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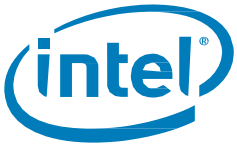
Intel® Solid-State Drive DC S3500 Series

Product Specification

- Capacity:
  - 2.5-inch: 80/120/160/240/300/480/600/800 GB
  - 1.8-inch: 80/240/400/800 GB
- Components:
  - Intel® 20nm NAND Flash Memory
  - Multi-Level Cell (MLC)
- Form Factor: 2.5–inch and 1.8-inch
- Read and Write IOPS[1,2] (Full LBA Range, Iometer* Queue Depth 32)
  - Random 4 KB[3] Reads: Up to 75,000 IOPS
  - Random 4 KB Writes: Up to 11,500 IOPS
  - Random 8 KB[3] Reads: Up to 47,500 IOPS
  - Random 8 KB Writes: Up to 5,500 IOPS
- Bandwidth Performance[1]
  - Sustained Sequential Read: Up to 500 MB/s[4]
  - Sustained Sequential Write: Up to 450 MB/s
- Latency (average sequential)
  - Read: 50 µs (TYP)
  - Write: 65 µs (TYP)
- Quality of Service[5, 6]
  - Read/Write: 500 µs / 5 ms (99.9%)
- AES 256-bit Encryption
- Compliance
  - SATA Revision 3.0; compatible with SATA 6Gb/s, 3Gb/s and 1.5Gb/s interface rates
  - ATA8-ACS2; 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
- Compatibility
  - Windows 7 and Windows 8
  - Windows Server 2012
  - Windows Server 2008 Enterprise 32/64bit SP2
  - Windows Server 2008 R2 SP1
  - Windows Server 2003 Enterprise R2 64bit SP2
  - Red Hat Enterprise Linux* 5.5, 5.6, 6.1, 6.3
  - SUSE* Linux Enterprise Server 10, 11 SP1
  - CentOS 64bit 5.7, 6.3
  - Intel® SSD Toolbox with Intel® SSD Optimizer
- Product Ecological Compliance
  - RoHS*
- Power Management
  - 2.5 inch: 5 V or 12 V SATA Supply Rail[7]
  - 1.8 inch: 3.3 V SATA Supply Rail
  - SATA Interface Power Management
  - OS-aware hot plug/removal
  - Enhanced power-loss data protection
- Power
  - Active: Up to 5.0 W (TYP)
  - Idle: 650 mW[8]
- Weight:
  - 2.5-inch 80-240 GB: 70 grams ± 2 grams
  - 2.5-inch 300-800 GB: 72 grams ± 2 grams
  - 1.8-inch 80 GB: 35 grams ± 2 grams
  - 1.8-inch 240-800 GB: 37 grams ± 2 grams
- Temperature
  - Operating: 0° C to 70° C
  - Non-Operating[9]: -55° C to 95° C
  - Temperature monitoring and logging
  - Thermal throttling
- Shock (operating and non-operating): 1,000 G/0.5 msec
- Vibration
  - Operating: 2.17 G_{RMS} (5-700 Hz)
  - Non-Operating: 3.13 G_{RMS} (5-800 Hz)
- Altitude (simulated)
  - Operating: -1,000 to 10,000ft
  - Non-Operating: -1,000 to 40,000ft
- Reliability
  - Uncorrectable Bit Error Rate (UBER):
  - 1 sector per 10^{17} bits read
  - Mean Time Between Failures (MTBF): 2,000,000 hours
  - End-to-End data protection
- Endurance Rating[10]:
  - 80 GB: 45 TBW
  - 120 GB: 70 TBW
  - 160 GB: 100 TBW
  - 240 GB: 140 TBW
  - 300 GB: 170 TBW
  - 400 GB: 225 TBW
  - 480 GB: 275 TBW
  - 600 GB: 330 TBW
  - 800 GB: 450 TBW
- Certifications and Declarations
  - UL*, CE*, C-Tick*, BSMI*, KCC*, Microsoft* WHCK, VCCI*, SATA-IO

1. Performance values vary by capacity and form factor
2. Performance specifications apply to both compressible and incompressible data
3. 4 KB = 4,096 bytes; 8 KB = 8,192 bytes
4. MB/s = 1,000,000 bytes/second.
5. 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
6. Measurement taken once the workload has reached steady state but including all background activities required for normal operation and data reliability
7. Defaults to 12V, if both 12V and 5V are present
8. Based on 5V supply
9. Please contact your Intel representative for details on the non-operating temperature range
10. Based on JESD218 standard

April 2013
Order Number: 328860-001US



Ordering Information

Contact your local Intel sales representative for ordering information.

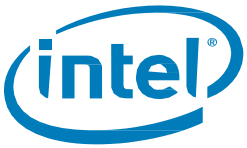
Contents

Revision History

Date	Revision	Description
April 2013	001	Initial release.

Terms and Acronyms

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 Note: 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 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



1.0 Overview

This document describes the specifications and capabilities of the Intel® SSD DC S3500.

