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# CloudSpeed Gen II Solid State Drives SMART Commands and Attributes

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### Revision History

Date	Revision	Section(s)	Description
March 20, 2017	01	All	Initial release.

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## 1.0 Introduction

Western Digital Corporation drives supports several Self-monitoring Analysis And Reporting Technology (SMART) subcommands designed to send an alert if a drive problem is detected. These subcommands are used to retrieve information regarding SMART attributes, such as the total number of hours the drive has been operational. While Western Digital Corporation or its affiliates adheres to the ATA Standard for SMART commands, the attributes are vendor-specific. Information contained in SMART attributes include the Power-on Hours (POH), temperature, writes to host, etc.

This document describes how to use SMART attributes to determine the “health” of the CloudSpeed 1500 drives.

### 1.1 Error Correction Levels

The CloudSpeed 1500 drive supports two levels of correction: Error Correcting Code (ECC) and Flexible Redundant Array of Independent Memory Elements (FRAME). When an error occurs, the drive attempts to correct the error using the ECC engine. If this engine does not correct the error, the second level (FRAME) attempts to resolve the data. Several SMART attributes track the error counts and rates associated with these two levels.

## 2.0 SMART Subcommands

As indicated in the ATA Standard, the SMART Operations command supports several subcommands, including Return Status and Read Data. For the purposes of monitoring drive health, the subcommands described in the following table are used.

Table 1: SMART Commands

Command Name	Function	Page Reference
Enable/Disable Attribute Autosave	Enables or disables the feature that causes the drive to save attribute values automatically	<a href="#">10</a>
Enable/Disable Operations	Enables or disables SMART functions on the drive. All other SMART commands return an ABORT if the Enable Operations command is not issued first.	<a href="#">10</a>
Execute Off-Line Immediate	Instructs the drive to execute the specified activity or self-test when the drive goes off-line	<a href="#">11</a>
Read Attribute Thresholds	Returns the defined threshold value for each supported attribute. At the time of this writing, this command is not supported.	<a href="#">12</a>
Read Data	Returns the current value for each supported attribute	<a href="#">12</a>
Read Log Sector	Returns the data contained in the specified log	<a href="#">14</a>
Return Status	Indicates whether or not an attribute value has exceeded the defined threshold. This command simply returns a pass or fail; it does not indicate the attribute that caused the failure.	<a href="#">14</a>
Write Log Sector	Writes a specific 512-byte sector to the indicated log page	<a href="#">15</a>

The following sections define the command and output registers.

### 2.1 SMART Subcommand Registers

All SMART commands are issued with the SMART Operations command opcode B0h. The Features field of the SMART Operations command defines the subcommand, with all other fields set to the values indicated in the following table. The following table shows 28-bit addressing as well as 48-bit addressing command format with the latter denoted by \*

Table 2: SMART Command Layout

Field	Bit							
	7	6	5	4	3	2	1	0
Features (7:0)	Subcommand Code							
Features (15:8)*	00h							
Sector Count (7:0)	00h or 01h (Depends on the sub command)							
Sector Count (15:8)*	00h							
LBA Low (7:0)	00h							
LBA Low (31:24)*	00h							
LBA Mid (15:8)	4Fh							
LBA Mid (39:32)*	00h							
LBA High (23:16)	C2h							
LBA High (47:40)*	00h							
Device/Head (27:24)	00h							
Command	B0h							

The drive returns an error if any of the fields are not set properly (for example, the low order LBA Mid is set to 00h).

