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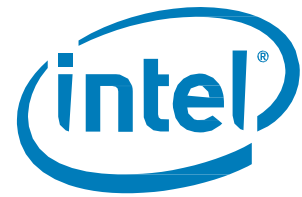
Contact us

Intel® Solid-State Drive DC S3510 Series

- 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[1,2]
  (Full LBA Range, IOMeter* Queue Depth 32)
  - Random 4KB[3] Reads: Up to 68,000 IOPS
  - Random 4KB Writes: Up to 20,000 IOPS
  - Random 8KB[3] Reads: Up to 46,000 IOPS
  - Random 8KB Writes: Up to 10,000 IOPS
- Bandwidth Performance[1]
  - Sustained Sequential Read: Up to 500 MB/s[4]
  - Sustained Sequential Write: Up to 460 MB/s
- Endurance: 0.3 drive writes per day[5] for 5 years
  - 80GB: 45TBW   – 120GB: 70TBW
  - 240GB: 140TBW   – 480GB: 275TBW
  - 800GB: 450TBW   – 1.2TB: 660TBW
  - 1.6TB: 880TBW
- Latency (average sequential)
  - Read: 55 µs (TYP)
  - Write: 66 µs (TYP)
- Quality of Service[6,8]
  - Read/Write: 500 µs / <5 ms (99.9%)
- Performance Consistency[7,8]
  - Read/Write: Up to 95%/95% (99.9%)
- AES 256-bit Encryption
- Altitude[9]
  - Operating: -1,000 to 10,000 ft
  - Operating[10]: 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[11]
  - SATA Interface Power Management
  - OS-aware hot plug/removal
  - Enhanced power-loss data protection feature
- Power[12]
  - Active: Up to 6.8 W[8] (TYP) 2.5"
  - Idle: 600 mW
- Weight:
  - 80GB, 120GB, 240GB, 480GB: 82 grams ± 2 grams
  - 800GB: 88 grams ± 2 grams
  - 1.2TB, 1.6TB: 94 grams ± 2 grams
- Temperature
  - Operating: 0° C to 70° C
  - Non-Operating[13]: -55° C to 95° C
  - Temperature monitoring and logging
  - Thermal throttling
- Shock (operating and non-operating):
  1,000 G/0.5 ms
- Vibration
  - Operating: 2.17 G_{RMS} (5-700 Hz)
  - Non-Operating: 3.13 G_{RMS} (5-800 Hz)
- Reliability
  - Uncorrectable Bit Error Rate (UBER): 1 sector per 10^{17} bits read
  - Mean Time Between Failures (MTBF): 2 million hours
  - End-to-End data protection
- Certifications and Declarations
  - UL*, CE*, C-Tick*, BSMI*, KCC*, Microsoft* WHCK, VCCI*, SATA-IO*
- Compatibility
  - Windows 7* and Windows 8*, and Windows 8.1*
  - 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. 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)
8. Measurement taken once the workload has reached steady state but including all background activities required for normal operation and data reliability
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 5Vpower supply

13.   Please contact your Intel representative for details on the non-operating temperature range

Revision History

Revision	Description	Date
001	Initial release.	May 2015
002	• Table 15, SMART Attributes: - SMART Attribute EAh - added bytes description - Added new SMART Attribute F3h description and status flags • Section 5.4.2: Updated SMART Attribute E2h decimal precision points from 3 to 2	July 2015

Ordering Information

Contact your local Intel sales representative for ordering information.

Intel may make changes to specifications and product descriptions at any time, without notice. Designers must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." Intel reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The information here is subject to change without notice. Do not finalize a design with this information.

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 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.

Copies of documents which have an order number and are referenced in this document, or other Intel literature, may be obtained by calling 1-800-548-4725, or go to: http://www.intel.com/design/literature.htm.

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*Other names and brands may be claimed as the property of others.

Contents

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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. ***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. 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 μs 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 (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: 2.5 Inch Random Read/Write Input/Output Operations Per Second (IOPS)[1]

Specification	Unit	Intel SSD DC S3510 Series						
		80GB	120GB	240GB	480GB	800GB	1.2TB	1.6TB
Random 4KB Read (up to)[2]	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)[3]	IOPS	41,500	46,000	46,500	46,500	45,000	45,000	44,5000
Random 8KB Write (up to)	IOPS	4,200	2,600	5,000	7,500	7,700	10,000	7,800
Random 4KB 70/30 Read/Write (up to)[2]	IOPS	22,000	14,500	25,000	32,500	32,000	38,000	32,000
Random 8KB 70/30 Read/Write (up to)[3]	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:   2.5-Inch Random Read/Write IOPS Consistency[1]

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

Notes:
1. 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
2. 4KB = 4,096 bytes
3. 8KB = 8,192 bytes

Table 4:   2.5-Inch Sequential Read and Write Bandwidth1

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

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

Table 5:   2.5-Inch Latency

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

Notes:
1. Device measured using IOMeter*. Latency measured using 4KB (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.
    For 95% of the time, the maximum time for power on to ready will be less than 15 seconds.

