



## StorFly® M.2 Type 2242 SATA Solid-State Drive

Series 3 (Gen1), SATA-III (6Gb/s), 3D TLC

VSFEM4C (C/I) 30GB – 240GB

Datasheet - Rev. 1.0



## 1. Description

Virtium's StorFly Series 3 M.2 is high-performance SATA-III 6Gb/s embedded solid-state drive (SSD) technology designed for the unique capacity and workload requirements of a broad range of embedded systems, including networking, industrial automation, medical monitoring and gaming equipment, point-of-sale terminals and data recorders.

## Features

### Capacity

- 30GB, 60GB, 120GB, 240GB

### 3D TLC NAND

### Sequential Performance<sup>(1)</sup>

- 128kB Sequential Read: 540 MB/s (QD: 32)
- 128kB Sequential Write: 520 MB/s (QD: 32)

### Random Performance<sup>(1)</sup>

- 4kB IOPS Read: up to 65,000
- 4kB IOPS Write: up to 72,000

### Voltage Supply: 3.3V±5%

### Power Consumption<sup>(1)</sup>

- 128kB Sequential Read: 1.20 W
- 128kB Sequential Write: 1.30 W
- 4kB Random Read: 1.30 W
- 4kB Random Write: 1.40 W
- Idle: 0.40 W

### Temperature Ranges

- Commercial: 0°C to 70°C
- Industrial: -40°C to 85°C
- Non-Operating: -40°C to 85°C

### Reliability

- Advanced LDPC ECC
- MTBF: >2M hours

### Endurance<sup>(1)</sup>

- JESD219A: 214 TBW
- Sequential: 370 TBW

### vtGuard® Power Fail Protection

- Integrated power fail protection
- Preserves static data in the event of power failure
- Cache/buffer contents restored at power-on

### SMART Attribute Reporting

- Monitors device health
- Anticipates and predicts failures

### Mechanical Dimensions

- M.2 Type 2242-D2-B-M Form Factor
- Length x Width x Height mm (inches)  
42.00 (1.650) x 22.00 (0.866) x 2.60 (0.102)

### Compliance

- SATA Revision 3.1 (SATA-III 6Gb/s)
- ATA/ATAPI-8 (ACS-3)
- FCC, CE, UL, RoHS, WEEE

### Environmental (Non-operating)

- Humidity (non-condensing): 5% to 95%
- Shock: 1500G, half-sine wave, 0.5ms duration
- Vibration: 20G, 20 Hz to 2000 Hz

### Data Security

- Integrated AES-256 encryption (data-at-rest)
- ATA Security Erase

### StorKit® Software – visit [virtium.com](http://virtium.com) to learn more.

- vtView®, vtSecure™, vtTools™

(1) Based on the 240GB device



Electrostatic Discharge (ESD) can damage this device. When handling the device, always wear a grounded wrist strap and use a static dissipative surface.



Any damage to the unit that occurs after its removal from the shipping package and ESD protective bag is the responsibility of the user.

## Part Numbering System

### V SF EM4 C C/I xxxG - V11

| Where:      |  |
|-------------|--|
| <b>V</b>    | = Virtium  |
| <b>SF</b>   | = StorFly  |
| <b>EM4</b>  | = Form Factor / Interface : EM4 = M.2 Type 2242-D2-B-M, SATA-III 6Gb/s                                   |
| <b>C</b>    | = Product Class : C = CE   |
| <b>C/I</b>  | = Operating Temperature :<br>C : Commercial (0°C to 70°C)<br>I : Industrial (-40°C to 85°C)              |
| <b>xxxG</b> | = Capacity (1GB = 1,000,000,000 bytes)<br>030G = 30 GB<br>060G = 60 GB<br>120G = 120 GB<br>240G = 240 GB |
| <b>V11</b>  | = Virtium Proprietary  |

## Order Information

| Capacity (GB) | Part Number      | Operating Temperature |
|---------------|------------------|-----------------------|
| 30            | VSFEM4CC030G-V11 | 0°C to 70°C           |
| 60            | VSFEM4CC060G-V11 |                       |
| 120           | VSFEM4CC120G-V11 |                       |
| 240           | VSFEM4CC240G-V11 |                       |
| 30            | VSFEM4CI030G-V11 | -40°C to 85°C         |
| 60            | VSFEM4CI060G-V11 |                       |
| 120           | VSFEM4CI120G-V11 |                       |
| 240           | VSFEM4CI240G-V11 |                       |