**NOTE: Because the extended fields for 48-bit addressing commands are to 00h, this document provides the command field values for 28-bit commands only.**

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## 2.2 OutputField

When the command succeeds, the drive returns the values indicated in the following table. The following table shows 28-bit addressing as well as 48-bit addressing command format with the latter fields denoted by \*

Table 3: Output Field

Field	Bit							
	7	6	5	4	3	2	1	0
Features (7:0)	Subcommand Code							
Features (15:8)*	00h							
Sector Count (7:0)	00h or 01h (Depends on the Command)							
Sector Count (15:8)*	00h							
LBA Low (7:0)	00h							
LBA Low (31:24)*	00h							
LBA Mid (15:8)	4Fh							
LBA Mid (39:32)*	00h							
LBA High (23:16)	C2h							
LBA High (47:40)*	00h							
Device/Head (27:23)	00h							
Command	B0h							

For the Return Status command, the low order LBA Mid and LBA High register values may return F4h and 2Ch, respectively. If this occurs, one or more of the supported attributes have exceeded the attribute threshold (or trigger point). See page 14 for more information about the Return Status command.

If an error occurs, the Status field is set to 51h, and the Error field (the first register) identifies the error that occurred. See the ATA specification for a description of the possible Error bits.

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**NOTE: The drive returns an error with the ABRT bit set if the drive receives a SMART subcommand and SMART operations are not enabled. See page 10 for more information.**

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If successful, the Read Data and Read Attribute Thresholds subcommands return 512 bytes of data containing the relevant SMART information.

### 3.0 SMART Commands

This section describes the SMART commands used to retrieve the SMART data.

#### 3.1 Enable/Disable Attribute Autosave

**Features:** D2h (210 decimal)

**Use:** Enables or disables the autosave feature on the drive. If enabled, the drive automatically updates attribute values after vendor-specific events (e.g., ECC error) have occurred. If disabled, the drive does not automatically update vendor-specific attribute values. The drive, however, continues to update attribute information for other events, such as a power cycle.

The Sector Count field toggles the feature:

- 00h disables the autosave feature
- F1h enables the autosave feature

The feature remains enabled/disabled across power cycles.

**Transfer:** None

**Input:** See the following table for the input fields.

**Table 4: SMART Enable/Disable Attribute Autosave command**

Field	Bit							
	7	6	5	4	3	2	1	0
Features	D2h							
Sector Count	00h (Disable) F1h (Enable)							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	00h							
Command	B0h							

#### 3.2 Enable/Disable SMART Operations

**Features:** D8h (Enable) (216 decimal); D9h (Disable) (217 decimal)

**Use:** Enables or disables SMART operations on the drive. Before you can retrieve SMART data, you must first enable SMART operations. SMART operations remain enabled across power cycles. To disable SMART operations, issue the Disable SMART Operations subcommand (D9h in the Features field).

**Transfer:** None

**Input:** See the following table for the command input.

**Table 5: SMART Enable/Disable Operations command**

Field	Bit							
	7	6	5	4	3	2	1	0
Features	D8h (Enable) or D9h (Disable)							
Sector Count	00h							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	00h							
Command	B0h							

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### 3.3 Execute Off-Line Immediate

**Features:** D4h (212 decimal)

**Use:** Immediately executes the specified activities or Self-Tests when the drive enters off-line or captive mode. In off-line mode, the drive clears the BSY bit in the Status field before executing the subcommand activity. Because the BSY bit is not set, the host can interrupt the drive activity by issuing certain commands. In captive mode, the drive sets the BSY bit, indicating the host cannot interrupt the activity. The LBA Low field value defines the activity to execute.

**Transfer:** None

**Input:** See the following table for the input fields.

**Table 6: Execute Off-Line Immediate Command**

Field	Bit							
	7	6	5	4	3	2	1	0
Features	D4h							
Sector Count	00h							
LBA Low	See <a href="#">table 7</a>							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	00h							
Command	B0h							

See the following table for a list of supported off-line immediate subcommands.

