

# Intel® Solid State Drive DC S3510 Series

## Product Specification

- **Capacity:**
  - 80GB, 120GB, 240GB, 480GB, 800GB, 1.2TB, 1.6TB
- **Components:**
  - 16nm NAND Flash Memory
  - Standard Endurance Technology (SET) Multi-Level Cell (MLC)
- **Form Factor:** 2.5-inch
- **Read and Write IOPS<sup>1,2</sup>**  
(Full LBA Range, IOMeter\* Queue Depth 32)
  - Random 4KB<sup>3</sup> Reads: Up to 68,000 IOPS
  - Random 4KB Writes: Up to 20,000 IOPS
  - Random 8KB<sup>3</sup> Reads: Up to 46,000 IOPS
  - Random 8KB Writes: Up to 10,000 IOPS
- **Bandwidth Performance<sup>1</sup>**
  - Sustained Sequential Read: Up to 500 MB/s<sup>4</sup>
  - Sustained Sequential Write: Up to 460 MB/s
- **Endurance: 0.3 drive writes per day<sup>5</sup> for 5 years**

|                  |                  |
|------------------|------------------|
| – 80GB: 45 TBW   | – 120GB: 70 TBW  |
| – 240GB: 140 TBW | – 480GB: 275 TBW |
| – 800GB: 450 TBW | – 1.2TB: 660 TBW |
| – 1.6TB: 880 TBW |                  |
- **Latency (average sequential)**
  - Read: 55 µs (TYP)
  - Write: 66 µs (TYP)
- **Quality of Service<sup>6,7</sup>**
  - Read/Write: 500 µs / <5 ms (99.9%)
- **Performance Consistency<sup>7,8</sup>**
  - Read/Write: Up to 95%/95% (99.9%)
- **AES 256-bit Encryption**
- **Altitude<sup>9</sup>**
  - Operating: -1,000 to 10,000 ft
  - Operating<sup>10</sup>: 10,000 to 15,000 ft
  - Non-operating: -1,000 to 40,000 ft
- **Product Ecological Compliance**
  - RoHS\*
- **Compliance**
  - SATA Revision 3.0; compatible with SATA 6Gb/s, 3Gb/s and 1.5Gb/s interface rates
  - ATA/ATAPI Command Set – 2 (ACS-2 Rev 7); includes SCT (Smart Command Transport) and device statistics log support
  - Enhanced SMART ATA feature set
  - Native Command Queuing (NCQ) command set
  - Data set management Trim command
- **Power Management**
  - 5V or 5V+12V SATA Supply Rail<sup>11</sup>
  - SATA Interface Power Management
  - OS-aware hot plug/removal
  - Enhanced power-loss data protection feature
- **Power<sup>12</sup>**
  - Active: Up to 5.6 W<sup>7</sup> (TYP)
  - Idle: 600 mW
- **Weight:**
  - 80GB, 120GB, 240GB: 63 grams ± 2 grams
  - 480GB, 800GB: 68 grams ± 2 grams
  - 1.2TB, 1.6TB: 71 grams ± 2 grams
- **Temperature**
  - Operating: 0° C to 70° C
  - Non-Operating<sup>13</sup>: -55° C to 95° C
  - Temperature monitoring and logging
  - Thermal throttling when approaching maximum operating temperature
- **Shock (operating and non-operating):**
  - 1,000 G/0.5 ms
- **Vibration**
  - Operating: 2.17 G<sub>RMS</sub> (5-700 Hz)
  - Non-Operating: 3.13 G<sub>RMS</sub> (5-800 Hz)
- **Reliability**
  - Uncorrectable Bit Error Rate (UBER): 1 sector per 10<sup>17</sup> bits read
  - Mean Time Between Failures (MTBF): 2 million hours
  - End-to-End data protection
- **Certifications and Declarations**
  - UL\*, CE\*, RMC Mark\*, BSMI\*, KCC\*, Microsoft\* WHCK, VCCI\*, SATA-IO\*
- **Compatibility**
  - Windows 7\*, Windows 8\*, Windows 8.1\* and Windows 10\*
  - Windows Server 2012\* R2
  - Windows Server 2012\*
  - Windows Server 2008\* Enterprise 32/64bit SP2
  - Windows Server 2008\* R2 SP1
  - Windows Server 2003\* Enterprise R2 64bit SP2
  - VMWare\* 5.1, 5.5
  - Red Hat\* Enterprise Linux\* 5.5, 5.6, 6.1, 6.3, 7.0
  - SUSE\* Linux\* Enterprise Server 10, 11 SP1
  - CentOS\* 64bit 5.7, 6.3
  - Intel® SSD Toolbox with Intel® SSD Optimizer

1. Performance values vary by capacity
2. Performance specifications apply to both compressible and incompressible data
3. 4KB = 4,096 bytes; 8KB = 8,192 bytes.
4. MB/s = 1,000,000 bytes/second
5. Based on JESD218 standard.
6. Based on Random 4KB QD=1 workload, measured as the time taken for 99.9 percentile of commands to finish the round-trip from host to drive and back to host
7. Measurement taken once the workload has reached steady state but including all background activities required for normal operation and data reliability
8. Based on Random 4KB QD=32 workload, measured as the (IOPS in the 99.9<sup>th</sup> percentile slowest 1-second interval)/(average IOPS during the test)
9. Altitude pressure is simulated in a test chamber; excludes soft error
10. Extended operation at a higher altitude might impact reliability.
11. If both 12V and 5V power supplies are present, defaults to 5V+ 12V power supplies. Does not support 12 volt only.
12. Based on 5V power supply
13. Please contact your Intel representative for details on the non-operating temperature range



## Revision History

| Revision | Description   | Date          |
|----------|---|---------------|
| 001      | <ul style="list-style-type: none"><li>Initial release.</li></ul>  | May 2015      |
| 002      | <ul style="list-style-type: none"><li>Table 15, SMART Attributes:<ul style="list-style-type: none"><li>SMART Attribute EAh - added bytes description</li><li>Added new SMART Attribute F3h description and status flags</li></ul></li><li>Section 5.4.2: Updated SMART Attribute E2h decimal precision points from 3 to 2</li></ul> | July 2015     |
| 003      | <ul style="list-style-type: none"><li>Updated Electrical Characteristics table and power value</li><li>Updated weight measurements with more precise values</li></ul>   | October 2015  |
| 004      | <ul style="list-style-type: none"><li>Updated Agency approval data</li><li>Removed reference to M.2 as not applicable to the S3510</li></ul>  | February 2016 |



## Ordering Information

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Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance. Consult other sources of information to evaluate performance as you consider your purchase.

**System Configuration for all performance testing:** Intel® Core™ i7-3960x on Intel® DX79SI desktop motherboard, BIOS Version 0537 – SIX7910J.86A.0537.2012.0723.1217 8GB DDR3 LSI 9265-8i, FW 3.190.25-1776, Intel® SSD DC S3510 FW G2010130

All documented endurance test results are obtained in compliance with JESD218 Standards; refer to individual sub-sections within this document for specific methodologies. See [www.jedec.org](http://www.jedec.org) for detailed definitions of JESD218 Standards.

The products described in this document may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available on request.

Contact your local Intel sales office or your distributor to obtain the latest specifications and before placing your product order.

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## Terminology

| Term  | Definition   |
|-------|--|
| ATA   | Advanced Technology Attachment   |
| CRC   | Cyclic Redundancy Check  |
| DAS   | Device Activity Signal   |
| DMA   | Direct Memory Access   |
| ECC   | Error Correction Code  |
| EXT   | Extended   |
| FPDMA | First Party Direct Memory Access   |
| GB    | Gigabyte. <b>Note:</b> The total usable capacity of the SSD may be less than the total physical capacity because a small portion of the capacity is used for NAND flash management and maintenance purposes.   |
| Gb    | Gigabit  |
| HDD   | Hard Disk Drive  |
| HET   | High Endurance Technology  |
| KB    | Kilobyte   |
| I/O   | Input/Output   |
| IOPS  | Input/Output Operations Per Second   |
| ISO   | International Standards Organization   |
| LBA   | Logical Block Address  |
| MB    | Megabyte (1,000,000 bytes)   |
| MLC   | Multi-level Cell   |
| MTBF  | Mean Time Between Failures   |
| NCQ   | Native Command Queuing   |
| NOP   | No Operation   |
| PB    | Petabyte   |
| PCB   | Printed Circuit Board  |
| PIO   | Programmed Input/Output  |
| RDT   | Reliability Demonstration Test   |
| RMS   | Root Mean Square   |
| SATA  | Serial Advanced Technology Attachment  |
| SCT   | SMART Command Transport  |
| SMART | Self-Monitoring, Analysis and Reporting Technology. This is an open standard for developing hard drives and software systems that automatically monitors the health of a drive and reports potential problems. |
| SSD   | Solid State Drive  |
| TB    | Terabyte   |
| TYP   | Typical  |
| UBER  | Uncorrectable Bit Error Rate   |



## 1 Overview

This document describes the specifications and capabilities of the Intel® SSD DC S3510 Series.

The Intel SSD DC S3510 Series delivers excellent performance and Quality of Service combined with high reliability for Serial Advanced Technology Attachment (SATA)-based computers in capacities of 80GB, 120GB, 240GB, 480GB, 800GB, 1.2TB and 1.6TB in a 2.5-inch form factor.

