS field (see 9.2);

b)   a one byte ERROR field (see 9.3);

c)   a one byte INTERRUPT REASON field (see 9.4), if required, for certain commands (e.g., PACKET, READ DMA QUEUED, READ DMA QUEUED EXT, WRITE DMA QUEUED, and WRITE DMA QUEUED EXT);

d)   a COUNT field (see 9.5), SATA STATUS field (see 9.7), and SACTIVE field (see 9.6), if required, for certain commands (e.g., the READ FPDMA QUEUED command, Sanitize Device feature set commands, and WRITE FPDMA QUEUED command); and

e)   an LBA field that may contain the LBA of First Unrecoverable Error (see 9.8.2).

9.2 Status field

9.2.1 Overview

The STATUS field is one byte and is conveyed as an output from the device to the host (see applicable transport standard). Each bit, when valid, is defined in Table 31 STATUS field.

Table 31   STATUS field

Bit	Name	Reference
7	BUSY bit	9.2.3
6	DEVICE READY bit	9.2.8
5	DEVICE FAULT bit	9.2.7
	STREAM ERROR bit	9.2.11
4	DEFERRED WRITE ERROR bit	9.2.6
3	DATA REQUEST bit	9.2.5
2	ALIGNMENT ERROR bit	9.2.2
1	SENSE DATA AVAILABLE bit	9.2.10
0	CHECK CONDITION bit	9.2.4
	ERROR bit	9.2.9

9.2.2 ALIGNMENT ERROR bit

The ALIGNMENT ERROR bit is set to one if:

a) the LOGICAL TO PHYSICAL SECTOR RELATIONSHIP SUPPORTED bit is set to one;

b) the LPS MISALIGNMENT REPORTING SUPPORTED bit is set to one;

c) the ALIGNMENT ERROR REPORTING field contains 01b or 10b; and

d) the device returns completion for a write command without an error where:

   A) the first byte of data transfer does not begin at the first byte of a physical sector; or

   B) the last byte of data transfer does not end at the last byte of a physical sector.

Otherwise, the ALIGNMENT ERROR bit is cleared to zero.

If an alignment error and another error occur during the processing of a write command, then the other error is returned and the alignment error is not reported in the STATUS field (i.e, the ALIGNMENT ERROR bit is cleared to zero). If an alignment error occurs, even if it is not reported in the STATUS field and there is space remaining in the LPS Mis-alignment log, then an entry must be made in the log.

9.2.3 BUSY bit

The BUSY bit is transport dependent (see 9.2.12). Refer to the applicable transport standard for the usage of the BUSY bit.

9.2.4 CHECK CONDITION bit

An ATAPI device shall set the CHECK CONDITION bit to one if the:

a) value in the SENSE KEY field (see 9.3.8) is greater than zero;

b) ABORT bit (see 9.3.2) is set to one;

c) END OF MEDIA bit (see 9.3.4) is set to one; or

d) ILLEGAL LENGTH INDICATOR bit (see 9.3.6) is set to one.

Otherwise, an ATAPI device shall clear the CHECK CONDITION bit to zero.

9.2.5 DATA REQUEST bit

The DATA REQUEST bit is transport dependent (see 9.2.12). Refer to the appropriate transport standard for the usage of the DATA REQUEST bit.

9.2.6 DEFERRED WRITE ERROR bit

The DEFERRED WRITE ERROR bit shall be set to one if an error was detected in a deferred write to the media for a previous WRITE STREAM DMA EXT command (see 12.68) or WRITE STREAM EXT command (see 12.69).

Otherwise, the DEFERRED WRITE ERROR bit shall be cleared to zero.

If the DEFERRED WRITE ERROR bit is set to one, then the location of the deferred error is only reported in the Write Stream Error Log.

9.2.7　DEVICE FAULT bit

If the device is in a condition where continued operation may affect the integrity of user data on the device (e.g., failure to spin-up without error, or no spares remaining for reallocation), then the device does:

a) return command aborted with the DEVICE FAULT bit set to one in response to all commands (e.g., IDENTIFY DEVICE commands, IDENTIFY PACKET DEVICE commands) except REQUEST SENSE DATA EXT commands;

b) complete a REQUEST SENSE DATA EXT command without error with a sense key of HARDWARE ERROR with additional sense code of INTERNAL TARGET FAILURE (see SPC-4), if:

  A) the SENSE DATA SUPPORTED bit is set to one; and

  B) the REQUEST SENSE DEVICE FAULT SUPPORTED bit is set to one;

or

c) return command aborted with the DEVICE FAULT bit set to one in response to a REQUEST SENSE DATA EXT command, if:

  A) the SENSE DATA SUPPORTED bit is cleared to zero; or

  B) the SENSE DATA SUPPORTED bit is set to one and the REQUEST SENSE DEVICE FAULT SUPPORTED bit is cleared to zero.

Power cycling the device is the only mechanism that may clear the DEVICE FAULT bit to zero.

If the DEVICE FAULT bit has been cleared to zero, then it may remain clear until a command that affects user data integrity is received by the device.

9.2.8　DEVICE READY bit

The DEVICE READY bit is transport dependent (see 9.2.12). Refer to the applicable transport standard for the usage of the DEVICE READY bit.

9.2.9　ERROR bit

An ATA device shall set the ERROR bit to one if any bit in the ERROR field (see 9.3) is set to one. Otherwise, an ATA device shall clear the ERROR bit to zero.

9.2.10　SENSE DATA AVAILABLE bit

The SENSE DATA AVAILABLE bit shall be set to one if:

a) the SENSE DATA SUPPORTED bit is set to one;

b) the SENSE DATA ENABLED bit is set to one; and

c) the device has sense data to report after processing any command.

Otherwise, the SENSE DATA AVAILABLE bit shall be cleared to zero.

The ERROR bit and the SENSE DATA AVAILABLE bit may both be set to one.

Bit 1 of the STATUS field is obsolete if:

a) the SENSE DATA SUPPORTED bit is cleared to zero; or

b) the SENSE DATA ENABLED bit is cleared to zero.

9.2.11　STREAM ERROR bit

The STREAM ERROR bit is set to one if an error occurred during the processing of a command in the Streaming feature set and the:

a)　READ CONTINUOUS bit is set to one in a read stream command; or

b)　WRITE CONTINUOUS bit is set to one in a write stream command.

Otherwise, the STREAM ERROR bit is cleared to zero.

If the STREAM ERROR bit is set to one, the value returned in the LBA field (47:0) contains the address of the first logical sector in error, and the COUNT field contains the number of consecutive logical sectors that may contain errors.

If:

a)　the READ CONTINUOUS bit is set to one in a read stream command or the WRITE CONTINUOUS bit is set to one in a write stream command; and

b)　the INTERFACE CRC bit, the UNCORRECTABLE ERROR bit, the ID NOT FOUND bit, the ABORT bit, or the COMMAND COMPLETION TIME OUT bit is set to one in the ERROR field (see 9.3.3),

then:

a)　the STREAM ERROR bit is set to one;

b)　the ERROR bit is cleared to zero; and

c)　the error information (e.g., bits set in the ERROR field) shall be saved in the appropriate:

  A)　Read Stream Error Log ; or

  B)　Write Stream Error log.

9.2.12　Transport Dependent bits and fields

All bits and fields that are labelled transport dependent are defined in the transport standards.

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9.3 ERROR field

9.3.1 Overview

The ERROR field is one byte and is conveyed as an output from the device to the host (see applicable transport standard). Each bit, when valid, is defined in Table 32 ERROR field

Table 32 ERROR field

Bit	Name	Reference
7:4	SENSE KEY field	9.3.8
7	INTERFACE CRC bit	9.3.7
6	UNCORRECTABLE ERROR bit	9.3.9
5	Obsolete	
4	ID NOT FOUND bit	9.3.5
3	Obsolete	
2	ABORT bit	9.3.2
1	END OF MEDIA bit	9.3.4
0	ILLEGAL LENGTH INDICATOR bit	9.3.6
	COMMAND COMPLETION TIME OUT bit	9.3.3
	CFA ERROR bit	

9.3.2 ABORT bit

The ABORT bit is set to one if the device aborts the command. The ABORT bit is cleared to zero if the device does not abort the command.

If the host requested an address outside of the range of user addressable addresses, then:

a) the ID NOT FOUND bit (see 9.3.5) is set to one and the ABORT bit is cleared to zero; or

b) the ID NOT FOUND bit is cleared to zero and the ABORT bit is set to one.

If a user addressable address was not found (see 9.3.5), the ABORT bit is cleared to zero.

If the INTERFACE CRC bit (see 9.3.7) is set to one, the ABORT bit is set to one.

9.3.3 COMMAND COMPLETION TIME OUT bit

The COMMAND COMPLETION TIME OUT bit is set to one if:

a) the STREAMING SUPPORTED bit is set to one (i.e., the Streaming feature set is supported); and

b) a command completion time out has occurred in response to a Streaming feature set command.

Otherwise, an ATA device shall clear the COMMAND COMPLETION TIME OUT bit to zero.

9.3.4 END OF MEDIA bit

The END OF MEDIA bit set to one indicates that the end of the media has been reached by an ATAPI device (see SFF 8020i). Otherwise, the END OF MEDIA bit is cleared to zero.

9.3.5   ID NOT FOUND bit

The ID NOT FOUND bit is set to one if:

a) a user-addressable address was not found; or

b) an address outside of the range of user-addressable addresses is requested and the ABORT bit (see 9.3.2) is cleared to zero.

Otherwise, the ID NOT FOUND bit is cleared to zero.

9.3.6   ILLEGAL LENGTH INDICATOR bit

The operation of the ILLEGAL LENGTH INDICATOR bit is specific to the SCSI command set implemented by ATAPI devices (e.g., devices defined by MMC-6).

9.3.7   INTERFACE CRC bit

The INTERFACE CRC bit is set to one if an interface CRC error occurred during an Ultra DMA data transfer.

The INTERFACE CRC bit is cleared to zero if an interface CRC error did not occur during an Ultra DMA data transfer.

The value of the INTERFACE CRC bit may be applicable to Multiword DMA transfers and PIO data transfers. If the INTERFACE CRC bit is set to one, the ABORT bit is set to one.

9.3.8   SENSE KEY field

The operation of this field is specific to the SCSI command set implemented by ATAPI devices (e.g., devices defined by MMC-6).

9.3.9   UNCORRECTABLE ERROR bit

The UNCORRECTABLE ERROR bit is set to one if the data contains an uncorrectable error. The UNCORRECTABLE ERROR bit is cleared to zero if the data does not contain an uncorrectable error.

9.4 INTERRUPT REASON field

9.4.1 Overview

The INTERRUPT REASON field (see Table 33 INTERRUPT REASON field) is an output from the device to the host for commands in the PACKET feature set and NCQ feature set.

Table 33 INTERRUPT REASON field

Bit	Name	Reference
7:2	Obsolete	
7	INPUT/OUTPUT bit	9.4.3
6	COMMAND/DATA bit	9.4.2

9.4.2 COMMAND/DATA bit

The COMMAND/DATA bit is cleared to zero if the transfer is data. Otherwise, the COMMAND/DATA bit is set to one.

9.4.3 INPUT/OUTPUT bit

The INPUT/OUTPUT bit is cleared to zero if the transfer is to the device. The INPUT/OUTPUT bit is set to one if the transfer is to the host.

9.5　COUNT field

9.5.1　OverView

The COUNT field is an output from the device to the host. The uses of the COUNT field depend on the command being processed. Commands may use the COUNT field to indicate the:

a)　number of contiguous logical sectors that contain potentially bad data for commands in the Streaming feature set; or

b)　the tag of an NCQ command (see 9.5.3) for commands in the NCQ feature set.

9.5.2　Contiguous stream logical sectors that contain potentially bad data

For commands in the Streaming feature set, the COUNT field may be used to indicate the number of contiguous logical sectors that contain potentially bad data.

9.5.3　NCQ Tag

For commands in the NCQ feature set, the COUNT field may be used to indicate the tag of an NCQ command that caused an error.

9.6　SACTIVE field

See ATA8-AST for a description of the SACTIVE field.

9.7　SATA STATUS field

See ATA8-AST for a description of the SATA STATUS field (i.e., word 0 of the Set Device Bits FIS).

9.8　LBA field

9.8.1　Overview

The LBA field is an output from the device to the host. The uses of the LBA field depend on the command being processed. Commands may use the LBA field to indicate the LBA of the first unrecovered error (see 9.8.2).

9.8.2　LBA of First Unrecoverable Error

For commands that return LBA of the first unrecoverable error, if an unrecoverable error was encountered prior to or during the processing of that command, then the LBA field contains the LBA of the first unrecoverable error.

This value does not provide any status information regarding any data transferred by the command that returned the error. The value may be outside the LBA range of the command that returned the error.

10 General Operation Descriptions

10.1 Reset Response

There are three types of reset in ATA as follows:

Power On Reset (POR)   The device executes a series of electrical circuitry diagnostics.

COMRESET   COMRESET is issued in Serial ATA bus.

The device resets the interface circuitry as well as Soft Reset.

Soft Reset (Software Reset)   SRST bit in the Device Control Register is set, and then is reset.

The device resets the interface circuitry according to the Set Features requirement.

The actions of each reset are shown in Table 34

Table 34   Reset Response

	POR	COMRESET	Soft Reset
Aborting Host interface	-	o	o
Aborting Device operation	-	(*1)	(*1)
Initialization of hardware	o	x	x
Internal diagnostic	o	x	x
Spinning spindle	(*6)	x	x
Initialization of registers (*2)	o	o	o

Reverting programmed parameters to default
   - Number of CHS
  (set by Initialize Device Parameter)
   - Multiple mode
   - Write cache
   - Read look-ahead
   - ECC bytes
	o	(*3)	(*3)

Disable Standby timer	o	x	x
Power mode	(*5)	(*4)	(*4)

o   ----   Execute
x   ----   Not execute

Table Notes

(*1)   Execute after the data in write cache has been written.

(*2)   Default value on POR is shown in Table 35 "Default Register Values" on page 61.

(*3)   The Set Features command with Feature register = CCh enables the device to revert these parameters to the power on defaults.

(*4)   In the case of Sleep mode, the device goes to Standby mode. In other case, the device does not change current mode.

(*5)   Idle when Power-Up in Standby feature set is disabled. Standby when Power-Up in Standby feature set is enabled.

(*6)   Spinning up when Power-Up in Standby feature set is disabled. Standby when Power-Up in Standby feature set is enabled.

10.1.1   Register Initialization

Table 35   Default Register Values

Register	Default Value
Error	Diagnostic Code
Sector Count	01h
Sector Number	01h
Cylinder Low	00h
Cylinder High	00h
Device/Head	00h
Status	50h
Alternate Status	50h

After power on, hard reset, or software reset, the register values are initialized as shown in Table 35.

Table 36   Diagnostic Codes

Code	Description
01h	No error Detected
02h	Formatter device error
03h	Sector buffer error
04h	ECC circuitry error
05h	Controller microprocessor error

The meaning of the Error Register diagnostic codes resulting from power on, hard reset or the Execute Device Diagnostic command is shown in Table 36

10.2   Diagnostic and Reset considerations

In each case of Power on Reset, COMRESET, Soft reset, and EXECUTE DEVICE DIAGNOSTIC command, the device is diagnosed.   And Error register is set as shown in Table 29   Error Register.

10.3　Sector Addressing Mode

All addressing of data sectors recorded on the device's media is by a logical sector address. The logical CHS address for HUS726060ALA64n is different from the actual physical CHS location of the data sector on the disk media. All addressing of data sectors recorded on the device's media.

HUS726060ALA64n support both Logical CHS Addressing Mode and LBA Addressing Mode as the sector addressing mode.

The host system may select either the currently selected CHS translation addressing or LBA addressing on a command-by-command basis by using the L bit in the DEVICE/HEAD register. So a host system must set the L bit to 1 if the host uses LBA Addressing mode.

10.3.1　Logical CHS Addressing Mode

The logical CHS addressing is made up of three fields: the cylinder number, the head number and the sector number. Sectors are numbered from 1 to the maximum value allowed by the current CHS translation mode but can not exceed 255(0FFh). Heads are numbered from 0 to the maximum value allowed by the current CHS translation mode but can not exceed 15(0Fh). Cylinders are numbered from 0 to the maximum value allowed by the current CHS translation mode but cannot exceed 65535(0FFFFh).

When the host selects a CHS translation mode using the INITIALIZE DEVICE PARAMETERS command, the host requests the number of sectors per logical track and the number of heads per logical cylinder. The device then computes the number of logical cylinders available in requested mode.

The default CHS translation mode is described in the Identify Device Information. The current CHS translation mode also is described in the Identify Device Information.

10.3.2　LBA Addressing Mode

Logical sectors on the device shall be linearly mapped with the first LBA addressed sector (sector 0) being the same sector as the first logical CHS addressed sector (cylinder 0, head 0, sector 1). Irrespective of the logical CHS translation mode currently in effect, the LBA address of a given logical sector does not change. The following is always true:

LBA = ((cylinder * heads_per_cylinder + heads)

　　　　　　　　* sectors_per_track) + sector - 1

　　Where heads_per_cylinder and sectors_per_track are the current translation mode values.

On LBA addressing mode, the LBA value is set to the following register.

Device/Head	←	LBA bits	27-24
Cylinder High	←	LBA bits	23-16
Cylinder Low	←	LBA bits	15- 8
Sector Number	←	LBA bits	7- 0

10.4 Power Management Feature

The power management feature set allows an application client to modify the behavior of a device in a manner that reduces the power required to operate. The power management feature set provides a set of commands and a timer that enables a device to implement low power consumption modes.

The Power Management feature set implements the following set of functions.

1. A Standby timer
2. Idle command
3. Idle Immediate command
4. Sleep command
5. Standby command
6. Standby Immediate command

10.4.1 Power Mode

The lowest power consumption when the device is powered on occurs in Sleep Mode. When in sleep mode, the device requires a reset to be activated.

In Idle Mode the device is capable of responding immediately to media access requests.

In Active Mode the device is under executing a command or accessing the disk media with read look-ahead function or writes cache function.

10.4.1.1 Active Idle mode

Servo is mostly off but heads are loaded. The spindle is rotated at the full speed.

10.4.1.2 Low Power Idle mode

Additional electronics are powered off, and heads are unloaded on the ramp, however the spindle is still rotated at the full speed.

10.4.1.3 Low RPM Idle mode

The heads are unloaded on the ramp, and the spindle is rotated at the 85-90% of the full speed.

10.4.1.4 Standby Mode

The device interface is capable of accepting commands, but as the media may not immediately accessible, there is a delay while waiting for the spindle to reach operating speed.

10.4.2   Power Management Commands

The Check Power Mode command allows a host to determine if a device is in, going, to or leaving standby or idle mode.

The Idle and Idle Immediate commands move a device to idle mode immediately from the active or standby modes. The idle command also sets the standby timer count and enables or disables the standby timer.

The Standby and Standby Immediate commands move a device to standby mode immediately from the active or idle modes. The standby command also sets the standby timer count and enables or disables the Standby timer.

The Sleep command moves a device to sleep mode. The device's interface becomes inactive after the device reports command completion for the sleep command. A device only transitions from sleep mode after processing hardware reset, a software reset.

10.4.3   Standby timer

The standby timer provides a method for the device to automatically enter standby mode from either active or idle mode following a host programmed period of inactivity. If the device is in the active or idle mode, the device waits for the specified time period and if no command is received, the device automatically enters the standby mode.

If the value of SECTOR COUNT Register on Idle command or Standby command is set to 00h, the standby timer is disabled.

10.4.4   Interface Capability for Power Modes

Each power mode affects the physical interface as defined in the following table:

Table 37   Power conditions

Mode		BSY	RDY	Interface active	Media
Active		x	x	Yes	Active
Idle		0	1	Yes	Active
Standby		0	1	Yes	Inactive
sleep		x	x	No	Inactive

Ready (RDY) is not a power condition. A device may post ready at the interface even though the media may not be accessible.

10.5   SMART Function

The intent of Self-monitoring, analysis and reporting technology (SMART) is to protect user data and prevent unscheduled system downtime that may be caused by predictable degradation and/or fault of the device. By monitoring and storing critical performance and calibration parameters, SMART devices employ sophisticated data analysis algorithms to predict the likelihood of near-term degradation or fault condition. By alerting the host system of a negative reliability status condition, the host system can warn the user of the impending risk of a data loss and advise the user of appropriate action.

10.5.1   Attributes

Attributes are the specific performance or calibration parameters that are used in analyzing the status of the device. Attributes are selected by the device manufacturer based on that attribute's ability to contribute to the prediction of degrading or faulty conditions for that particular device. The specific set of attributes being used and the identity of these attributes is vendor specific and proprietary.

10.5.2   Attribute values

Attribute values are used to represent the relative reliability of individual performance or calibration attributes. The valid range of attribute values is from 1 to 253 decimal. Higher attribute values indicate that the analysis algorithms being used by the device are predicting a lower probability of a degrading or faulty condition existing. Accordingly, lower attribute values indicate that the analysis algorithms being used by the device are predicting a higher probability of a degrading or faulty condition existing.

10.5.3   Attribute thresholds

Each attribute value has a corresponding attribute threshold limit which is used for direct comparison to the attribute value to indicate the existence of a degrading or faulty condition. The numerical values of the attribute thresholds are determined by the device manufacturer through design and reliability testing and analysis. Each attribute threshold represents the lowest limit to which its corresponding attribute value can be equal while still retaining a positive reliability status. Attribute thresholds are set at the device manufacturer's factory and cannot be changed in the field. The valid range for attribute thresholds is from 1 through 253 decimal.

10.5.4   Threshold exceeded condition

If one or more attribute values, whose Pre-failure bit of their status flag is set, are less than or equal to their corresponding attribute thresholds, then the device reliability status is negative, indicating an impending degrading or faulty condition.

10.5.5   SMART commands

The SMART commands provide access to attribute values, attribute thresholds and other logging and reporting information.

10.5.6   Off-line Read Scanning

The device provides the off-line read scanning feature with reallocation. This is the extension of the off-line data collection capability. The device performs the entire read scan with reallocation for the marginal sectors to prevent the user data lost.

If interrupted by the host during the read scanning, the device services the host command.

10.5.7   Error Log

Logging of reported errors is supported. The device provides information on the last five errors that the device reported as described in SMART error log sector. The device may also provide additional vendor specific information on these reported errors. The error log is not disabled when SMART is disabled. Disabling SMART shall disable the delivering of error log information via the SMART READ LOG SECTOR command.

If a device receives a firmware modification, all error log data is discarded and the device error count for the life of the device is reset to zero.

10.5.8   Self-test

The device provides the self-test features which are initiated by SMART Execute Off-line Immediate command. The self-test checks the fault of the device, reports the test status in Device Attributes Data and stores the test result in the SMART self-test log sector as described in SMART self-test log data structure. All SMART attributes are updated accordingly during the execution of self-test.

If interrupted by the host during the self-tests, the device services the host command.

If the device receives a firmware modification, all self-test log data is discarded.

10.6   Security Mode Feature Set

Security Mode Feature Set is a powerful security feature. With a device lock password, a user can prevent unauthorized access to hard disk device even if the device is removed from the computer.

The following commands are supported for this feature.

Security Set Password	('F1'h)
Security Unlock	('F2'h)
Security Erase Prepare	('F3'h)
Security Erase Unit	('F4'h)
Security Freeze Lock	('F5'h)
Security Disable Password	('F6'h)

10.6.1   Security mode

Following security modes are provided.

Device Locked mode   The device disables media access commands after power on. Media accesses commands are enabled by either a security unlock command or a security erases unit command.

Device Unlocked mode   The device enables all commands. If a password is not set this mode is entered after power on, otherwise it is entered by a security unlock or a security erases unit command.

Device Frozen mode   The device enables all commands except those which can update the device lock function, set/change password. The device enters this mode via a Security Freeze Lock command. It cannot quit this mode until power off.

10.6.2   Security Level

Following security levels are provided.

High level security   When the device lock function is enabled and the User Password is forgotten the device can be unlocked via a Master Password.

Maximum level security   When the device lock function is enabled and the User Password is forgotten then only the Master Password with a Security Erase Unit command can unlock the device. Then user data is erased.

10.6.3   Password

This function can have 2 types of passwords as described below.

Master Password   When the Master Password is set, the device does NOT enable the Device Lock Function, and the device can NOT be locked with the Master Password, but the Master Password can be used for unlocking the device locked.

Identify Device Information word 92 contains the value of the Master Password Revision Code set when the Master Password was last changed. Valid values are 0001h through FFFEh.

User Password   The User Password should be given or changed by a system user. When the User Password is set, the device enables the Device Lock Function, and then the device is locked on next power on reset or hard reset.

The system manufacturer/dealer who intends to enable the device lock function for the end users, must set the master password even if only single level password protection is required.

10.6.4 Operation example

10.6.4.1 Master Password setting

The system manufacturer/dealer can set a new Master Password from default Master Password using the Security Set Password command, without enabling the Device Lock Function.

The Master Password Revision Code is set to FFFEh as shipping default by the HDD manufacturer

10.6.4.2 User Password setting

When a User Password is set, the device will automatically enter lock mode the next time the device is powered on.
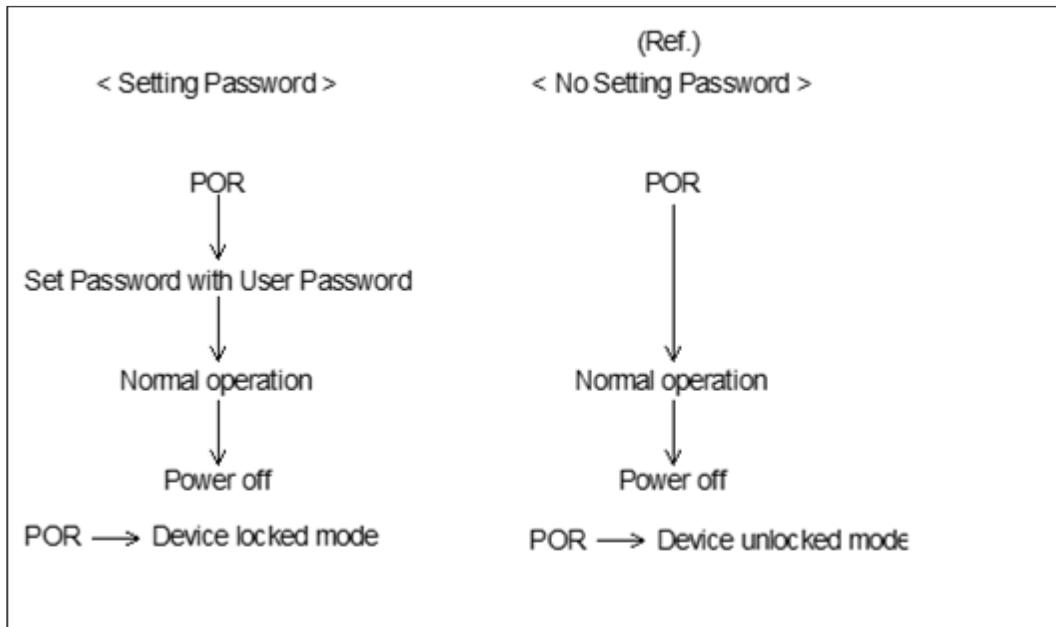
Figure 10   Initial Setting

10.6.4.3 Operation from POR after User Password is set

When Device Lock Function is enabled, the device rejects media access command until a Security Unlock command is successfully completed.
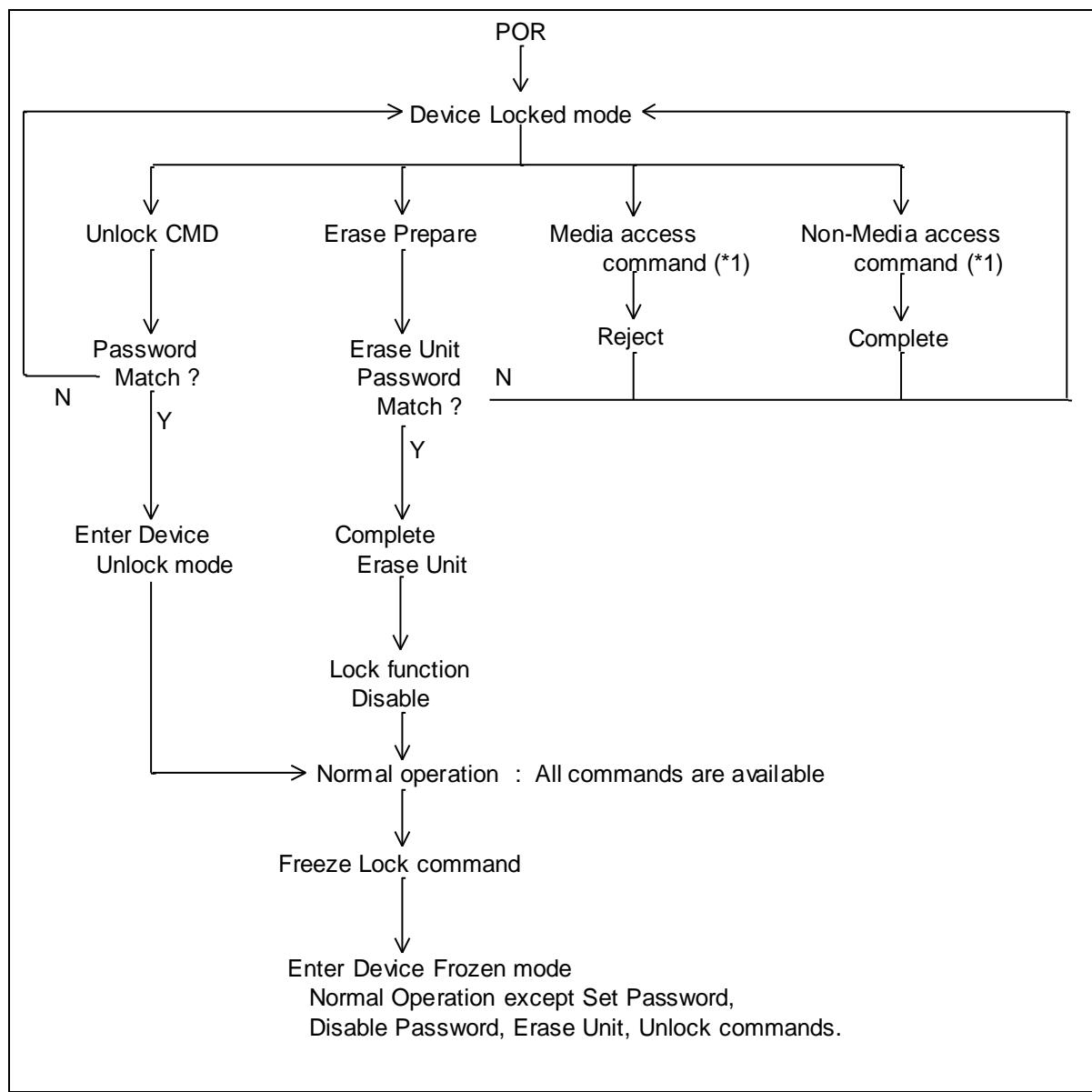
(*1) Refer to 10.6.5 on the page.71

Figure 11   Usual Operation

10.6.4.4 User Password Lost

If the User Password is forgotten and High level security is set, the system user can't access any data. However, the device can be unlocked using the Master Password.

If a system user forgets the User Password and Maximum security level is set, data access is impossible. However, the device can be unlocked using the Security Erase Unit command to unlock the device and erase all user data with the Master Password.

```
           User Password Lost
                    |
                    v
                               High
           LEVEL ?---------------------> Unlock CMD with Master Password
                    |
                 Maximum
                    |
                    v
      Erase Prepare Command
      Erase Unit    Command
          with Master Password
                    |
                    v                                    v
   Normal operation but data lost              Normal operation
```
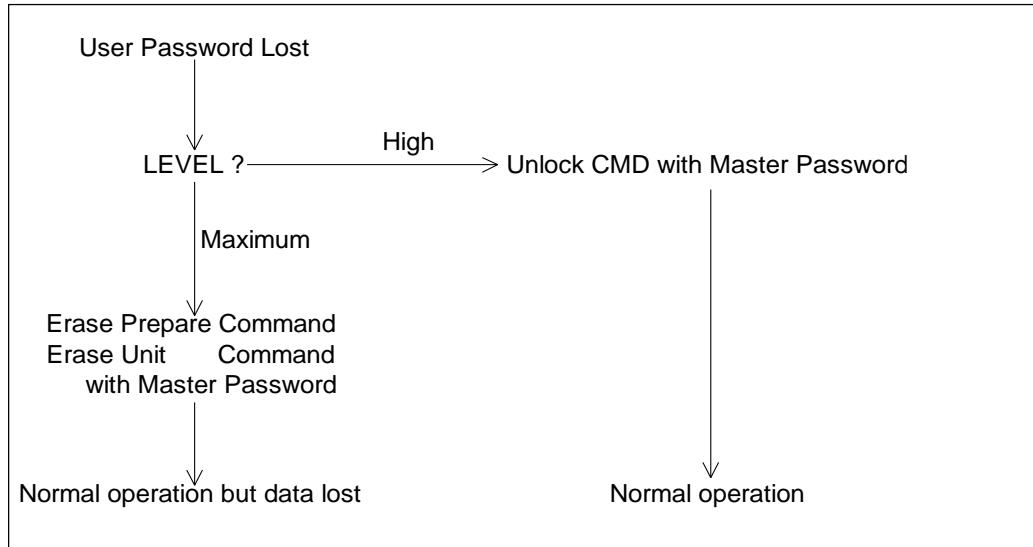
Figure 12   Password Lost

10.6.4.5 Attempt limit for SECURITY UNLOCK command

The SECURITY UNLOCK command has an attempt limit. The purpose of this attempt limit is to prevent that someone attempts to unlock the drive by using various passwords many times.

The device counts the password mismatch. If the password does not match, the device counts it up without distinguishing the Master password and the User password. If the count reaches 5, EXPIRE bit (bit 4) of Word 128 in Identify Device information is set, and then SECURITY ERASE UNIT command and SECURITY UNLOCK command are aborted until a hard reset or a power off. The count and EXPIRE bit are cleared after a power on reset or a hard reset.

10.6.5　Command Table

This table shows the device's response to commands when the Security Mode Feature Set (Device lock function) is enabled.

Table 38　Command table for device lock operation -1

Command	Locked Mode	Unlocked Mode	Frozen Mode
Check Power Mode	Executable	Executable	Executable
Configure Stream	Command aborted	Executable	Executable
Crypto Scramble Ext (data encryption model only)	Command aborted	Executable	Executable
Device Configuration Restore	Command aborted	Executable	Executable
Device Configuration Freeze Lock	Command aborted	Executable	Executable
Device Configuration Identify	Command aborted	Executable	Executable
Device Configuration Set	Command aborted	Executable	Executable
Download Microcode	Command aborted	Executable	Executable
Download Microcode DMA	Command aborted	Executable	Executable
Execute Device Diagnostic	Executable	Executable	Executable
Flush Cache	Command aborted	Executable	Executable
Flush Cache Ext	Command aborted	Executable	Executable
Format Track	Command aborted	Executable	Executable
Identify Device	Executable	Executable	Executable
Idle	Executable	Executable	Executable
Idle Immediate	Executable	Executable	Executable
Initialize Device Parameters	Executable	Executable	Executable
NCQ NON-DATA	Command aborted	Executable	Executable
Overwrite Ext	Command aborted	Executable	Executable
Read Buffer	Executable	Executable	Executable
Read DMA	Command aborted	Executable	Executable
Read DMA Ext	Command aborted	Executable	Executable
Read FPDMA Queued	Command aborted	Executable	Executable
Read Log Ext	Executable	Executable	Executable
Read Log DMA Ext	Executable	Executable	Executable
Read Multiple	Command aborted	Executable	Executable
Read Multiple Ext	Command aborted	Executable	Executable
Read Native Max Address	Executable	Executable	Executable
Read Native Max Ext	Executable	Executable	Executable
Read Sector(s)	Command aborted	Executable	Executable
Read Sector(s) Ext	Command aborted	Executable	Executable
Read Stream DMA Ext	Command aborted	Executable	Executable
Read Stream Ext	Command aborted	Executable	Executable
Read Verify Sector(s)	Command aborted	Executable	Executable
Read Verify Sector(s) Ext	Command aborted	Executable	Executable
Recalibrate	Executable	Executable	Executable
Receive FPDMA Queued	Command aborted	Executable	Executable
Request Sense Data Ext	Executable	Executable	Executable
Sanitize Freeze Lock Ext	Command aborted	Executable	Executable

Table 39   Command table for device lock operation -2

Command	Locked Mode	Unlocked Mode	Frozen Mode
Sanitize Status Ext	Executable	Executable	Executable
SCT Read/Write Long	Command aborted	Command aborted	Command aborted
SCT Write Same	Command aborted	Executable	Executable
SCT Error Recovery Control	Command aborted	Executable	Executable
SCT Feature Control	Command aborted	Executable	Executable
SCT Data Table	Command aborted	Executable	Executable
SCT Read Status	Executable	Executable	Executable
Security Disable Password	Command aborted	Executable	Command aborted
Security Erase Prepare	Executable	Executable	Command aborted
Security Erase Unit	Executable	Executable	Command aborted
Security Freeze Lock	Command aborted	Executable	Executable
Security Set Password	Command aborted	Executable	Command aborted
Security Unlock	Executable	Executable	Command aborted
Seek	Executable	Executable	Executable
Set Features	Executable	Executable	Executable
Set Max Address	Command aborted	Executable	Executable
Set Max Address Ext	Command aborted	Executable	Executable
Set Multiple Mode	Executable	Executable	Executable
Sleep	Executable	Executable	Executable
SMART Disable Operations	Executable	Executable	Executable
SMART Enable/Disable Attribute Autosave	Executable	Executable	Executable
SMART Enable Operations	Executable	Executable	Executable
SMART Execute Off-line Immediate	Executable	Executable	Executable
SMART Read Attribute Values	Executable	Executable	Executable
SMART Read Attribute Thresholds	Executable	Executable	Executable
SMART Return Status	Executable	Executable	Executable
SMART Save Attribute Values	Executable	Executable	Executable
SMART Read Log Sector	Executable	Executable	Executable
SMART Write Log Sector	Executable	Executable	Executable
SMART Enable/Disable Automatic Off-Line	Executable	Executable	Executable
Standby	Executable	Executable	Executable
Standby Immediate	Executable	Executable	Executable
Write Buffer	Executable	Executable	Executable
Write DMA	Command aborted	Executable	Executable
Write DMA Ext	Command aborted	Executable	Executable
Write DMA FUA Ext	Command aborted	Executable	Executable
Write FPDMA Queued	Command aborted	Executable	Executable

Table 40   Command table for device lock operation -3

Command	Locked Mode	Unlocked Mode	Frozen Mode
Write Log Ext	Command aborted	Executable	Executable
Write Log DMA Ext	Command aborted	Executable	Executable
Write Multiple	Command aborted	Executable	Executable
Write Multiple Ext	Command aborted	Executable	Executable
Write Multiple FUA Ext	Command aborted	Executable	Executable
Write Sector(s)	Command aborted	Executable	Executable
Write Sector(s) Ext	Command aborted	Executable	Executable
Write Stream DMA Ext	Command aborted	Executable	Executable
Write Stream Ext	Command aborted	Executable	Executable
ZAC CLOSE ZONE EXT	Command aborted	Executable	Executable
ZAC FINISH ZONE EXT	Command aborted	Executable	Executable
ZAC OPEN ZONE EXT	Command aborted	Executable	Executable
ZAC REPORT ZONES EXT	Command aborted	Executable	Executable
ZAC RESET WRITE POINTERS EXT	Command aborted	Executable	Executable

10.7   Host Protected Area Feature

Host Protected Area Feature is to provide the 'protected area' which can not be accessed via conventional method. This 'protected area' is used to contain critical system data such as BIOS or system management information. The contents of entire system main memory may also be dumped into 'protected area' to resume after system power off. The LBA/CYL changed by following command affects the Identify Device Information.

The following set of commands is implemented for this function.

Read Native Max ADDRESS   ('F8'h)

Set Max ADDRESS   ('F9'h)

10.7.1   Example for operation (In LBA mode)

Assumptions:

For better understanding, the following example uses actual values for LBA, size, etc. Since it is just an example, these values could be different.

Device characteristics

Capacity (native)	:	6,498,680,832	byte (6.4GB)
Max LBA (native)	:	12,692,735	(C1ACFFh)
Required size for protected area	:	206,438,400	byte
Required blocks for protected area	:	403,200	(062700h)
Customer usable device size	:	6,292,242,432	byte (6.2GB)
Customer usable sector count	:	12,289,536	(BB8600h)
LBA range for protected area	:	BB8600h to C1ACFFh	

1. Shipping HDDs from HDD manufacturer

    When the HDDs are shipped from HDD manufacturer, the device has been tested to have usable capacity of 6.4GB besides flagged media defects not to be visible by system.

2. Preparing HDDs at system manufacturer

    Special utility software is required to define the size of protected area and store the data into it.
    The sequence is:

    Issue Read Native Max Address command to get the real device maximum LBA. Returned value shows that native device Maximum LBA is 12,692,735 (C1ACFFh) regardless of the current setting.

    Make entire device be accessible including the protected area by setting device Maximum LBA as 12,692,735 (C1ACFFh) via Set Max Address command. The option could be either nonvolatile or volatile.

    Test the sectors for protected area (LBA >=   12,289,536 (BB8600h)) if required.

    Write information data such as BIOS code within the protected area.

    Change maximum LBA using Set Max Address command to 12,289,535 (BB85FFh) with nonvolatile option.

    From this point, the protected area cannot be accessed till next Set Max Address command is issued. Any BIOSes, device drivers, or application software access the HDD as if that is the 6.2GB device because the device acts exactly the same as real 6.2GB device does.

3. Conventional usage without system software support

    Since the HDD works as 6.2GB device, there is no special care to use this device for normal use.

4. Advanced usage using protected area

    The data in the protected area is accessed by following.

    Issue Read Native Max Address command to get the real device maximum LBA. Returned value shows that native device Maximum LBA is 12,692,735 (C1ACFFh) regardless of the current setting.

    Make entire device be accessible including the protected area by setting device Maximum LBA as

12,692,735 (C1ACFFh) via Set Max Address command with volatile option. By using this option, unexpected power removal or reset will not make the protected area remained accessible.

Read information data from protected area.

Issue hard reset or POR to inhibit any access to the protected area.

10.7.2   Security extensions

1. Set Max Set Password
2. Set Max Lock
3. Set Max Freeze Lock
4. Set Max Unlock.

The Set Max Set Password command allows the host to define the password to be used during the current power on cycle. The password does not persist over a power cycle but does persist over a hardware or software reset. This password is not related to the password used for the Security Mode Feature set. When the password is set the device is in the Set_Max_Unlocked mode. The Set Max Lock command allows the host to disable the Set Max commands (except set Max Unlock) until the next power cycle or the issuance and acceptance of the Set Max Unlock command. When this command is accepted the device is in the Set_Max_Locked mode. The Set Max Unlock command changes the device from the Set_Max_Locked mode to the Set_Max_Unlocked mode. The Set Max Freeze Lock command allows the host to disable the Set Max commands (including Set Max UNLOCK) until the next power cycle. When this command is accepted the device is in the Set_Max_Frozen mode.

The IDENTIFY DEVICE response word 83, bit 8 indicates that this extension is supported if set, and word 86, bit 8 indicate the Set Max security extension enabled if set.

10.8   Write Cache Function

Write cache is a performance enhancement whereby the device reports as completing the write command (Write Sector(s), Write Multiple and Write DMA) to the host as soon as the device has received all of the data into its buffer. And the device assumes responsibility to write the data subsequently onto the disk.

- While writing data after completed acknowledgment of a write command, soft reset or hard reset does not affect its operation. But power off terminates writing operation immediately and unwritten data are to be lost.

- Soft reset, Standby (Immediate) command and Flush Cache commands during writing the cached data are executed after the completion of writing to media. So the host system can confirm the completion of write cache operation by issuing Soft reset, Standby (Immediate) command or Flush Cache command to the device before power off.

10.9   Reassign Function

The reassign Function is used with read commands and write commands. The sectors of data for reassignment are prepared as the spare data sector.

This reassignment information is registered internally, and the information is available right after completing the reassign function. Also the information is used on the next power on reset or hard reset.

If the number of the spare sector reaches 0 sectors, the reassign function will be disabled automatically.

The spare tracks for reassignment are located at regular intervals from Cylinder 0. As a result of reassignment, the physical location of logically sequenced sectors will be dispersed.

10.9.1   Auto Reassign Function

The sectors that show some errors may be reallocated automatically when specific conditions are met. The spare tracks for reallocation are located at regular intervals from Cylinder 0. The conditions for auto-reallocation are described below.

Non recovered write errors
When a write operation can not be completed after the Error Recovery Procedure (ERP) is fully carried out, the sector(s) are reallocated to the spare location. An error is reported to the host system only when the write cache is disabled and the auto reallocation is failed.

If the write cache function is ENABLED, and when the number of available spare sectors reaches 0 sectors, both auto reassign function and write cache function are disabled automatically.

Non recovered read errors
When a read operation is failed after defined ERP is fully carried out, a hard error is reported to the host system. This location is registered internally as a candidate for the reallocation. When a registered location is specified as a target of a write operation, a sequence of media verification is performed automatically. When the result of this verification meets the criteria, this sector is reallocated.

Recovered read errors
When a read operation for a sector failed once then recovered at the specific ERP step, this sector of data is reallocated automatically. A media verification sequence may be run prior to the relocation according to the pre-defined conditions.

10.10 Power-up in Standby feature set

Power-Up In Standby feature set allows devices to be powered-up into the Standby power management state to minimize inrush current at power-up and to allow the host to sequence the spin-up of devices.

This feature set will be enabled/disabled via the SET FEATURES command. The enabling of this feature set shall be persistent after power cycle.

A device needs a SET FEATURES subcommand to spin-up to active state when the device has powered-up into Standby. The device remains in Standby until the SET FEATURES subcommand is received.

If power-up into Standby is enabled, when an IDENTIFY DEVICE is received while the device is in Standby as a result of powering up into Standby, the device shall set word 0 bit 2 to one to indicate that the response is incomplete, then only words 0 and 2 are correctly reported.

The IDENTIFY DEVICE information indicates the states as follows:
- identify device information is complete or incomplete
- this feature set is implemented
- this feature set is enabled or disabled
- the device needs the Set Features command to spin-up into active state

10.11 Advanced Power Management feature set (APM)

This feature allows the host to select an advanced power management level. The advanced power management level is a scale from the lowest power consumption setting of 01h to the maximum performance level of FEh. Device performance may increase with increasing advanced power management levels. Device power consumption may increase with increasing advanced power management levels. The advanced power management levels contain discrete bands, described in the section of Set Feature command in detail. This feature set uses the following functions:

1. A SET FEATURES subcommand to enable Advanced Power Management
2. A SET FEATURES subcommand to disable Advanced Power Management

Advanced Power Management is independent of the Standby timer setting. If both Advanced Power Management and the Standby timer are set, the device will go to the Standby state when the timer times out or the device's Advanced Power Management algorithm indicates that the Standby state should be entered.

The IDENTIFY DEVICE response word 83, bit 3 indicates that Advanced Power Management feature is supported if set. Word 86, bit 3 indicates that Advanced Power Management is enabled if set. Word 91, bits 7-0 contain the current Advanced Power Management level if Advanced Power Management is enabled.

10.12 48-bit Address Feature Set

The 48-bit Address feature set allows devices:
a) with capacities up to 281,474,976,710,655 logical sectors (i.e., up to 144,115,188,075,855,360 bytes for a 512-byte logical block device); and
b) to transfer up to 65536 logical sectors in a single command.

The 48-bit Address feature set operates in LBA addressing only. Devices also implement commands using 28-bit addressing, and 28-bit and 48-bit commands may be intermixed.

Support of the 48-bit Address feature set is indicated in the Identify Device response bit 10 words 83. In addition, the maximum user LBA address accessible by 48-bit addressable commands is contained in Identify Device response words 230 through 233.

When the 48-bit Address feature set is implemented, the native maximum address is the value returned by a Read Native Max Address Ext command. If the native maximum address is equal to or less than 268,435,455, a Read Native Max Address shall return the native maximum address. If the native maximum address is greater than 268,435,455, a Read Native Max Address shall return a value of 268,435,455.

10.13 Streaming feature Set

The Streaming feature set is an optional feature set that allows a host to request delivery of data from a contiguous logical block address range within an allotted time. This places a priority on time to access the data rather than the integrity of the data. Streaming feature set commands only support 48-bit addressing.

A device that implements the Streaming feature set shall implement the following minimum set of commands:

- Configure Stream
- Read Stream Ext
- Write Stream Ext
- Read Stream DMA Ext
- Write Stream DMA Ext
- Read Log Ext

Support of the Streaming feature set is indicated in Identify Device work 84 bit 4.

Note that PIO versions of these commands limit the transfer rate (16.6 MB/s), provide no CRC protection, and limit status reporting as compared to a DMA implementation.

10.13.1 Streaming commands

The streaming commands are defined to be time critical data transfers rather than the standard data integrity critical commands. Each command shall be completed within the time specified in the Configure Stream command or in the streaming command itself in order to ensure the stream requirements of the AV type application. The device may execute background tasks as long as the Read Stream and Write Stream command execution time limits are still met.

Using the Configure Stream command, the host may define the various stream properties including the default Command Completion Time Limit (CCTL) to assist the device in setting up its caching for best performance. If the host does not use a Configure Stream command, the device shall use the CCTL specified in each streaming command, and the time limit is effective for one time only. If the CCTL is not set by Configure Stream command, the operation of a streaming command with a zero CCTL is device vendor specific. If Stream ID is not set by a Configure Stream command, the device shall operate according to the Stream ID set by the streaming command. The operation is device vendor specific.

The streaming commands may access any user LBA on a device. These commands may be interspersed with non-streaming commands, but there may be an impact on performance due to the unknown time required to complete the non-streaming commands.

The streaming commands should be issued using a specified minimum number of sectors transferred per command, as specified in word 95 of the Identify Device response. The transfer length of a request should be a multiple of the minimum number of sectors per transfer.
The host provided numeric stream identifier, Stream ID, may be used by the device to configure its resources to support the streaming requirements of the AV content. One Stream ID may be configured for each read and write operation with different command completion time limits be each Configure Stream command.

10.13.1.1 Urgent bit

The Urgent bit in the Read Stream and Write Stream commands specifies that the command should be completed in the minimum possible time by the device and shall be completed within the specified Command Completion Time Limit.

10.13.1.2 Flush to Disk bit

The Flush to Disk bit in the Write Stream command specifies that all data for the specified stream shall be flushed to the media before posting command completion. If a host requests flushes at times other than the end of each Allocation Unit, streaming performance may be degraded. The Set Features command to enable/disable caching shall not affect caching for streaming commands.

10.13.1.3   Not Sequential bit

The Not Sequential bit specifies that the next read stream command with the same Stream ID may not be sequential in LBA space.   This information helps the device with pre-fetching decisions.

10.13.1.4   Read Continuous bit

If the Read Continuous bit is set to one for the command, the device shall transfer the requested amount of data to the host within the Command Completion Time Limit even if an error occurs.   The data sent to the host by the device in an error condition is vendor specific.

10.13.1.5   Write Continuous bit

If the Write Continuous bit is set to one for the command, and an error is encountered, the device shall complete the request without posting an error.   If an error cannot be resolved within the Command Completion Time Limit, the erroneous section on the media may be unchanged or may contain undefined data.   A future read of this area may not report an error, even though the data is erroneous.

10.13.1.6   Handle Streaming Error bit

The Handle Streaming Error bit specifies to the device that this command starts at the LBA of a recently reported error section, so the device may attempt to continue its corresponding error recovery sequence where it left off earlier. This mechanism allows the host to schedule error recovery and defect management for content critical data.

10.13.2   Streaming Logs

The Streaming Data Transfer feature set provides two error logs; the Read Stream Error Log (12.22.7) and the Write Stream Error Log (12.22.8). These error logs are 512 bytes in length and retain the last 31 errors that occurred during any Streaming Data transfer. A host can access these logs via the READ LOG EXT command (12.22). The information included in these error logs is volatile and is not maintained across power cycles, hard resets, or sleep.