**Table 7: Execute Off-Line Immediate Subcommands**

Subcommand Name	Description	LBA Low
Execute Off-Line Routine	Indicates the drive will execute the routine in off-line mode only (not captive mode)	00h
Execute Short Self-Test in Off-Line Mode	Executes the short self-test in off-line mode	01h
Execute Extended Self-Test in Off-Line Mode	Executes the extended self-test in off-line mode	02h
Execute Selective Self-Test in Off-Line Mode	Executes the selective self-test, which includes the extended self-test and a read scan, in off-line mode.	04h
Abort Off-Line Mode Self-Test	Interrupts the drive and causes it to end the self-test routine	7Fh
Execute Short Self-Test in Captive Mode	Executes the short self-test in captive mode only	81h
Execute Extended Self-Test in Captive Mode	Executes the extended self-test in captive mode only	82h
Execute Selective Self-Test in Captive Mode	Executes the selective self-test, which includes the extended self-test and a read scan, in captive mode only.	84h

### 3.4 Read Attribute Thresholds

**Features:** D1h (209 decimal)

**Use:** Returns 512 bytes of information specific to each of the supported SMART attributes. This command is obsolete in ACS-3 and this may return undesired values.

**Transfer:** PIOData-In

**Input:** See the following table for the input field

**Table 8: SMART Read Attribute Thresholds Command**

Register	Bit							
	7	6	5	4	3	2	1	0
Features	D1h							
Sector Count	01h							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	00h							
Command	B0h							

**Output:** Similar to the Read Data subcommand (see page 12), the Read Attribute Thresholds subcommand returns 512 bytes of data which are invalid as we do not support this subcommand.

### 3.5 Read Data

**Features:** D0h (208 decimal)

**Use:** Returns 512 bytes of information specific to each supported SMART attribute.

**Transfer:** PIOData-In

**Input:** See the following table for the input fields.

**Table 9: SMART Read Data Command**

Field	Bit							
	7	6	5	4	3	2	1	0
Features	D0h							
Sector Count	01h							

Table 9: SMART Read Data Command (Continued)

Field	Bit							
	7	6	5	4	3	2	1	0
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	00h							
Command	B0h							

**Output:** Each offset defines the specific attribute and the associated raw data. See the following table for the byte values for an example of the data.

Table 10: Read Data Bytes

Byte(s)	Data		Comments
	Field Size	Content	
000:001	1 Word	Revision	Vendor-specific (0010)
002:013	12 Bytes Each	1 <sup>st</sup> Attribute	Attribute Layout (Each) Byte(s) Description 0 ID Number 1:2 Status 3 Normalized Value 4 WorstValue 5:11 Raw Data
014:025	12 Bytes Each	2 <sup>nd</sup> Attribute	
026:037	12 Bytes Each	3 <sup>rd</sup> Attribute	
...	...	...	
350:361	12 Bytes Each	30 <sup>th</sup> Attribute	
362	Byte	Off-Line Data Collection Status	
363	Byte	Self-Test Execution Status	
364:365	2 Bytes	Total Time to Complete Off-Line Data Collection*	Value in seconds
366	Byte	Reserved	
367	Byte	Off-Line Data Collection Capabilities	
368:369	2 Bytes	SMART Capability	
370	Byte	Error Logging Capability	Bit 0 = Error Logging Supported (if set to 1)
371	Byte	Vendor Information	
372	Byte	Short Self-Test Routine Recommended Polling Time*	Value in minutes
373	Byte	Extended Self-Test Routing Recommended Polling Time	Value in minutes
374	Byte	Recommended Polling Time for Conveyance Self-Test	Value in minutes
375:376	2 Bytes	Time for Extended Self-Test if >255	
377:385	9 Bytes	Reserved	
386	Byte	Percentage completed for Complete Off-Line Data Collection	
387:510	124 Bytes	Vendor Information	
511	Byte	Checksum	

**NOTE: Some of the values associated with self-tests and off-line scans may not be reported correctly.**

**3.6 Read Log**

**Features:** D5h (213 decimal)

**Use:** Returns a specified number of sectors from the requested log. The LBA Low field identifies the log address.

**Transfer:** PIOData-In

**Input:** See the following table for the input.

**Table 11: Read Log Command**

Field	Bit							
	7	6	5	4	3	2	1	0
Features	D5h							
Sector Count	Number of Sectors to Read							
LBA Low	Log Address							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	00h							
Command	B0h							

**Output:** Each log contains a different byte structure.

**3.7 Return Status**

**Features:** DAh (218 decimal)

**Use:** Indicates the current status of the supported SMART attributes. If the LBA Mid and LBA High field contain F4h and 2Ch (that is, the nibbles are reversed), one or more of the attributes exceed the defined threshold level.