The Intel® SSD DC S3500 delivers leading performance and Quality of Service combined with world-class reliability for Serial Advanced Technology Attachment (SATA)-based computers in nine capacities: 80 GB, 120 GB, 160 GB, 240 GB, 300 GB, 400 GB, 480 GB, 600 GB and 800 GB.

By combining 20nm Intel® NAND Flash Memory technology with SATA 6Gb/s interface support, the Intel® SSD DC S3500 delivers sequential read speeds of up to 500 MB/s and sequential write speeds of up to 450 MB/s. Intel SSD DC S3500 delivers Quality of Service of 500 us for random 4KB reads measured at a queue depth of 1.

The industry-standard 2.5-inch and 1.8-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 S3500 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
- Enhanced ruggedness
- Temperature monitor and logging
- Power loss protection capacitor self-test

2.0 Product Specifications

2.1 Capacity

Table 1. User Addressable Sectors

Intel SSD DC S3500	Unformatted Capacity (Total User Addressable Sectors in LBA Mode)
80 GB	156,301,488
120 GB	234,441,648
160 GB	312,581,808
240 GB	468,862,128
300 GB	586,072,368
400 GB	781,422,768
480 GB	937,703,088
600 GB	1,172,123,568
800 GB	1,562,824,368

Notes: 1 GB = 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)

Specification[1]	Unit	Intel SSD DC S3500							
		80 GB (2.5/ 1.8")	120 GB	160 GB	240 GB (2.5"/ 1.8")	300 GB	400 GB (1.8")	480 / 600 GB	800 GB (2.5"/ 1.8")
Random 4 KB Read (up to)[2]	IOPS	70,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Random 4 KB Write (up to)	IOPS	7,000	4,600	7,500	7,500	9,000	11,000	11,000	11,500
Random 8 KB Read (up to)[3]	IOPS	39,000	47,000	47,500	47,500	47,500	47,500	47,500	47,500
Random 8 KB Write (up to)	IOPS	3,700	2,300	3,800	3,800	4,400	5,500	5,500	5,500

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. 4 KB = 4,096 bytes
3. 8 KB = 8,192 bytes
4. 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

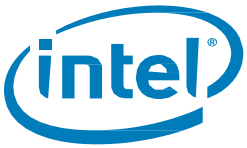


Table 3. Random Read/ Write IOPS Consistency

Specification[4]	Unit	Intel SSD DC S3500							
		80GB (2.5/ 1.8")	120GB	160GB	240GB (2.5"/ 1.8")	300GB	400GB (1.8")	480 / 600 GB	800GB (2.5"/ 1.8")
Random 4 KB Read (up to)[2]	%	90	90	90	90	90	90	90	90
Random 4 KB Write (up to)	%	75	75	75	75	75	75	75	75
Random 8 KB Read (up to)[3]	%	90	90	90	90	90	90	90	90
Random 8 KB Write (up to)	%	75	75	75	75	75	75	75	75

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. 4 KB = 4,096 bytes
3. 8 KB = 8,192 bytes
4. 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, including all background activities required for normal operation and data reliability

Table 4. Sequential Read and Write Bandwidth

Specification	Unit	Intel SSD DC S3500							
		80GB (2.5/ 1.8")	120GB	160GB	240GB (2.5"/ 1.8")	300GB	400GB (1.8")	480 / 600 GB	800GB (2.5"/ 1.8")
Sequential Read (SATA 6Gb/s)[1]	MB/s	340	445	475	500	500	500	500	500
Sequential Write (SATA 6Gb/s)[1]	MB/s	100	135	175	260	315	380	410	450

Notes: 1. Performance measured using Iometer* with 128 KB (131,072 bytes) of transfer size with Queue Depth 32.

Table 5. Latency

Specification	Intel SSD DC S3500	
	80GB (2.5/ 1.8"), 120GB, 160GB, 240GB (2.5"/ 1.8"), 300GB, 400GB (1.8"), 480GB, 600 GB	800GB (2.5"/ 1.8")
Latency[1] (TYP)		
Read	50 µs	50 µs
Write	65 µs	65 µs
Power On to Ready[2]	2.0 s	3.0 s

Table 6. Quality of Service

Specification	Unit	Intel SSD DC S3500			
		Queue Depth=1		Queue Depth=32	
		80/120/160/240 GB	300/400/480/600/800 GB	80/120/160/240 GB	300/400/480/600/800 GB
Quality of Service[3, 4] (99.9%)					
Reads	ms	0.5	0.5	2	2
Writes	ms	5	2	20	10
Quality of Service[3,4] (99.9999%)					
Reads	ms	10	5	10	5
Writes	ms	10	10	30	30

Notes:
1. Device measured using Iometer. Latency measured using 4 KB (4,096 bytes) transfer size with Queue Depth equal to 1 on a sequential workload.
2. Power On To Ready time assumes proper shutdown. Time varies if shutdown is not preceded by STANDBY IMMEDIATE command.
3. Device measured using Iometer. Quality of Service measured using 4 KB (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.
4. 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 for 2.5-inch Form Factor