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## 2. Revision History

| Date       | Revision | Page(s) | Description   |
|------------|----------|---------|---|
| 08/31/2022 | 0.1      | All     | Initial Release                                     |
| 10/03/2022 | 1.0      | All     | Principal Release<br>Document review and formatting |
| 10/28/2022 | 1.1      | Page 2  | Order Information PNs# Capacities                   |

### 3. Specifications

#### Capacity

| Unformatted Capacity (GB) <sup>(1)</sup> | User-Addressable LBA <sup>(2)</sup> | User-Addressable Capacity Bytes |
|--|-------------------------------------|---------------------------------|
| 30                                       | 58,626,288                          | 30,016,659,456                  |
| 60                                       | 117,231,408                         | 60,022,480,896                  |
| 120                                      | 234,441,648                         | 120,034,123,776                 |
| 240                                      | 468,862,128                         | 240,057,409,536                 |

(1) 1GB = 1,000,000,000 bytes. LBA : Logical Block Address; Logical Block Size = 512 Bytes/1 Sector.  
 (2) LBA : Logical Block Address; Logical Block Size = 512 Bytes/1 Sector.

#### Performance

| Capacity (GB) | Performance Throughput <sup>(1)</sup><br>128kB File, Queue Depth (QD) = 32 |                       | IOPS <sup>(1)</sup><br>4kB File, Queue Depth (QD) = 32 |                   |
|---------------|--|-----------------------|--|-------------------|
|               | Sequential Read MB/s   | Sequential Write MB/s | 100% Random Read                                       | 100% Random Write |
| 30            | 490  | 270                   | 30,000   | 63,000            |
| 60            | 500  | 270                   | 30,000   | 63,000            |
| 120           | 540  | 460                   | 37,000   | 71,000            |
| 240           | 540  | 510                   | 55,000   | 72,000            |

(1) Performance is based on fresh out-of-box condition formatted with NTFS filesystem and running CrystalDiskMark 8.0.0 with file size 1024MB. Actual results may vary depending on file system, workload, and SSD condition.

#### Power Consumption – 3.3V Supply

| Capacity (GB) | Sequential Read <sup>(1)</sup><br>128kB, QD = 32 | Sequential Write <sup>(1)</sup><br>128kB, QD = 32 | Random Read <sup>(1)</sup><br>4kB, QD = 32 | Random Write <sup>(1)</sup><br>4kB, QD = 32 | Idle | Unit |
|---------------|--|---|--|---|------|------|
| 30            | 1.20   | 1.30  | 1.30                                       | 1.40  | 0.40 | W    |
| 60            | 1.50   | 1.40  | 1.20                                       | 1.20  | 0.40 | W    |
| 120           | 1.20   | 1.30  | 1.30                                       | 1.40  | 0.40 | W    |
| 240           | 1.20   | 1.30  | 1.30                                       | 1.40  | 0.40 | W    |

(1) Power consumption tests were done using Keysight test system at 25°C

#### Temperature and Humidity

| Part Number   | Operating Temperature | Non-Operating <sup>(1)</sup> Temperature | Humidity (Non-Condensing) |
|---|-----------------------|--|---------------------------|
| VSFEM4CCxxxG-V11  | 0°C to 70°C           | -40°C to 85°C                            | 5% to 95%                 |
| VSFEM4CIxxxG-V11  | -40°C to 85°C         | -40°C to 85°C                            | 5% to 95%                 |
| (1) Maximum non-operating temperature assumes data is stored on the SSD. Temperatures above 85°C are beyond NAND specification for data retention. Please see <i>Temperature Considerations for Industrial Embedded SSDs</i> whitepaper under the industrial SSD section of Virtium website (Virtium.com) |                       |  |                           |

## Shock and Vibration

| Reliability | Test Conditions                       | Reference Standards |
|-------------|---------------------------------------|---------------------|
| Shock       | 1500G, half-sine wave, 0.5ms duration | JESD22-B110B.01     |
| Vibration   | 20G, 20 Hz to 2000 Hz                 | JESD22-B103B.01     |

## 4. Reliability

### Endurance

| Capacity (GB) | JESD218A <sup>(1)</sup> & JESD219 Enterprise Workloads |                                | 100% Sequential Workloads    |                                |
|---------------|--|--------------------------------|------------------------------|--------------------------------|
|               | Total Bytes Written TBW (TB)                           | Drive Writes per day (3 years) | Total Bytes Written TBW (TB) | Drive Writes per day (3 years) |
| 30            | 17   | 0.50                           | 40                           | 1.20                           |
| 60            | 45   | 0.68                           | 86                           | 1.30                           |
| 120           | 98   | 0.74                           | 180                          | 1.37                           |
| 240           | 214  | 0.80                           | 370                          | 1.40                           |