**Transfer:** None

**Input:** See the following table for the input.

**Table 12: SMART Return Status Command**

Field	Bit							
	7	6	5	4	3	2	1	0
Features	Dah							
Sector Count	00h							
LBA Low	00h							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	00h							

**Table 12: SMART Return Status Command (Continued)**

Field	Bit							
	7	6	5	4	3	2	1	0
Command	B0h							

**3.8 Write Log**

**Features:** D6h (214 decimal)

**Use:** Writes a specified number of sectors to the requested log. The LBA Low field identifies the log address.

**Transfer:** PIO Data-Out

**Input:** See the following table for the input values.

**Table 13: Write Log Command**

Field	Bit							
	7	6	5	4	3	2	1	0
Features	D6h							
Sector Count	Number of Sectors to Write							
LBA Low	Log Address							
LBA Mid	4Fh							
LBA High	C2h							
Device/Head	00h							
Command	B0h							

## 4.0 Supported Attributes

This section describes the data structure and returned information for each SMART attribute. See the following table for a list of supported attributes and the threshold values.

**Table 14: Supported Attributes**

Attribute ID (Decimal)	Threshold (Decimal)	Attribute Name	Page Reference
05h (5)	None	Lifetime Reallocated Erase Block Count	<a href="#">17</a>
09h (9)	None	Power On Hours (POH)	<a href="#">17</a>
0Dh (13)	65535	Soft Read Error Rate (Lifetime UECC Count)	<a href="#">18</a>
20h (32)	None	Write Amplification	<a href="#">18</a>
21h (33)	None	Trailing Hour Write Amplification Factor	<a href="#">19</a>
AAh (170)	None	Reserve Erase Block Count	<a href="#">19</a>
ABh (171)	None	Program Fail Count	<a href="#">20</a>
ACh (172)	None	Erase Fail Count	<a href="#">20</a>
AFh (175)	None	Power Loss Protection Failure	<a href="#">21</a>
B2h (178)	None	Percent Drive Life Remaining in higher resolution	<a href="#">21</a>
B7h (183)	None	Lifetime Link Rate Downgrade Count	<a href="#">22</a>
BFh (191)	None	Clean Lifetime Shutdown Count on Power Loss	<a href="#">22</a>
C0h (192)	None	Unclean Lifetime Shutdown Count on Power Loss	<a href="#">23</a>
C2h (194)	70	Drive Temperature	<a href="#">23</a>
C4h (196)	None	Lifetime Retired Block Count	<a href="#">24</a>
C7h (199)	None	UDMA CRC Error	<a href="#">24</a>
D3h (211)	None	Lifetime Read Disturb Reallocation Events	<a href="#">25</a>
E9h (233)	None	Lifetime NAND Writes	<a href="#">25</a>
EBh (235)	0	Capacitor Health	<a href="#">26</a>
F1h (241)	None	Lifetime Writes From Host	<a href="#">26</a>
F2h (242)	None	Lifetime Reads to Host	<a href="#">27</a>
F4h (244)	None	Lifetime Thermal Throttle Activations	<a href="#">27</a>
F5h (245)	1%	Percent Drive Life Remaining	<a href="#">28</a>
FDh (253)	1	SPI Tests Remaining	<a href="#">28</a>

**4.1 Lifetime Reallocated Erase Block Count**

**Attribute ID:** 05h(5 decimal)

**Threshold:** None

**Description:** The total number of erase blocks added to the defect list after manufacturing. See the following table for the byte definitions. This count is incremented by one whenever an erase block is added to the defect list due to erase failure, program failure or frame invokes.