By combining 16nm NAND Flash Memory technology with SATA 6Gb/s interface support, the Intel SSD DC S3510 Series delivers Sequential Read speeds of up to 500 MB/s and Sequential Write speeds of up to 460 MB/s. The Intel SSD DC S3510 Series also delivers Random 4k Read speeds of up to 68,000 IOPS and Random 4K Write speeds of up to 20,000 IOPS, and Quality of Service of 500  $\mu$ s for random 4KB reads measured at a queue depth of 1.

The industry-standard 2.5-inch form factors enable interchangeability with existing hard disk drives (HDDs) and native SATA HDD drop-in replacement with the enhanced performance, reliability, ruggedness, and power savings offered by an SSD.

Intel SSD DC S3510 Series offers these key features:

- Standard Endurance Technology
- High I/O and throughput performance
- Consistent I/O latency
- Enhanced power-loss data protection
- End-to-End data protection
- Thermal throttling
- Temperature Sensor
- Inrush current management
- Low power
- High reliability
- Temperature monitor and logging
- Power loss protection capacitor self-test



## 2 Product Specifications

### 2.1 Capacity

**Table 1: User-Addressable Sectors**

| Intel SSD DC S3510 Series | Unformatted Capacity<br>(Total User Addressable Sectors in LBA Mode) |
|---------------------------|--|
| 80GB                      | 156,301,488  |
| 120GB                     | 234,441,648  |
| 240GB                     | 468,862,128  |
| 480GB                     | 937,703,088  |
| 800GB                     | 1,562,824,368  |
| 1.2TB                     | 2,344,225,968  |
| 1.6TB                     | 3,125,627,568  |

**Notes:**

1GB = 1,000,000,000 bytes; 1 sector = 512 bytes.

LBA count shown represents total user storage capacity and will remain the same throughout the life of the drive.

The total usable capacity of the SSD may be less than the total physical capacity because a small portion of the capacity is used for NAND flash management and maintenance purposes.

### 2.2 Performance

**Table 2: Random Read/Write Input/Output Operations Per Second (IOPS)<sup>1</sup>**

| Specification                                       | Unit | Intel SSD DC S3510 Series |        |        |        |        |        |        |
|---|------|---------------------------|--------|--------|--------|--------|--------|--------|
|   |      | 80GB                      | 120GB  | 240GB  | 480GB  | 800GB  | 1.2TB  | 1.6TB  |
| Random 4KB Read (up to) <sup>2</sup>                | IOPS | 68,000                    | 68,000 | 68,000 | 68,000 | 67,000 | 67,000 | 65,000 |
| Random 4KB Write (up to)                            | IOPS | 8,400                     | 5,300  | 10,200 | 15,100 | 15,300 | 20,000 | 15,200 |
| Random 8KB Read (up to) <sup>3</sup>                | IOPS | 41,500                    | 46,000 | 46,500 | 46,500 | 45,000 | 45,000 | 44,500 |
| Random 8KB Write (up to)                            | IOPS | 4,200                     | 2,600  | 5,000  | 7,500  | 7,700  | 10,000 | 7,800  |
| Random 4KB<br>70/30 Read/Write (up to) <sup>2</sup> | IOPS | 22,000                    | 14,500 | 25,000 | 32,500 | 32,000 | 38,000 | 32,000 |
| Random 8KB<br>70/30 Read/Write (up to) <sup>3</sup> | IOPS | 10,500                    | 7,500  | 13,000 | 18,000 | 18,500 | 23,500 | 19,000 |

**Notes:**

1. Performance measured using IOMeter\* with Queue Depth 32. Measurements are performed on a full Logical Block Address (LBA) span of the drive.
2. 4KB = 4,096 bytes
3. 8KB = 8,192 bytes

**Table 3: Random Read/Write IOPS Consistency<sup>1</sup>**

| Specification                        | Unit | Intel SSD DC S3510 Series |       |       |       |       |       |       |
|--------------------------------------|------|---------------------------|-------|-------|-------|-------|-------|-------|
|                                      |      | 80GB                      | 120GB | 240GB | 480GB | 800GB | 1.2TB | 1.6TB |
| Random 4KB Read (up to) <sup>2</sup> | %    | 90                        | 92    | 94    | 93    | 95    | 95    | 95    |
| Random 4KB Write (up to)             | %    | 95                        | 89    | 88    | 85    | 90    | 95    | 92    |
| Random 8KB Read (up to) <sup>3</sup> | %    | 90                        | 90    | 95    | 95    | 94    | 95    | 93    |
| Random 8KB Write (up to)             | %    | 88                        | 80    | 72    | 86    | 96    | 92    | 88    |

**Notes:**

- Performance consistency measured using IOMeter\* based on Random 4KB QD=32 workload, measured as the (IOPS in the 99.9th percentile slowest 1-second interval) / (average IOPS during the test). Measurements are performed on a full Logical Block Address (LBA) span of the drive once the workload has reached steady state but including all background activities required for normal operation and data reliability
- 4KB = 4,096 bytes
- 8KB = 8,192 bytes

**Table 4: Sequential Read and Write Bandwidth<sup>1</sup>**

| Specification                              | Unit | Intel SSD DC S3510 Series |       |       |       |       |       |       |
|--|------|---------------------------|-------|-------|-------|-------|-------|-------|
|  |      | 80GB                      | 120GB | 240GB | 480GB | 800GB | 1.2TB | 1.6TB |
| Sequential Read (SATA 6Gb/s) <sup>1</sup>  | MB/s | 375                       | 475   | 500   | 500   | 500   | 500   | 500   |
| Sequential Write (SATA 6Gb/s) <sup>1</sup> | MB/s | 110                       | 135   | 260   | 440   | 460   | 440   | 430   |

**Note:**

- Performance measured using IOMeter\* with 128KB (131,072 bytes) of transfer size with Queue Depth 32.

**Table 5: Latency**

| Specification                  | Intel SSD DC S3510 Series |                   |
|--------------------------------|---------------------------|-------------------|
|                                | 80GB, 120GB, 240GB, 400GB | 800GB/1.2TB/1.6TB |
| Latency (TYP) <sup>1</sup>     |                           |                   |
| Read                           | 55 µs                     | 55 µs             |
| Write                          | 66 µs                     | 66 µs             |
| Power On to Ready <sup>2</sup> | 5.0 s                     | 7.0 s             |

**Notes:**

- Device measured using IOMeter\*. Latency measured using 4KB (4,096 bytes) transfer size with Queue Depth equal to 1 on a sequential workload.
- Power On To Ready time assumes proper shutdown. Time varies if shutdown is not preceded by STANDBY IMMEDIATE command. For 95% of the time, the maximum time for power on to ready will be less than 15 seconds.



**Table 6: Quality of Service**

| Specification  | Unit | Intel SSD DC S3510 Series |                 |                       |                |                 |                       |
|--|------|---------------------------|-----------------|-----------------------|----------------|-----------------|-----------------------|
|  |      | Queue Depth=1             |                 |                       | Queue Depth=32 |                 |                       |
|  |      | 80GB/<br>120GB            | 240GB/<br>480GB | 800GB/1.2TB/<br>1.6TB | 80GB/<br>120GB | 240GB/<br>480GB | 800GB/1.2TB/<br>1.6TB |
| <b>Quality of Service<sup>1,2</sup><br/>(99.9%)</b>    |      |                           |                 |                       |                |                 |                       |
| Reads  | ms   | <500 μs                   | <500 μs         | <500 μs               | <5             | <2              | <2 /<2 /<5            |
| Writes   | ms   | <5                        | <2              | <1 /<500 μs/<1        | <15            | <10             | <10 /<5 /<10          |
| <b>Quality of Service<sup>1,2</sup><br/>(99.9999%)</b> |      |                           |                 |                       |                |                 |                       |
| Reads  | ms   | <5                        | <5              | <2 /<5 /<2            | <5             | <5              | <5 /<5 /<10           |
| Writes   | ms   | <15                       | <10             | <5                    | <20            | <15             | <15 /<15 /<20         |

**Notes:**

1. Device measured using IOMeter\*. Quality of Service measured using 4KB (4,096 bytes) transfer size on a random workload on a full Logical Block Address (LBA) span of the drive once the workload has reached steady state but including all background activities required for normal operation and data reliability.
2. Based on Random 4KB QD=1, 32 workloads, measured as the time taken for 99.9(or 99.9999) percentile of commands to finish the round-trip from host to drive and back to host.

### 2.3 Electrical Characteristics

**Table 7: Operating Voltage**

| Electrical Characteristics                 | Intel SSSDC S3510 Series                                 |
|--|--|
|  | 80GB, 120GB, 240GB, 480GB, 800GB, 1.2TB, 1.6TB           |
| <b>5 V Operating Characteristics:</b>      |  |
| Operating Voltage range                    | 5 V (±5%)  |
| Rise time (Max/Min)                        | 1 s / 1 ms   |
| Fall time (Min) <sup>1</sup>               | 1 ms   |
| Noise level                                | 500 mV pp 10 Hz – 100 KHz<br>50 mV pp 100 KHz – 20 MHz   |
| Min Off time <sup>2</sup>                  | 500 ms   |
| Inrush Current (Typical Peak) <sup>3</sup> | 1.2 A <sub>i</sub> , < 1 s                               |
| <b>12 V Operating Characteristics:</b>     |  |
| Operating Voltage range                    | 12 V (±10%)  |
| Rise time (Max/Min)                        | 1 s / 1 ms   |
| Fall time (Min) <sup>1</sup>               | 1 ms   |
| Noise level                                | 1000 mV pp 10 Hz – 100 KHz<br>100 mV pp 100 KHz – 20 MHz |
| Min Off time <sup>2</sup>                  | 500 ms   |
| Inrush Current (Typical Peak) <sup>3</sup> | 1.2 A <sub>i</sub> , < 1 s                               |

**Notes:**

1. Fall time must be equal or better than minimum in order to guarantee full functionality of enhanced power loss management.
2. The drive must be powered off for at least 500msec before powering on.
3. Measured from initial device power supply application.