(1) JESD218A assumes an active temperature at 55°C and a retention temperature at 40°C

### Mean Time Between Failures (MTBF)

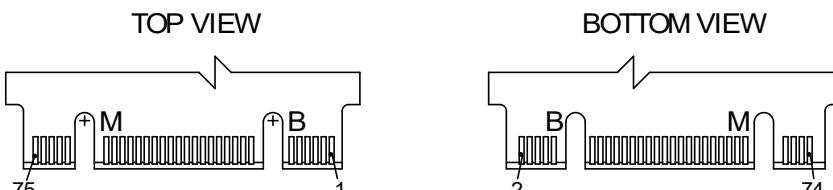
The SSD achieves a MTBF of greater than 2,000,000 hours predicted and is derived from the component reliability data using Telcordia SR-332 methods at 40°C and tested under standard environmental operating conditions.

### vtGuard® Power-Fail Protection

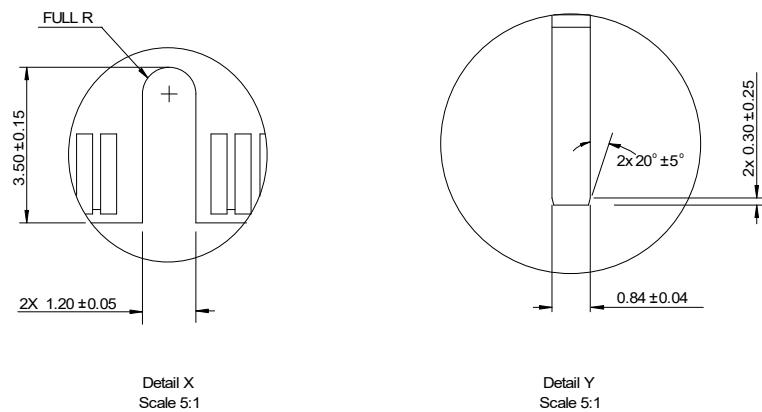
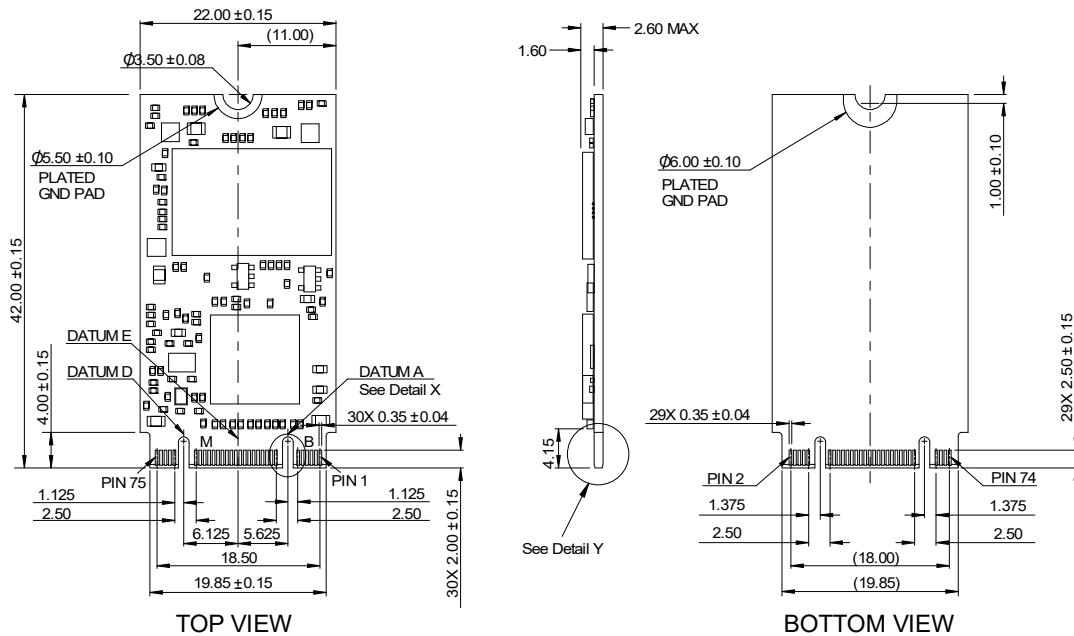
vtGuard is an integrated power failure protection technology that will preserve data on the SSD if a sudden power failure should occur. It will also transfer the write cache (metadata, mapping tables) contents to the non-volatile flash and restore the contents upon power restoration. This data will be preserved regardless of the duration of the power failure event. This technology also ensures that the SSD will be recoverable after sudden power failure events although a rebuild of the mapping tables may delay readiness of the SSD on the ensuing power cycle on larger capacities.