10.14 SATA BIST (Built-in Self Test)

The device supports the following BIST modes, and begins operations when it receives BIST Activate FIS.

   F – Far End Analog Loopback.

   L – Far End Retimed Loopback

   T – Far End Transmit only

   A – ALIGN Bypass (valid only in combination with T bit)

   S – Bypass Scrambling (valid only in combination with T bit)

10.15 SATA Interface Power Management

The device supports both receiving host-initiated interface power management requests and initiating interface power management. The device initiates interface power management when the device enters its power saving mode whose power consumption is lower than Idle mode.

10.16 Software Setting Preservation

When a device is enumerated, software will configure the device using SET FEATURES and other commands. These software settings are often preserved across software reset but not necessarily across hardware reset. In Parallel ATA, only commanded hardware resets can occur, thus legacy software only reprograms settings that are cleared for the particular type of reset it has issued. In Serial ATA, COMRESET is equivalent to hard reset and a non-commanded COMRESET may occur if there is an asynchronous loss of signal. Since COMRESET is equivalent to hardware reset, in the case of an asynchronous loss of signal some software settings may be lost without legacy software knowledge. In order to avoid losing important software settings without legacy driver knowledge, the software settings preservation ensures that the value of important software settings is maintained across a COMRESET. Software settings preservation may be enabled or disabled using SET FEATURES with a subcommand code of 06h. If a device supports software settings preservation, the feature shall be enabled by default.

10.16.1 COMRESET Preservation Requirements

The software settings that shall be preserved across COMRESET are listed below. The device is only required to preserve the indicated software setting if it supports the particular feature/command the setting is associated with.
INITIALIZE DEVICE PARAMETERS: Device settings established with the INITIALIZE DEVICE PARAMETERS command.

Power Management Feature Set Standby Timer: The Standby timer used in the Power Management feature set.

Read/Write Stream Error Log: The Read Stream Error Log and Write Stream Error Logs (accessed using READ LOG EXT and WRITE LOG EXT).

Security mode state: The security mode state established by Security Mode feature set commands (refer to section 6.13 of the ATA/6 specification). The device shall not transition to a different security mode state based on a COMRESET. For example, the device shall not transition from the SEC5: Unlocked / not Frozen state to state SEC4: Security enabled / Locked when a COMRESET occurs, instead the device shall remain in the SEC5: Unlocked / not Frozen state.

SECURITY FREEZE LOCK: The Frozen mode setting established by the SECURITY FREEZE LOCK command.

SECURITY UNLOCK: The unlock counter that is decremented as part of a failed SECURITY UNLOCK command attempt.

SET ADDRESS MAX (EXT): The maximum LBA specified in SET ADDRESS MAX or SET ADDRESS MAX EXT.

SET FEATURES (Write Cache Enable/Disable): The write cache enable/disable setting established by the SET FEATURES command with subcommand code of 02h or 82h.

SET FEATURES (Set Transfer Mode): PIO, Multiword, and UDMA transfer mode settings established by the SET FEATURES command with subcommand code of 03h.

SET FEATURES (Advanced Power Management Enable/Disable): The advanced power management enable/disable setting established by the SET FEATURES command with subcommand code of 05h or 85h. The advanced power management level established in the Sector Count register when advanced power management is enabled (SET FEATURES subcommand code 05h) shall also be preserved.

SET FEATURES (Read Look-Ahead): The read look-ahead enable/disable setting established by the SET FEATURES command with subcommand code of 55h or AAh.

SET FEATURES (Reverting to Defaults): The reverting to power-on defaults enable/disable setting established by the SET FEATURES command with a subcommand code of CCh or 66h.

SET MULTIPLE MODE: The block size established with the SET MULTIPLE MODE command.

SANITIZE FREEZE LOCK MODE: The Sanitize Frozen state established by the SANITIZE FREEZE LOCK EXT command.

10.17 Serial ATA Revision 3.0 Optional Features

There are several optional features defined in Serial ATA Revision 3.0. The following shows whether these features are supported or not.

10.17.1 Asynchronous Signal Recovery

The device supports asynchronous signal recovery defined in Serial ATA Revision 3.0.

10.17.2 Device Power Connector Pin 11 Definition

Serial ATA Revision 3.0 specification defines that Pin 11 of the power segment of the device connector may be used to provide the host with an activity indication and disabling of staggered spin-up.

10.17.3 Phy Event Counters

Phy Event Counters are an optional feature to obtain more information about Phy level events that occur on the interface. This information may aid designers and integrators in testing and evaluating the quality of the interface. A device indicates whether it supports the Phy event counters feature in IDENTIFY (PACKET) DEVICE Word 76, bit 10. The host determines the current values of Phy event counters by issuing the READ LOG EXT command with a log page of 11h. The counter values shall not be retained across power cycles. The counter values shall be preserved across COMRESET and software resets.

The counters defined can be grouped into three basic categories: those that count events that occur during Data FIS transfers, those that count events that occur during non-Data FIS transfers, and events that are unrelated to FIS transfers. Counters related to events that occur during FIS transfers may count events related to host-to-device FIS transfers, device-to-host FIS transfers, or bi-directional FIS transfers. A counter that records bi-directional events is not required to be the sum of the counters that record the same events that occur on device-to-host FIS transfers and host-to-device FIS transfers.

Implementations that support Phy event counters shall implement all mandatory counters, and may support any of the optional counters as shown in Table 41   Phy Event Counter Identifiers. Note that some counters may increment differently based on the speed at which non-Data FIS retries are performed by the host and device. Implementations may record CRC and non-CRC error events differently. For example, there is a strong likelihood that a disparity error may cause a CRC error. Thus, the disparity error may cause both the event counter that records non-CRC events and the event counter that records CRC events to be incremented for the same event. Another example implementation difference is how a missing EOF event is recorded; a missing EOF primitive may imply a bad CRC even though the CRC on the FIS may be correct. These examples illustrate that some Phy event counters are sensitive to the implementation of the counters themselves, and thus these implementation sensitive counters cannot be used as an absolute measure of interface quality between different implementations.

10.17.3.1 Counter Reset Mechanisms

There are two mechanisms by which the host can explicitly cause the Phy counters to be reset.
The first mechanism is to issue a BIST Activate FIS to the device. Upon reception of a BIST Activate FIS the device shall reset all Phy event counters to their reset value. The second mechanism uses the READ LOG EXT command. When the device receives a READ LOG EXT command for log page 11h and bit 0 in the Features register is set to one, the device shall return the current counter values for the command and then reset all Phy event counter values.

10.17.3.2 Counter Identifiers

Each counter begins with a 16-bit identifier. 0 defines the counter value for each identifier. Any unused counter slots in the log page should have a counter identifier value of 0h.
Optional counters that are not implemented shall not be returned in log page 11h. A value of '0' returned for a counter means that there have been no instances of that particular event. There is no required ordering for event counters within the log page; the order is arbitrary and selected by the device vendor.

For all counter descriptions, 'transmitted' refers to items sent by the device to the host and 'received' refers to items received by the device from the host.

Bits 14:12 of the counter identifier convey the number of significant bits that counter uses. All counter values consume a multiple of 16-bits. The valid values for bits 14:12 and the corresponding counter sizes are:

> 1h 16-bit counter
>
> 2h 32-bit counter
>
> 3h 48-bit counter
>
> 4h 64-bit counter

Any counter that has an identifier with bit 15 set to one is vendor specific. This creates a vendor specific range of counter identifiers from 8000h to FFFFh. Vendor specific counters shall observe the number of significant bits 14:12 as defined above.

Table 41 Phy Event Counter Identifiers

Identifier (Bits 11:0)	Mandatory/ Optional	Description
000h	Mandatory	No counter value; marks end of counters in the page
001h	Mandatory	Command failed and ICRC bit set to one in Error register
002h	Optional	R_ERR response for Data FIS
003h	Optional	R_ERR response for Device-to-Host Data FIS
004h	Optional	R_ERR response for Host-to-Device Data FIS
005h	Optional	R_ERR response for Non-data FIS
006h	Optional	R_ERR response for Device-to-Host Non-data FIS
007h	Optional	R_ERR response for Host-to-Device Non-data FIS
008h	Optional	Not supported (Device-to-Host non-Data FIS retries)
009h	Optional	Transitions from drive PhyRdy to drive PhyNRdy
00Ah	Mandatory	Signature Device-to-Host Register FISes sent due to a COMRESET
00Bh	Optional	CRC errors within a Host-to-Device FIS
00Dh	Optional	Non-CRC errors within a Host-to-Device FIS
00Fh	Optional	Not supported (R_ERR response for Host-to-Device Data FIS due to CRC errors)
010h	Optional	Not supported (R_ERR response for Host-to-Device Data FIS due to non-CRC errors)
012h	Optional	Not supported (R_ERR response for Host-to-Device Non-data FIS due to CRC errors)
013h	Optional	Not supported (R_ERR response for Host-to-Device Non-data FIS due to non-CRC errors)

10.17.3.2.1 Counter Definitions

The counter definitions in this section specify the events that a particular counter identifier represents.

10.17.3.2.1.1 Identifier 000h

There is no counter associated with identifier 000h. A counter identifier of 000h indicates that there are no additional counters in the log page.

10.17.3.2.1.2 Identifier 001h

The counter with identifier 001h returns the number of commands that returned an ending status with the ERR bit set to one in the Status register and the ICRC bit set to one in the Error register.

10.17.3.2.1.3 Identifier 002h

The counter with identifier 002h returns the sum of (the number of transmitted Device-to-Host Data FISes to which the host responded with R_ERR$_P$) and (the number of received Host-to-Device Data FISes to which the device responded with R_ERR$_P$).

10.17.3.2.1.4 Identifier 003h

The counter with identifier 003h returns the number of transmitted Device-to-Host Data FISes to which the host responded with R_ERR$_P$.

10.17.3.2.1.5 Identifier 004h

The counter with identifier 004h returns the number of received Host-to-Device Data FISes to which the device responded with R_ERR$_P$.   The count returned for identifier 004h is not required to be equal to the sum of the counters with identifiers 00Fh and 010h.

10.17.3.2.1.6 Identifier 005h

The counter with identifier 005h returns the sum of (the number of transmitted Device-to-Host non-Data FISes to which the host responded with R_ERR$_P$) and (the number of received Host-to-Device non-Data FISes to which the device responded with R_ERR$_P$). Retries of non-Data FISes are included in this count.

10.17.3.2.1.7 Identifier 006h

The counter with identifier 006h returns the number of transmitted Device-to-Host non-Data FISes to which the host responded with R_ERR$_P$. Retries of non-Data FISes are included in this count.

10.17.3.2.1.8 Identifier 007h

The counter with identifier 007h returns the number of received Host-to-Device non-Data FISes to which the device responded with R_ERR$_P$. Retries of non-Data FISes are included in this count.

10.17.3.2.1.9 Identifier 009h

The counter with identifier 009h returns the number of times the device transitioned into the PHYRDY state from the PHYNRDY state, including but not limited to asynchronous signal events, power management events, and COMRESET events. If interface power management is enabled, then this counter may be incremented due to interface power management transitions.

10.17.3.2.1.10 Identifier 00Ah

The counter with identifier 00Ah returns the number of transmitted Device-to-Host Register FISes with the device reset signature in response to a COMRESET, which were successfully followed by an R_OK from the host.

10.17.3.2.1.11 Identifier 00Bh

The counter with identifier 00Bh returns the number of received Host-to-Device FISes of all types (Data and non-Data) to which the device responded with R_ERR$_P$ due to CRC error.

10.17.3.2.1.12 Identifier 00Dh

The counter with identifier 00Dh returns the number of received Host-to-Device FISes of all types (Data and non-Data) to which the devices responded with R_ERR$_P$ for reasons other than CRC error.

10.17.3.3   READ LOG EXT Log Page 11h

READ LOG EXT log page 11h is one page (512 bytes) in length. The first Dword of the log page contains information that applies to the rest of the log page. Software should continue to process counters until a counter identifier with value 0h is found or the entire page has been read. A counter identifier with value 0h indicates that the log page contains no more counter values past that point. Log page 11h is defined in Table 42

Table 42   READ LOG EXT Log Page 11h data structure definition

Byte	7	6	5	4	3	2	1	0
0	Reserved							
1	Reserved							
2	Reserved							
3	Reserved							
…	…							
n	Counter n Identifier							
n+1								
n+2	Counter n Value							
n + Counter n Length								
…	…							
508	Reserved							
509								
510								
511	Data Structure Checksum							

Counter n Identifier

  Phy event counter identifier that corresponds to Counter n Value. Specifies the particular event counter that is being reported. The Identifier is 16 bits in length.
  Valid identifiers are listed in.

Counter n Value

  Value of the Phy event counter that corresponds to Counter n Identifier. The number of significant bits is determined by Counter n Identifier bits 14:12 (as defined in section 10.17.3.2). The length of Counter n Value shall always be a multiple of 16-bits. All counters are one-extended. For example, if a counter is only physically implemented as 8-bits when it reaches the maximum value of 0xFF, it shall be one-extended to 0xFFFF. The counter shall stop (and not wrap to zero) after reaching its maximum value.

Counter n Length

  Size of the Phy event counter as defined by bits 14:12 of Counter n Identifier.
  The size of the Phy event counter shall be a multiple of 16-bits.

Data Structure Checksum

  The data structure checksum is the 2's complement of the sum of the first 511 bytes in the data structure. Each byte shall be added with unsigned arithmetic and overflow shall be ignored. The sum of all 512 bytes of the data structure will be zero when the checksum is correct.

Reserved All reserved fields shall be cleared to zero

10.17.4 NCQ NON-DATA (63h)

The NCQ NON-DATA feature allows the host to manage the outstanding NCQ commands and/or affect the processing of NCQ commands.

The NCQ NON-DATA command is a non-data NCQ command. Only specified NCQ NON-DATA subcommands are executed as Immediate NCQ commands.

If NCQ is disabled and an NCQ NON-DATA command is issued to the device, then the device aborts the command with the ERR bit set to one in the Status register and the ABRT bit set to one in the Error register. This command is prohibited for devices that implement the PACKET feature set. The queuing behavior of the device depends on which subcommand is specified.

Table 43   NCQ NON-DATA – Command definition

Register	7	6	5	4	3	2	1	0
Features(7:0)	Subcommand Specific				Subcommand			
Features(15:8)	Subcommand Specific							
Count(7:0)	TAG					Reserved		
Count(15:8)	Subcommand Specific							
LBA(7:0)	Subcommand Specific							
LBA(15:8)	Subcommand Specific							
LBA(23:16)	Subcommand Specific							
LBA(31:24)	Subcommand Specific							
LBA(39:32)	Subcommand Specific							
LBA(47:40)	Subcommand Specific							
ICC(7:0)	Reserved							
Auxiliary(7:0)	Reserved							
Auxiliary(15:8)	Reserved							
Auxiliary(23:16)	Subcommand Specific							
Auxiliary(31:24)	Reserved							
Device(7:0)	Res	1	Res	0	Reserved			
Command(7:0)	63h							

Table 43 defines the Subcommand values. If an invalid subcommand is specified, then the device aborts the command with the ERR bit set to one in the Status register, the ABRT bit set to one in the Error register, and causes all outstanding commands to be aborted.

Table 44   Subcommand Field

Subcommand	Description	Reference
0h	Abort NCQ queue	12.16.1
1h	Deadline Handling	12.16.2
2h - 4h	Reserved	-
5h	Set Features	Not supported
6h	Reserved	-
7h	ZAC Management Out	12.71.3
8h..Fh	Reserved	-

Subcommand Specific (TTAG) is the selected queue TAG. This allows the host to select the specific outstanding queued command to be managed.

The error and normal returns for this command are subcommand specific.

10.17.4.1   Abort NCQ Queue Subcommand (0h)

A Subcommand set to 0h specifies the Abort NCQ Queue subcommand (see 12.16.1). The Abort NCQ Queue subcommand is an immediate NCQ command. Support for this subcommand is indicated in the NCQ Queue Management log (see 10.17.4.4).

The Abort NCQ Queue subcommand affects only those NCQ commands for which the device has indicated command acceptance before accepting this NCQ NON-DATA command.

This command is prohibited for devices that implement the PACKET feature set.

Normal Outputs

If a supported Abort Type parameter is specified, then the device indicates success, even if the command results in no commands being aborted.

When an Abort NCQ Queue command completes successfully, a Set Device Bits FIS is sent to the host to complete the Abort subcommand and commands that were aborted as a consequence of the Abort subcommand by setting the ACT bits for those commands to one. This SDB FIS may also indicate other completed commands.

Error Outputs

The device returns command aborted if:

a) NCQ is disabled and an Abort NCQ queue command is issued to the device;

b) The value of the TTAG field equals the value of the TAG field;

c) The value of the TTAG field is an invalid TAG number; or

d) An unsupported Abort type parameter is specified.

10.17.4.2   Deadline Handling Subcommand (1h)

A Subcommand set to 1h specifies the Deadline Handling Subcommand (see 12.16.2). This subcommand controls how NCQ Streaming commands are processed by the device. Support for this subcommand is indicated in the NCQ NON-DATA Log (see 10.17.4.4).

The state of the WDNC and RDNC bits are preserved across software resets and COMRESETs (via Software Setting Preservations), and are not preserved across power cycles.

Normal Outputs

If this Deadline Handling Subcommand command is supported, the device returns command completed with no error.

When a Deadline Handling Subcommand command completes successfully, a Set Device Bits FIS is sent to the host to complete the Deadline Handling subcommand. This SDB FIS may also indicate other completed commands.

Error Outputs

The device returns command aborted if:

a)   NCQ is disabled and a Deadline Handling command is issued to the device;

b)   The value of the TTAG field equals the value of the TAG field;

c)   The value of the TTAG field is an invalid TAG number; or

d)   An unsupported Abort type parameter is specified.

10.17.4.3   SET FEATURES Subcommand (5h)

Ultrastar Archive Ha10 does not support Set Features Subcommand. When the drive receives Set Features Subcommand from the host, the drive will abort the command.

10.17.4.4　READ LOG EXT Log Page 12h(NCQ Non-data Log)

To determine the supported NCQ NON-DATA subcommands and their respective features, host software reads log address 12h. This log is supported if the NCQ NON-DATA command is supported (i.e., IDENTIFY DEVICE word 77 bit 5 is set to one).　Table 45 defines the 512 bytes that make up the SATA NCQ NON-DATA log. The value of the General Purpose Logging Version word is 0001h.

Table 45　NCQ NON-DATA Log (12h) data structure definition

Dword	Bits	Description
0	Subcommand 0h	
	31-5	Reserved
	4	Supports Abort Selected TTAG
	3	Supports Abort Non-Streaming
	2	Supports Abort Streaming
	1	Supports Abort All
	0	Supports Abort NCQ
1	Subcommand 1h	
	31-3	Reserved
	2	Supports Read Data Not Continue
	1	Supports Write Data Not Continue
	0	Supports DEADLINE HANDLING
2-4	31-0	Reserved
5	Subcommand 5h	
	31-1	Reserved
	0	Supports Set Features
6	31-0	Reserved
7	31-1	Reserved
	0	Support ZAC Management Out
8-127	31-0	Reserved

10.17.4.4.1　Supports the Abort NCQ subcommand

If Supports the Abort NCQ subcommand is set to one, then the device supports the Abort NCQ Queue command (12.16.1). If Supports the Abort NCQ subcommand is cleared to zero, then the device does not support the Abort NCQ Queue command.

10.17.4.4.2　Supports Abort All

If Supports Abort All is set to one, then the device supports the value of Abort All for the Abort Type parameter of the Abort NCQ Queue command. If Supports Abort All is cleared to zero, then the device does not support the value of Abort All for the Abort Type parameter of the Abort NCQ Queue command.

10.17.4.4.3　Supports Abort Streaming

If Supports Abort Streaming is set to one, then the device supports the value of Abort Streaming for the Abort Type parameter of the Abort NCQ Queue command. If Supports Abort Streaming is cleared to zero, then the device does not support the value of Abort Streaming for the Abort Type parameter of the Abort NCQ Queue command.

10.17.4.4.4　Supports Abort Non-Streaming

If Supports Abort Non-Streaming is set to one, then the device supports the value of Abort Non-Streaming for the Abort Type parameter of the Abort NCQ Queue command. If Supports Abort Non-Streaming is cleared to zero, then the device does not support the value of Abort Non-Streaming for the Abort Type parameter of the Abort NCQ Queue command.

10.17.4.4.5　Supports the Abort Selected TTAG

If Supports Abort Selected TTAG is set to one, then the device supports the value of Abort Selected for the Abort Type parameter of the Abort NCQ Queue command. If Supports Abort Selected TTAG is cleared to zero, then the device does not support the value of Abort Selected for the Abort Type parameter of the Abort NCQ Queue command.

10.17.4.4.6   Supports the Deadline Handling subcommand

If Supports the Deadline Handling subcommand is set to one, then the device supports the Deadline Handling command. If the Supports the Deadline Handling subcommand is cleared to zero, then the device does not support the Deadline Handling command.

10.17.4.4.7   Supports WDNC

If Supports WDNC is set to one, then the device supports the WDNC bit of the DEADLINE HANDLING command. If Supports WDNC is cleared to zero, then the device does not support the WDNC bit of the DEADLINE HANDLING command.

10.17.4.4.8   Supports RDNC

If Supports RDNC is set to one, then the device supports the RDNC bit of the Deadline Handling command. If Supports RDNC is cleared to zero, then the device does not support the WDNC bit of the Deadline Handling command.

10.17.4.4.9   Supports Set Features

If Supports Set Features is set to one, then the device supports the value of Set Features for the SET FEATURES subcommand of the NCQ NON-DATA command. If the Set Features bit is cleared to zero, then the device does not support the SET FEATURES subcommand of the NCQ NONDATA command.

10.17.5   Rebuild Assist log (15h)

If the device supports the Rebuild Assist feature (i.e., IDENTIFY DEVICE data Word 78 bit 11 is set to one), then the Rebuild Assist log shall be supported.

Table 46   Rebuild Assist log (15h) data structure definition

Byte	7	6	5	4	3	2	1	0
0	Reserved							Rebuild Assist Enabled
1…6	Reserved							
7	Physical Element Length (N)							
8	(MSB)							
	Disabled Physical Element Mask							
7 + N								(LSB)
8 + N	(MSB)							
	Disabled Physical Elements							
7+(2×N)								(LSB)
8+(2×N)..511	Reserved							

Physical Element Length
The Physical Element Length field indicates the number of bytes in the Disabled Physical Element Mask field and the number of bytes in the Disabled Physical Elements field.
The device shall ignore any attempt by the host to change the value of this field when writing to the Rebuild Assist log.

Disabled Physical Element Mask
The Disabled Physical Element Mask field indicates that bits in the Disabled Physical Elements field are supported. The device shall ignore any attempt by the host to change the value of this field when writing to the Rebuild Assist log.

Disabled Physical Elements
The Disabled Physical Elements field specifies if physical elements shall be disabled. Each bit that is set to one in the Disabled Physical Elements field specifies that LBAs associated with this physical element shall respond to read commands and write commands as if the associated LBAs have predicted errors.
Each bit that is set to zero in the Disabled Physical Elements field specifies that LBAs associated with this physical element shall respond to read commands and write commands as if the associated LBAs do not have predicted errors.

10.18 SCT Command Transport feature Set

10.18.1 Overview

10.18.1.1 Introduction

SMART Command Transport (SCT) is the method for the drive to receive commands using log page E0h and transporting data using log page E1h. These log pages are used as follows:

Table 47   SCT Log Page and direction

	Log page E0h		Log Page E1h
Write log page	Issue Command		Send Data to the drive
Read log page	Return Status		Received Data from the drive

There are two ways to access the log pages: using SMART READ/WRITE LOG and READ/WRITE LOG EXT. Both sets of commands access the same log pages and provide the same capabilities.

The log directory for log pages E0h and E1h should report a length of one. The length of log page E1h does not indicate the length of an SCT data transfer.

If SMART is supported, but not enabled, the drive supports SMART READ/WRITE LOG for Log page E0h and E1h.

If security is enabled and password has not been issued to unlock the device, all SCT commands will fail.

10.18.1.2 Capability definition

Capability Identification is performed by issuing Identify Device command. Word 206 of Identify Data is used to determine if SCT is enabled and which SCT Action Codes are supported.

Table 48   Identify Device Information Word 206

Word	Description	
206	SCT Command set support	
	15-12	Vendor Specific
	11-6	Reserved
	5	Action Code 5 (SCT Data Table) supported
	4	Action Code 4 (Features Control) supported
	3	Action Code 3 (Error Recovery Control) supported
	2	Action Code 2 (SCT Write Same) supported
	1	Obsolete
	0	SCT Feature Set supported (includes SCT status)

10.18.1.3 SCT Command Nesting and intermingling with Standard commands

In general, standard ATA commands can be intermingled with SCT Commands but SCT commands cannot be nested. SCT commands that do require a follow-on data transfer operation never have an issue with being intermixed with any ATA commands or each other. SCT commands that do require data transfer, on the other hand, may not be nested; that is, if a key command that requires a data transfer is issued, all data transfer – to or from the host – must complete before another SCT command is issued. In most cases, however, ATA read/write commands may be inserted in between SCT data transfers, that is, between complete SMART Read Log/Write Log commands. Furthermore, any reset (power-on, software or hardware) will cause the SCT command to be aborted.

10.18.1.4 Resets

If an SCT command is executing, any reset including Soft Reset, Hard Reset, COMRESET, and Power-On Reset all cause the command to be terminated. This could result in partial command execution or data loss. There is no indication once the drive becomes ready that the previous command was terminated.

10.18.2 SCT Command Protocol

10.18.2.1 Command Transport

SCT Command Transport occurs when a 512-byte data packet (called "Key Sector") is created and the written to SMART or extended log page E0h. The key sector specifies Action and Function Codes along with the parameters that are required to perform the action.

10.18.2.1.1 Issue SCT Command Using SMART

Table 49   Output Registers of SCT Command Using SMART

Command Block Output Registers									
Register	7	6	5	4	3	2	1	0
Feature	D6h							
Sector Count	01h							
Sector Number	E0h							
Cylinder Low	4Fh							
Cylinder High	C2h							
Device/Head	-	-	-	D	-	-	-	-
Command	B0h							

Table 50   Input Registers of SCT Command Using SMART

Command Block Input Registers (Success)										Command Block Input Registers (Error)									
Register	7	6	5	4	3	2	1	0	Register	7	6	5	4	3	2	1	0
Error	00h								Error	04h							
Sector Count	Depends on command (LSB)								Sector Count	Extended Status code (LSB)							
Sector Number	Depends on command (MSB)								Sector Number	Extended Status code (MSB)							
Cylinder Low	Number of sectors to transfer (LSB)								Cylinder Low	Number of sectors to transfer (LSB)							
Cylinder High	Number of sectors to transfer (MSB)								Cylinder High	Number of sectors to transfer (MSB)							
Device/Head	-	-	-	-	-	-	-	-	Device/Head	-	-	-	-	-	-	-	-
Status	50h								Status	51h							

10.18.2.1.2   Issue SCT Command Using Write Log Ext

Table 51   Input Registers of SCT Command Using Write Log Ext

Command Block Output Registers										
Register		7	6	5	4	3	2	1	0	
Feature	Current	Reserved								
	Previous	Reserved								
Sector Count	Current	01h								
	Previous	00h								
LBA Low	Current	E0h								
	Previous	Reserved								
LBA Mid	Current	00h								
	Previous	00h								
LBA High	Current	Reserved								
	Previous	Reserved								
Device/Head		-	-	-	D	-	-	-	-	
Command		3Fh								

Table 52   Output Registers of SCT Command Using Write Log Ext

Command Block Input Registers (Success)											Command Block Input Registers (Error)										
Register		7	6	5	4	3	2	1	0		Register		7	6	5	4	3	2	1	0	
Error		00h									Error		04h								
Sector Count	HOB=0	Depends on command (LSB)									Sector Count	HOB=0	Extended Status Code (LSB)								
	HOB=1	Reserved										HOB=1	Reserved								
LBA Low	HOB=0	Depends on command (MSB)									LBA Low	HOB=0	Extended Status Code (MSB)								
	HOB=1	Reserved										HOB=1	Reserved								
LBA Mid	HOB=0	Number of sectors (LSB)									LBA Mid	HOB=0	Number of sectors (LSB)								
	HOB=1	Reserved										HOB=1	Reserved								
LBA High	HOB=0	Number of sectors (MSB)									LBA High	HOB=0	Number of sectors (MSB)								
	HOB=1	Reserved										HOB=1	Reserved								
Device/Head		-	-	-	-	-	-	-	-		Device/Head		-	-	-	-	-	-	-	-	
Status		50h									Status		51h								

All ATA "previous" registers are reserved in Write Log Ext responses.

10.18.2.1.3   Key Sector Format

An SCT command (Key Sector) is always 512 bytes long. Table below shows the generic format of an SCT command.

Table 53   Key Sector Format

Byte	Field	Words	Description
1:0	Action Code	1	This field defines the command type and generally specifies the type of data being accessed, such as sector or physical action being performed, such as seek.
3:2	Function Code	1	This field specifies the type of access, and varies by command. For example, this can specify read, write, verify, etc.
X:4	Parameter1	Depends on command	Depends on command
Y:x+1	Parameter2	Depends on command	Depends on command
…	…	…	…
	Total Words	256	

The action codes are defined in Table below.

Table 54   SCT Action Code List

Action Code	Block Data	TF Data	Description
0000h	-	-	Reserved
0001h	Read/Write	Y	Long Sector Access (Not Supported)
0002h	Write	N	SCT Write Same
0003h	-	Y	Error Recovery Control
0004h	-	Y	Features Control
0005h	Read	N	SCT Data Table
0006h-BFFFh	-	-	Reserved
C000h-FFFFh	-	-	Vendor Specific

10.18.2.1.4 Extended Status Code

Table 55 Extended Status Code

Status Code	Definition
0000h	Command complete without error
0001h	Invalid Function Code
0002h	Input LBA out of range
0003h	Request sector count overflow. The number of sectors requested to transfer (Sector Count register) in the read or write log command is larger than required by SCT command.
0004h	Invalid Function code in Error Recovery command
0005h	Invalid Selection code in Error Recovery command
0006h	Host read command timer is less than minimum value
0007h	Host write command timer is less than minimum value
0008h	Background SCT command was aborted because of an interrupting host command
0009h	Background SCT command was terminated because of unrecoverable error
000Ah	Invalid Function code in Long Sector Access command
000Bh	SCT data transfer command was issued without first issuing an SCT command
000Ch	Invalid Function code in Feature Control command
000Dh	Invalid Feature code in Feature Control command
000Eh	Invalid New State value in Feature Control command
000Fh	Invalid Option Flags in Feature Control command
0010h	Invalid SCT Action code
0011h	Invalid Table ID (table not supported)
0012h	Command was aborted due to drive security being locked
0013h	Invalid revision code
0015h	SCT Timeout
0017h	Blocking SCT Write Same command was terminated because of unrecoverable error
0018h-BFFFh	Reserved
C000h-C002h	Vendor Specific
C003h	Overlay switch failure in Long Sector Access command
C004h	Read Long failure
C005h	Write Long failure
C006h	Write Cache enable failure
C007h-FFEFh	Vendor Specific
FFF0h-FFFEh	Reserved
FFFFh	SCT command executing in background

10.18.2.2   Data transfer

Once an SCT command has been issued, status can be checked and data can be transferred. Data transfer uses log page E1h.

10.18.2.2.1   Read/Write SCT Data Using SMART

Table 56   Input Registers of SCT Data Transfer Using SMART

Command Block Output Registers									
Register	7	6	5	4	3	2	1	0	
Feature	D5h(Read)/D6h(Write)								
Sector Count	Number of sectors to be transferred								
Sector Number	E1h								
Cylinder Low	4Fh								
Cylinder High	C2h								
Device/Head	-	-	-	D	-	-	-	-	
Command	B0h								

10.18.2.2.2   Read/Write SCT Data Using Read/Write Log Ext

Table 57   Input Registers of SCT Data Transfer using Read/Write Log Ext

Command Block Output Registers										
Register		7	6	5	4	3	2	1	0	
Feature	Current	Reserved								
	Previous	Reserved								
Sector Count	Current	01h or 08h								
	Previous	00h								
LBA Low	Current	E1h								
	Previous	Reserved								
LBA Mid	Current	00h								
	Previous	00h								
LBA High	Current	Reserved								
	Previous	Reserved								
Device/Head		-	-	-	D	-	-	-	-	
Command		2Fh(Read)/3Fh(Write)								

10.18.2.3 SCT Status Request

Once an SCT command has been issued, a status is reported in the ATA registers. This status indicates that the command was accepted or that an error occurred. This ATA status return does not indicate successful completion of the SCT actions. Some commands can take several minutes or even hours to execute. In this case, the host can determine execution progress by requesting SCT status.

Log page E0h contains the status information. Reading log page E0h retrieves the status information. The SCT status may be acquired any time that the host is allowing to send a command to the device. This command will not change the power state of the drive, nor terminate any background activity, including any SCT command in progress.

10.18.2.3.1   SCT Status Request Using SMART

Table 58   Input Registers of SCT Status Request Using SMART

Command Block Output Registers									
Register	7	6	5	4	3	2	1	0
Feature	D5h								
Sector Count	01h								
Sector Number	E0h								
Cylinder Low	4Fh								
Cylinder High	C2h								
Device/Head	-	-	-	D	-	-	-	-
Command	B0h								

10.18.2.3.2   SCT Status Request Using Read Log Ext

Table 59   Input Registers of SCT Status Request Using Read Log Ext

Command Block Output Registers										
Register		7	6	5	4	3	2	1	0
Feature	Current	Reserved								
	Previous	Reserved								
Sector Count	Current	01h								
	Previous	00h								
LBA Low	Current	E0h								
	Previous	Reserved								
LBA Mid	Current	00h								
	Previous	00h								
LBA High	Current	Reserved								
	Previous	Reserved								
Device/Head		-	-	-	D	-	-	-	-
Command		2Fh								

10.18.2.3.3   Format of SCT Status Response

Table 60   Data Format of SCT Status Response -1

Byte	Type	Field Name	Value	Description
1:0	Word	Format Version	0003h	Status Response format version number
3:2	Word	SCT Version		Manufacturer's vendor specific implementation version number
5:4	Word	SCT Spec.	0001h	Highest level of SCT Technical Report supported
9:6	Dword	Status Flags		Bit 0 : Segment Initialized Flag If this bit is set to 1, an SCT Write Same command write to all LBAs of the drive has completed without error. This bit shall be cleared to 0 when any user LBA is written, even if write cache is enabled. This bit is else cleared if the capacity of the drive is changed via SETMAX, SETMAX EXT or DCO. This bit is preserved through a power cycle. Bit 1-31 : Reserved
10	Byte	Drive Status		0 = Active waiting for a command 1 = Stand-by 2 = Sleep 3 = DST executing in background 4 = SMART ODC executing in background 5 = SCT executing in background
13:11	Byte[3]	reserved	00h	
15:14	Word	Extended Status Code		Status Of last SCT command issued. FFFFh if SCT command executing in background.
17:16	Word	Action Code		Action code of last SCT command issued. If the Extended Status Code is FFFFh, this is the Action Code of the command that is current executing.
19:18	Word	Function Code		Function code of last SCT command issued. If the Extended Status Code is FFFFh, this is the Function Code of the command that is current executing.
39:20	Byte[20]	reserved	00h	
47:40	Qword	LBA		Current LBA of SCT command execution in background. If there is no command currently executing in the background, this field is undefined.
199:48	Byte[152]		00h	
200	Byte	HDA Temp		Current HDA temperature in degrees Celsius. This is a 2's complement number. 80h indicates that this value is invalid.
201	Byte	Min Temp		Minimum HDA temperature in degrees Celsius. This is a 2's complement integer. 80h indicates that this value is invalid.
202	Byte	Max Temp		Maximum HDA temperature in degrees Celsius. This is a 2's complement number. 80h indicates that this value is invalid.
203	Byte	Life Min Temp		Minimum HDA temperature in degrees Celsius seen for the life of the device. This is a 2's complement integer. 80h indicates that this value is invalid.
204	Byte	Life Max Temp		Maximum HDA temperature in degrees Celsius seen for the life of the drive. This is a 2's complement number. 80h indicates that this value is invalid.

Table 61   Data Format of SCT Status Response -2

Byte	Type	Field Name	Value	Description
205	Byte	Reserved	00h	
209:206	Dword	Over Limit Count		Number of temperature recording Intervals since the last power-on reset where the recorded temperature was greater than Max Op Limit. See Table 72 for information about this Interval.
213:210	Dword	Under Limit Count		Number of temperature recording Intervals since the last power-on reset where the recorded temperature was less than Min Op Limit. See Table 72 for information about this Interval.
479:214	Byte[275]	Reserved	00h	
511:480	Byte[32]	Vendor Specific	00h	

10.18.3   SCT Command Set

10.18.3.1   SCT Write Same (action code : 0002h)

Table 62   SCT Write Same (Inputs)

Inputs: (Key Sector)

Word	Name	Value	Description
0	Action Code	0002h	This action writes a pattern or sector of data repeatedly to the media. This capability could also be referred to as "Write All" or "Write Same".
1	Function Code	0001h	Repeat Write Pattern (Background Operation)
		0002h	Repeat Write Sector (Background Operation)
		0101h	Repeat Write Pattern (Blocking Operation)
		0102h	Repeat Write Sector (Blocking Operation)
5:2	Start LBA	Qword	First LBA
9:6	Count	Qword	Number of sectors to fill
11:10	Pattern	Dword	If the Function Code is 0001h, this field contains a 32-bit pattern that is written on the media starting at the location specified in words two through five
255:12	reserved	0000h	

Table 63   SCT Write Same (Outputs)

Outputs: (TF Data)

Command Block Input Registers (Success)	
Error	00h
Sector Count	Reserved
Sector Number	Reserved
Cylinder Low	Number of sectors to transfer (LSB) = 01h
Cylinder High	Number of sectors to transfer (MSB) = 00h
Device/Head	Reserved
Status	50h

The SCT Write Same command will begin writing sectors from Start LBA in incrementing order until Count sectors have been written. The HPA feature determines the last user LBA. This command will not write over a hidden partition when hidden partitions are enabled using the Host Protected Area drive capabilities. Automatic sector reassignment is permitted during the operation of this function.

If Start LBA or Start LBA + Count go beyond the last user LBA then an error is reported and the SCT command is not executed.

Once the key sector has been issued, if the Function Code was 0002h or 0102h and the TF Data indicates that the drive is ready to receive data, log page E1h should be written to transfer the data.

Implementation note for Background Operation (Function code = 0001h, 0002h)

In this mode, the drive will return command completion status when the drive finished receiving data.

Any command, including IDENTIFY DEVICE, other than SCT Status, issued to the drive while this command is in progress will terminate the SCT Write Same command. The incoming command is executed.

Use the SCT Status command to retrieve status information about the current SCT command. Example status information includes: command active or complete, current LBA, and errors. When this command is in progress, the SCT status error code will be FFFFh, and set to 0000h if the command completes without error. It will be less than FFFFh and grater the 0000h if the command terminated prematurely for any reason.

Possible Extended Status Code for Background Operation (Function code = 0001h, 0002h)	
0008h	Background SCT command was aborted because of an interrupting host command
0009h	Background SCT command was terminated because of unrecoverable error
FFFFh	SCT command executing in background

Implementation note for Blocking Operation (Function code = 0101h, 0102h)

In this mode, the drive will return command completion status when the drive finished the SCT Write Same operation.

Outputs for Error

Command Block Input Registers (Error)									
Register	7	6	5	4	3	2	1	0
Error	04h								
Sector Count	Extended Status code (LSB)								
Sector Number	Extended Status code (MSB)								
Cylinder Low	N/A								
Cylinder High	N/A								
Device/Head	-	-	-	-	-	-	-	-
Status	51h								

Possible Extended Status Code for Blocking Operation (Function code = 0101h, 0102h)	
0017h	Blocking SCT Write Same command was terminated because of unrecoverable error

Write pointer that is used for checking sequential write will be updated by this command.

10.18.3.2 Error Recovery Control command (action code : 0003h)

Table 64 Error Recovery Control command (Inputs)

Inputs: (Key Sector)

Word	Name	Value	Description
0	Action Code	0003h	Set the read and write error recovery time
1	Function Code	0001h	Set New Value
		0002h	Return Current Value
2	Selection Code	0001h	Read Timer
		0002h	Write Timer
3	Value	Word	If the function code is 0001h, then this field contains the recovery time limit in 100ms units. The minimum SCT timeout value is 65 (=6.5 second). When the specified time limit is shorter than 6.5 second, the issued command is aborted.
255:4	reserved	0000h	

Table 65 Error Recovery Control command (Outputs)

Outputs: (TF Data)

Command Block Input Registers (Success)	
Error	00h
Sector Count	If Function Code was 0002h, then this is the LSB of the requested recovery limit. Otherwise, this field is reserved.
Sector Number	If Function Code was 0002h, then this is the MSB of the requested recovery limit. Otherwise, this field is reserved.
Cylinder Low	reserved
Cylinder High	reserved
Device/Head	reserved
Status	50h

The Error Recovery Control command can be used to set time limits for read and write error recovery. For non-queued commands, these timers apply to command completion at the host interface. For queued commands where in order data delivery is enabled, these timers begin counting when the command is sent to the device. These timers do not apply to streaming commands, or to queued commands when out-of-order data delivery is enabled.

These command timers are volatile. The default value is 0 (i.e. disable command time-out).

10.18.3.3 Feature Control Command (action code : 0004h)

Table 66   Feature Control command (Inputs)

Inputs: (Key Sector)

Word	Name	Value	Description
0	Action Code	0004h	Set or return the state of drive features described in Table 68
1	Function Code	0001h	Set state for a feature
		0002h	Return the current state of a feature
		0003h	Return feature option flags
2	Feature Code	Word	See Table 68 for a list of the feature codes
3	State	Word	Feature code dependent value
4	Option Flags	Word	Bit15:1 = Reserved If the function code is 0001h, setting bit 0 to one causes the requested feature state change to be preserved across power cycles. If the function code is 0001h, setting bit 0 to zero causes the requested feature state change to be volatile. A hard reset causes the drive to revert to default, or last non-volatile setting.
255:5	reserved	0000h	

Table 67   Feature Control command (Outputs)

Outputs: (TF Data)

Command Block Input Registers (Success)	
Error	00h
Sector Count	If Function Code was 0002h, then this is the LSB of Feature State. If Function Code was 0003h, then this is the LSB of Option Flags. Otherwise, this field is reserved.
Sector Number	If Function Code was 0002h, then this is the MSB of Feature State. If Function Code was 0003h, then this is the MSB of Option Flags. Otherwise, this field is reserved.
Cylinder Low	reserved
Cylinder High	reserved
Device/Head	reserved
Status	50h

Table 68   Feature Code List

Feature Code	State Definition
0001h	0001h : Allow write cache operation to be determined by Set Feature command 0002h : Force write cache enabled 0003h : Force write cache disabled If State 0001h is selected, the ATA Set Feature command will determine the operation state of write cache. If State 0002h or 0003h is selected, write cache will be forced into the corresponding operation state, regardless of the current ATA Set Feature state. Any attempt to change the write cache setting through Set Feature shall be accepted, but otherwise ignored, and not affect the operation state of write cache and complete normally without reporting an error. In all cases, bit 5 of word 85 in the Identify Device information will reflect the true operation state of write cache, one indicating enabled and zero indicating disabled. The default state is 0001h.
0002h	0001h : Enable Write Cache Reordering 0002h : Disable Write Cache Reordering The default state is 0001h. The drive does not return error for setting state 0002h, but the state is ignored.
0003h	Set time interval for temperature logging. 0000h is invalid. 0001h to FFFFh logging interval in minutes. This value applies to the Absolute HDA Temperature History queue. Issuing this command will cause the queue to be reset and any prior values in the queue will be lost. Queue Index shall be set to zero and the first queue location will be set to the current value. All remaining queue locations are set to 80h. The Sample Period, Max Op Limit, Over Limit, Min Op Limit and Under Limit values are preserved. Default value is 0001h.
0004h-CFFFh	Reserved
D000h-FFFFh	Vendor Specific

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10.18.3.4 SCT Data Table Command (action code : 0005h)

Table 69   SCT Data Table command (Inputs)

Inputs: (Key Sector)

Word	Name	Value	Description
0	Action Code	0005h	Read a data table
1	Function Code	0001h	Read Table
2	Table ID	Word	See Table 72 for a list of data tables
255:2	reserved	0000h	

Table 70   SCT Data Table command (Outputs)

Outputs: (TF Data)

Command Block Input Registers (Success)	
Error	00h
Sector Count	reserved
Sector Number	reserved
Cylinder Low	Number of sectors to transfer (LSB) = 01h
Cylinder High	Number of sectors to transfer (MSB) = 00h
Device/Head	reserved
Status	50h

Table 71   Table ID

Table ID	Description
0000h	Invalid
0001h	Reserved
0002h	HDA Temperature History Table (in absolute degree C). See Note 1 – *The Absolute HDA Temperature History is preserved across power cycles with the requirement that when the drive powers up, a new entry is made in the history queue of 80h, an invalid absolute temperature value. This way an application viewing the history can see the discontinuity in temperature result from the drive being turned off.* *Note 2 – When the Absolute HDA Temperature history is cleared, for new drives or after changing the Logging Interval, the Queue Index shall be set to zero and the first queue location shall be set to the current Absolute HDA Temperature value. All remaining queue locations are set to 80h.*
0003h-CFFFh	Reserved
D000h-FFFFh	Vendor Specific

Table 72 Data Format of HDA Absolute Temperature History Table -1

Byte	Size	Field Name	Description
1:0	Word	Format Version	Data table format version (=0002h)
3:2	Word	Sampling Period	Absolute HDA Temperature sampling period in minutes. 0000h indicates sampling is disabled.
5:4	Word	Interval	Timer interval between entries in the history queue.
6	Byte	Max Op Limit	Maximum recommended continuous operating temperature. This is a one byte 2's complement number that allows a range from -127°C to +127°C to be specified. 80h is an invalid value. This is a fixed value.
7	Byte	Over Limit	Maximum temperature limit. This is a one byte 2's complement number that allows a range from -127°C to +127°C to be specified. 80h is an invalid value. This is a fixed value.
8	Byte	Min Op Limit	Minimum recommended continuous operating limit. This is a one byte 2's complement number that allows a range from -127°C to +127°C to be specified. 80h is an invalid value. This is a fixed value.
9	Byte	Under Limit	Minimum temperature limit. This is a one byte 2's complement number that allows a range from -127°C to +127°C to be specified. 80h is an invalid value. This is a fixed value.
29:10	Byte[20]	Reserved	
31:30	Word	Queue Size	Number of entry locations in history queue. This value is 128.
33:32	Word	Queue Index	Last updated entry in queue. Queue Index is zero-based, so Queue Index 0000h is the first location in the buffer (at offset 34). The most recent temperature entered in the buffer is at Queue Index + 34. See Note 1 and Note 2.

Table 73 Data Format of HDA Absolute Temperature History Table -2

Byte	Size	Field Name	Description
(Queue Size+33):34	Byte[Queue Size]	Queue Buffer	This is a circular buffer of absolute HDA Temperature values. These are one byte 2's complement numbers, which allow a range from -127°C to +127°C to be specified. A value of 80h indicates an initial value or a discontinuity in temperature recording. The Actual time between samples may vary because commands may not be interrupted. The sampling period is the minimum time between samples. See Note 1. If the host changes the logging interval using the volatile option, the interval between entries in the queue may change between power cycles with no indication to the host.
511⊗Queue Size +34)	Byte [512-Queue Size-34]	Reserved	

Note 1 – The Absolute HDA Temperature History is preserved across power cycles with the requirement that when the drive powers up, a new entry is made in the history queue of 80h, an invalid absolute temperature value. This way an application viewing the history can see the discontinuity in temperature result from the drive being turned off.

Note 2 – When the Absolute HDA Temperature history is cleared, for new drives or after changing the Logging Interval, the Queue Index shall be set to zero and the first queue location shall be set to the current Absolute HDA Temperature value. All remaining queue locations are set to 80h.

10.19 Extended Power Conditions (EPC) feature

The Extended Power Conditions feature set provides a host with additional methods to control the power condition of a device. Host can check power condition using Check Power Mode command.

Subcommand code 4Ah enables, disables, and configures the use of the Extended Power Conditions feature set. If the EPC feature set is not supported, then the device return command aborted Table 74 describes the EPC subcommands and Table 75 describes the power condition IDs.

Table 74   Extended Power Conditions Subcommands

EPC Subcommand	Description
0h	Restore Power Condition Settings
1h	Go To Power Condition
2h	Set Power Condition Timer
3h	Set Power Condition State
4h	Enable the EPC feature
5h	Disable the EPC feature
6h … Fh	Reserved

Table 75   Power Condition IDs

Power Condition ID	Power Condition Name	Description
00h	standby_z	Standby
curre01h	standby_y	Low RPM Idle
02h…80h		Reserved
81h	idle_a	Active Idle
82h	idle_b	Low Power Idle
83h	idle_c	Low RPM Idle
84h … FEh		Reserved
FFh	All	All supported EPC power conditions

10.19.1   Power conditions

idle_a, idle_b and idle_c are power conditions within the PM1:Idle power management state. standby_y and standby_z are power conditions within the PM2:Standby power management state. Please refer to ACS-2 "3.1 Definitions and abbreviations" about PM1:Idle and PM2:Standby. The power conditions are ordered from highest power consumption (i.e., shortest recovery time) to lowest power consumption (i.e., longest recovery time) as follows:

idle_a power >= idle_b power >= idle_c power >= standby_y power >= standby_z power

Each of these power conditions has a set of current, saved and default settings. Default settings are not modifiable. Default and saved settings persist across power cycles. The current settings do not persist across power cycles.

10.19.2   Power condition timers

The device has manufacturer specified power-on default settings for the power condition timers. Power condition timers are changeable with the SET FEATURES Extended Power Conditions subcommand.

A power condition timer set to zero indicates that the associated power condition is disabled.

If the power condition is enabled, then the value of each timer specifies the time after command completion that the device waits before transitioning to the power condition. All enabled power condition timers run concurrently.

On command completion all timers that were stopped are initialized with the Current Timer settings values and started.

As a result of processing any command, the device may change to a different power condition.

If an enabled timer associated with a power condition lower than the power condition that the device is currently in expires, then the device transitions to the power condition associated with that timer (e.g., if the standby_z timer is set to a smaller interval than the idle_b timer, and the device is currently in the standby_z power condition, then the device remains in the Standby_z power condition when the idle_b timer expires). If the timer expiration qualifies the device to transition to more than one enabled power condition, then the device transitions to the power condition with the least power consumption.

If a command is accepted that requires a transition to Active, then the timers are stopped. If a command is accepted that does not require a transition to Active (e.g., a Check Power Mode command), then the timers continues to run.

Prior to entering into any power condition that prevents accessing the media (e.g., before a hard drive stops its spindle motor during transition to the standby_z power condition) and if volatile write cache is enabled, then the device shall write all cached data to the medium for the device (e.g., as a device does in response to a flush command).

10.19.3   Interaction with resets, commands and other features

On successful processing of a power cycle, the EPC enables sub command, the device:
When EPC is Enabling, the following content is executed.
1)   stop all EPC timers.
2)   copy the Saved Timer Enabled field to the Current Timer Enabled field, for all supported power conditions.
3)   copy the Saved Timer Settings field to the Current Timer Settings field, for all supported power conditions.
4)   initialize and restart all enabled EPC timers with Current values.

On successful processing of a hardware reset, a software reset, or a DEVICE RESET command, the device:
When EPC is Enabling, the following content is executed.
1)   stop all EPC timers.
2)   remain in the current power condition.
3)   initialize and restart all enabled EPC timers with Current values.

The Extended Power Conditions feature set and the Advanced Power Management feature set are mutually exclusive. All EPC subcommands, except Enable the EPC feature set, returns command aborted if the EPC feature set is disabled. If the device processes a SET FEATURES Enable APM subcommand without error and IDENTIFY DEVICE data word 120 bit 7 is set to one, then the device shall disable the EPC feature set.

