The SMART Command Feature Set

Introduction

The SMART command (0xB0) is the self-monitoring, analysis, and reporting technology (SMART) feature set.

The intent of the SMART command feature set is to protect user data and minimize the likelihood of 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 feature set devices attempt to predict the likelihood of near-term degradation or fault condition. Providing the host system the knowledge of a negative reliability condition allows the host system to warn the user of the impending risk of a data loss and advise the user of appropriate action. Support of this feature set is indicated in the IDENTIFY DEVICE data.

If the SMART feature set is implemented, these commands will be implemented:
- SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE
- SMART ENABLE OPERATIONS
- SMART DISABLE OPERATIONS
- SMART RETURN STATUS

If the SMART feature set is implemented, these commands are optional:
- SMART READ DATA
- SMART EXECUTE OFF-LINE IMMEDIATE
- SMART READ LOG
- SMART WRITE LOG

The SMART feature set implemented by Micron:
- SMART READ DATA
- SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE
- SMART ENABLE OPERATIONS
- SMART DISABLE OPERATIONS
- SMART RETURN STATUS
- SMART EXECUTE OFF-LINE IMMEDIATE
- SMART READ LOG
- SMART WRITE LOG
- SMART READ WARRANTY FAILURE THRESHOLDS

Table 1:   SMART Commands

Command	Feature	Sector Count	LBA Low	LBA Middle	LBA High	Drive Head	Command
SMART READ DATA	0xD0	0x01	XX	0x4F	0xC2	0xA0	0xB0
SMART READ WARRANTY FAILURE THRESHOLDS	0xD1	0x01	XX	0x4F	0xC2	0xA0	0xB0
SMART ENABLE ATTRIBUTE AUTOSAVE	0xD2	0xF1	XX	0x4F	0xC2	0xA0	0xB0
SMART DISABLE ATTRIBUTE AUTOSAVE	0xD2	0x00	XX	0x4F	0xC2	0xA0	0xB0
SMART EXECUTE OFF-LINE IMMEDIATE	0xD4	Sub-cmd	XX	0x4F	0xC2	0xA0	0xB0
SMART READ LOG	0xD5	Sec count	Log addr	0x4F	0xC2	0xA0	0xB0
SMART WRITE LOG	0xD6	Sec count	Log addr	0x4F	0xC2	0xA0	0xB0
SMART ENABLE OPS	0xD8	XX	XX	0x4F	0xC2	0xA0	0xB0
SMART DISABLE OPS	0xD9	XX	XX	0x4F	0xC2	0xA0	0xB0
SMART RETURN STATUS	0xDA	XX	XX	0x4F	0xC2	0xA0	0xB0

Command Interface with Host

Communication to or from the device is through the data register and command block registers (see the table below).

Table 2:   Register Addressing

Offset Address	Read	Write	Value Type
0x00	Data	Data	Word
0x01	Error	Feature	Byte
0x02	Sector count	Sector count	Byte
0x03	LBA low	LBA low	Byte
0x04	LBA middle	LBA middle	Byte
0x05	LBA high	LBA high	Byte
0x06	Drive head	Drive head	Byte
0x07	Status	Command	Byte

Notes: 1. Input = from host to device; output = from device to host

SMART Read Data and Attributes

Protocol PIO Data-In

Input

Register	7	6	5	4	3	2	1	0
Feature	0xD0							
Sector count	0x01							
LBA low	XX							
LBA middle	0x4F							
LBA high	0xC2							
Drive head	1	0	1	0	0	0	0	0
Command	0xB0							

2

Normal Output

Register	7	6	5	4	3	2	1	0
Error				XX				
Sector count				XX				
LBA low				XX				
LBA middle				XX				
LBA high				XX				
Drive head				XX				
Status				0x50				

Description

This command returns the device SMART data structure to the host.