Table 8: Power Consumption (5V Supply)

| Specification                           | Unit | Intel SSD DC S3510 Series |       |       |       |       |       |       |
|---|------|---------------------------|-------|-------|-------|-------|-------|-------|
|   |      | 80GB                      | 120GB | 240GB | 480GB | 800GB | 1.2TB | 1.6TB |
| Active Write - RMS Average <sup>1</sup> | W    | 1.91                      | 2.14  | 3.06  | 4.45  | 4.74  | 5.24  | 5.60  |
| Active Write - Burst <sup>2</sup>       | W    | 2.04                      | 2.43  | 3.36  | 5.42  | 7.08  | 8.34  | 8.44  |
| Active Write - Max Burst <sup>3</sup>   | W    | 3.72                      | 3.52  | 4.49  | 6.80  | 8.02  | 8.80  | 9.90  |
| Active Read - RMS Average <sup>4</sup>  | W    | 1.93                      | 2.14  | 2.21  | 2.32  | 2.39  | 2.61  | 2.69  |
| Active Read - Burst <sup>5</sup>        | W    | 2.06                      | 2.32  | 2.97  | 3.63  | 3.61  | 3.96  | 4.14  |
| Active Read - Max Burst <sup>6</sup>    | W    | 3.58                      | 3.52  | 3.86  | 4.09  | 4.66  | 5.31  | 5.34  |
| Idle                                    | W    | 0.6                       | 0.6   | 0.6   | 0.6   | 0.7   | 0.7   | 0.7   |

**Notes:**

1. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential writes. RMS (Root Mean Squared) Average Power is measured using Agilent Power Analyzer over a 100 ms sample period with PLI capacitor charge enabled.
2. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential writes. RMS (Root Mean Squared) Burst Power is measured using Agilent Power Analyzer over a 500  $\mu$ s sample period with PLI capacitor charge disabled.
3. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential writes. RMS (Root Mean Squared) Max Burst power is measured using Agilent Power Analyzer over a 500  $\mu$ s sample period with PLI capacitor charge enabled. Pulse is 0.25% of total time.
4. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential reads. RMS (Root Mean Squared) average power is measured using Agilent Power Analyzer over a 100 ms sample period with PLI capacitor charge enabled.
5. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential reads. RMS (Root Mean Squared) burst power is measured using Agilent Power Analyzer over a 500  $\mu$ s sample period with PLI capacitor charge disabled.
6. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential reads. RMS (Root Mean Squared) Max Burst power is measured using Agilent Power Analyzer over a 500  $\mu$ s sample period with PLI capacitor charge enabled. Pulse is approximately 0.25% of total time.



**Table 9: Power Consumption (5V + 12V Supply)**

| Specification <sup>1</sup>              | Unit | Intel SSD DC S3510 Series |      |       |      |       |      |       |      |       |      |       |      |       |      |
|---|------|---------------------------|------|-------|------|-------|------|-------|------|-------|------|-------|------|-------|------|
|   |      | 800GB                     |      | 120GB |      | 240GB |      | 480GB |      | 800GB |      | 1.2TB |      | 1.6TB |      |
|   |      | 5V                        | 12V  | 5V    | 12V  | 5V    | 12V  | 5V    | 12V  | 5V    | 12V  | 5V    | 12V  | 5V    | 12V  |
| Active Write - RMS Average <sup>1</sup> | W    | 1.22                      | 0.78 | 1.26  | 1.0  | 1.40  | 1.87 | 1.71  | 2.95 | 1.76  | 3.11 | 1.99  | 3.24 | 2.13  | 3.63 |
| Active Write - Burst <sup>2</sup>       | W    | 1.22                      | 0.77 | 1.25  | 1.01 | 1.40  | 1.85 | 1.72  | 3.01 | 1.85  | 3.21 | 1.98  | 3.30 | 2.12  | 3.64 |
| Active Write - Max Burst <sup>3</sup>   | W    | 2.98                      | 0.88 | 2.72  | 1.14 | 2.89  | 2.14 | 3.47  | 4.00 | 3.55  | 5.99 | 4.26  | 7.00 | 4.60  | 7.09 |
| Active Read - RMS Average <sup>4</sup>  | W    | 1.43                      | 0.56 | 1.49  | 0.72 | 1.55  | 0.75 | 1.64  | 0.77 | 1.69  | 0.76 | 1.88  | 0.81 | 1.90  | 0.88 |
| Active Read - Burst <sup>5</sup>        | W    | 1.42                      | 0.56 | 1.50  | 0.71 | 1.54  | 0.76 | 1.62  | 0.77 | 1.73  | 0.95 | 1.89  | 0.82 | 1.88  | 0.87 |
| Active Read – Max Burst <sup>6</sup>    | W    | 3.13                      | 0.70 | 2.79  | 0.91 | 2.79  | 1.34 | 3.23  | 1.40 | 3.45  | 1.68 | 3.97  | 1.71 | 4.40  | 1.84 |
| Idle                                    | W    | 0.60                      | 0.01 | 0.60  | 0.01 | 0.60  | 0.01 | 0.60  | 0.01 | 0.60  | 0.01 | 0.70  | 0.01 | 0.70  | 0.01 |

**Notes:**

1. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential writes. RMS (Root Mean Squared) Average Power is measured using Agilent Power Analyzer over a 100 ms sample period with PLI capacitor charge enabled.
2. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential writes. RMS (Root Mean Squared) Burst Power is measured using Agilent Power Analyzer over a 500 μs sample period with PLI capacitor charge disabled.
3. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential writes. RMS (Root Mean Squared) Max Burst power is measured using Agilent Power Analyzer over a 500 μs sample period with PLI capacitor charge enabled. Pulse is 0.25% of total time.
4. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential reads. RMS (Root Mean Squared) average power is measured using Agilent Power Analyzer over a 100 ms sample period with PLI capacitor charge enabled.
5. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential reads. RMS (Root Mean Squared) burst power is measured using Agilent Power Analyzer over a 500 μs sample period with PLI capacitor charge disabled.
6. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential reads. RMS (Root Mean Squared) Max Burst power is measured using Agilent Power Analyzer over a 500 μs sample period with PLI capacitor charge enabled. Pulse is approximately 0.25% of total time.



## 2.4 Environmental Conditions

**Table 10: Temperature, Shock, Vibration**

| Temperature   | Range  |
|---|--|
| Case Temperature<br>Operating<br>Non-operating <sup>1</sup>     | 0 – 70° C<br>-55 – 95° C   |
| Temperature Gradient <sup>2</sup><br>Operating<br>Non-operating | 30° C/hr (Typical)<br>30° C/hr (Typical)                                     |
| Humidity<br>Operating<br>Non-operating                          | 5 – 95 %<br>5 – 95 %   |
| Shock and Vibration   | Range  |
| Shock <sup>3</sup><br>Operating<br>Non-operating                | 1,000 G (Max) at 0.5 ms<br>1,000 G (Max) at 0.5 ms                           |
| Vibration <sup>4</sup><br>Operating<br>Non-operating            | 2.17 G <sub>RMS</sub> (5-700 Hz) Max<br>3.13 G <sub>RMS</sub> (5-800 Hz) Max |

**Notes:**

- Contact your Intel representative for details on the non-operating temperature range.
- Temperature gradient measured without condensation.
- Shock specifications assume the SSD is mounted securely with the input vibration applied to the drive-mounting screws. Stimulus may be applied in the X, Y or Z axis. Shock specification is measured using Root Mean Squared (RMS) value.
- Vibration specifications assume the SSD is mounted securely with the input vibration applied to the drive-mounting screws. Stimulus may be applied in the X, Y or Z axis. Vibration specification is measured using RMS value.

## 2.5 Product Regulatory Compliance

Intel SSD DC S3510 Series meets or exceeds the regulatory or certification requirements listed in the following table.

**Table 11: Product Regulatory Compliance Specifications**

| Title  | Description  | Region For Which Conformity Declared |
|--|--|--------------------------------------|
| TITLE 47-Telecommunications CHAPTER 1—<br>FEDERAL COMMUNICATIONS COMMISSION PART<br>15 — RADIO FREQUENCY DEVICES<br>ICES-003, Issue 5 Interference-Causing Equipment<br>Standard Digital Apparatus | FCC Part 15B Class B<br><br>CA/CSA-CEI/IEC CISPR 22-10. This is CISPR<br>22:2008 | USA<br><br>Canada                    |
| IEC 55024 Information Technology Equipment —<br>Immunity characteristics— Limits and methods of<br>measurement CISPR24:2010  | EN-55024: 2010 and its amendments  | European Union                       |
| IEC 55022 Information Technology Equipment —<br>Radio disturbance Characteristics— Limits and<br>methods of measurement CISPR24:2008 (Modified)  | EN-55022: 2010 and its amendments  | European Union                       |
| EN-60950-1 2 <sup>nd</sup> Edition   | Information Technology Equipment —<br>Safety — Part 1: General Requirements      | USA/Canada                           |
| UL/CSA EN-60950-1 2 <sup>nd</sup> Edition  | Information Technology Equipment —<br>Safety — Part 1: General Requirements      | USA/Canada                           |



## 2.6 Reliability

Intel SSD DC S3510 Series meets or exceeds SSD endurance and data retention requirements as specified in the JESD218 standard. Reliability specifications are listed in the following table.