**Table 15: Lifetime Reallocated Erase Block Count Bytes**

Byte(s)	Value	Indication
0	05h	This is the attribute ID (5 decimal)
1:2	3300h	These two bytes are always set to 3300h
3	100	Normalized value
4	100	Worst value recorded
5:8	Variable	Total number of reallocated blocks (little-endian)
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** The value is fixed at 100 (64h).

**4.2 Power-On Hours (POH)**

**Attribute ID:** 09h(9 decimal)

**Threshold:** None

**Description:** The POH attribute indicates the total number of hours the drive has had power applied to it since the Date Of Manufacture (DOM). Although the value is updated hourly, the attribute tracks the number of seconds between each update. The number of seconds returns to zero when the hour count is updated. See the following for the byte definitions.

**Table 16: Power-On Hours (POH) Bytes**

Byte(s)	Value	Indication
0	09h	This is the attribute ID (9 decimal)
1:2	3200h	These two bytes are always set to 3200h
3	Variable	Normalized value
4	Variable	Normalized value
5:8	Variable	The number of hours the drive has been powered on over its lifetime (little-endian)
9:11	Variable	Number of seconds since the last hour update (little-endian)

**Normalized Value:** Range is 100-1. The value is the percentage of the total number of hours in ten years. The value decrements approximately every tenth of a year as defined by the following formula:  $100 - (POH/(HPY/10))$ , where *POH* is POH, and *HPY* is the number of hours in a year.

**4.3 Soft Read Error Rate (Lifetime UECC Count)**

**Attribute ID:** 0Dh (13 decimal)

**Threshold:** 65535

**Description:** The Soft Read Error Rate attribute returns the count of errors that are uncorrectable by both the first level of correction (ECC engine) and second level of correction (FRAME) over the life of the drive. This count is incremented by the number of AUs that are uncorrectable.

**Table 17: Soft Read Error Rate Bytes**

Byte(s)	Value	Indication
0	0Dh	This is the attribute ID (13 decimal)
1:2	1200h	These bytes are always set to 1200h
3	0-64h	Normalized value
4	64h	Worst value recorded
5:8	Variable	Count of uncorrectable errors that occurred (little-endian)
9:11	00	These bytes are reserved set to 00h

**Normalized Value:** Ranges between 0 to 64h. If threshold is reached it returns 0

**4.4 Write Amplification**

**Attribute ID:** 20h (32 decimal)

**Threshold:** None

**Description:** This is the ratio of number of flash writes to the number of host writes during the life of the drive. In order to accurately measure the value, a test should run long enough to ensure the drive has reached a steady state condition.

**Table 18: Write Amplification Bytes**

Byte(s)	Value	Indication
0	20h	This is the attribute ID (32 decimal)
1:2	0200h	These two bytes are always set to 0200h
3	64h	Normalized value
4	64h	Worst value recorded
5:8	Variable	The write amplification multiplied by 100 (for example, a write amplification of 1 has a value of 100) (little-endian).
9:11	00h	These bytes are reserved set to 00h

**Normalized Value:** Set to 64h (100 decimal)



#### 4.5 Trailing Hour write Amplification Factor

**Attribute ID:** 21h(33 decimal)

**Threshold:** None

**Description:** This is the ratio of number of flash write to the number of host write of the last hour  
See the following table for the byte definitions.

**Table 19: Trailing Hour write Amplification Factor**

Byte(s)	Value	Indication
0	21h	This is the attribute ID (33 decimal)
1:2	0200h	These bytes are always set to 0200h
3	64h	Normalized value, this is set to 64h
4	64h	Worst value, this is set to 64h
5:8	Variable	Trailing Hour Write Amp * 64h. This will return 100 if no writes are done
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h.

#### 4.6 Reserve Erase Block Count

**Attribute ID:** AAh(170 decimal)

**Threshold:** None

**Description:** The Reserve Erase Block Count attribute returns the total number of reserve blocks (or spares) remaining. This attribute is related to attribute 5 (Reallocated Block Count) as this value decreases whenever the Reallocated Block Count value increases. See the following table for the byte definitions.