Electrical Characteristics	Intel SSDDC S3500
	80 GB, 120 GB, 160 GB, 240 GB, 300 GB, 480 GB, 600 GB, 800 GB
5 V Operating Characteristics:	
Operating Voltage range	5 V (±5%)
Rise time (Max/Min)	1 s / 1 ms
Fall time (Min)[2]	1 ms
Noise level	500 mV pp 10 Hz – 100 KHz 50 mV pp 100 KHz – 20 MHz
Min Off time[3]	500 ms
Inrush Current (Typical Peak) [1]	1.0 A, < 1 s
12 V Operating Characteristics:	
Operating Voltage range	12 V (±10%)
Rise time (Max/Min)	1 s / 1 ms
Fall time (Min)[2]	1 ms
Noise level	1000 mV pp 10 Hz – 100 KHz 100 mV pp 100 KHz – 20 MHz
Min Off time[3]	500 ms
Inrush Current (Typical Peak) [1]	1.0 A, < 1 s

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

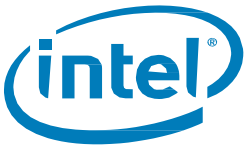


Table 8. Power Consumption for 2.5-inch Form Factor (5V Supply)

Specification	Unit	Intel SSD DC S3500							
		80 GB	120 GB	160 GB	240 GB	300 GB	480 GB	600 GB	800 GB
Active Write - RMS Average [1]	W	1.8	2.0	2.3	2.9	3.5	4.3	4.5	5.0
Active Write - RMS Burst [2]	W	2.0	2.4	2.7	3.2	3.9	5.2	5.5	7.3
Idle	W	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Table 9. Power Consumption for 2.5-inch Form Factor (12V Supply)

Specification[1]	Unit	Intel SSD DC S3500							
		80 GB	120 GB	160 GB	240 GB	300 GB	480 GB	600 GB	800 GB
Active Write - RMS Average	W	2.0	2.3	2.5	3.1	3.5	4.3	4.5	5.0
Active Write - RMS Burst	W	2.2	2.5	2.8	3.4	4.2	5.5	6.8	7.8
Idle	W	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9

Notes:
1. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential writes. Root Mean Squared (RMS) average power is measured using scope trigger over a 100 ms sample period.
2. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential writes. Root Mean Squared (RMS) burst power is measured using scope trigger over a 500 us sample period.

Table 10. Operating Voltage and Power Consumption for 1.8-inch Form Factor

Electrical Characteristics	Intel SSD DC S3500			
	80 GB	240 GB	400 GB	800 GB
Operating Voltage for 3.3 V (±5%)				
Min	3.13 V			
Max	3.47 V			
Rise time (Max/Min)	1 s / 1 ms			
Fall time (Min)[2]	1 ms			
Noise level	300 mV pp 10 Hz – 100 KHz 500 mV pp 100 KHz – 20 MHz			
Min Off time[3]	500 ms			
Inrush Current (Typical Peak) [1]	1.2 A, < 1 s			

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

Table 11. Power Consumption for 1.8-inch Form Factor

Specification[1]	Unit	Intel SSD DC S3500			
		80 GB	240 GB	400 GB	800 GB
Active Write - RMS Average @ 3.3V	W	2.0	3.5	4.5	5.2
Active Write - RMS Burst @ 3.3V	W	2.2	3.8	5.0	7.5
Idle @ 3.3V	W	0.6	0.6	0.6	0.6

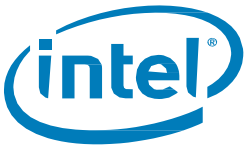
Notes:
1. The workload equates 128 KB (131,072 bytes) Queue Depth equal to 32 sequential writes. Root Mean Squared (RMS) power is measured using scope trigger over a 100 ms sample period.

2.4 Environmental Conditions

Table 12. Temperature, Shock, Vibration

Temperature	Range
Case Temperature Operating Non-operating[1]	 0 – 70 °C -55 – 95 °C
Temperature Gradient[2] Operating Non-operating	 30 °C/hr (Typical) 30 °C/hr (Typical)
Humidity Operating Non-operating	 5 – 95 % 5 – 95 %
Shock and Vibration	**Range**
Shock[3] Operating Non-operating	 1,000 G (Max) at 0.5 msec 1,000 G (Max) at 0.5 msec
Vibration[4] Operating Non-operating	 2.17 G_{RMS} (5-700 Hz) Max 3.13 G_{RMS} (5-800 Hz) Max

Notes:
1. Please contact your Intel representative for details on the non-operating temperature range.
2. Temperature gradient measured without condensation.
3. 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.
3. 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 S3500 meets or exceeds the regulatory or certification requirements in Table 13.