## 5. Physical Specifications

### Pin Layout / Assignments

| Pin Assignments  |             |                          |             |             |             |
|--|-------------|--------------------------|-------------|-------------|-------------|
| Top Side   |             |                          | Bottom Side |             |             |
| Pin  | Signal Name | Description              | Pin         | Signal Name | Description |
| 1  | CONFIG_3    | Ground                   |             |             |             |
| 3  | GND         | Ground                   | 2           | 3.3V        | 3.3V Source |
| 5  | N/C         | No Connect               | 4           | 3.3V        | 3.3V Source |
| 7  | N/C         | No Connect               | 6           | N/C         | No Connect  |
| 9  | N/C         | No Connect               | 8           | N/C         | No Connect  |
| 11   | N/C         | No Connect               | 10          | DAS/DSS     | No Connect  |
| Key  |             |                          | Key         |             |             |
| 21   | CONFIG_0    | Ground                   | 20          | N/C         | No Connect  |
| 23   | N/C         | No Connect               | 22          | N/C         | No Connect  |
| 25   | N/C         | No Connect               | 24          | N/C         | No Connect  |
| 27   | GND         | Ground                   | 26          | N/C         | No Connect  |
| 29   | N/C         | No Connect               | 28          | N/C         | No Connect  |
| 31   | N/C         | No Connect               | 30          | N/C         | No Connect  |
| 33   | GND         | Ground                   | 32          | N/C         | No Connect  |
| 35   | N/C         | No Connect               | 34          | N/C         | No Connect  |
| 37   | N/C         | No Connect               | 36          | N/C         | No Connect  |
| 39   | GND         | Ground                   | 38          | DEVSLP      | No Connect  |
| 41   | SATA +B     | SATA B differential pair | 40          | N/C         | No Connect  |
| 43   | SATA -B     |                          | 42          | N/C         | No Connect  |
| 45   | GND         | Ground                   | 44          | N/C         | No Connect  |
| 47   | SATA -A     | SATA A differential pair | 46          | N/C         | No Connect  |
| 49   | SATA +A     |                          | 48          | N/C         | No Connect  |
| 51   | GND         | Ground                   | 50          | N/C         | No Connect  |
| 53   | N/C         | No Connect               | 52          | N/C         | No Connect  |
| 55   | N/C         | No Connect               | 54          | N/C         | No Connect  |
| 57   | GND         | Ground                   | 56          | MFG1        | No Connect  |
| Key  |             |                          | 58          | MFG2        | No Connect  |
| 67   | N/C         | No Connect               | Key         |             |             |
| 69   | CONFIG_1    | Ground                   | 68          | SUSCLK      | No Connect  |
| 71   | GND         | Ground                   | 70          | 3.3V        | 3.3V Source |
| 73   | GND         | Ground                   | 72          | 3.3V        | 3.3V Source |
| 75   | CONFIG_2    | Ground                   | 74          | 3.3V        | 3.3V Source |
| Pin Layout   |             |                          |             |             |             |
|  |             |                          |             |             |             |

## Mechanical Dimensions



**Note:**

Note:

1. All dimensions are in millimeters
2. The dimensional diagram is for reference only

## 6. ATA Commands

The SSDs support all mandatory ATA commands as defined in the ATA/ATAPI-8 (ACS-3) specification.

### General Feature Set

| Command                   | Code       | Protocol                  |
|---------------------------|------------|---------------------------|
| Execute Device Diagnostic | 90h        | Execute Device Diagnostic |
| Flush Cache               | E7h        | Non-data                  |
| Identify Device           | Ech        | PIO data-in               |
| Read DMA                  | C8h        | DMA                       |
| Read Multiple             | C4h        | PIO data-in               |
| Read Sector(s)            | 20h        | PIO data-in               |
| Read Verify Sector(s)     | 40h or 41h | Non-data                  |
| Set Feature               | Efh        | Non-data                  |
| Set Multiple Mode         | C6h        | Non-data                  |
| Write DMA                 | Cah        | DMA                       |
| Write Multiple            | C5h        | PIO data-out              |
| Write Sector(s)           | 30h        | PIO data-out              |
| NOP                       | 00h        | Non-data                  |
| Read Buffer               | E4h        | PIO data-in               |
| Write Buffer              | E8h        | PIO data-out              |
| Write Buffer DMA          | E9h        | DMA                       |
| Download Microcode        | 92h        | PIO data-out              |
| Download Microcode DMA    | 93h        | DMA                       |