**Table 12: Reliability Specifications**

| Parameter   | Value  |
|---|--|
| Uncorrectable Bit Error Rate (UBER)   | < 1 sector per 10 <sup>17</sup> bits read  |
| Uncorrectable bit error rate will not exceed one sector in the specified number of bits read. In the unlikely event of a non-recoverable read error, the SSD will report it as a read failure to the host; the sector in error is considered corrupt and is not returned to the host. |  |
| Mean Time Between Failures (MTBF)   | 2 million hours  |
| Mean Time Between Failures is estimated based on Telcordia* methodology and demonstrated through Reliability Demonstration Test (RDT).  |  |
| Power On/Off Cycles   | 24 per day   |
| Power On/Off Cycles is defined as power being removed from the SSD, and then restored. Most host systems remove power from the SSD when entering suspend and hibernate as well as on a system shutdown.   |  |
| Insertion Cycles  | 50 on SATA cable<br>500 on backplane   |
| SATA/power cable insertion/removal cycles.  |  |
| Data Retention  | 3 months power-off retention once SSD reaches rated write endurance at 40 °C   |
| The time period for retaining data in the NAND at maximum rated endurance.  |  |
| Endurance Rating  | 80GB: Up to 45 TBW<br>120GB: Up to 70 TBW<br>240GB: Up to 140 TBW<br>480GB: Up to 275 TBW<br>800GB: Up to 450 TBW<br>1.2TB: Up to 660 TBW<br>1.6TB: Up to 880 TBW<br>while running JESD218 standard <sup>1</sup> |
| While running JESD218 standard <sup>1</sup> and based on JESD219 workload.  |  |

**Note:**

1. Refer to JESD218 standard table 1 for UBER, FFR and other Enterprise SSD endurance verification requirements. Endurance verification acceptance criterion based on establishing <1E-16 at 60 confidence.



## 2.7 Temperature Sensor

The Intel SSD DC S3510 Series has an internal temperature sensor with an accuracy of +/-2° C over a range of -20° C to +80° C which can be monitored using two SMART attributes: Airflow Temperature (BEh) and Device Internal Temperature (C2h). Both attributes report the same temperature value. For more information on supported SMART attributes, see "SMART Attributes" on page 20.

## 2.8 Power Loss Capacitor Test

The Intel SSD DC S3510 Series supports testing of the power loss capacitor, which can be monitored using the following SMART attribute: (175, AFh).

## 2.9 Hot Plug Support

Hot Plug insertion and removal is supported in the presence of a proper connector and appropriate operating system (OS), as described in the SATA 3.0 specification.

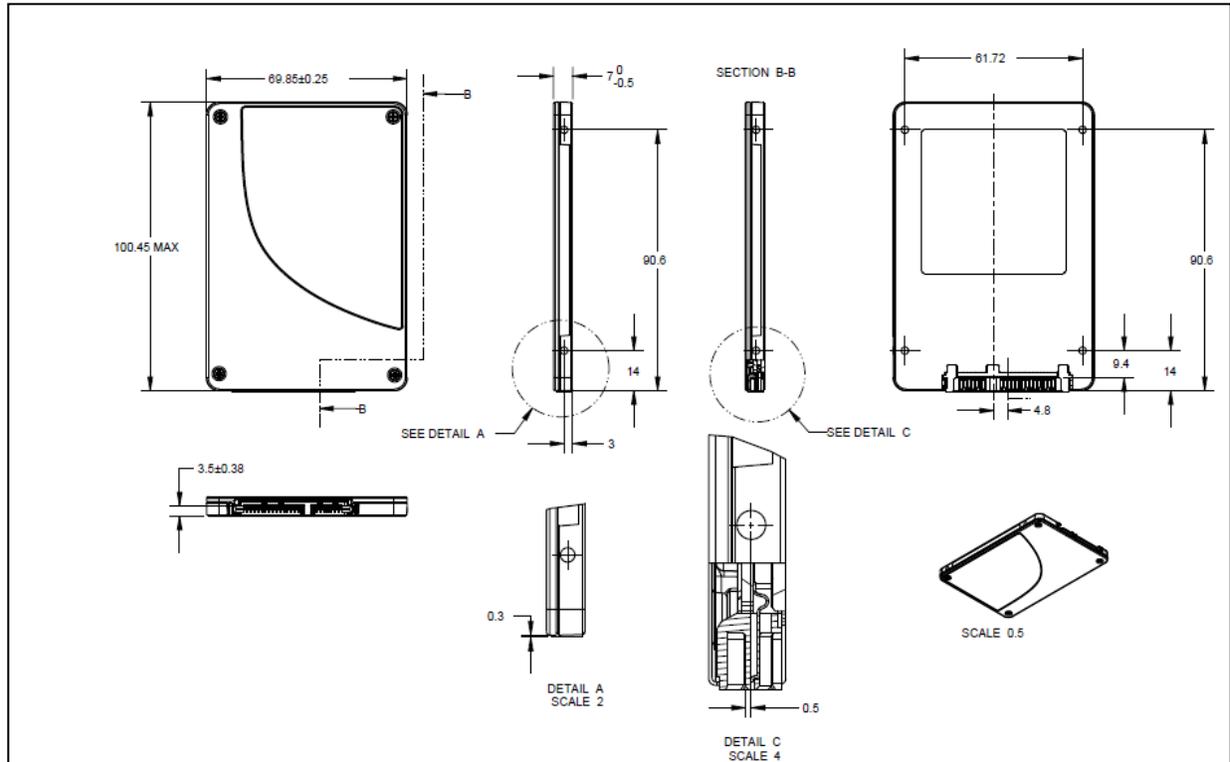
This product supports asynchronous signal recovery and issues an unsolicited COMINIT when first mated with a powered connector to guarantee reliable detection by a host system without hardware device detection.

User Data is protected from planned or unplanned power loss by the Enhanced Power Management technology on the Intel® SSD DC S3510 Series.

### 3 Mechanical Information

Figure 1 shows the physical package information for the Intel SSD DC S3510 Series in the 2.5 inch form factor. All dimensions are in millimeters.

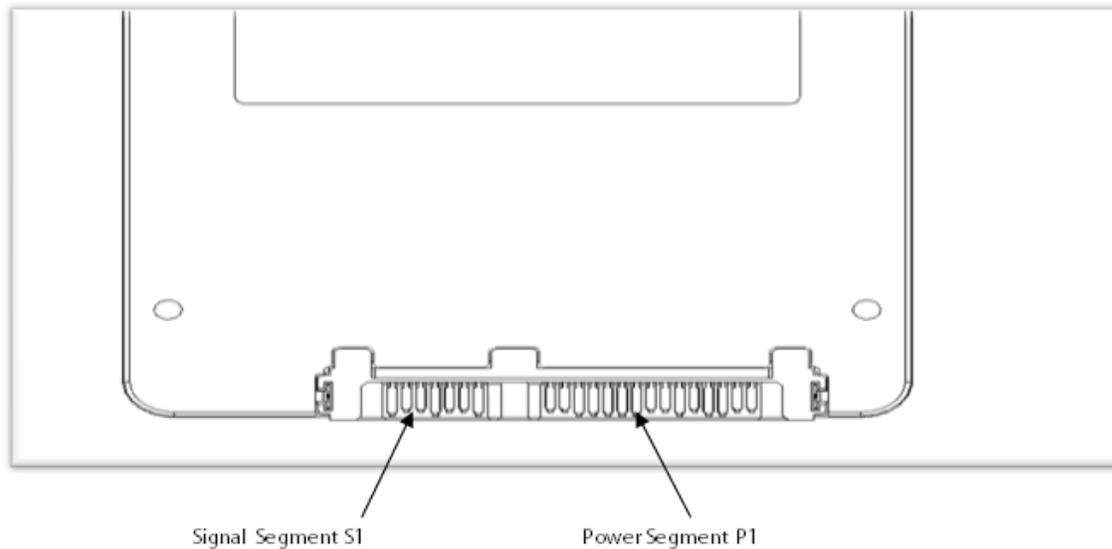
Figure 1: Intel® SSD DC S3510 Series 2.5-inch Dimensions



## 4 Pin and Signal Descriptions

### 4.1 2.5-inch Form Factor Pin Locations

Figure 2: Layout of 2.5-inch Form Factor Signal and Power Segment Pins



**Note:** 2.5-inch connector supports built in latching capability.

### 4.2 Connector Pin Signal Definitions

Table 13: Serial ATA Connector Pin Signal Definitions—2.5-inch Form Factor

| Pin | Function | Definition                 |
|-----|----------|----------------------------|
| S1  | Ground   | 1 <sup>st</sup> mate       |
| S2  | A+       | Differential signal pair A |
| S3  | A-       |                            |
| S4  | Ground   | 1 <sup>st</sup> mate       |
| S5  | B-       | Differential signal pair B |
| S6  | B+       |                            |
| S7  | Ground   | 1 <sup>st</sup> mate       |

