Technical Note

SMART Attributes for the C400 SSD

Introduction

This document provides a list with technical descriptions of SMART parameters recorded by the Micron C400 solid state drive (SSD).

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 drive. By monitoring and storing critical performance and calibration parameters, the SMART feature set attempts to predict the likelihood of near-term degradation or a fault condition. Providing the host system with 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.

This technical note applies to all C400 firmware releases for the 1.8-inch, 2.5-inch, and mSATA configurations (C400-MTFDDAxxxxMAM). It is not applicable to other Micron products, and may not be applicable to drives installed as original equipment in a desktop or notebook computer. If your product has been purchased as part of a computer system, please contact the computer manufacturer to verify SMART definitions.

Table 1: SMART Attribute Definitions

ID	Description
1	Raw Read Error Rate
5	Reallocated Block Count
9	Power-On Hours Count
12	Device Power-Cycle Count
170	New Failing-Block Count
171	Program-Fail Count
172	Erase-Fail Count
173	Average Block-Erase Count
174	Unexpected Power-Loss Count
181	Non-Page-Aligned Access Count
183	SATA Interface Downshift
184	End-to-End Error Detection
187	Uncorrectable Errors Count
188	Command Timeout Count
189	Factory Bad-Block Count
194	Enclosure Temperature (not used in most C400 configurations)
195	Cumulative ECC Bit-Correction Count
196	Reallocation Event Count
197	Current Pending-Sector Count
198	SMART Off-line Scan Uncorrectable-Error Count
199	Ultra-DMA CRC Error Count
202	Percent Lifetime Used
206	Write Error Rate

SMART ID 1: Raw Read Error Rate

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 the total number of correctable and uncorrectable ECC error events divided by the total host pages read over the life of the drive.

Note that ECC errors occurring while reading non-user data will still contribute to this rate. The Current Value will not be calculated and remains as 0x64 until the host read page count is not less than (100,000 × total block count ÷ 2).

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 (48 bits)

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

Reserved/Threshold (8 bits)

The threshold for this attribute is set to 0x32 (50%).

SMART ID 5: Reallocated Block Count

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 displayed as a ratio of unused reserved blocks divided by the total available reserved (also called spare) blocks. It is normalized as a percentage value from 1% to 100% (0x01 to 0x64).

Worst Value (8 bits)

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

Raw Data (48 bits)

This value is calculated to be the grown NAND Flash bad-block count multiplied by the Block_Sector_Count, which is 256 x 8 for 64Gb NAND (32GB, 64GB, and 128GB) or 256 x 16 for 128Gb NAND (256GB and 512GB).

Reserved/Threshold (8 bits)

The threshold for this attribute is set to 0x0a, meaning the threshold is set to 90% of the total available reallocated sectors used.

SMART ID 9: Power-On Hours Count

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 (48 bits)

This value gives the raw number of hours that the drive has been under power over its lifetime. It does not count time in which the drive is in DIPM SLEEP mode.

Calculation: Total_Power_On_Minutes ÷ 60 in whole-number increments.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 12: Device Power-Cycle Count

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 (48 bits)

This value gives the raw number of power-cycle events experienced over the life of the drive.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 170: New Failing-Block Count

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error Rate = 0
- Event Count = 1
- Self-Preservation = 1

Current Value (8 bits)

100 - (unused reserved blocks ÷ total reserved blocks) × 100. It is normalized as a percentage value from 1% to 100% (0x01 to 0x64).

Worst Value (8 bits)

This is the lowest value recorded over the life of the device.

Raw Data (48 bits)

This value gives the total bad-block count recorded since leaving the factory. It does not include the number of blocks marked as unusable during the manufacturing process.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 171: Program-Fail Count

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error Rate = 0
- Event Count = 1
- Self-Preservation = 1

Current Value (8 bits)

100 - ((# of program fails) ÷ (# of program fails + the number of current reserved blocks)) × 100.

Worst Value (8 bits)

This value is the lowest Current Value recorded over the life of the drive.

Raw Data (48 bits)

This value contains the raw number of PROGRAM failure events over the life of the drive. A program fail results from an unsuccessful attempt to write data to a NAND page.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 172: Erase-Fail Count

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error Rate = 0
- Event Count = 1
- Self-Preservation = 1

Current Value (8 bits)

100 - (((# of erase fails) ÷ (# of erase fails + # of current reserved blocks)) × 100).