During background activities, all EPC timers may be stopped. On completion of the activity, any stopped EPC timers are restarted from where they were stopped.

10.20 Sanitize Device feature set

10.20.1 Overview

The Sanitize Device feature set allows hosts to request that devices modify the content of all user data areas in the device using sanitize operations. Sanitize operations use one of the operations defined in this sub clause to make all previously written content in the user data area of the device unable to be read. Sanitize operations affect the following:

a) user data areas
b) user data areas that are not currently allocated (e.g., previously allocated areas and physical sectors that have become inaccessible)
c) user data caches

Sanitize operations render user data previously stored in caches, using any methods, unable to be read.
The Sanitize Device feature set is implemented, the following commands are supported:

a) SANITIZE STATUS EXT
b) SANITIZE FREEZE LOCK EXT
c) CRYPTO SCRAMBLE EXT (data encryption model only)
d) OVERWRITE EXT

If physical sectors that have become inaccessible are not successfully sanitized, then Sanitize operations don't cause a transition to the SD3: Sanitize Operation Failed state.
Sanitize operations don't affect non-user data areas (e.g., logs, and Device SMART data structure).
Sector reallocation is able to be performed during the operation of this function. After completion of a sanitize operation, if:

a) all physical sectors that are available to be allocated for user data have been successfully sanitized
b) any physical areas that were not successfully sanitized were removed from use,

then:

a) the Sanitize Device state machine transitions to SD4: Sanitize Operation Succeeded; and
b) in subsequent SANITIZE STATUS EXT commands, set the SANITIZE OPERATION COMPLETED WITHOUT ERROR bit to one in the Normal Outputs

Conversely, if physical sectors that are available to be allocated for user data (e.g. allocated physical sectors) were not successfully

sanitized, then:

a) the Sanitize Device state machine transitions to SD3: Sanitize Operation Failed; and
b) in subsequent SANITIZE STATUS EXT commands, return an error and set the LBA field of the Error Outputs to report the value of Sanitize Command Unsuccessful

To initiate a sanitize operation the host issues one of the following sanitize operation commands:

a) A CRYPTO SCRAMBLE EXT command (data encryption model only)
b) An OVERWRITE EXT command

The sanitize operation continues after command completion of the initiating sanitize operation command. The SANITIZE STATUS EXT command to reports progress and completion.

After a device has started processing a sanitize operation, and until the device transitions to the SD0:

Sanitize Idle state, the device aborts all commands other than:

a) IDENTIFY DEVICE command
b) IDLE IMMEDIATE command with UNLOAD feature
c) Request Sense Data Ext command;
d) SANITIZE STATUS EXT command;
e) SMART READ LOG command requesting log address E0h;
f) READ LOG EXT command requesting one of the following log addresses:
   A) E0h;
   B) 30h; or
   C) 10h;

g) READ LOG DMA EXT command requesting one of the following log addresses:
   A) E0h;
   B) 30h; or
   C) 10h;
h) SMART RETURN STATUS command; or
i) SET FEATURES PUIS feature set device spin-up subcommand.

If a sanitize operation is interrupted by a power-on reset, the sanitize operation continues. If the device processes a power-on reset and enters the PM5: PUIS and spin-up subcommand not supported state (see Figure 13), then the device resumes processing the sanitize operation after receiving a media access command. (The media access command reports failure because the sanitize operation does not allow media access commands. However, since the device has received a media access command, the device is spin-up.)

The SANITIZE STATUS EXT command returns information about the current sanitize operation, if any, including a percentage of completion if a sanitize operation is in progress.

A CRYPTO SCRAMBLE EXT command (data encryption model only), or OVERWRITE EXT command that returns command completion with no error transitions the device into the SD2: Sanitize Operation state. The device remains in this state until the device has completed the sanitize operation (see Figure 13).

The SANITIZE FREEZE LOCK EXT command causes the device to transition to the SD1: Sanitize Frozen state and causes any subsequent CRYPTO SCRAMBLE EXT command (data encryption model only) or OVERWRITE EXT command to be aborted. If the device processes a power-on reset or a hardware reset, then the device transitions from the Sanitize Frozen state to the Sanitize Idle state.

The crypto scramble operation makes previously written contents in the user data area irretrievable. (data encryption model only)

The overwrite operation fills all user data with a four byte pattern passed within the LBA field of the command. Parameters for the OVERWRITE EXT command include a count for multiple overwrites and the option to invert the four byte pattern between consecutive overwrite passes.

A software reset does not cause the SD2: Sanitize Operation state to transition to another state.

10.20.2   Sanitize Device Feature

Sanitize Device Feature Set is a powerful data erase feature. Two data erase features are supported. One is an Overwrite Ext command, and the other is Crypto Scramble Ext command. Crypto Scramble Ext command can be supported with a data encryption model only.

Individual Sanitize Device commands are identified by the value specified in the FEATURE field.

The following commands are supported for this feature.

Command	COMMAND field value	FEATURE field value
SANITIZE STATUS EXT	('B4'h)	('0000'h)
CRYPTO SCRAMBLE EXT (data encryption model only)	('B4'h)	('0011'h)
OVERWRITE EXT	('B4'h)	('0014'h)
SANITIZE FREEZE LOCK EXT	('B4'h)	('0020'h)

10.20.3   Sanitize Device state machine

Figure 13 describes the operation of the Sanitize Device state machine.

10.20.3.1   SD0: Sanitize Idle State

In SD0: Sanitize Idle state the Sanitize Device state machine is ready for a sanitize operation command or a SANITIZE FREEZE LOCK EXT command.

This state is entered when the device processes a power-on reset while in the SD1: Sanitize Freeze Lock state or the SD4: Sanitize Operation Succeeded state.

While in this state, Sanitize Device state machine does not change state if the device processes:

a) a hardware reset or power-on reset
b) a SANITIZE STATUS EXT command

Transition SD0:SD1: If the device processes a SANITIZE FREEZE LOCK EXT command, then the device transitions to the SD1: Sanitize Frozen state.

Transition SD0:SD2: If the device successfully processes a supported sanitize operation command, then the device transitions to the SD2: Sanitize Operation state.
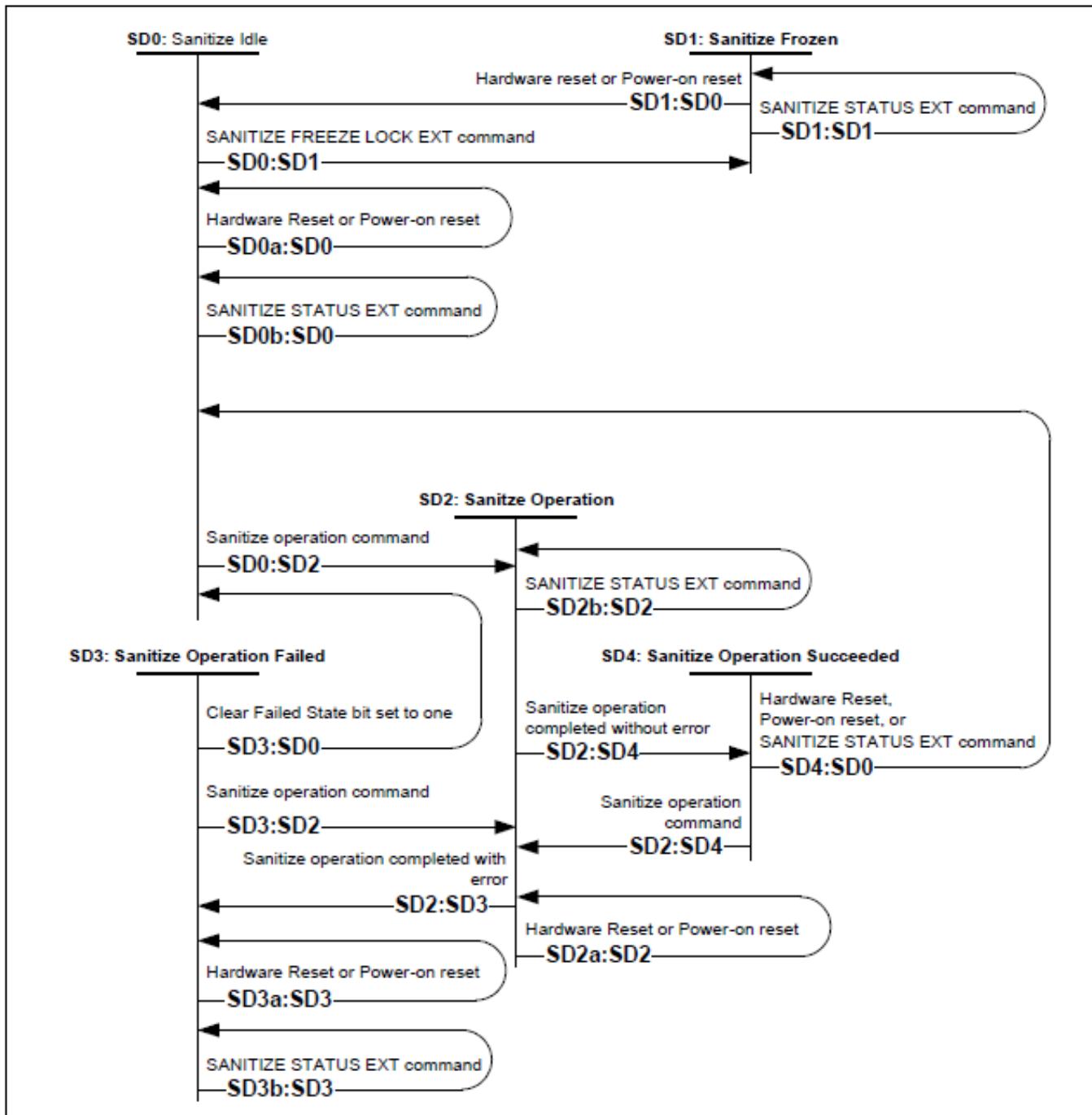
Figure 13   Sanitize Device state machines

10.20.3.2   SD1: Sanitize Frozen State

In SD1: Sanitize Frozen state, the device will abort Sanitize operation commands.

While in this state, Sanitize Device state machine does not change state if the device processes a SANITIZE STATUS EXT command.

Transition SD1:SD0:   If the device processes a hardware reset or a power-on reset, then the device transitions to the SD0: Sanitize Idle state.

10.20.3.3   SD2: Sanitize Operation State

In the SD2: Sanitize Operation state, the device is processing a sanitize operation.

While in this state, Sanitize Device state machine does not change state if the device processes:

    a)   a hardware reset or power-on reset; and

    b)   a SANITIZE STATUS EXT command.

Transition SD2:SD3:   If a sanitize operation completes with an error, then the device transitions to the SD3: Sanitize Operation Failed state.

Transition SD2:SD4:   If a sanitize operation completes without an error, then the device transitions to the SD4: Sanitize Operation Succeeded state.

10.20.3.4   SD3: Sanitize Operation Failed State

In the SD3: Sanitize Operation Failed state, the device has completed processing a sanitize operation without success.

While in this state, Sanitize Device state machine does not change state if the device processes:

    a)   a hardware reset or power-on reset; and

    b)   a SANITIZE STATUS EXT command with the CLEAR SANITIZE OPERATION FAILED bit cleared to zero.

Transition SD3:SD0:   If

    a)   the Sanitize operation was initiated by a Sanitize operation command with the FAILURE MODE bit set to one; and

    b)   the SANITIZE STATUS EXT command has been successfully processed with the CLEAR SANITIZE OPERATION FAILED bit set to one,

then the device transitions to the SD0: Sanitize Idle state.

Transition SD3:SD2:   If the device processes a supported sanitize operation command that reports command completion with no error, then the device transitions to the SD2: Sanitize Operation state.

10.20.3.5   SD4: Sanitize Operation Succeeded State

In the SD4: Sanitize Operation Succeeded state, the device has completed processing a successful sanitize operation.

Transition SD4:SD0:   If the device processes

    a)   a hardware reset;

    b)   a power-on reset; or

    c)   a SANITIZE STATUS EXT command

then the device transitions to the SD0: Sanitize Idle state.

Transition SD4:SD2:   If the device successfully processes a supported Sanitize operation command, then the device transitions to the SD2: Sanitize Operation state.

10.21 Zone types

10.21.1   Conventional zones

A Conventional zone is a type of zone:
   a) that is not associated with a write pointer; and
   b) on which the device:
      A) does not return the errors described in 10.21.2.2; and
      B) processes commands as described in ACS-4.

10.21.2   Write pointer zones

10.21.2.1   Features common to all write pointer zones

A write pointer zone is a type of zone that has a write pointer that indicates a location within that zone. Each write pointer zone has one write pointer. That write pointer indicates the LBA that the host should specify in the LBA field of a subsequent write command for that write pointer zone.

Each write pointer zone in a device is in one of the states defined by the Zone Condition state machine (see 10.21.2.3). The state of each zone affects the contents of the ZONE CONDITION field in the data structure returned by the REPORT ZONES command (see 12.71.7).

Depending on the state of a zone, the write pointer for that zone may or may not be valid (see 10.21.2.3.1).

If a write command is able to write some but not all of the specified logical sectors before encountering an error that prevents further writing to the media, then the value of the write pointer is outside the scope of this standard. The host should use the REPORT ZONES command (see 12.71.7) to determine the current write pointer and other characteristics of the zone.

A RESET WRITE POINTERS EXT command (see 12.71.8) sets the write pointer in a write pointer zone to the lowest LBA of that write pointer zone.

Figure 14   shows a write pointer zone where no LBAs have been written since the last RESET WRITE POINTERS
EXT command (see 12.71.8) for that zone. The write pointer is set to the lowest LBA of that zone.

lowest LBA	lowest LBA+1	lowest LBA+2	...	lowest LBA
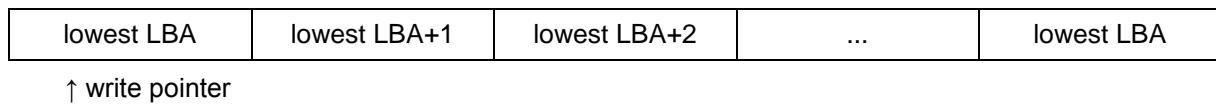
↑ write pointer

Figure 14   Write pointer zone and write pointer after reset write pointer with no subsequent writes

Figure 15 shows a write pointer zone where LBAs have been written since the last RESET WRITE POINTERS EXT command (see 12.71.8) for that zone (i.e., LBAs less than the write pointer value) and LBAs have not been written since the last RESET WRITE POINTERS EXT command for that zone (i.e., LBAs greater than or equal to the write pointer value).

lowest LBA	...			...	highest LBA

↑ write pointer

Key

	blocks that have been written
	blocks that have not been written

Figure 15   Write pointer zone and write pointer

Figure 16 shows the relationship of the write pointer for the following example:

1. at time 1, the write pointer zone starts with the write pointer set to the lowest LBA in that zone;
2. at time 2, a write command writes data starting at that zone's lowest LBA and sets the write pointer to the last LBA written by the command plus one;
3. at time 3, a write command:
   1) writes data that starts at the write pointer position after time 2 and extends to the end of that zone;
   2) transitions that zone to the ZC5: Full state (see 10.21.2.3.6); and
   3) makes the write pointer invalid;
   and
   4) at time 4, a RESET WRITE POINTERS EXT command (see 12.71.8) sets the write pointer to the lowest LBA of that write pointer zone.

Time 1 Write pointer set to the lowest LBA of that zone

lowest LBA	...	highest LBA
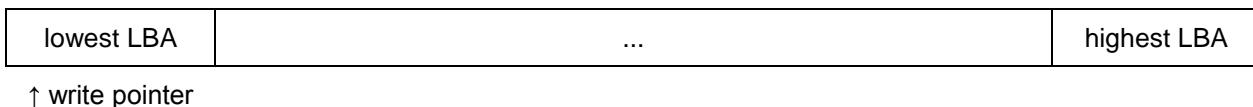
↑ write pointer

Time 2 A write operation increases the write pointer

lowest LBA	...			...	highest LBA

↑ write pointer

Time 3 A write operation writes data to the end of that zone

lowest LBA	...			...	highest LBA
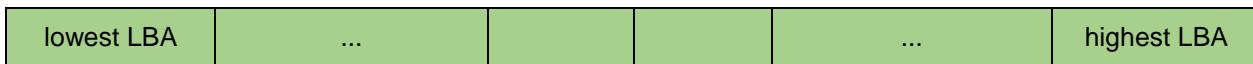
Time 4 RESET WRITE POINTERS EXT command sets the write pointer back to the lowest LBA of that zone

lowest LBA	...	highest LBA

↑ write pointer

Key

	blocks that have been written
	blocks that have not been written
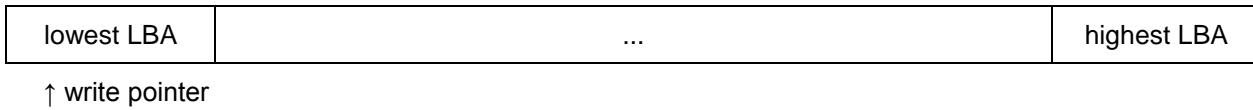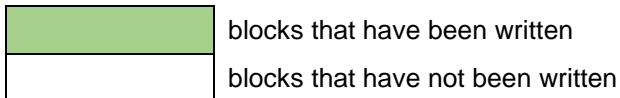
Figure 16   Write pointer zone example operations

The interactions between write pointer zones and the Sanitize Device feature set (see ACS-4) are described in 10.22.4.

10.21.2.2 Sequential Write Required zones

A Sequential Write Required zone is a write pointer zone (see 10.21.2.1) in which the device requires that write commands specify a starting LBA that is equal to that zone's write pointer.

If the device processes a write command without error, the write pointer is modified to indicate the LBA where a subsequent write command within the Sequential Write Required zone shall be performed.

If the ending LBA of a write command that completed without error is equal to the highest LBA of a Sequential Write Required zone, then the zone transitions to the ZC5: Full state (see 10.21.2.3.6).

An invalid write pointer becomes valid after:
  a) a RESET WRITE POINTERS EXT command (see 12.71.8);
  b) a sanitize operation command (see ACS-4); or
  c) a SECURITY ERASE UNIT command (see ACS-4).

After a write command returns command completion with an error, value of the write pointer may be unknown to the host. The host should use the REPORT ZONES command (see 12.71.7) to determine the current write pointer and other characteristics of the zone.

If the number of open zones that are open is equal to the value in the MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field, then any command (e.g., a write command) that causes a zone to transition into the ZC2: Implicit_Open state (see 10.21.2.3.3) or the ZC3: Explicit_Open state (see 10.21.2.3.4) is completed with an error as described in 10.21.2.3.7.

If the device receives a read command with:
  a)   the starting LBA in a Sequential Write Required zone;
  b)   the ending LBA is in the same Sequential Write Required zone; and
  c)   is less than the write pointer,
then the device shall process that read command.

If the device receives a write command with:
  a)   the starting LBA equal to the write pointer;
  b)   the ending LBA is in the same Sequential Write Required zone; and
  c)   an ending LBA that is equal to the last logical sector within a physical sector (see ACS-4),
then the device shall process that write command.

If the device receives a write command with:
  a)   the starting LBA in a Sequential Write Required zone that is not equal to the write pointer; or
  b)   an ending LBA that is not equal to the last logical sector within a physical sector (see ACS-4),
then the device shall:
  a)   not write any data;
  b)   return command completion with an error; and
  c)   set the sense key to ILLEGAL REQUEST and the additional sense code to UNALIGNED WRITE COMMAND (see ACS-4 and SPC-5).

If the device receives a write command with an ending LBA that is not in the same Sequential Write Required zone as the starting LBA, then the device shall:
  a)   not write any data;
  b)   return command completion with an error; and
  c)   set the sense key to ILLEGAL REQUEST and the additional sense code to WRITE BOUNDARY VIOLATION (see ACS-4 and SPC-5).

If the device receives a read command with:
  a)   the starting LBA:
    A)   less than the write pointer and the ending LBA greater than or equal to the write pointer in the same Sequential Write Required zone; or
    B)   greater than or equal to the write pointer and the ending LBA greater than or equal to the write pointer in the same Sequential Write Required zone,;
  and

b) the URSWRZ bit is set to:
  A) zero, then the device shall:
    a) not read any data;
    b) return command completion with an error; and
    c) set the sense key to ILLEGAL REQUEST and the additional sense code to ATTEMPT TO READ INVALID DATA (see ACS-4 and SPC-5); or
  B) one, then the device shall return data set to the last initialization pattern that was set by:
    a) the manufacturer; or
    b) OVERWRITE EXT command (see ACS-4), if any.

If the device receives a read command with the ending LBA in a different Sequential Write Required zone than the starting LBA and the URSWRZ bit is set to:

a) zero, then the device shall:
  A) not read any data;
  B) return command completion with an error; and
  C) set the sense key to ILLEGAL REQUEST and the additional sense code to READ BOUNDARY VIOLATION (see ACS-4 and SPC-5).;

  or

b) one, then
  A) if one or more LBAs specified by the command are not in a Sequential Write Required zone, then the device shall:
  a) not read any data;
  b) return command completion with an error; and
  c) set the sense key to ILLEGAL REQUEST and the additional sense code to READ BOUNDARY VIOLATION (see ACS-4 and SPC-5);

  or

  B) if all LBAs specified by the command are in a Sequential Write Required zone, then:
  a) for any LBA that has been written since the zone was last in the ZC1: Empty state (see 10.21.2.3.2), the device shall return the written data; or
  b) for any LBA that has not been written since the zone was last in the ZC1: Empty state; the device shall return data set to the last initialization pattern that was set by:
    A) the manufacturer; or
    B) OVERWRITE EXT command (see ACS-4), if any.

If the device receives a write command that specifies:
  a) a starting LBA that is not in a Sequential Write Required zone; and
  b) access to an LBA that is in a Sequential Write Required zone,
then the device shall:
  a) not write any data;
  b) return command completion with an error; and
  c) set the sense key to ILLEGAL REQUEST and the additional sense code to WRITE BOUNDARY VIOLATION (see ACS-4 and SPC-5).

If the device receives a read command that specifies:
  a) a starting LBA that is not in a Sequential Write Required zone; and
  b) access to an LBA that is in a Sequential Write Required zone,
then the device shall:
  a) not read any data;
  b) return command completion with an error; and
  c) set the sense key to ILLEGAL REQUEST and the additional sense code to ATTEMPT TO READ INVALID DATA (see ACS-4 and SPC-5).

If the device sets the additional sense code to:
  a) UNALIGNED WRITE COMMAND;
  b) WRITE BOUNDARY VIOLATION; or

c) ATTEMPT TO READ INVALID DATA,

then the device shall set the LBA field in the error outputs to the value of write pointer associated with the Sequential Write Required zone specified by the starting LBA in the command.

10.21.2.3   Zone Condition state machine

10.21.2.3.1   Overview

The Zone Condition state machine (see Figure 17) controls the operational characteristics of each write pointer zone. This state machine consists of the following states:
a)   ZC1: Empty state (see 10.21.2.3.2);
b)   ZC2: Implicit_Open state (see 10.21.2.3.3);
c)   ZC3: Explicit_Open state (see 10.21.2.3.4);
d)   ZC4: Closed state (see 10.21.2.3.5);
e)   ZC5: Full state (see 10.21.2.3.6);
f)   ZC6: Read_Only state (Not Supported); and
g)   ZC7: Offline state (Not Supported).

Read_Only state and Offline state which are defined in ZAC are not supported.
Specific transitions in this state machine require the device to include processing of an Implicit Close function (see 10.21.2.3.7) in the actions performed in response to specific commands.

The characteristics associated with the state of a zone are summarized in Table 76

Table 76   Characteristics associated with zone state

Zone state	Zone characteristics			
	Write pointer valid [a]	Write resources available [b]	Accessible for	
			Reads	Writes
ZC1: Empty	Yes	No	see[c]	see[d]
ZC2: Implicit_Open	Yes	Yes	Yes	Yes
ZC3: Explicit_Open	Yes	Yes	Yes	Yes
ZC4: Closed	Yes	No	Yes	sse[d]
ZC5: Full	No	No	Yes	No
ZC6:Read_Only	No	No	Yes	No
ZC7: Offline	No	No	No	No
a) A valid write pointer indicates specific LBA in the zone as described in 10.21.2.1. An invalid write pointer provides no information.				
b) In each zone, write resources maintain the accuracy of the write pointer and the ability to access the media during the processing of write commands.				
c) This zone is accessible for reads if the URSWRZ bit is set to one.				
d) This zone is accessible for writes if the Implicit Close function (see 10.21.2.3.7) is able to complete with success and the zone transitions to the ZC2: Implicit_Open state.				

The device server shall maintain the zone state after processing all resets except a power-on reset (see ACS-4).
After a power-on reset, the initial state for each write pointer zone is:
a)   ZC1: Empty state for a zone in which the write pointer is valid and indicates the first LBA of the zone;
b)   ZC4: Closed state for a zone in which write pointer is valid and indicates an LBA that is not the first LBA of the zone; and
c)   ZC5: Full state for a zone that was a full zone before the power-on reset;
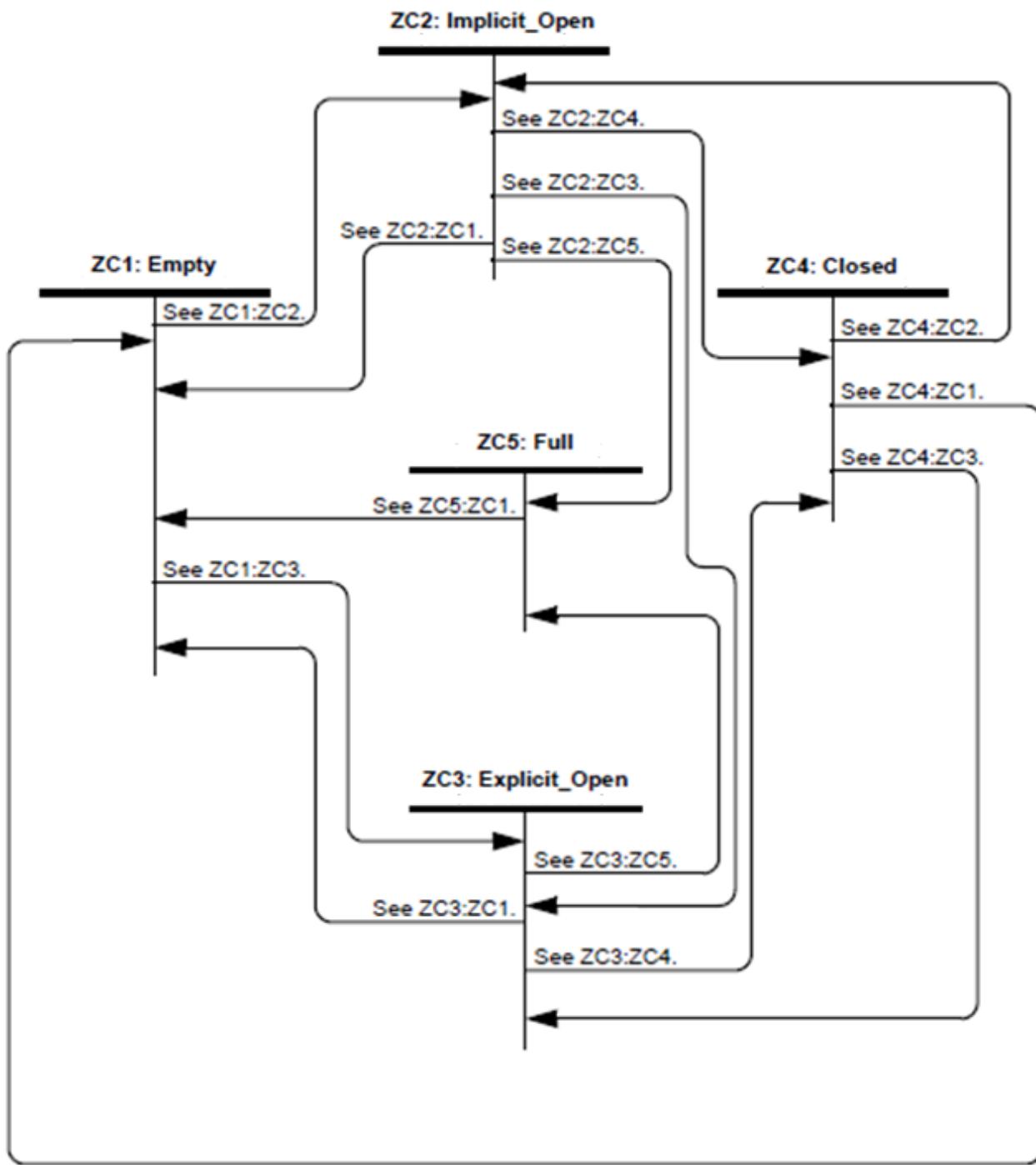
Figure 17   Zone Condition state machine

10.21.2.3.2   ZC1: Empty state

The ZC1: Empty state is entered:
 a)   after the successful processing of a RESET WRITE POINTERS EXT command (see 12.71.8); and
 b)   if the write pointer indicates the lowest LBA in the zone, then:
   A) after successful completion of a CLOSE ZONE EXT command (see 12.71.4); or
   B) as the result of the zone selection and other processing performed by the Implicit Close function(see 10.21.2.3.7).

For a zone in this state:
 a)   the write pointer is valid and indicates the lowest LBA in the zone;

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b) the device is not required to maintain write resources that ensure the accuracy of the write pointer and the ability to access the media during the processing of write commands;

c) if the zone is a Sequential Write Required zone (see 10.21.2.2) and the device receives a read command, then the device shall:

  A) return command completion with an error; and

  B) set the sense key to ILLEGAL REQUEST and the additional sense code to ATTEMPT TO READ INVALID DATA;

Transition ZC1:ZC2: The zone shall transition from the ZC1: Empty state to the ZC2: Implicit_Open state (see 10.21.2.3.3)   if:

    a) the device processes:

        A) a write command; or

        B) a Finish Zone function ,

    and

    b) the OZR Available state machine variable indicates a success return.

The device shall continue processing the write command or Finish Zone function in the ZC2: Implicit_Open state.

> NOTE x1 - The processing of a write command that specifies a zone in the ZC1: Empty state includes the processing of an Implicit Close function (see 10.21.2.3.7) the results of which affect the success of the write command.

Transition ZC1:ZC3: The zone shall transition to the ZC3: Explicit_Open state (see 10.21.2.3.4) after successful completion of an OPEN ZONE EXT command (see 12.71.6).

> NOTE x2 - The processing of an OPEN ZONE EXT command includes the processing of an Implicit Close function (see 10.21.2.3.7) the results of which affect the success of the OPEN ZONE EXT command.

10.21.2.3.3   ZC2: Implicit_Open state

The ZC2: Implicit_Open state is entered as part of the processing of a successful write command that specifies a zone in the ZC1: Empty state or the ZC4: Closed state.

For a zone in this state:

a) the write pointer is valid and does not indicate the lowest LBA in the zone; and

b) the device shall maintain write resources that ensure the accuracy of the write pointer and the ability to access the media during the processing of write commands.

Transition ZC2:ZC1: The zone shall transition to the ZC1: Empty state (see 10.21.2.3.2):

a) after successful completion of a RESET WRITE POINTERS EXT command (see 12.71.8);

b) if the write pointer indicates the lowest LBA in the zone, then:

  A) after successful completion of a CLOSE ZONE EXT command (see 12.71.4); or

  B) as the result of the zone selection and other processing performed by the Implicit Close function (see 10.21.2.3.7).

Transition ZC2:ZC3: The zone shall transition to the ZC3: Explicit_Open state (see 10.21.2.3.4) after successful completion of an OPEN ZONE EXT command (see 12.71.6).

> NOTE x3 - The processing of an OPEN ZONE EXT command includes the processing of an Implicit Close function (see 10.21.2.3.7) the results of which affect the success of the OPEN ZONE EXT command.

Transition ZC2:ZC4: If the write pointer does not indicate the lowest LBA in the zone, the zone shall transition to the ZC4: Closed state (see 10.21.2.3.5):

a) after successful completion of a CLOSE ZONE EXT command (see 12.71.4); or

b) as the result of the zone selection and other processing performed by the Implicit Close function (see 10.21.2.3.7).

Transition ZC2:ZC5:   The zone shall transition to the ZC5: Full state (see 10.21.2.3.6) after successful completion of:

a)   a FINISH ZONE EXT command (see 12.71.5); or

b)   a write command with the starting LBA equal to the write pointer that writes the highest LBA in the zone.

This transition may occur after successful completion of a non-sequential write command in a Sequential Write Preferred zone.

10.21.2.3.4   ZC3: Explicit_Open state

The ZC3: Explicit_Open state is entered after successful completion of an OPEN ZONE EXT command (see 12.71.6).

For a zone in this state:
 a)   the write pointer is valid; and
 b)   the device shall maintain write resources that ensure the accuracy of the write pointer and the ability to access the media during the processing of write commands.

Transition ZC3:ZC1:   The zone shall transition to the ZC1: Empty state (see 10.21.2.3.2) after successful completion of:
 a)   a CLOSE ZONE EXT command (see 12.71.4) if the write pointer indicates the lowest LBA in the zone; or
 b)   a RESET WRITE POINTERS EXT command (see 12.71.8).

Transition ZC3:ZC4: If the write pointer does not indicate the lowest LBA in the zone, the zone shall transition to the ZC4: Closed state (see 10.21.2.3.5) after successful completion of a CLOSE ZONE EXT command (see 12.71.4).

Transition ZC3:ZC5: The zone shall transition to the ZC5: Full state (see 10.21.2.3.6) after successful completion of:
 a)   a FINISH ZONE EXT command (see 12.71.5); or
 b)   a write command with the starting LBA equal to the write pointer that writes the highest LBA in the zone.

10.21.2.3.5   ZC4: Closed state

If the write pointer does not indicate the lowest LBA in the zone, the ZC4: Closed state is entered:
 a)   after successful completion of a CLOSE ZONE EXT command (see 12.71.4); or
 b)   as the result of the zone selection and other processing performed by the Implicit Close function (see 10.21.2.3.7).

For a zone in this state:
 a)   the write pointer is valid and does not indicate the lowest LBA in the zone; and
 b)   the device is not required to maintain write resources that ensure the accuracy of the write pointer and the ability to access the media during the processing of write commands.

Transition ZC4:ZC1:   The zone shall transition to the ZC4: Closed state (see 10.21.2.3.5) after successful completion of a RESET WRITE POINTERS EXT command (see 12.71.8).

Transition ZC4:ZC2:   The zone shall transition from the ZC4: Closed state to the ZC2: Implicit_Open state (see 10.21.2.3.3) if:
 a) the device processes:
  A) a write command; or
  B) a Finish Zone function,
 and
 b) the OZR Available state machine variable indicates a success return.
The device shall continue processing the write command or Finish Zone function in the ZC2: Implicit_Open state.

 NOTE x4 - The processing of a write command that specifies a zone in the ZC1: Empty state includes the processing of an Implicit Close function (see 10.21.2.3.7) the results of which affect the success of the write command.

Transition ZC4:ZC3:   The zone shall transition to the ZC3: Explicit_Open state (see 10.21.2.3.4) after successful completion of an OPEN ZONE EXT command (see 12.71.6).

 NOTE x5 - The processing of an OPEN ZONE EXT command includes the processing of an Implicit Close function (see 10.21.2.3.7) the results of which affect the success of the OPEN ZONE EXT command.

10.21.2.3.6   ZC5: Full state

The ZC5: Full state is entered after successful completion of:
  a)   a FINISH ZONE EXT command (see 12.71.5); or
  b)   a write command with the starting LBA equal to the write pointer that writes the highest LBA in the zone.

This state may be entered after successful completion of a non-sequential write command in a Sequential Write Preferred zone.

For a zone in this state:
  a)   the write pointer is valid and does not indicate the highest LBA in the zone;
  b)   all LBAs in the zone are able to return data in response to a read command; and
  c)   the device is not required to maintain write resources that ensure the accuracy of the write pointer and the ability to access the media during the processing of write commands.

Transition ZC5:ZC1: The zone shall transition to the ZC5: Full state (see 10.21.2.3.6) after successful completion of a RESET WRITE POINTERS EXT command (see 12.71.8).

10.21.2.3.7   Implicit Close function

10.21.2.3.7.1   Overview

The processing required to make some state machine transitions (e.g., the transition from the ZC1: Empty state (see 10.21.2.3.2) to the ZC2: Implicit_Open state (see 10.21.2.3.3) that results from the processing of a write command) includes performing the Implicit Close function defined in 10.21.2.3.7.

In response to specific conditions described in 10.21.2.3.7, the Implicit Close function limits the total number of open zones by transitioning a selected zone to the ZC4: Closed state (see 10.21.2.3.5) based on the contents of the MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field.

The Implicit Close function is composed of the following steps:
  1)   determine that closing a Sequential Write Required zone (see 10.21.2.2) is not required in order to maintain a maximum number of open zones (see 10.21.2.3.7.4);
  2)   determine that too many Sequential Write Required zone are open to allow successful processing of this Implicit Close function (see 10.21.2.3.7.3);
  3)   close a Sequential Write Required zone in order to maintain a maximum number of open zones (see 10.21.2.3.7.4).

If any of these steps detects that no further processing is required to complete this instance of the Implicit Close function, then the remaining steps shall be skipped.

If too many zones are open to allow successful processing of this instances of the Implicit Close function, then a failure is returned by the Implicit Close function that results in some kind of failure handling (e.g., the command that required action by the Implicit Close function is completed with an error).

An instance of the Implicit Close function is successful if:
  a)   closing a zone is not required in order to maintain a maximum number of open zones; or
  b)   a zone is closed in order to maintain a maximum number of open zones.

The acronyms shown in Table 78 are used throughout 10.21.2.3.7

Table 77   Implicit Close function acronyms

Acronym	Description
EXP_OPN_REQ	number of Sequential Write Required zones (see 10.21.2.2) in the ZC3: Explicit_Open state (see 10.21.2.3.4)
IMP_OPN_REQ	number of Sequential Write Required zones in the ZC2: Implicit_Open state (see 10.21.2.3.3)
MAX_OPN_REQ	contents of the MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field

10.21.2.3.7.2   Do not perform an Implicit Close

The processing of an Implicit Close function limits the closing of Sequential Write Required zones (see 10.21.2.2) by performing the test described in this subclause.

If EXP_OPN_REQ + IMP_OPN_REQ is less than MAX_OPN_REQ, then the device shall return an indication of successful processing for the Implicit Close function. Otherwise, the actions described in this subclause shall not result in completion of an instance of the Implicit Close function.

10.21.2.3.7.3   Determine the inability, if any, to perform a required Implicit Close

The processing of an Implicit Close function determines that the limit on the number of open Sequential Write Required zones (see 10.21.2.2) does not allow another zone to be opened by performing the actions described in this subclause.

If EXP_OPN_REQ is greater than or equal to MAX_OPN_REQ, then the device shall return an indication of failed processing for the Implicit Close function. Otherwise, the actions described in this subclause shall not result in completion of an instance of the Implicit Close function.

10.21.2.3.7.4   Perform an Implicit Close to maintain a maximum number of open zones

The processing of an Implicit Close function maintains the maximum number of open Sequential Write Required zones (see 10.21.2.2) by performing the actions described in this subclause.

> NOTE x6 - The tests performed in 10.21.2.3.7.2 and 10.21.2.3.7.3 assure that the actions in this subclause result in a Sequential Write Requires zone being closed.

If:
 a) EXP_OPN_REQ + IMP_OPN_REQ is greater than or equal to MAX_OPN_REQ; and
 b) IMP_OPN_REQ is greater than zero,

then the device shall:
 a) select one Sequential Write Required zone in the ZC2: Implicit_Open state (see 10.21.2.3.3) and transition that zone to the ZC4: Closed state (see 10.21.2.3.5); and
 b) return an indication of successful processing for the Implicit Close function.

The processing required to make some state machine transitions (e.g., the transition from the ZC1: Empty state (see 10.21.2.3.2) to the ZC2: Implicit_Open state (see 10.21.2.3.3) that results from the processing of a write command) includes performing the Implicit Close function defined in 10.21.2.3.7.

In response to specific conditions described in 10.21.2.3.7, the Implicit Close function limits the total number of open zones by transitioning a selected zone to the ZC4: Closed state (see 10.21.2.3.5) based on the contents of:
 a) the MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field.

The Implicit Close function is composed of the following steps:
 a) determine that closing a Sequential Write Required zone (see 10.21.2.2) is not required in order to maintain a maximum number of open zones;
 b) determine that too many Sequential Write Required zone are open to allow successful processing of this Implicit Close function;
 c) close a Sequential Write Required zone in order to maintain a maximum number of open zones.

If any of these steps detects that no further processing is required to complete this instance of the Implicit Close function, then the remaining steps shall be skipped.

If too many zones are open to allow successful processing of this instances of the Implicit Close function, then a failure is returned by the Implicit Close function that results in some kind of failure handling (e.g., the command that required action by the Implicit Close function is completed with an error).

An instance of the Implicit Close function is successful if:
 a) closing a zone is not required in order to maintain a maximum number of open zones; or
 b) a zone is closed in order to maintain a maximum number of open zones.

The acronyms shown in Table 78   Implicit Close function acronyms are used in the definition of the Implicit Close steps in this sub clause.

Table 78   Implicit Close function acronyms

Acronym	Description
EXP_OPN_REQ	number of Sequential Write Required zones (see 10.21.2.2) in the ZC3:Explicit_Open state (see 10.21.2.3.4)
IMP_OPN_REQ	number of Sequential Write Required zones in the ZC2:Implicit_Open state (see 10.21.2.3.3)
MAX_OPN_REQ	contents of the MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field

The device shall process an Implicit Close function as follows:
 1) if EXP_OPN_REQ + IMP_OPN_REQ is:
   A) less than MAX_OPN_REQ, then the device shall return an indication of successful processing for the Implicit Close function; or
   B) greater than or equal to MAX_OPN_REQ, then the device shall not complete processing of the Implicit Close function;
 2) if EXP_OPN_REQ is:
   A) greater than or equal to MAX_OPN_REQ, then the device shall return an indication of failed processing for the Implicit Close function; or
   B) less than MAX_OPN_REQ, then the device shall not complete processing of the Implicit Close function;
and
 3) if:
   A) EXP_OPN_REQ + IMP_OPN_REQ is greater than or equal to MAX_OPN_REQ; and
   B) IMP_OPN_REQ is greater than zero,
    then the device shall:
   A) return an indication of successful processing for the Implicit Close function.

10.22 Additional features for the Host Aware Zones feature set and the Host Managed Zones feature set

10.22.1 Zoned device internal resource management

A device that supports the Host Aware Zones feature set or the Host Managed Zones feature set requires internal resources to maintain each zone. Insufficient resources may result in degraded functionality (e.g., reduced performance, increased power consumption, or increased reporting of write errors).

The device uses the RESET bit in each zone descriptor (see 12.71.7.4.6.5) to report that an insufficient resources condition has been detected for the indicated zone.

The host clears the insufficient resources condition by sending a RESET WRITE POINTERS EXT command (see 12.71.8) that specifies the affected zone to the device. Before sending the RESET WRITE POINTERS EXT command, the host may copy the logical sector data in the affected zone to another location.

10.22.2 Unexpected power removal

If power is removed from a zoned device prior to the device completing the processing of a power loss event and:
  a)   there are partially completed write operations;
  b)   there is logical block data in volatile write cache; or
  c)   write pointers for completed write operations are not saved to a nonvolatile location,
then an unexpected power removal condition has occurred.

An unexpected power removal condition may cause write pointers for partially completed write commands to be updated to reflect the partial logical block data written to the medium (e.g., the LBA plus one of the last logical block that the device attempted to write).
If after an unexpected power removal condition the host sends a REPORT ZONES command (see 12.71.7), the write pointers in the log may not correspond to the ending LBA plus one of the last command to report completion in the write pointer zone.

10.22.3 Media failure

Failures may cause some or all of the media to become inaccessible in a device that supports the Host Managed Zones feature set. If media is still available to be used after a failure, the media may continue to work properly.

10.22.4 Interactions with the Sanitize Device feature set

If a device that supports the Host Aware Zones feature set or the Host Managed Zones feature set also supports the Sanitize Device feature set (see ACS-4), the additional requirements described in this subclause apply.

The ZONED NO RESET bit shall be supported as described in ACS-4 for each of the following commands that

are supported:

a) the CRYPTO SCRAMBLE EXT command (see ACS-4);

b) the OVERWRITE EXT command (see ACS-4).

A CRYPTO SCRAMBLE EXT command, or OVERWRITE EXT command affects all zones as follows:
  a)   the specified sanitize operation is performed as specified in ACS-4 for each Conventional zone (see 10.21.1); and
  b)   the specified sanitize operation is performed as specified in ACS-4 for each write pointer zone (see 10.21.2) with the following additional requirements:
   A)   a successful sanitize operation shall include processing of the ZONED NO RESET bit as described in ACS-4; and
   B)   a failed sanitize operation followed by a SANITIZE STATUS EXT command with the CLEAR SANITIZE OPERATION FAILED bit set to one (see ACS-4) should result in the equivalent of a successful RESET WRITE POINTERS EXT command being performed.

11 Command Protocol

The commands are grouped into different classes according to the protocols followed for command execution. The command classes with their associated protocols are defined below.

Please refer to Serial ATA Revision 3.0 about each protocol.

For all commands, the host must first check if BSY=1, and should proceed no further unless and until BSY=0. For all commands, the host must also wait for RDY=1 before proceeding.

A device must maintain either BSY=1 or DRQ=1 at all times until the command is completed. The INTRQ signal is used by the device to signal most, but not all, times when the BSY bit is changed from 1 to 0 during command execution.

A command shall only be interrupted with a COMRESET or software reset. The result of writing to the Command register while BSY=1 or DRQ=1 is unpredictable and may result in data corruption. A command should only be interrupted by a reset at times when the host thinks there may be a problem, such as a device that is no longer responding.

Interrupts are cleared when the host reads the Status Register, issues a reset, or writes to the Command Register.

11.1 PIO Data In commands

These commands are:
- Device Configuration Identify
- Identify Device
- Read Buffer
- Read Log Ext
- Read Multiple
- Read Multiple Ext
- Read Sector(s)
- Read Sector(s) Ext
- Read Stream Ext
- SMART Read Attribute Values
- SMART Read Attribute Thresholds
- SMART Read Log Sector

Execution includes the transfer of one or more 512 byte sectors of data from the device to the host.

11.2   PIO Data Out commands

These commands are:

- Device Configuration Set
- Download Microcode
- Format Track
- Security Disable Password
- Security Erase Unit
- Security Set Password
- Security Unlock
- Set Max Set Password command
- Set Max Unlock command
- SMART Write Log Sector
- Write Buffer
- Write Log Ext
- Write Multiple
- Write Multiple Ext
- Write Multiple FUA Ext
- Write Sector(s)
- Write Sector(s) Ext
- Write Stream Ext

Execution includes the transfer of one or more 512 byte sectors of data from the host to the device.

11.3   Non-Data commands

These commands are:

- Check Power Mode
- Configure Stream
- Crypto Scramble Ext (data encryption model only)
- Device Configuration Freeze Lock
- Device Configuration Restore
- Execute Device Diagnostic
- Flush Cache
- Flush Cache Ext
- Format Unit
- Idle
- Idle Immediate
- Initialize Device Parameters
- NCQ NON-DATA
- NOP
- Overwrite Ext
- Read Native Max Address
- Read Native Max Address Ext
- Read Verify Sector(s)
- Read Verify Sector(s) Ext
- Recalibrate
- Sanitize Freeze Lock Ext
- Sanitize Status Ext
- Security Erase Prepare
- Security Freeze Lock
- Seek
- Set Features
- Set Max Address
- Set Max Address Ext
- Set Max Lock command
- Set Max Freeze Lock command
- Set Multiple Mode
- Sleep
- SMART Disable Operations
- SMART Enable/Disable Attribute Autosave
- SMART Enable Operations
- SMART Execute Off-line Data Collection
- SMART Return Status
- SMART Save Attribute Values
- SMART Enable/Disable Automatic Off-Line
- Standby
- Standby Immediate
- ZAC CLOSE ZONE EXT
- ZAC FINISH ZONE EXT
- ZAC OPEN ZONE EXT
- ZAC RESET WRITE POINTERS EXT

Execution of these commands involves no data transfer.

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11.4   DMA Data In commands and DMA Data Out commands

These commands are:
*   Download Microcode DMA
*   Read DMA
*   Read DMA Ext
*   Read Log DMA Ext
*   Read Stream DMA Ext
*   Write DMA
*   Write DMA Ext
*   Write DMA FUA Ext
*   Write Log DMA Ext
*   Write Stream DMA Ext
*   ZAC REPORT ZONES EXT

Execution of this class of command includes the transfer of one or more blocks of data between the device and the host using DMA transfer.

11.5   First-party DMA commands

These commands are:
*   Read FPDMA Queued
*   Write FPDMA Queued
*   Receive FPDMA Queued

Execution of this class of commands includes command queuing and the transfer of one or more blocks of data between the device and the host. The protocol is described in the section 13.6 "Native Command Queuing" of "Serial ATA Revision 3.0".

Host knowledge of I/O priority may be transmitted to the device as part of the command. There are two priority classes for NCQ command as high priority, the host is requesting a better quality of service for that command than the commands issued with normal priority.

The classes are forms of soft priority. The device may choose to complete a normal priority command before an outstanding high priority command, although preference is given to the high priority commands. The priority class is indicated in bit 7 (Priority Information) in the Sector Count register for NCQ commands (READ FPDMA QUEUED and WRITE FPDMA QUEUED). This bit can indicate either the normal priority or high priority class. If a command is marked by the host as high priority, the device attempts to provide better quality of service for the command. The device may not process all high priority requests before satisfying normal priority requests.