**Note:** Key and spacing separate signal and power segments.



### 4.3 Power Pin Signal Definitions

Table 14: Serial ATA Power Pin Definitions—2.5-inch Form Factors

| Pin <sup>1</sup>   | Function        | Definition               | Mating Order         |
|--------------------|-----------------|--------------------------|----------------------|
| P1 <sup>2</sup>    | Not connected   | (3.3V Power)             | --                   |
| P2 <sup>2</sup>    | Not connected   | (3.3V Power)             | --                   |
| P3 <sup>2</sup>    | Not connected   | (3.3V Power; pre-charge) | 2 <sup>nd</sup> Mate |
| P4 <sup>3,4</sup>  | Ground          | Ground                   | 1 <sup>st</sup> Mate |
| P5 <sup>3</sup>    | Ground          | Ground                   | 1 <sup>st</sup> Mate |
| P6 <sup>3</sup>    | Ground          | Ground                   | 1 <sup>st</sup> Mate |
| P7 <sup>3,5</sup>  | V <sub>5</sub>  | 5V Power                 | 1 <sup>st</sup> Mate |
| P8 <sup>3,5</sup>  | V <sub>5</sub>  | 5V Power                 | 2 <sup>nd</sup> Mate |
| P9 <sup>3,5</sup>  | V <sub>5</sub>  | 5V Power                 | 2 <sup>nd</sup> Mate |
| P10 <sup>3</sup>   | Ground          | Ground                   | 1 <sup>st</sup> Mate |
| P11 <sup>6</sup>   | DAS             | Device Activity Signal   | 2 <sup>nd</sup> Mate |
| P12 <sup>3,4</sup> | Ground          | Ground                   | 1 <sup>st</sup> Mate |
| P13 <sup>7</sup>   | V <sub>12</sub> | 12V Power                | 1 <sup>st</sup> Mate |
| P14 <sup>7</sup>   | V <sub>12</sub> | 12V Power                | 2 <sup>nd</sup> Mate |
| P15 <sup>7</sup>   | V <sub>12</sub> | 12V Power                | 2 <sup>nd</sup> Mate |

**Notes:**

1. All pins are in a single row, with a 1.27 mm (0.050-inch) pitch.
2. Pins P1, P2 and P3 are connected together, although they are not connected internally to the device. The host may put 3.3V on these pins.
3. The mating sequence is:
  - ground pins P4-P6, P10, P12 and the 5V power pin P7
  - signal pins and the rest of the 5V power pins P8-P9
4. Ground connectors P4 and P12 may contact before the other 1st mate pins in both the power and signal connectors to discharge ESD in a suitably configured backplane connector.
5. Power pins P7, P8, and P9 are internally connected to one another within the device.
6. The host may ground P11 if it is not used for Device Activity Signal (DAS).
7. Pins P13, P14 and P15 are internally connected to one another within the device. The host may put 12V on these pins.



## 5 Supported Command Sets

The Intel SSD DC S3510 Series supports all mandatory ATA (Advanced Technology Attachment) commands defined in the ATA8-ACS specification described in this section.

### 5.1 ATA General Feature Command Set

The Intel SSD DC S3510 Series supports the ATA General Feature command set (non- PACKET), which consists of:

- EXECUTE DEVICE DIAGNOSTIC
- SET FEATURES
- IDENTIFY DEVICE

**Note:** See Appendix A, "IDENTIFY DEVICE Command Data" for details on the sector data returned after issuing an IDENTIFY DEVICE command.

The Intel SSD DC S3510 Series also supports the following optional commands:

- READ DMA
- WRITE DMA
- READ SECTOR(S)
- READ VERIFY SECTOR(S)
- READ MULTIPLE
- SEEK
- SET FEATURES
- WRITE SECTOR(S)
- SET MULTIPLE MODE<sup>1</sup>
- WRITE MULTIPLE
- FLUSH CACHE
- READ BUFFER
- WRITE BUFFER
- NOP
- DOWNLOAD MICROCODE
- WRITE UNCORRECTABLE EXT

1. The only multiple supported will be multiple 1

### 5.2 Power Management Command Set

The Intel SSD DC S3510 Series supports the Power Management command set, which consists of:

- CHECK POWER MODE
- IDLE
- IDLE IMMEDIATE
- SLEEP
- STANDBY
- STANDBY IMMEDIATE

### 5.3 Security Mode Feature Set

The Intel SSD DC S3510 Series supports the Security Mode command set, which consists of:

- SECURITY SET PASSWORD
- SECURITY UNLOCK
- SECURITY ERASE PREPARE
- SECURITY ERASE UNIT
- SECURITY FREEZE LOCK
- SECURITY DISABLE PASSWORD



## 5.4 SMART Command Set

The Intel SSD DC S3510 Series supports the SMART command set, which consists of:

- SMART READ DATA
- SMART READ ATTRIBUTE THRESHOLDS
- SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE
- SMART SAVE ATTRIBUTE VALUES
- SMART EXECUTE OFF-LINE IMMEDIATE
- SMART READ LOG SECTOR
- SMART WRITE LOG SECTOR
- SMART ENABLE OPERATIONS
- SMART DISABLE OPERATIONS
- SMART RETURN STATUS
- SMART ENABLE/DISABLE AUTOMATIC OFFLINE

### 5.4.1 Attributes

Table 15 lists the SMART attributes supported by the Intel SSD DC S3510 Series and the corresponding status flags and threshold settings.

**Table 15: SMART Attributes**

| ID   | Attribute  | Status Flags |    |    |    |    |    | Threshold |
|------|--|--------------|----|----|----|----|----|-----------|
|      |  | SP           | EC | ER | PE | OC | PW |           |
| 05h  | Re-allocated Sector Count<br>The raw value of this attribute shows the number of retired blocks since leaving the factory (grown defect count).  | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| 09h  | Power-On Hours Count<br>The raw value reports power-on time, cumulative over the life of the SSD, integer number in hour time units.   | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| 0Ch  | Power Cycle Count<br>The raw value of this attribute reports the cumulative number of power cycle events over the life of the device.  | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| AAh  | Available Reserved Space (See Attribute E8)  | 1            | 1  | 0  | 0  | 1  | 1  | 10        |
| ABh  | Program Fail Count<br>The raw value of this attribute shows total count of program fails and the normalized value, beginning at 100, shows the percent remaining of allowable program fails.   | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| ACH  | Erase Fail Count<br>The raw value of this attribute shows total count of erase fails and the normalized value, beginning at 100, shows the percent remaining of allowable erase fails.   | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| A Eh | Unexpected Power Loss<br>Also known as "Power-off Retract Count" per magnetic-drive terminology.<br>Reports number of unclean shutdowns, cumulative over the life of the SSD.<br>An "unclean shutdown" is the removal of power without STANDBY IMMEDIATE as the last command (regardless of PLI activity using capacitor power). | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |



| ID  | Attribute  | Status Flags |    |    |    |    |    | Threshold |
|-----|--|--------------|----|----|----|----|----|-----------|
|     |  | SP           | EC | ER | PE | OC | PW |           |
| AFh | <p>Power Loss Protection Failure<br/>Last test result as microseconds to discharge cap, saturates at max value. Also logs minutes since last test and lifetime number of tests.</p> <p>Bytes 0-1: Last test result as microseconds to discharge cap, saturates at max value. Test result expected in range 25 &lt;= result &lt;= 5000000, lower indicates specific error code</p> <p>Bytes 2-3: Minutes since last test, saturates at max value.</p> <p>Bytes 4-5: Lifetime number of tests, not incremented on power cycle, saturates at max value.</p> | 1            | 1  | 0  | 0  | 1  | 1  | 10        |
| B7h | <p>SATA Downshift Count<br/>The count of the number of times SATA interface selected lower signaling rate due to error.</p>  | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| B8h | <p>End-to-End Error Detection Count<br/><i>Raw value:</i> reports number of LBA tag mismatches in end-to-end data protection path.<br/><i>Normalized value:</i> always 100.</p>  | 1            | 1  | 0  | 0  | 1  | 1  | 90        |
| BBh | <p>Uncorrectable Error Count<br/>The raw value shows the count of errors that could not be recovered using Error Correction Code (ECC).<br/><i>Normalized value:</i> always 100.</p>   | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| BEh | <p>Case Temperature - Reports the SSD case temperature. Same values as reported in the attribute C2h.<br/>Raw value suggests 100 - case temperature in C degrees.</p>  | 1            | 0  | 0  | 0  | 1  | 0  | 0 (none)  |
| C0h | <p>Power-Off Retract Count (Unsafe Shutdown Count)<br/>The raw value of this attribute reports the cumulative number of unsafe (unclean) shutdown events over the life of the device. An unsafe shutdown occurs whenever the device is powered off without STANDBYIMMEDIATE being the last command.</p>  | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| C2h | <p>Temperature - Device Internal Temperature<br/>Reports internal temperature of the SSD. Temperature reading is the value direct from the printed circuit board (PCB) sensor without offset.</p>  | 1            | 0  | 0  | 0  | 1  | 0  | 0 (none)  |
| C5h | <p>Pending Sector Count<br/>Number of current unrecoverable read errors that will be re-allocated on next write.</p>   | 0            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| C7h | <p>CRC Error Count<br/>The total number of encountered SATA interface cyclic redundancy check (CRC) errors.</p>  | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| E1h | <p>Host Writes<br/>The raw value of this attribute reports the total number of sectors written by the host system. The raw value is increased by 1 for every 65,536 sectors (32MB) written by the host.</p>  | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |



