



Seagate Technology

Seagate SMART Attribute Specification

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1.0 SMART Attribute Sector

Data that may be useful in determining the health of a particular disk drive are stored as SMART Attributes. The following data structure describes the Seagate Technology implementation of the ATA/ATAPI-5 SMART Attribute Sector specification (the description of the sector was removed in later versions). This sector contains up to 30 SMART attributes, Seagate unique information and information used by Drive Self-Test.

Smart Read Attributes (D0) command is used to retrieve Smart Attribute sector. The Smart Attribute Sector is updated and saved on each of the following conditions:

- B0/D0 Smart Read Attribute Command
- B0/D3 Smart Save Attribute Command. Attributes are not updated prior saving.
- B0/DA Smart Return Status Command. DST also updates Smart Attribute sector when performing Smart Check Test.
- After Power On Reset.

Table 1 below shows the SMART Attribute sector format.

Table 1 – SMART Attribute Sector

Byte	Description
0:1	SMART structure version number (expected to be 0xA)
2	First Stored Attribute (Attribute 1)
3:4	Status
5	Nominal
6	Worst Ever
7:13	Raw Data
14:25	Next Stored Attribute (Attribute 3)
26:361	Next Stored Attributes (Max of 30 collected Attributes, incl. above)
362	Off-line data collection status C0h-FFh Vendor specific 87h-BFh Reserved 83h Reserved 81h Reserved 40h-7Fh Vendor specific 07h-3Fh Reserved 06h or 86h Off-line activity aborted by device with a fatal error. 05h or 85h Off-line activity aborted by command from host. 04h or 84h Off-line activity suspended by command from host. 03h Off-line activity in progress. 02h or 82h Off-line activity completed without error. 01h Reserved 00h or 80h Off-line activity was never started.
363	Self-test execution status byte Bit Fh Self-test routine in progress. Bit 9h-Eh Reserved. Bit 8h Previous self-test test element failed - handling damage. Bit 7h Previous self-test read element failed. Bit 6h Previous self-test servo element failed.

	Bit 5h Previous self-test electrical element failed. Bit 4h Previous self-test test element failed – source is not known. Bit 3h Fatal error or unknown test error occurred unable to complete. Bit 2h Self-test routine interrupted by host - hardware or software reset Bit 1h Self-test routine was aborted by the host Bit 0h Previous self-test routine completed - no error or not ever run.
364:365	Total time in seconds to complete off-line data collection activity
366	Reserved
367	Off-line data collection capability Bit 7 = Reserved Bit 6 = Selected Self Test Supported Bit 5 = Conveyance Self test Supported Bit 4 = Self Test Supported Bit 3 =Offline Scan with Sparing Supported Bit 2 =Offline Aborted by Command Supported Bit 1 =Auto Offline Command Supported Bit 0 =Off Line Immediate Command Supported Default Value = 53h
368:369	SMART capability Bits 15:2 = Reserved Bit 1 =Auto Save capable Bit 0 =Auto Save prior to Power mode Change Default Value = 3
370	Error logging capability Bits 7:1 Reserved Bit 0 1=Device error logging supported
371	Next Self Test Step
372	Short self-test routine recommended polling time (in minutes)
373	Extended self-test routine recommended polling time (in minutes)
374	Conveyance Self-Test Recommended Polling Time
375:376	Time for Extended Self-Test if > 255 (373 -> 0xFF)
377:385	Reserved
386:510	Vendor Info
511	Data structure checksum (Not actually stored on disk)

2.0 Seagate Supported Attributes

Attributes are data collected by the drive about the current or past operation of that drive. The desire is to find attributes that are effective as predictors of failure. Most Attributes are normalized between 100 (the best value) and 1 (the worst value). The Threshold is set so that it will be crossed by bad drives and never crossed by good drives. Some Attributes may not be good indicators of drive failure and have a zero threshold that will be impossible to cross.

Seagate supports the listed attributes. However, due to different build flags for different products, some attributes may be excluded. Finding the attribute number to be 0x0 means the end of attribute list. The following table defines the Attributes that are being collected in our current drives.

Table 2 – Seagate Attributes

Attribute Name	No.	Normalized Attribute Range	Attribute Threshold ¹	Status Byte Value ²	Pre-Fail Warranty ³	Notes
Raw Error Rate	1	1-166	6 Near Line=44	0Fh	Customer Specific	Updated online from Avalanche Onward
Spin Up Time	3	1-100	0	03h	No	No threshold.
Start/Stop Count	4	1-100	20	32h	Yes	
Retired Sectors Count	5	1-100	36	33h	Yes	64% of guaranteed available spares used
Seek Error Rate	7	1-100	30	0Fh	Yes	Threshold of 30
Power On Hours	9	1-100	0	32h	No	No threshold.
Spin Retry Count	10 Ah	1-100	97	13h	Yes	
Drive Power Cycle Count	12 Ch	1-100	20	32h	Yes	No threshold
Attribute ID 184: Reported IOEDC errors	184 B8h	1-100	99	32h	No	
Reported Uncorrectables	187 BBh	1-100	0	32h	No	
Command Timeout Count	188 BCh	1-100	0	32h	No	
High Fly Writes	189 BDh	1-100	0	3Ah	No	
Airflow Temperature	190 BEh	-127 to 127	45	22h	No	
Temperature	194 C2h	-127 to 127	0	22h	No	Degrees C. New in Vail.
ECC On the Fly Count	195	1-166	0	1Ah	No	