12 Command Descriptions

Table 79   Command Set

Protocol	Command	Code (Hex)	7	6	5	4	3	2	1	0
						Binary Code Bit				
3	Check Power Mode	E5	1	1	1	0	0	1	0	1
3	Check Power Mode*	98	1	0	0	1	1	0	0	0
3	Configure Stream	51	0	1	0	1	0	0	0	1
3	Crypto Scramble Ext (data encryption model only)	B4	1	0	1	1	0	1	0	0
3	Device Configuration Restore	B1	1	0	1	1	0	0	0	1
3	Device Configuration Freeze Lock	B1	1	0	1	1	0	0	0	1
1	Device Configuration Identify	B1	1	0	1	1	0	0	0	1
2	Device Configuration Set	B1	1	0	1	1	0	0	0	1
2	Download Microcode	92	1	0	0	1	0	0	1	0
3	Execute Device Diagnostic	90	1	0	0	1	0	0	0	0
3	Flush Cache	E7	1	1	1	0	0	1	1	1
3	Flush Cache Ext	EA	1	1	1	0	1	0	1	0
2	Format Track	50	0	1	0	1	0	0	0	0
3	Format Unit	F7	1	1	1	1	0	1	1	1
1	Identify Device	EC	1	1	1	0	1	1	0	0
3	Idle	E3	1	1	1	0	0	0	1	1
3	Idle*	97	1	0	0	1	0	1	1	1
3	Idle Immediate	E1	1	1	1	0	0	0	0	1
3	Idle Immediate*	95	1	0	0	1	0	1	0	1
3	Initialize Device Parameters	91	1	0	0	1	0	0	0	1
3	NCQ Queue Management	63	0	1	1	0	0	0	1	1
3	Overwrite Ext	B4	1	0	1	1	0	1	0	0
1	Read Buffer	E4	1	1	1	0	0	1	0	0
4	Read DMA	C8	1	1	0	0	1	0	0	0
4	Read DMA	C9	1	1	0	0	1	0	0	1
4	Read DMA Ext	25	0	0	1	0	0	1	0	1
5	Read FPDMA Queued	60	0	1	1	0	0	0	0	0
1	Read Log Ext	2F	0	0	1	0	1	1	1	1
4	Read Log DMA Ext	47	0	1	0	0	0	1	1	1
1	Read Multiple	C4	1	1	0	0	0	1	0	0
1	Read Multiple Ext	29	0	0	1	0	1	0	0	1
3	Read Native Max Address	F8	1	1	1	1	1	0	0	0
3	Read Native Max Address Ext	27	0	0	1	0	0	1	1	1
1	Read Sector(s)	20	0	0	1	0	0	0	0	0
1	Read Sector(s)	21	0	0	1	0	0	0	0	1
1	Read Sector(s) Ext	24	0	0	1	0	0	1	0	0
4	Read Stream DMA Ext	2A	0	0	1	0	1	0	1	0
4	Read Stream Ext	2B	0	0	1	0	1	0	1	0
3	Read Verify Sector(s)	40	0	1	0	0	0	0	0	0
3	Read Verify Sector(s)	41	0	1	0	0	0	0	0	1
3	Read Verify Sector(s) Ext	42	0	1	0	0	0	0	1	0
3	Recalibrate	1x	0	0	0	1	-	-	-	-

Table 80   Command Set –Continued–

Protocol	Command	Code (Hex)	7	6	5	4	3	2	1	0
5	Receive FPMDA Queued	65	0	1	1	0	0	1	0	1
3	Sanitize Freeze Lock Ext	B4	1	0	1	1	0	1	0	0
3	Sanitize Status Ext	B4	1	0	1	1	0	1	0	0
2	Security Disable Password	F6	1	1	1	1	1	0	1	0
3	Security Erase Prepare	F3	1	1	1	1	0	0	1	1
2	Security Erase Unit	F4	1	1	1	1	0	1	0	0
3	Security Freeze Lock	F5	1	1	1	1	0	1	0	1
2	Security Set Password	F1	1	1	1	1	0	0	0	1
2	Security Unlock	F2	1	1	1	1	0	0	1	0
3	Seek	7x	0	1	1	1	-	-	-	-
3	Set Features	EF	1	1	1	0	1	1	1	1
3	Set Max Address	F9	1	1	1	1	1	0	0	1
3	Set Max Address Ext	37	0	0	1	1	0	1	1	1
3	Set Multiple Mode	C6	1	1	0	0	0	1	1	0
3	Sleep	E6	1	1	1	0	0	1	1	0
3	Sleep*	99	1	0	0	1	1	0	0	1
3	SMART Disable Operations	B0	1	0	1	1	0	0	0	0
3	SMART Enable/Disable Attribute Auto save	B0	1	0	1	1	0	0	0	0
3	SMART Enable Operations	B0	1	0	1	1	0	0	0	0
3	SMART Execute Off-line Data Collection	B0	1	0	1	1	0	0	0	0
1	SMART Read Attribute Values	B0	1	0	1	1	0	0	0	0
1	SMART Read Attribute Thresholds	B0	1	0	1	1	0	0	0	0
3	SMART Return Status	B0	1	0	1	1	0	0	0	0
3	SMART Save Attribute Values	B0	1	0	1	1	0	0	0	0
2	SMART Write Log Sector	B0	1	0	1	1	0	0	0	0
3	SMART Enable/Disable Automatic Off-line	B0	1	0	1	1	0	0	0	0
3	Standby	E2	1	1	1	0	0	0	1	0
3	Standby*	96	1	0	0	1	0	1	1	0
3	Standby Immediate	E0	1	1	1	0	0	0	0	0
3	Standby Immediate*	94	1	0	0	1	0	1	0	0
2	Write Buffer	E8	1	1	1	0	1	0	0	0
4	Write DMA	CA	1	1	0	0	1	0	1	0
4	Write DMA	CB	1	1	0	0	1	0	1	1
4	Write DMA Ext	35	0	0	1	1	0	1	0	1
4	Write DMA FUA Ext	3D	0	0	1	1	1	1	0	1
5	Write FPDMA Queued	61	0	1	1	0	0	0	0	1
2	Write Log Ext	3F	0	0	1	1	1	1	1	1
4	Write Log DMA Ext	57	0	1	0	1	0	1	1	1
2	Write Multiple	C5	1	1	0	0	0	1	0	1
2	Write Multiple Ext	39	0	0	1	1	1	0	0	1
2	Write Multiple FUA Ext	CE	1	1	0	0	1	1	1	0

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Table 81   Command Set –Continued–

Protocol	Command	Code (Hex)	7	6	5	4	3	2	1	0
			Binary Code Bit							
2	Write Sector(s)	30	0	0	1	1	0	0	0	0
2	Write Sector(s)	31	0	0	1	1	0	0	0	1
2	Write Sector(s) Ext	34	0	0	1	1	0	1	0	0
4	Write Stream DMA Ext	3A	0	0	1	1	1	0	1	0
4	Write Stream Ext	3B	0	0	1	1	1	0	1	1
3	ZAC CLOSE ZONE EXT	9F	1	0	0	1	1	1	1	1
3	ZAC FINISH ZONE EXT	9F	1	0	0	1	1	1	1	1
3	ZAC OPEN ZONE EXT	9F	1	0	0	1	1	1	1	1
4	ZAC REPORT ZONES EXT	4A	0	1	0	0	1	1	0	0
3	ZAC RESET WRITE POINTERS EXT	9F	1	0	0	1	1	1	1	1

Protocol :   1 :   PIO data IN command
              2 :   PIO data OUT command
              3 :   Non data command
              4 :   DMA command
              5 :   DMA Queued command
              + :   Vendor specific command

Commands marked * are alternate command codes for previous defined commands.

Table 82   Command Set (Subcommand)

Command (Subcommand)	Command code (Hex)	Feature Register (Hex)
(SMART Function)		
SMART Read Attribute Values	B0	D0
SMART Read Attribute Thresholds	B0	D1
SMART Enable/Disable Attribute Autosave	B0	D2
SMART Save Attribute Values	B0	D3
SMART Execute Off-line Data Collection	B0	D4
SMART Read Log	B0	D5
SMART Write Log	B0	D6
SMART Enable Operations	B0	D8
SMART Disable Operations	B0	D9
SMART Return Status	B0	DA
SMART Enable/Disable Automatic Off-line	B0	DB
(Set Features)		
Enable Write Cache	EF	02
Set Transfer Mode	EF	03
Enable Advanced Power Management	EF	05
Enable Power-up in Standby Feature Set	EF	06
Power-up in Standby Feature Set Device Spin-up	EF	07
Disable read look-ahead feature	EF	55
Disable reverting to power on defaults	EF	66
Disable write cache	EF	82
Disable Advanced Power Management	EF	85
Disable Power-up in Standby Feature Set	EF	86
Enable read look-ahead feature	EF	AA
Enable reverting to power on defaults	EF	CC
(Sanitize Device Feature Set)		
Sanitize Status Ext	B4	0000
Crypto Scramble Ext (data encryption model only)	B4	0011
Overwrite Ext	B4	0014
Sanitize Freeze Lock Ext	B4	0020
(NCQ NON-DATA)		
Abort NCQ queue – Abort All	63	00
Abort NCQ queue – Abort Streaming	63	10
Abort NCQ queue – Abort Non-Streaming	63	20
Abort NCQ queue – Abort Selected	63	30
Deadline Handling – WDNC	63	Set:11 Clear:01
Deadline Handling – RDNC	63	Set:21 Clear:01

Table 79 Command Set on the page 130 and Table 80 Command Set – Continued- on the page 131 show the commands that are supported by the device.   Table 82 Command Set (Subcommand) on the page 133 shows the sub-commands they are supported by each command or feature.

The following symbols are used in the command descriptions:

Output Registers

0   Indicates that the bit must be set to 0.

1   Indicates that the bit must be set to 1.

D   The device number bit.   Indicates that the device number bit of the Device/Head Register should be specified. This bit is reserved since all Serial ATA devices behave like Device 0.

H   Head number.   Indicates that the head number part of the Device/Head Register is an output parameter and should be specified.

L   LBA mode.   Indicates the addressing mode. Zero specifies CHS mode and one does LBA addressing mode.

R   Retry. Original meaning is already obsolete, there is no difference between 0 and 1. (Using 0 is recommended for future compatibility.)

B   Option Bit. Indicates that the Option Bit of the Sector Count Register should be specified. (This bit is used by Set Max ADDRESS command)

V   Valid. Indicates that the bit is part of an output parameter and should be specified.

X   Indicates that the hex character is not used.

-   Indicates that the bit is not used.

Input Registers

0   Indicates that the bit is always set to 0.

1   Indicates that the bit is always set to 1.

H   Head number. Indicates that the head number part of the Device/Head Register is an input parameter and will be set by the device.

V   Valid. Indicates that the bit is part of an input parameter and will be set to 0 or 1 by the device.

-   Indicates that the bit is not part of an input parameter.

The command descriptions show the contents of the Status and Error Registers after the device has completed processing the command and has interrupted the host.

Please refer to ATA interface specifications about other commands' descriptions which are not described in this SATA interface specification.   However, be careful that Serial ATA Device/Head register bit-4 (d) is different from that of Parallel ATA.   In Serial ATA, Device/Head register bit-4 is reserved for all commands.

12.1 Check Power Mode (E5h/98h)

Table 83   Check Power Mode Command (E5h/98h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 E5h or 98h

Normal Outputs

Field	Description
ERROR	N/A

COUNT	**Value Description**
	00h Device is in the:
	   PM2:Standby state and the EPC feature set is not enabled; or
	   PM2:Standby state, the EPC feature set is enabled, and the device is in the Standby_z power condition.
	01h Device is in the PM2:Standby state, the EPC feature set is enabled, and the device is in the Standby_y power condition.
	02h..3Fh Reserved
	40h..41h Obsolete
	42h..7Fh Reserved
	80h Device is in the
	   PM1:Idle state and EPC feature set is not supported; or
	   PM1:Idle state and EPC feature set is supported and the EPC feature set is disabled.
	81h Device is in the PM1:Idle state, the EPC feature set is enable, and the device is in the Idle_a power condition.
	82h Device is in the PM1:Idle state, the EPC feature set is enabled, and the device is in the Idle_b power condition.
	83h Device is in the PM1:Idle state, the EPC feature set is enabled, and the device is in the Idle_c power condition.
	84h..FEh Reserved
	FFh Device is in the PM0:Active state or PM1:Idle state.

LBA	If the LOW POWER STANDBY SUPPORTED bit is set to one, then this field is as described in this table. Otherwise this field is N/A.
	Bit Description
	27:20 Device is waiting to enter a lower power condition:
	     Value Description
	    - 00h Standby_z
	    - 01h Standby_y
	    - 02h..80h Reserved
	    - 81h Idle_a
	    - 81h Idle_b
	    - 82h Idle_c
	    - 83h..FEh Reserved
	    - FFh Device is not waiting to enter a lower power condition
	19 Device is held in the current power condition
	18:0 Reserved

DEVICE	**Bit Description**

	7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Error Outputs

Field	Description
ERROR	**Bit Description** 7:3 N/A 2 ABORT bit 1:0 N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4:2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Check Power Mode command will report whether the device is spun up and the media is available for immediate access.

12.2   Configure Stream (51h)

Table 84   Configure Stream Command (51h)

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 DEFAULT CCTL field 7 ADD/REMOVE STREAM bit. 6 Obsolete 5:3 Reserved 2:0 STREAM ID field
COUNT	Allocation Unit
LBA	Reserved
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 51h

Normal Outputs

Field	Description
ERROR	N/A
COUNT	Reserved
LBA	Reserved
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 STREAM ERROR bit 4 N/A 3 Transport Dependent 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Error Outputs

Field	Description
ERROR	**Bit Description** 7:3 N/A 2 ABORT bit 1:0 N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved

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STATUS	**Bit Description**
	7:6 Transport Dependent
	5 STREAM ERROR bit
	4 N/A
	3 Transport Dependent
	2 N/A
	1 SENSE DATA AVAILABLE bit
	0 ERROR bit

The Configure Stream command specifies the operating parameters of an individual stream. A Configure Stream command may be issued for each stream that is to be added or removed from the current operating configuration. If ADD/REMOVE STREAM bit = 1 and the specified ID is already valid at the device, the new parameters shall replace the old parameters, unless Command Abort is returned (see abort conditions for Error Register). In this case the old parameters for the specified Stream ID shall remain in effect.

The default Command Completion Time Limit (CCTL).

The value is calculated as follows:
(Default CCTL) = ((content of the Features register)* (Identify Device words (99:98))) microseconds.
This time shall be used by the device when a streaming command with the same stream ID and a CCTL of zero are issued.   The time is measured from the write of the command register to the final INTRQ for command completion. The device has minimum CCTL value. When the specified value is shorter than the minimum value, CCTL is set to the minimum value. Actual minimum CCTL value is described in the "Deviations from Standard" section.

Abort conditions for Error register are the following.

- The device does not support the Streaming Feature Set.
- A/R is cleared to zero and the Feature field contains a Stream ID that has not been sent in a previous CONFIGURE STREAM command.

12.3   Device Configuration Overlay (B1h)

Table 85   Device Configuration Overlay Command (B1h)

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	1	0	1	0	V	V	V	V
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	-	-	-	D	-	-	-	-
Command	1	0	1	1	0	0	0	1

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	V	V	V	V	V	V	V	V
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	V	V	V	V	V	V	V	V
Cylinder High	V	V	V	V	V	V	V	V
Device/Head	-	-	-	-	-	-	-	-
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
V	V	0	-	V	-	-	V

Individual Device Configuration Overlay feature set commands are identified by the value placed in the Features register. The table below shows these Features register values.

Table 86   Device Configuration Overlay Features register values

Value	Command
C0h	DEVICE CONFIGURATION RESTORE
C1h	DEVICE CONFIGURATION FREEZE LOCK
C2h	DEVICE CONFIGURATION IDENTIFY
C3h	DEVICE CONFIGURATION SET
other	Reserved

12.3.1   Device Configuration Restore (Subcommand C0h)

The Device Configuration Restore command disables any setting previously made by a Device Configuration Set command and returns the content of the Identify Device or Identify Packet Device command response to the original settings as indicated by the data returned from the execution of a Device Configuration Identify command.

12.3.2   Device Configuration Freeze Lock (Subcommand C1h)

The Device Configuration Freeze Lock command prevents accidental modification of the Device Configuration Overlay settings. After successful execution of a Device Configuration Freeze Lock command, all Device Configuration Set, Device Configuration Freeze Lock, Device Configuration Identify, and Device Configuration Restore commands are aborted by the device. The Device Configuration Freeze Lock condition shall be cleared by a power-down. The Device Configuration Freeze Lock condition shall not be cleared by hardware or software reset.

12.3.3   Device Configuration Identify (Subcommand C2h)

The Device Configuration Identify command returns a 512 byte data structure via PIO data-in transfer. The content of this data structure indicates the selectable commands, modes, and feature sets that the device is capable of supporting. If a Device Configuration Set command has been issued reducing the capabilities, the response to an Identify Device or Identify Packet Device command will reflect the reduced set of capabilities, while the Device Configuration Identify command will reflect the entire set of selectable capabilities.

The format of the Device Configuration Overlay Data structure is shown on next page.

12.3.4   Device Configuration Set (Subcommand C3h)

The Device Configuration Set command allows a device manufacturer or a personal computer system manufacturer to reduce the set of optional commands, modes, or feature sets supported by a device as indicated by a Device Configuration Identify command. The Device Configuration Set command transfers an overlay that modifies some of the bits set in words 63, 82, 83, 84, and 88 of the Identify Device command response. When the bits in these words are cleared, the device no longer supports the indicated command, mode, or feature set. If a bit is set in the overlay transmitted by the device that is not set in the overlay received from a Device Configuration Identify command, no action is taken for that bit.

The format of the overlay transmitted by the device is described in the table on next page. The restrictions on changing these bits are described in the text following that table. If any of the bit modification restrictions described is violated or any setting is changed with Device Configuration Set command, the device shall return command aborted. At that case, error reason code is returned to sector count register, invalid word location is returned to cylinder high register, and invalid bit location is returned to cylinder low register. The Definition of error information is shown on page 142.

Error Information Example 1:
After establish a protected area with Set Max address, if a user attempts to change maximum LBA   address (Device Configuration Set or Device Configuration Restore), device shall abort that command and return error reason code as below.

Cylinder high	:	03h	= word 3 is invalid
Cylinder low	:	00h	this register is not assigned in this case
Sector Number	:	00h	this register is not assigned in this case
Sector count	:	06h	= Protected area is now established

Error Information Example 2:

When device is enabled the Security feature set, if user attempts to disable that feature, device abort that command and return error reason code as below.

Cylinder high	:	07h	= word 7 is invalid
Cylinder low	:	00h	= bit 8-15 are valid
Sector Number	:	08h	= bit 3 is invalid
Sector count	:	04h	= now Security feature set is enabled

Table 87   Device Configuration Overlay Data structure

Word	Content		
0	0002h	Data Structure revision	
1	Multiword DMA modes supported		
	15-3	Reserved	
	2	1 = Multiword DMA mode 2 and below are supported	
	1	1 = Multiword DMA mode 1 and below are supported	
	0	1 = Multiword DMA mode 0 is supported	
2	Ultra DMA modes supported		
	15-7	Reserved	
	6	1 = Ultra DMA mode 6 and below are supported	
	5	1 = Ultra DMA mode 5 and below are supported	
	4	1 = Ultra DMA mode 4 and below are supported	
	3	1 = Ultra DMA mode 3 and below are supported	
	2	1 = Ultra DMA mode 2 and below are supported	
	1	1 = Ultra DMA mode 1 and below are supported	
	0	1 = Ultra DMA mode 0 is supported	
3-6	Maximum LBA address		
7	Command set/feature set supported		
	15	0 = Reserved	
	14	0 = Reserved	
	13	0 = Reserved	
	12	1 = SMART Selective self-test is supported	
	11	1 = Forced Unit Access is supported	
	10	0 = Reserved	
	9	1 = Streaming feature set is supported	
	8	1 = 48-bit Addressing feature set supported	
	7	1 = Host Protected Area feature set supported	
	6	0 = Reserved	
	5	1 = Read/Write DMA Queued commands supported	
	4	1 = Power-up in Standby feature set supported	
	3	1 = Security feature set supported	
	2	1 = SMART error log supported	
	1	1 = SMART self-test supported	
	0	1 = SMART feature set supported	
8	Serial ATA command / feature sets supported		
	15-5	Reserved	
	4	1 = Supports software settings preservation	
	3	Reserved	
	2	1 = Supports interface power management	
	1	1 = Supports non-zero buffer offset in DMA Setup FIS	
	0	1 = Supports native command queuing	
9-20	Reserved		

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Table 88   Device Configuration Overlay Data structure –Continued-

Word	Content		
21	15-10	Reserved	
	9	1 = Extended Power Conditions feature set supported	
	8-0	Reserved	
22-254	Reserved		
255	Integrity word <Note .>		
	15-8	Checksum	
	7-0	Signature (A5h)	

Note.
Bits 7:0 of this word contain the value A5h. Bits 15:8 of this word contain the data structure checksum. The data structure checksum is the two's complement of the sum of all byte in words 0 through 254 and the byte consisting of bits 7:0 of word 255. Each byte is added with unsigned arithmetic, and overflow is ignored. The sum of all bytes is zero when the checksum is correct.

Table 89   DCO error information definition

Cylinder high	invalid word location	
Cylinder low	invalid bit location (bits (15:8))	
Sector number	invalid bit location (bits (7:0))	
Sector count	error reason code & description	
	01h	DCO feature is frozen
	02h	Device is now Security Locked mode
	03h	Device's feature is already modified with DCO
	04h	User attempt to disable any feature enabled
	05h	Device is now SET MAX Locked or Frozen mode
	06h	Protected area is now established
	07h	DCO is not supported

12.4 Download Microcode (92h)

Table 90   Download Microcode Command (92h)

Command Input

Field	Description
FEATURE	SUBCOMMAND field
COUNT	BLOCK COUNT field (7:0)
LBA	Bit Description 27:24 Reserved 23:8 BUFFER OFFSET field 7:0 BLOCK COUNT field (15:8)
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 92h

Normal Outputs

Field	Description
FEATURE	Subcommand code. 03h : Download and save microcode with offsets. (See 12.4.3) 07h : Download and save microcode. 0Eh : Download and save microcode with offsets for future use. (See 12.4.4) 0Fh : Activate downloaded microcode. (See 12.4.5) Other values are reserved.
COUNT	Lower byte of 16-bit sector count value to transfer from the host. (See 12.4.2)
NUMBER	Higher byte of 16-bit sector count value to transfer from the host. (See 12.4.2)
CYLINDER	Buffer offset (only used for Feature = 03h or 0Eh)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6:3 N/A 2 ABORT bit 1:0 N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

12.4.1   Overview

This command enables the host to alter the device's microcode. The data transferred using the Download Microcode commands is vendor specific.

In reloading new microcode, when the spin-up of the device is disabled, the device spins down after reloading new microcode.

The device may abort the Download Microcode command and discard all previously downloaded Microcode, if the current buffer offset is not equal to the sum of the previous Download Microcode command buffer offset and the previous sector count. The first Download Microcode command must have a buffer offset of zero. The new firmware should become effective immediately after the transfer of the last data segment has completed.

When the device detects the last Download Microcode command for the firmware download the device performs any device required verification and saves the complete set of downloaded microcode.

Power on reset prior to the receipt of the last segment will discard all of the microcode segments received.

12.4.2   Sector Count / Sector Number

All transfers be an integer multiple of the sector size. The size of the data transfer is determined by the contents of the Sector Number and Sector Count registers. The Sector Number register is used to extend the Sector Count register to create a 16-bit sector count value. The Sector Number register is the most significant eight bits and the Sector Count register is the least significant eight bits. A value of zero in both the Sector Number and Sector Count registers indicate no data is to be transferred.

12.4.3   Download and save microcode with offsets

A Features register value of 03h indicates that the microcode will be transferred in one or more Download Microcode commands using the offset transfer method. The buffer offset value is defined by the value in Cylinder registers. The buffer offset value is the starting location in the microcode file, which varies in 512 byte increments. All microcode segments will be sent to the device in sequence.

12.4.4   Download and save microcode with offsets for future use

A Features register value of 0Eh indicates that the microcode will be transferred in one or more Download Microcode commands using the offset transfer method, and stored for deferred update. The buffer offset value is defined by the value in Cylinder registers. The buffer offset value is the starting location in the microcode file, which varies in 512 byte increments.
All microcode segments will be sent to the device in sequence.

12.4.5   Activate downloaded microcode

The device may abort the Download Microcode command and discard all previously downloaded Microcode, if the current buffer offset is not equal to the sum of the previous Download Microcode command buffer offset and the previous sector count. The first Download Microcode command must have a buffer offset of zero.

After the transfer of the last data segment has completed, the device performs any device required verification and stores the complete set of downloaded microcode which has not been activated. The new firmware will be activated after the device receives following Download Microcode command with a Features register value of 0Fh.

Power on reset prior to the receipt of the last segment or activate downloaded microcode will discard all of the microcode segments which are received or stored.

12.4.6   Error Outputs

ABT will be set to 1 in the Error Register if the value in the Feature register is neither 03h, 07h, 0Eh nor 0Fh, or the device is in Security Locked mode. When the reload of new microcode is requested in the data sent by the host for this Download command, UNC error will be set to 1 in the Error Register if the device fails to reload new microcode. This error is reported only when the reload of microcode is requested.

12.5   Download Microcode DMA (93h)

Table 91   Download Microcode DMA Command (93h)

Command Input

Field	Description
FEATURE	SUBCOMMAND field
COUNT	BLOCK COUNT field(7:0)
LBA	Bit Description 27:24 Reserved 23:8 BUFFER OFFSET field 7:0 BLOCK COUNT field (15:8)
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 93h

Normal Outputs

Field	Description
FEATURE	Subcommand code. 03h : Download and save microcode with offsets. (See 12.5.3) 07h : Download and save microcode. 0Eh : Download and save microcode with offsets for future use. (See 12.5.4) 0Fh : Activate downloaded microcode. (See 12.5.5) Other values are reserved.
COUNT	Lower byte of 16-bit sector count value to transfer from the host. (See 12.5.2)
NUMBER	Higher byte of 16-bit sector count value to transfer from the host. (See 12.5.2)
CYLINDER	Buffer offset (only used for Feature = 03h, 0Eh)

Error Register

See Error Register in 12.4 Download Microcode (92h)

12.5.1   Overview

This command enables the host to alter the device's microcode. The data transferred using the Download Microcode DMA commands is vendor specific.
In reloading new microcode, when the spin-up of the device is disabled, the device spins down after reloading new microcode.

The device may abort the Download Microcode DMA command and discard all previously downloaded Microcode, if the current buffer offset is not equal to the sum of the previous Download Microcode DMA command buffer offset and the previous sector count. The first Download Microcode DMA command must have a buffer offset of zero.
The new firmware should become effective immediately after the transfer of the last data segment has completed.

When the device detects the last Download Microcode command for the firmware download the device performs any device required verification and saves the complete set of downloaded microcode.

Power on reset prior to the receipt of the last segment will discard all of the microcode segments received.

12.5.2   Sector Count / Sector Number

All transfers shall be an integer multiple of the sector size. The size of the data transfer is determined by the contents of the Sector Number and Sector Count registers. The Sector Number register is used to extend the Sector Count register to create a 16-bit sector count value. The Sector Number register is the most significant eight bits and the Sector Count register is the least significant eight bits.

12.5.3   Download and save microcode with offsets

A Features register value of 03h indicates that the microcode will be transferred in one or more Download Microcode DMA commands using the offset transfer method. The buffer offset value is defined by the value in Cylinder registers. The buffer offset value is the starting location in the microcode file, which varies in 512 byte increments. All microcode segments will be sent to the device in sequence.

12.5.4   Download and save microcode with offsets for future use

A Features register value of 0Eh indicates that the microcode will be transferred in one or more Download Microcode DMA commands using the offset transfer method, and stored for deferred update. The buffer offset value is defined by the value in Cylinder registers. The buffer offset value is the starting location in the microcode file, which varies in 512 byte increments.
All microcode segments will be sent to the device in sequence.

12.5.5   Activate downloaded microcode

The device may abort the Download Microcode DMA command and discard all previously downloaded Microcode, if the current buffer offset is not equal to the sum of the previous Download Microcode DMA command buffer offset and the previous sector count. The first Download Microcode DMA command must have a buffer offset of zero.

After the transfer of the last data segment has completed, the device performs any device required verification and stores the complete set of downloaded microcode which has not been activated. The new firmware will be activated after the device receives following Download Microcode DMA command with a Features register value of 0Fh.

Power on reset prior to the receipt of the last segment or activate downloaded microcode will discard all of the microcode segments which are received or stored.

12.5.6   Error Outputs

ABT will be set to 1 in the Error Register if the value in the Feature register is neither 03h, 07h, 0Eh nor 0Fh, or the device is in Security Locked mode. When the reload of new microcode is requested in the data sent by the host for this Download command, UNC error will be set to 1 in the Error Register if the device fails to reload new microcode. This error is reported only when the reload of microcode is requested.

12.6   Execute Device Diagnostic (90h)

Table 92   Execute Device Diagnostic Command (90h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 90h

Normal Outputs

Field	Description
ERROR	Diagnostic Results – The diagnostic code as described in Table 36 is returned.
COUNT	0x01
LBA	0x00ABCD01
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 For ATAPI devices, the CHECK CONDITION bit For ATA devices, be cleared to zero

The Execute Device Diagnostic command performs the internal diagnostic tests implemented by the device. The results of the test are stored in the Error Register.

The normal Error Register bit definitions do not apply to this command. Instead, the register contains a diagnostic code. See Table 36 page 61 for its definition.

12.7   Flush Cache (E7h)

Table 93   Flush Cache Command (E7h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 E7h

Normal Outputs

Field	Description
ERROR	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent. 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Error Outputs

Field	Description
ERROR	**Bit Description** 7:3 N/A 2 ABORT bit 1:0 N/A
COUNT	N/A
LBA	LBA of First Unrecoverable Error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

This command causes the device to complete writing data from its cache.

The device returns good status after data in the write cache is written to disk media.

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12.8   Flush Cache Ext (EAh)

Table 94   Flush Cache Ext Command (EAh)

Command Input

Field	Description
FEATURE	Reserved
COUNT	Reserved
LBA	Reserved
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 EAh

Normal Outputs

Field	Description
ERROR	Reserved
COUNT	Reserved
LBA	Reserved
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Error Outputs

Field	Description
ERROR	**Bit Description** 7:3 N/A 2 ABORT bit 1:0 N/A
COUNT	N/A
LBA	LBA of First Unrecoverable Error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

This command causes the device to complete writing data from its cache.

The device returns good status after data in the write cache is written to disk media.

12.9   Format Track (50h)

Table 95   Format Track Command (50h)

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-
Sector Count	-	-	-	-	-	-	-	-
Sector Number	V	V	V	V	V	V	V	V
Cylinder Low	V	V	V	V	V	V	V	V
Cylinder High	V	V	V	V	V	V	V	V
Device/Head	1	L	1	D	H	H	H	H
Command	0	1	0	1	0	0	0	0

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	V	V	V	V	V	V	V	V
Cylinder Low	V	V	V	V	V	V	V	V
Cylinder High	V	V	V	V	V	V	V	V
Device/Head	-	-	-	-	H	H	H	H
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	V	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	V	-	0	-	V

Cold storage product does not support Format Track command. When the drive receives Format Track command from the host, the drive will abort the command

The Format Track command formats a single logical track on the device. Each good sector of data on the track will be initialized to zero with write operation. At this time, whether the sector of data is initialized correctly is not verified with read operation. Any data previously stored on the track will be lost.

The host may transfer a sector of data containing a format table to the device. But the device ignores the format table and writes zero to all sectors on the track regardless of the descriptors.

Since device performance is optimal at 1:1 interleave, and the device uses relative block addressing internally, the device will always format a track in the same way no matter what sector numbering is specified in the format table.

Output Parameters To The Device

Sector Number   In LBA mode, this register specifies LBA address bits 0 – 7 to be formatted. (L=1)

Cylinder High/Low   The cylinder number of the track to be formatted. (L=0)
In LBA mode, this register specifies LBA address bits 8-15 (Low), 16-23 (High) to be formatted. (L=1)

H   The head number of the track to be formatted. (L=0)
In LBA mode, this register specifies LBA address bits 24-27 to be formatted. (L=1)

Input Parameters From The Device

Sector Number   In LBA mode, this register specifies current LBA address bits 0-7. (L=1)

Cylinder High/Low   In LBA mode, this register specifies current LBA address bits 8-15 (Low), 16-23 (High)

H   In LBA mode, this register specifies current LBA address bits 24-27. (L=1)

Error   The Error Register. An Abort error (ABT=1) will be returned when LBA out of range.

In LBA mode, this command formats a single logical track including the specified LBA.

12.10 Format Unit (F7h)

Table 96   Format Unit Command (F7h)

Command Input

Field	Description
FEATURE	11h
COUNT	Reserved
LBA	Reserved
DEVICE	**Bit Description** 5:7 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 50h

Normal Outputs

Field	Description
ERROR	Reserved
COUNT	Reserved
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Error Outputs

Field	Description
ERROR	**Bit Description** 7:3 N/A 2 ABORT bit 1:0 N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved

The Format Unit command only initializes the Indirection Table to initialize all user data sectors in sequential write required zones and also initializes all user data sectors in conventional write zone with media write, after merging reassigned sector location into the defect information of the device and clearing the reassign information. Both new reassign information and new defect information are available right after command completion of this command. Previous information of reassign and defect are erased from the device by executing this command.

Note that the Format Unit command initializes from LBA 0 to Native MAX LBA regardless of setting by Initialize Device Parameter (91h) command, Device Configuration Overlay, or Set Max Address (F9h) command, so the protected area defined by these commands is also initialized.

Security Erase Prepare (F3h) commands should be completed just prior to the Format Unit command. If the device receives a Format Unit command without a prior Security Erase Prepare command, the device aborts the Format Unit command.

All values in Feature register are reserved, and any values other than 11h should not be put into Feature register.

This command does not request to data transfer.

Command execution time depends on drive capacity. To determine command timeout value, Word 89 of Identify Device data should be referred.

12.11 Identify Device (ECh)

Table 97   Identify Device Command (ECh)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 ECh

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.4 Download Microcode (92h)

The Identify Device command requests the device to transfer configuration information to the host. The device will transfer a sector to the host containing the information described in the following pages.

Table 98   Identify device information

Word	Content		Description	
00	045AH or 045EH		Drive classification, bit assignments:	
			15 (=0):	1=ATAPI device, 0=ATA device
			14 – 8 :	Retired
			7 (=0):	1=removable cartridge device
			6 (=1):	1=fixed device
			5-3 :	Retired
			2 (=0):	Response incomplete
			1 :	Retired
			0 (=0):	Reserved
01	xxxxH		Number of cylinders in default translate mode	
02	C837H		Specific Configuration	
			37C8H:	Need Set Feature for spin-up after power-up Identify Device is incomplete
			738CH:	Need Set Feature for spin-up after power-up Identify Device is complete
			8C73H:	No Need Set Feature for spin-up after power-up Identify Device is incomplete
			C837H:	No Need Set Feature for spin-up after power-up Identify Device is complete
03	00xxH		Number of heads in default translate mode	
04	0	*	Reserved	
05	0	*	Reserved	
06	003FH		Number of sectors per track in default translate mode	
07	0000H	*	Number of bytes of sector gap	
08	0000H	*	Number of bytes in sync field	
09	0000H	*	Reserved	
10-19	XXXX		Serial number in ASCII (0 = not specified)	
20	0003H	*	Controller type: 0003: dual ported, multiple sector buffer with look-ahead read	
21	XXXXH	*	Buffer size in 512-byte increments. In case of 64MB buffer, it is set to 0x0000.	
22	0038H	*	Reserved	
23-26	XXXX		Microcode version in ASCII	
27-46	XXXX		Model number in ASCII	
47	80xxH		15-8 (=80H)	80h

			7-0 (=xxH)	Maximum number of sectors that can be transferred per interrupt on Read and Write Multiple commands
				  If logical sector size is 512 bytes, the content of this bits are 10H.
				  If logical sector size is 4096 bytes, the content of this bits are 02H.

48	4000H		Trusted Computing feature set options	
			15 (=0) :	Shall be cleared to zero
			14 (=1) :	Shall be set to one
			13-1 (=0) :	Reserved for the Trusted Computing Group
			0 (=0) :	0=Trusted Computing feature set is not supported

Table 99 Identify device information –Continued-

Word	Content	Description		
49	xF00H	Capabilities, bit assignments:		
		15-14 (=0)	Reserved	
		13	Standby timer	
		(=1)	values as specified in ATA standard are supported	
		(=0)	values are vendor specific	
		12 (=0)	Reserved	
		11 (=1)	IORDY Supported	
		10 (=1)	IORDY can be disabled	
		9 (=1)	LBA supported	
		8 (=1)	DMA supported	
		7- 0 (=0)	Reserved	
50	4000H	Capabilities, bit assignments:		
		15-14 (=01)	word 50 is valid	
		13-1(=0)	Reserved	
		0(=0)	Minimum value of Standby timer less than 5 minutes	
51	0200H	PIO data transfer cycle timing mode		
52	0200H *	DMA data transfer cycle timing mode Refer Word 62 and 63		
53	0007H	Validity flag of the word		
		15-8 (=0)	Free-fall Control Sensitivity 00h = Vendor's recommended setting	
		7-3 (=0)	Reserved	
		2 (=1)	1=Word 88 is Valid	
		1 (=1)	1=Word 64-70 are Valid	
		0 (=1)	1=Word 54-58 are Valid	
54	xxxxH	Number of current cylinders		
55	xxxxH	Number of current heads		
56	xxxxH	Number of current sectors per track		
57-58	xxxxH	Current capacity in sectors Word 57 specifies the low word of the capacity		
59	xxxxH	Sanitize capabilities and Current Multiple setting. Bit assignments		
		15 (=0)	The BLOCK ERASE EXT command is not supported	
		14 (=1)	The OVERWRITE EXT command is supported	
		13 (=0or1)	The CRYPTO SCRAMBLE EXT command is supported	
		12 (=1)	The Sanitize Device Feature Set is supported	
		11-9 (=0)	Reserved	
		8	1= Multiple Sector Setting is Valid	
		7-0	xxh = Current setting for number of sectors	
60-61	xxxxH	Total Number of User Addressable Sectors Word 60 specifies the low word of the number FFFFFFFFh=The 48-bit native max address is greater than 268,435,455		
62	0000H	Reserved		
63	xx07H	Multiword DMA Transfer Capability		
		15- 8	Multi word DMA transfer mode active	
		7-0 (=7)	Multi word DMA transfer modes supported (support mode 0,1 and 2)	
64	0003H	Flow Control PIO Transfer Modes Supported		
		15-8 (=0)	Reserved	
		7-0 (=3)	Advanced PIO Transfer Modes Supported	
			'11' = PIO Mode 3 and 4 Supported	

Table 100   Identify device information –Continued-

Word	Content	Description	
65	0078H	Minimum Multiword DMA Transfer Cycle Time Per Word	
		15-0 (=78)	Cycle time in nanoseconds (120ns, 16.6MB/s)
66	0078H	Manufacturer's Recommended Multiword DMA Transfer Cycle Time	
		15-0 (=78)	Cycle time in nanoseconds (120ns, 16.6MB/s)
67	0078H	Minimum PIO Transfer Cycle Time Without Flow Control	
		15-0 (=78)	Cycle time in nanoseconds (120ns, 16.6MB/s)
68	0078H	Minimum PIO Transfer Cycle Time With IORDY Flow Control	
		15-0 (=78)	Cycle time in nanoseconds (120ns, 16.6MB/s)
69	0C08H	Additional Supported	
		11 (=1)	READ BUFFER DMA command is supported
		10 (=1)	WRITE BUFFER DMA command is supported
		4 (=0)	1=Device Encrypts All User Data on the device
		3 (=1)	Extended Number of User Addressable Sectors is supported
70-74	0000H	Reserved	
75	001FH	Queue depth	
		15-5 (=0)	Reserved
		4-0 (=1F)	Maximum queued depth – 1
76	970xH	SATA capabilities	
		15 (=1)	READ LOG DMA EXT command is supported
		14-13 (=0)	Reserved
		12 (=1)	High Priority command (Please see 6.5 First-party DMA commands)
		11 (=0)	Unload while NCQ commands are outstanding is supported
		10 (=1)	Phy event counters
		9 (=1)	Receipt of host-initiated interface power management requests
		8 (=1)	Native Command Queuing supported
		7-4 (=0)	Reserved
		3 (=x)	SATA Gen-3 speed (6.0Gbps) supported
		2 (=x)	SATA Gen-2 speed (3.0Gbps) supported
		1 (=1)	SATA Gen-1 speed (1.5Gbps) supported
		0 (=0)	Reserved
77	007xH	15-7 (=0)	Reserved
		6 (=1)	Support RECEIVE FPDMA QUEED and SEND FPDMA QUEUED
		5 (=1)	Supports NCQ NON-DATA Command
		4 (=1)	Supports NCQ Streaming
		3-1 (=011)	Current negotiated SATA speed Gen-3 speed of 6.0Gbps
		(=010)	Current negotiated SATA speed Gen-2 speed of 3.0Gbps
		(=001)	Current negotiated SATA speed Gen-1 speed of 1.5Gbps
		0 (=0)	Reserved

Table 101   Identify device information –Continued-

Word	Content	Description	
78	0CDEH	SATA supported features	
		15-12 (=0)	Reserved
		11 (=1)	Rebuild Assist
		10 (=1)	Device Initiated Interface Power Management Software Settings
		9-8 (=0)	Reserved
		7 (=1)	NCQ Autosense
		6 (=1)	Software setting preservation
		5 (=0)	Reserved
		4 (=1)	In-order data delivery
		3 (=1)	Device initiated interface power management
		2 (=1)	DMA Setup Auto-Activate optimization
		1 (=1)	Non-zero buffer offset in DMA Setup FIS
		0 (=0)	Reserved
79	0040H	SATA enabled features	
		15-7 (=0)	Reserved
		6 (=1)	Software setting preservation
		5 (=0)	Reserved
		4 (=0)	In-order data delivery
		3 (=0)	Device initiated interface power management
		2 (=0)	DMA Setup Auto-Activate optimization
		1 (=0)	Non-zero buffer offset in DMA Setup FIS
		0 (=0)	Reserved
80	03FCH	Major version number	
		15-0(=3FCh)	ATA-2, ATA-3, ATA/ATAPI-4, ATA/ATAPI-5, ATA/ATAPI-6. ATA/ATAPI-7 and ATA8-ACS and ACS2
81	0029H	Minor version number	
		15-0(=29h)	ATA8-ACS Revision 4
82	746BH	Command set supported	
		15 (=0)	Reserved
		14 (=1)	NOP command
		13 (=1)	READ BUFFER command
		12 (=1)	WRITE BUFFER command
		11 (=0)	Reserved
		10 (=1)	Host Protected Area Feature Set
		9 (=0)	DEVICE RESET command
		8 (=0)	SERVICE interrupt
		7 (=0)	Release interrupt
		6 (=1)	LOOK AHEAD
		5 (=1)	WRITE CACHE
		4 (=0)	PACKET Command feature set
		3 (=1)	Power management feature set
		2 (=0)	Removable feature set
		1 (=1)	Security feature set
		0 (=1)	SMART feature Set

Table 102   Identify device information –Continued-

Word	Content	Description	
83	7D69H	Command set supported	
		15-14(=01)	Word 83 is valid
		13 (=1)	FLUSH CACHE EXT command supported
		12 (=1)	FLUSH CACHE command supported
		11 (=1)	Device Configuration Overlay command supported
		10 (=1)	48-bit Address feature set supported
		9 (=0)	Reserved
		8 (=1)	SET Max Security extension
		7 (=0)	Set Features Address Offset feature mode
		6 (=1)	SET FEATURES subcommand required to spin-up after power-up
		5 (=1)	Power-Up In Standby feature set supported
		4 (=0)	Removable Media Status Notification feature
		3 (=1)	Advanced Power Management feature set
		2 (=0)	CFA feature set
		1 (=0)	READ/WRITE DMA QUEUED
		0 (=1)	Download Microcode command
84	4163H or 4773H	Command set/feature supported extension	
		15-14 (=01)	Word 84 is valid
		13 (=0)	IDLE IMMEDIATE with UNLOAD FEATURE supported
		12-11 (= 0)	Reserved
		10 (=x)	URG bit supported for WRITE STREAM DMA Ext and WRITE STREAM Ext
		9 (=x)	URG bit supported for READ STREAM DMA Ext and READ STREAM Ext
		8 (=1)	World wide name supported
		7 (=0)	WRITE DMA QUEUED FUA EXT command supported
		6 (=1)	WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands supported
		5 (=1)	General Purpose Logging feature set supported
		4 (=x)	Streaming feature set supported
		3 (=0)	Media Card Pass Through Command feature set supported
		2 (=0)	Media serial number supported
		1 (=1)	SMART self-test supported
		0 (=1)	SMART error logging supported
85	xxxxH	Command set/feature enabled	
		15	Reserved
		14	NOP command
		13	READ BUFFER command
		12	WRITE BUFFER command
		11	Reserved
		10	Host Protected Area feature set
		9	DEVICE RESET command
		8	SERVICE interrupt
		7	RELEASE interrupt
		6	LOOK AHEAD
		5	WRITE CACHE
		4	PACKET Command feature set
		3	Power management feature set
		2	Removable media feature set
		1	Security feature set
		0	SMART feature set

Table 103   Identify device information –Continued-

Word	Content	Description	
86	xxxxH	Command set/feature enabled	
		15	Words 120:119 are valid.
		14	Reserved
		13	FLUSH CACHE EXT command supported
		12	FLUSH CACHE command supported
		11	Device Configuration Overlay command enabled
		10	48-bit Address features set supported
		9	Reserved
		8	Set Max Security extensions enabled
		7	Set Features Address Offset mode
		6	Set Features subcommand required to spin-up after power-up
		5	Power-Up In Standby feature set enabled
		4	Removable Media Status Notification feature
		3	Advanced Power Management Feature set
		2	CFA Feature set
		1	READ/WRITE DMA QUEUED
		0	Download Microcode command
87	4163H or 4763H or 4773H	Command set/feature default	
		15-14 (=01)	Word 87 is valid
		13 (=0)	IDLE IMMEDIATE with UNLOAD FEATURE supported
		12-11 (= 0)	Reserved
		10 (=x)	URG bit supported for WRITE STREAM DMA Ext and WRITE STREAM Ext
		9 (=x)	URG bit supported for READ STREAM DMA Ext and READ STREAM Ext
		8 (=1)	World wide name supported
		7 (=0)	WRITE DMA QUEUED FUA EXT command supported
		6 (=1)	WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands supported
		5 (=1)	General Purpose Logging feature set supported
		4 (=x)	Valid CONFIGURE STREAM command has been executed
		3 (=0)	Media Card Pass Through Command feature set enabled
		2 (=0)	Media serial number is valid
		1 (=1)	SMART self-test supported
		0 (=1)	SMART error logging supported

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Table 104   Identify device information –Continued-

Word	Content	Description				
88	xx7FH	Ultra DMA Transfer modes				
		15- 8(=xx)	Current active Ultra DMA transfer mode			
			15	Reserved (=0)		
			14	Mode 6	1 = Active	0 = Not Active
			13	Mode 5	1 = Active	0 = Not Active
			12	Mode 4	1 = Active	0 = Not Active
			11	Mode 3	1 = Active	0 = Not Active
			10	Mode 2	1 = Active	0 = Not Active
			9	Mode 1	1 = Active	0 = Not Active
			8	Mode 0	1 = Active	0 = Not Active
		7- 0 (=7F)	Ultra DMA Transfer mode supported			
			7	Reserved (=0)		
			6	Mode 6	1 = Support	
			5	Mode 5	1 = Support	
			4	Mode 4	1 = Support	
			3	Mode 3	1 = Support	
			2	Mode 2	1 = Support	
			1	Mode 1	1 = Support	
			0	Mode 0	1 = Support	
89	xxxxH	Time required for security erase unit completion				
			15	1=Extended Time is reported in bits 14:0		
				0=Time is reported in bits 7:0		
		If bit 15 is set to one				
			14:0	Time required for security erase unit completion		
		Time= value(xxxxh)x2 [minutes]				
		If bit 15 is set to zero				
			14:8	Reserved		
			7:0	Time required for security erase unit completion		
		Time= value(xxxxh)x2 [minutes]				
90	xxxxH	Time required for Enhanced security erase completion				
			15	1=Extended Time is reported in bits 14:0		
				0=Time is reported in bits 7:0		
		If bit 15 is set to one				
			14:0	Time required for Enhanced security erase completion		
		If bit 15 is set to zero				
			14:8	Reserved		
			7:0	Time required for Enhanced security erase completion		
91	00FEH	Current Advanced power management value				
92	FFFEH	Current Password Revision Code				
93	0000H	COMRESET result				
94	0000H	Reserved				
95	xxxxH	Stream Minimum Request Size Number of sectors that provides optimum performance in streaming environment. This number shall be a power of two, with a minimum of eight sectors (4096 bytes). The starting LBA value for each streaming command should be evenly divisible by this request size.				
96	xxxxH	Streaming Transfer Time – DMA The worst-case sustainable transfer time per sector for the device is calculated as follows: Streaming Transfer Time = (word 96) * (words(99:98) / 65536) If the Streaming Feature set is not supported by the device, the content of word 96 shall be zero.				

Table 105   Identify device information –Continued—

Word	Content	Description		
97	xxxxH	Streaming Access Latency – DMA and PIO The worst-case access latency of the device for a streaming command is calculated as follows: Access Latency = (word 97) * (words(99:98) / 256) If the Streaming Feature set is not supported by the device, the content of word 97 shall be zero.		
98	xxxxH	Streaming Performance Granularity		
99	xxxxH	Streaming Performance Granularity		
100-103	xxxxH	Total Number of User Addressable Logical Sectors for 48-bit commands		
104	xxxxH	Streaming Transfer Time – PIO The worst-case sustainable transfer time per sector for the device is calculated as follows: Streaming Transfer Time = (word 104) * (words(99:98) / 65536) If the Streaming Feature set is not supported by the device, the content of word 104 shall be zero.		
105	0000H	Reserved		
106	x00xH	Physical sector size / logical sector size		
			15 (=0)	Shall be cleared to zero
			14 (=1)	Shall be set to one.
			13 (=x)	Device has multiple logical sectors per physical sector If logical sector size is 512 bytes, the content of this bit is 1b. If logical sector size is 4096 bytes, the content of this bit is 0b.
			12 (=x)	Device logical sector is longer than 256 words If logical sector size is 512 bytes, the content of this bit is 0b. If logical sector size is 4096 bytes, the content of this bit is 1b.
			11-4 (=00H)	Reserved
			3-0 (=xH)	2^0 logical sectors per physical sector If logical sector size is 512 bytes, the content of this bits are 0011b. If logical sector size is 4096 bytes, the content of this bits are 0000b.
107	5A87H	Inter-seek delay for ISO-7779 acoustic testing in microseconds		
108-111	xxxxH	World wide name the optional value of the world wide name for the device		
112-116	0000H	Reserved		
117-118	xxxxH	Words per logical sector This word is set number of words per logical sector when sector size is longer than 256 words. If logical sector size is 512 bytes, the content of this bits are 0000H. If logical sector size is 4096 bytes, the content of this bits are 0800H.		
119	40D8h	Supported settings (Continued from word 84:82)		
			15	Shall be cleared to zero
			14	Shall be set to one.
			13-8	Reserved
			7	1=Extended Power Conditions feature set is supported
			6	1=Sense data is supported
			5	0=Free-fall Control feature set is not supported
			4	1=The segmented feature for Download Microcode is supported.
			3	1=The READ/ WRITE LOG DMA EXT commands are supported.
			2	0=WRITE UNCORRECTABLE EXT is not supported.
			1	0=Write-Read-Verify feature set is not supported
			0	Reserved

Table 106   Identify device information –Continued—

Word	Content		Description	
120	4098h		Command set/feature enabled/supported. (Continued from word 87:85)	
		15	Shall be cleared to zero	
		14	Shall be set to one.	
		13-8	Reserved	
		7	1=Extended Power Conditions feature set is enabled	
		6	0=Sense data is disabled	
		5	0=Free-fall Control feature set is disabled	
		4	1=The segmented feature for Download Microcode is supported.	
		3	1=The READ/ WRITE LOG DMA EXT commands are supported.	
		2	0= WRITE UNCORRECTABLE EXT is not supported.	
		1	0=Write-Read-Verify feature set is not enabled	
		0	Reserved	
121-126	0000H		Reserved	
127	0000H		Removable Media Status Notification feature set	
			0000H=Not supported	
128	xxxxH		Security status. Bit assignments	
		15-9	Reserved	
		8	Security Level	1= Maximum, 0= High
		7-6	Reserved	
		5	Enhanced erase	1= Support
		4	Expired	1= Expired
		3	Freeze	1= Frozen
		2	Lock	1= Locked
		1	Enabled/Disable	1= Enable
		0	Capability	1= Support
129	xxxxH *		Current Set Feature Option. Bit assignments	
		15-4	Reserved	
		3	Auto reassign enabled	1= Enable
		2	Reverting enabled	1= Enable
		1	Read Look-ahead enabled	1= Enable
		0	Write Cache enabled	1= Enable
130-159	xxxxH *		Reserved	
160-167	0000H		Reserved	
168	0002H		15-4	Reserved	
		3-0	Device Nominal Form Factor	02H shows 3.5inch nominal form factor
169-175	0000H		Reserved	
176-205	0000H		Current media serial number (0000H=Not supported)	
206	003DH		SCT Command set support	
		15-12	Vendor specific	
		11-6	Reserved	
		5	Action Code 5 (SCT Data Table)	1= Support
		4	Action Code 4 (Features Control)	1= Support
		3	Action Code 3 (Error Recovery Control)	1= Support
		2	Action Code 2 (SCT Write Same)	1= Support
		1	Action Code 1 (Long Sector Access)	0= Not Support
		0	SCT Feature Set (includes SCT status)	1= Support

Note.   The '*' mark in 'Content' field indicates the use of those parameters are vendor specific.