Table 13. Product Regulatory Compliance Specifications

Title	Description	Region For Which Conformity Declared
TITLE 47-Telecommunications CHAPTER 1— FEDERAL COMMUNMICATIONS COMMISSION PART 15 — RADIO FREQUENCY DEVICES	FCC Part 15B Class B	USA
ICES-003, Issue 4 Interference-Causing Equipment Standard Digital Apparatus	CA/CSA-CEI/IEC CISPR 22:02. This is CISPR 22:1997 with Canadian Modifications	Canada
IEC 55024 Information Technology Equipment — Immunity characteristics— Limits and methods of measurement CISPR24:2010	EN-55024: 1998 and its amendments	European Union
IEC 55022 Information Technology Equipment — Radio disturbance Characteristics— Limits and methods of measurement CISPR24:2008 (Modified)	EN-55022: 2006 and its amendments	European Union
EN-60950-1 2nd Edition	Information Technology Equipment — Safety — Part 1: General Requirements	USA/Canada
UL/CSA EN-60950-1 2nd Edition	Information Technology Equipment — Safety — Part 1: General Requirements	USA/Canada

2.6 Reliability

Intel SSD DC S3500 meets or exceeds SSD endurance and data retention requirements as specified in the JESD218 standard. Reliability specifications are listed in the table below:

Table 14. Reliability Specifications

Parameter	Value
Uncorrectable Bit Error Rate (UBER) 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.	< 1 sector per 10^{17} bits read
Mean Time Between Failures (MTBF) Mean Time Between Failures is estimated based on Telcordia* methodology and demonstrated through Reliability Demonstration Test (RDT).	2,000,000 hours
Power On/Off Cycles 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.	24 per day

Table 14. Reliability Specifications

Parameter	Value
Insertion Cycles SATA/power cable insertion/removal cycles.	50 on SATA cable 500 on backplane
Data Retention The time period for retaining data in the NAND at maximum rated endurance.	3 months power-off retention once SSD reaches rated write endurance at 40 °C
Endurance Rating Based on JESD219 workload.	80 GB: 45 TBW 120 GB:70 TBW 160 GB: 100 TBW 240 GB: 140 TBW 300 GB: 170 TBW 400 GB: 225 TBW 480 GB: 275 TBW 600 GB: 330 TBW 800 GB: 450 TBW while running JESD218 standard[1]

1. Refer to JESD218 standard table 1 for UBER, FFR and other Enterprise SSD requirements

2.7 Temperature Sensor

The Intel SSD DC S3500 has an internal temperature sensor with an accuracy of +/-2C over a range of -20C to +80C which can be monitored using two SMART attributes: Airflow Temperature (BEh) and Device Internal Temperature (C2h).

For more information on supported SMART attributes, see “SMART Attributes” on page 18.

2.8 Power Loss Capacitor Test

The Intel SSD DC S3500 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.

3.0 Mechanical Information

Figures 1 and 2 show the physical package information for the Intel SSD DC S3500 in the 2.5- and 1.8-inch form factors. All dimensions are in millimeters.