Vendor Specific Data Bytes 0-361

Byte Offset	Length (Bytes)	Attribute ID	Description
0	2	0x0010	SMART structure version
2 + (12 × 0)	12	0xXX	Attribute entry 1
2 + (12 × 1)	12	0xXX	Attribute entry 2
2 + (12 × n)	12	0xXX	Attribute entry n
…	…	…	…
2 + (12 × 29)		(Reserved)	

Table 3: Attribute Table Format

Length (Bytes)	Description	Value
1	Attribute ID	0x01, 0x09, 0x12, and so forth...
2	Flags: Bit 0 - Warranty Bit 1 - Offline Bit 2 - Performance Bit 3 - Error rate Bit 4 - Event count Bit 5 - Self-preservation Bits 6–15 - Reserved	Varies by attribute
1	Current Value	Current value of the attribute, normalized from 1 to 100 (0x01-0x64), if that has meaning for the attribute
1	Worst value	Lowest normalized value of the attribute, from 1 to 100 (0x01-0x64), if that has meaning for the attribute
4	Data	32 bits of raw attribute data
2	Attribute specific	Some attributes use these two bytes to store raw data
1	Threshold	Currently all attribute has a threshold of 0 (no threshold)

4

Table 4: SMART Attribute Summary

AttribID	HexID	Name	SMART Trip	Implementation	Marketing
1	0x01	Raw Read Error Rate	No	Raw CECC + UECC correction events Normalized values are errors per MB	Raw rate of media errors per megabyte of data over the SATA interface
5	0x05	Re-allocated Sectors Count	Yes (Warranty trip) (Rate metric)	New failing block count	
9	0x09	Power On Hours Count	No	Lifetime hours powered on	Total number of operation hours from the time the device leaves the factory
12	0x0C	Power Cycle Count	No	Count of power cycles	True power cycles, excluding power mode commands
170	0xAA	Grown Failing Block Count	Yes (Warranty trip) (Rate metric)	FTL reserved block count (Total BB - OTP BB)	This attribute tracks the number of blocks/pages utilized to replace bad blocks. This is based on specified NAND part/die
171	0xAB	Program Fail Count	No	# of NAND program status fails [16:0] PROGRAM failure events; maximum = 0xFFFF	This attribute is used to count the number of NAND program fails
172	0xAC	Erase Fail Count	No	# of NAND Erase Status fails [16:0] ERASE failure events; maximum = 0xFFFF	This attribute is used to count the number of NAND program erase failures
173	0xAD	Wear Leveling Count	Yes (Warranty trip) (Rate metric)	Average erase count of all good blocks	
174	0xAE	Unexpected Power Loss Count	No	Internal table rebuild count, for example, the DPT block is corrupted or the last page is corrupted	This attribute is used to count the number of times unexpected power loss occurs
181	0xB5	Non-4k Aligned Access	No	LBA % 8 != 0 and sector counts % 8 != 0 Raw data (32 bits): [16:0] unaligned reads counter [32:17] unaligned writes counter [48:33] sum of the other two counters All counters represent the internal raw value divided by 60,000 and stop at 0xFFFF	This attribute tracks the number of user data accesses (both reads and writes) where LBAs are not 4KB aligned (LBA % 8 != 0) or where size is not modulus 4KB (block count != 8), assuming logical block size (LBS) = 512B)
183	0xB7	SATA Interface Downshift	No	Count of SATA Phy downshifts from 6.0G -> 3.0G or 3.0G -> 1.5G	This attribute is used to count the number of interface downshifts encountered between the host and the device
187	0xBB	Reported Uncorrectable Errors	No	SMART UECC count — smart.CumUECC	This attribute tracks the number of uncorrectable (UNC) media errors {51h 10h, 51h 44h, 51h 01h} reported back to the host for all data access commands. Errors encountered by drive self test (DST) are NOT included

Table 4:   SMART Attribute Summary (Continued)