Table 6:   Quality of Service 2.5 Inch

Specification	Unit	Intel 2.5-inch SSD DC S3510 Series					
		Queue Depth=1			Queue Depth=32		
		80GB/ 120GB	240GB/ 480GB	800GB/1.2TB/ 1.6TB	80GB/ 120GB	240GB/ 480GB	800GB/1.2TB/ 1.6TB
Quality of Service[1,2] (99.9%)							
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
Quality of Service[1,2] (99.9999%)							
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 for 2.5-inch Form Factor

Electrical Characteristics	Intel SSD DC S3510 Series
	200GB, 400GB, 480GB, 800GB, 1.2TB, 1.6TB
5V Operating Characteristics: Operating Voltage range Inrush Current (Typical Peak) [1]	5V (±5%) 1.2A for the first 1s
12V Operating Characteristics: Operating Voltage range Inrush Current (Typical Peak) [1]	12V (±10%) 1.2A for the first 1s

Note:
1.   Measured from initial device power supply application.

Table 8:   Power Consumption for 2.5–inch Form Factor (5V Supply)

Specification	Unit	Intel SSD DC S3510 Series						
		80GB	**120GB**	**240GB**	**480GB**	**800GB**	**1.2TB**	**1.6TB**
Active Write - RMS Average[1]	W	1.91	2.14	3.06	4.45	4.74	5.24	5.59
Active Write - Burst[2]	W	2.04	2.43	3.36	5.42	7.08	8.34	8.44
Active Write - Max Burst[3]	W	3.72	3.52	4.49	6.80	8.02	8.80	9.90
Active Read - RMS Average[4]	W	1.93	2.14	2.21	2.32	2.39	2.61	2.69
Active Read - Burst[5]	W	2.06	2.32	2.97	3.63	3.61	3.96	4.14
Active Read – Max Burst[6]	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 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.

Table 9:   Power Consumption for 2.5-inch Form Factor (5V + 12V Supply)

Specification[1]	Unit	Intel SSD DC S3510 Series												
		800GB 5V 12V		120GB 5V 12V		240GB 5V 12V		480GB 5V 12V		800GB 5V 12V		1.2TB 5V 12V		1.6TB 5V 12V	
Active Write - RMS Average[1]	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[2]	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[3]	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[4]	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[5]	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[6]	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
    Operating
    Non-operating[1]
	0 – 70º C
	-55 – 95º C

Temperature Gradient[2]
    Operating
    Non-operating
	30º C/hr (Typical)
	30º 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 ms
	1,000 G (Max) at 0.5 ms

Vibration[4]
    Operating
    Non-operating
	2.17 G_{RMS} (5-700 Hz) Max
	3.13 G_{RMS} (5-800 Hz) Max

Notes:
1. 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.
4. 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 Table 11 below.

Table 11:   Product Regulatory Compliance Specifications

Title	Description	Region For Which Conformity Declared
TITLE 47-Telecommunications CHAPTER 1—FEDERAL COMMUNMICATIONS COMMISSION PART 15 — RADIO FREQUENCY DEVICES ICES-003, Issue 4 Interference-Causing Equipment Standard Digital Apparatus	FCC Part 15B Class B CA/CSA-CEI/IEC CISPR 22:02. This is CISPR 22:1997 with Canadian Modifications	USA 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 S3510 Series meets or exceeds SSD endurance and data retention requirements as specified in the JESD218 standard. Reliability specifications are listed in Table 12 below:

Table 12:   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 million 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
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 While running JESD218 standard[1] and based on JESD219 workload.	80GB: Up to 45TBW 120GB: Up to 70TBW 240GB: Up to 140TBE 480GB: Up to 275TBW 800GB: Up to 450TBW 1.2TB: Up to 660TBW 1.6TB: Up to 880TBW while running JESD218 standard[1]

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 +/-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.

NOTE: The M.2 product will report the same value for both SMART attributes.

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.

NOTE: Hot plug is not supported in the M.2 Specification. However, the M.2 can support hot plug operations when used with an interposer design that electrically supports hot plug operations. User Data is protected from planned or unplanned power loss by the Enhanced Power Management technology on the 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 and M.2 form factors. All dimensions are in millimeters.