Table 107　Identify device information –Continued-

Word	Content	Description		
207-208	0000H	Reserved		
209	4000H	Alignment of logical blocks within a physical block (This word is valid if bit 13 of word 106 is set to one.)		
		15　(=0)	Shall be cleared to zero	
		14　(=1)	Shall be set to one	
		13-0　(=x)	Logical sector offset within the first physical sector where the first logical sector is placed	
210-211	0000H	Write-Read-Verify Sector Count Mode 3 (Dword)		
		0000H=Not supported		
212-213	0000H	Write-Read-Verify Sector Count Mode 2 (Dword)		
		0000H=Not supported		
214	0000H	NV Cache Capabilities		
		0000H=Not supported		
215-216	0000H	NV Cache Size in Logical Blocks (Dword)		
217	1C20H	Nominal media rotation rate (=7200rpm)		
218	0000H	Reserved		
219	0000H	NV Cache Options		
		0000H=Not supported		
220	0000H	15-8 (=0)	Reserved	
		7-0 (=0)	Write-Read-Verify feature set current mode(not supported)	
221	0000H	Reserved		
222	10FFH	Transport major version number		
		15-12 (=1)	Transport Type (1= Serial)	
		11-8 (=0)	Reserved	
		7　(=1)	SATA Rev 3.2	
		6　(=1)	SATA Rev 3.1	
		5　(=1)	SATA Rev 3.0	
		4　(=1)	SATA Rev 2.6	
		3　(=1)	SATA Rev 2.5	
		2　(=1)	SATA II: Extensions	
		1　(=1)	SATA 1.0a	
		0　(=1)	ATA8-AST	
223	0021H	Transport minor version number (ATA8-AST T13 Project D1697 Revision 0b)		
224-229	0000H	Reserved		
230-233	xxxxH	Extended Number of User Addressable Sectors		
234	0008H	Minimum number of 512-byte data blocks per Download Microcode command for mode 3		
235	0000H	Maximum number of 512-byte data blocks per Download Microcode command for mode 3		
236-254	0000H	Reserved		
255	xxA5H	15-8	Checksum. This value is the two's complement of the sum of all bytes in byte 0 through 510	
		7-0	(A5)　Signature	

12.12 Idle (E3h/97h)

Table 108   Idle Command (E3h/97h)

Command Input

Field	Description
FEATURE	N/A
COUNT	Standby timer period
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 E3h or 97h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

Field	Description
ERROR	**Bit Description** 7:3 N/A 2 ABORT bit 1:0 N/A
COUNT	N/A
LBA	LBA of First Unrecoverable Error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Idle command causes the device to enter Idle mode immediately, and set auto power down timeout parameter (standby timer). And then the timer starts counting down.

When the Idle mode is entered, the device is spun up to operating speed. If the device is already spinning, the spin up sequence is not executed.

During Idle mode the device is spinning and ready to respond to host commands immediately.

Standby timer period   Timeout Parameter.   If zero, then the automatic power down sequence is disabled. If non-zero, then the automatic power down sequence is enabled, and the timeout interval is shown below:

Value	Description
0	Timer disabled
1-240	Value * 5
241-251	(Value-240) * 30 minutes
252	21 minutes
253	8 hours
254	Aborted
255	21 minutes 15 seconds

When the automatic power down sequence is enabled, the drive will enter Standby mode automatically if the timeout interval expires with no drive access from the host. The timeout interval will be reinitialized if there is a drive access before the timeout interval expires.

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12.13 Idle Immediate (E1h/95h)

Table 109   Idle Immediate Command (E1h/95h)

Command Input

Field	Description
FEATURE	N/A except when the Unload feature is requested
COUNT	N/A except when the Unload feature is requested
LBA	N/A except when the Unload feature is requested
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 E1h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in12.12 Idle (E3h/97h)

The Idle Immediate command causes the device to enter Idle mode.

The device is spun up to operating speed. If the device is already spinning, the spin up sequence is not executed.

During Idle mode the device is spinning and ready to respond to host commands immediately.

The Idle Immediate command will not affect to auto power down timeout parameter.

12.14 Initialize Device Parameters (91h)

Table 110   Initialize Device Parameters Command (91h)

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-
Sector Count	V	V	V	V	V	V	V	V
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	H	H	H	H
Command	1	0	0	1	0	0	0	1

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	-	-	-	-	-	-	-	-
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	-	-	-	-	-	-	-	-
Status	...See Below...							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

The Initialize Device Parameters command enables the host to set the number of sectors per track and the number of heads minus 1, per cylinder. Words 54-58 in Identify Device Information reflect these parameters.

The parameters remain in effect until following events:
- Another Initialize Device Parameters command is received.
- The device is powered off.
- Soft reset occurs and the Set Feature option of CCh is set instead of 66h.

Output Parameters To The Device

Sector Count   The number of sectors per track. 0 does not mean there are 256 sectors per track, but there is no sector per track.

H   The number of heads minus 1 per cylinder. The minimum is 0 and the maximum is 15.

Note:
The following conditions needs to be satisfied to avoid invalid number of cylinders beyond FFFFh.

(Total number of user addressable sectors)/((Sector Count)*(H+1)) = < FFFFh
The total number of user addressable sectors is described in Identify Device command.

12.15 Logical Depop Feature Set Command(FCh)

12.15.1   Inquiry Depopulated Heads(FCh/01h)

Table 111   Inquiry Depopulated Heads

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 N/A 7:0 01h
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 FCh

Normal Outputs

Field	Description
ERROR	N/A
COUNT	**Bit Description** 15:8 Head presence at factory shipping time (head 7:0) bit 8 = head 0, bit 9 = head 1 … bit 15 = head 7 bit value 0: head not present / bit value 1: head present 7:0 Head depop status (head 7:0) bit 0 = head 0, bit 1 = head 1 … bit 7 = head 7 bit value 0: not depoped / bit value 1: depoped
LBA	**Bit Description** 47:24 Head presence at factory shipping time (head 31:8) bit 24 = head 8, bit 25 = head 9 … bit 47 = head 31 bit value 0: head not present / bit value 1: head present 23:0 Head depop status (head 31:8) bit 0 = head 8, bit 1 = head 9 … bit 23 = head 31 bit value 0: not depoped / bit value 1: depoped
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Protocol: Non-data

Inquiry Depopulated Heads is used to report heads depopulated at command reception time and heads present at factory shipping time

12.15.2 Format Unit with Depopulation(FCh/02h)

Table 112 Format Unit with Depopulation

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 N/A 7:0 02h

COUNT	**Bit Description**
	7:0 Depopulated head specifier for head 7:0 (in factory shipping head number)
	    bit 0 = head 0, bit 1 = head 1 … bit 7 = head 7
	    bit value 0: test pass / bit value 1: test fail

LBA	**Bit Description**
	23:0 Depopulated head specifier for head 31:7 (in factory shipping head number)
	    bit 0 = head 8, bit 1 = head 9 … bit 23 = head 31
	    bit value 0: not change / bit value 1: depop

DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 FCh

Normal Outputs

Field	Description
ERROR	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Protocol: Non-data

Command input

Format Unit with Depopulation initiates special format operation that excludes specified head(s) as not present.　Use *Get Format Unit Status (FCh/03h)* to query progress of format.　Native device capacity is reduced according to the number of physical blocks on surface(s) associated with specified head(s)

All LBAs are initialized as part of format operation. For data encryption model, user data is cryptographically discarded by changing internal encryption key

Normal outputs

Special format operation is initiated in background upon successful completion of *Format Unit with Depopulation*. During format operation, only following commands are accepted:
Get Format Unit Status
Read Log Ext (log address 10h: NCQ error log)
Read Log DMA Ext (log address 10h: NCQ error log)

12.15.3 Get Format Unit Status (FCh/03h)

Table 113   Get Format Unit Status

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 N/A 7:0 03h
COUNT	**N/A**
LBA	**N/A**
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 FCh

Normal Outputs

Field	Description
ERROR	N/A
COUNT	**Format unit progress** 0 .. 63h Progress in % 64h .. FEh Reserved FFh Format has completed
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Protocol: Non-data

Get Format Unit Status is used to query progress of special format initiated by *Format Unit with Depopulation*

12.16 NCQ NON-DATA (63h)

Table 114   NCQ Queue Management command (63h)

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 Reserved 7:4 Subcommand specific 3:0 SUBCOMMAND field
COUNT	**Bit Description** 15:14 PRIO field 13:8 Reserved 7:3 NCQ TAG field 2:0 Reserved
LBA	**Bit Description** 47:8 Reserved 7:3 Subcommand specific 2:0 Reserved
AUXILIARY	15:0 Subcommand specific
DEVICE	**Bit Description** 7 Reserved 6 Shall be set to one 5 Reserved 4 Shall be cleared to zero 3:0 Reserved
Command	7:0 63h

Table 44   Subcommand Field defines the NCQ NON-DATA subcommands. See the referenced sections for additional information in this table.
The output from the host to the device, the command acceptance outputs for this command, the normal outputs for this command and the error outputs for this command are subcommand specific. See 12.16.1 and 12.16.2.

12.16.1 Abort NCQ Queue Subcommand (0h)

Table 115   Abort NCQ Queue Subcommand (0h)

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 Reserved 7:4 ABORT TYPE field 3:0 Subcommand field – shall be set to 0h
COUNT	**Bit Description** 15:14 PRIO field 13:8 Reserved 7:3 NCQ TAG field 2:0 Reserved
LBA	**Bit Description** 47:8 Reserved 7:3 TTAG field 2:0 Reserved
DEVICE	**Bit Description** 7 Reserved 6 Shall be set to one 5 Reserved 4 Shall be cleared to zero 3:0 Reserved
Command	7:0 63h

Normal Outputs

If a supported Abort Type parameter is specified, then the device indicates success, even if the command results in no commands being aborted.

When an Abort NCQ Queue command completes successfully, a Set Device Bits FIS is sent to the host to complete the Abort subcommand and commands that were aborted as a consequence of the Abort subcommand by setting the ACT bits for those commands to one. This SDB FIS may also indicate other completed commands.

Error Outputs

The device returns command aborted if:
  a)   NCQ is disabled and an Abort NCQ Queue command is issued to the device;
  b)   the value of the TTAG field equals the value of the TAG field;
  c)   the value of the TTAG field is an invalid TAG number; or
  d)   an unsupported Abort type parameter is specified.

Output Parameters To The Device

Feature Current

Subcommand (bits 3-0)	When bits(3:0) is 0h, Abort NCQ Queue Abort Subcommand.
Subcommand Specific (bits 7-4)	Abort Type, bit(7:4), describes the action requested. The NCQ NON-DATA Log (see 10.17.4.4) provides a list of abort types supported by the device. The value of Abort type are defined in the below the table.

Feature Previous

Sector Count Current .

TAG (bits 7-3)	The TAG value is assigned to be different from all other queued commands. The value does not exceed the maximum queue depth specified by the Word 75 of the Identify Device information.

Sector Count Previous

Sector Number Current

TTAG (bits 7-3)	The TTAG field contains the value of the TAG of the outstanding command that is requested to be aborted. The TTAG value is only valid when the Abort Type field is set to 3h (Abort Selected). TTAG does not exceed the value specified in IDENTIFY DEVICE word 75.

Cylinder Low Current

Cylinder Low Previous

Cylinder High Current

Cylinder High Previous

Device/Head

Input Parameters From The Device

Sector Number (HOB=0)

Sector Number (HOB=1)

Cylinder Low (HOB=0)

Cylinder Low (HOB=1)

Cylinder High (HOB=0)

Cylinder High (HOB=1)

Table 116 Abort Type Field

Abort Type Parameters		
Abort Type	Abort Type	Description
0h	Abort All	The device attempts to abort all outstanding NCQ commands.
1h	Abort Streaming	The device attempts to abort all outstanding NCQ Streaming commands. All non-streaming NCQ commands are unaffected.
2h	Abort Non-Streaming	The device attempts to abort all outstanding NCQ Non-Streaming commands. All NCQ Streaming commands are unaffected.
3h	Abort Selected	The device attempts to abort the outstanding NCQ command associated with the tag represented in TTAG field.

12.16.2   Deadline handling Subcommand (1h)

Table 117   Deadline handling Subcommand (1h)

Command Input

Field	Description
FEATURE	**Bit Description** 15:6 Reserved 5 RDNC bit 4 WDNC bit 3:0 Subcommand (1h)
COUNT	**Bit Description** 15:14 PRIO field 13:8 Reserved 7:3 NCQ TAG field 2:0 Reserved
LBA	**Bit Description** 47:8 Reserved 7:3 TTAG field 2:0 Reserved
DEVICE	**Bit Description** 7 Reserved 6 Shall be set to one 5 Reserved 4 Shall be cleared to zero 3:0 Reserved
Command	7:0 63h

Normal Outputs

If this Deadline Handling Subcommand command is supported, the device returns the command completed with no error.

When a Deadline Handling Subcommand command completes successfully, a Set Device Bits FIS is sent to the host to complete the Deadline Handling subcommand. This SDB FIS may also indicate other completed commands.

Error Outputs

The device returns command aborted if:
a)   NCQ is disabled and a DEADLINE HANDLING command is issued to the device;
b)   The value of the TTAG field equals the value of the TAG field;
c)   The value of the TTAG field is an invalid TAG number; or
d)   An unsupported Abort type parameter is specified.

Feature

> **Subcommand (bits 3-0)**   When bits (3:0) is 1h, Deadline Handling Subcommand.
>
> **WDNC(bits 4)**   If the WDNC (Write Data Not Continue) bit is cleared to zero, then the device allows WRITE FPDMA QUEUED command completion times to exceed what the ICC parameter specified. If the WDNC bit is set to one, then the all WRITE FPDMA QUEUED commands are completed by the time specified by the ICC timer value, otherwise the device returns command aborted for all outstanding commands. WDNC is only applicable to WRITE FPDMA QUEUED commands with PRIO is set to 01b (Isochronous – deadline dependent priority)
>
> **RDNC(bits 5)**   If the RDNC (Read Data Not Continue) bit is cleared to zero, then the device allows READ FPDMA QUEUED command completion times to exceed what the ICC parameter specified. If the RDNC bit is set to one, then the all READ FPDMA QUEUED commands are completed by the time specified by the ICC timer value, otherwise the device returns command aborted for all outstanding commands. RDNC is only applicable to READ FPDMA QUEUED commands with PRIO is set to 01b (Isochronous – deadline dependent priority)

Count

TAG (bits 7-3)   The TAG value is assigned to be different from all other queued commands. The value does not exceed the maximum queue depth specified by the Word 75 of the Identify Device information.

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12.17 Read Buffer (E4h)

Table 118 Read Buffer Command (E4h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description**
	7 Obsolete
	6 N/A
	5 Obsolete
	4 Transport Dependent
	3:0 Reserved
Command	7:0 E4h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Register

See Error Register in 12.4 Download Microcode (92h)

The Read Buffer command transfers a sector of data from the sector buffer of device to the host.

The sector is transferred through the Data Register 16 bits at a time.

The sector transferred will be from the same part of the buffer written to by the last Write Buffer command.   The contents of the sector may be different if any reads or writes have occurred since the Write Buffer command was issued.

12.18 Read Buffer DMA (E9h)

Table 119   Read Buffer DMA Command (E9h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 E9h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Register

See Error Register in 12.4 Download Microcode (92h)

The Read Buffer DMA command transfers a sector of data from the sector buffer of device to the host.

The sector is transferred through the Data Register 16 bits at a time.

The sector transferred will be from the same part of the buffer written to by the last Write Buffer command.   The contents of the sector may be different if any reads or writes have occurred since the Write Buffer command was issued.

12.19 Read DMA(C8h/C9h)

Table 120   Read DMA Command (C8h/C9h)

Command Input

Field	Description
FEATURE	N/A
COUNT	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 C8h or C9h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6 UNCORRECTABLE ERROR bit 5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1:0 Obsolete
COUNT	N/A
LBA	LBA of First Unrecoverable Error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Read DMA command reads one or more sectors of data from disk media, then transfers the data from the device to the host.The sectors are transferred through the Data Register 16 bits at a time.The host initializes a slave-DMA channel prior to issuing the command. The data transfers are qualified by DMARQ and are performed by the slave-DMA channel. The device issues only one interrupt per command to indicate that data transfer has terminated and status is available.

If an uncorrectable error occurs, the read will be terminated at the failing sector.

Output Parameters To The Device

Sector Count   The number of continuous sectors to be transferred. If zero is specified, then 256 sectors will be transferred.

Sector Number   The sector number of the first sector to be transferred. (L=0)
In LBA mode, this register specifies LBA address bits 0-7 to be transferred. (L=1)

Cylinder High/Low   The cylinder number of the first sector to be transferred. (L=0)
In LBA mode, this register specifies LBA address bits 8-15 (Low) 16-23 (High) to be transferred. (L=1)

H   The head number of the first sector to be transferred. (L=0)
In LBA mode, this register specifies LBA bits 24-27 to be transferred. (L=1)

R   The retry bit, but this bit is ignored.

Input Parameters From The Device

Sector Count   The number of requested sectors not transferred. This will be zero, unless an unrecoverable error occurs.

Sector Number   The sector number of the last transferred sector. (L=0)
In LBA mode, this register contains current LBA bits 0-7. (L=1)

Cylinder High/Low   The cylinder number of the last transferred sector. (L=0)
In LBA mode, this register contains current LBA bits 8-15 (Low), 16-23 (High). (L=1)

H   The head number of the sector to be transferred. (L=0)
In LBA mode, this register contains current LBA bits 24-27. (L=1)

12.20 Read DMA Ext (25h)

Table 121   Read DMA Ext Command (25h)

Command Input

Field	Description
FEATURE	Reserved
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 25h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6 UNCORRECTABLE ERROR bit 5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1:0 Obsolete
COUNT	Reserved
LBA	LBA of First Unrecoverable Error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Read DMA command reads one or more sectors of data from disk media, and then transfers the data from the device to the host.

The sectors are transferred through the Data Register 16 bits at a time.

The host initializes a slave-DMA channel prior to issuing the command. The data transfers are qualified by DMARQ and are performed by the slave-DMA channel. The device issues only one interrupt per command to indicate that data transfer has terminated and status is available.

If an uncorrectable error occurs, the read will be terminated at the failing sector.

Output Parameters To The Device

Sector Count Current	The number of sectors to be transferred low order, bits (7:0).
Sector Count Previous	The number of sectors to be transferred high order, bits (15:8). If 0000h in the Sector Count register is specified, then 65,536 sectors will be transferred.
Sector Number Current	LBA (7:0)
Sector Number Previous	LBA (31:24)
Cylinder Low Current	LBA (15:8)
Cylinder Low Previous	LBA (39:32)
Cylinder High Current	LBA (23:16)
Cylinder High Previous	LBA (47:40)

Input Parameters From The Device

Sector Number (HOB=0)	LBA (7:0) of the address of the first unrecoverable error.
Sector Number (HOB=1)	LBA (31:24) of the address of the first unrecoverable error.
Cylinder Low (HOB=0)	LBA (15:8) of the address of the first unrecoverable error.
Cylinder Low (HOB=1)	LBA (39:32) of the address of the first unrecoverable error.
Cylinder High (HOB=0)	LBA (23:16) of the address of the first unrecoverable error.
Cylinder High (HOB=1)	LBA (47:40) of the address of the first unrecoverable error.

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12.21 Read FPDMA Queued (60h)

Table 122   Read FPDMA Queued Command (60h)

Command Input

Field	Description
FEATURE	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred
COUNT	**Bit Description** 15:14 PRIO field 13:8 Reserved 7:3 NCQ TAG field 2:0 Reserved
LBA	LBA of first logical sector to be transferred
ICC	7:0 ICC field
DEVICE	**Bit Description** 7 FUA bit 6 Shall be set to one 5 Reserved 4 Shall be cleared to zero 3:0 Reserved
Command	7:0 60h

Normal Outputs

Field	Description
ERROR	Shall be cleared to zero
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7:4 N/A 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 STREAM ERROR bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

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Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6:3 N/A 2 ABORT bit. 1:0 N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7:4 N/A 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Read FPDMA command reads one or more sectors of data from disk media, and then transfers the data from the device to the host.

If an uncorrectable error occurs, the read will be terminated at the failing sector.

FUA bit
When the FUA bit is set to 1, the requested data is always retrieved from the media regardless of whether the data are held in the sector buffer or not.

When the FUA bit is set to 0, the data may be retrieved from the media or from the cached data left by previously processed Read or Write commands.

ICC field
The Isochronous Command Completion (ICC) field is valid when PRIO is set to a value of 01b. It is assigned by the host based on the intended deadline associated with the command issued. When a deadline has expired, the device continues to complete the command as soon as possible. The host can modify this behavior if the device supports the NCQ NON-DATA command (see 12.16) and supports the Deadline Handling subcommand (see 12.16.2). This subcommand allows the host to set whether the device aborts commands that have exceeded the time set in ICC.

There are several parameters encoded in the ICC field: Fine or Coarse timing, Interval and the Max Time. The Interval indicates the time units of the Time Limit parameter.

If ICC Bit 7 cleared to zero, then the time interval is fine-grained.

Interval $= 10$msec

Time Limit $= (ICC[6:0] + 1) * 10$ msec

If ICC Bit 7 is set to one (coarse encoding), then the time interval is coarse grained.

Interval $= 0.5$ sec

Time Limit $= (ICC[6:0] + 1) * 0.5$ sec

12.22 Read Log Ext (2Fh)

Table 123   Read Log Ext Command (2Fh)

Command Input

Field	Description
FEATURE	If not defined by the log specified by the LOG ADDRESS field, this field is reserved.
COUNT	LOG PAGE COUNT field
LBA	**Bit Description** 47:40 Reserved 39:32 PAGE NUMBER field (15:8) 31:16 Reserved 15:8 PAGE NUMBER field (7:0) 7:0 LOG ADDRESS field
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 2Fh

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6 UNCORRECTABLE ERROR bit 5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1:0 Obsolete
COUNT	Reserved
LBA	Reserved
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

This command returns the specified log to the host. The device shall interrupt for each DRQ block transferred.

Table 124   Log Address Definition

Log address	Content	Feature set	Type
00h	Log directory	N/A	Read Only
03h	Extended Comprehensive SMART error log	SMART error logging	Read Only
04h	Device Statistics	N/A	Read Only
06h	SMART self-test log	SMART self-test	See Note
07h	Extended SMART self-test log	SMART self-test	Read Only
08h	Power Conditions log	Extended Power Condition	Read Only
10h	Command Error	Native Command Queuing	Read Only
11h	Phy Event Counters	Serial ATA	Read Only
12h	NCQ NON-DATA log	Native Command Queuing	Read Only
13h	Send and Receive log	Native Command Queuing	Read Only
21h	Write Stream Error log	Streaming	Read Only
22h	Read Stream Error log	Streaming	Read Only
30h	Identify Device Data log	N/A	Read Only
80h-9Fh	Host vendor specific	SMART	Read/Write

Note: If log address 06h is accessed using the Read Log Ext or Write Log Ext commands, command abort shall be returned.

Note: Please see 10.17.3 about Phy Event Counter.

Note: Please see 10.17.4 about NCQ NON-DATA.

The Extended SMART self-test log sector shall support 48-bit and 28-bit addressing. All 28-bit entries contained in the SMART self-test log sector shall also be included in the Comprehensive SMART self-test log sector with the 48-bit entries.

If the feature set associated with the log specified in the Sector Number register is not supported or enabled, or if the values in the Sector Count, Sector Number or Cylinder Low registers are invalid, the device shall return command aborted.

12.22.1 General Purpose Log Directory

Table 125 General Purpose Log Directory defines the 512 bytes that make up the General Purpose Log Directory.

Table 125   General Purpose Log Directory

Description	Bytes	Offset
General Purpose Logging Version	2	00h
Number of sectors in the log at log address 01h (7:0)	1	02h
Number of sectors in the log at log address 01h (15:8)	1	03h
Number of sectors in the log at log address 02h (7:0)	1	04h
Number of sectors in the log at log address 02h (15:8)	1	05h
...		
Number of sectors in the log at log address 20h (7:0)	1	40h
Number of sectors in the log at log address 20h (15:8)	1	41h
Number of sectors in the log at log address 21h (7:0)	1	42h
Number of sectors in the log at log address 21h (15:8)	1	43h
Number of sectors in the log at log address 22h (7:0)	1	44h
Number of sectors in the log at log address 22h (15:8)	1	45h
...		
Number of sectors in the log at log address 80h (7:0)	1	100h
Number of sectors in the log at log address 80h (15:8)	1	101h
...		
Number of sectors in the log at log address FFh (7:0)	1	1FEh
Number of sectors in the log at log address FFh (15:8)	1	1FFh
	512	

The value of the General Purpose Logging Version word shall be 0001h. A value of 0000h indicates that there is no General Purpose Log Directory.

The logs at log addresses 80-9Fh shall each be defined as 16 sectors long.

12.22.2   Extended Comprehensive SMART Error log

Table 126   Extended Comprehensive SMART Error Log defines the format of each of the sectors that comprise the Extended Comprehensive SMART error log. Error log data structure shall not include errors attributed to the receipt of faulty commands such as command codes not implemented by the device or requests with invalid parameters or in valid addresses.

Table 126   Extended Comprehensive SMART Error Log

Description	Bytes	Offset
SMART error log version	1	00h
Reserved	1	01h
Error log index (7:0)	1	02h
Error log index (15:8)	1	03h
1st error log data structure	124	04h
2nd error log data structure	124	80h
3rd error log data structure	124	FCh
4th error log data structure	124	178h
Device error count	2	1F4h
Reserved	9	1F6h
Data structure checksum	1	1FFh
	512	

12.22.2.1   Error log version

The value of this version shall be 01h.

12.22.2.2   Error log index

This indicates the error log data structure representing the most recent error. If there have been no error log entries, it is cleared to 0. Valid values for the error log index are 0 to 4.

12.22.2.3   Extended Error log data structure

An error log data structure shall be presented for each of the last four errors reported by the device.
These error log data structure entries are viewed as a circular buffer. The fifth error shall create an error log structure that replaces the first error log data structure. The next error after that shall create an error log data structure that replaces the second error log structure, etc.
Unused error log data structures shall be filled with zeros.

Data format of each error log structure is shown below.

Table 127   Extended Error log data structure

Description	Bytes	Offset
1st command data structure	18	00h
2nd command data structure	18	12h
3rd command data structure	18	24h
4th command data structure	18	36h
5th command data structure	18	48h
Error data structure	34	5Ah
	124	

Command data structure: Data format of each command data structure is shown below.

Table 128   Command data structure

Description	Bytes	Offset
Device Control register	1	00h
Features register (7:0) (see Note)	1	01h
Features register (15:8)	1	02h
Sector count register (7:0)	1	03h
Sector count register (15:8)	1	04h
Sector number register (7:0)	1	05h
Sector number register (15:8)	1	06h
Cylinder Low register (7:0)	1	07h
Cylinder Low register (15:8)	1	08h
Cylinder High register (7:0)	1	09h
Cylinder High register (15:8)	1	0Ah
Device/Head register	1	0Bh
Command register	1	0Ch
Reserved	1	0Dh
Timestamp (milliseconds from Power-on)	4	0Eh
	18	

Note: bits (7:0) refer to the most recently written contents of the register. Bits (15:8) refer to the contents of the register prior to the most recent write to the register.

Error data structure: Data format of error data structure is shown below.

Table 129   Error data structure

Description	Bytes	Offset
Reserved	1	00h
Error register	1	01h
Sector count register (7:0) (see Note)	1	02h
Sector count register (15:8) (see Note)	1	03h
Sector number register (7:0)	1	04h
Sector number register (15:8)	1	05h
Cylinder Low register (7:0)	1	06h
Cylinder Low register (15:8)	1	07h
Cylinder High register (7:0)	1	08h
Cylinder High register (15:8)	1	09h
Device/Head register	1	0Ah
Status register	1	0Bh
Extended error data (vendor specific)	19	0Ch
State	1	1Fh
Life timestamp (hours)	2	20h
	34	

Note: bits (7:0) refer to the contents if the register is read with bit 7 of the Device Control register cleared to zero. Bits (15:8) refer to the contents if the register is read with bit 7 of the Device Control register set to one.

State shall contain a value indicating the state of the device when the command was issued to the device or the reset occurred as described below.

Value	State
x0h	Unknown
x1h	Sleep
x2h	Standby (If the EPC feature set is enabled, Standby is standby_y or standby_z)
x3h	Active/Idle (If the EPC feature set is enabled, Active/Idle is idle_a or idle_b or idle_c)
x4h	SMART Off-line or Self-test
x5h-xAh	Reserved
xBh-xFh	Vendor specific

Note: The value of x is vendor specific.

12.22.2.4   Device error count

This field shall contain the total number of errors attributable to the device that have been reported by the device during the life of the device. This count shall not include errors attributed to the receipt of faulty commands such as commands codes not implemented by the device or requests with invalid parameters or invalid addresses. If the maximum value for this field is reached the count shall remain at the maximum value when additional errors are encountered and logged.

12.22.3 Device Statistics log

The Device Statistics log contains selected statistics about the device.
The number of log pages may be greater than one.
See Table 130   Defined Device Statistics log pages for a list of defined log pages. Each supported log page consists of a header field that may be followed by defined statistics fields. If the Revision Number field in the log page header is 0000h, then that log page is not supported. All log page data following the last defined statistic for that log page is reserved.
If an unsupported log page is requested, then 512 bytes of all zeros are returned for that log page.

Table 130   Defined Device Statistics log pages

Description	Log page
List of supported log pages (Table 131 List of supported Device Statistics log pages)	00h
General Statistics (Table 132 General Statistics)	01h
Free Fall Statistics (Not Support)	02h
Rotating Media Statistics (Table 133 Rotating Media Statistics)	03h
General Errors Statistics (Table 134 General Error Statistics)	04h
Temperature Statistics (Table 136 Temperature Statistics (part 2 of 2) Table 135 Temperature Statistics (part 1 of 2))	05h
Transport Statistics (Table 137 Transport Statistics)	06h
Solid State Device Statistics (Not Support)	07h
Reserved	08h..FFh

12.22.3.1 List of Supported Device Statistics log pages (log page 00h)

The List of Supported Device Statistics log pages contains a list of the supported device statistics log pages as described in Table 131   List of supported Device Statistics log pages. Entries are in order of ascending log page number. Every log page for which there is at least one supported statistic is listed.

Table 131   List of supported Device Statistics log pages

Description	Bytes	Offset
Device Statistics Information Header. This device statistics log page lists the number of the supported device statistics log pages. Bit Description 63:24 Reserved 23:16 Log page number. (00h) 15:0 Revision number. (0001h)	8	00h
Number of entries (n) in the following list	1	08h
Log page number of first supported device statistics log page (00h)	1	09h
Log page number of second supported device statistics log page	1	0Ah
…		
Log page number of nth supported device statistics log page	1	n+08h
Reserved		n+09h..1FFh

12.22.3.2 General Statistics (log page 01h)

The General Statistics log page contains general information about the device as described in Table 132   General Statistics.

Table 132   General Statistics

Description		Bytes	Offset
Device Statistics Information Header		8	00h
Bit	Description		
63:24	Reserved		
23:16	Log page number. (01h)		
15:0	Revision number. (0002h)		
Lifetime Power-On Resets		8	08h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Number of times that the device has processed a Power-On Reset event (DWord)		
Power-on Hours		8	10h
Bit	Description		
63:32	Reserved		
31:0	Power-on Hours (DWord)		
Logical Sectors Written		8	18h
Bit	Description		
63:56	Device Statistics Flags		
55:48	Reserved		
47:0	Logical Sectors Written		
Number of Write Commands		8	20h
Bit	Description		
63:56	Device Statistics Flags		
55:48	Reserved		
47:0	Number of Write Commands		
Logical Sectors Read		8	28h
Bit	Description		
63:56	Device Statistics Flags		
55:48	Reserved		
47:0	Logical Sectors Read		
Number of Read Commands		8	30h
Bit	Description		
63:56	Device Statistics Flags		
55:48	Reserved		
47:0	Number of Read Commands		
Reserved		1	38h..1FFh

12.22.3.3 Rotating Media Statistics (log page 03h)

The Rotating Media Statics log page contains device rotating media information as described in Table 133 Rotating Media Statistics

Table 133 Rotating Media Statistics

Description		Bytes	Offset
Device Statistics Information Header		8	00h
Bit	Description		
63:24	Reserved		
23:16	Log page number. (03h)		
15:0	Revision number. (0001h)		
Spindle Motor Power-on Hours		8	08h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Spindle Motor Power-on Hours (DWord)		
Head Flying Hours		8	10h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Head Flying Hours (DWord)		
Head Load Events		8	18h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Head Load Events (DWord)		
Number of Reallocated Logical Sectors		8	20h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Number of Reallocated Logical Sectors (DWord)		
Read Recovery Attempts		8	28h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Read Recovery Attempts (DWord)		
Number of Mechanical Start Failures		8	30h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Number of Mechanical Start Failures (DWord)		
Reserved		1	38h..1FFh

12.22.3.4   General Errors Statistics (log page 04h)

General Errors Statistics log page contains general error information about the device as described in Table 134 General Error Statistics

Table 134   General Error Statistics

Description		Bytes	Offset
Device Statistics Information Header		8	00h
Bit	Description		
63:24	Reserved		
23:16	Log page number. (04h)		
15:0	Revision number. (0001h)		
Number of Reported Uncorrectable Errors		8	08h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Number of Reported Uncorrectable Errors (DWord)		
Number of Resets Between Command Acceptance and Command Completion		8	10h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Number of Resets Between Command Acceptance and Command Completion (DWord)		
Reserved		1	18h..1FFh

12.22.3.5   Temperature Statistics (log page 05h)

The Temperature Statistics log page contains general information about the device as described in Table 135 Temperature Statistics (part 1 of 2).
The value in the temperature field is a two's complement integer in degrees Celsius.

Table 135   Temperature Statistics (part 1 of 2)

Description		Bytes	Offset
Device Statistics Information Header		8	00h
Bit	Description		
63:24	Reserved		
23:16	Log page number. (05h)		
15:0	Revision number. (0001h)		
Current Temperature		8	08h
Bit	Description		
63:56	Device Statistics Flags		
55:8	Reserved		
7:0	Current Temperature (signed byte)		
Average Short Term Temperature		8	10h
Bit	Description		
63:56	Device Statistics Flags		
55:8	Reserved		
7:0	Average Short Term Temperature (signed byte)		
Average Long Term Temperature		8	18h
Bit	Description		
63:56	Device Statistics Flags		
55:8	Reserved		
7:0	Average Long Term Temperature (signed byte)		

Table 136 Temperature Statistics (part 2 of 2)

Highest Temperature			8	20h
Bit	Description			
63:56	Device Statistics Flags			
55:8	Reserved			
7:0	Highest Temperature (signed byte)			
Lowest Temperature			8	28h
Bit	Description			
63:56	Device Statistics Flags			
55:8	Reserved			
7:0	Lowest Temperature (signed byte)			
Highest Average Short Term Temperature			8	30h
Bit	Description			
63:56	Device Statistics Flags			
55:8	Reserved			
7:0	Highest Average Short Term Temperature (signed byte)			
Lowest Average Short Term Temperature			8	38h
Bit	Description			
63:56	Device Statistics Flags			
55:8	Reserved			
7:0	Lowest Average Short Term Temperature (signed byte)			
Highest Average Long Term Temperature			8	40h
Bit	Description			
63:56	Device Statistics Flags			
55:8	Reserved			
7:0	Highest Average Long Term Temperature (signed byte)			
Lowest Average Long Term Temperature			8	48h
Bit	Description			
63:56	Device Statistics Flags			
55:8	Reserved			
7:0	Lowest Average Long Term Temperature (signed byte)			
Time in Over-Temperature			8	50h
Bit	Description			
63:56	Device Statistics Flags			
55:32	Reserved			
31:0	Time in Over-Temperature (DWord)			
Specified Maximum Operating Temperature			8	58h
Bit	Description			
63:56	Device Statistics Flags			
55:8	Reserved			
7:0	Specified Maximum Operating Temperature (signed byte)			
Time in Under-Temperature			8	60h
Bit	Description			
63:56	Device Statistics Flags			
55:32	Reserved			
31:0	Time in Under-Temperature (DWord)			
Specified Minimum Operating Temperature			8	68h
Bit	Description			
63:56	Device Statistics Flags			
55:8	Reserved			
7:0	Specified Minimum Operating Temperature (signed byte)			
Reserved			1	70h..1FFh

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12.22.3.6 Transport Statistics (log page 06h)

The Transport Statistics log page contains interface transport information about the device as described in Table 137 Transport Statistics.

Table 137   Transport Statistics

Description		Bytes	Offset
Device Statistics Information Header		8	00h
Bit	Description		
63:24	Reserved		
23:16	Log page number. (06h)		
15:0	Revision number. (0001h)		
Number of hardware resets		8	08h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Number of hardware resets (DWord)		
Number of ASR Events		8	10h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Number of ASR Events (DWord)		
Head Load Events		8	18h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Head Load Events (DWord)		
Number of Interface CRC Errors		8	20h
Bit	Description		
63:56	Device Statistics Flags		
55:32	Reserved		
31:0	Number of Interface CRC Errors (DWord)		
Reserved		1	28h..1FFh

12.22.4 Extended Self-test log sector

Table 138 Extended Self-test log data structure defines the format of each of the sectors that comprise the Extended SMART self-test log.

The Extended SMART self-test log sector shall support 48-bit and 28-bit addressing. All 28-bit entries contained in the SMART self-test log, defined in 12.52.6 Self-test log data structure on page 291 shall also be included in the Extended SMART self-test log with all 48-bit entries.

Table 138   Extended Self-test log data structure

Description	Bytes	Offset
Self-test log data structure revision number	1	00h
Reserved	1	01h
Self-test descriptor index (7:0)	1	02h
Self-test descriptor index (15:8)	1	03h
Descriptor entry 1	26	04h
Descriptor entry 2	26	1Eh
...		
Descriptor entry 18	26	1D8h
Vendor specific	2	1F2h
Reserved	11	1F4h
Data structure checksum	1	1FFh
	512	

These descriptor entries are viewed as a circular buffer. The nineteenth self-test shall create a descriptor entry that replaces descriptor entry 1. The next self-test after that shall create a descriptor entry that replaces descriptor entry 2, etc. All unused self-test descriptors shall be filled with zeros.

12.22.4.1 Self-test log data structure revision number

The value of this revision number shall be 01h.

12.22.4.2 Self-test descriptor index

This indicates the most recent self-test descriptor. If there have been no self-tests, this is set to zero. Valid values for the Self-test descriptor index are 0 to 18.

12.22.4.3   Extended Self-test log descriptor entry

The content of the self-test descriptor entry is shown below.

Table 139   Extended Self-test log descriptor entry

Description	Bytes	Offset
Self-test number	1	00h
Self-test execution status	1	01h
Power-on life timestamp in hours	2	02h
Self-test failure check point	1	04h
Failing LBA (7:0)	1	05h
Failing LBA (15:8)	1	06h
Failing LBA (23:16)	1	07h
Failing LBA (31:24)	1	08h
Failing LBA (39:32)	1	09h
Failing LBA (47:40)	1	0Ah
Vendor specific	15	0Bh
	26	

12.22.5   Power Conditions log

Defines the Power Conditions log. If the Extended Power Conditions feature set is not supported, then the Power Conditions log not is supported. Each Power is composed of the following formats.

Table 140   Idle power conditions

Offset	Type	Description
0-63	Byte	Idle_a power conditions descriptor. Power condition supported is set to one to indicate that the idle_a power condition is supported.
64-127	Byte	Idle_b power conditions descriptor. Power condition supported is set to one to indicate that the idle_b power condition is supported.
128-191	Byte	Idle_c power conditions descriptor. Power condition supported is set to one to indicate that the idle_c power condition is supported.
192-511	Byte	Reserved

Table 141   Standby power conditions (log page 01h)

Offset	Type	Description
0-383	Byte	Reserved
384-447	Byte	Standby_y power conditions descriptor. Power condition supported is set to one to indicate that the standby_y power condition is supported.
448-511	Byte	Standby_z power conditions descriptor. Power condition supported is set to one to indicate that the standby_z power condition is supported.

Table 142 Power Conditions log descriptor

Offset	Type	Description
0	Byte	Reserved
1	Byte	Power Condition Flags Bit Description 7 Power Condition Supported The Power Condition Supported bit is valid if the EPC feature set is supported, regardless of whether EPC is enabled or disabled. If the Power Condition Supported bit is set to one, then the power condition is supported. If the Power Condition Supported bit is cleared to zero, then the power condition is not supported. 6 Timer Savable The Timer Savable bit is valid if the Power Condition Supported bit is set to one, regardless of whether EPC is enabled or disabled. If the Timer Savable bit is set to one, then the power condition is savable if EPC is enabled. If the Timer Savable bit is cleared to zero, then the power condition is not savable. 5 Timer Changeable The Timer Changeable bit is valid if the Power Condition Supported bit is set to one, regardless of whether EPC is enabled or disabled. If the Timer Changeable bit is set to one, then the power condition is changeable if EPC is enabled. If the Timer Changeable bit is cleared to zero, then the power condition is not changeable. 4 Default Timer Enabled The Default Timer Enabled bit is valid if the Power Condition Supported bit is set to one, regardless of whether EPC is enabled or disabled. 3 Saved Timer Enabled The Saved Timer Enabled bit is valid if the Power Condition Supported bit is set to one, regardless of whether EPC is enabled or disabled. 2 Current Timer Enabled If EPC is disabled, then the Current Timer Enabled bit shall be cleared to zero. If EPC is enabled and the Current Timer Setting field is non-zero and the Current Timer Enabled bit is set to one, then the power condition timer is enabled. If EPC is enabled and the Current Timer Enabled bit is cleared to zero, then the power condition timer is disabled. 1-0 Reserved
2-3	Byte	Reserved
4-7	DWord	Default Timer setting The Default Timer field is set at the time of manufacture. The Default Timer Setting field is valid if the Power Condition Supported bit is set to one, regardless of whether EPC is enabled or disabled. A value of FFFF_FFFFh indicates that the time is greater than or equal to 429_496_729_500 milliseconds. Measurement Units: 100 milliseconds.
8-11	DWord	Saved Timer setting The Saved Timer Setting field is a value that has been saved by a SET FEATURES Set Power Condition Timer subcommand. The Saved Timer Setting field is valid if the Power Condition Supported bit is set to one, regardless of whether EPC is enabled or disabled. A value of zero indicates that this power condition is disabled if the EPC feature set is enabled. A value of FFFF_FFFFh indicates that the time is greater than or equal to 429_496_729_500 milliseconds. Measurement Units: 100 milliseconds.

12-15	DWord	Current Timer setting
		The Current Timer setting is the minimum time that the device shall wait after command completion before entering this power condition if the EPC feature set is enabled.
		The Current Timer Setting field shall be cleared to zero if:
		  a) EPC is disabled;
		  b) the Power Condition Supported bit is cleared to zero; or
		  c) the Current Timer Enabled field is cleared to zero.
		A value of FFFF_FFFFh indicates that the time is greater than or equal to 429_496_729_500 milliseconds.
		Measurement Units: 100 milliseconds

16-19	DWord	Nominal Recovery time from to PM0:Active power management state The Nominal Recovery time from power to PM0: Active is the nominal time required to transition from power to PM0: Active power management state. This time does not include processing time for the command that caused this transition to occur. A value of zero indicates that the nominal recovery time is not specified. A value of FFFF_FFFFh indicates that the recovery time is greater than or equal to 429 496 729 500 milliseconds. Measurement Units: 100 milliseconds. This value is preserved over all resets.
20-23	DWord	Minimum timer setting The Minimum timer setting is the minimum timer value allowed by the Set Power Condition Timer subcommand for the timer. A value of zero indicates that the minimum timer value is not specified. A value of FFFF_FFFFh indicates that the minimum timer value is greater than or equal to 429 496 729 500 milliseconds. Measurement Units: 100 milliseconds This value be preserved over all resets
24-27	DWord	Maximum timer setting The Maximum timer setting is the maximum timer value allowed by the Set Power Condition Timer subcommand for the timer. A value of zero indicates that the maximum timer value is not specified. A value of FFFF_FFFFh indicates that the maximum timer value is greater than or equal to 429 496 729 500 milliseconds. Measurement Units: 100 milliseconds This value be preserved over all resets
28-63	DWord	Reserved

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12.22.6   NCQ Command Error (log page 10h)

Table 143 defines the format of the Command Error data structure.

Table 143   Command Error log (part 1 of 2)

Byte	7	6	5	4	3	2	1	0
0	NQ	UNL	Reserved	NCQ TAG				
1	Reserved							
2	Status							
3	Error							
4	LBA field(7:0)							
5	LBA field(15:8)							
6	LBA field(23:16)							
7	DEVICE field							
8	LBA field(31:24)							
9	LBA field(39:32)							
10	LBA field(47:40)							
11	Reserved							
12	COUNT field(7:0)							
13	COUNT field(15:8)							
14	Reserved							
15	ADDITIONAL SENSE CODE field							
16	ADDITIONAL SENSE CODE QUALIFIER filed							
17..255	Reserved							
256 – 510	Vendor Unique							
511	Data Structure Checksum							

Table 144   NCQ Command Error log (part 2 of 2)

Byte	Description
512	WRITE POINTER VALID field (7:0)
513	WRITE POINTER VALID field (15:8)
514	WRITE POINTER VALID field (23:16)
515	WRITE POINTER VALID field (31:24)
516	WRITE POINTER[0] field (7:0) (
517	WRITE POINTER[0] field (15:8)
518	WRITE POINTER[0] field (23:16)
519	WRITE POINTER[0] field (31:24)
520	WRITE POINTER[0] field (39:32)
521	WRITE POINTER[0] field (47:40)
….	….
702	WRITE POINTER[31] field (7:0)
703	WRITE POINTER[31] field (15:8)
704	WRITE POINTER[31] field (23:16)
705	WRITE POINTER[31] field (31:24)
706	WRITE POINTER[31] field (39:32)
707	WRITE POINTER[31] field (47:40)
708..1022	Reserved
1023	Wite Pointer checksum

The TAG field (Byte 0 Bits 4-0) contains the tag number corresponding to a queued command if the NQ bit is cleared.
The NQ field (Byte 0 Bit 7) indicates whether the error condition was a result of a non-queued or not. If it is cleared the error information corresponds to a queued command specified by the tag number indicated in the TAG field.
The bytes 1 to 13 correspond to the contents of Shadow Register Block when the error was reported.
The Data Structure Checksum (Byte 511) contains the 2's complement of the sum of the first 511 bytes in the data structure. The sum of all 512 bytes of the data structure will be zero when the checksum is correct.

12.22.7 Read Stream Error log

Table 145 Read Stream Error Log defines the format of the Read Stream Error log. Entries are placed into the Read Stream Error log only when the SE bit is set to one in the Status Register. The 512 bytes returned shall contain a maximum of 31 error entries. The Read Stream Error Count shall contain the total number of Read Stream Errors detected since the last successful completion of the Read Log Ext command with LBA Low register set to 22h. This error count may be greater than 31, but only the most recent 31 errors are represented by entries in the log. If the Read Stream Error Count reaches the maximum value that can be represented after the next error is detected the Read Stream Error Count shall remain at the maximum value. After successful completion of a Read Log Ext command with the LBA Low Register set to 22h, the Read Stream Error Log shall be reset to a power-on or hardware reset condition, with the Error Log Index and Read Stream Error Count cleared to zero. The Read Stream Error Log is not preserved across power cycles and hardware reset.

Table 145 Read Stream Error Log

Description	Bytes	Offset
Structure Version	1	00h
Error Log Index	1	01h
Read Stream Error Log Count	2	02h
Reserved	12	04h
Read Stream Error Log Entry #1	16	10h
Read Stream Error Log Entry #2	16	20h
...		
Read Stream Error Log Entry #31	16	1F0h
	512	

The Data Structure Version field shall contain a value of 02h indicating the second revision of the structure format.

The Read Stream Error Log Count field shall contain the number of uncorrected sector entries currently reportable to the host. This value may exceed 31.

The Error Log Index indicates the error log data structure representing the most recent error. Only values (31:1) are valid. Table 146 Stream Error Log entry defines the format of each entry in the Read Stream Error Log.

Table 146   Stream Error Log entry

Description	Bytes	Offset
Feature Register Contents Value (current)	1	00h
Feature Register Contents Value (previous)	1	01h
Status Register Contents Value	1	02h
Error Register Contents Value	1	03h
LBA (7:0)	1	04h
LBA (15:8)	1	05h
LBA (23:16)	1	06h
LBA (31:24)	1	07h
LBA (39:32)	1	08h
LBA (47:40)	1	09h
Reserved	2	0A-0Bh
Sector Count (LSB)	1	0Ch
Sector Count (MSB)	1	0Dh
Reserved	2	0E-0Fh

Byte (1:0) contains the contents of the Feature Register when the error occurred.   This Value shall be set to 0FFFFh for s deferred write error.

Byte 2 contains the contents of the Status Register when the error occurred.

Byte 3 contains the contents of the Error Register when the error occurred.

Byte (9:4) indicates the starting LBA of the error.

Byte (13:12) indicate the length of the error.   Therefore, each entry may describe a range of sectors at the given address and spanning the specified number of sectors.

12.22.8   Write Stream Error log

Table 147   Write Stream Error Log defines the format of the Write Stream Error log. Entries are placed into the Write Stream Error log only when the SE bit is set to one in the Status Register.   The 512 bytes returned shall contain a maximum of 31 error entries.   The Write Stream Error Count shall contain the total number of Write Stream Errors detected since the last successful completion of the Read Log Ext command with LBA Low register set to 21h. This error count may be greater than 31, but only the most 31 errors are represented by entries in the log.   If the Write Stream Error Count reaches the maximum value that can be represented after the next error is detected the Write Stream Error Count shall remain at the maximum value.   After successful completion of a Read Log Ext command with the LBA Low Register set to 21h, the Write Stream Error Log shall be reset to a power-on or hardware reset condition, with the Error Log Index and Write Stream Error Count cleared to zero.   The Write Stream Error Log is not reserved across power cycles and hardware reset.

Table 147   Write Stream Error Log

Description	Bytes	Offset
Structure Version	1	00h
Error Log Index	1	01h
Write Stream Error Log Count	2	02h
Reserved	12	04h
Write Stream Error Log Entry #1	16	10h
Write Stream Error Log Entry #2	16	20h
...		
Write Stream Error Log Entry #31	16	1F0h
	512	

The Data Structure Version field shall contain a value of 02h indicating the second revision of the structure format.

The Write Stream Error Log Count field shall contain the number of Write Stream command entries since the last power on, since this log was last read, or since hardware reset was executed.

The Error Log Index indicates the error log data structure representing the most recent error.   Only values (31:0) are valid.

Table 146   Stream Error Log entry defines the format of each entry in the Error Log.

12.22.9 Identify Device Data log

IDENTIFY DEVICE data log reports device configuration information. This log is read-only. See Table 148   Identify Device Data Log for a list of defined pages. Each page consists of a header field that is followed by defined statistics fields. If the Revision Number field in the page header is 0000h, then that page is not supported. All page data following the last defined statistic for that page is reserved.

Table 148   Identify Device Data Log

Description	Page
List of supported pages	00h
Copy of IDENTIFY DEVICE data	01h
Capacity	02h
Supported Capabilities	03h
Current Settings	04h
ATA Strings	05h
Security	06h
Reserved for Parallel ATA	07h
Serial ATA	08h
Zoned-device Information	09h
Reserved	0Ah..FFh

12.22.9.1 List of Supported IDENTIFY DEVICE data log pages (Page 00h)

IDENTIFY DEVICE data log page 00h contains a list of the supported pages. Entries are in order of ascending page number (e.g., 00h, 01h, 07h).

Table 149   List of supported IDENTIFY DEVICE data pages

Offset	Type	Content
0..7	QWord	IDENTIFY DEVICE data log Information Header. This log page lists the numbers of the supported log pages
		Bit Meaning 63:24 Reserved 23:16 Page Number. Set to 00h. 15:0 Revision number. Set to 0001h
8	Byte	Number of entries (n) in the following list
9	Byte	Set to zero to indicate that page 00h is supported
10	Byte	Set to one to indicate that page 01h is supported
…		
n+8	Byte	Page number of nth supported IDENTIFY DEVICE data log page
n+9..511		Reserved

12.22.9.2 Copy of IDENTIFY DEVICE data (page 01h)

This page is a copy of IDENTIFY DEVICE data words 0..255.