| ID  | Attribute  | Status Flags |    |    |    |    |    | Threshold |
|-----|--|--------------|----|----|----|----|----|-----------|
|     |  | SP           | EC | ER | PE | OC | PW |           |
| E2h | <p>Timed Workload Media Wear</p> <p>Measures the wear seen by the SSD (since reset of the workload timer, attribute E4h), as a percentage of the maximum rated cycles.</p>   | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| E3h | <p>Timed Workload Host Read/Write Ratio</p> <p>Shows the percentage of I/O operations that are read operations (since reset of the workload timer, attribute E4h).</p>   | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| E4h | <p>Timed Workload Timer</p> <p>Measures the elapsed time (number of minutes since starting this workload timer).</p>   | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| E8h | <p>Available Reserved Space</p> <p>This attribute reports the number of reserve blocks remaining. The normalized value begins at 100 (64h), which corresponds to 100 percent availability of the reserved space. The threshold value for this attribute is 10 percent availability.</p>  | 1            | 1  | 0  | 0  | 1  | 1  | 10        |
| E9h | <p>Media Wearout Indicator</p> <p>This attribute reports the number of cycles the NAND media has undergone. The normalized value declines linearly from 100 to 1 as the average erase cycle count increases from 0 to the maximum rated cycles. Once the normalized value reaches 1, the number will not decrease, although it is likely that significant additional wear can be put on the device.</p>  | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| EAh | <p>Thermal Throttle Status</p> <p>Reports Percent Throttle Status and Count of events</p> <p>Byte 0 = Throttling status. Decimal value 0 = No Throttle Applied, 100 = 100% throttling applied. Intermediate percentages are supported. A value larger than 100d is invalid.</p> <p>Bytes 1-4 = Throttling event count. 32 bit counter indicates the number of times thermal throttle has activated. Value is preserved over power cycles.</p> <p>Byte 5 = Reserved</p> | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| F1h | <p>Total LBAs Written</p> <p>The raw value of this attribute reports the total number of sectors written by the host system. The raw value is increased by 1 for every 65,536 sectors (32MB) written by the host.</p>  | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |
| F2h | <p>Total LBAs Read</p> <p>The raw value of this attribute reports the total number of sectors read by the host system. The raw value is increased by 1 for every 65,536 sectors (32MB) read by the host.</p>   | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |



| ID  | Attribute   | Status Flags |    |    |    |    |    | Threshold |
|-----|---|--------------|----|----|----|----|----|-----------|
|     |   | SP           | EC | ER | PE | OC | PW |           |
| F3h | <p>Total Bytes Written</p> <p>The raw value of this attribute reports the total number of sectors written to the NAND media. This includes NAND writes triggered by host writes, defrag, background data refresh and wear level relocation writes etc. The raw value is increased by 1 for every 65,536 sectors (32MB) writes to the NAND media. Upon NAND write, new value returned once per minute.</p> | 1            | 1  | 0  | 0  | 1  | 0  | 0 (none)  |

**Table 16: SMART Attribute Status Flags**

| Status Flag | Description                 | Value = 0                              | Value = 1   |
|-------------|-----------------------------|--|---|
| SP          | Self-preserving attribute   | Not a self-preserving attribute        | Self-preserving attribute                         |
| EC          | Event count attribute       | Not an event count attribute           | Event count attribute                             |
| ER          | Error rate attribute        | Not an error rate attribute            | Error rate attribute                              |
| PE          | Performance attribute       | Not a performance attribute            | Performance attribute                             |
| OC          | Online collection attribute | Collected only during offline activity | Collected during both offline and online activity |
| PW          | Pre-fail warranty attribute | Advisory                               | Pre-fail  |

## 5.4.2 Timed Workload Endurance Indicators

### Timed Workload Media Wear Indicator — ID E2h

This attribute tracks the drive wear seen by the device during the last wear timer loop, as a percentage of the maximum rated cycles. The raw value tracks the percentage up to 2 decimal precision points. This value should be divided by 1024 to get the percentage.

For example: if the raw value is 4455, the percentage is  $4455/1024 = 4.35\%$ . The raw value is held at FFFFh until the wear timer (attribute E4h) reaches 60 (minutes) after a SMART EXECUTE OFFLINE IMMEDIATE (B0h/D4h) subcommand 40h to the SSD. The normalized value is always set to 100 and should be ignored.

### Timed Workload Host Reads Percentage — ID E3h

This attribute shows the percentage of I/O operations that are read operations during the last workload timer loop. The raw value tracks this percentage and is held at FFFFh until the workload timer (attribute E4h) reaches 60 (minutes). The normalized value is always set to 100 and should be ignored.

### Workload Timer — ID E4h

This attribute is used to measure the time elapsed during the current workload. The attribute is reset when a SMART EXECUTE OFFLINE IMMEDIATE (D4h) subcommand 40h is issued to the drive. The raw value tracks the time in minutes and has a maximum value of  $2^{32} = 4,294,967,296$  minutes (8,171 years). The normalized value is always set to 100 and should be ignored.



## User Notes

- Sending a SMART EXECUTE OFFLINE IMMEDIATE (B0h/D4h) subcommand 40h to the SSD resets and starts all three attributes (Media Wear Indicator, Attribute E2h, Host Reads Percentage, Attribute E3h, and the Workload timer, Attribute E4h to FFFFh.
- The Attribute raw values are held at FFFFh until the Workload timer (Attribute E4h) reaches a total of 60 (minutes) of power on time. After 60 minutes, the Timed Workload data is made available.
- After the Workload timer (E4h) reaches 60 (minutes), the Timed Workload data is saved every minute so only 59 seconds of data is lost if power is removed without receiving ATA STANDBY IMMEDIATE. Accumulated data is not reset due to power loss.
- Upon power up, the attributes hold a snapshot of their last saved values for 59 seconds and live data is available after 60 seconds, once the initial one hour interval is completed.

## Example Use Cases

The Timed Workload Endurance attributes described in this section are intended to be used to measure the amount of media wear that the drive is subjected to during a timed workload.

Ideally, the system that the drive is being used in should be capable of issuing SMART commands. Otherwise, provisions have been provided to allow the media wear attributes to be persistent so the drive can be moved to a SMART capable system to read out the drive wear attribute values.

### Use Case 1 – With a System Capable of SMART Commands

1. On a SMART capable system, issue the SMART EXECUTE OFF-LINE IMMEDIATE (D4h) sub-command 40h to reset the drive wear attributes.
2. Run the workload to be evaluated for at least 60 minutes. Otherwise the drive wear attributes will not be available.
3. Read out the drive wear attributes with the SMART READ DATA (D0h) command.

### Use Case 2 – With a System Not Capable of SMART Commands

1. On a SMART capable system, issue the SMART EXECUTE OFF-LINE IMMEDIATE (D4h) sub-command 40h to reset the drive wear attributes.
2. Move the drive to the system where the workload will be measured (and not capable of SMART commands).
3. Run the workload to be evaluated for at least 60 minutes. Otherwise the drive wear attributes will not be available.
4. Do a clean system power down by issuing the ATA STANDBY IMMEDIATE command prior to shutting down the system. This will store all the drive wear SMART attributes to persistent memory within the drive.
5. Move the drive to a SMART capable system.
6. Read out the drive wear attributes with the SMART READ DATA (D0h) command within 59 seconds after power-up.



### Example Calculation of Drive Wear

The following is an example of how the drive wear attributes can be used to evaluate the impact of a given workload. The Host Writes SMART attribute (E1h) can also be used to calculate the amount of data written by the host during the workload by reading this attribute before and after running the workload. This example assumes that the steps shown in “Example Use Cases” on page 24 were followed to obtain the following attribute values:

- Timed Workload Media Wear (E2h) has a raw value of 16. Therefore, the percentage wear =  $16/1024 = 0.016\%$ .
- Timed Workload Host Read/Write Ratio (E3h) has a normalized value of 80, indicating that 80% of operations were reads.
- Workload Timer (E4h) has a raw value of 500. Therefore the workload ran for 500 minutes.
- Host Writes Count (E1h) had a raw value of 100,000 prior to running the workload and a value of 130,000 at the end of the workload. Therefore, the number of sectors written by the host during the workload was  $30,000 * 65,535 = 1,966,050,000$  sectors or  $1,966,050,000 * 512/1,000,000,000 = 1,007$  GB.

The following conclusions can be made for this example case:

The workload took 500 minutes to complete with 80% reads and 20% writes. A total of 1,007 GB of data was written to the device, which increased the media wear in the drive by 0.016%. At this point in time, this workload is causing a wear rate of 0.016% for every 500 minutes, or 0.00192%/hour.

#### 5.4.3 SMART Logs

The Intel SSD DC S3510 Series implements the following Log Addresses: 00h, 02h, 03h, 06h, and 07h.

The DC S3510 Series implements host vendor specific logs (addresses 80h-9Fh) as read and write scratchpads, where the default value is zero (0). Intel SSD DC S3510 does not write any specific values to these logs unless directed by the host through the appropriate commands.

The DC S3510 Series also implements a device vendor specific log at address A9h as a read-only log area with a default value of zero (0). Besides that, the DC S3510 Series also implements log address B8h (if the drive is in disable logical mode, log address B8h will have the word error code for \*BAD\_CTX). Finally the DC S3510 Series also implements log at addresses B9h and BAh (both of them are Intel error logs, and read only for customers).

#### 5.5 Device Statistics

In addition to the SMART attribute structure, statistics pertaining to the operation and health of the Intel SSD DC S3510 Series can be reported to the host on request through the Device Statistics log as defined in the ATA specification.

The Device Statistics log is a read-only GPL/SMART log located at read log address 0x04 and is accessible using READ LOG EXT, READ LOG DMA EXT or SMART READ LOG commands.

The following table lists the Device Statistics supported by the Intel SSD DC S3510 Series.