**Table 20: Reserve Erase Block Count Bytes**

Byte(s)	Value	Indication
0	AAh	This is the attribute ID (170 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Because there is no normalized value, this is set to 64h
4	64h	Because there is no worst value, this is set to 64h
5:8	Variable	Total number of reserve erase blocks available (little-endian). For 3840 GB the value ranges from 53913 to 0 blocks For 3200 GB the value ranges from 134784 to 0 blocks
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h.

#### 4.7 Program Fail Count

**Attribute ID:** ABh (171 decimal)

**Threshold:** None

**Description:** The Program Fail Count attribute counts the total number of program failures that have occurred on the drive since the DOM.

See the following table for the byte definitions.

**Table 21: Program Fail Count Bytes**

Byte(s)	Value	Indication
0	ABh	This is the attribute ID (171 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Because there is no normalized value, this is set to 64h
4	64h	Worst value, this is set to 64h
5:8	Variable	Total number of program failures. The count is incremented by one for each program failure (little-endian).
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)

#### 4.8 Erase Fail Count

**Attribute ID:** ACh (172 decimal)

**Threshold:** None

**Description:** The Erase Fail Count attribute counts the total number of erase failures that have occurred on the drive since the DOM.

See the following table for the byte definitions.

**Table 22: Erase Fail Count Bytes**

Byte(s)	Value	Indication
0	ACh	This is the attribute ID (172 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Because there is no normalized value, this is set to 64h
4	64h	Because there is no worst value, this is set to 64h
5:8	Variable	Total number of erase failures that have occurred in the drive lifetime. The count is incremented by one for each erase failure (little-endian).
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)

**4.9 Power Loss Protection Failure**

**Attribute ID:** AFh (175 decimal)

**Threshold:** None

**Description:** This attribute is not implemented and the raw data is hard coded to 0

**Table 23: Power Loss Protection Failure Bytes**

Byte(s)	Value	Indication
0	AFh	This is the attribute ID (AFh)
1:2	3200h	These bytes are always set to 3200h
3	64h	Normalized value
4	64h	Worst value recorded
5:8	00h	Set to a fixed value 0
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** 64h

**4.10 Percent Drive Life Remaining in Higher Resolution**

**Attribute ID:** B2h (178 decimal)

**Threshold:** None

**Description:** The Percent Drive Life Remaining attribute returns the percentage of the drive life remaining. The amount of drive life used is calculated as the percentage of PE cycles issued to the drive compared to total PE cycles. . This is the percent drive life remaining in 0.01% resolution.

**Table 24: Percent Drive Life remaining in higher resolution Bytes**

Byte(s)	Value	Indication
0	B2h	This is the attribute ID (178 decimal)
1:2	1200h	These bytes are always set to 1200h
3	64h	Normalized value
4	64h	Worst value
5:8	Variable	The percentage of drive life remaining in higher resolution (little-endian) Range between 0 and 0x2710
9:11	00h	These bytes are reserved and set to zero

**Normalized Value:** Set to 64h (100 decimal)

#### 4.11 Lifetime Link Rate Downgrade Count

**Attribute ID:** B7h(183decimal)

**Threshold:** None

**Description:** At power-up, the drive detects the SATA link rate. If, after a COMRESET, the link rate drops the counter is incremented by one.

Table 25: Lifetime Link Rate Downgrade Count

Byte(s)	Value	Indication
0	B7h	This is the attribute ID (183 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Normalized value
4	64h	Worst value
5:8	Variable	Range between 0 and 0xFFFFFFFF
9:11	00h	These bytes are reserved and set to zero

**Normalized Value:** Set to 64h (100 decimal)

#### 4.12 Clean Lifetime Shutdown Count on Power Loss

**Attribute ID:** BFh(191 decimal)

**Threshold:** None

**Description:** This is the count of power down by firmware. All power down are considered as clean power down because the drive is protected from unclean power down using holdup capacitor.