Figure 1: Intel SSD DC S3500 2.5-inch Dimensions

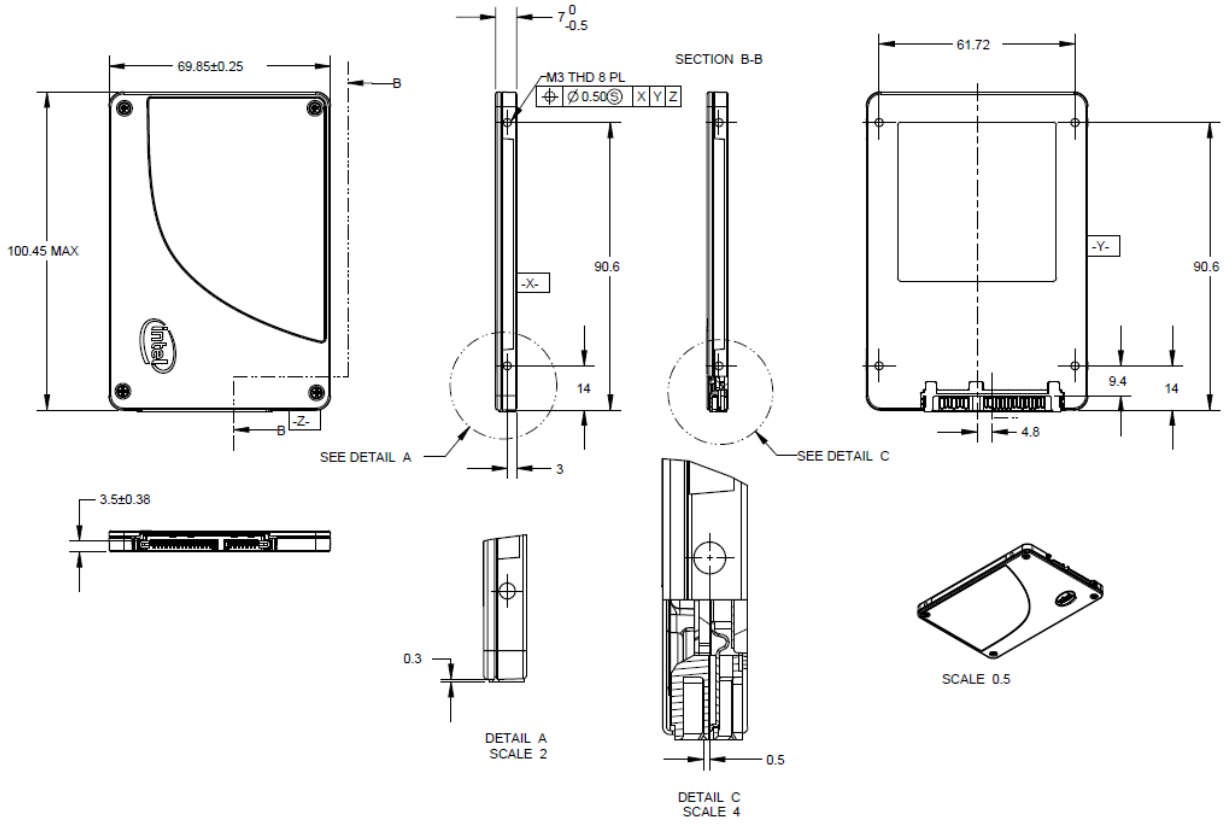
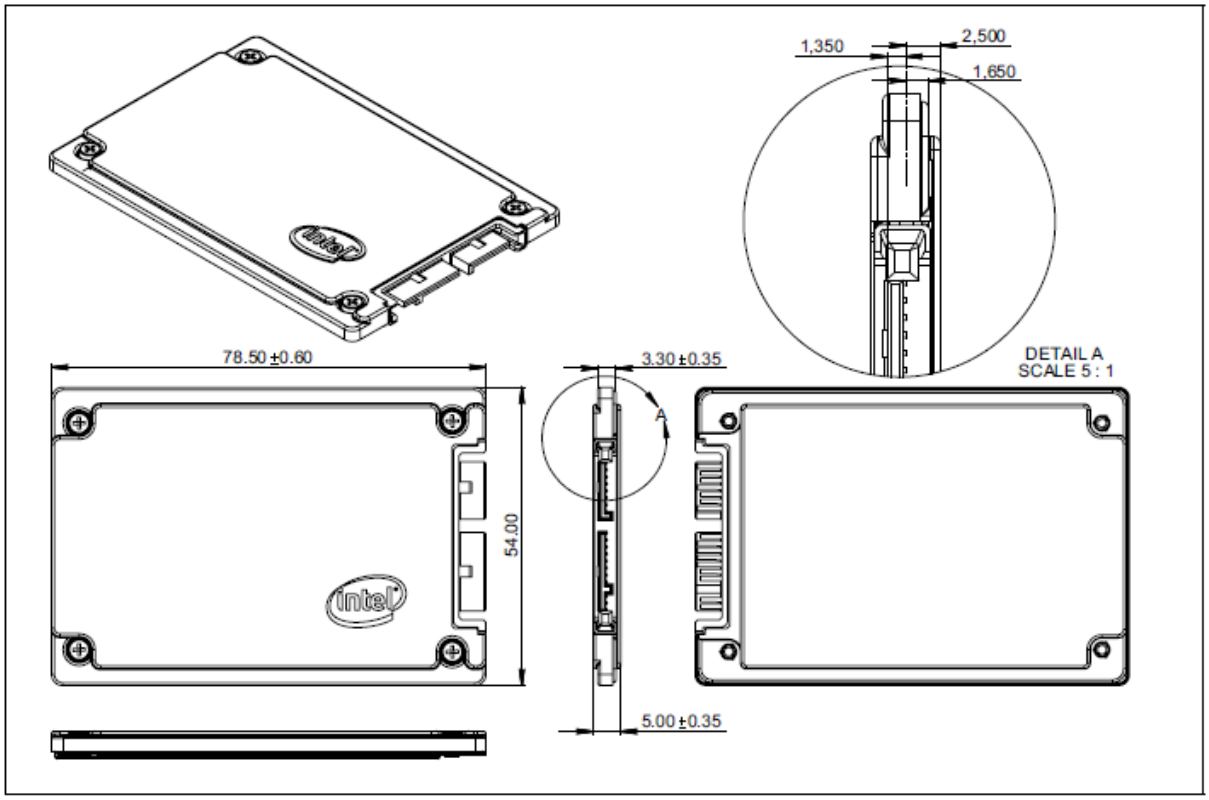