**Table 17: Serial ATA Power Pin Definitions—2.5-inch Form Factors**

| Page                                 | Offset | Description  | Equivalent SMART attribute (if applicable)              |
|--------------------------------------|--------|--|---|
| 0x00                                 | --     | List of Supported Pages                                      | --  |
| 0x01 – General Statistics            | 0x08   | Power Cycle Count  | 0Ch   |
|                                      | 0x10   | Power-On Hours   | 09h   |
|                                      | 0x18   | Logical Sectors Written                                      | E1h   |
|                                      | 0x20   | Num Write Commands – incremented by one for every host write | --  |
|                                      | 0x28   | Logical Sectors Read   | F2h   |
|                                      | 0x30   | Num Read Commands – incremented by one for every host read   | --  |
| 0x04 – General Error Statistics      | 0x08   | Num Reported Uncorrectable Errors                            | BBh   |
|                                      | 0x10   | Num Resets Between Command Acceptance and Completion         | --  |
| 0x05 – Temperature Statistics        | 0x00   | Device Statistics Information Header                         | --  |
|                                      | 0x08   | Current Temperature  | --  |
|                                      | 0x10   | Average Short Term Temperature                               | --  |
|                                      | 0x18   | Average Long Term Temperature                                | --  |
|                                      | 0x20   | Highest Temperature  | --  |
|                                      | 0x28   | Lowest Temperature   | --  |
|                                      | 0x30   | Highest Average Short Term Temperature                       | --  |
|                                      | 0x38   | Lowest Average Short Term Temperature                        | --  |
|                                      | 0x40   | Highest Average Long Term Temperature                        | --  |
|                                      | 0x48   | Lowest Average Long Term Temperature                         | --  |
|                                      | 0x50   | Time in Over-Temperature                                     | --  |
|                                      | 0x58   | Specified Maximum Operating Temperature                      | --  |
|                                      | 0x60   | Time in Under-Temperature                                    | --  |
|                                      | 0x68   | Specified Minimum Operating Temperature                      | --  |
| 0x06 – Transport Statistics          | 0x08   | Number of Hardware Resets                                    | --  |
|                                      | 0x10   | Number of ASR Events   | --  |
|                                      | 0x18   | Number of Interface CRC Errors                               | --  |
| 0x07 – Solid State Device Statistics | 0x08   | Percentage Used Endurance Indicator                          | E9h<br>Note: This device statistic counts from 1 to 150 |



## 5.6 SMART Command Transport (SCT)

With SMART Command Transport (SCT), a host can send commands and data to an SSD and receive status and data from an SSD using standard write/read commands to manipulate two SMART Logs:

- Log Address E0h ("SCT Command/Status") — used to send commands and retrieve status
- Log Address E1h ("SCT Data Transfer") — used to transport data

Intel SSD DC S3510 supports the following standard SCT actions:

- Write Same — DC S3510 Series implements this action code as described in the ATA specification.
- Error Recovery Control — DC S3510 Series accepts this action code, and will store and return error-recovery time limit values.
- Feature Control - DC S3510 Series supports feature code 0001h (write cache) feature code 0002h (write cache reordering), and feature code 0003h (time interval for temperature logging). It also supports D000h (Power Safe Write Cache capacitor test interval), D001h (read/write power governor mode), D002h (read thermal governor mode), D003h (read power governor burst power), and D004h (read power governor average power).
- Data table command - DC S3510 Series supports data table command as specified in ATA8-ACS2. This will read out temperature logging information in table ID 0002h.
- Read Status Support - DC S3510 supports read status log
- By using SCT command 0xD801 with State=0, Option=1, ID Word 106 can be changed from 0x6003 to 0x4000 (4KB physical sector size to 512B physical sector size support change).

## 5.7 Data Set Management Command Set

Intel SSD DC S3510 Series supports the Data Set Management command set Trim attribute, which consists of:

- DATA SET MANAGEMENT

## 5.8 Host Protected Area Command Set

Intel SSD DC S3510 Series supports the Host Protected Area command set, which consists of:

- READ NATIVE MAX ADDRESS
- SET MAX ADDRESS
- READ NATIVE MAX ADDRESS EXT
- SET MAX ADDRESS EXT

Intel SSD DC S3510 Series also supports the following optional commands:

- SET MAX SET PASSWORD
- SET MAX LOCK
- SET MAX FREEZE LOCK
- SET MAX UNLOCK



## 5.9 48-Bit Address Command Set

Intel SSD DC S3510 Series supports the 48-bit Address command set, which consists of:

- FLUSH CACHE EXT
- READ DMA EXT
- READ NATIVE MAX ADDRESS EXT
- READ SECTOR(S) EXT
- READ VERIFY SECTOR(S) EXT
- SET MAX ADDRESS EXT
- WRITE DMA EXT
- WRITE MULTIPLE EXT
- WRITE SECTOR(S) EXT
- WRITE MULTIPLE FUA EXT
- WRITE DMA FUA EXT

## 5.10 General Purpose Log Command Set

Intel SSD DC S3510 Series supports the General Purpose Log command set, which consists of:

- READ LOG EXT
- WRITE LOG EXT

## 5.11 Native Command Queuing

Intel SSD DC S3510 Series supports the Native Command Queuing (NCQ) command set, which includes:

- READ FPDMA QUEUED
- WRITE FPDMA QUEUED

**Note:** With a maximum Queue Depth set to 32.

## 5.12 Software Settings Preservation

Intel SSD DC S3510 Series supports the SET FEATURES parameter to enable/disable the preservation of software settings.



## 6 Certifications and Declarations

The following table describes the Device Certifications supported by the Intel SSD DC S3510 Series.

**Table 18: Device Certifications and Declarations**

| Certification      | Description  |
|--------------------|--|
| CE Compliant       | Low Voltage DIRECTIVE 2006/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2006, and EMC Directive 2004/108/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004.   |
| UL Recognized      | Underwriters Laboratories, Inc. Bi-National Component Recognition; UL 60950-1, 2nd Edition, 2007-03-27 (Information Technology Equipment - Safety - Part 1: General Requirements)<br>CSA C22.2 No. 60950-1-07, 2nd Edition, 2007-03 (Information Technology Equipment - Safety - Part 1: General Requirements) |
| RCM Mark Compliant | Compliance with the Australia/New Zealand Standard AS/NZS3548 and Electromagnetic Compatibility (EMC) Framework requirements of the Australian Communication Authority (ACA).  |
| BSMI Compliant     | Compliance to the Taiwan EMC standard CNS 13438: Information technology equipment - Radio disturbance Characteristics - limits and methods of measurement, as amended on June 1, 2006, is harmonized with CISPR 22: 2005.04.   |
| KCC                | Compliance with paragraph 1 of Article 11 of the Electromagnetic Compatibility Control Regulation and meets the Electromagnetic Compatibility (EMC) Framework requirements of the Radio Research Laboratory (RRL) Ministry of Information and Communication Republic of Korea.                                 |
| VCCI               | Voluntary Control Council for Interface to cope with disturbance problems caused by personal computers or facsimile.   |
| RoHS Compliant     | Restriction of Hazardous Substance Directive   |
| WEEE               | Directive on Waste Electrical and Electronic Equipment   |



## 7 References

The following table identifies the standards information referenced in this document.

**Table 19: Standards References**

| Date   | Title  | Location  |
|--|--|---|
| July 2012                                    | Solid State Drive (SSD) Requirements and Endurance Test Method (JESD219)   | <a href="http://www.jedec.org/standards-documents/results/jesd219">http://www.jedec.org/standards-documents/results/jesd219</a>         |
| Sept 2010                                    | Solid State Drive (SSD) Requirements and Endurance Test Method (JESD218)   | <a href="http://www.jedec.org/standards-documents/docs/jesd218/">http://www.jedec.org/standards-documents/docs/jesd218/</a>             |
| Dec 2008                                     | VCCI   | <a href="http://www.vcci.jp/vcci_e/">http://www.vcci.jp/vcci_e/</a>   |
| June 2009                                    | RoHS   | <a href="http://qdms.intel.com/">http://qdms.intel.com/</a><br>Click Search MDDS Database and search for material description datasheet |
| August 2009                                  | ACS-2-ATA/ATAPI Command Set 2 Specification  | <a href="http://www.t13.org/">http://www.t13.org/</a>   |
| June 2009                                    | Serial ATA Revision 3.0  | <a href="http://www.sata-io.org/">http://www.sata-io.org/</a>   |
| May 2006                                     | SFF-8223, 2.5-inch Drive w/Serial Attachment Connector   | <a href="http://www.sffcommittee.org/">http://www.sffcommittee.org/</a>   |
| May 2005                                     | SFF-8201, 2.5-inch drive form factor   | <a href="http://www.sffcommittee.org/">http://www.sffcommittee.org/</a>   |
| 1995<br>1996<br>1995<br>1995<br>1997<br>1994 | International Electrotechnical Commission EN 61000<br>4-2 (Electrostatic discharge immunity test)<br>4-3 (Radiated, radio-frequency, electromagnetic field immunity test)<br>4-4 (Electrical fast transient/burst immunity test)<br>4-5 (Surge immunity test)<br>4-6 (Immunity to conducted disturbances, induced by radio-frequency fields)<br>4-11 (Voltage Variations, voltage dips, short interruptions and voltage variations immunity tests) | <a href="http://www.iec.ch/">http://www.iec.ch/</a>   |
| 1995   | ENV 50204<br>(Radiated electromagnetic field from digital radio telephones)  | <a href="http://www.dbicorporation.com/radimmun.htm/">http://www.dbicorporation.com/radimmun.htm/</a>                                   |