12.22.9.3 Capacity (page 02h)

The Capacity log page provides information about the capacity of the device.

Table 150 Capacity log page

Offset	Type	Content
0..7	QWord	Capacity page information header
		Bit Meaning 63 Set to one. 62:24 Reserved 23:16 Page Number. Shall be set to 02h. 15:0 Revision number. Shall be set to 0001h
8..15	QWord	Device Capacity
		Bit Meaning 63 Set to one. 62:48 Reserved 47:0 ACCESSIBLE CAPACITY field
16..23	QWord	Physical/Logical Sector Size
		Bit Meaning 63 Contents of the QWord are valid 62 LOGICAL TO PHYSICAL SECTOR RELATIONSHIP SUPPORTED bit 61 LOGICAL SECTOR SIZE SUPPORTED bit 60:22 Reserved 21:20 ALIGNMENT ERROR REPORTING field 19:16 LOGICAL TO PHYSICAL SECTOR RELATIONSHIP field 15:0 LOGICAL SECTOR OFFSET field
24..31	QWord	Logical Sector Size
		Bit Meaning 63 Contents of the QWord are valid 62..32 Reserved 31..0 LOGICAL SECTOR SIZE field
32..39	QWord	Nominal Buffer Size
		Bit Meaning 63 Contents of the QWord are valid 62:0 BUFFER SIZE field
40..511		Reserved

12.22.9.4 Supported Capabilities (page 03h)

The Supported Capabilities log page provides a mechanism for the device to report support for feature sets, features, commands and other device capabilities.

Table 151 Supported Capabilities log page

Offset	Type	Content
0..7	QWord	Supported Capabilities page information header.
		Bit Meaning 63 Set to one. 62:24 Reserved 23:16 Page Number. Set to 03h. 15:0 Revision number. Set to 0001h
8..15	QWord	Supported Capabilities
		Bit Meaning 63 Set to one. 62:46 Reserved 45 REQUEST SENSE DEVICE FAULT SUPPORTED bit 44 DSN SUPPORTED bit 43 LOW POWER STANDBY SUPPORTED bit 42 SET EPC POWER SOURCE SUPPORTED bit 41 AMAX ADDR SUPPORTED bit 40 Reserved for CFA 39 DRAT SUPPORTED bit 38 LPS MISALIGNMENT REPORTING SUPPORTED bit 37 Reserved 36 READ BUFFER DMA SUPPORTED bit 35 WRITE BUFFER DMA SUPPORTED bit 34 Reserved 33 Download Microcode DMA SUPPORTED bit 32 28-BIT SUPPORTED bit 31 RZAT SUPPORTED bit 30 Reserved 29 NOP SUPPORTED bit 28 READ BUFFER SUPPORTED bit 27 WRITE BUFFER SUPPORTED bit 26 Reserved 25 READ LOOK-AHEAD SUPPORTED bit 24 VOLATILE WRITE CACHE SUPPORTED bit 23 SMART bit 22 FLUSH CACHE EXT SUPPORTED bit 21 Reserved 20 48-BIT SUPPORTED bit 19 Reserved 18 SPIN-UP SUPPORTED bit 17 PUIS SUPPORTED bit 16 APM SUPPORTED bit 15 CFA SUPPORTED bit 14 Download Microcode SUPPORTED bit 13 UNLOAD SUPPORTED bit 12 The WRITE DMA FUA EXT and WRITE MULTIPLE FUA EXT commands are supported 11 GPL SUPPORTED bit 10 STREAMING SUPPORTED bit 9 Reserved 8 SMART SELF-TEST SUPPORTED bit 7 SMART ERROR LOGGING SUPPORTED bit 6 EPC SUPPORTED bit 5 SENSE DATA SUPPORTED bit 4 FREE-FALL SUPPORTED bit 3 DM MODE 3 SUPPORTED bit 2 GPL DMA SUPPORTED bit 1 WRITE UNCORRECTABLE SUPPORTED bit 0 WRV SUPPORTED bit

Table 152   Supported Capabilities log page –Continued-

16..23	QWord	Download Microcode Capabilities
		Bit Meaning 63 Contents of the QWord are valid 62:35 Reserved 34DM OFFSETS DEFERRED SUPPORTED bit 33 DM IMMEDIATE SUPPORTED bit 32 DM OFFSETS IMMEDIATE SUPPORTED bit 31:16 DM MAXIMUM TRANSFER SIZE field 15:0 DM MINIMUM TRANSFER SIZE field
24..31	QWord	Nominal Media Rotation Rate **Bit Meaning** 63 Set to one 62:16 Reserved 15:0 NOMINAL MEDIA ROTATION RATE field
32..39	QWord	Nominal Form Factor [was word 168]
		Bit Meaning 63 Contents of the QWord are valid 62:4 Reserved 3:0 Nominal Form Factor
40..47	QWord	Write-Read-Verify Sector Count Mode 3
		Bit Meaning 63 Contents of the QWord are valid 62:32 Reserved 31:0 WRV MODE 3 COUNT field
48..55	QWord	Write-Read-Verify Sector Count Mode 2
		Bit Meaning 63 Contents of the QWord are valid 62:32 Reserved 31:0 WRV MODE 2 COUNT field
56..71	DQWord	World wide name [was word 108]
		Bit Meaning 127 Set to one 126:64 Reserved 63:0 World wide name
72..79	QWord	DATA SET MANAGEMENT
		Bit Meaning 63 Set to one 62:1 Reserved 0 TRIM SUPPORTED bit
80..103	QWord	Reserved
104..111	QWord	Zoned Capabilities
		Bit Meaning 63 Contents of the QWord are valid 62:2 Reserved 1:0 ZONED field
112..119	QWord	Supported ZAC Capabilities

		Bit Meaning
		  63 Contents of the QWord are valid
		62:5 Reserved
		    4 NON-DATA RESET WRITE POINTERS EXT SUPPORTED bit
		    3 NON-DATA FINISH ZONE EXT SUPPORTED bit
		    2 NON-DATA CLOSE ZONE EXT SUPPORTED bit
		    1 NON-DATA OPEN ZONE EXT SUPPORTED bit
		    0 REPORT ZONES EXT SUPPORTED bit

120..511		Reserved

12.22.9.5   Current Settings (page 04h)

The Current Settings log page provides a mechanism for the device to report the current settings for feature sets, features, and other device capabilities.

Table 153   Current Settings log page

Offset	Type	Content
0..7	QWord	Supported Capabilities page information header.
		Bit Meaning 63 Set to one. 62:24 Reserved 23:16 Page Number. Set to 04h. 15:0 Revision number. Set to 0001h
8..15	QWord	Current Settings
		Bit Meaning 63 Set to one. 62:17 Reserved 16 DSN ENABLED bit 15 EPC ENABLED bit 14 8-BIT PIO ENABLED bit 13 VOLATILE WRITE CACHE ENABLED bit 12 Reserved for CFA 11 REVERTING TO DEFAULTS ENABLED bit 10 SENSE DATA ENABLED bit 9 Reserved 8 NON-VOLATILE WRITE CACHE bit 7 READ LOOK-AHEAD ENABLED bit 6 SMART ENABLED bit 5 Reserved 4 Reserved 3 PUIS ENABLED bit 2 APM ENABLED bit 1 FREE-FALL ENABLED bit 0 WRV ENABLED bit
16..23	QWord	Feature Settings
		Bit Meaning 63 Contents of the QWord are valid 62:16 reserved 17:16 POWER SOURCE field 15:8 APM LEVEL field 7:0 WRV MODE field
24..31	QWord	DMA Host Interface Sector Times
		Bit Meaning 63 Contents of the QWord are valid 62:16 Reserved 15:0 DMA SECTOR TIME field
32..39	QWord	PIO Host Interface Sector Times
		Bit Meaning 63 Contents of the QWord are valid 62:16 Reserved 15:0 PIO SECTOR TIME field
40..47	QWord	Streaming minimum request size
		Bit Meaning 63 Contents of the QWord are valid 62:16 Reserved 15:0 STREAM MIN REQUEST SIZE field

Table 154 Current Settings log page –Continued-

Offset	Type	Content
48..55	QWord	Streaming access latency
		Bit Meaning 63 Contents of the QWord are valid 62:16 Reserved 15:0 STREAM ACCESS LATENCY field
56..63	QWord	Streaming Performance Granularity
		Bit Meaning 63 Contents of the QWord are valid 62:32 Reserved 31:0 STREAM GRANULARITY field
64..71	QWord	Free-fall Control Sensitivity
		Bit Meaning 63 Contents of the QWord are valid 62:16 Reserved 7:0 FREE-FALL SENSITIVITY field
72..79	QWord	Device Maintenance Schedule
		Bit Meaning 63 Contents of the QWord are valid 62:48 Reserved 47:32 Time scheduled for device maintenance 31:16 Time to performance degradation 15:0 Minimum inactive time
80..511		Reserved

12.22.9.6   Strings (page 05h)

The Strings log page provides a mechanism for the device to report ATA String based information.

Table 155 Strings log page

Offset	Type	Content
0..7	QWord	Strings page information header.
		Bit Meaning 63 Set to one. 62:24 Reserved 23:16 Page Number. Set to 05h. 15:0 Revision number. Set to 0001h
8..27	ATA String	Serial number
28..31		Reserved
32..39	ATA String	Firmware revision
40..47		Reserved
48..87	ATA String	Model number
88..95		Reserved
96..103	ATA String	Additional Product Identifier
104..511		Reserved

12.22.9.7   Security (page 06h)

The Security log page provides a mechanism for the device to report Security based information.

Table 156   Security log page

Offset	Type	Content
0..7	QWord	Security page information header.
		Bit Meaning 63 Set to one. 62:24 Reserved 23:16 Page Number. Set to 06h. 15:0 Revision number. Set to 0001h
8..15	QWord	Master Password Identifier [was word 92]
		Bit Meaning 63 Contents of the QWord are valid. 62:16 Reserved 15:0 Master Password Identifier
16..23	QWord	Security Status
		Bit Meaning 63 Contents of the QWord are valid 62:7 Reserved 6 SECURITY SUPPORTED bit 5 MASTER PASSWORD CAPABILITY bit 4 ENHANCED SECURITY ERASE SUPPORTED bit 3 SECURITY COUNT EXPIRED bit 2 SECURITY FROZEN bit 1 SECURITY LOCKED bit 0 SECURITY ENABLED bit
24..31	QWord	Time required for an Enhanced Erase mode SECURITY ERASE UNIT command [was word 90]
		Bit Meaning 63 Contents of the QWord are valid 62:15 Reserved 14:0 ENHANCED SECURITY ERASE TIME field
32..39	QWord	Time required for a Normal Erase mode SECURITY ERASE UNIT command [was word 89]
		Bit Meaning 63 Contents of the QWord are valid 62:15 Reserved 14:0 NORMAL SECURITY ERASE TIME field
40..47	QWord	Trusted Computing feature set
		Bit Meaning 63 Contents of the QWord are valid 62:1 Reserved 0 TRUSTED COMPUTING SUPPORTED bit
48..55	QWord	Security Capabilities
		Bit Meaning 63 Contents of the QWord are valid 62:5 Reserved 4 BLOCK ERASE SUPPORTED bit 3 OVERWRITE SUPPORTED bit 2 CRYPTO SCRAMBLE SUPPORTED bit 1 SANITIZE SUPPORTED bit 0 ENCRYPT ALL SUPPORTED bit
56..511		Reserved

12.22.9.8   Parallel ATA (page 07h)

The Parallel ATA log page provides information about the Parallel ATA Transport.   This page is not supported.

12.22.9.9   Serial ATA (page 08h)

The Serial ATA log page provides information about the Serial ATA Transport.

Table 157   Serial ATA log page

Offset	Type	Content
0..7	QWord	Serial ATA page information header.
		Bit Meaning 63 Set to one. 62:24 Reserved 23:16 Page Number. Set to 08h. 15:0 Revision number. Set to 0001h
8..15	QWord	SATA Capabilities
		Bit Meaning 63 Set to one 62:26 Reserved for Serial ATA 24 NCQ AUTOSENSE SUPPORTED bit 23 SOFTWARE SETTINGS PRESERVATION SUPPORTED bit 22 HARDWARE FEATURE CONTROL SUPPORTED bit 21 IN-ORDER DATA DELIVERY SUPPORTED bit 20 DEVICE INITIATED POWER MANAGEMENT SUPPORTED bit 19 DMA SETUP AUTO-ACTIVATION SUPPORTED bit 18 NON-ZERO BUFFER OFFSETS SUPPORTED bit 17 SEND AND RECEIVE QUEUED COMMANDS SUPPORTED bit 16 NCQ NON-DATA COMMAND SUPPORTED bit 15 NCQ STREAMING SUPPORTED bit 14 READ LOG DMA EXT AS EQUIVALENT TO READ LOG EXT SUPPORTED bit 13 DEVICE AUTOMATIC PARTIAL TO SLUMBER TRANSITIONS SUPPORTED bit 12 HOST AUTOMATIC PARTIAL TO SLUMBER TRANSITIONS SUPPORTED bit 11 NCQ PRIORITY INFORMATION SUPPORTED bit 10 UNLOAD WHILE NCQ COMMANDS ARE OUTSTANDING SUPPORTED bit 9 SATA PHY EVENT COUNTERS LOG SUPPORTED bit 8 RECEIPT OF HOST INITIATED POWER MANAGEMENT REQUESTS SUPPORTED bit 7 NCQ FEATURE SET SUPPORTED bit 6:3 Reserved for Serial ATA 2 SATA GEN3 SIGNALING SPEED SUPPORTED bit 1 SATA GEN2 SIGNALING SPEED SUPPORTED bit 0 SATA GEN1 SIGNALING SPEED SUPPORTED bit
16..23	QWord	Current SATA Settings
		Bit Meaning 63 Set to one 62:10 Reserved 9 AUTOMATIC PARTIAL TO SLUMBER TRANSITIONS ENABLED bit 8 SOFTWARE SETTINGS PRESERVATION ENABLED bit 7 HARDWARE FEATURE CONTROL IS ENABLED bit 6 IN-ORDER DATA DELIVERY ENABLED bit 5 DEVICE INITIATED POWER MANAGEMENT ENABLED bit) 4 DMA SETUP AUTO-ACTIVATION ENABLED bit 3 NON-ZERO BUFFER OFFSETS ENABLED bit 2:0 CURRENT SERIAL ATA SIGNAL SPEED field
24..39		Reserved for Serial ATA
40..41	Word	CURRENT HARDWARE FEATURE CONTROL IDENTIFIER field
42..43	Word	SUPPORTED HARDWARE FEATURE CONTROL IDENTIFIER field
44..511		Reserved for SATA

12.22.9.10 Zoned-device Information (page 09h)

The Zoned-device Information log page (see Table 158   Zoned-device Information) provides information about the capabilities and functional settings of a zoned-block device.

12.22.9.10.1   Overview

Table 158   Zoned-device Information

Offset	Type	Content
0..7	QWord	Zoned-device Information page information header.
		Bit Meaning 63 Shall be set to one. 62:24 Reserved 23:16 Page Number. Shall be set to 09h. 15:0 Revision number. Shall be set to 0001h.
8..15	QWord	Zoned-device capabilities
		Bit Meaning 63 Shall be set to one. 62:1 Reserved 0 URSWRZ bit (see 12.22.9.10.2)
16..23	QWord	Zoned-device settings
		Bit Meaning 63 Shall be set to one. 62:0 Reserved
24..39		Reserved
40..47	QWord	Maximum number of open sequential write required zones
		Bit Meaning 63 Shall be set to one. 62..32 Reserved 31..0 MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field(see 12.22.9.10.3)
48..55	QWord	Version information
		Bit Meaning 63 Shall be set to one. 62:57 Reserved 56 ZAC SUPPORTED bit (see 12.22.9.10.4.1) 55:16 Reserved 15:0 ZAC MINOR VERSION field (see 12.22.9.10.4.2)
56..511		Reserved

12.22.9.10.2   URSWRZ bit

An unrestricted read in sequential write required zone (URSWRZ) bit set to zero indicates that the device server does not support reading unwritten logical blocks or reads across zone boundaries in sequential write required zones.   A URSWRZ bit set to one indicates that the device server supports reading unwritten logical blocks and reads across zone boundaries in sequential write required zones.

The details of processing reads in sequential write required zones.

12.22.9.10.3   MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field

The MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field indicates the maximum number of sequential write required zones that are allowed to be in the ZC3: Explicit_Open state.   The Implicit Close function enforces this limit.
A value of FFFF FFFFh indicates that there is no limit for the number of open sequential write required zones.

12.22.9.10.4 Version information

12.22.9.10.4.1 ZAC supported bits

If the ZAC SUPPORTED bit is set to one, the device supports ZAC (i.e., ANSI INCITS 537-201x or the equivalent international standard ISO/IEC 17760-171). If the ZAC SUPPORTED bit is cleared to zero, the device does not support ZAC.

12.22.9.10.4.2 ZAC MINOR VERSION field

If The ZAC MINOR VERSION field (see Table 159) indicates the version of the standard that guided the device Implementation.

Table 159   ZAC MINOR Version field

Value	Minor version
000h..A36Bh	Reserved
A36Ch	ZAC revision 04
A36Dh..FFFEh	Reserved
FFFFh	ZAC minor version is not reported

12.23 Read Log DMA Ext(47h)

Table 160   Read Log DMA Ext Command (47h)

Command Input

Field	Description
FEATURE	If not defined by the log specified by the LOG ADDRESS field, this field is reserved.
COUNT	Block Count
LBA	**Bit Description** 47:40 Reserved 39:32 PAGE NUMBER field (15:8) 31:16 Reserved 15:8 PAGE NUMBER field (7:0) 7:0 LOG ADDRESS field
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 47h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

See Error Outputs in 12.22 Read Log DMA Ext (47h)

The content of this command is the same as Read Log Ext. See 12.22

12.24 Read Multiple (C4h)

Table 161   Read Multiple Commands (C4h)

Command Input

Field	Description
FEATURE	N/A
COUNT	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 C4h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.19 Read DMA (C8h/C9h)

The Read Multiple command reads one or more sectors of data from disk media, and then transfers the data from the device to the host.

The sectors are transferred through the Data Register 16 bits at a time. Command execution is identical to the Read Sector(s) command except that an interrupt is generated for each block (as defined by the Set Multiple command) instead of for each sector.

12.25 Read Multiple Ext (29h)

Table 162   Read Multiple Ext Command (29h)

Command Input

Field	Description
FEATURE	Reserved
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 29h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6 UNCORRECTABLE ERROR bit 5 N/A 4 ID NOT FOUND bit 3 N/A 2 ABORT bit 1 N/A 0 Obsolete
COUNT	Reserved
LBA	LBA of First Unrecoverable Error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Read Multiple Ext command reads one or more sectors of data from disk media, and then transfers the data from the device to the host.

The sectors are transferred through the Data Register 16 bits at a time. Command execution is identical to the Read Sector(s) command except that an interrupt is generated for each block (as defined by the Set Multiple command) instead of for each sector.

12.26 Read Native Max Address (F8h)

Table 163   Read Native Max ADDRESS (F8h)

Block Normal Outputs Command	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	L	1	D	-	-	-	-
Command	1	1	1	1	1	0	0	0

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	V	V	V	V	V	V	V	V
Cylinder Low	V	V	V	V	V	V	V	V
Cylinder High	V	V	V	V	V	V	V	V
Device/Head	-	-	-	-	H	H	H	H
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

This command returns the native max LBA/CYL of HDD which is not affected by Set Max Address command.

The 48-bit native max address is greater than 268,435,455; the Read Native Max Address command shall return a value of 268,435,455.

Input Parameters From The Device

Sector Number   In LBA mode, this register contains native max LBA bits 0-7. (L=1)
                       In CHS mode, this register contains native max sector number. (L=0)
Cylinder High/Low In LBA mode, this register contains native max LBA bits 8-15 (Low), 16-23 (High). (L=1)
                       In CHS mode, this register contains native max cylinder number. (L=0)
H   In LBA mode, this register contains native max LBA bits 24-27. (L=1)
                       In CHS mode, this register contains native max head number.(L=0)

12.27 Read Native Max Address Ext (27h)

Table 164 Read Native Max Address Ext (27h)

Command Block Normal Outputs		7	6	5	4	3	2	1	0
Register		7	6	5	4	3	2	1	0
Data Low		-	-	-	-	-	-	-	-
Data High		-	-	-	-	-	-	-	-
Feature	Current	-	-	-	-	-	-	-	-
	Previous	-	-	-	-	-	-	-	-
Sector Count	Current	-	-	-	-	-	-	-	-
	Previous	-	-	-	-	-	-	-	-
Sector Number	Current	-	-	-	-	-	-	-	-
	Previous	-	-	-	-	-	-	-	-
Cylinder Low	Current	-	-	-	-	-	-	-	-
	Previous	-	-	-	-	-	-	-	-
Cylinder High	Current	-	-	-	-	-	-	-	-
	Previous	-	-	-	-	-	-	-	-
Device/Head		1	1	1	D	-	-	-	-
Command		0	0	1	0	0	1	1	1

Command Block Command Input		7	6	5	4	3	2	1	0
Register		7	6	5	4	3	2	1	0
Data Low		-	-	-	-	-	-	-	-
Data High		-	-	-	-	-	-	-	-
Error		…See Below…							
Sector Count	HOB=0	-	-	-	-	-	-	-	-
	HOB=1	-	-	-	-	-	-	-	-
Sector Number	HOB=0	V	V	V	V	V	V	V	V
	HOB=1	V	V	V	V	V	V	V	V
Cylinder Low	HOB=0	V	V	V	V	V	V	V	V
	HOB=1	V	V	V	V	V	V	V	V
Cylinder High	HOB=0	V	V	V	V	V	V	V	V
	HOB=1	V	V	V	V	V	V	V	V
Device/Head		-	-	-	-	-	-	-	-
Status		…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

This command returns the native max LBA of HDD which is not affected by Set Max Address Ext command.

Input Parameters From The Device

Sector Number (HOB=0) LBA (7:0) of the address of the Native max address.

Sector Number (HOB=1) LBA (31:24) of the address of the Native max address.

Cylinder Low (HOB=0) LBA (15:8) of the address of the Native max address.

Cylinder Low (HOB=1) LBA (39:32) of the address of the Native max address.

Cylinder High (HOB=0) LBA (23:16) of the address of the Native max address.

Cylinder High (HOB=1) LBA (47:40) of the address of the Native max address.

12.28 Read Sector(s) (20h/21h)

Table 165   Read Sector(s) Command (20h/21h)

Command Input

Field	Description
FEATURE	N/A
COUNT	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 20h or 21h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.19 Read DMA (C8h/C9h)

The Read Sector(s) command reads one or more sectors of data from disk media, and then transfers the data from the device to the host.

The sectors are transferred through the Data Register 16 bits at a time.

If an uncorrectable error occurs, the read will be terminated at the failing sector.

12.29 Read Sector(s) Ext (24h)

Table 166   Read Sector(s) Ext Command (24h)

Command Input

Field	Description
FEATURE	Reserved
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolet 4 Transport Dependent 3:0 Reserved
Command	7:0 24h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

See Error Outputs in 12.25 Read Multiple Ext (29h)

The Read Sector(s) Ext command reads from 1 to 65,536 sectors of data from disk media, and then transfers the data from the device to the host.

The sectors are transferred through the Data Register 16 bits at a time.

If an uncorrectable error occurs, the read will be terminated at the failing sector.

12.30 Read Stream DMA Ext(2Ah)

Table 167   Read Stream DMA Ext Command (2Ah)

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 COMMAND CCTL field 7 Obsolete 6 READ CONTINUOUS bit 5 NOT SEQUENTIAL bit 4 Obsolete 3 Reserved 2:0 STREAM ID field
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 2Ah

Normal Outputs

See Normal Outputs in 12.2 Configure Stream(51h)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6 UNCORRECTABLE ERROR bit 5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1 Obsolete 0 COMMAND COMPLETION TIME OUT bit
COUNT	Length of stream error – number of contiguous logical sectors containing potentially bad data, beginning with the LBA indicated in the LBA field.
LBA	LBA of the lowest numbered unrecoverable error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 STREAM ERROR bit 4 DEFERRED WRITE ERROR bit 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Read Stream DMA Ext command reads one to 65536 sectors as specified in the Sector Count register.   A value of 0000h in the Sector Count register requests 65536 sectors.

The RC bit indicates that the drive operate in a continuous read mode for the Read Stream command. When RC is cleared to zero the drive shall operate in normal Streaming read mode.

When the Read Continuous mode is enabled, the device shall transfer data of the requested length without setting the ERR bit to one.   The SE bit shall be set to one if the data transferred includes errors. The data may be erroneous in this case.

If the Read Continuous bit is set to one, the device shall not stop execution of the command due to errors.   If the RC bit is set to one and errors occur in reading or transfer of the data, the device shall continue to transfer the amount of data requested and then provide ending status with the BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and the type of error, ICRC, UNC, IDNF or ABRT, reported in the error log.   If the RC bit is set to one and the Command Completion Time Limit expires, the device shall stop execution of the command and provide ending status with BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and report the fact that the Command Completion Time Limit expired by setting the CCTO bit in the error log to one,   In all cases, the device shall attempt to transfer the amount of data requested within the Command Completion Time Limit event if some data transferred is in error.

CCTL field
The time allowed for the current command's completion is calculated as follows:
Command Completion Time Limit = (content of the Feature register revious) * (Identify Device words (99:98)) microseconds
If the value is zero, the device shall use the Default CCTL supplied with a previous Configure Stream command for this Stream ID.   If the Default CCTL   is zero, or no previous Configure Stream command was defined for this Stream ID, the drive will ignore the CCTL.   The time is measured from the write of the command register to the final INTRQ for command completion. The device has minimum CCTL value. When the specified value is shorter than the minimum value, CCTL is set to the minimum value. Actual minimum CCTL value is described in the "Deviations from Standard" section.

NOT SEQUENTIAL bit
Not Sequential bit may be set to one if the next read stream command with the same Stream ID may not be sequential in LBA space.

STREAM ID field
Stream ID specifies the stream to be read.   The device shall operate according to the Stream ID set by the Read Stream command.

12.31 Read Stream Ext (2Bh)

Table 168   Read Stream Ext Command (2Bh)

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 COMMAND CCTL field 7 Obsolete 6 READ CONTINUOUS bit 5 NOT SEQUENTIAL bit 4 Obsolete 3 Reserved 2:0 STREAM ID field
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 2Bh

Normal Outputs

See Normal Outputs in 12.2 Configure Stream (51h)

Error Outputs

See Normal Outputs in 12.31 Read Stream Ext (2Bh)

The Read Stream DMA Ext command reads one to 65536 sectors as specified in the Sector Count register.   A value of 0000h in the Sector Count register requests 65,536 sectors.

The RC bit indicates that the drive operate in a continuous read mode for the Read Stream command. When RC is cleared to zero the drive shall operate in normal Streaming read mode.

When the Read Continuous mode is enabled, the device shall transfer data of the requested length without setting the ERR bit.   The SE bit shall be set to one if the data transferred includes errors. The data may be erroneous in this case.

If the Read Continuous bit is set to one, the device shall not stop execution of the command due to errors.   If the RC bit is set to one and errors occur in reading or transfer of the data, the device shall continue to transfer the amount of data requested and then provide ending status with the BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and the type of error, ICRC, UNC, IDNF or ABRT, reported in the error log.   If the RC bit is set to one and the Command Completion Time Limit expires, the device shall stop execution of the command and provide ending status with BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and report the fact that the Command Completion Time Limit expired by setting the CCTO bit in the error log to one,   In all cases, the device shall attempt to transfer the amount of data requested within the Command Completion Time Limit event if some data transferred is in error.

CCTL field
The time allowed for the current command's completion is calculated as follows:
Command Completion Time Limit = (content of the Feature register revious) * (Identify Device words (99:98)) microseconds
If the value is zero, the device shall use the Default CCTL supplied with a previous Configure Stream command for this Stream ID.   If the Default CCTL   is zero, or no previous Configure Stream command was defined for this Stream ID, the drive will ignore the CCTL.   The time is measured from the write of the command register to the final INTRQ for command completion. The device has minimum CCTL value. When the specified value is shorter than the minimum value, CCTL is set to the minimum value. Actual minimum CCTL value is described in the "Deviations from Standard" section.

NOT SEQUENTIAL bit
Not Sequential bit may be set to one if the next read stream command with the same Stream ID may not be sequential in LBA space.

STREAM ID field
Stream ID specifies the stream to be read.   The device shall operate according to the Stream ID set by the Read Stream command.

12.32 Read Verify Sector(s) (40h/41h)

Table 169   Read Verify Sector(s) Command (40h/41h)

Command Input

Field	Description
FEATURE	N/A
COUNT	The number of logical sectors to be verified. A value of 00h indicates that 256 logical sectors are to be verified
LBA	LBA of first logical sector to be verified
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 40h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.19 Read DMA (C8h/C9h)

The Read Verify Sector(s) verifies one or more sectors on the device. No data is transferred to the host.

The difference between Read Sector(s) command and Read Verify Sector(s) command is whether the data is transferred to the host or not.

If an uncorrectable error occurs, the read verify will be terminated at the failing sector.

12.33 Read Verify Sector(s) Ext (42h)

Table 170   Read Verify Sector(s) Ext Command (42h)

Command Input

Field	Description
FEATURE	N/A
COUNT	The number of logical sectors to be verified. A value of 0000h indicates that 65536 logical sectors are to be verified
LBA	LBA of first logical sector to be verified
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 42h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

See Error Outputs in 12.25 Read Multiple Ext (29h)

The Read Verify Sector(s) Ext verifies one or more sectors on the device. No data is transferred to the host.

The difference between the Read Sector(s) Ext command and the Read Verify Sector(s) Ext command is whether the data is transferred to the host or not.

If an uncorrectable error occurs, the Read Verify Sector(s) Ext will be terminated at the failing sector.

12.34 Recalibrate (1xh)

Table 171   Recalibrate Command (1xh)

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-
Command	0	0	0	1	-	-	-	-

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	-	-	-	-	-	-	-	-
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	V	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	V	-	0	-	V

The Recalibrate command moves the read/write heads from anywhere on the disk to cylinder 0.

If the device cannot reach cylinder 0, T0N (Track 0 Not Found) will be set in the Error Register.

12.35 RECEIVE FPDMA QUEUED (65h)

Table 172   RECEIVE FPDMA QUEUED

Command Input

Field	Description
FEATURE	The number of 512-byte blocks of data to be transferred. A value of 0000h indicates that 65 536 512-byte blocks of data are to be transferred
COUNT	**Bit Description** 15:14 PRIO field 13 Reserved 12:8 SUBCOMMAND field – See Table 173 7:3 NCQ TAG field 2:0 Reserved
LBA	Subcommand specific
AUXILIARY	Subcommand specific
DEVICE	**Bit Description** 7 Reserved 6 Shall be set to one 5 Reserved 4 Shall be cleared to zero 3:0 Reserved
Command	7:0 65h

Table 173   defines the RECEIVE FPDMA QUEUED subcommands. See the referenced sections for additional information in this table.

Table 173   RECEIVE FPDMA QUEUED subcommands

Subcommand	Description	Reference
0h	Reserved	-
1h	READ LOG DMA EXT	No Support
2h	ZAC Management In	12.71.2 ZAC MAMANGEMENT IN
3h – 1Fh	Reserved	-

Command Acceptance Outputs

Table 174   NCQ Command Acceptance Normal Output

Field	Description
ERROR	Shall be clear to zero
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7:4 N/A 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent. 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Normal Outputs

Table 175   NCQ Normal Output

Field	Description
SATA STATUS	Transport Dependent
ERROR	Shall be clear to zero
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent. 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit
SACTIVE	**Bit Description** 31:0 Transport Dependent completion indicator

Error Outputs
The device sets the ERROR bit to one and aborts the command in response to an invalid value in the SUBCOMMAND field, a duplicate tag number, an invalid tag number, or an Interface CRC error (see Table 176 NCQ Command Acceptance Error).
Errors that occur during the processing of this command are reported by returning a transport dependent indicator (see Table 177) with additional information available in the NCQ Command Error log (see 12.22.6).

Table 176   NCQ Command Acceptance Error

Field	Description
ERROR	Bit Description 7 INTERFACE CRC bit 6:3 N/A 2 ABORT bit 1:0 N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7:4 N/A 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent. 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Table 177   NCQ Write Command Aborted Error

Field	Description
SATA STATUS	Transport Dependent
ERROR	**Bit Description** 7 INTERFACE CRC bit 6:5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1:0 Obsolete
STATUS	**Bit Description** 7 Shall be cleared to zero 6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Shall be cleared to zero. 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit
SACTIVE	**Bit Description** 31:0 Transport Dependent completion indicator

12.36 Request Sense Data Ext (0Bh)

Table 178   Request Sense Data Ext command (0Bh)

Command Input

Field	Description
FEATURE	Reserved
COUNT	Reserved
LBA	Reserved
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 0Bh

Normal Outputs

Field	Description
ERROR	Reserved
COUNT	Reserved
LBA	**Bit Description** 47:24 Vendor Specific 23:20 Reserved 19:16 SENSE KEY field 15:8 ADDITIONAL SENSE CODE field 7:0 ADDITIONAL SENSE CODE QUALIFIER field
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5:2 Reserved 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

The Request Sense Data Ext command allows the reporting of the most recent sense data from the device.
When sense data is available, the sense key (K), additional sense code (C), and additional sense code qualifier (Q) fields are set to values that are defined in the SPC-4 standard.
Otherwise, the sense key, additional sense code, and additional sense code qualifier are cleared to zero.

The default reporting for the Sense Data Reporting feature set is invalid
The Request Sense Data Ext command returns the KCQ of the last command execution result and the KCQ information is deleted after command execution.
If another command is executed before the Request Sense Data Ext command, the KCQ information will be overwritten by the command.
Sense data reporting feature and NCQ Autosense feature are independent features.
The KCQ are cleared after:
  a)   Receiving any reset;
  b)   Acceptance of a command other than Request Sense Data Ext command that does not read the NCQ Command Error log; or
  c)   Completion of a Request Sense Data Ext command.
If the Request Sense Data Ext command is executed before the Read Log Ext, page 10h command, the Sense Data will be invalid and the contents of Read Log Ext, page 10h is not guaranteed

About Status Register bit 1(Sense Data Available)

The Sense Data Available bit shall be set to one if:
  a) IDENTIFY DEVICE data word 119 bit 6 is set to one;
  b) IDENTIFY DEVICE data word 120 bit 6 is set to one; and
  c) Device has sense data to report after processing any command.

The Error bit and the Sense Data Available may both be set to one.
Bit 1 of the Status Register is obsolete if:
  a) IDENTIFY DEVICE data word 119 bit 6 is cleared to zero; or
  b) IDENTIFY DEVICE data word 120 bit 6 is cleared to zero.

12.37 Sanitize Device Feature Set (B4h)

12.37.1 Crypto Scramble Ext Command (feature: 0011h) (data encryption model only)

Table 179   Crypto Scramble Ext Command (B4h/0011h) (data encryption model only)

Command Input

Field	Description
FEATURE	0011h
COUNT	**Bit Description** 15:5 Reserved 4 FAILURE MODE bit 3:0 Reserved
LBA	**Bit Description** 47:32 Reserved 31:0 shall be set to 4372_7970h (DWord)
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B4h

Normal Outputs

Field	Description
ERROR	Reserved
COUNT	**Bit Description** 15 SANITIZE OPERATION COMPLETED WITHOUT ERROR bit – the contents of the Sanitize Operation Completed Without Error value 14 1 = the device is in the SD2: Sanitize Operation In Progress state 0 = the device is not in the SD2: Sanitize Operation In Progress state 13 1 = the device is in the SD1: Sanitize Frozen state 0 = the device is not in the SD1: Sanitize Frozen state 12 SANITIZE ANTIFREEZE bit – the contents of the Sanitize Antifreeze value 11:0 Reserved
LBA	**Bit Description** 47:16 Reserved 15:0 SANITIZE PROGRESS INDICATION field – This value indicates the fraction complete of the sanitize operation while the device is in the SD2: Sanitize Operation In Progress state. The value is a numerator that has 65536 (1_0000h) as its denominator. This value shall be set to FFFFh if the device is not in the SD2: Sanitize Operation In Progress state (i.e., a sanitize operation is not in process).
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent. 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Error Outputs

Field	Description
ERROR	**Bit Description** 7:3 Reserved 2 ABORT bit 1:0 Reserved
COUNT	Reserved.
LBA	**Bit Description** 47:8 Reserved 7:0 SANITIZE DEVICE ERROR REASON field **Value Description** 00h Reason not reported or sanitize device command failed 01h Sanitize Command Unsuccessful – The sanitize operation completed with physical sectors that are available to be allocated for user data that were not successfully sanitized. 02h Invalid or unsupported value in the Sanitize Device FEATURE field 03h Device is in the SD1: Sanitize Frozen state 04h SANITIZE FREEZE LOCK command failed as a result of the SanitizeAntifreeze Lock value being set to one 05h..FFh Reserved
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The CRYPTO SCRAMBLE EXT command is only supported by data encryption model.
The CRYPTO SCRAMBLE EXT command starts a crypto scramble operation (i.e., a sanitize operation that changes the internal encryption keys that are used for user data) causing the user data to become irretrievable.
After a successful crypto scramble operation, the contents of the user data area may be indeterminate.
The CRYPTO SCRAMBLE EXT command only is processed if:
  a) the Sanitize Device feature set is supported
  b) the device is in the SD0: Sanitize Idle state, the SD3: Sanitize Operation Failed state, or the SD4: Sanitize Operation Succeeded state.

The FAILURE MODE bit
  1: the device may exit the SD3: Sanitize Operation Failed state with successful processing of a SANITIZE STATUS EXT command.
  0: the SD3: Sanitize Operation Failed state returns command aborted for sanitize operations with the FAILURE MODE bit set to one until the device returns to the SD1: Sanitize Idle state.

Sanitize Operation Completed Without Error.
  1: the Sanitize Device state machine enters SD4: Sanitize Operation Succeeded.
  0: the Sanitize Device state machine enters SD2: Sanitize Operation. The value of this bit is maintained across power-on resets.

The Sanitize Progress Indication (15:8).
Progress indicator for the current sanitizes operation when the Sanitize Device state machine is in the SD2: Sanitize Operation state. This value is FFFFh if the Sanitize Device state machine is not in the
SD2: Sanitize Operation state (i.e., a sanitize operation is not in process). The returned value is a numerator that has 65,536 (10000h) as its denominator

Error Output

The ABORT bit is set to one if a SANITIZE DEVICE FREEZE LOCK EXT command has successfully completed since the last power-on reset.

The device returns command aborted if:
  a) the device is in the SD3:Sanitize Operation Failed state
  b) the completed sanitize command (i.e., CRYPTO SCRAMBLE EXT, or OVERWRITE EXT) specified the FAILURE MODE bit cleared to zero; and
  c) a CRYPTO SCRAMPLE EXT command with the FAILURE MODE bit set to one is received.

Sanitize Device Error (7:0)
  00h Reason not reported
  01h Sanitize Command Unsuccessful. The sanitize operation completed with physical sectors that are available to be allocated for user data that were not successfully sanitized.
  02h Invalid or unsupported Sanitize Device Feature Field Value
  03h Device is in the Sanitize Frozen state
  04h..FFh Reserved

12.37.2 Overwrite Ext Command (feature: 0014h)

Table 180   Overwrite Ext Command (B4h/0014h)

Command Input

Field	Description
FEATURE	0014h
COUNT	**Bit Description** 15:8 Reserved 7 INVERT PATTERN BETWEEN OVERWRITE PASSES bit 6:5 Reserved 4 FAILURE MODE bit 3:0 OVERWRITE PASS COUNT field
LBA	**Bit Description** 47:32 shall be set to 4F57h (word) 31:0 OVERWRITE PATTERN field (DWord)
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B4h

Normal Outputs

See Normal Outputs in 12.37.1 Crypto Scramble Ext Command (feature: 0011h) (data encryption model only)

Error Outputs

See Error Outputs in 12.37.1 Crypto Scramble Ext Command (feature: 0011h) (data encryption model only)

The OVERWRITE EXT command starts an overwrite operation (i.e., a sanitize operation on the internal media that stores user data) which fills the user data area with a four byte pattern specified in the LBA field of the command. Parameters for the OVERWRITE EXT command include a count for multiple overwrites and the option to invert the four byte pattern between consecutive overwrite passes.

After the overwrite operation has been successfully applied, affected data blocks are readable without error.

The OVERWRITE EXT command only is processed if:
  a) the Sanitize Device feature set is supported
  b) the device is in the SD0: Sanitize Idle state, the SD3: Sanitize Operation Failed state, or the SD4: Sanitize Operation Succeeded state.

Error Output

The ABORT bit is set to one if a SANITIZE DEVICE FREEZE LOCK EXT command has successfully completed since the last power-on reset.

The device returns command aborted if:
  a) the device is in the SD3:Sanitize Operation Failed state
  b) the completed sanitize command (i.e., CRYPTO SCRAMBLE EXT (data encryption model only), or OVERWRITE EXT) contained the FAILURE MODE bit cleared to zero
  c) an OVERWRITE EXT command with the FAILURE MODE bit set to one is received.

12.37.3 Sanitize Freeze Lock Ext Command (feature: 0020h)

Table 181   Sanitize Freeze Lock Ext Command (B4h/0020h)

Command Input

Field	Description
FEATURE	0020h
COUNT	Reserved
LBA	**Bit Description** 47:32 Reserved 31:0 shall be set to 4672_4C6Bh (DWord)
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B4h

Normal Outputs

See Normal Outputs in 12.37.1 Crypto Scramble Ext Command (feature: 0011h) (data encryption model only)

Error Outputs

See Error Outputs in 12.37.1 Crypto Scramble Ext Command (feature: 0011h) (data encryption model only)

The SANITIZE FREEZE LOCK EXT command sets the Sanitize Device state machine to the SD1: Sanitize Frozen state. After command completion all sanitize commands other than SANITIZE STATUS EXT command returns command aborted. The Sanitize Device state machine transitions from the SD1: Sanitize Frozen state to the SD0: Sanitize Idle state after a power-on reset or hardware reset.

12.37.4　Sanitize Status Ext Command (feature: 0000h)

Table 182　Sanitize Status Ext Command (B4h/0000h)

Command Input

Field	Description
FEATURE	0000h
COUNT	Reserved
LBA	**Bit Description** 47:32 Reserved 31:0 shall be set to 4672_4C6Bh (DWord)
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B4h

Normal Outputs

See Normal Outputs in 12.37.1 Crypto Scramble Ext Command (feature: 0011h) (data encryption model only)

Error Outputs

See Error Outputs in 12.37.1 Crypto Scramble Ext Command (feature: 0011h) (data encryption model only)

The SANITIZE STATUS EXT command returns information about current or previously completed sanitizes operations. This includes:

  a)　progress indication on a current sanitize operation
  b)　whether a previous sanitize operation completed successfully or unsuccessfully
  c)　if an unsupported sanitize device command was received.

The SANITIZE STATUS EXT command is valid in every state of the Sanitize Device state machine.

Error Output

After the sanitize operation has completed, if any physical sector that is available to be allocated for user data was not successfully sanitized, then this command returns the ABORT bit set to one.

12.38 Security Disable Password (F6h)

Table 183   Security Disable Password Command (F6h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 F6h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.4 Download Microcode (92h)

The Security Disable Password command disables the security mode feature (device lock function).

The Security Disable Password command requests a transfer of a single sector of data from the host including information specified in 12.34 Recalibrate (1xh) on the page 230. Then the device checks the transferred password. If the User Password or Master Password matches the given password, the device disables the security mode feature (device lock function). This command does not change the Master Password which may be re-activated later by setting User Password. This command should be executed in device unlock mode.

When security is disabled and the Identifier bit is set to User, then the device shall return command aborted.

Table 184   Password Information for Security Disable Password command

Word	Description	
00	Control word	
	bit 0	: Identifier (1-Master, 0-User)
	bit 1-15	: Reserved
01-16	Password	(32 bytes)
17-255	Reserved	

The device will compare the password sent from this host with that specified in the control word.

Identifier   Zero indicates that the device should check the supplied password against the user password stored internally. One indicates that the device should check the given password against the master password stored internally.

12.39 Security Erase Prepare (F3h)

Table 185   Security Erase Prepare Command (F3h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 F3h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

The Security Erase Prepare Command must be issued immediately before the Security Erase Unit Command to enable device erasing and unlocking.

The Security Erase Prepare Command must be issued immediately before the Format Unit Command. This command is to prevent accidental erasure of the device.

This command does not request to transfer data.

12.40 Security Erase Unit (F4h)

Table 186 Security Erase Unit Command (F4h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 F4h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.4 Download Microcode (92h)

The Security Erase Unit command initializes all user data sectors, and then disables the device lock function.

Note that the Security Erase Unit command initializes from LBA 0 to Native MAX LBA. Host MAX LBA set by Initialize Drive Parameter, Device Configuration Overlay, or Set MAX Address command is ignored. So the protected area by Set MAX Address command is also initialized.

This command requests to transfer a single sector data from the host including information specified in Table 187 Erase Unit Information on the page 244.

When security is disabled and the Identifier bit is set to User, then the device shall return command aborted.
If the password does not match, then the device rejects the command with an Aborted error.

Table 187 Erase Unit Information

Word	Description	
00	Control word	
	bit 0	: Identifier (1-Master, 0-User)
	bit 1	: Erase mode (1- Enhanced, 0- Normal) Enhanced mode is not supported
	bit 2-15	: Reserved
01-16	Password	(32 bytes)
17-255	Reserved	

Identifier   Zero indicates that the device should check the supplied password against the user password stored internally. One indicates that the device should check the given password against the master password stored internally.

The Security Erase Unit command erases all user data and disables the security mode feature (device lock function). So after completing this command, all user data will be initialized to zero with write operation. At this time, it is not verified with read operation whether the sector of data is initialized correctly. Also, the defective sector information and the reassigned sector information for the device are not updated. The security erase prepare command should be completed immediately prior to the Security Erase Unit command. If the device receives a Security Erase Unit command without a prior Security Erase Prepare command, the device aborts the security erase unit command.

This command disables the security mode feature (device lock function), however the master password is still stored internally within the device and may be re-activated later when a new user password is set. If you execute this command on disabling the security mode feature (device lock function), the password sent by the host is NOT compared with the password stored in the device for both the Master Password and the User Password, and then the device only erases all user data.

The execution time of this command is set in word 89 of Identify device information.

12.41 Security Freeze Lock (F5h)

Table 188   Security Freeze Lock Command (F5h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 F5h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

The Security Freeze Lock Command allows the device to enter frozen mode immediately.

After this command is completed, the command which updates Security Mode Feature (Device Lock Function) is rejected.

Frozen mode is quit only by Power off.

The following commands are rejected when the device is in frozen mode. For detail, refer to   Table 38   Command table for device lock operation -1, Table 39   Command table for device lock operation -2 and Table 40   Command table for device lock operation -3 on the page 71.

- Security Set Password
- Security Unlock
- Security Disable Password
- Security Erase Unit

12.42 Security Set Password (F1h)

Table 189 Security Set Password Command (F1h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 F1h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.4 Download Microcode (92h)

The Security Set Password command enables security mode feature (device lock function), and sets the master password or the user password.

The security mode feature (device lock function) is enabled by this command, and the device is not locked immediately. The device is locked after next power on reset. When the MASTER password is set by this command, the master password is registered internally, but the device is NOT locked after next power on reset or hard reset.

This command requests a transfer of a single sector of data from the host including the information specified in Table 189   Security Set Password Command (F1h) on the page 246.

The data transferred controls the function of this command.

Table 190 Security Set Password Information

Word	Description	
00	Control word	
	bit 0	: Identifier (1-Master, 0-User)
	bit 1-7	: Reserved
	bit 8	: Security level (1-Maximum, 0-High)
	bit 9-15	: Reserved
01-16	Password (32 byte)	
17	Master Password Revision Code (valid if Word 0 bit 0 = 1)	
18-255	Reserved	

Identifier Zero indicates that the device regards Password as User Password. One indicates that device regards Password as Master Password.

Security Level Zero indicates High level, one indicates Maximum level. If the host sets High level and the password is forgotten, then the Master Password can be used to unlock the device. If the host sets Maximum level and the user password is forgotten, only a Security Erase Prepare/Security Unit command can unlock the device and all data will be lost.

Password The text of the password – all 32 bytes are always significant.

Master Password Revision Code The revision code field is returned in the IDENTIFY DEVICE word 92. The valid revision codes are 0001h through FFFEh. The device accepts the command with a value of 0000h or FFFFh in this field, but does not change Master Password Revision code.

The setting of the Identifier and Security level bits interact as follows.

Identifier=User / Security level = High

The password supplied with the command will be saved as the new user password. The security mode feature (lock function) will be enabled from the next power on. The file may then be unlocked by either the user password or the previously set master password.

Identifier=Master / Security level = High

This combination will set a master password but will NOT enable the security mode feature (lock function).

Identifier=User / Security level = Maximum

The password supplied with the command will be saved as the new user password. The security mode feature (lock function) will be enabled from the next power on. The file may then be unlocked by only the user password. The master password previously set is still stored in the file but may NOT be used to unlock the device.

Identifier=Master / Security level = Maximum

This combination will set a master password but will NOT enable the security mode feature (lock function).

12.43 Security Unlock (F2h)

Table 191   Security Unlock Command (F2h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 F2h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.4 Download Microcode (92h)

This command unlocks the password and causes the device to enter device unlock mode. If power on reset or hard reset is done without executing the Security Disable Password command after this command is completed, the device will be in device lock mode. The password has not been changed yet.

The Security Unlock command requests to transfer a single sector of data from the host including information specified in Table 191   Security Unlock Command (F2h) on the page 248.

If the Identifier bit is set to master and the file is in high security mode then the password supplied will be compared with the stored master password. If the file is in maximum security mode then the security unlock will be rejected.

If the Identifier bit is set to user, then the file compares the supplied password with the stored user password.

If the password compare fails, then the device returns an abort error to the host and decrements the unlock attempt counter. This counter is initially set to 5 and is decremented for each password mismatch.

When security is disabled and the Identifier bit is set to User, then the device shall return command aborted.

When this counter reaches zero then all password protected commands are rejected until a hard reset or a power off.

Table 192   Security Unlock Information

Word	Description	
00	Control word	
	bit 0	: Identifier (1-Master, 0-User)
	bit 1-15	: Reserved
01-16	Password	(32 bytes)
17-255	Reserved	

Identifier   Zero indicates that device regards Password as User Password. One indicates that device regards Password as Master Password.

The user can detect if the attempt to unlock the device has failed due to a mismatched password as this is the only reason that an abort error will be returned by the file AFTER the password information has been sent to the device. If an abort error is returned by the device BEFORE the password data has been sent to the file then another problem exists.

12.44 Seek (7xh)

Table 193   Seek Command (7xh)

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-
Sector Count	-	-	-	-	-	-	-	-
Sector Number	V	V	V	V	V	V	V	V
Cylinder Low	V	V	V	V	V	V	V	V
Cylinder High	V	V	V	V	V	V	V	V
Device/Head	1	L	1	D	H	H	H	H
Command	0	1	1	1	-	-	-	-

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	V	V	V	V	V	V	V	V
Cylinder Low	V	V	V	V	V	V	V	V
Cylinder High	V	V	V	V	V	V	V	V
Device/Head	-	-	-	-	H	H	H	H
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	V	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	V	-	0	-	V

The Seek command initiates a seek to the designated track and selects the designated head. The device need not be formatted for a seek to execute properly.