AttribID	HexID	Name	SMART Trip	Implementation	Marketing
188	0xBC	Command Timeout	No	Upon any HRESET, COMRESET, SRST: adds active ATA commands in the queue to a lifetime counter - Mt_SmartCheckAtaCommandTimeout()	This attribute tracks the number of command time outs as defined by an active command being interrupted by a HRESET, COMRESET, SRST, or other command
189	0xBD	Factory Bad Block Count	No	OTP bad block count	
196	0xC4	Re-allocation Event Count	No	New failing block count: each new failing block will be re-allocated with a free block	
197	0xC5	Current Pending Sector Count	No	Will always be 0 as error handling will be done at the field	
198	0xC6	Smart Off-line Scan Uncorrectable Error Count	No	Uncorrectable error count detected during SMART off-line scan	
199	0xC7	Ultra DMA CRC Error Rate	No	All SATA (general) FIS CRC errors	The rate of CRC errors occurring in Ultra ATA transfers to or from the host. See the Ultra ATA CRC specification for Normalized and Worst Ever definitions
202	0xCA	Percentage Of The Rated Lifetime Used	Yes (Non-warranty trip)	The average erase count of all blocks on Channel 0 CE 0 divided by the specified MaxEraseCount (5k for MLC or 100k for SLC), reported as a percentage from 0 to 100% (0x00 to 0x64)	Block erase counts are summed across one CE. The normalized total block erase count is between 0–100 using integer division. Divide by 50 for MLC NAND and 1000 for SLC NAND. The return value is the difference between the calculated number and 100
206	0xCE	Write Error Rate	No	# of NAND program status fails per MB of SATA data written	Raw error rate when writing

SMART Attribute: Raw Read Error Rate (1/01h)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

The current value field is calculated in Mt_SmartCalcReadErrorRate().

The value it returns is the total number of correctable and uncorrectable ECC error events (event is a correction per AU) divided by the total number of megabytes (MB) read over the life of the drive, normalized as a percentage value from 1% to 100% (0x01 to 0x64). The total bytes read is calculated from the sector count field in ATA READ commands.

Note that ECC errors occurring while reading non-user data will still contribute to this rate.

Worst Value (8 bits)

The worst value of this field is the lowest value of the Current Value field ever calculated over the life of the drive, always between 1% and 100% (0x01 to 0x64).

Raw Data (32 bits)

The data field holds the raw sum of correctable and uncorrectable ECC error events over the life of the drive. If this ever exceeds 0xFFFFFFFF, this value will wrap around.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Re-Allocated Block Count (5/05h)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

> This value is hard coded to 100% (0x64).

Raw Data (32 bits)

> This value is calculated via Mt_CalcReservedBlocksUsed().

> This value gives the total bad block count of the drive minus the number of one-time programmable (OTP) bad blocks.

Reserved (24 bits)

> The three reserved bytes are set to 0.

Threshold (8 bits)

> The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Power-On Hours Count (9/09h)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

> This value is hard coded to 100% (0x64).

Worst Value (8 bits)

> This value is hard coded to 100% (0x64).

Raw Data (32 bits)

> This value gives the raw number of hours that the device has been online over its life.

> Calculation: MetaInfo.smart.PowerOnTime / 60

Reserved (24 bits)

> The three reserved bytes are set to 0.

Threshold (8 bits)

> The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Power Cycle Count (12/0Ch)

- Attribute Flags (0x32)
- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

This value gives the raw number of power cycle events that this drive has experienced.

This value is stored in MetaInfo.smart.PowerOnCycles;

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: New Failing Block Count (170/AAh)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

This value is calculated via Mt_CalcReservedBlocksUsed().

This value gives the total bad block count of the drive minus the number of OTP-bad blocks.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Program Fail Count (171/ABh)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is calculated as the sum of all PROGRAM failure events during drive life divided by the total number of pages in the drive, normalized to a percentage, 1 to 100 (0x01 to 0x64).

Worst Value (8 bits)

This value holds the lowest ever Current Value seen. It should always equal the current value.

Raw Data (32 bits)

The lower 16 bits of this value contains the raw number of PROGRAM failure events. If this value ever would exceed 0xFFFF, it will stay at 0xFFFF.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Erase Fail Count (172/ACh)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is calculated as the sum of all ERASE failure events during drive life divided by the total number of blocks in the drive, normalized to a percentage, 1 to 100 (0x01 to 0x64).