## Appendix A: IDENTIFY DEVICE Command Data

Table 20: Returned Sector Data

| Word  | F = Fixed<br>V = Variable<br>X = Both | Default Value   | Description  |
|-------|---------------------------------------|---|--|
| 0     | X                                     | 0040h   | General configuration bit-significant information                            |
| 1     | X                                     | 3FFFh   | Obsolete - Number of logical cylinders (16,383)                              |
| 2     | V                                     | C837h   | Specific configuration   |
| 3     | X                                     | 0010h   | Obsolete - Number of logical heads (16)                                      |
| 4-5   | X                                     | 0h  | Retired  |
| 6     | X                                     | 003Fh   | Obsolete - Number of logical sectors per logical track (63)                  |
| 7-8   | V                                     | 0h  | Reserved for assignment by the CompactFlash* Association (CFA)               |
| 9     | X                                     | 0h  | Retired  |
| 10-19 | F                                     | varies  | Serial number (20 ASCII characters)  |
| 20-21 | X                                     | 0h  | Retired  |
| 22    | X                                     | 0h  | Obsolete   |
| 23-26 | F                                     | varies  | Firmware revision (8 ASCII characters)                                       |
| 27-46 | F                                     | varies  | Model number (Intel® Solid State Drive)                                      |
| 47    | F                                     | 8001h   | 7:0—Maximum number of sectors transferred per interrupt on multiple commands |
| 48    | F                                     | 4000h   | Trusted Computing Feature Set  |
| 49    | F                                     | 2F00h   | Capabilities   |
| 50    | F                                     | 4000h   | Capabilities   |
| 51-52 | X                                     | 0h  | Obsolete   |
| 53    | F                                     | 0007h   | Words 88 and 70:64 valid   |
| 54    | X                                     | 3FFFh   | Obsolete - Number of logical cylinders (16,383)                              |
| 55    | X                                     | 0010h   | Obsolete - Number of logical heads (16)                                      |
| 56    | X                                     | 003Fh   | Obsolete - Number of logical sectors per logical track (63)                  |
| 57-58 | X                                     | FC1000FBh   | Obsolete   |
| 59    | F                                     | BF01  | Number of sectors transferred per interrupt on multiple commands             |
| 60-61 | V                                     | 80GB: 0950F8B0h<br>120GB: 0DF94B80h<br>200GB: 0FFFFFFFh<br>400GB: 0FFFFFFFh<br>480GB: 0FFFFFFFh<br>800GB: 0FFFFFFFh<br>1200GB: 0FFFFFFFh<br>1600GB: 0FFFFFFFh | Total number of user-addressable sector for 28-bit commands                  |
| 62    | X                                     | 0h  | Obsolete   |
| 63    | X                                     | 0007h   | Multi-word DMA modes supported/selected                                      |
| 64    | F                                     | 0003h   | PIO modes supported  |
| 65    | F                                     | 0078h   | Minimum multiword DMA transfer cycle time per word                           |
| 66    | F                                     | 0078h   | Manufacturer's 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                                     | 4030h   | Additional Supported   |
| 70    | F                                     | 0000h   | Reserved   |
| 71-74 | F                                     | 0h  | Reserved for IDENTIFY PACKET DEVICE command                                  |



| Word    | F = Fixed<br>V = Variable<br>X = Both | Default Value   | Description  |
|---------|---------------------------------------|---|--|
| 75      | F                                     | 001Fh   | Queue depth  |
| 76      | F                                     | 850Eh   | Serial ATA capabilities  |
| 77      | F                                     | 0006h   | Reserved for future Serial ATA definition  |
| 78      | F                                     | 0040h   | Serial ATA features supported  |
| 79      | V                                     | 0040h   | Serial ATA features enabled  |
| 80      | F                                     | 03FCh   | Major version number   |
| 81      | F                                     | 0110h   | Minor version number   |
| 82      | F                                     | 746Bh   | Command set supported  |
| 83      | F                                     | 7501h   | Command sets supported   |
| 84      | F                                     | 6163h   | Command set/feature supported extension  |
| 85      | X                                     | 7469h   | Command set/feature enabled  |
| 86      | X                                     | B401h   | Command set/feature enabled  |
| 87      | X                                     | 6163h   | Command set/feature default  |
| 88      | X                                     | 407Fh   | Ultra DMA Modes  |
| 89      | F                                     | 0002h   | Time required for security erase unit completion   |
| 90      | F                                     | 0002h   | Time required for enhanced security erase completion   |
| 91      | V                                     | 0h  | Current advanced power management value  |
| 92      | V                                     | OFFFEh  | Master Password Revision Code  |
| 93      | X                                     | 0h  | Hardware reset result: the contents of bits (12:0) of this word shall change only during the execution of a hardware reset |
| 94      | V                                     | 0h  | Vendor's recommended and actual acoustic management value  |
| 95      | F                                     | 0h  | Stream minimum request size  |
| 96      | V                                     | 0h  | Streaming transfer time - DMA  |
| 97      | V                                     | 0h  | Streaming access latency - DMA and PIO   |
| 98-99   | F                                     | 0h  | Streaming performance granularity  |
| 100-103 | V                                     | 80GB: 0950F8B0h<br>120GB: 0DF94BB0h<br>200GB: 1749F1B0h<br>400GB: 2E9390B0h<br>480GB: 37E436B0h<br>800GB: 5D26CEB0h<br>1200GB: 8BBA0CB0h<br>1600GB: BA4D4AB0h | Maximum user LBA for 48-bit address feature set  |
| 104     | V                                     | 0h  | Streaming transfer time - PIO  |
| 105     | V                                     | 0006h   | Maximum number of 512-byte blocks of LBA Range Entries per DATA SET MANAGEMENT command                                     |
| 106     | F                                     | 6003h   | Physical sector size / logical sector size – User Changeable by SCT command to report 512B                                 |
| 107     | F                                     | 0h  | Inter-seek delay for ISO-7779 acoustic testing in microseconds   |
| 108-111 | F                                     | varies  | Unique ID  |
| 112-115 | F                                     | 0h  | Reserved for worldwide name extension to 128 bits  |
| 116     | V                                     | 0h  | Reserved for technical report  |
| 117-118 | F                                     | 0h  | Words per logical sector   |
| 119     | F                                     | 405Ch   | Supported settings   |
| 120     | X                                     | 401Ch   | Command set/feature enabled/supported  |
| 121-126 | F                                     | 0h  | Reserved   |
| 127     | X                                     | 0h  | Removable Media Status Notification feature set support  |
| 128     | X                                     | 0021h   | Security status  |



| Word    | F = Fixed<br>V = Variable<br>X = Both | Default Value | Description  |
|---------|---------------------------------------|---------------|--|
| 129     | V                                     | 001Ch         | Vendor-specific  |
| 130-139 | X                                     | 0h            | Vendor-specific  |
| 140-149 | X                                     | 0h            | Disable Logical Error Field  |
| 150-159 | X                                     | 0h            | Vendor-specific  |
| 160     | X                                     | 0h            | CompactFlash Association (CFA) power mode 1  |
| 161-167 | X                                     | 0h            | Reserved for assignment by the CFA   |
| 168     | X                                     | 0003h         | Reserved for assignment by the CFA   |
| 169     | X                                     | 0001h         | Data set management Trim attribute support   |
| 170-175 | F                                     | 0h            | Reserved for assignment by the CFA   |
| 176-205 | V                                     | Varies        | Current media serial number  |
| 206     | X                                     | 003Dh         | SCT Command Transport  |
| 207-208 | F                                     | 0000h         | Reserved   |
| 209     | X                                     | 4000h         | Alignment of logical blocks within a physical block                                |
| 210-211 | V                                     | 0000h         | Write-Read-Verify Sector Count Mode 3 (DWord)                                      |
| 212-213 | F                                     | 0000h         | Write-Read-Verify Sector Count Mode 2 (DWord)                                      |
| 214     | X                                     | 0000h         | NV Cache Capabilities  |
| 215-216 | V                                     | 0000h         | NV Cache Size in Logical Blocks (DWord)  |
| 217     | F                                     | 0001h         | Nominal media rotation rate  |
| 218     | V                                     | 0000h         | Reserved   |
| 219     | F                                     | 0000h         | NV Cache Options   |
| 220     | V                                     | 0000h         | Write-Read-Verify feature set  |
| 221     | X                                     | 0000h         | Reserved   |
| 222     | F                                     | 101Fh         | Transport major version number   |
| 223     | F                                     | 0000h         | Transport minor version number   |
| 224-229 | F                                     | 0000h         | Reserved   |
| 230-233 | X                                     | 0000h         | Extended Number of User Addressable Sectors (QWord)                                |
| 234     | F                                     | 0001h         | Minimum number of 512-byte data blocks per DOWNLOAD MICROCODE command for mode 03h |
| 235     | F                                     | FFFFh         | Maximum number of 512-byte data blocks per DOWNLOAD MICROCODE command for mode 03h |
| 236-254 | X                                     | 0000h         | Reserved   |
| 255     | V                                     | Varies        | Integrity word   |

**Notes:**

**F = Fixed.** The content of the word is fixed and does not change. For removable media devices, these values may change when media is removed or changed.

**V = Variable.** The state of at least one bit in a word is variable and may change depending on the state of the device or the commands executed by the device.

**X = F or V.** The content of the word may be fixed or variable.