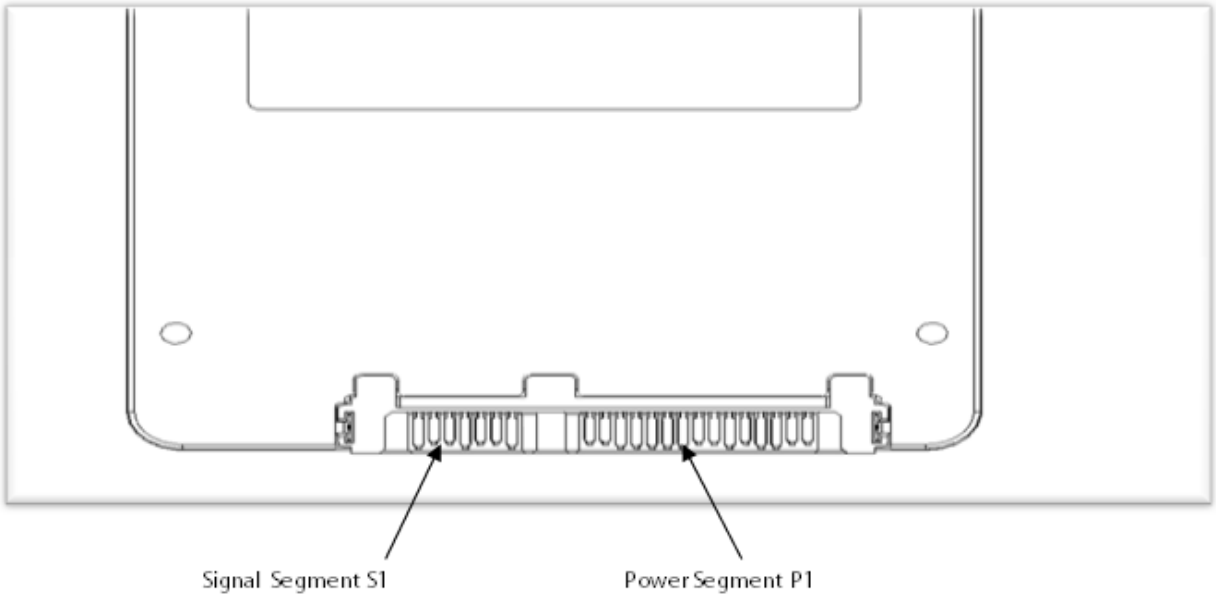
Figure 2: Intel SSD DC S35001.8-inch Dimensions



4.0 Pin and Signal Descriptions

4.1 2.5-inch Form Factor Pin Locations

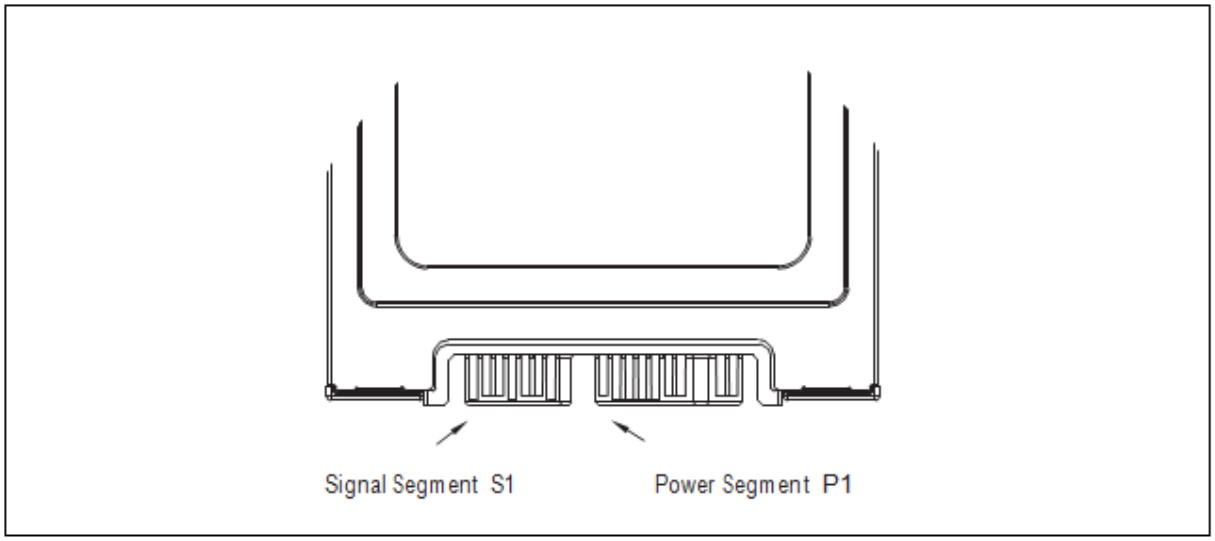
Figure 3: Layout of 2.5-inch Form Factor Signal and Power Segment Pins



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

4.2 1.8-inch Form Factor Pin Locations

Figure 4: Layout of 1.8-inch Form Factor Signal and Power Segment Pins



4.3 Connector Pin Signal Definitions

Table 15. Serial ATA Connector Pin Signal Definitions—2.5-inch and 1.8-inch Form Factors

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

Note: Key and spacing separate signal and power segments.

4.4 Power Pin Signal Definitions

Table 16. Serial ATA Power Pin Definitions—2.5-inch Form Factors

Pin[1]	Function	Definition	Mating Order
P1[2]	Not connected	(3.3 V Power)	--
P2[2]	Not connected	(3.3 V Power)	--
P3[2]	Not connected	(3.3 V Power; pre-charge)	2nd Mate
P4[3,4]	Ground	Ground	1st Mate
P5[3]	Ground	Ground	1st Mate
P6[3]	Ground	Ground	1st Mate
P7[3,5]	V_5	5 V Power	1st Mate
P8[3,5]	V_5	5 V Power	2nd Mate
P9[3,5]	V_5	5 V Power	2nd Mate
P10[3]	Ground	Ground	1st Mate
P11[6]	DAS/DSS	Device Activity Signal/Disable Staggered Spin-up	2nd Mate
P12[3,4]	Ground	Ground	1st Mate
P13[7]	V_{12}	12 V Power	1st Mate
P14[7]	V_{12}	12 V Power	2nd Mate
P15[7]	V_{12}	12 V Power	2nd 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 3.3 V 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 12 V on these pins.