### Power Management

| Command           | Code | Protocol |
|-------------------|------|----------|
| Check Power Mode  | E5h  | Non-data |
| Idle              | E3h  | Non-data |
| Idle Immediate    | E1h  | Non-data |
| Sleep             | E6h  | Non-data |
| Standby           | E2h  | Non-data |
| Standby Immediate | E0h  | Non-data |

### Sanitize

| Command  | Code | Protocol |
|----------|------|----------|
| Sanitize | B4h  | Non-data |

### Security Mode

| Command                   | Code | Protocol     |
|---------------------------|------|--------------|
| Security Set Password     | F1h  | PIO data-out |
| Security Unlock           | F2h  | PIO data-out |
| Security Erase Prepare    | F3h  | Non-data     |
| Security Erase Unit       | F4h  | PIO data-out |
| Security Freeze Lock      | F5h  | Non-data     |
| Security Disable Password | F6h  | PIO data-out |

## SMART Commands

| Command                          | Code | Protocol     |
|----------------------------------|------|--------------|
| SMART Disable Operations         | B0h  | Non-data     |
| SMART Enable/Disable Autosave    | B0h  | Non-data     |
| SMART Enable Operations          | B0h  | Non-data     |
| SMART Execute OFF-LINE Immediate | B0h  | Non-data     |
| SMART Read Log                   | B0h  | PIO data-in  |
| SMART Read Data                  | B0h  | PIO data-in  |
| SMART Read Threshold             | B0h  | PIO data-in  |
| SMART Return Status              | B0h  | Non-data     |
| SMART Save Attribute Values      | B0h  | Non-data     |
| SMART Write Log                  | B0h  | PIO data-out |
| SMART Write Thresholds           | B0h  | PIO data-out |

## Host Protected Area

| Command                 | Code | Protocol     |
|-------------------------|------|--------------|
| Read Native Max Address | F8h  | Non-data     |
| Set Max Address         | F9h  | Non-data     |
| Set Max Set Password    | F9h  | PIO data-out |
| Set Max Lock            | F9h  | Non-data     |
| Set Max Freeze Lock     | F9h  | Non-data     |
| Set Max Unlock          | F9h  | PIO data-out |

## 48-bit Address Feature Set

| Command                     | Code | Protocol     |
|-----------------------------|------|--------------|
| Flush Cache Ext             | Eah  | Non-data     |
| Read Sector(s) Ext          | 24h  | PIO data-in  |
| Read DMA Ext                | 25h  | DMA          |
| Read Log Ext                | 2Fh  | PIO data-in  |
| Read Log DMA Ext            | 47h  | DMA          |
| Read Multiple Ext           | 29h  | PIO data-in  |
| Read Native Max Address Ext | 27h  | Non-data     |
| Read Verify Sector(s) Ext   | 42h  | Non-data     |
| Set Max Address Ext         | 37h  | Non-data     |
| Write DMA Ext               | 35h  | DMA          |
| Write DMA FUA Ext           | 3Dh  | DMA          |
| Write Multiple Ext          | 39h  | PIO data-out |
| Write Multiple FUA Ext      | Ceh  | PIO data-out |
| Write Sector(s) Ext         | 34h  | PIO data-out |

## Native Command Queuing (NCQ)

| Command            | Code | Protocol   |
|--------------------|------|------------|
| Read FPDMA Queued  | 60h  | DMA Queued |
| Write FPDMA Queued | 61h  | DMA Queued |

## Trusted

| Command             | Code | Protocol     |
|---------------------|------|--------------|
| Trusted Send        | 5Eh  | PIO data-out |
| Trusted Send DMA    | 5Fh  | DMA          |
| Trusted Receive     | 5Ch  | PIO data-in  |
| Trusted Receive DMA | 5Dh  | DMA          |
| Trusted (Non-Data)  | 5Bh  | Non-data     |
| Trusted Send        | 5Eh  | PIO data-out |

## Data Set Management and Seek

| Command             | Code | Protocol |
|---------------------|------|----------|
| Data Set Management | 06h  | DMA      |
| Seek                | 70h  | Non-data |

## Identify Device (Ech) Data

The Identify Device (Ech) command enables the host to receive parameter information from the controller. This command has the same protocol as the Read Sector(s) command. The parameter words in the buffer have the arrangement and meanings defined in the following table.