Worst Value (8 bits)

This value is the lowest Current Value recorded over the life of the drive.

Raw Data (48 bits)

This value contains the raw number of ERASE failure events over the lifetime of the device. An erase fail results from an unsuccessful attempt to erase data from a NAND block.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 173: Average Block-Erase Count

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error Rate = 0
- Event Count = 1
- Self-Preservation = 1

Current Value (8 bits)

100 - (average erase count ÷ BLOCK_LIFE) × 100.

This is normalized as a percentage value from 1% to 100% (0x01 to 0x64). BLOCK_LIFE is a hard-coded value that corresponds to the Erase Count Specification for the NAND components. Refer to the NAND component data sheets to determine this number.

Worst Value (8 bits)

This value is the lowest recorded Current Value.

Raw Data (48 bits)

This value is the average erase count of all good blocks across the NAND array, rounded to the nearest whole number.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 174: Unexpected Power-Loss Count

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 (48 bits)

This value is the total number of times the drive has been power-cycled unexpectedly. If the host system does not issue an ATA power mode command (STBY, STBI, or SLEEP) before shutting off power to the drive, an unexpected power loss can occur.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 181: Non-Page-Aligned Access Count

Unaligned operations are defined as operations for which the starting offset does not align with a physical NAND page boundary. Most modern operating systems such as Windows® 7 and Mac® OS-X will do most operations on page boundaries, providing the most efficient use of NAND-based SSDs.

Attribute Flags (0x22)

- Warranty = 1
- Offline = 0
- Performance = 0
- Error Rate = 0
- Event Count = 1
- Self-Preservation = 0

Current Value (8 bits)

100 - #non-physical page aligned access count ÷ 1,000,000 data accesses.

Worst Value (8 bits)

This value is the lowest recorded Current Value.

Raw Data (48 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 middle order 16 bits of the raw data contain the total unaligned writes counter, divided by 60,000, with a ceiling value of 0xFFFF.

The high order 16 bits of the raw data 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.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 183: SATA Interface Downshift

This attribute tracks the total number of time the device negotiates with the host system to an interface speed lower than SATA 6.0 Gb/s.

Attribute Flags (0x32)

- Warranty = 1
- Offline = 0
- 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 (48 bits)

This 48-bit value is the count of downshift.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 184: End-to-End Error Detection

Attribute Flags (0x32)

- Warranty = 1
- Offline = 0
- Performance = 0
- Error Rate = 0
- Event Count = 1
- Self-Preservation = 1

Current Value (8 bits)

(100 - # of non-recoverable errors - (recoverable errors ÷ 2)) ÷ 100.

Worst Value (8 bits)

This value is the same as the Current Value.

Raw Data (48 bits)

This 48-bit value is the count of end-to-end correction events.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 187: Uncorrectable Errors Count

Attribute Flags (0x32)

- Warranty = 1
- Offline = 0
- 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 (48 bits)

This value is the total number of UECC errors reported by the sequencer. This reflects the number of hard data errors, which cannot be recovered by the drive's error correction code.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 188: Command Timeout Count

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 (48 bits)

This value is the total count of host command timeouts over the life of the drive. A command timeout reflects the inability of the device to respond to a host command in the amount of time specified by the host.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 189: Factory Bad-Block Count

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 (48 bits)

This value is the total number of NAND blocks retired during the manufacturing process. This value does not change over the life of the drive.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 194: Enclosure Temperature

This attribute tracks the current and worst temperature of the device, based on measurement by the onboard thermal sensor. This attribute is **not** available in most C400 configurations. For devices with no thermal sensor, temperature is always reported as 0xFF.

Attribute Flags (0x32)

- Warranty = 0
- Offline = 1
- Performance = 0
- Error Rate = 0
- Event Count = 1
- Self-Preservation = 1

Current Value (8 bits)

100 - current temperature.

Worst Value (8 bits)

100 - max temperature.

Raw Data (48 bits)

[1:0] current temperature.

[3:2] min temperature.