Output Parameters To The Device

Sector Number   In LBA mode, this register specifies LBA address bits 0 – 7 for seek. (L=1)

Cylinder High/Low   The cylinder number of the seek.
In LBA mode, this register specifies LBA address bits 8 – 15 (Low), 16 – 23 (High) for seek. (L=1)

H   The head number of the seek.
In LBA mode, this register specifies LBA address bits 24 – 27 for seek. (L=1)

Input Parameters From The Device

Sector Number   In LBA mode, this register contains current LBA bits 0 – 7. (L=1)

Cylinder High/Low   In LBA mode, this register contains current LBA bits 8 – 15 (Low), 16 – 23 (High). (L=1)

H   In LBA mode, this register contains current LBA bits 24 – 27. (L=1)

12.45 SEND FPDMA QUEUED (64h)

Table 194   SEND FPDMA QUEUED

Command Input

Field	Description
FEATURE	The number of 512-byte blocks of data to be transferred. A value of 0000h indicates that 65 536 512-byte blocks of data are to be transferred
COUNT	**Bit Description** 15:14 PRIO field 13 Reserved 12:8 SUBCOMMAND field 7:3 NCQ TAG field 2:0 Reserved
LBA	Subcommand specific
AUXILIARY	Subcommand specific
DEVICE	**Bit Description** 7 Reserved 6 Shall be set to one 5 Reserved 4 Shall be cleared to zero 3:0 Reserved
Command	7:0 64h

Ultrastar Archive Ha10 does not support SEND FPDMA QUEUED command. When the drive receives SEND FPDMA QUEUED command from the host, the drive will abort the command.

12.46 Sense Condition (F0h : Vendor specific)

Table 195   Sense Condition command (F0h)

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register								
Data	-	-	-	-	-	-	-	-
Feature	0	0	0	0	0	0	0	1
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	-	-	-	-	-	-	-	-
Command	1	1	1	1	0	0	0	0

Command Block Command Input	7	6	5	4	3	2	1	0
Register								
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	V	V	V	V	V	V	V	V
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	-	-	-	-	-	-	-	-
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
V	V	V	-	V	-	0	V

The Sense Condition command is used to sense temperature in a device.

This command is executable even if a device is in Power up in standby mode.

Output Parameters To The Device

Feature   The Feature register must be set to 01h. All other value is rejected with setting ABORT bit in status register.

Input Parameters From The Device

Sector Count   The Sector Count register contains result value.

Value	Description
00h	Temperature is equal to or lower than -20 deg C
01h-FEh	Temperature is (Value / 2 - 20) deg C
FFh	Temperature is higher than 107 deg C

12.47 Set Features (EFh)

Table 196   Set Features Command (EFh)

Command Input

Field	Description
FEATURE	SET FEATURES SUBCOMMAND field
COUNT	Subcommand specific
LBA	Subcommand specific
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 EFh

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

The Set Feature command is to establish the following parameters which affect the execution of certain features as shown in below table.

ABT will be set to 1 in the Error Register if the Feature register contains any undefined values.

Subcommands code

Feature	Destination code for this command
02H	Enable write cache
03H	Set transfer mode based on value in sector count register
05H	Enable Advanced Power Management
06H	Enable Power-up in Standby feature set
07H	Power-Up In Standby feature set device spin-up
10H	Enable use of Serial ATA feature
43H	Set Maximum Host Interface Sector Time
4Ah	Extended Power Conditions
55H	Disable read look-ahead feature
66H	Disable reverting to power on defaults
82H	Disable write cache
85H	Disable Advanced Power Management
86H	Disable Power-up in Standby mode
90H	Disable use of Serial ATA feature
AAH	Enable read look-ahead feature
CCH	Enable reverting to power on defaults

Note.
After power on reset or hard reset, the device is set to the following features as default.

Write cache	: Enable
Read look-ahead	: Enable
Reverting to power on defaults	: Disable
Release interrupt	: Disable

12.47.1 Set Transfer Mode

When Feature register is 03h (=Set Transfer Mode), the Sector Count Register specifies the transfer mechanism. The upper 5 bits define the type of transfer and the low order 3 bits encode the mode value.

PIO Default Transfer Mode	00000	000	
PIO Default Transfer Mode Disable IORDY	00000	001	
PIO Flow Control Transfer Mode x	00001	nnn	(nnn=000,001,010,011,100)
Multiword DMA mode x	00100	nnn	(nnn=000,001,010)
Ultra DMA mode x	01000	nnn	(nnn=000,001,010,011,100,101,110)

12.47.2 Write Cache

If the number of auto reassigned sector reaches the device's reassignment capacity, the write cache function will be automatically disabled. Although the device still accepts the Set Features command with Feature register = 02h without error, but the write cache function will remains disabled. For current write cache function status, please refer to Identify Device Information (word 85 or 129) by Identify Device command.

12.47.3 Serial ATA Feature

When the Feature register is set to 10h or 90h, the value set to the Sector Count register specifies the specific Serial ATA feature to enable or disable.

Sector Count Value	Description
01h	Non-zero buffer offset in DMA Setup FIS
02h	DMA Setup FIS Auto-Activate optimization
03h	Device-initiated interface power state transitions
04h	Guaranteed In-Order Data Delivery
06h	Software Settings Preservation

12.47.4　Advanced Power Management

When the value in the Feature register is 05h (=Enable Advanced Power Management), the Sector Count Register specifies the Advanced Power Management level.

FFh ---	Aborted
C0 – FEh ---	The deepest power saving mode is Idle mode (the same as Disable Advanced Power Management)
80 – BFh ---	The deepest power saving mode is Low power Idle mode
01 – 7Fh ---	The deepest power saving mode is Low RPM Idle mode
00h ---	Aborted

The idle time to Low power idle mode and Low RPM idle mode vary according to the value in Sector Count register as follows:

When Low power idle mode is the deepest power saving mode,

Y_1=(x-80h) * 5+120 [sec]　　(120<= Y_1<=435)

Y_2=N/A(the device does not go to Low RPM idle mode)

When Low RPM idle mode is the deepest power saving mode and the value in Sector Count register is between 40h and 7Fh,

120<=Y_1<=435 [sec]　　(default: 120 [sec])

Y_2=(x-40h) * 60 + 600[sec]　　(600<=Y_2<=4380)

When Low RPM idle mode is the deepest power saving mode and the value in Sector Count register is between 01h and 3Fh,

120<=Y_1<=435 [sec]　　(default: 120 [sec])

Y_2=600 [sec]

Where x is the value in Sector Count register, y_1 is the idle time to Low Power Idle mode, and y_2 is the idle time to Low RPM idle mode.

If Low power idle mode has already been enabled (i.e., y_1 has been set) before Low RPM idle mode is enabled, y_1 is preserved. If Low power idle mode is disabled (i.e., y_1 has not been set yet), y_1 becomes 120[sec] when Low RPM idle mode is enabled.

Enabled power saving mode and idle time (y_1 and y_2) are preserved until Advanced Power Management is disabled, the deepest power saving mode becomes Idle mode, or new time is set. They are initialized with a hard/soft reset unless Reverting to power on defaults is disabled and the device receives a soft reset.

12.47.5　Set Maximum Host Interface Sector Time

Sector Count	Typical PIO Mode Host Interface Sector Time (7:0)
LBA Low	Typical PIO Mode Host Interface Sector Time (15:8)
LBA Mid	Typical DMA Mode Host Interface Sector Time (7:0)
LBA High	Typical DMA Mode Host Interface Sector Time (15:8)

Subcommand code 43h allows the host to inform the device of a host interface rate limitation.　The typical Host Interface Sector Times have the same units as Identify Device word 96 for DMA and word 104 for PIO. A value of zero indicates that the host interface shall be capable of transferring data at the maximum rate allowed by the selected transfer mode.　The Typical PIO Mode Host Interface Sector Time includes the host's interrupt service time.

12.47.6 Extended Power Conditions (EPC) feature

12.47.6.1 Restore Power Condition Settings subcommand

Table 197   Restore Power Condition Settings subcommand

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	0	1	0	0	1	0	1	0
Sector Count	V	V	V	V	V	V	V	V
Sector Number	-	V	-	V	0	0	0	0
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-
Command	1	1	1	0	1	1	1	1

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	-	-	-	-	-	-	-	-
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

On successful completion of this EPC subcommand, the device updates the Power Conditions log for the selected Power Condition ID as follows:
1) if Default is set to one, then:
   A) copy the Default Timer Settings field to the Current Timer Settings field; and
   B) copy the Default Timer Enabled field to the Current Timer Enabled field;
2) if Default is cleared to zero, then:
   A) copy the Saved Timer Settings field to the Current Timer Settings field; and
   B) copy the Saved Timer Enabled field to the Current Timer Enabled field;
    and
3) if Save is set to one and the power condition is savable, then:
   A) copy the Current Timer Settings field to the Saved Timer Settings field;

Output Parameters To The Device

Sector Count   Power Condition ID (See Table 75   Power Condition IDs)

Sector Number   **bit Description**

                            7 Reserved

                            6 Default

                                 1   Restore from Default settings

                                 0   Restore from Saved settings

                            5 Reserved

                            4 Save

                                 1   Save settings on completion

                                 0   Do not save settings on completion

                        3-0 0h Restore Power Condition subcommand (See Table 74   Extended Power Conditions Subcommands)

Error Output
If any selected Power Condition is not supported, or is not changeable, or if Extended Power Condition feature set is disable, or if Save is set to one and any selected power condition is not savable, then the device returns command aborted .

12.47.6.2 Go To Power Condition subcommand

Table 198 Go To Power Condition subcommand

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	0	1	0	0	1	0	1	0
Sector Count	V	V	V	V	V	V	V	V
Sector Number	-	-	-	-	0	0	0	1
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-
Command	1	1	1	0	1	1	1	1

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	-	-	-	-	-	-	-	-
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

On successful completion of this EPC subcommand, the device:
1) stops all enabled EPC timers;
2) enters the selected EPC power condition after command completion of the SET FEATURES command without having to wait for any timers to expire; and
3) the device remains in the selected power condition until the device processes the next command or reset.

Output Parameters To The Device

Sector Count   Power Condition ID (See Table 75   Power Condition IDs)

Sector Number   **bit Description**
  7-4 Reserved
  3-0 1h Go To Power Condition subcommand (See Table 74   Extended Power Conditions Subcommands)

Error Output
If the Power condition ID is FFh, a reserved value, or is not supported, or if Extended Power Condition feature set is disable, then the device returns command aborted .

12.47.6.3   Set Power Condition Timer subcommand

Table 199   Set Power Condition Timer subcommand

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	0	1	0	0	1	0	1	0
Sector Count	V	V	V	V	V	V	V	V
Sector Number	V	-	V	V	0	0	1	0
Cylinder Low	V	V	V	V	V	V	V	V
Cylinder High	V	V	V	V	V	V	V	V
Device/Head	1	-	1	D	-	-	-	-
Command	1	1	1	0	1	1	1	1

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	-	-	-	-	-	-	-	-
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

On successful completion of this EPC subcommand, the device updates the Power Conditions log for the selected and supported Power Condition as follows:

1) copy the Timer field to the Current Timer Settings field;

2) if Enable is set to one and the Timer field is non-zero, then enable the Current Timer;

3) if Enable is set to one and the Timer field is zero, then disable the Current Timer;

4) if Enable is cleared to zero, then disable the Current Timer; and

5) if Save is set to one and the Power Condition settings are savable, then:

   A) copy the Current Timer Settings field to the Saved Timer Settings field; and

   B) copy the Current Timer Enabled field to the Saved Timer Enabled field.

Output Parameters To The Device

Sector Count   Power Condition ID (See Table 75   Power Condition IDs)

Sector Number   **bit**   **Description**

7   Timer Units
If the Timer Units bit is cleared to zero, then the Timer (Cylinder High and Cylinder Low bit 15-0) are specified in units of 100 milliseconds. If the Timer Units bit is set to one, then the Timer (Cylinder High and Cylinder Low bit 15-0) are specified in units of 1 minute.

6   Reserved

5   Enable

1   Enable the selected power condition

0   Disable the selected power condition

4   Save

1   Save settings on completion

0   Do not save settings on completion

3-0   2h Set Power Condition Timer subcommand (See Table 74   Extended Power Conditions Subcommands)

Cylinder Low   **15-0**   If the new timer value is greater than the maximum value setting, then the device set the value to the maximum setting. If the new timer value is less than the minimum setting, then the device set the value to the minimum setting.
Cylinder High   (Cylinder High and Cylinder Low bit 15-0)

Error Output
The device returns command aborted If:

a) the new timer value is:

A)   less than the maximum setting.

B)   greater than the minimum setting.

C)   not supported by the device.

b) the Extended Power Condition feature set is disabling.

c) the power condition is not changeable or not supported.

d) the Save bit is set to one and the selected power condition is not savable.

e) the new time value is greater than the maximum setting and the device did not set the timer to the maximum setting.

f)   the new time value is less than the minimum setting and the device did not set the timer to the minimum setting.

If command aborted is returned, then the device makes no modifications to the power condition settings.
Maximum Setting is 3BFFC4h (100ms unit). Minimum Setting is zero.

12.47.6.4   Set Power Condition State subcommand

Table 200   Set Power Condition State subcommand

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	0	1	0	0	1	0	1	0
Sector Count	V	V	V	V	V	V	V	V
Sector Number	-	-	V	V	0	0	1	1
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-
Command	1	1	1	0	1	1	1	1

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	-	-	-	-	-	-	-	-
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

On successful completion of this EPC subcommand, the device updates the Power Conditions log for the Power Condition as follows:

1) If the Enable bit is set to one, then enable the Current Timer; otherwise disable the Current Timer; and
2) If the Save bit is set to one, then copy the Current Timer Enabled field to the Saved Timer Enabled field.

Output Parameters To The Device

Sector Count   Power Condition ID (See Table 75   Power Condition IDs)

Sector Number   **bit**   **Description**

  7-6 Reserved

  5 Enable

  1   Enable the selected power condition

  0   Disable the selected power condition

  4 Save

  1   Save settings on completion

  0   Do not save settings on completion

  3-0 3h Set Power Condition State subcommand (See Table 74   Extended Power Conditions Subcommands)

Error Output

If the Power Condition is not changeable, or not supported, or if Extended Power Conditions feature set is disabling, then the device returns command aborted. If the Save bit is set to one and the selected power condition is not savable, then the device returns command aborted. If command aborted is returned, then the device makes no modifications to the power condition settings.

12.47.6.5 Enable the EPC feature subcommand

Table 201   Enable the EPC feature subcommand

Command Block Normal Outputs										Command Block Command Input									
Register	7	6	5	4	3	2	1	0		Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-		Data	-	-	-	-	-	-	-	-
Feature	0	1	0	0	1	0	1	0		Error			…See Below…					
Sector Count	-	-	-	-	-	-	-	-		Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	0	1	0	0		Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-		Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-		Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-		Device/Head	-	-	-	-	-	-	-	-
Command	1	1	1	0	1	1	1	1		Status			…See Below…					

Error Register									Status Register							
7	6	5	4	3	2	1	0		7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN		BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	0	0	0	0	V	0	0		0	V	0	-	-	0	-	V

On successful completion of this EPC subcommand, the device:
  a) enables the EPC feature set;
  b) sets IDENITFY DEVICE data word 120 bit 7 to one; and
  c) disables the APM feature set.
  d) if the Saved Timer Setting field is cleared to zero, then:
      copy the value of the Default Timer Setting to the Current Timer Setting; and
  e) if the Saved Timer Setting field is non-zero, then:
      copy the value of the Saved Timer Setting to the Current Timer Setting; and
  f) if the Current Timer Setting field is non-zero and the Current Timer Enabled is set to one,
      then initialize and start the timer.

If the EPC feature set is enabled, then the EPC feature set remains enabled across all resets (i.e., power-on reset, hardware reset, and software reset).

Output Parameters To The Device

Sector Number   bit Description
                   7-4 Reserved
                   3-0 4h Enable the EPC feature subcommand (See Table 74   Extended Power
                            Conditions Subcommands)

Error Output

If the Extended Power Condition feature set is not supported then the device returns command aborted.

12.47.6.6 Disable the EPC feature subcommand

Table 202   Disable the EPC feature subcommand

Command Block Normal Outputs										Command Block Command Input									
Register	7	6	5	4	3	2	1	0		Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-		Data	-	-	-	-	-	-	-	-
Feature	0	1	0	0	1	0	1	0		Error				…See Below…				
Sector Count	-	-	-	-	-	-	-	-		Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	0	1	0	1		Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-		Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-		Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-		Device/Head	-	-	-	-	-	-	-	-
Command	1	1	1	0	1	1	1	1		Status				…See Below…				

Error Register								Status Register							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN	BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	0	0	0	0	V	0	0	0	V	0	-	-	0	-	V

On successful completion of this EPC subcommand, the device:
 a)   stop all EPC timers
 b)   disables the EPC feature set; and
 c)   clears IDENITFY DEVICE data word 120 bit 7 to zero.

If the EPC feature set is disabled, then the EPC feature set remains disabled across all resets (i.e., power-on reset, hardware reset, and software reset).

Output Parameters To The Device

Sector Number   bit Description
                   7-4 Reserved
                   3-0 5h Disable the EPC feature subcommand (See Table 74   Extended Power Conditions Subcommands)

Error Output

If the Extended Power Condition feature set is disabling, not supported then the device returns command aborted.

12.48 Set Max Address (F9h)

Table 203   Set Max ADDRESS (F9h)

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	V	V	V	V	V	V	V	V
Sector Count	-	-	-	-	-	-	-	B
Sector Number	V	V	V	V	V	V	V	V
Cylinder Low	V	V	V	V	V	V	V	V
Cylinder High	V	V	V	V	V	V	V	V
Device/Head	1	L	1	D	H	H	H	H
Command	1	1	1	1	1	0	0	1

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	V	V	V	V	V	V	V	V
Cylinder Low	V	V	V	V	V	V	V	V
Cylinder High	V	V	V	V	V	V	V	V
Device/Head	-	-	-	-	H	H	H	H
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

The device regards as Set Max Address command, if this command is immediately preceded by a Read Native Max Address command. The device receives this command without a prior Read Native Max Address command, the device regards as Set Max security extensions command according to feature register value. Valid features values are as follows:

1. 01h indicates Set Max Set Password command
2. 02h indicates Set Max Lock command
3. 03h indicates Set Max Unlock command
4. 04h indicates Set Max Freeze LOCK command

This command overwrites the maximum number of Address of HDD in a range of actual device capacity. Once device receives this command, all accesses beyond that Address are rejected with setting ABORT bit in status register. Identify device command returns the Address which is set via this command as a default value.

Device returns command aborted for a second non-volatile Set Max Address command until next power on or hardware reset.

Device returns command aborted during Set Max Locked mode or Set Max Frozen mode.

After a successful command completion, Identify Device response words (61:60) shall reflect the maximum address set with this command.

If the 48-bit Address feature set is supported, the value placed in Identify Device response words (103:100) shall be the same as the value placed in words (61:60). However, if the device contains greater than 268,435,455 sectors, the capacity addressable with 28-bit commands, and the address requested is 268,435,455, the max address shall be changed to the native maximum address, the value placed in words (61:60) shall be 268,435,455 and the value placed in words (103:100) shall be the native maximum address.

If a host protected area has been established by a Set Max Address Ext command, the device shall return command aborted.

Output Parameters To The Device

B   Option bit for selection whether nonvolatile or volatile. B=0 is volatile condition. When B=1, MAX Address which is set by Set Max Address command is preserved by POR. When B=0, MAX Address which is set by Set Max Address command will be lost by POR. B=1 is not valid when the device is in Address Offset mode.

Sector Number   In LBA mode, this register contains LBA bits 0 – 7 which is to be input.(L=1)
                             In CHS mode, this register is ignored. (L=0)

Cylinder High/Low   In LBA mode, this register contains LBA bits 8 – 15 (Low), 16 – 23 (High) which is to be set. (L=1)
                             In CHS mode, this register contains cylinder number which is to be set.(L=0)

H   In LBA mode, this register contains LBA bits 24 – 27 which is to be set.(L=1)
                             In CHS mode, this register is ignored. (L=0)

Input Parameters From The Device

Sector Number   In LBA mode, this register contains max LBA bits 0 – 7 which is set.(L=1)
                             In CHS mode, this register contains max sector number (= 63). (L=0)

Cylinder High/Low   In LBA mode, this register contains max LBA bits 8 – 15 (Low), 16 – 23 (High) which is set. (L=1)
                             In CHS mode, this register contains max cylinder number which is set. (L=0)

H   In LBA mode, this register contains max LBA bits 24 – 27 which is set. (L=1)
                             In CHS mode, this register contains max head number.(L=0)

12.48.1 Set Max Set Password (Feature = 01h)

Table 204   Set Max set Password

Command Block Normal Outputs	7	6	5	4	3	2	1	0	Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0	Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-	Data	-	-	-	-	-	-	-	-
Feature	0	0	0	0	0	0	0	1	Error			…See Below…					
Sector Count	-	-	-	-	-	-	-	-	Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-	Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-	Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-	Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-	Device/Head	1	-	1	D	-	-	-	-
Command	1	1	1	1	1	0	0	1	Status			…See Below…					

Error Register								Status Register							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN	BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	0	0	0	0	V	0	0	0	V	0	-	-	0	-	V

The device regards as Set Max Address command, if this command is immediately preceded by a Read Native Max Address command.

This command requests a transfer of a single sector of data from the host including the information specified in Table 204   Set Max set Password.

The password is retained by the device until the next power cycle. When the device accepts this command the device is in Set_Max_Unlocked state.

Table 205   Set Max Set Password data contents

Word	Description
0	Reserved
01-16	Password (32 byte)
17-255	Reserved

12.48.2 Set Max Lock (Feature = 02h)

Table 206 Set Max Lock

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	0	0	0	0	0	0	1	0
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-
Command	1	1	1	1	1	0	0	1

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

The device regards as Set Max Address command, if this command is immediately preceded by a Read Native Max Address command.

This command sets the device into Set_Max_Locked state. After this command is completed any other Set Max commands except Set Max Unlock and Set Max Freeze Lock are rejected. The device remains in this state until a power cycle or the acceptance of a Set Max Unlock or Set Max Freeze Lock command.

12.48.3 Set Max Unlock (Feature = 03h)

Table 207   Set Max Unlock (F9h)

Command Block Normal Outputs	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Feature	0	0	0	0	0	0	1	1
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-
Command	1	1	1	1	1	0	0	1

Command Block Command Input	7	6	5	4	3	2	1	0
Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-
Error	…See Below…							
Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-
Status	…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

The device regards as Set Max Address command, if this command is immediately preceded by a Read Native Max Address command.

This command requests a transfer of a single sector of data from the host including the information specified in Table 204   Set Max set Password on the page 265 with the stored SET MAX password.

If the password compare fails then the device returns an abort error to the host and decrements the unlock attempt counter. This counter is initially set to 5 and is decremented for each password mismatch. When this counter reaches zero then all Set Max Unlock commands are rejected until a hard reset or a power off.

If the password compares matches, then the device set the Set_Max_Unlocked state and all Set Max commands shall be accepted.

12.48.4 Set Max Freeze Lock (Feature = 04h)

Table 208   Set Max Freeze Lock (F9h)

Command Block Normal Outputs									Command Block Command Input								
Register	7	6	5	4	3	2	1	0	Register	7	6	5	4	3	2	1	0
Data	-	-	-	-	-	-	-	-	Data	-	-	-	-	-	-	-	-
Feature	0	0	0	0	0	1	0	0	Error				…See Below…				
Sector Count	-	-	-	-	-	-	-	-	Sector Count	-	-	-	-	-	-	-	-
Sector Number	-	-	-	-	-	-	-	-	Sector Number	-	-	-	-	-	-	-	-
Cylinder Low	-	-	-	-	-	-	-	-	Cylinder Low	-	-	-	-	-	-	-	-
Cylinder High	-	-	-	-	-	-	-	-	Cylinder High	-	-	-	-	-	-	-	-
Device/Head	1	-	1	D	-	-	-	-	Device/Head	1	-	1	D	-	-	-	-
Command	1	1	1	1	1	0	0	1	Status				…See Below…				

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

The device regards as Set Max Address command, if this command is immediately preceded by a Read Native Max Address command.

The Set Max Freeze Lock command sets the device to Set_Max_Frozen state. After command completion any subsequent Set Max commands are rejected. Commands disabled by Set Max Freeze Lock are:

1. Set Max Address
2. Set Max Set PASSWORD
3. Set Max Lock
4. Set Max Unlock

12.49 Set Max Address Ext (37h)

Table 209 Set Max Address Ext Command (37h)

Command Block Normal Outputs		7	6	5	4	3	2	1	0
Register		7	6	5	4	3	2	1	0
Data Low		-	-	-	-	-	-	-	-
Data High		-	-	-	-	-	-	-	-
Feature	Current	-	-	-	-	-	-	-	-
	Previous	-	-	-	-	-	-	-	-
Sector Count	Current	-	-	-	-	-	-	-	B
	Previous	-	-	-	-	-	-	-	-
Sector Number	Current	V	V	V	V	V	V	V	V
	Previous	V	V	V	V	V	V	V	V
Cylinder Low	Current	V	V	V	V	V	V	V	V
	Previous	V	V	V	V	V	V	V	V
Cylinder High	Current	V	V	V	V	V	V	V	V
	Previous	V	V	V	V	V	V	V	V
Device/Head		-	1	-	D	-	-	-	-
Command		0	0	1	1	0	1	1	1

Command Block Command Input		7	6	5	4	3	2	1	0
Register		7	6	5	4	3	2	1	0
Data Low		-	-	-	-	-	-	-	-
Data High		-	-	-	-	-	-	-	-
Error		…See Below…							
Sector Count	HOB=0	-	-	-	-	-	-	-	-
	HOB=1	-	-	-	-	-	-	-	-
Sector Number	HOB=0	V	V	V	V	V	V	V	V
	HOB=1	V	V	V	V	V	V	V	V
Cylinder Low	HOB=0	V	V	V	V	V	V	V	V
	HOB=1	V	V	V	V	V	V	V	V
Cylinder High	HOB=0	V	V	V	V	V	V	V	V
	HOB=1	V	V	V	V	V	V	V	V
Device/Head		-	-	-	-	-	-	-	-
Status		…See Below…							

Error Register							
7	6	5	4	3	2	1	0
CRC	UNC	0	IDN	0	ABT	T0N	AMN
0	0	0	0	0	V	0	0

Status Register							
7	6	5	4	3	2	1	0
BSY	RDY	DF	DSC	DRQ	COR	IDX	ERR
0	V	0	-	-	0	-	V

This command is immediately preceded by a Read Native Max Address Ext command.

This command overwrites the maximum number of Address of HDD in a range of actual device capacity. Once device receives this command, all accesses beyond that Address are rejected with setting ABORT bit in status register.

When the address requested is greater than 268,435,455, words (103:100) shall be modified to reflect the requested value, but words (61:60) shall not be modified. When the address requested is equal to or less than 268,435,455, words (103:100) shall be modified to reflect the requested value, and words (61:60) shall also be modified.

If this command is not supported, the maximum value to be set exceeds the capacity of the device, a host protected area has been established by a Set Max Address command, the command is not immediately preceded by a Read Native Max Address Ext command, or the device is in the Set Max Locked or Set Max Frozen state, the device shall return command aborted.

The device returns the command aborted for a second non-volatile Set Max Address Ext command until next power on or hardware reset.

Output Parameters To The Device

B   Option bit for selection whether nonvolatile or volatile. B=0 is volatile condition. When B=1, MAX Address which is set by Set Max Address Ext command is preserved by POR. When B=0, MAX Address which is set by Set Max Address Ext command will be lost by POR. B=1 is not valid when the device is in Address Offset mode.

Sector Number Current   Set Max LBA (7:0).

Sector Number Previous   Set Max LBA (31:24).

Cylinder Low Current   Set Max LBA (15:8).

Cylinder Low Previous   Set Max LBA (39:32).

Cylinder High Current   Set Max LBA (23:16).

Cylinder High Previous   Set Max LBA (47:40).

Input Parameters From The Device

Sector Number (HOB=0)   Set Max LBA (7:0).

Sector Number (HOB=1)   Set Max LBA (31:24).

Cylinder Low (HOB=0)   Set Max LBA (15:8).

Cylinder Low (HOB=1)   Set Max LBA (39:32).

Cylinder High (HOB=0)   Set Max LBA (23:16).

Cylinder High (HOB=1)   Set Max LBA (47:40).

12.50 Set Multiple Mode (C6h)

Table 210   Set Multiple Mode Commands (C6h)

Command Input

Field	Description
FEATURE	N/A
COUNT	DRQ data block count
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 C6h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

The Set Multiple command enables the device to perform Read and Write Multiple commands and establishes the block size for these commands. The block size is the number of sectors to be transferred for each interrupt.

If an invalid block size is specified, an Abort error will be returned to the host, and Read Multiple and Write Multiple commands will be disabled.

12.51 Sleep (E6h/99h)

Table 211   Sleep Command (E6h/99h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description**
	7 Obsolete
	6 N/A
	5 Obsolete
	4 Transport Dependent
	3:0 Reserved
Command	7:0 E6h or 99h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

This command causes the device to enter Sleep Mode.

The device is spun down and the interface becomes inactive. If the device is already spun down, the spin down sequence is not executed.

The only way to recover from Sleep Mode is with software reset or hardware reset.

12.52 SMART Function Set (B0h)

The SMART Function Set command provides access to Attribute Values, Attribute Thresholds and other low level subcommands that can be used for logging and reporting purposes and to accommodate special user needs. The SMART Function Set command has several separate subcommands which are selectable via the device's Features Register when the SMART Function Set command is issued by the host.

12.52.1 SMART Subcommand

In order to select a subcommand the host must write the subcommand code to the device's Features Register before issuing the SMART Function Set command. The subcommands and their respective codes are listed below.

Code	Subcommand
D0h	SMART Read Attribute Values
D1h	SMART Read Attribute Thresholds
D2h	SMART Enable/Disable Attribute Autosave
D3h	SMART Save Attribute Values
D4h	SMART Execute Off-line Immediate
D5h	SMART Read Log Sector
D6h	SMART Write Log Sector
D8h	SMART Enable Operations
D9h	SMART Disable Operations
DAh	SMART Return Status
DBh	SMART Enable/Disable Automatic Off-Line

12.52.1.1 SMART Read Attribute Values (Subcommand D0h)

This subcommand returns the device's Attribute Values to the host. Upon receipt of the SMART Read Attribute Values subcommand from the host, the device saves any updated Attribute Values to the Attribute Data sectors, and then transfers the 512 bytes of Attribute Value information to the host.

12.52.1.2 SMART Read Attribute Thresholds (Subcommand D1h)

This subcommand returns the device's Attribute Thresholds to the host. Upon receipt of the SMART Read Attribute Thresholds subcommand from the host, the device reads the Attribute Thresholds from the Attribute Threshold sectors, and then transfers the 512 bytes of Attribute Thresholds information to the host.

12.52.1.3 SMART Enable/Disable Attribute Autosave (Subcommand D2h)

Table 212 SMART Enable/Disable Attribute Autosave (B0h-D2h)

Command Input

Field	Description
FEATURE	D2h
COUNT	Value Description 00h Disable attribute autosave 01h-F0h N/A F1h Enable attribute autosave F2h-FFh N/A
LBA	**Bit Description** 27:24 N/A 23:8 C24Fh 7:0 N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B0h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

This subcommand Enables and Disables the Attribute Autosave feature of the device. The SMART Enable/Disable Attribute Autosave subcommand either allows the device to automatically save its updated Attribute Values to the Attribute Data Sector periodically; or this subcommand causes the Autosave feature to be disabled. The state of the Attribute Autosave feature (either enabled or disabled) will be preserved by the device across power cycle.

A value of 00h written by the host into the device's Sector Count Register before issuing the SMART Enable/Disable Attribute Autosave subcommand will cause this feature to be disabled. Disabling this feature does not preclude the device from saving Attribute Values to the Attribute Data sectors during some other normal operation such as during 10

12.52.1.4 SMART Save Attribute Values (Subcommand D3h)

This subcommand causes the device to immediately save any updated Attribute Values to the device's Attribute Data sector regardless of the state of the Attribute Autosave feature. Upon receipt of the SMART Save Attribute Values subcommand from the host, the device writes any updated Attribute Values to the Attribute Data sector.

12.52.1.5 SMART Execute Off-line Immediate (Subcommand D4h)

Table 213   SMART Enable/Disable Attribute Autosave (B0h-D4h)

Command Input

Field	Description
FEATURE	D4h
COUNT	N/A
LBA	**Bit Description** 27:24 N/A 23:8 C24Fh 7:0 Defines the subcommand that shall be processed
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B0h

Normal Outputs

Field	Description
ERROR	N/A
COUNT	N/A

LBA	**Bit Description**
	27:24 N/A
	23:8
	Value Description
	  C24Fh: The subcommand specified a captive self-test that has completed without error.
	  All Other Values: The subcommand specified an off-line routine including an off-line self-test routine.
	7:0 N/A

DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Error Outputs

Field	Description
ERROR	**Bit Description**
	7:5 N/A
	4 ID NOT FOUND bit
	3 N/A
	2 ABORT bit
	1 N/A
	0 Obsolete
COUNT	Reserved
LBA	**Bit Description**
	27:24 N/A
	23:8
	Value Description
	C24Fh: Subcommand specified a captive self-test and some error other than a self-test routine failure occurred (i.e., if the sub-command is not supported or field values are invalid)
	2CF4h: the subcommand specified a captive self-test routine that has failed during processing.
	All Other Values: the subcommand specified an off-line routine including an off-line self-test routine.
	7:0 N/A
DEVICE	**Bit Description**
	7 Obsolete
	6 N/A
	5 Obsolete
	4 Transport Dependent
	3:0 Reserved
STATUS	**Bit Description**
	7:6 Transport Dependent
	5 DEVICE FAULT bit
	4 N/A
	3 Transport Dependent
	2 N/A
	1 SENSE DATA AVAILABLE bit
	0 ERROR bit

This subcommand causes the device to immediately initiate the set of activities that collect Attribute data in an off-line mode (off-line routine) or execute a self-test routine in either captive or off-line mode. The Sector Number register shall be set to specify the operation to be executed.

Subcommand	Operation to be executed
0	Execute SMART off-line data collection routine immediately
1	Execute SMART Short self-test routine immediately in off-line mode
2	Execute SMART Extended self-test routine immediately in off-line mode
4	Execute SMART Selective self-test routine immediately in off-line mode
127	Abort off-line mode self-test routine
129	Execute SMART Short self-test routine immediately in captive mode
130	Execute SMART Extended self-test routine immediately in captive mode
132	Execute SMART Selective self-test routine immediately in captive mode

Off-line mode: The device executes command completion before executing the specified routine. During execution of the routine the device will not set BSY nor clear DRDY. If the device is in the process of performing its routine and is interrupted by a new command from the host, the device will abort or suspend its routine and service the host within two seconds after receipt of the new command. After servicing the interrupting command, the device will resume its routine automatically or not start its routine depending on the interrupting command.

Captive mode: When executing self-test in captive mode, the device sets BSY to one and executes the specified self-test routine after receipt of the command. At the end of the routine, the device sets the execution result in the Self-test execution status byte (Table 221 Device Attribute Thresholds Data Structure) and ATA registers as below and executes command completion.

12.52.1.6 SMART Read Log Sector (Subcommand D5h)

Table 214 SMARTRead Log Sector (B0h-D5h)

Command Input

Field	Description
FEATURE	D5h
COUNT	Specifies the number of log pages to be read from the specified log. The log transferred by the ATA device shall start at the first page in the specified log, regardless of the Count requested
LBA	**Bit Description** 27:24 N/A 23:8 C24Fh 7:0 LOG ADDRESS field – specifies the log to be read
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B0h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6 UNCORRECTABLE ERROR bit 5 N/A 4 ID NOT FOUND bit 3 N/A 2 ABORT bit 1 N/A 0 Obsolete
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

This command returns the specified log sector contents to the host.

The 512 bytes data are returned at a command and the Sector Count value shall be set to one. Count field shall be set to specify the log sector address.

Table 215   Log sector addresses

Log sector address	Content	Type
00h	Log directory	Read Only
01h	Summary SMART Error Log	Read Only
03h	Extended Comprehensive SMART Error Log	See Note
06h	SMART Self-test Log	Read Only
07h	Extended Self-test Log	See Note
09h	Selective self-test Log	Read/Write
80h-9Fh	Host vendor specific	Read/Write

Note: Log addresses 03h and 07h are used by the Read Log Ext and Write Log Ext commands. If these log addresses are used with the SMART Read Log Sector command, the device shall return command aborted.

12.52.1.7   SMART Write Log (Subcommand D6h)

Table 216   SMART Write Log (B0h-D6h)

Command Input

Field	Description
FEATURE	D6h
COUNT	Specifies the number of log pages that shall be written. The data transferred to the device shall be stored starting at the first block in the specified log. If the device receives a value of zero in this field, then the device shall report command aborted
LBA	**Bit Description** 27:24 N/A 23:8 C24Fh 7:0 LOG ADDRESS field
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B0h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6:5 N/A 4 ID NOT FOUND bit 3 N/A 2 ABORT bit 1 N/A 0 Obsolete
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

This command writes 512 bytes data to the specified log sector.

The 512 bytes data are transferred at a command and the Sector Count value shall be set to one. The Sector Number shall be set to specify the log sector address (Table 215   Log sector addresses). If Read Only log sector is specified, the device returns ABRT error.

12.52.1.8 SMART Enable Operations (Subcommand D8h)

Table 217 SMART Enable Operations (B0h-D8h)

Command Input

Field	Description
FEATURE	D8h
COUNT	N/A
LBA	**Bit Description** 27:24 N/A 23:8 C24Fh 7:0 N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B0h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

This subcommand enables access to all SMART capabilities within the device. Prior to receipt of a SMART Enable Operations subcommand, Attribute Values are neither monitored nor saved by the device. The state of SMART (either enabled or disabled) will be preserved by the device across power cycles. Once enabled, the receipt of subsequent SMART Enable Operations subcommands will not affect any of the Attribute Values.

Upon receipt of the SMART Enable Operations subcommand from the host, the device enables SMART capabilities and functions, and then saves any updated Attribute Values to the Attribute Data sector.

12.52.1.9 SMART Disable Operations (Subcommand D9h)

This subcommand disables all SMART capabilities within the device including the device's attribute autosave feature. After receipt of this subcommand the device disables all SMART operations. Non self-preserved Attribute Values will no longer be monitored. The state of SMART (either enabled or disabled) is preserved by the device across power cycles.

Upon receipt of the SMART Disable Operations subcommand from the host, the device disables SMART capabilities and functions, and then saves any updated Attribute Values to the Attribute Data sector.

After receipt of the device of the SMART Disable Operations subcommand from the host, all other SMART subcommands – with the exception of SMART Enable Operations – are disabled, and invalid and will be aborted by the device (including the SMART Disable Operations subcommand), returning the error code as specified in Table 231   SMART Error Codes on the page 293.

Any Attribute Values accumulated and saved to volatile memory prior to receipt of the SMART Disable Operations command will be preserved in the device's Attribute Data Sectors. If the device is re-enabled, these Attribute Values will be updated, as needed, upon receipt of a SMART Read Attribute Values or SMART Save Attribute Values command.

12.52.1.10 SMART Return Status (Subcommand DAh)

Table 218   SMART RETURN STATUS command (B0h-DAh)

Command Input

Field	Description
FEATURE	DAh
COUNT	N/A
LBA	**Bit Description** 27:24 N/A 23:8 C24Fh 7:0 N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 B0h

Normal Outputs

Field	Description
ERROR	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A or ALIGNMENT ERROR bit 1 SENSE DATA AVAILABLE bit 0 ERROR bit

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

This command is used to communicate the reliability status of the device to the host's request. Upon receipt of the SMART Return Status subcommand the device saves any updated Pre-failure type Attribute Values to the reserved sector and compares the updated Attribute Values to the Attribute Thresholds.

If the device does not detect a Threshold Exceeded Condition, the device loads 4Fh into the Cylinder Low register, C2h into the Cylinder High register.

If the device detects a Threshold Exceeded Condition, the device loads F4h into the Cylinder Low register, 2Ch into the Cylinder High register.

12.52.1.11 SMART Enable/Disable Automatic Off-Line (Subcommand DBh)

This subcommand enables and disables the optional feature that causes the device to perform the set of off-line data collection activities that automatically collect attribute data in an off-line mode and then save this data to the device's non-volatile memory. This subcommand may either cause the device to automatically initiate or resume performance of its off-line data collection activities or cause the automatic off-line data collection feature to be disabled.

A value of zero written by the host into the device's Sector Count Register before issuing this subcommand shall cause the feature to be disabled. Disabling this feature does not preclude the device from saving attribute values to non-volatile memory during some other normal operation such as during a power-on or power-off sequence or during an error recovery sequence.

A value of F8h written by the host into the device's Sector Count Register before issuing this subcommand shall cause this feature to be enabled. Any other non-zero value written by the host into this register before issuing this subcommand is vender specific and will not change the current Automatic Off-Line Data Collection, but the device may respond with the error code specified in Table 231   SMART Error Codes on the page 293.

12.52.2 Device Attributes Data Structure

The following defines the 512 bytes that make up the Attribute Value information. This data structure is accessed by the host in its entirety using the SMART Read Attribute Values subcommand. All multi-byte fields shown in these data structures are in byte ordering, namely that the least significant byte occupies the lowest numbered byte address location in the field.

Table 219   Device Attribute Data Structure

Description	Bytes	Offset	Value
Data Structure Revision Number	2	00h	0010h
1st Device Attribute	12	02h	
…	..		
…	..		
30th Device Attribute	12	15Eh	
Off-line data collection status	1	16Ah	
Self-test execution status	1	16Bh	
Total time in seconds to complete off-line data collection activity	2	16Ch	
Vender specific	1	16Eh	
Off-line data collection capability	1	16Fh	1Bh
SMART capability	2	170h	0003h
SMART device error logging capability	1	172h	01h
Self-test failure check point	1	173h	
Short self-test completion time in minutes	1	174h	
Extended self-test completion time in minutes. If 0FFh, use bytes 177h and 178h for completion time.	1	175h	
Reserved	1	176h	
Extended self-test completion time in minutes. (word)	2	177h	
Reserved	9	179h	
Vendor specific	125	182h	
Data structure checksum	1	1FFh	
	512		

12.52.2.1   Data Structure Revision Number

The Data Structure Revision Number identifies which version of this data structure is implemented by the device. This revision number identifies both the Attribute Value and Attribute Threshold Data structures.

12.52.2.2 Individual Attribute Data Structure

The following defines the 12 bytes that make up the information for each Attribute entry in the Device Attribute Data Structure.

Table 220   Individual Attribute Data Structure

Description	Bytes	Offset
Attribute ID Number (01h to FFh)	1	00h
Status Flags	2	01h
Attribute Value (valid values from 01h to FDh)	1	03h
Vender specific	8	04h
Total Bytes	12	

Attribute ID Numbers: Any non-zero value in the Attribute ID Number indicates an active attribute. The device supports following Attribute ID Numbers.

ID	Attribute Name
0	Indicates that this entry in the data structure is not used
1	Raw Read Error Rate
2	Throughput Performance
3	Spin Up Time
4	Start/Stop Count
5	Reallocated Sector Count
7	Seek Error Rate
8	Seek Time Performance
9	Power-On Hours Count
10	Spin Retry Count
12	Device Power Cycle Count
192	Power off Retract count
193	Load Cycle count
194	Temperature
196	Reallocation Event Count
197	Current Pending Sector Count
198	Off-Line Scan Uncorrectable Sector Count
199	Ultra DMA CRC Error Count

Status Flag Definitions

Bit	Definition
0	Pre-failure/advisory bit

    0   An Attribute Value less than or equal to its corresponding Attribute Threshold indicates an advisory condition where the usage or age of the device has exceeded its intended design life period.

    1   An Attribute Value less than or equal to its corresponding attribute threshold indicates a pre-Failure condition where imminent loss of data is being predicted.

1   On-Line Collective bit

    0   The Attribute Value is updated only during Off-Line testing

    1   The Attribute Value is updated during On-Line testing or during both On-Line and Off-Line testing.

2-5   Vendor specific

6-15   Reserved (0)

Normalized Values: The device will perform conversion of the raw Attribute Values to transform them into normalized values, which the host can then compare with the Threshold values. A Threshold is the excursion limit for a normalized Attribute Value.

12.52.2.3   Off-Line Data Collection Status

The value of this byte defines the current status of the off-line activities of the device. Bit 7 indicates Automatic Off-Line Data Collection Status.

Bit 7   Automatic Off-Line Data Collection Status

0   Automatic Off-Line Data Collection is disabled.

1   Automatic Off-Line Data Collection is enabled.

Bits 0 thru 6 represent a hexadecimal status value reported by the device.

Value   Definition

0   Off-line data collection never started

2   All segments completed without errors.

4   Off-line data collection suspended by interrupting command

5   Off-line data collecting aborted by interrupting command

6   Off-line data collection aborted with fatal error

12.52.2.4   Self-test execution status

Bit   Definition

0-3   Percent Self-test remaining

An approximation of the percent of the self-test routine remaining until completion in ten percent increments. Valid values are 0 through 9.

4-7   Current Self-test execution status

0   The self-test routine completed without error or has never been run

1   The self-test routine aborted by the host

2   The self-test routine interrupted by the host with a hard or soft reset

3   The device was unable to complete the self-test routine due to a fatal error or unknown test error

4   The self-test routine completed with unknown element failure

5   The self-test routine completed with electrical element failure

6   The self-test routine completed with servo element failure

7   The self-test routine completed with read element failure

15   The self-test routine in progress

12.52.2.5   Total Time in Seconds to Complete Off-line Data Collection Activity

This field tells the host how many seconds the device requires completing the off-line data collection activity.

12.52.2.6   Off-Line Data Collection Capability

Bit   **Definition**
0   Execute Off-line Immediate implemented bit
  - **0**   SMART Execute Off-line Immediate subcommand is not implemented
  - **1**   SMART Execute Off-line Immediate subcommand is implemented

1   Enable/disable Automatic Off-line implemented bit
  - **0**   SMART Enable/disable Automatic Off-line subcommand is not implemented
  - **1**   SMART Enable/disable Automatic Off-line subcommand is implemented

2   abort/restart off-line by host bit
  - **0**   The device will suspend off-line data collection activity after an interrupting command and resume it after some vendor specific event
  - **1**   The device will abort off-line data collection activity upon receipt of a new command

3   Off-line Read Scanning implemented bit
  - **0**   The device does not support Off-line Read Scanning
  - **1**   The device supports Off-line Read Scanning

4   Self-test implemented bit
  - **0**   Self-test routine is not implemented
  - **1**   Self-test routine is implemented

5-7   Reserved (0)
6   Selective self-test implemented bit
  - **0**   Selective self-test routine is not implemented
  - **1**   Selective self-test routine is implemented

12.52.2.7   SMART Capability

This word of bit flags describes the SMART capabilities of the device. The device will return 03h indicating that the device will save its Attribute Values prior to going into a power saving mode and supports the SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE command.

Bit   **Definition**
0   Pre-power mode attribute saving capability

　　　　　If bit = 1, the device will save its Attribute Values prior to going into a power saving mode (Standby or Sleep mode).

1   Attribute autosave capability
　　　　　If bit = 1, the device supports the SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE command.

2-15   Reserved (0)

12.52.2.8   Error Logging Capability

Bit   **Definition**
7-1   Reserved (0)
0   Error Logging support bit
　　　　　If bit = 1, the device supports the Error Logging

12.52.2.9   Self-test failure check point

This byte indicates the section of self-test where the device detected a failure.

12.52.2.10 Self-test completion time

These bytes are the minimum time in minutes to complete self-test.

12.52.2.11 Data Structure Checksum

The Data Structure Checksum is the 2's compliment of the result of a simple 8-bit addition of the first 511 bytes in the data structure.

12.52.3　Device Attribute Thresholds Data Structure

The following defines the 512 bytes that make up the Attribute Threshold information. This data structure is accessed by the host in its entirety using the SMART Read Attribute Thresholds. All multi-byte fields shown in these data structures follow the ATA/ATAPI-7 specification for byte ordering, namely that the least significant byte occupies the lowest numbered byte address location in the field.

The sequence of active Attribute Thresholds will appear in the same order as their corresponding Attribute Values.

Table 221　Device Attribute Thresholds Data Structure

Description	Bytes	Offset	Value
Data Structure Revision Number	2	00h	0010h
1st Attribute Threshold	12	02h	
…	..		
…	..		
30th Attribute Threshold	12	15Eh	
Reserved	18	16Ah	00h
Vendor specific	131	17Ch	00h
Data structure checksum	1	1FFh	
	512		

12.52.3.1　Data Structure Revision Number

This value is the same as the value used in the Device Attributes Values Data Structure.

12.52.3.2　Individual Thresholds Data Structure

The following defines the 12 bytes that make up the information for each Threshold entry in the Device Attribute Thresholds Data Structure. Attribute entries in the Individual Threshold Data Structure are in the same order and correspond to the entries in the Individual Attribute Data Structure.

Table 222　Individual Threshold Data Structure

Description	Bytes	Offset
Attribute ID Number (01h to FFh)	1	00h
Attribute Threshold	1	01h
Reserved (00h)	10	02h
Total Bytes	12	

12.52.3.3　Attribute ID Numbers

Attribute ID Numbers supported by the device are the same as Attribute Values Data Structures.

12.52.3.4　Attribute Threshold

These values are preset at the factory and are not meant to be changeable.

12.52.3.5　Data Structure Checksum

The Data Structure Checksum is the 2's compliment of the result of a simple 8-bit addition of the first 511 bytes in the data structure.

12.52.4   SMART Log Directory

Table 223 SMART Log Directory defines the 512 bytes that make up the SMART Log Directory. The SMART Log Directory is SMART Log Address zero and is defined as one sector long.

Table 223   SMART Log Directory

Description	Bytes	Offset
SMART Logging Version	2	00h
Number of sectors in the log at log address 1	1	02h
Reserved	1	03h
Number of sectors in the log at log address 2	1	04h
Reserved	1	05h
…	…	…
Number of sectors in the log at log address 255	1	1Feh
Reserved	1	1FFh
	512	

The value of the SMART Logging Version word shall be 01h. The logs at log addresses 80-9Fh shall each be defined as 16 sectors long.

12.52.5   SMART summary error log sector

The following defines the 512 bytes that make up the SMART summary error log sector. All multi-byte fields shown in this data structure follow the ATA/ATAPI-7 specifications for byte ordering.

Table 224   SMART summary error log sector

Description	Bytes	Offset
SMART error log version	1	00h
Error log index	1	01h
1st error log data structure	90	02h
2nd error log data structure	90	5Ch
3rd error log data structure	90	B6h
4th error log data structure	90	110h
5th error log data structure	90	16Ah
Device error count	2	1C4h
Reserved	57	1C6h
Data structure checksum	1	1FFh
	512	

12.52.5.1   SMART error log version

This value is set to 01h.

12.52.5.2   Error log index

This points the most recent error log data structure. Only values 1 through 5 are valid.

12.52.5.3   Device error count

This field contains the total number of errors. The value will not roll over.

12.52.5.4   Error log data structure

Data format of each error log structure is shown below.

Table 225   Error log data structure

Description	Bytes	Offset
1st error log data structure	12	00h
2nd error log data structure	12	0Ch
3rd error log data structure	12	18h
4th error log data structure	12	24h
5th error log data structure	12	30h
Error data structure	30	3Ch
	90	

Command data structure: Data format of each command data structure is shown below.

Table 226   Command data structure

Description	Bytes	Offset
Device Control register	1	00h
Features register	1	01h
Sector count register	1	02h
Sector number register	1	03h
Cylinder Low register	1	04h
Cylinder High register	1	05h
Device/Head register	1	06h
Command register	1	07h
Timestamp (milliseconds from Power On)	4	08h
	12	

Error data structure: Data format of error data structure is shown below.

Table 227   Error data structure

Description	Bytes	Offset
Reserved	1	00h
Error register	1	01h
Sector count register	1	02h
Sector number register	1	03h
Cylinder Low register	1	04h
Cylinder High register	1	05h
Device/Head register	1	06h
Status register	1	07h
Extended error data (vendor specific)	19	08h
State	1	1Bh
Life timestamp (hours)	2	1Ch
	30	

State field contains a value indicating the device state when command was issued to the device.

Value	State
x0h	Unknown
x1h	Sleep
x2h	Standby (If the EPC feature set is enabled, Standby is standby_y or standby_z)
x3h	Active/Idle
	(If the EPC feature set is enabled, Active/Idle is idle_a or idle_b or idle_c)
x4h	SMART Off-line or Self-test
x5h-xAh	Reserved
xBh-xFh	Vendor specific

Note: The value of x is vendor specific.