Worst Value (8 bits)

This value holds the lowest ever Current Value seen. It should always equal the current value.

Raw Data (32 bits)

The lower 16 bits of this value contains the raw number of ERASE failure events. If this value ever would exceed 0xFFFF, it will stay at 0xFFFF.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attributes: Block Wear Leveling Count/Average Block Erase Count (173/ADh)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

Average erase count of all good blocks.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Unexpected Power Loss Count (174/AEh)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

The total number of times that the device has been power cycled unexpectedly.

This is determined by the number of times the operating system issues IDENTIFY DEVICE without issuing an IDLE IMMEDIATE or FLUSH CACHE command (typically issued when the volume is unmounted).

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Non-4K Aligned Access Count (181/B5h)

Attribute Flags (0x12)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 0

Current Value (8 bits)

This value is calculated by Mt_SmartCalculateUnalignedRate().

An unaligned access is defined as an attempt to read or write via ATA command which specifies a start LBA which is not aligned to a page boundary, or which specifies a non-page-aligned number of sectors to read or write. A command that does both will cause the associated counters to increment twice. A separate counter is maintained for reads and writes; this attribute reports both counter values.

The reported value is a close approximation to the running average of the number of unaligned read/write accesses over the last one million read/write commands, normalized to 1% to 100% (0x01 to 0x64).

Worst Value (8 bits)

This value is set to the lowest Current Value ever seen (and gives the highest ever percentage of unaligned reads and writes over a given sequence of one million commands seen by the device).

Raw Data (32 bits)

The low order 16 bits of the raw data contain the total unaligned reads counter, divided by 60,000, with a ceiling value of 0xFFFF.

The high order 16 bits of the raw data contain the total unaligned writes counter, divided by 60,000, with a ceiling value of 0xFFFF.

Reserved (24 bits)

The first two reserved bytes contain the sum total of the unaligned read and unaligned write counters, divided by 60,000, with a ceiling value of 0xFFFF. The division on the sum is done after summing the raw values of reads and writes- the sum of the two counters may appear higher than summing normalized reads and writes.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: SATA Interface Downshift (183/B7h)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

At completion of speed negotiation between host and device, the firmware records the value of the newly negotiated speed. This value is compared to the previously recorded value; if the new value is lower than the previous, a downshift has occurred and the downshift counter is incremented.

The downshift counter is stored in the global variable SmartSataSpeedDownshiftRate.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Reported Uncorrectable Errors (187/BBh)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

This value is the total number of ECC correction failures reported by the sequencer.

This value is stored in MetaInfo.smart.CumUECC counter. If it ever exceeds 0xFFFFFFFF, then this counter will wrap around.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Command Timeouts (188/BCh)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

This counter is incremented by the number of outstanding commands when the host issues a soft reset, host reset, or a comreset. This value is stored in MetaInfo.smart.CommandTimeout.

The raw data holds the value of this counter. If it ever exceeds 0xFFFFFFFF, it will wrap around.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attributes: Factory Bad Block Count (189/BDh)

Attribute Flags (0xE)

- Warranty = 0
- Offline = 1
- Performance = 1
- Error rate = 1
- Event count = 0
- Self-preservation = 0

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

OTP Bad block count.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attributes: Reallocation Event Count (196/C4h)

TN-FD-03: The SMART Command Feature Set
SMART Read Data and Attributes

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

This value is calculated via Mt_CalcReservedBlocksUsed().

This value gives the total bad block count of the drive minus the number of OTP-bad blocks.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attributes: Current Pending Sector Count (197/C5h)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

Will always be 0 because reallocation will be done on the fly.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attributes: SMART Off-Line Scan Uncorrectable Error Count (198/C6h)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

Uncorrectable errors detected during SMART off-line scan.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Ultra DMA CRC Error Rate (199/C7h)

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error rate = 0
- Event count = 1
- Self-preservation = 1

Current Value (8 bits)

This value is hard coded to 100% (0x64).