[5:4] max temperature.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 195: Cumulative ECC Bit-Correction Count

Attribute Flags (0x3C)

- Warranty = 0
- Offline = 0
- Performance = 1
- Error Rate = 1
- 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 (48 bits)

This value gives the total number of bits corrected by ECC over the life of the drive.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 196: Reallocation Event Count

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 (48 bits)

This value gives the total bad NAND block count of the drive minus the number of FACTORY bad NAND blocks. One NAND block is equivalent to 256 NAND pages.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 197: Current Pending-Sector Count

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 (48 bits)

This value will always be 0, as reallocation will be done on-the-fly.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 198: SMART Off-line Scan Uncorrectable Error Count

Attribute Flags (0x30)

- Warranty = 0
- Offline = 0
- 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 (48 bits)

This value is the cumulative number of unrecoverable read errors found in SMART long or short self-tests.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 199: Ultra-DMA CRC Error Count

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 (48 bits)

This value is the cumulative number of CRC (cycle redundancy check) error counts. This is a count of errors that occur on the interface, without distinguishing between device and host problems.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 202: Percent Lifetime Used

This attribute is used to provide the end user of a client computing system with a method to track the expected lifetime of the drive. The value is reported as a number from 0 to 100.

This Percent Lifetime Used value is the greater of two other calculations (which are not reported elsewhere in the SMART table):

- **PercentEraseCountUsed** is the ratio of the Maximum Average Erase Count (across all the segments in the NAND array) to the expected Program/Erase Count of the part in question (typically 3k to 5k for MLC NAND parts; this number can be found in the NAND component data sheet). The Maximum Average Erase Count is the maximum value of the average erase counts on all segments in the NAND array.
- **PercentSpareBlockUsed** describes the amount of the spare area that has been used in replacing bad NAND blocks. The PercentSpareBlockUsed is the highest percentage of all the NAND segments on the drive. If any one NAND segment reaches 100% of spares used, then the drive would be unable to maintain its IDEMA-specified capacity at the next failed block within that segment. At that point, the drive puts itself in write protect mode. The drive will not function as an operating system drive, but the user data is recoverable in read-only mode.

Attribute Flags (0x31)

- Warranty = 1
- Offline = 0
- Performance = 0
- Error Rate = 0
- Event Count = 1
- Self-Preservation = 1

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%. A value of 0% indicates that 100% of the expected lifetime has been used.

Worst Value (8 bits)

This field holds the same value as the Current Value.

Raw Data (48 bits)

This value is the highest of the two values, **PercentageEraseCountUsed** and **PercentageSpareBlockUsed.**

Sample Calculation

For a drive with 32GB NAND and four segments, assume the TotalSpare is 200, as shown in the following table.

Segment	AverageErsCnt	TotalBadBlock	OtpBadBlock	PctSpareBlkUsed
1	3000	136	20	64
2	3100	127	20	59
3	2900	138	30	63
4	2800	135	27	62

The PercentageLifetimeUsed is calculated as:

$$\text{PercentageEraseCountUsed} = \frac{3100}{5000} \text{x } 100 = 62$$

$$\text{PercentageSpareBlockUsed} = \frac{138 - 30}{200 - 30} \text{ x } 100 = 63$$

The value of 5000 in the first equation is taken from the component data sheet.

Note that even if **PercentageSpareBlockUsed** is higher on segment 1, the segment that has the highest Bad Block Count is chosen to calculate the **PercentageSpareBlockUsed**.

THEREFORE, the **PercentageLifetimeUsed** = max(63,62) = **63** (0x3F), and the current value would be 100 - 63 = 37 (0x25).

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

SMART ID 206: Write Error Rate

Attribute Flags (0x0e)

- Warranty = 0
- Offline = 1
- Performance = 1
- Error Rate = 1
- Event Count = 0
- Self-Preservation = 0

Current Value (8 bits)

This value is the write error rate, calculated as (((NAND program fails <<11) x100) ÷ total sectors written) >>11.

Worst Value (8 bits)

This value is the worst Current Value.

Raw Data (48 bits)

This value is the NAND Program Fail count.

Reserved/Threshold (8 bits)

This attribute is informational only. The threshold for this attribute is set to 0. This will not cause a SMART threshold trip.

Revision History

Rev. B – 7/13

- Finalized SMART definitions.

Rev. A – 2/13

- Initial release.

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