12.52.6   Self-test log data structure

The following defines the 512 bytes that make up the Self-test log sector. All multi-byte fields shown in these data structures follow the ATA/ATAPI-7 specifications for byte ordering.

Table 228   Self-test log data structure

Description	Bytes	Offset
Data structure revision	2	00h
Self-test number	1	n*18h+02h
Self-test execution status	1	n*18h+03h
Life time power on hours	2	n*18h+04h
Self-test failure check point	1	n*18h+06h
LBA of first failure	4	n*18h+07h
Vendor specific	15	n*18h+0Bh
…		
Vendor specific	2	1Fah
Self-test index	1	1FCh
Reserved	2	1FDh
Data structure checksum	1	1FFh
	512	

Note: n is 0 through 20

The data structure contains the descriptor of Self-test that the device has performed. Each descriptor is 24 bytes long and the self-test data structure is capable to contain up to 21 descriptors.

After 21 descriptors have been recorded, the oldest descriptor will be overwritten with new descriptor.

Self-test index points the most recent descriptor. When there is no descriptor the value is 0. When there is descriptor(s) the value is 1 through 21.

12.52.7 Selective self-test log data structure

The Selective self-test log is a log that may be both written and read by the host. This log allows the host to select the parameters for the self-test and to monitor the progress of the self-test. The following table defines the contents of the Selective self-test log which is 512 bytes long. All multi-byte fields shown in these data structures follow the ATA/ATAPI-7 specifications for byte ordering.

Table 229   Selective self-test log data structure

Description	Bytes	Offset	Read/Write
Data structure revision	2	00h	R/W
Starting LBA for test span 1	8	02h	R/W
Ending LBA for test span 1	8	0Ah	R/W
Starting LBA for test span 2	8	12h	R/W
Ending LBA for test span 2	8	1Ah	R/W
Starting LBA for test span 3	8	22h	R/W
Ending LBA for test span 3	8	2Ah	R/W
Starting LBA for test span 4	8	32h	R/W
Ending LBA for test span 4	8	3Ah	R/W
Starting LBA for test span 5	8	42h	R/W
Ending LBA for test span 5	8	4Ah	R/W
Reserved	256	52h	Reserved
Vendor specific	154	152h	Vendor specific
Current LBA under test	8	1Ech	Read
Current span under test	2	1F4h	Read
Feature flags	2	1F6h	R/W
Vendor specific	4	1F8h	Vendor specific
Selective self-test pending time	2	1FCh	R/W
Reserved	1	1Feh	Reserved
Data structure checksum	1	1FFh	R/W
	512		

12.52.7.1 Feature flags

The Feature flags define the features of Selective self-test to be executed.

Table 230   Selective self-test feature flags

Bit	Description
0	Vendor specific
1	When set to one, perform off-line scan after selective test.
2	Vendor specific
3	When set to one, off-line scan after selective test is pending.
4	When set to one, off-line scan after selective test is active.
5-15	Reserved.

12.52.8   Error Reporting

The following table shows the values returned in the Status and Error Outputs when specific error conditions are encountered by a device.

Table 231   SMART Error Codes

Error Condition	Status Register	Error Register
A SMART FUNCTION SET command was received by the device without the required key being loaded into the Cylinder High and Cylinder Low registers.	51h	04h
A SMART FUNCTION SET command was received by the device with a subcommand value in the Features Register that is either invalid or not supported by this device.	51h	04h
A SMART FUNCTION SET command subcommand other than SMART ENABLE OPERATIONS was received by the device while the device was in a "SMART disabled" state.	51h	04h
The device is unable to read its Attribute Values or Attribute Thresholds data structure.	51h	10h or 40h
The device is unable to write to its Attribute Values data structure.	51h	10h

12.53 Standby (E2h/96h)

Table 232 Standby Command (E2h/96h)

Command Input

Field	Description
FEATURE	N/A
COUNT	Standby timer period
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 E2h or 96h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

The Standby command causes the device to enter the Standby Mode immediately, and set auto power down timeout parameter (standby timer).

When the Standby mode is entered, the drive is spun down but the interface remains active. If the drive is already spun down, the spin down sequence is not executed.

During the Standby mode the device will respond to commands, but there is a delay while waiting for the spindle to reach operating speed.

The automatic power down sequence is enabled and the timer starts counting down when the drive returns to Idle mode.

If the EPC feature set is enabled, device enters into the Standby_Z power condition.

Standby timer period   Timeout Parameter. If zero, the timeout interval (Standby Timer) is NOT disabled. If non-zero, then the automatic power down sequence is enabled, and the timeout interval is shown blow:

Value	Description
0	Timer disabled
1-240	Value * 5 seconds
241-251	(Value-240) * 30 minutes
252	21 minutes
253	8 hours
254	Aborted
255	21 minutes 15 seconds

When the automatic power down sequence is enabled, the drive will enter Standby mode automatically if the timeout interval expires with no drive access from the host. The timeout interval will be reinitialized if there is a drive access before the timeout interval expires.

12.54 Standby Immediate (E0h/94h)

Table 233   Standby Immediate Command (E0h/94h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 E0h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

The Standby Immediate command causes the device to enter Standby mode immediately.

The device is spun down but the interface remains active. If the device is already spun down, the spin down sequence is not executed.

During the Standby mode, the device will respond to commands, but there is a delay while waiting for the spindle to reach operating speed.

The Standby Immediate command will not affect the auto power down timeout parameter.

If the EPC feature set is enabled, device enters into the Standby_Z power condition.

12.55 Write Buffer (E8h)

Table 234   Write Buffer Command (E8h)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 E8h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.4 Download Microcode (92h)

The Write Buffer command transfers a sector of data from the host to the sector buffer of the device. The sectors of data are transferred through the Data Register 16 bits at a time.

The Read Buffer and Write Buffer commands are synchronized such that sequential Write Buffer and Read Buffer commands access the same 512 byte within the buffer.

12.56 Write Buffer DMA (EBh)

Table 235   Write Buffer DMA Command (EBh)

Command Input

Field	Description
FEATURE	N/A
COUNT	N/A
LBA	N/A
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 EBh

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.4 Download Microcode (92h)

The Write Buffer DMA command transfers a sector of data from the host to the sector buffer of the device. The sectors of data are transferred through the Data Register 16 bits at a time.

The Read Buffer and Write Buffer commands are synchronized such that sequential Write Buffer and Read Buffer commands access the same 512 byte within the buffer.

12.57 Write DMA (CAh/CBh)

Table 236   Write DMA Command (CAh/CBh)

Command Input

Field	Description
FEATURE	N/A
COUNT	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 CAh or CBh

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6:5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1:0 Obsolete
COUNT	N/A
LBA	LBA of First Unrecoverable Error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Write DMA command transfers one or more sectors of data from the host to the device, then the data is written to the disk media.

The sectors of data are transferred through the Data Register 16 bits at a time.

The host initializes a slave-DMA channel prior to issuing the command. Data transfers are qualified by DMARQ and are performed by the slave-DMA channel. The device issues only one interrupt per command to indicate that data transfer has terminated and status is available.

If an uncorrectable error occurs, the write will be terminated at the failing sector.

12.58 Write DMA FUA Ext (3Dh)

Table 237   Write DMA FUA Ext Command (3Dh)

Command Input

Field	Description
FEATURE	Reserved
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 3Dh

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6:5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1 Obsolete 0 N/A
COUNT	Reserved
LBA	LBA of First Unrecoverable Error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Write DMA FUA Ext command transfers one or more sectors of data from the host to the device, and then the data is written to the disk media.   This command provides the same function as the Write DMA Ext command except that the transferred data shall be written to the media before the ending status for this command is reported also when write caching is enabled.

The host initializes a slave-DMA channel prior to issuing the command. Data transfers are qualified by DMARQ and are performed by the slave-DMA channel. The device issues only one interrupt per command to indicate that data transfer has terminated and status is available.

If an unrecoverable error occurs, the write will be terminated at the failing sector.

Output Parameters To The Device

Sector Count Current	The number of continuous sectors to be transferred low order, bits (7:0).
Sector Count Previous	The number of continuous sectors to be transferred high order bits (15:8). If zero is specified in the Sector Count register, then 65,536 sectors will be transferred.
Sector Number Current	LBA (7:0).
Sector Number Previous	LBA (31:24).
Cylinder Low Current	LBA (15:8).
Cylinder Low Previous	LBA (39:32).
Cylinder High Current	LBA (23:16).
Cylinder High Previous	LBA (47:40).

Input Parameters From The Device

Sector Number (HOB=0)	LBA (7:0) of the address of the first unrecoverable error.
Sector Number (HOB=1)	LBA (31:24) of the address of the first unrecoverable error.
Cylinder Low (HOB=0)	LBA (15:8) of the address of the first unrecoverable error.
Cylinder Low (HOB=1)	LBA (39:32) of the address of the first unrecoverable error.
Cylinder High (HOB=0)	LBA (23:16) of the address of the first unrecoverable error.
Cylinder High (HOB=1)	LBA (47:40) of the address of the first unrecoverable error.

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12.59 Write DMA Ext (35h)

Table 238   Write DMA Ext Command (35h)

Command Input

Field	Description
FEATURE	Reserved
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 35h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

See Error Outputs in 12.58 Write DMA FUA Ext (3Dh)

The Write DMA Ext command transfers one or more sectors of data from the host to the device, and then the data is written to the disk media.

The host initializes a slave-DMA channel prior to issuing the command. Data transfers are qualified by DMARQ and are performed by the slave-DMA channel. The device issues only one interrupt per command to indicate that data transfer has terminated and status is available.

If an uncorrectable error occurs, the write will be terminated at the failing sector

Output Parameters To The Device

Sector Count Current   The number of continuous sectors to be transferred low order, bits (7:0).

Sector Count Previous   The number of continuous sectors to be transferred high order bits (15:8). If zero is specified in the Sector Count register, then 65,536 sectors will be transferred.

Sector Number Current   LBA (7:0).

Sector Number Previous   LBA (31:24).

Cylinder Low Current   LBA (15:8).

Cylinder Low Previous   LBA (39:32).

Cylinder High Current   LBA (23:16).

Cylinder High Previous   LBA (47:40).

Input Parameters From The Device

Sector Number (HOB=0)   LBA (7:0) of the address of the first unrecoverable error.

Sector Number (HOB=1)   LBA (31:24) of the address of the first unrecoverable error.

Cylinder Low (HOB=0)   LBA (15:8) of the address of the first unrecoverable error.

Cylinder Low (HOB=1)   LBA (39:32) of the address of the first unrecoverable error.

Cylinder High (HOB=0)   LBA (23:16) of the address of the first unrecoverable error.

Cylinder High (HOB=1)   LBA (47:40) of the address of the first unrecoverable error.

12.60 Write FPDMA Queued (61h)

Table 239   Write FPDMA Queued Command (61h)

Command Input

Field	Description
FEATURE	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred
COUNT	**Bit Description** 15:14 PRIO field 13:8 Reserved 7:3 NCQ TAG field 2:0 Reserved
LBA	LBA of first logical sector to be transferred
ICC	7:0 ICC field
DEVICE	**Bit Description** 7 FUA bit 6 Shall be set to one 5 Reserved 4 Shall be cleared to zero 3:0 Reserved
Command	7:0 61h

Normal Outputs

See Normal Outputs in 12.21 Read FPDMA Queued (60h)

Error Outputs

See Error Outputs in 12.21 Read FPDMA Queued (60h)

The Write FPDMA Queued command transfers one or more sectors of data from the host to the device, and then the data is written to the disk media.

If an unrecoverable error occurs, the write will be terminated at the failing sector

FUA bit
When the FUA bit is set to 1, the completion status is indicated after the transferred data are written to the media also when Write Cache is enabled.
When the FUA bit is set to 0, the completion status may be indicated before the transferred data are written to the media successfully when Write Cache is enabled.

ICC field
The Isochronous Command Completion (ICC) field is valid when PRIO is set to a value of 01b. It is assigned by the host based on the intended deadline associated with the command issued. When a deadline has expired, the device continues to complete the command as soon as possible. The host can modify this behavior if the device supports the NCQ NON-DATA command (see 12.16) and supports the Deadline Handling subcommand (see 12.16.2). This subcommand allows the host to set whether the device aborts commands that have exceeded the time set in ICC.

There are several parameters encoded in the ICC field: Fine or Coarse timing, Interval and the Max Time. The Interval indicates the time units of the Time Limit parameter.

If ICC Bit 7 cleared to zero, then the time interval is fine-grained.
   Interval   = 10msec
   Time Limit   = (ICC[6:0] + 1) * 10 msec
If ICC Bit 7 is set to one (coarse encoding), then the time interval is coarse grained.
   Interval   = 0.5 sec
   Time Limit   = (ICC[6:0] + 1) * 0.5 sec

PRIO bit

The Priority (PRIO) value shall be assigned by the host based on the priority of the command issued. The device makes a best effort to complete High priority requests in a more timely fashion than Normal and isochronous priority requests. The device tries to complete isochronous requests prior to its associated deadline. The Priority values are defined as follows:

    00b   Normal priority
    01b   Isochronous – deadline dependent priority
    10b   High priority

NCQ TAG

The TAG value shall be assigned to be different from all other queued commands. The value shall not exceed the maximum queue depth specified by the Word 75 of the Identify Device information.

12.61 Write Log Ext (3Fh)

Table 240   Write Log Ext Command (3Fh)

Command Input

Field	Description
FEATURE	Reserved
COUNT	LOG PAGE COUNT field
LBA	**Bit Description** 47:40 Reserved 39:32 PAGE NUMBER field (15:8) 31:16 Reserved 15:8 PAGE NUMBER field (7:0) 7:0 LOG ADDRESS field – specifies the log to be written
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent – See 9.2.12 3:0 Reserved
Command	7:0 3Fh

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6:5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1 Obsolete 0 N/A
COUNT	Reserved
LBA	Reserved
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

This command writes a specified number of 512 byte data sectors to the specific log. The device shall interrupt for each DRQ block transferred.

LOG PAGE COUNT field
The LOG PAGE COUNT field specifies the number of log pages that shall be written to the specified log. If the number is zero, or the number is greater than the number indicated in the GPL Directory (see table A.3), the device shall return command aborted.

PAGE NUMBER field
The PAGE NUMBER field specifies the first page number to be written to the specified log

Error Outputs
A drive returns command aborted for the command if:
  a) the LOG PAGE COUNT field is cleared to zero;
  b) the feature set associated with the log specified in the LOG ADDRESS field is not supported or not enabled;
  c) the values in the FEATURE field, LOG PAGE COUNT field, or LBA field (47:8) are invalid;
  d) the host attempts to write to a read only log; or
  e) the value in the PAGE NUMBER field plus the value in the LOG PAGE COUNT field is larger than the log size reported in the GPL Directory.

If the log data is not available or a data structure checksum error occurred, then the device shall return command completion for the command with the ID NOT FOUND bit set to one.

A drive may return command completion with the ERROR bit set to one if an Interface CRC error has occurred.

12.62 Write Log DMA Ext (57h)

Table 241 Write Log DMA Ext Command (57h)

Command Input

Field	Description
FEATURE	Reserved
COUNT	LOG PAGE COUNT field
LBA	**Bit Description** 47:40 Reserved 39:32 PAGE NUMBER field (15:8) 31:16 Reserved 15:8 PAGE NUMBER field (7:0) 7:0 LOG ADDRESS field – specifies the log to be written
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent – See 9.2.12 3:0 Reserved
Command	7:0 57h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

See Error Outputs in 12.61 Write Log Ext (3Fh)

The content of this command is the same as Write Log Ext. See 12.61

12.63 Write Multiple (C5h)

Table 242   Write Multiple Command (C5h)

Command Input

Field	Description
FEATURE	N/A
COUNT	The number of logical sectors to be transferred. A value of 00h indicates that 256 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7:5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 C5h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6:5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1:0 Obsolete
COUNT	N/A
LBA	LBA of First Unrecoverable Error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 DEVICE FAULT bit 4 N/A 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Write Multiple command transfers one or more sectors from the host to the device, and then the data is written to the disk media.

Command execution is identical to the Write Sector(s) command except that an interrupt is generated for each block (as defined by the Set Multiple command) instead of for each sector. The sectors are transferred through the Data Register 16 bits at a time.

12.64 Write Multiple Ext (39h)

Table 243   Write Multiple Ext Command (39h)

Command Input

Field	Description
FEATURE	Reserved
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 39h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

See Error Outputs in 12.58 Write DMA FUA Ext (3Dh)

The Write Multiple Ext command transfers one or more sectors from the host to the device, and then the data is written to the disk media.

Command execution is identical to the Write Sector(s) Ext command except that an interrupt is generated for each block (as defined by the Set Multiple command) instead of for each sector. The sectors are transferred through the Data Register 16 bits at a time.

12.65 Write Multiple FUA Ext (CEh)

Table 244   Write Multiple FUA Ext Command (CEh)

Command Input

Field	Description
FEATURE	Reserved
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 CEh

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

See Error Outputs in 12.58 Write DMA FUA Ext (3Dh)

The Write Multiple Ext command transfers one or more sectors from the host to the device, and then the data is written to the disk media.   This command provides the same function as the Write Multiple Ext command except that the transferred data shall be written to the media before the ending status for this command is reported also when write caching is enabled.

Command execution is identical to the Write Sector(s) Ext command except that an interrupt is generated for each block (as defined by the Set Multiple command) instead of for each sector. The sectors are transferred through the Data Register 16 bits at a time.

12.66 Write Sector(s) (30h/31h)

Table 245   Write Sector(s) Command (30h/31h)

Command Input

Field	Description
FEATURE	Reserved
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65 536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 34h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

See Error Outputs in 12.58 Write DMA FUA Ext (3Dh)

The Write Sector(s) command transfers one or more sectors from the host to the device, and then the data is written to the disk media.

The sectors are transferred through the Data Register 16 bits at a time.

If an uncorrectable error occurs, the write will be terminated at the failing sector.

Output Parameters To The Device

Sector Count   The number of continuous sectors to be transferred.   If zero is specified, then 256 sectors will be transferred.

Sector Number   The sector number of the first sector to be transferred. (L=0)
In LBA mode, this register contains LBA bits 0 - 7. (L=1)

Cylinder High/Low   The cylinder number of the first sector to be transferred. (L=0)
In LBA mode, this register contains LBA bits 8 - 15 (Low), 16 - 23 (High). (L=1)

H   The head number of the first sector to be transferred. (L=0)
In LBA mode, this register contains LBA bits 24 - 27. (L=1)

R   The retry bit, but this bit is ignored.

Input Parameters From The Device

Sector Count   The number of requested sectors not transferred.   This will be zero, unless an unrecoverable error occurs.

Sector Number   The sector number of the last transferred sector. (L=0)
In LBA mode, this register contains current LBA bits 0 - 7. (L=1)

Cylinder High/Low   The cylinder number of the last transferred sector. (L=0)
In LBA mode, this register contains current LBA bits 8 - 15 (Low), 16 - 23 (High). (L=1)

H   The head number of the last transferred sector. (L=0)
In LBA mode, this register contains current LBA bits 24 - 27. (L=1)

12.67 Write Sector(s) Ext (34h)

Table 246   Write Sector(s) Ext Command (34h)

Command Input

Field	Description
FEATURE	Reserved
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65,536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 34h

Normal Outputs

See Normal Outputs in 12.8 Flush Cache Ext (EAh)

Error Outputs

See Error Outputs in 12.58 Write DMA FUA Ext (3Dh)

The Write Sector(s) Ext command transfers one or more sectors from the host to the device, and then the data is written to the disk media.

The sectors are transferred through the Data Register 16 bits at a time.

If an uncorrectable error occurs, the write will be terminated at the failing sector.

12.68 Write Stream DMA Ext (3Ah)

Table 247   Write Stream DMA Ext Command (3Ah)

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 COMMAND CCTL field. 7 Obsolete 6 WRITE CONTINUOUS bit 5 FLUSH bit 4 Obsolete 3 Reserved 2:0 STREAM ID field
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 3Ah

Normal Outputs

See Normal Outputs in 12.2 Configure Stream (51h)

Error Outputs

Field	Description
ERROR	**Bit Description** 7 INTERFACE CRC bit 6:5 Obsolete 4 ID NOT FOUND bit 3 Obsolete 2 ABORT bit 1 Obsolete 0 COMMAND COMPLETION TIME OUT bit
COUNT	Length of stream error – number of contiguous logical sectors containing potentially bad data, beginning with the LBA indicated in the LBA field.
LBA	LBA of the lowest numbered unrecoverable error
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent 5 STREAM ERROR bit 4 DEFERRED WRITE ERROR bit 3 Transport Dependent 2 N/A 1 SENSE DATA AVAILABLE bit 0 ERROR bit

The Write Stream DMA Ext command allows the host to write data using the DMA data transfer protocol. This command allows for the host to specify to the device that additional actions need to be performed prior to the completion of the command if the required bits are set.

If the Write Continuous bit is set to one, the device shall not stop execution of the command due to errors. If the WC bit is set to one and errors occur in the transfer or writing of the data, the device shall continue to transfer the amount of data requested and then provide ending status with the BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and the type of error, ICRC, IDNF, or ABRT, reported in the error log. If the WC bit is set to one and the Command Completion Time Limit expires, the device shall stop execution of the command and provide ending status with BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and report the fact that the Command Completion Time Limit expired by setting the CCTO bit in the error log to one, In all cases, the device shall attempt to transfer the amount of data requested within the Command Completion Time Limit event if some data transferred is in error.

WRITE CONTINUOUS(WC) bit
WC specifies Write Continuous mode enabled. If the Write Continuous bit is set to one, the device shall not stop execution of the command due to errors.
If the WC bit is set to one and errors occur in transfer or writing of the data, the device shall continue to transfer the amount of data requested and then provide ending status with BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and the type of error, ICRC, IDNF or ABRT reported in the error log.
If the WC bit is set to one and the Command Completion Time Limit expires, the device shall stop execution of the command and provide ending status with the BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and report the fact that the Command Completion Time Limit expired by setting the CCTO bit in the error log to one.

In all cases, the device shall attempt to transfer the amount of data requested within the Command Completion Time Limit even if some data transferred is in error.

FLUSH bit
FLUSH bit specifies that all data for the specified stream shall be flushed to the media before command complete is reported when set to one.

STREAM ID field
Stream ID specifies the stream being written. The device shall operate according to the Stream ID set by the Write Stream command.

12.69 Write Stream Ext (3Bh)

Table 248   Write Stream Ext Command (3Bh)

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 COMMAND CCTL field. 7 Obsolete 6 WRITE CONTINUOUS bit 5 FLUSH bit 4 Obsolete 3 Reserved 2:0 STREAM ID field
COUNT	The number of logical sectors to be transferred. A value of 0000h indicates that 65536 logical sectors are to be transferred
LBA	LBA of first logical sector to be transferred
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 3Bh

Normal Outputs

See Normal Outputs in 12.2 Configure Stream(51h)

Error Outputs

See Error Outputs in 12.68 Write Stream DMA Ext (3Ah)

This command writes from 1 to 65536 sectors as specified in the Sector Count register.   A sector count of 0 requests 65,536 sectors.

If the Write Continuous bit is set to one, the device shall not stop execution of the command due to errors.   If the WC bit is set to one and errors occur in the transfer or writing of the data, the device shall continue to transfer the amount of data requested and then provide ending status with the BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and the type of error, IDNF, or ABRT, reported in the error log.   If the WC bit is set to one and the Command Completion Time Limit expires, the device shall stop execution of the command and provide ending status with BSY bit cleared to zero, the SE bit set to one, the ERR bit cleared to zero, and report the fact that the Command Completion Time Limit expired by setting the CCTO bit in the error log to one,   In all cases, the device shall attempt to transfer the amount of data requested within the Command Completion Time Limit event if some data transferred is in error.

12.70 Write Uncorrectable Ext (45h)

Table 249   Write Uncorrectable Ext Command (45h)

Command Input

Field	Description
FEATURE	**Bit Description** 15:8 Reserved 7:0 Uncorrectable options Value Description 00h-54h Reserved 55h Create a pseudo-uncorrectable error with logging 56h-59h Reserved 5Ah Vendor specific 5Bh-A4h Reserved A5h Vendor Specific A6h-A9h Reserved AAh Create a flagged error without logging ABh-FFh Reserved
COUNT	The number of logical sectors to be marked. A value of 0000h indicates that 65,536 logical sectors are to be marked
LBA	LBA of first logical sector to be marked
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent 3:0 Reserved
Command	7:0 45h

Normal Outputs

See Normal Outputs in 12.7 Flush Cache (E7h)

Error Outputs

See Error Outputs in 12.12 Idle (E3h / 97h)

Ultrastar Archive Ha10 does not support Write Uncorrectable Ext command. When the drive receives Write Uncorrectable Ext command from the host, the drive will abort the command.

12.71 Zone management commands

12.71.1 Overview

Each zone management command (see Table 250 Zone management commands) defines a management function to be performed by a zoned device using:

a) a command using the command field input; and

b) a data transfer method (i.e., Non-Data, DMA In, or DMA Out).

Table 250 Zone management commands

Command	Template	Data Transfer	Reference
CLOSE ZONE EXT	Out	Non-Data	12.71.4
FINISH ZONE EXT	Out	Non-Data	12.71.5
OPEN ZONE EXT	Out	Non-Data	12.71.6
REPORT ZONES EXT	In	DMA In	12.71.7
RESET WRITE POINTERS EXT	Out	Non-Data	12.71.8
Key: In = ZAC MANAGEMENT IN(see 12.71.2) Out = ZAC MANAGEMENT OUT(see 12.71.3)			

12.71.2 ZAC MANAGEMENT IN command template, 4Ah, DMA In

12.71.2.1 Feature Set

Commands based on this 48-bit command template are for devices the implement the Host Managed Zones feature set.

12.71.2.2 Description

Commands based on the ZAC MANAGEMENT IN command template transfer one or more 512-byte pages of data from the device to the host. What data is transferred is specified by the contents of the ZM_ACTION field (see 12.71.2.3.2) and other command inputs.

12.71.2.3 Inputs

12.71.2.3.1 Overview

Table 251   ZAC MANAGEMENT IN command template inputs shows the command inputs defined for all commands that use the ZAC MANAGEMENT IN command template.

Table 251   ZAC MANAGEMENT IN command template inputs

Field	Description
FEATURE	**Bit** **Description** 15:8 Action specific – See 12.71.2.3.3 7:5 Reserved 4:0 ZM_ACTION field – See 12.71.2.3.2
COUNT	RETURN PAGE COUNT field – See 12.71.2.3.4
LBA	Action specific – See 12.71.2.3.3
DEVICE	**Bit** **Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent – See ACS-4 3:0 Reserved
COMMAND	7:0 4Ah

12.71.2.3.2 ZM_ACTION filed

The ZM_ACTION field (see Table 252   ZM_ACTION field) and the command field specify:
a) the zone management command that the device shall process;
b) the definitions for action specific fields (see 12.71.2.3.3) in that command's input, if any; and
c) the definitions of the normal outputs and error outputs for that command.

Table 252   ZM_ACTION field

Code	Command	Reference
00h	REPORT ZONES EXT	12.71.7
01h	CLOSE ZONE EXT	12.71.4
02h	FINISH ZONE EXT	12.71.5
03h	OPEN ZONE EXT	12.71.6
04h	RESET WRITE POINTERS EXT	12.71.8
All others	Reserved	

12.71.2.3.3 Action specific fields

Each zone management command (see 12.71.1) defines the usage, if any, of the action specific fields in that command's inputs.

12.71.2.3.4 RETURN PAGE COUNT field

The device shall return the number of 512-byte pages specified in the RETURN PAGE COUNT field.

If the RETURN PAGE COUNT field specifies fewer 512-byte pages than the device has available to be returned, the device:
a) shall truncate the returned data to the specified number of 512-byte pages; and
b) shall not modify any of the returned data as a result of the truncation.

The value 0000h is reserved in the RETURN PAGE COUNT field.

12.71.2.4 Normal Outputs and Error Outputs

The normal outputs and error outputs for a command that uses the ZAC MANAGEMENT IN command template are defined based on the contents of the ZM_ACTION field (see 12.71.2.3.2 and 12.71.2.1).

12.71.3 ZAC MANAGEMENT OUT command template, 9Fh, Non-Data or DMA Out

12.71.3.1 Feature Set

Commands based on this 48-bit command template are for devices the implement the Host Managed Zones feature set.

12.71.3.2 Description

Commands based on the ZAC MANAGEMENT OUT command template transfer zero or more 512-byte pages of data from the host to the device. What data is transferred is specified by the contents of the ZM_ACTION field (see 12.71.2.3.2 and 12.71.1) and other command inputs.

The device processes any command that uses the ZAC MANAGEMENT OUT command template in the NCQ feature set environment (see ACS-4) if that:
  a) Non-Data command is encapsulated in a NCQ NON-DATA command (see ACS-4); or
  b) DMA Out command is encapsulated in a SEND FPDMA QUEUED command (see ACS-4).

12.71.3.3 Inputs

12.71.3.3.1 Overview

Table 253   ZAC MANAGEMENT OUT command template inputs shows the command inputs defined for all commands that use the ZAC MANAGEMENT OUT, Non-Data command template or the ZAC MANAGEMENT OUT, DMA Out command template.

Table 253   ZAC MANAGEMENT OUT command template inputs

Field	Description
FEATURE	**Bit** **Description** 15:8 Action specific – See 12.71.2.3.3 7:5 Reserved 4:0 ZM_ACTION field – See 12.71.2.3.2
COUNT	ZAC MANAGEMENT OUT, Non-Data: Action specific – See 12.71.2.3.3 ZAC MANAGEMENT OUT, DMA Out: PAGES TO SEND field – See 12.71.3.3.2
LBA	Action specific – See 12.71.2.3.3
DEVICE	**Bit Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent – See ACS-4 3:0 Reserved
COMMAND	7:0 9Fh

12.71.3.3.2 PAGES TO SEND field

The PAGES TO SEND field specifies the number of 512-byte pages that the device shall transfer from the host.

If the PAGES TO SEND field is cleared to zero in a ZAC MANAGEMENT OUT, DMA Out command, the device shall return command aborted.

12.71.3.4 Normal Outputs and Error Outputs

The normal outputs and error outputs for a command that uses the ZAC MANAGEMENT OUT command template are defined based on the contents of the ZM_ACTION field (see 12.71.2.3.2 and 12.71.1).

12.71.4   CLOSE ZONE EXT command – 9Fh/01h, Non-Data

12.71.4.1   Feature Set

This 48-bit command is for devices that implement the Host Aware Zones feature set or the Host Managed Zones feature set.

12.71.4.2   Description

The CLOSE ZONE EXT command allows the host to request that one or all write pointer zones transition to:
   a)   the ZC4: Closed state if the write pointer in that zone does not indicate the lowest LBA in the zone; or
   b)   the ZC1: Empty state if the write pointer in that zone indicates the lowest LBA in the zone.

12.71.4.3   Inputs

12.71.4.3.1   Overview

See Table 254   CLOSE ZONE EXT command inputs for the CLOSE ZONE EXT command inputs.

Table 254   CLOSE ZONE EXT command inputs

Field	Description
FEATURE	**Bit Description** 15:9 Reserved 8 CLOSE ALL bit – See 12.71.4.3.2 7:5 Reserved 4:0 ZM_ACTION field, shall be set to 01h – See 12.71.2.3.2
COUNT	Reserved
LBA	ZONE ID field – See 12.71.4.3.3

DEVICE	**Bit Description**
	   7 Obsolete
	   6 Shall be set to one
	   5 Obsolete
	   4 Transport Dependent – See ACS-4
	3:0 Reserved

COMMAND	7:0 9Fh

12.71.4.3.2   CLOSE ALL bit

If the CLOSE ALL bit is set to one, then the device shall:
  a)   ignore the contents of the ZONE ID field; and
  b)   transition all open write pointer zones to:
    A)   the ZC4: Closed state if the write pointer in that zone does not indicate the lowest LBA in the zone; or
    B)   the ZC1: Empty state if the write pointer in that zone indicates the lowest LBA in the zone.
If the CLOSE ALL bit is cleared to zero, then:
  a)   if the zone specified by the ZONE ID field (see 12.71.4.3.3), if any, is an open zone, then the device server shall:
    A)   the ZC4: Closed state if the write pointer in that zone does not indicate the lowest LBA in the zone; or
    B)   the ZC1: Empty state if the write pointer in that zone indicates the lowest LBA in the zone.
  b)   if the zone specified by the ZONE ID field is an empty zone, a closed zone or a full zone, then the device server shall:
    A)   not change the zone's state; and
    B)   return successful command completion;

12.71.4.3.3 ZONE ID field

The ZONE ID field specifies the lowest LBA of the write pointer zone for which the device shall process the command specified by the ZM_ACTION field (see 12.71.2.3.2) and the COMMAND field.
If the ZONE ID field does not specify the lowest LBA of the write pointer zone, the device shall return command completion with an error.

12.71.4.4 Error Outputs

The device shall return command completion with an error if the CLOSE ALL bit is cleared to zero and:
  A)   the ZONE ID field does not contain the starting LBA of a write pointer zone as described in 12.71.4.3.3;

12.71.5 FINISH ZONE EXT command – 9Fh/02h, Non-Data

12.71.5.1 Feature Set

This 48-bit command is for devices that implement the Host Aware Zones feature set or the Host Managed Zones feature set.

12.71.5.2 Description

The FINISH ZONE EXT command allows the host to request that the zone fill function (see 12.71.5.4) be performed on one or more write pointer zones.

If the device is unable to transition one zone to the ZC2: Implicit_Open state due to the limit indicated by the MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field (see 12.22.9.10.3), then the device should:

  a) return command completion with an error; and
  b) set the sense key to ILLEGAL REQUEST and the additional sense code to INSUFFICIENT ZONE RESOURCES (see ACS-4 and SPC-5).

The FINISH ZONE EXT command is based on the Non-Data ZAC MANAGEMENT OUT command template (see 12.71.3) and is able to use the template's NCQ encapsulation capability.

12.71.5.3 Inputs

12.71.5.3.1 Overview

See Table 255   FINISH ZONE EXT command inputs for the FINISH ZONE EXT command inputs.

Table 255   FINISH ZONE EXT command inputs

Field	Description		
FEATURE	**Bit Description** 15:9 Reserved 8 FINISH ALL bit – See 12.71.5.3.2 7:5 Reserved 4:0 ZM_ACTION field, shall be set to 02h – See 12.71.2.3.2		
COUNT	Reserved		
LBA	ZONE ID field – See 12.71.4.3.3		

DEVICE	**Bit Description**
	   7 Obsolete
	   6 Shall be set to one
	   5 Obsolete
	   4 Transport Dependent – See ACS-4
	 3:0 Reserved		

COMMAND	7:0 9Fh		

12.71.5.3.2   FINISH ALL bit

If the FINISH ALL bit is set to one, then the device shall ignore the contents of the ZONE ID field and process a zone fill function (see 12.71.5.4) for each open zone and each closed zone.

If the FINISH ALL bit is cleared to zero, then:
 a)   if the zone specified by the ZONE ID field (see 12.71.4.3.3) is a full zone, then the device shall:
   A)   not change the zone's state; and
   B)   return successful command completion;
      or
   C)   the device shall process a zone fill function (see 12.71.5.4) for the zone specified by the ZONE ID field.

12.71.5.4   Zone fill function

For a specified zone, the zone fill function writes the initialization pattern to any unwritten logical sectors in the specified zone and completes with the specified zone in the ZC5: Full state   as follows:
 1)   if the specified zone is in the ZC1:Empty state or ZC4:Closed state , then the device shall transition the specified zone to the ZC2:Implicit_Open state;
 2)   for the LBA range that begins with the LBA indicated by the write pointer and ends with the highest LBA in the zone, the device shall write:
   A)   the manufacturer's default initialization pattern;
   B)   the initialization pattern set by the most recent OVERWRITE EXT command (see ACS-4), if any;
   and
 3)   the device shall transition the specified zone to the ZC5: Full state.

12.71.5.5   Error Outputs

The device shall return command completion with an error if the FINISH ALL bit is cleared to zero and:
 a) the ZONE ID field does not contain the starting LBA of a write pointer zone as described in 12.71.4.3.3;

12.71.6　OPEN ZONE EXT command – 9Fh/03h, Non-Data

12.71.6.1　Feature Set

This 48-bit command is for devices that implement the Host Aware Zones feature set or the Host Managed Zones feature set.

12.71.6.2　Description

The OPEN ZONE EXT command allows the host to request that one or more write pointer zones transition to the ZC3: Explicit_Open state.

The OPEN ZONE EXT command is based on the Non-Data ZAC MANAGEMENT OUT command template (see 12.71.3) and is able to use the template's NCQ encapsulation capability.

12.71.6.3　Inputs

12.71.6.3.1　Overview

See Table 256　OPEN ZONE EXT command inputs for the OPEN ZONE EXT command inputs.

Table 256　OPEN ZONE EXT command inputs

Field	Description
FEATURE	**Bit**　**Description** 15:9　Reserved 　8　　OPEN ALL bit – See 12.71.6.3.2 7:5　Reserved 4:0　　ZM_ACTION field, shall be set to 03h – See 12.71.2.3.2
COUNT	Reserved
LBA	ZONE ID field – See 12.71.4.3.3
DEVICE	**Bit**　**Description** 　7　　Obsolete 　6　　Shall be set to one 　5　　Obsolete 　4　　Transport Dependent – See ACS-4 3:0　　Reserved
COMMAND	7:0　　9Fh

12.71.6.3.2　OPEN ALL bit

If the OPEN ALL bit is set to one and the MAXIMUM NUMBER OF OPEN SEQUENTIAL WRITE REQUIRED ZONES field (see 12.22.9.10.3) indicates that opening all the Sequential Write Required zones that are in the ZC4: Closed state is:

 a)　possible without exceeding the maximum, then the device shall transition all Sequential Write Required zones that are in the ZC4: Closed state to the ZC3: Explicit_Open state ; and

 b)　not possible without exceeding the maximum, then the device shall:

　　A)　return command completion with an error; and

　　B)　set the sense key to ILLEGAL REQUEST and the additional sense code to INSUFFICIENT ZONE RESOURCES (see ACS-4 and SPC-5).

If the OPEN ALL bit is cleared to zero, then:

 1)　if the zone specified by the ZONE ID field (see 12.71.4.3.3) is:

　　A) in the ZC3: Explicit_Open state or the ZC5: Full state , then the device server shall:

　　　a)　not change the zone's state; and

　　　b)　return successful command completion;

　　　or

 2)　if the processing of an Implicit Close function :

A) results in an error, then the device shall:

   a) return command completion with an error; and

   b) set the sense key to ILLEGAL REQUEST and the additional sense code to INSUFFICIENT ZONE RESOURCES;

   or

B) results in success, then the device shall transition the zone specified by the ZONE ID field to the ZC3: Explicit_Open state.

12.71.6.4 Error Outputs

The device shall return command completion with an error if:

a) the OPEN ALL bit is set to one and the device is unable to open all the Sequential Write Required zones that are in the ZC4: Closed state as described in 12.71.6.3.2;

b) the OPEN ALL bit is cleared to zero and:

   A) the ZONE ID field does not contain the starting LBA of a write pointer zone as described in 12.71.4.3.3; or

   B) the processing of an Implicit Close function results in an error as described in 12.71.6.3.2.

   .

12.71.7 REPORT ZONES EXT command – 4Ah/00h, DMA In

12.71.7.1 Feature Set

This 48-bit command is for devices that implement the Host Aware Zones feature set or the Host Managed Zones feature set.

Notice

a) Parameter data returned by REPORT ZONES EXT command represents the zone structure at the time of command reception.

b) REPORT ZONES EXT command is aborted if RETURN PAGE COUNT filed value exceeds 0x16B0.

12.71.7.2 Description

The REPORT ZONES EXT command returns the zone structure of a zoned device.

The REPORT ZONES EXT command is based on the ZAC MANAGEMENT IN command template (see 12.71.2) and is able to use the template's NCQ encapsulation capability.

12.71.7.3 Inputs

12.71.7.3.1 Overview

See Table 257　REPORT ZONES EXT command inputs for the REPORT ZONES EXT command inputs.

Table 257　REPORT ZONES EXT command inputs

Field	Description
FEATURE	**Bit**　**Description** 　15　　PARTIAL bit – See 12.71.7.3.2 　14　　Reserved 13:8　　REPORTING OPTIONS field – See 12.71.7.3.3 　7:5　　Reserved 　4:0　　ZM_ACTION field, shall be set to 00h – See 12.71.2.3.2
COUNT	RETURN PAGE COUNT field – See 12.71.2.3.4
LBA	ZONE LOCATOR field – See 12.71.7.3.4
DEVICE	**Bit**　**Description** 　7　　Obsolete 　6　　Shall be set to one 　5　　Obsolete 　4　　Transport Dependent – See ACS-4 3:0　　Reserved
COMMAND	7:0　　4Ah

12.71.7.3.2 PARTIAL bit

The PARTIAL bit modifies the definition of the ZONE LIST LENGTH field as described in 12.71.7.4.2

12.71.7.3.3 REPORTING OPTIONS field

The REPORTING OPTIONS field (see Table 258 REPORTING OPTIONS field) specifies the information to be returned by the REPORT ZONES EXT command.

Table 258 REPORTING OPTIONS field

Code	Description
00h	List the zones in the zoned device for all values in the ZONE CONDITION field, NON_SEQ bit and RESET bit
01h	List the empty zones (i.e., zones in the ZC1: Empty state
02h	List the implicit open zones (i.e., zones in the ZC2: Implicit_Open state)
03h	List the explicit open zones (i.e., zones in the ZC3: Explicit_Open state)
04h	List the closed zones (i.e., zones in the ZC4: Closed state)
05h	List the full zones (i.e., zones in the ZC5: Full state)
06h..0Fh	Reserved
10h	List the zones with the RESET bit set to one (see 12.71.7.4.6.5).
11h	List the zones with the NON_SEQ bit set to one (see 12.71.7.4.6.4).
12h..3Fh	Reserved
3Fh	List all zones that are not write pointer zones (i.e., zones with the ZONE CONDITION field set to 0h (see 12.71.7.4.6.3)).

12.71.7.3.4 ZONE LOCATOR field

The ZONE LOCATOR field should specify the starting LBA of the first zone to be reported.

If the ZONE LOCATOR field does not specify the starting LBA of a zone, the first zone to be reported is the zone that contains the LBA specified by the ZONE LOCATOR field.

12.71.7.4 Input From the Device to the Host Data Structure

12.71.7.4.1 Overview

The format of the data input from the device to the host is shown in Table 259 REPORT ZONES EXT input from device to host.

Table 259 REPORT ZONES EXT input from device to host

Offset	Type	Description
0..3	DWord	ZONE LIST LENGTH field (see 12.71.7.4.2)
4	Byte	**Bits Description** 7:4 Reserved 3:0 SAME field (see 12.71.7.4.3)
5..7		Reserved
8..15	QWord	**Bits Description** 63:48 Reserved 47:0 MAXIMUM LBA field (see 12.71.7.4.4)
16..63		Reserved
64..127	Bytes	Zone descriptor 0 (see 12.71.7.4.6)
128..191	Bytes	Zone descriptor 1
…		…
s–63..s	Bytes	Last zone descriptor N
s+1..(512xpc–1)	Bytes	Zero padding (see 12.71.7.4.6)

12.71.7.4.2   ZONE LIST LENGTH field

If the PARTIAL bit (see Table 257) is:

      a) cleared to zero, then the ZONE LIST LENGTH field shall:

            A) contain the length in bytes of the zone descriptors list; and

            B) not be altered based on the RETURN PAGE COUNT field (see 12.71.2.3.4);

            or

      b) set to one, then the ZONE LIST LENGTH field shall contain the lesser of:

            A) the number of zones that match the reporting options (see 12.71.7.3.3) multiplied by 64; or

            B) maxlen = (return length x 512) – 64

                where:

                      return length is the contents of the RETURN PAGE COUNT field.

The zone list length is the number of zones reported multiplied by 64.

12.71.7.4.3   SAME field

The SAME field (see Table 260   SAME field) indicates same zone type and same zone length relationships between the zones on the zoned device.

Table 260   SAME field

Code	Description
0h	The zone type and zone length in each zone descriptor may be different.
1h	The zone type and zone length in each zone descriptor are equal to the zone type and zone length indicated in the zone descriptor for the first zone on the zoned device(i.e., the zone that starts at LBA 0).
2h	The zone type in each zone descriptor is equal to the zone type indicated in the zone descriptor for the first zone on the zoned device (i.e., the zone that starts at LBA 0). The zone length of each zone except the last zone is equal to the zone length of the zone descriptor for the first zone on the zoned device. The zone length of the last zone is different than the zone length of the other zones.
3h	The zone length in each zone descriptor is equal to the zone length indicated in the zone descriptor for the first zone on the zoned device (i.e., the zone that starts at LBA 0). The zone types for each descriptor may be different.
all others	Reserved

12.71.7.4.4   MAXIMUM LBA field

The MAXIMUM LBA field indicates the LBA of the last logical sector on the device, including all logical sectors in all zones.

12.71.7.4.5   Zero padding

The total bytes input from the device to the host shall be 512xpc, where pc is the contents of the RETURN PAGE COUNT field in the command inputs (see 12.71.2.3.4). The device shall insert as many bytes cleared to zero after the last zone descriptor as are required to make total bytes input from the device to the host equal of 512xpc.

12.71.7.4.6   Zone descriptor format

12.71.7.4.6.1   Overview

Each zone descriptor (see Table 261   Zone descriptor format) describes one zone.

Table 261   Zone descriptor format

Offset	Type	Description
0	Byte	**Bit Meaning** 7:4 Reserved 3:0 ZONE TYPE field (see 12.71.7.4.6.2)
1	Byte	**Bit Meaning** 7:4 ZONE CONDITION field (see 12.71.7.4.6.3) 3:2 Reserved 1 NON-SEQ bit (see 12.71.7.4.6.4) 0 RESET bit (see 12.71.7.4.6.5)
2..7	Byte	Reserved
8..15	QWord	**Bits Description** 63:48 Reserved 47:0 ZONE LENGTH field (see 12.71.7.4.6.6)
16..23	QWord	**Bits Description** 63:48 Reserved 47:0 ZONE START LBA field (see 12.71.7.4.6.7)
24..31	QWord	**Bits Description** 63:48 Reserved 47:0 WRITE POINTER LBA field (see 12.71.7.4.6.8)
32..63	Byte	Reserved

12.71.7.4.6.2   ZONE TYPE field

The ZONE TYPE field (see Table 262   ZONE TYPE field) indicates the type of zone.

Table 262   ZONE TYPE field

Code	Description
0h	Reserved
1h	Conventional
2h	Sequential Write Required
3h	Sequential Write Preferred
4h..Fh	Reserved

12.71.7.4.6.3　ZONE CONDITION field

The ZONE CONDITION field (see Table 263   ZONE CONDITION field) indicates the condition of the zone.

Table 263   ZONE CONDITION field

Code	Applies to zone type (see Table 262 ZONE TYPE field)	Description	write pointer valid
0h	conventional	This zone does not have a write pointer. This zone is availableto perform read commands and write commands.	No
1h	sequential write required	This zone is in the ZC1: Empty state	Yes
2h	sequential write required	This zone is in the ZC2: Implicit_Open state	Yes
3h	sequential write required	This zone is in the ZC3: Explicit_Open state	Yes
4h	sequential write required	This zone is in the ZC4: Closed state	Yes
5h to Ch		Reserved	
Eh	sequential write required	This zone is in the ZC5: Full state	No

12.71.7.4.6.4　NON-SEQ bit

A NON_SEQ (non-sequential) bit cleared to zero at Conventional and Sequential Write Required zone.
This product support only Conventional and Sequential Write Required zone, a NON_SEQ bit is always zero.

12.71.7.4.6.5　RESET bit

A RESET bit cleared to zero indicates that the device has sufficient resources to maintain the zone described by this zone descriptor. A RESET bit set to one indicates that the host should send a RESET WRITE POINTERS EXT command (see 12.71.8) that specifies the zone described by this zone.

If the zone type is conventional, the device shall not set the RESET bit to one.

12.71.7.4.6.6　ZONE LENGTH field

The ZONE LENGTH field indicates the number of logical sectors in the zone described by this zone descriptor.

12.71.7.4.6.7　ZONE START LBA field

The ZONE START LBA field indicates the lowest LBA in the zone described by this zone descriptor.

12.71.7.4.6.8　WRITE POINTER LBA field

The WRITE POINTER LBA field indicates the starting LBA that the host should specify in the next write command associated with the zone described by this zone descriptor.

The host should ignore the contents of the WRITE POINTER LBA field if the ZONE CONDITION field indicates that are not valid (see Table 263   ZONE CONDITION field).

12.71.8 RESET WRITE POINTERS EXT command – 9Fh/04h, Non-Data

12.71.8.1 Feature Set

This 48-bit command is for devices that implement the Host Aware Zones feature set or the Host Managed Zones feature set.

12.71.8.2 Description

The RESET WRITE POINTERS EXT command allows the host to reset write pointers for one or more write pointer zones.
The RESET WRITE POINTERS EXT command is based on the Non-Data ZAC MANAGEMENT OUT command template (see 12.71.3).

12.71.8.3 Inputs

12.71.8.3.1 Overview

See Table 264   RESET WRITE POINTERS EXT command inputs for the RESET WRITE POINTERS EXT command inputs.

Table 264   RESET WRITE POINTERS EXT command inputs

Field	Description
FEATURE	**Bit** **Description** 15:9 Reserved 8 RESET ALL bit – See 12.71.8.3.2 7:5 Reserved 4:0 ZM_ACTION field, shall be set to 04h – See 12.71.2.3.2
COUNT	Reserved
LBA	ZONE ID field – See 12.71.4.3.3
DEVICE	**Bit** **Description** 7 Obsolete 6 Shall be set to one 5 Obsolete 4 Transport Dependent – See ACS-4 3:0 Reserved
COMMAND	7:0 9Fh

12.71.8.3.2　RESET All bit

If the RESET ALL bit is set to one, then:
 a) the device shall ignore the contents of the ZONE ID field; and
 b) for each open zone, each closed zone, and each full zone the device shall:
   A) set the write pointer to the lowest LBA in that zone; and
   B) transition that zone to the ZC1: Empty state.
If the RESET ALL bit is cleared to zero, then:
 a) if the zone specified by the ZONE ID field (see 12.71.4.3.3) is an empty zone, then the device shall:
   A) not change the zone's state; and
   B) return successful command completion;
    or
 b) the device shall:
   A) set the write pointer to the lowest LBA in the zone specified by the ZONE ID field; and
   B) transition the zone specified by the ZONE ID field to the ZC1: Empty state..

12.71.8.4　Error Outputs

The device shall return command completion with an error if the RESET ALL bit is cleared to zero and:
  a) the ZONE ID field does not contain the starting LBA of a write pointer zone as described in 12.71.4.3.3.

13 Device Signatures for Normal Output

Table 266 Device signatures for COUNT and LBA field specifies the normal outputs for the READ SECTOR(S) command (see ACS-4), the IDENTIFY DEVICE command (see ACS-4), and the EXECUTE DEVICE DIAGNOSTIC command (see ACS-4).

Table 265   Device Signatures for Normal Output

Field	Description
ERROR	Diagnostic Results – The diagnostic code as described in Table 36 Diagnostic Codes is returned. This field shall be reserved for the EXECUTE DEVICE DIAGNOSTIC command (see 12.6).
COUNT	See Table 266 Device signatures for COUNT and LBA field
LBA	
DEVICE	**Bit Description** 7 Obsolete 6 N/A 5 Obsolete 4 Transport Dependent – See ACS-4 3:0 Reserved
STATUS	**Bit Description** 7:6 Transport Dependent – See ACS-4 5 DEVICE FAULT bit – See ACS-4 4 N/A 3 Transport Dependent – See ACS-4 2 N/A 1 N/A 0 shall be cleared to zero

Table 266   Device signatures for COUNT and LBA field

Bits	Host Managed Zoned device	All others
COUNT field (7:0)	01h	See ACS-4
LBA field (27:24)	Reserved	
LBA field (23:16)	ABh	
LBA field (15:8)	CDh	
LBA field (7:0)	01h	