Worst Value (8 bits)

This value is hard coded to 100% (0x64).

Raw Data (32 bits)

Gives the number of captured FIS interface general CRC errors over the life of the drive, for both reads and writes, since the most recent power cycle.

This counter is stored in the global variable SmartCrcErrorRate.

If this counter ever reaches 0xFFFFFFFF, it will wrap around.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Attribute: Percentage Lifetime Used (202/CAh)

Attribute Flags (0x18)

- Warranty = 0
- Offline = 0
- Performance = 0
- Error rate = 1
- Event count = 1
- Self-preservation = 0

Current Value (8 bits)

This value gives the threshold inverted value of the data value below. That is, if 30% of the lifetime has been used, this value will report 70%. If the value is 0% (100% lifetime used), it is adjusted to 1% to avoid causing a SMART trip. The calculation uses 100k cycle SLC and 5k cycle MLC.

Worst Value (8 bits)

This field holds the same value as the Current Value, since the Current Value is mono-tonically decreasing.

Data (32 bits)

The average erase count of all blocks on Channel 0 CE 0 divided by the specified MaxEraseCount (10k for MLC or 100k for SLC), reported as a percentage from 0 to 100% (0x00 to 0x64).

$$PercentLifeUsed = \frac{\Sigma EraseCounts}{\Sigma Blocks \bullet MaxEraseCount}$$

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, meaning that it will never cause a SMART threshold trip.

SMART Attribute: Write Error Rate (206/CEh)

Attribute Flags (0x07)

- Warranty = 0
- Offline = 1
- Performance = 1
- Error rate = 1
- Event count = 0
- Self-preservation = 0

Current Value (8 bits)

This value gives the normalized number of PROGRAM failure events over the number of megabytes that the user has attempted to write throughout the life of the drive as specified by the LBA and sector count fields of ATA write commands, as a percentage, 1% to 100% (0x01 to 0x64).

Worst Value (8 bits)

This field gives the lowest calculated value in the history of the device for the Current Value calculation above, 1%-100% (0x01 to 0x64).

Data (32 bits)

The lower 16 bits of this field report the raw number of PROGRAM failures divided by 60000. If the value ever reaches 0xFFFF, it will remain there thereafter.

Reserved (24 bits)

The three reserved bytes are set to 0.

Threshold (8 bits)

The threshold for this attribute is set to 0, which means the threshold will never cause a SMART threshold trip.

SMART Enable Attribute Autosave

Protocol PIO Non-Data

Input

Register	7	6	5	4	3	2	1	0
Feature	0xD2							
Sector count	0xF1							
LBA low	XX							
LBA middle	0x4F							
LBA high	0xC2							
Drive head	1	0	1	0	0	0	0	0
Command	0xB0							

Normal Output

Register	7	6	5	4	3	2	1	0
Error				XX				
Sector count				XX				
LBA low				XX				
LBA middle				XX				
LBA high				XX				
Drive head				XX				
Status				0x50				

Description

This command enables the optional attribute auto save feature of the device.

This command may allow the device, after some vendor specified even, to save the device updated attributes to nonvolatile memory. The state of the attribute autosave feature will be preserved by the device during all power and reset events.

SMART Enable/Disable Attribute Autosave

Protocol PIO Non-Data

Input

Register	7	6	5	4	3	2	1	0
Feature				0xD2				
Sector count				0x00 or 0xF1				
LBA low				XX				
LBA middle				0x4F				
LBA high				0xC2				
Drive head	1	0	1	0	0	0	0	0
Command				0xB0				

Normal Output

Register	7	6	5	4	3	2	1	0
Error				XX				
Sector count				XX				
LBA low				XX				
LBA middle				XX				
LBA high				XX				
Drive head				XX				
Status				0x50				

Description

If sector count is 0x00, then the SMART autosave attribute is disabled.

If sector count is 0xF1, then the SMART autosave attribute is enabled.