| Word  | F/V/X | Value | Description   |
|-------|-------|-------|---|
| 0     | F     | 0440h | General Configuration   |
| 1     | X     | 3FFFh | Default Number of Cylinders   |
| 2     | V     | C837h | Reserved  |
| 3     | X     | 0010h | Default Number of Heads   |
| 4     | X     | 0000h | Obsolete  |
| 5     | X     | 0000h | Obsolete  |
| 6     | X     | 003Fh | Default Number of Sectors per Track                                   |
| 7-8   | V     | 0000h | Reserved  |
| 9     | X     | 0000h | Obsolete  |
| 10-19 | F     | XXXXh | Serial Number in ASCII (Right justified)                              |
| 20    | X     | 0000h | Obsolete  |
| 21    | X     | 4000h | Obsolete  |
| 22    | X     | 0004h | Obsolete  |
| 23-26 | F     | XXXXh | Firmware Revision in ASCII; Big Endian Byte Order in Word             |
| 27-46 | F     | XXXXh | Model Number in ASCII (Left justified); Big Endian Byte Order in Word |
| 47    | F     | 0000h | Maximum Number of Sectors on Read/Write Multiple Command              |
| 48    | F     | 4000h | Trusted computing feature set options                                 |
| 49    | F     | 2F00h | Capabilities  |
| 50    | F     | 4000h | Capabilities  |
| 51    | X     | 0000h | Obsolete  |
| 52    | X     | 0000h | Obsolete  |
| 53    | F     | 0007h | Words 88 and 70 :64 valid   |
| 54    | X     | 3FFFh | Obsolete  |
| 55    | X     | 0010h | Obsolete  |
| 56    | X     | 003Fh | Obsolete  |
| 57    | X     | FC10h | Obsolete  |
| 58    | X     | 00FBh | Obsolete  |
| 59    | V     | 0101h | Multiple Sector Setting   |
| 60-61 | F     | XXXXh | Total number of user addressable logic sectors                        |

| Word    | F/V/X | Value | Description   |
|---------|-------|-------|---|
| 62      | X     | 0000h | Obsolete  |
| 63      | F     | 0007h | Multiple DMA transfer   |
| 64      | F     | 0003h | Advanced PIO transfer mode supported  |
| 65      | F     | 0078h | Minimum Multiword DMA Transfer Cycle Time per Word  |
| 66      | F     | 0078h | Recommended Multiword DMA Transfer Cycle Time   |
| 67      | F     | 0078h | Minimum PIO Transfer Cycle Time without Flow Control  |
| 68      | F     | 0078h | Minimum PIO Transfer Cycle Time with IORDY Flow Control   |
| 69      | F     | 4100h | Additional Features   |
| 70-74   | F     | 0000h | Reserved  |
| 75      | F     | 001Fh | Queue Depth   |
| 76      | F     | C50Eh | Serial ATA Capabilities <ul style="list-style-type: none"> <li>Supports Serial ATA Gen3</li> <li>Supports Serial ATA Gen2</li> <li>Supports Serial ATA Gen1</li> <li>Supports receipt of Host Initiated Power Management requests</li> <li>Supports Native Command Queuing</li> </ul> |
| 77      | F     | 0006h | Serial ATA Additional Capability; DevSleep_to_ReducedPwerState  |
| 78      | F     | 0044h | Serial ATA Features Supported <ul style="list-style-type: none"> <li>Supports Software Settings Preservation</li> <li>Supports Initiating Power Management</li> </ul>   |
| 79      | V     | 0040h | Serial ATA features enabled   |
| 80      | F     | 07F0h | Major Version Number (ACS-3)  |
| 81      | F     | 0028h | Minor Version Number  |
| 82      | F     | 446Bh | Command Sets Supported 0  |
| 83      | F     | 7401h | Command Sets Supported 1  |
| 84      | F     | 4161h | Command Sets Supported 2  |
| 85      | V     | 4029h | Command Set/Feature Enabled 0   |
| 86      | V     | B401h | Command Set/Feature Enabled 1   |
| 87      | V     | 4161h | Command Set/Feature Enabled 2   |
| 88      | V     | 207Fh | Ultra DMA Mode Supported and Selected   |
| 89      | F     | 8001h | Time required for a Normal Erase Mode Security Erase Unit Command   |
| 90      | F     | 800Ah | Time required for an Enhanced Erase Mode Security Erase Unit Command  |
| 91      | V     | 00Feh | Current Advanced Power Management Value   |
| 92      | V     | 0000h | Master Password revision code   |
| 93-99   | V     | 0000h | Reserved  |
| 100-103 | V     | XXXXh | Maximum User LBA for 48-bit Address Feature Set   |
| 104-105 | V     | 0000h | Reserved  |
| 106     | F     | 4000h | Sector size   |
| 107-127 | V     | 0000h | Reserved  |
| 128     | V     | 0021h | Security Status   |
| 129-159 | X     | XXXXh | Virtium Specific  |
| 160     | X     | 0000h | Power Requirement Description   |
| 161-167 | X     | 0000h | Reserved  |
| 168     | F     | 0003h | Reserved  |
| 169     | X     | 0001h | Data Set Management supported   |
| 170-205 | F     | 0000h | Reserved  |
| 206     | F     | 0038h | SCT Command Transport   |
| 207-208 | F     | 0000h | Reserved  |
| 209     | X     | 4000h | Reserved  |
| 210-216 | X     | 0000h | Reserved  |
| 217     | X     | 0001h | Non-rotating Media (SSD)  |
| 218-221 | X     | 0000h | Reserved  |