¹ The threshold values in this table are default values. Refer to the individual programs for the current settings.

² The status flag in this table are default values. Refer to the individual programs for the current settings.

³ Bit 0 of Status byte indicates if the attribute is pre-fail Warranty. 1 is yes.

	C3h					
Pending-Sparing Count	197 C5h	1-100	0	12h	No	
Uncorrectable Sectors Count	198 C6h	1-100	0	10h	No	
Ultra DMA CRC Error Count	199 C7h	1-200	0	3Eh	No	R-Errs in SATA drives

3.0 Normalization Calculations

The “**Normalized**” Attribute values can range from 1-255. Most range from 1-100. Higher numbers indicate a “healthier” attribute than low numbers.

Raw Usage - Different drive manufacturers use the 7 raw bytes of each attribute differently. Except in those cases where specific raw fields are defined in this document, attribute raw fields in Seagate drives contain Seagate-confidential data relating to healthy and/or error information, and may change even when no errors are present. Unless specific raw bytes are shown in this document, their contents are to be treated as indeterminate.

3.1 Attribute ID 1: Raw Error Rate

$$\text{Normalized Raw Error Rate} = 10 * \log_{10}(\text{NumberOfSectorsTransferredToOrFromHost} * 512 * 8 / (\text{Number of sectors requiring retries}))$$

Where the factor of 512*8 is to convert from sectors to bits. The attribute value is only computed when the number of bits in the "transferred bits" count is in the range 10^{10} to 10^{12} . The counts are cleared when Number Of Bits Transferred To Or From Host $> 10^{12}$. “Number of sectors requiring retries” does not count free retry or hidden retry. Normalized Raw Error Rate is evaluated to a number between 1 and 166.

Raw Usage

Raw [3 – 0] = Number of sector reads
Raw [6 - 4] = Number of read errors.

3.2 Attribute ID 3: Spin Up Time

Normalized Spin Up Time = 100 - average of the last 8 Spin Up Times
where Spin Up Time = minimum(30s, Actual Spin-up Time)

Raw Usage

No raw values.

3.3 Attribute ID 4: Start/Stop Count

Normalized Start/Stop Count = 100 - (LifetimeNumberOfSpinUps / 1024)

Raw Usage

Raw [3 – 0] = Spinup Count

3.4 Attribute ID 5: Retired Sectors Count

Normalized Retired Sectors Count = 100 - (100 * NumberOfRetiredSectors / (MinimumNumberOfSparesAvailable))

where MinimumNumberOfSparesAvailable depends on factory certification method, and available spare locations.

Raw Usage

Raw [1 – 0] = Current Retired Sector Count
Raw [3 - 2] = Current Retired Sector Count since SMART was last reset.

3.5 Attribute ID 7: Seek Error Rate

Monitor seeks requiring one or more retries. Exclude calibration seeks and seeks in system area.

Normalized Seek Error Rate = $10 * \log_{10}(\text{SeekCount} / \text{SeekErrors})$ which is only updated when SeekCount is in the range 10^6 to 10^9 . The counts are cleared when SeekCount = 10^9 . (Evaluates to a value from 1 to 100).

Raw Usage

Raw [3 – 0] = Number of seeks

Raw [5 – 4] = Number of seek errors

3.6 Attribute ID 9: Power On Hours

Normalized Power On Hours = $100 - (\text{PowerOnHours} / (\text{HOURS_PER_YEAR} / 10))$. This will decrement by one for each 1/10 of a year and will go to minimum value in 10 years.

Raw Usage

Raw [3 – 0] = Total # of power-on hours

Raw [6 – 4] = Total # of milliseconds since last hour increment

3.7 Attribute ID 10: Spin Retry Count

Normalized Spin Retry Count = $100 - \text{average number of retries in the last eight spin ups}$

Raw Usage

No raw values.

3.8 Attribute ID 12: Drive Power Cycle Count

Normalized Drive Power Cycle Count = $100 - (\text{NumberOfPowerCycles} / 1024)$

Raw Usage

Raw [3 – 0] = Power Cycle Count

3.9 Attribute ID 184: Reported IOEDC errors

Normalized Reported IOEDC Error = $100 - \text{Life Time IOEDC Errors}$.