This command has no practical effect on our drive at this point.

SMART Enable Operations

Protocol PIO Non-Data

Input

Register	7	6	5	4	3	2	1	0
Feature				0xD8				
Sector count				XX				
LBA low				XX				
LBA middle				0x4F				
LBA high				0xC2				
Drive head	1	0	1	0	0	0	0	0
Command				0xB0				

Normal Output

Register	7	6	5	4	3	2	1	0
Error				XX				
Sector count				XX				
LBA low				XX				
LBA middle				XX				
LBA high				XX				
Drive head				XX				
Status				0x50				

Description

This command enables access to all SMART capabilities within the device. The state of SMART enabled will be preserved by the device during all power and reset events.

SMART Disable Operations

Protocol PIO Non-Data

Input

Register	7	6	5	4	3	2	1	0
Feature				0xD9				
Sector count				XX				
LBA low				XX				
LBA middle				0x4F				
LBA high				0xC2				
Drive head	1	0	1	0	0	0	0	0
Command				0xB0				

Normal Output

Register	7	6	5	4	3	2	1	0
Error				XX				
Sector count				XX				
LBA low				XX				
LBA middle				XX				
LBA high				XX				
Drive head				XX				

Register	7	6	5	4	3	2	1	0
Status				0x50				

Description

This command disables access to all SMART capabilities within the device. After receipt of this command by the device, with the exception of SMART ENABLE OPERATIONS command, all other SMART commands including SMART DISABLE OPERATIONS commands are disabled and will be command aborted by the device. The state of SMART disabled will be preserved by the device during all power and reset events.

Any off-line self-test/data collection will be aborted too.

SMART Return Status

Protocol PIO Non-Data

Input

Register	7	6	5	4	3	2	1	0
Feature				0xDA				
Sector count				XX				
LBA low				XX				
LBA middle				0x4F				
LBA high				0xC2				
Drive head	1	0	1	0	0	0	0	0
Command				0xB0				

Normal Output

Register	7	6	5	4	3	2	1	0
Error				XX				
Sector count				XX				
LBA low				XX				
LBA middle				0x4F				
LBA high				0xC2				
Drive head				XX				
Status				0x50				

Trip Output

Register	7	6	5	4	3	2	1	0
Error				XX				
Sector count				XX				
LBA low				XX				
LBA middle				0xF4				
LBA high				0x2C				
Drive head				XX				
Status				0x50				

Description

In the normal output case, all SMART attribute values are currently higher than the threshold value associated with that attribute.

In the trip output case, at least a single SMART attribute value has fallen below the threshold value associated with that attribute.

SMART Read Warranty Thresholds

Protocol PIO Data-In

Input

Register	7	6	5	4	3	2	1	0
Feature	0xD1							
Sector count	XX							
LBA low	XX							
LBA middle	0x4F							
LBA high	0xC2							
Drive head	1	0	1	0	0	0	0	0
Command	0xB0							

Normal Output

Register	7	6	5	4	3	2	1	0
Error	XX							
Sector count	XX							
LBA low	XX							
LBA middle	XX							
LBA high	XX							
Drive head	XX							
Status	0x50							

Description

Returns a sector in the following format, n, varying from 0 to 29, one for each table entry.

Table 5: SMART Atrribute Entry Format

Byte Offset	Length (bytes)	Contents ID	Description
0	2	0x0010	SMART structure version
2 + (12 × n)	1	AttributeID	The attribute ID
2 + (12 × n) + 1	1	Threshold	The threshold value for it
2 + (12 × n) + 2	10	0x00	Reserved
362	18	0x00	Reserved
380	131	VU	VU space
511	1	Checksum	Two's complement checksum of preceding 511B

SMART Execute Off-Line Immediate

Protocol PIO Non-Data

Input

Register	7	6	5	4	3	2	1	0
Feature				0xD4				
Sector count				XX				
LBA low				subcommand				
LBA middle				0x4F				
LBA high				0xC2				
Drive head	1	0	1	0	0	0	0	0
Command				0xB0				

Normal Output

Register	7	6	5	4	3	2	1	0
Error				XX				
Sector count				XX				
LBA low	XX							
LBA middle				XX				
LBA high				XX				
Drive head				XX				
Status				0x50				

Description

Allow the host to request various self tests. Please refer to ATA8-ACS2(T13/2015-D Revision 2) 7.55.5 for more information.