| Word    | F/V/X | Value | Description   |
|---------|-------|-------|---|
| 222     | X     | 103Fh | Transport Major Revision (SATA Revision 3.1)            |
| 223-233 | X     | 0000h | Reserved  |
| 234     | X     | 0001h | Minimum number of 512 byte units per segmented download |
| 235     | X     | 0100h | Maximum number of 512 byte units per segmented download |
| 236-254 | X     | 0000h | Reserved  |
| 255     | X     | XXXXh | Integrity Word – Checksum                               |

**Notes:**

1. F = content (byte) is fixed and does not change.
2. V = content (byte) is variable and may change depending on the state of the device or the commands executed by the device.
3. X = content (byte) is specific to manufacturer and may be fixed or variable.

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## 7. SMART Attributes

### Introduction

*Self-Monitoring, Analysis, and Reporting Technology* (SMART) is a system that monitors the device condition according to indicators reported by the device itself. This system is designed to anticipate and predict any failures that might occur, thereby allowing the user to prevent data loss or corruption.

This section is for informational purposes only and about the SMART commands and attributes implemented by Virtium LLC., including the data structures returned by those commands.

**Note:** Please refer to ACS-3 Specification for information on how to invoke the SMART command.

### SMART Subcommands

The following table defines the SMART command set that is supported by the SSDs.

| Value | Command                          |
|-------|----------------------------------|
| D0h   | SMART Read Data                  |
| D1h   | SMART Read Attribute Threshold   |
| D2h   | SMART Enable/Disable Auto-save   |
| D3h   | SMART Save Attribute Values      |
| D4h   | SMART Execute Off-Line immediate |
| D5h   | SMART Read Log                   |
| D6h   | SMART Write Log                  |
| D8h   | SMART Enable Operations          |
| D9h   | SMART Disable Operations         |
| Dah   | SMART Return Status              |

## SMART Attribute Definitions

The following table defines the SMART data attributes that are currently supported. These SMART attributes are located at Offset 2 of the SMART Data Structure.

| ID (Hex) | ID (Decimal) | Description  | Type              |
|----------|--------------|--|-------------------|
| 01       | 1            | Raw Read Error Rate : Rate of CRC errors occurred over the total number of LBA read. Legacy attribute from HDDs. Kept in SMART for host compatibility issues.              | Reset at power on |
| 05       | 5            | Reallocated Sector Count : Count of sectors moved to the spare area.   |                   |
| 09       | 9            | Power-On Time Count : Cumulative number of power-on hours while drive is in active mode over the life of the device.   | Life Cumulative   |
| 0C       | 12           | Drive Power Cycle Count : Cumulative count of power cycle event (on/off) over the life of the device. This attribute includes both proper power down and unsafe power down | Life Cumulative   |
| A0       | 160          | Uncorrectable Sector Count Read/Write : Total Count of uncorrectable errors when device performing reading/writing operation   | Reset at power on |
| A1       | 161          | Total number of overall valid spare block  |                   |
| A3       | 163          | Number of Initial Invalid Block : Total number of bad blocks found during the card initialization  |                   |
| A4       | 164          | Total Erase Count : Total number of erase operations those have been performed   | Life Cumulative   |
| A5       | 165          | Maximum Erase Count : The maximum number of erase operations on any active block   | Life Cumulative   |
| A6       | 166          | Minimum Erase Count : The minimum number of erase operations on any active block   | Life Cumulative   |
| A7       | 167          | Average Erase Count : Total number of erase operations over the total available blocks   | Life Cumulative   |
| A8       | 168          | NAND Endurance : Max erase count of the NAND   |                   |
| B1       | 177          | Total wear level count : Total number of wear leveling events  | Life Cumulative   |
| B5       | 181          | Total Program Fail : Total number of failed program requests (failed writes)   | Life Cumulative   |
| B6       | 182          | Total Erase Fail : Total number of failed erase requests   | Life Cumulative   |
| BB       | 187          | Uncorrectable Error Count : The count of errors that could not be recovered using hardware ECC   | Life Cumulative   |
| C0       | 192          | Unsafe Power Off : Count of Unsafe power off. Power off without STANDBY-IMMEDIATE command being the last command   | Life cumulative   |
| C2       | 194          | SSD Temperature : Indicates the current internal temperature of the SSD controller (in degrees centigrade).  |                   |
| C3       | 195          | Hardware ECC Recovered : Count of correctable ECC  | Life cumulative   |
| C4       | 196          | Reallocation Event Count : Count of Sector remap operations. Number of all (successful and failed) remap operations  | Life Cumulative   |
| C6       | 198          | Off-Line Uncorrectable Sector Count : Count of uncorrectable errors when reading/writing   |                   |
| C7       | 199          | UltraDMA CRC Error Count : Total CRC error count of the SATA interface   | Life Cumulative   |
| E8       | 232          | Available Reserved Space : Reports the reserved space of the SSD as a percentage (100% to 0%). When this number reaches zero, the SSD will go into read-only mode          | Life cumulative   |
| F1       | 241          | Total LBAs Written : Total LBAs written (each write unit = 32MB)   | Life cumulative   |
| F2       | 242          | Total LBAs Read : Total LBAs read (each read unit = 32MB)  | Life cumulative   |