Table 26: Clean Lifetime Shutdown Count on Power Loss

Byte(s)	Value	Indication
0	BFh	This is the attribute ID (191 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Normalized value, this is set to 64h
4	64h	Worst value, this is set to 64h
5:8	Variable	Range between 0 and 0xFFFFFFFF
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)

**4.13 Unclean lifetime Shutdown Count on Power Loss**

**Attribute ID:** C0h (192 decimal)

**Threshold:** None

**Description:** As the drive is protected by holdup capacitor, there is no possibility of unclean shutdown. This attribute’s Raw Data is hard coded to 0.

**Table 27: Unclean Lifetime Shutdown Count on Power Loss**

Byte(s)	Value	Indication
0	C0h	This is the attribute ID (192 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Normalized value, this is set to 64h
4	64h	Worst value, this is set to 64h
5:8	Variable	Set to a value 0
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)

**4.14 Drive Temperature**

**Attribute ID:** C2h (194 decimal)

**Threshold:** 70

**Description:** The Temperature attribute indicates the current, the lifetime lowest, and the lifetime highest temperature (in °C). See the following table for the byte definitions.

**Table 28: Drive Temperature Bytes**

Byte(s)	Value	Indication
0	C2h	This is the attribute ID (194 decimal)
1:2	2200h	These bytes are always set to 2200h
3	Variable	Normalized value (100 – current drive temperature in °C)
4	Variable	Worst value recorded (100 – highest temperature)
5:6	Variable	The current internal temperature (in °C) of the drive (little-endian)
7	Variable	The lowest recorded temperature (in °C) in the drive lifetime (little-endian)
8	Variable	The highest recorded temperature (in °C) in the drive lifetime (little-endian)
9:11	0	This byte is reserved and set to 00h

**Normalized Value:** (100 – current drive temperature in °C), in °C, is the normalized temperature. The temperature ranges from 0 - 100.

**4.15 Lifetime Retired Block Count**

**Attribute ID:** C4h (196 decimal)

**Threshold:** None

**Description:** This is the total number of erase blocks added to the defect list after manufacturing. This count is incremented by one whenever an erase block is added to the defect list due to erase failure, program failure or frame invokes. . See the following table for the byte definitions .

**Table 29: Lifetime Retired Block Count Bytes**

Byte(s)	Value	Indication
0	C4h	This is the attribute ID (196 decimal)
1:2	1B00h	These bytes are always set to 1B00h
3	64h	Normalized value
4	64h	Worst value recorded
5:8	Variable	The total number of grown retired blocks (little-endian)
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** The range is 64h (100 decimal).

**4.16 UDMA CRC Error**

**Attribute ID:** C7h (199 decimal)

**Threshold:** None

**Description:** This is the host to device data FIS CRC error count. This is reset after a COMRESET from the host.

Note that this is new to 4TB CloudSpeed Gen II

**Table 30: UDMA CRC Error Count Bytes**

Byte(s)	Value	Indication
0	C7h	This is the attribute ID (199 decimal)
1:2	3E00h	These bytes are always set to 3E00h
3	64h	Normalized value
4	64h	Worst value recorded
5:8	Variable	Error count
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)

**4.17 Life time read disturb reallocation events**

**Attribute ID:** D3h (211 decimal)

**Threshold:** None

**Description:** This is a Read Disturb recycle event count. The count is incremented when the reallocation occurs due to Read Disturb

**Table31: Life time read disturb reallocation events**

Byte(s)	Value	Indication
0	D3h	This is the attribute ID (211 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Normalized value
4	64h	Worst value recorded
5:8	Variable	Range between 0 and 0xFFFFFFFF
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)

**4.18 Life time NAND writes**

**Attribute ID:** E9h (233 decimal)

**Threshold:** None

**Description:** The number of lifetime NAND writes since the date of manufacture. The attribute raw value shows the number of Gbyte of writes done. Raw value is updated after every 64 GBytes of write.