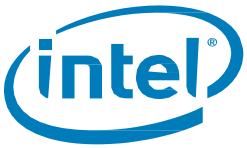


Table 17. Serial ATA Power Pin Definitions—1.8-inch Form Factors

Pin	Function	Definition	Mating Order[1]
P1[2]	V_{33}	3.3 V Power	2nd Mate
P2[2]	V_{33}	3.3 V Power, per-charge	2nd Mate
P3[3]	Ground	--	1st Mate
P4[3]	Ground	--	1st Mate
P5[4]	V_5	5 V Power; not connected.	1st Mate
P6[4]	V_5	5 V Power; not connected.	2nd Mate
P7[5]	DAS/DSS	Device Activity Signal/Disable Staggered Spin-up	2nd Mate
Key	Key	NC	NC
P8[6]	Optional	Manufacturing Test Pin	2nd Mate
P9[6]	Optional	Manufacturing Test Pin	2nd Mate

Notes:
1. All mate sequences assume zero angular offset between connectors.
2. P1 and P2 are internally connected to one another within the device.
3. Ground connectors P3 and P4 may contact before the other 1st mate pins in both the power and signal connectors to discharge ESD in a suitably configure backplane connector.
4. Pins P5 and P6 are not connected internally to the device but there is an option to connect through a zero ohm stuffing resistor. The host may put 5V on these pins.
5. The host may ground P7 if it is not used for Device Activity Signal (DAS).
6. P8 and P9 should not be connected by the host.

5.0 Supported Command Sets

Intel SSD DC S3500 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 S3500 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” on page 27 for details on the sector data returned after issuing an IDENTIFY DEVICE command.

Intel SSD DC S3500 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[1]
- WRITE MULTIPLE
- FLUSH CACHE
- READ BUFFFER
- WRITE BUFFER
- NOP
- DOWNLOAD MICROCODE
- WRITE UNCORRECTABLE EXT

1. The only multiple supported will be multiple 1

5.2 Power Management Command Set

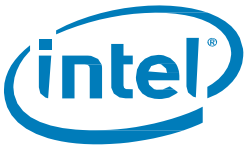
Intel SSD DC S3500 supports the Power Management command set, which consists of:

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

5.3 Security Mode Feature Set

Intel SSD DC S3500 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

Intel SSD DC S3500 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 SMART Attributes

Table 18 lists the SMART attributes supported by the Intel SSD DC S3500 and the corresponding status flags and threshold settings.

Table 18. SMART Attributes

ID	Attribute	Status Flags						Threshold
		SP	EC	ER	PE	OC	PW	
05h	Re-allocated Sector Count *Raw value*: shows the number of retired blocks since leaving the factory (grown defect count). *Normalized* value: beginning at 100, shows the percent remaining of allowable grown defect count.	1	1	0	0	1	0	0 (none)
09h	Power-On Hours Count *Raw* value: reports power-on time, cumulative over the life of the SSD, integer number in hour time units. *Normalized* value: always 100.	1	1	0	0	1	0	0 (none)
0Ch	Power Cycle Count *Raw* value: reports the cumulative number of power cycle events over the life of the device. *Normalized* value: always 100.	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 *Raw* value: shows total count of program fails. *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 *Raw value*: shows total count of erase fails. *Normalized value*: beginning at 100, shows the percent remaining of allowable erase fails.	1	1	0	0	1	0	0 (none)
AEh	Unexpected Power Loss Also known as “Power-off Retract Count” per magnetic-drive terminology. *Raw value*: reports number of unclean shutdowns, cumulative over the life of the SSD. An “unclean shutdown” is the removal of power without STANDBY IMMEDIATE as the last command (regardless of PLI activity using capacitor power). *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
AFh	Power Loss Protection Failure Last test result as microseconds to discharge cap, saturates at max value. Also logs minutes since last test and lifetime number of tests. *Raw value*: Bytes 0-1: Last test result as microseconds to discharge cap, saturates at max value. Test result expected in range	1	1	0	0	1	1	10