This attribute tracks the number of IOEDC errors encountered during host initiated reads and writes.

Raw Usage

Raw [3 – 0] = LifeTime IOEDC Count

3.10 Attribute ID 187: Reported Uncorrectables

Normalized Reported Uncorrectables = $100 - \# \text{Uncorrectable Errors reported to the Host}$.

This attribute tracks the number of uncorrectable errors reported back to the host for all data access commands.

Raw Usage

Raw [1 – 0] = Total # of Uncorrectable Errors Reported to Host Max Hold FFFF

3.11 Attribute ID 188: Command Timeout Count

Normalized Command Timeout Count = 100 – Command Timeout Count .

This attribute tracks the number of command time outs as defined by an active command being interrupted by a HRESET and COMRESET or SRST or another command

The normalized value is only computed when the number of commands is in the range 10^3 to 10^4 . The CommandCount and ErroCount are cleared when Number Of Commands reaches 10^4 .

The error count used to compute normalized value is not reported in attribute Raw value. It is reported in vendor info area of Attribute sector, bytes 474:475.

If Command Timeout Count is > 99, normalize value of 1 is reported.

The initial Worst Value is set to 0xFD as a special case.

Raw Usage

Raw [1 – 0] = Total # of command timeouts, with Max hold of FFFFh

Raw [3 – 2] = Total # of commands with > 5 second completion, including those > 7.5 seconds

Raw [5 – 4] = Total # of commands with > 7.5 second completion

3.12 Attribute ID 189: High Fly Writes

Normalized High Fly Writes = 100 – Number of High Fly Writes detected

Raw Usage

Raw [1 – 0] = Total # of High Fly Writes detected Max Hold FFFF

3.13 Attribute ID 190: Airflow Temperature

Normalized Airflow Temperature = 100 – Degrees Celsius

Raw Usage

Raw [1 - 0] = Current Temperature in degrees Celsius

Raw [2] = Lowest temperature recorded during this power cycle

Raw [3] = Highest temperature recorded during this power cycle

Raw [5 – 4] = Number of Times attribute below Threshold
(i.e. “High Temperature” conditions). Max Hold FFFF

3.14 Attribute ID 194: Temperature

Normalized Temperature = Raw Temperature in Celsius + Temperature Variation, which give a good correlation to the HDA Temperature.

Raw Usage

Raw [1 – 0] = Current Temp

Raw [5 – 4] = Worst case Coldest Temperature

3.15 Attribute ID 195: ECC On the Fly Count

Normalized ECC On the Fly Count = $10 * \log_{10}(\text{NumberOfSectorsTransferredToOrFromHost} * 512 * 8 / (\text{Number of On-The-Fly ECC corrected sectors}))$ where the factor of $512*8$ is to convert from sectors to bits. The attribute value is only computed when the number of bits in the "transferred bits" count is in the range 10^{10} to 10^{12} . The counts are cleared when $\text{NumberOfSectorsTransferredToOrFromHost} \geq 10^{12}$.

Raw Usage

Raw [3 – 0] = Number of Sector reads

Raw [6 - 4] = Number of ECC OTF errors .

3.16 Attribute ID 197: Pending-Sparing Count

Normalized Pending-Sparing Count = $100 - (100 * \text{PendingSectorCount} / \text{DefectTableEntries})$

Raw Usage

Raw [1 – 0] = Current Pending Spare Count

Raw [3 - 2] = Current Pending Spare Count since SMART was last reset.

3.17 Attribute ID 198: Uncorrectable Sectors Count

Normalized This attributes is the same as attribute 197 Pending-Sparing Count.

Raw Usage

Raw [3 – 0] = Current uncorrectable sector Count

3.18 Attribute ID 199: Ultra DMA CRC Error Count

Normalized Ultra DMA CRC Error Count = $200 - (\text{OfCRCErrors} * \text{SampleSize} / \text{\#SectorsTransferred})$ where $\text{SampleSize} = 8000$. The attribute is computed if sectors transferred is $\geq \text{SampleSize}$.

Note – Replace CRC errors with R-Errs for SATA drives.

Raw Usage

Raw [3 – 0] = Current CRC/R_Errs Error Count

4.0 SMART Temperature Values

There are multiple areas in the SMART attributes to read the temperature. Table 3 below outlines which attributes contain these temperature values and their meaning.

Table 3 – Temperatures Available

Current Temp (°C)	Non-Volatile		This Power-cycle	
	Hottest	Coldest	Hottest	Coldest
Attrib194.Nominal Attrib194.Raw[0] Attrib190.Raw[0] 100- Attrib190.Nominal	Attrib194.Worst	Attrib194.Raw[4]	Attrib190.Raw[3]	Attrib190.Raw[2]