Figure 1:   Intel SSD DC S3510 Series 2.5-inch Dimensions
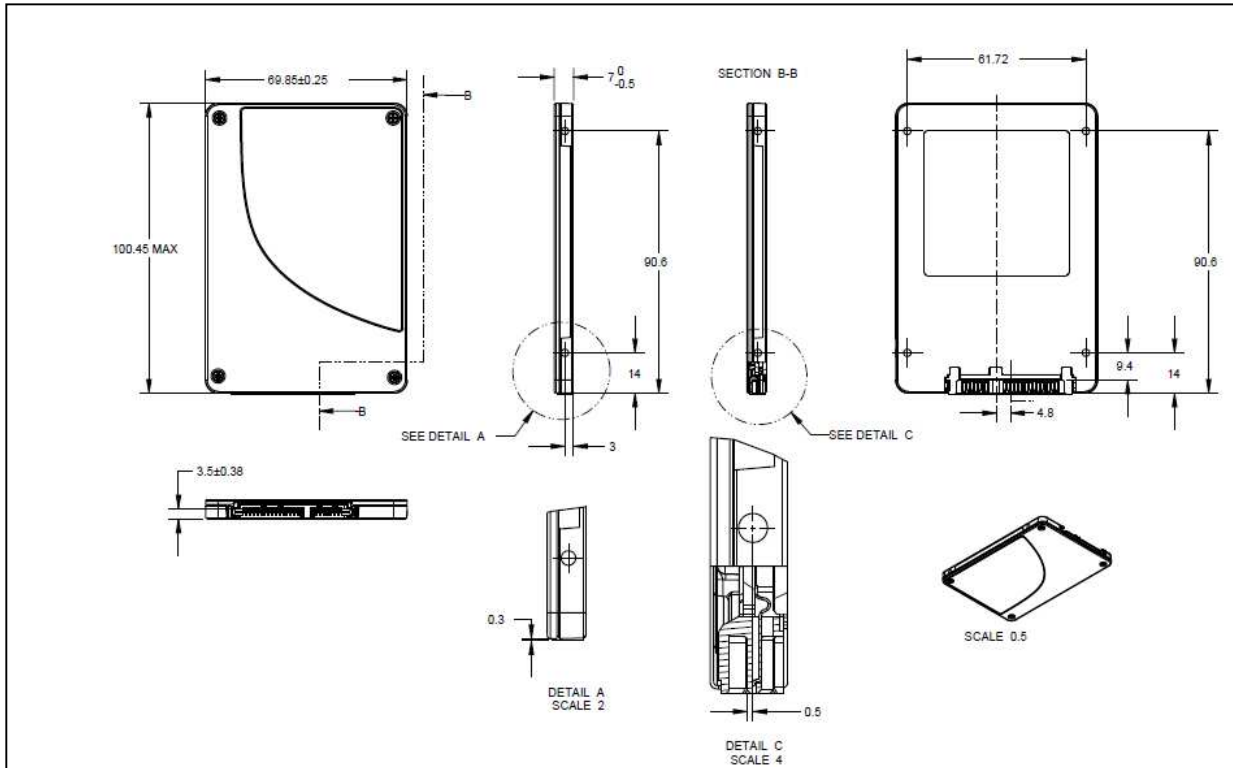
4 Pin and Signal Descriptions

4.1 2.5-inch Form Factor Pin Locations

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

Signal Segment S1   Power Segment P1
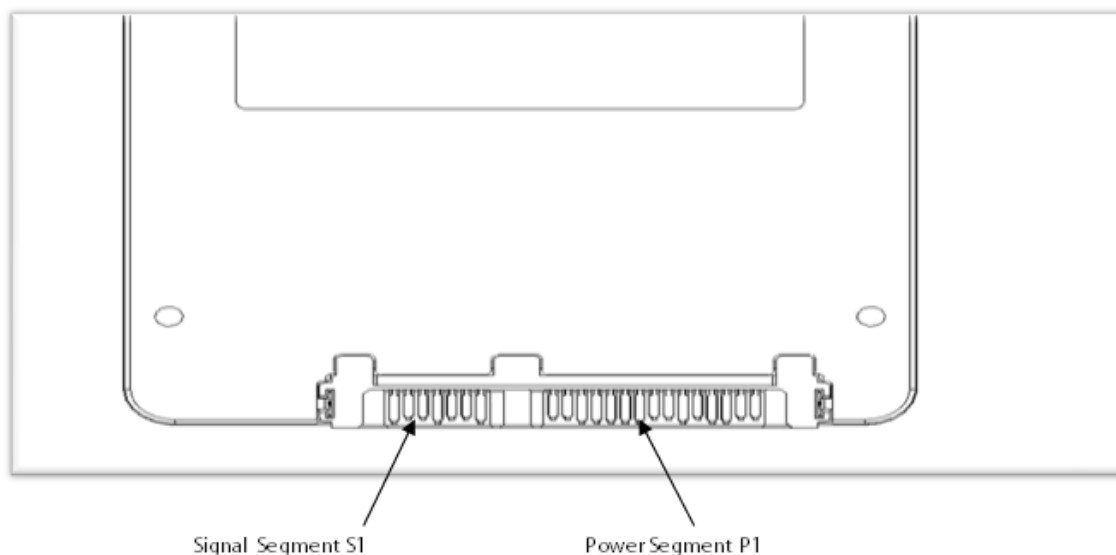
Note: 2.5-inch connector supports built in latching capability.