**Table 32: Life time NAND writes**

Byte(s)	Value	Indication
0	E9h	This is the attribute ID (233 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Normalized value
4	64h	Worst value recorded
5:8	Variable	Range between 0 and 0xFFFFFFFF
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)

#### 4.19 Capacitor Health

**Attribute ID:** EBh (235 decimal)

**Threshold:** 0

**Description:** This attribute is used to report the health of holdup capacitor. A value 100 means capacitor is in good health. A value of 0 means the capacitor is bad.

Note that this is new to 4TB CloudSpeed Gen II

**Table 33: Capacitor Health**

Byte(s)	Value	Indication
0	EBh	This is the attribute ID (235 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Normalized value
4	64h	Worst value recorded
5:8	Variable	100 or 0. 0 means capacitor health is bad
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)

#### 4.20 Lifetime Writes from Host

**Attribute ID:** F1h (241 decimal)

**Threshold:** None

**Description:** The number of lifetime host writes since the date of manufacture. The attribute raw value shows the number of Gbyte of writes done. Raw value is updated after every 64 GBytes of write.

See the following table for the byte definitions.

**Table 34: Lifetime Writes from Host Bytes**

Byte(s)	Value	Indication
0	F1h	This is the attribute ID (241 decimal)
1:2	3200h	These bytes are always set to 3200h
3	64h	Normalized value
4	64h	Worst value
5:8	Variable	Range between 0 and 0xFFFFFFFF
9:11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)



**4.21 Lifetime Reads to Host****Attribute ID:** F2h (242 decimal)**Threshold:** None**Description:** The number of lifetime host reads since the date of manufacture. The attribute raw value shows the number of GByte of reads done. Raw value is updated after every 64 GBytes of read done.

See the following table for the byte definitions.

**Table 35: Lifetime Reads to Host Bytes**

(Bytes)	Value	Indication
0	F2h	This is the attribute ID (244 decimal)
1-2	3200h	These bytes are always to set 3200h
3	64h	Nominal Value
4	64h	Worst value
5-8	Variable	Range between 0 and 0xFFFFFFFF
9-11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)**4.22 Lifetime Thermal Throttle Activations****Attribute ID:** F4h (244 decimal)**Threshold:** None**Description:** The variable increases each time thermal throttling is activated**Table 36: Lifetime Thermal throttle activations**

(Bytes)	Value	Indication
0	F4h	This is the attribute ID (244 decimal)
1-2	3200h	These bytes are always to set 3200h
3	64h	Nominal Value
4	64h	Worst value
5-8	Variable	Range between 0 and 0xFFFFFFFF
9-11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)

### 4.23 Percent Drive Life Remaining

**Attribute ID:** F5h (245 decimal)

**Threshold:** 1%

**Description:** This is the percentage of drive life remaining. The amount of drive life used is calculated as the percentage of PE cycles issued to the drive compared to total PE cycles. Drive life remaining is calculated as 100 – drive life used.

**Table 37: Percent Drive Remaining Bytes**

(Bytes)	Value	Indication
0	F5h	This is the attribute ID (245 decimal)
1-2	1200h	These bytes are always to set 1200h
3	64h-0	Normalized value
4	64h-0	Worst value
5-8	Variable	The amount of drive life used is calculated as the percentage of PE cycles issued to the drive compared to total PE cycles. Drive life remaining is calculated as 100 – drive life used.
9-11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Ranges from 64h to 0

### 4.24 SPI Tests Remaining

**Attribute ID:** FDh (253 decimal)

**Threshold:** 1h (1 decimal)

**Description:** Header sections of SPI firmware areas are read and checksum computed. If the checksum is not correct, the SPI is corrupt and a SMART trip will occur

**Table 38: SPI Tests Remaining**

(Bytes)	Value	Indication
0	FDh	This is the attribute ID (253 decimal)
1-2	1200h	These bytes are always to set 1200h
3	64h	Nominal Value
4	64h	Worst value
5-8	Variable	Normal value is 0. A non-zero value indicates an error condition.
9-11	00h	These bytes are reserved and set to 00h

**Normalized Value:** Set to 64h (100 decimal)