The implement will resume off-line self-test upon completing a new host command unless the command is SMART DISABLE OPERATIONS, SMART ABORT OFF-LINE MODE SELF-TEST, IDLE IMMEDIATE, STANDBY IMMEDIATE, or SLEEP.

SMART Logging

Supported SMART/GPL (General Purpose Logging) Logs

Table 6:   Supported SMART/GPL Logs

Log Address	Page Count	Log Name	R/W	Access
00h	1	SMART Log Directory	RO	SMART/GPL
01h	1	Summary SMART Error Log	RO	SMART
02h	51	Comprehensive SMART Error Log	RO	SMART
03h	16383	Extended Comprehensive SMART Error Log	RO	GPL
04h	255	Device Statistics	RO	SMART/GPL
06h	1	SMART Self-Test Log	RO	SMART
07h	3449	Extended SMART Self-Test Log	RO	GPL
09h	1	Selective Self-Test Log	R/W	SMART

Table 6:   Supported SMART/GPL Logs

Log Address	Page Count	Log Name	R/W	Access
10h	1	NCQ Command Error	RO	GPL
11h	1	SATA Phy Event Counters	RO	GPL
21h	1	Write Stream Error Log	RO	GPL
22h	1	Read Stream Error Log	RO	GPL
80h-9Fh	16 each	Host Vendor Specific Logs	R/W	SMART/GPL
A0h		Error Log [VU]	RO	SMART/GPL
E0h	1	SCT Command/Status	R/W	SMART/GPL
E1h	1	SCT Data Transfer	R/W	SMART/GPL

Please refer to Annex A of ACS-2 for detailed description on these logs.

For Log Address 6/7, that is, SMART self-test logs, please note that the entry is logged once the self-test is started but not until the test is completed.

SMART Read Log

Protocol PIO Data-In

Input

Register	7	6	5	4	3	2	1	0
Feature				0xD5				
Sector count				01				
LBA low				Log address				
LBA middle				0x4F				
LBA high				0xC2				
Drive head	1	0	1	0	0	0	0	0
Command				0xB0				

Normal Output

Register	7	6	5	4	3	2	1	0
Error				XX				
Sector count				0x01				
LBA low				XX				
LBA middle				XX				
LBA high				XX				
Drive head				XX				
Status				0x50				

SMART READ Log via GPL (READ LOG EXT)

Protocol PIO Data-In

48-bit Command

Name	Description		
Feature	XX		
Count	0x01		
LBA	Bit	Description	Value
	47:40	Reserved	0x00
	39:32	Page # (15:8)	XX (ignored)
	31:16	Reserved	0x00
	15:8	Page # (7:0)	XX (ignored)
	7:0	Log address	Refer to 10.3.1 and 10.3.2
Device	0x00		
Command	(7:0) 0x2F		

SMART Write Log

Protocol PIO Data-In

Input

Register	7	6	5	4	3	2	1	0
Feature	0xD6							
Sector count	Log Address							
LBA low	XX							
LBA middle	0x4F							
LBA high	0xC2							
Drive head	1	0	1	0	0	0	0	0
Command	0xB0							

Normal Output

Register	7	6	5	4	3	2	1	0
Error	XX							
Sector count	0x01							
LBA low	XX							
LBA middle	XX							
LBA high	XX							
Drive head	XX							
Status	0x50							

Reference

1. T13/2015-D, "Information technology - ATA/ATAPI Command Set - 2 (ACS-2)," Revision 2, American National Standard of Accredited Standards Committee INCITS, August 3, 2009.

Revision History

- Initial release.