4.2 Connector Pin Signal Definitions

Table 13: **Serial ATA Connector Pin Signal Definitions—2.5-inch 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.

4.3   Power Pin Signal Definitions

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

Pin[1]	Function	Definition	Mating Order
P1[2]	Not connected	(3.3V Power)	--
P2[2]	Not connected	(3.3V Power)	--
P3[2]	Not connected	(3.3V 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	5V Power	1st Mate
P8[3,5]	V_5	5V Power	2nd Mate
P9[3,5]	V_5	5V Power	2nd Mate
P10[3]	Ground	Ground	1st Mate
P11[6]	DAS	Device Activity Signal	2nd Mate
P12[3,4]	Ground	Ground	1st Mate
P13[7]	V_{12}	12V Power	1st Mate
P14[7]	V_{12}	12V Power	2nd Mate
P15[7]	V_{12}	12V 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 3.3V 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[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

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** 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 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 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 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)

ID	Attribute	Status Flags						Threshold
		SP	EC	ER	PE	OC	PW	
ACh	Erase Fail Count 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)

AEh	Unexpected Power Loss
	    Also known as "Power-off Retract Count" per magnetic-drive terminology.
	    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).
		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.
	
	    Bytes 0-1: Last test result as microseconds to discharge cap, saturates at max value. Test result expected in range 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.
		1	1	0	0	1	1	10

B7h	SATA Downshift Count The count of the number of times SATA interface selected lower signaling rate due to error.	1	1	0	0	1	0	0 (none)

B8h	End-to-End Error Detection Count
	    Raw value: reports number of LBA tag mismatches in end-to-end data protection path.
	    Normalized value: always 100.
		1	1	0	0	1	1	90

BBh	Uncorrectable Error Count
	    The raw value shows the count 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) Reports the SSD case temperature. Raw value suggests 100 - case temperature in C degrees.	1	0	0	0	1	0	0 (none)
C0h	Power-Off Retract Count (Unsafe Shutdown Count) 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.	1	1	0	0	1	0	0 (none)
C2h	Temperature - Device Internal Temperature Reports internal temperature of the SSD. Temperature reading is the value direct from the printed circuit board (PCB) sensor without offset.	1	0	0	0	1	0	0 (none)

ID	Attribute	Status Flags						Threshold
		SP	**EC**	**ER**	**PE**	**OC**	**PW**	
C5h	Pending Sector Count Number of current unrecoverable read errors that will be re-allocated on next write.	0	1	0	0	1	0	0 (none)
C7h	CRC Error Count The total number of encountered SATA interface cyclic redundancy check (CRC) errors.	1	1	0	0	1	0	0 (none)
E1h	Host Writes 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.	1	1	0	0	1	0	0 (none)
E2h	Timed Workload Media Wear Measures the wear seen by the SSD (since reset of the workload timer, attribute E4h), as a percentage of the maximum rated cycles.	1	1	0	0	1	0	0 (none)
E3h	Timed Workload Host Read/Write Ratio Shows the percentage of I/O operations that are read operations (since reset of the workload timer, attribute E4h).	1	1	0	0	1	0	0 (none)
E4h	Timed Workload Timer Measures the elapsed time (number of minutes since starting this workload timer).	1	1	0	0	1	0	0 (none)
E8h	Available Reserved Space 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.	1	1	0	0	1	1	10
E9h	Media Wearout Indicator 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.	1	1	0	0	1	0	0 (none)
EAh	Thermal Throttle Status Reports Percent Throttle Status and Count of events 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. Bytes 1-4 = Throttling event count. 32 bit counter indicates the number of times thermal throttle has activated. Value is preserved over power cycles. Byte 5 = Reserved	1	1	0	0	1	0	0 (none)

ID	Attribute	Status Flags						Threshold
		SP	EC	ER	PE	OC	PW	
F1h	Total LBAs Written 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.	1	1	0	0	1	0	0 (none)
F2h	Total LBAs Read 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.	1	1	0	0	1	0	0 (none)
F3h	Total Bytes Written 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.	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) subcommand 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) subcommand 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 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.

5.4.3 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.

Table 17 lists the Device Statistics supported by the Intel SSD DC S3510 Series.