Table 18. SMART Attributes

ID	Attribute	Status Flags						Threshold
		SP	EC	ER	PE	OC	PW	
	25 <= result <= 5000000, lower indicates specific error code. Bytes 2-3: Minutes since last test, saturates at max value. Bytes 4-5: Lifetime number of tests, not incremented on power cycle, saturates at max value. *Normalized value*: set to 1 on test failure or 11 if the capacitor has been tested in an excessive temperature condition, otherwise 100.							
B7h	SATA Downshift Count *Raw value*: reports number of times SATA interface selected lower signaling rate due to error. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
B8h	End-to-End Error Detection Count *Raw value*: reports number of End-to-End detected and corrected errors by hardware. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
BBh	Uncorrectable Error Count *Raw value*: shows the number of errors that could not be recovered using Error Correction Code (ECC). *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
BEh	Temperature - Airflow Temperature (Case) *Raw value*: reports SSD case temperature statistics. Bytes 0-1: Current case temperature, Celsius Byte 2: Recent min case temperature, Celsius Byte 3: Recent max case temperature, Celsius Bytes 4-5: Over temperature counter. Number of times sampled temperature exceeds drive max operating temperature specification. *Normalized value*: 100 – case temperature in C degrees.	1	0	0	0	1	0	0 (none)
C0h	Power-Off Retract Count (Unsafe Shutdown Count) *Raw* value: 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. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
C2h	Temperature - Device Internal Temperature *Raw value*: Reports internal temperature of the SSD in degrees Celsius. Temperature reading is the value direct from the printed circuit board (PCB) sensor without offset. *Normalized value*: 150 – device temperature in C degrees, 100 if device temperature less than 50.	1	0	0	0	1	0	0 (none)
C5h	Pending Sector Count *Raw value*: number of current unrecoverable read errors that will be re-allocated on next write. *Normalized value*: always 100.	0	1	0	0	1	0	0 (none)
C7h	CRC Error Count *Raw value*: shows total number of encountered SATA interface cyclic redundancy check (CRC) errors. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
E1h	Host Writes *Raw* value: reports 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. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)

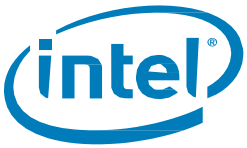


Table 18. SMART Attributes

ID	Attribute	Status Flags						Threshold
		SP	EC	ER	PE	OC	PW	
E2h	Timed Workload Media Wear *Raw value*: measures the wear seen by the SSD (since reset of the workload timer, attribute E4h), as a percentage of the maximum rated cycles. Divide the raw value by 1024 to derive the percentage with 3 decimal points. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
E3h	Timed Workload Host Read/Write Ratio *Raw* value: shows the percentage of I/O operations that are read operations (since reset of the workload timer, attribute E4h). Reported as integer percentage from 0 to 100. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
E4h	Timed Workload Timer *Raw value*: measures the elapsed time (number of minutes since starting this workload timer). *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
E8h	Available Reserved Space *Raw value*: reports number of reserve blocks remaining. *Normalized value*: begins at 100 , which corresponds to 100 percent availability of the reserved space. The threshold value for this attribute is 10 percent availability.	1	1	0	0	1	1	10
E9h	Media Wearout Indicator *Raw* value: always 0. *Normalized value*: reports the number of cycles the NAND media has undergone. 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.	1	1	0	0	1	0	0 (none)
EAh	Thermal Throttle Status *Raw value*: reports Percent Throttle Status and Count of events Byte 0: Throttle status reported as integer percentage. Bytes 1-4: Throttling event count. Number of times thermal throttle has activated. Preserved over power cycles. Byte 5: Reserved. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
F1h	Total LBAs Written *Raw value*: 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. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)
F2h	Total LBAs Read *Raw value*: 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. *Normalized value*: always 100.	1	1	0	0	1	0	0 (none)

Table 19. 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

5.4.1 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 3 decimal points. This value should be divided by 1024 to get the percentage.

For example: if the raw value is 4450, the percentage is 4450/1024 = 4.345%. The raw value is held at FFFFh until the wear timer (attribute E4h) reaches 60 (minutes). 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 232 = 4,294,967,296 minutes (8,171 years). The normalized value is always set to 100 and should be ignored.

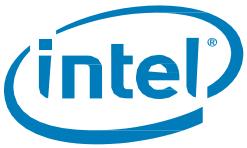
Example Use Cases

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. 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 E4h (workload timer) attribute.
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 60 minutes 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 18 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.

5.4.2 SMART Logs

Intel SSD DC S3500 implements the following Log Addresses: 00h, 02h, 03h, 06h, and 07h.

DC S3500 implements host vendor specific logs (addresses 80h-9Fh) as read and write scratchpads, where the default value is zero (0). Intel SSD DC S3500 does not write any specific values to these logs unless directed by the host through the appropriate commands.

DC S3500 also implements a device vendor specific log at address A9h as a read-only log area with a default value of zero (0).

5.5 Device Statistics

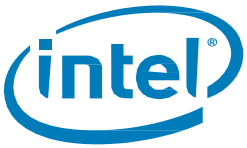
In addition to the SMART attribute structure, statistics pertaining to the operation and health of the Intel SSD DC S3500 can be reported to the host on request through the Device Statistics log as defined in the ATA specification.

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.

Table 20 lists the Device Statistics supported by the Intel SSD DC S3500.

Table 20. Device Statistics Log

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 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 S3500 supports the following standard SCT actions:

- Write Same — DC S3500 implements this action code as described in the ATA specification
- Error Recovery Control — DC S3500 accepts this action code, and will store and return error-recovery time limit values
- Feature Control - DC S3500 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), D004h(read power governor average power)
- Data table command - DC S3500 supports data table command as specified in ATA8-ACS2. This will read out temperature logging information in table ID 0002h
- Read Status Support - DC S3500 supports read status log

5.7 Data Set Management Command Set

Intel SSD DC S3500 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 S3500 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 S3500 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 S3500 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 S3500 supports the General Purpose Log command set, which consists of:

- READ LOG EXT
- WRITE LOG EXT