| ID (Hex)  | ID (Decimal) | Description   | Type            |
|---|--------------|---|-----------------|
| F8  | 248          | Remaining Life Left: Reports remaining life of the SSD as a percentage (100% to 0%). When this number reaches zero, the SSD will not go into read-only mode and will continue to operate as normal. The percentage is based on the number of factors and accounts for the number of program/erases cycles the device's NAND flash can endure. This provides guidance on the anticipated lifespan for the device and allows for proactive transfer of data before eventual device failure. | Life cumulative |
| F9  | 249          | Remaining Spare Block: Reports remaining spare blocks as a percentage (100% to 0%). When this number reaches zero, the SSD will go into read-only mode.   | Life Cumulative |
| FA  | 250          | Total written to NAND (SLC): Total Written to NAND SLC region (each write unit = 32MB)  | Life Cumulative |
| FB*   | 251          | Total written to NAND (TLC): Total Written to NAND TLC region (each write unit = 32MB)  | Life Cumulative |
| (*) For Product Class: XE devices all writes will be written in SLC region and this attribute will always report 0. |              |   |                 |

## 8. Industry Standards

| Reference Title                 | Date / Revision | Location  |
|---------------------------------|-----------------|---|
| ATA/ATAPI-8                     | September 2008  | <a href="http://www.t13.org">http://www.t13.org</a>   |
| ACS-3 – ATA/ATAPI Command Set-3 | October 2013    | <a href="http://www.t13.org">http://www.t13.org</a>   |
| SATA 3.1                        | July 2011       | <a href="http://www.sata-io.org">http://www.sata-io.org</a>   |
| JEDEC                           | JESD22-B110B.01 | Mechanical Shock – Device and Subassembly, Revision of JESD22-B110B, June 2019, <a href="http://www.jedec.org">http://www.jedec.org</a> |
| JEDEC                           | JESD22-B103B.01 | Vibration, Variable Frequency, Minor revision to JESD22-B103-B, September 2016, <a href="http://www.jedec.org">http://www.jedec.org</a> |
| JEDEC                           | JESD218A        | Solid-State Drive (SSD) Requirements and Endurance Test Method, February 2011, <a href="http://www.jedec.org">http://www.jedec.org</a>  |
| JEDEC                           | JESD219         | Solid-State Drive (SSD) Endurance Workloads, September 2010, <a href="http://www.jedec.org">http://www.jedec.org</a>                    |

## 9. Certifications and Compliance

| Compliance / Certification | Description  |
|----------------------------|--|
| CE and FCC Compliant       | Class : FCC Part 15 Subpart B Class B :2011<br>Declaration of Conformity registration No. STE120607699 |
| RoHS Compliant             | Restriction of Hazardous Substance Directive   |
| UL Certified               | Underwriters Laboratories, Inc. 94V-0  |
| WEEE Certified             | Waste, Electrical and Electronic Equipment Directive   |

## 10. Contact Information

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Virtium manufactures storage and memory and solutions for the world's foremost industrial embedded OEMs. For over two decades, we have designed, manufactured and supported our products in the USA – fortified by a network of global locations. Our world-class technology and unsurpassed support provide a superior customer experience that continuously results in better industrial embedded products for an increasingly interconnected world.

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