Intel® Solid-State Drive 320 Series

Enterprise Server / Storage Application

Product Specification Addendum

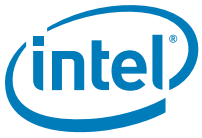
- Form Factors: 1.8-inch and 2.5-inch
- Capacity:
  - 80/160/300 GB (1.8-inch)
  - 40/80/120/160/300/600 GB (2.5-inch)
- Components: Intel® 25nm NAND Flash Memory Multi-Level Cell (MLC)
- Read and Write IOPS[1] (Iometer* Queue Depth 32)
  - Random 4 KB[2] reads: Up to 39,500 IOPS
  - Random 4 KB writes (100% LBA range): Up to 600 IOPS
- Bandwidth Performance[1]
  - Sustained sequential read: Up to 270 MB/s
  - Sustained sequential write: Up to 220 MB/s
- Latency (average sequential)
  - Read: 75 µs (TYP)
  - Write: 90 µs (TYP)
- AES 128-bit Encryption
- Compatibility
  - Intel® SSD Toolbox with Intel® SSD Optimizer
  - Intel® Data Migration Software
  - Intel® Rapid Storage Technology
  - Intel® 6 Series Express Chipsets (with SATA 6Gb/s)
  - SATA Revision 2.6
  - ATA8-ACS; includes SCT (Smart Command Transport) support
  - SSD-enhanced S.M.A.R.T. ATA feature set
  - Native Command Queuing (NCQ) command set
  - Data Set Management Command Trim attribute
- Power Management
  - 3.3 V (1.8-inch form factor) or 5 V (2.5-inch form factor) SATA Supply Rail
  - SATA Interface Power Management
  - OS-aware hot plug/removal
  - Enhanced power-loss data protection
- Power[3]
  - Active: Up to 4 W (TYP)
  - Idle: 700 mW (non-DIPM)
- Temperature
  - Operating: 0^{o} C to 70^{o} C
  - Non-Operating: -55^{o} C to 95^{o} C
- Reliability
  - Uncorrectable Bit Error Rate (UBER): 1 sector per 10^{16} bits read
  - Mean Time Between Failures (MTBF): 1,200,000 hours
  - Lifetime Endurance[4]: Up to 60 TB
- Shock (operating and non-operating): 1,500 G/0.5 msec
- Vibration
  - Operating: 2.17 G_{RMS} (5-700 Hz)
  - Non-operating: 3.13 G_{RMS} (5-800 Hz)
- Weight
  - 1.8-inch form factor: up to 49 grams
  - 2.5-inch 7mm form factor: up to 82 grams
  - 2.5-inch 9.5mm form factor: up to 88 grams
- Certifications and Declarations
  - UL*
  - CE*
  - C-Tick*
  - BSMI*
  - KCC*
  - Microsoft* WHQL
  - VCCI*
  - SATA-IO*
- Product Ecological Compliance
  - RoHS*

1. Performance values vary by capacity.
2. 4 KB = 4,096 bytes.
3. Workload equates to Iometer running 64 KB (65,536 bytes) sequential writes with a Queue Depth of 32.
4. Based on 4 KB (4,096 bytes) of full random writes with Queue Depth of 32; values vary by capacity.

Order Number: 325170-002US
April 2011

Ordering Information

Contact your local Intel sales representative for ordering information.



Contents

1.0 Overview

This document describes the random IOPS, typical power consumption, and endurance specifications of the Intel® Solid-State Drive 320 Series (Intel® SSD 320 Series) targeted for server and storage applications in an enterprise environment.

For complete specifications and product description, see the *Intel® Solid-State Drive 320 Series Product Specification*.

2.0 Product Specifications

2.1 Performance

Table 1 details the random read/write performance of the Intel SSD 320 Series in Input/Output Operations Per Second (IOPS) using two different methods. The first method measures IOPS across a 100% LBA range of the drive to align with enterprise-based requirements. The second method measures IOPS across an 8GB LBA range of the drive for client-based requirements. In both cases, measurements are taken using 4 KB (4,096 bytes) transfer sizes running Iometer* with a queue depth of 32 with the SSD write-cache enabled.

Note: Random Write IOPS on a full LBA range of the drive varies with over-provisioning.

Table 1. Random Read and Write Input/Output Operations Per Second (IOPS)

Performance	Unit	Intel SSD 320 Series					
		40 GB	80 GB	120 GB	160 GB	300 GB	600 GB
Random Read (up to)	IOPS	30,000	38,000	38,000	39,000	39,500	39,500
Random Write (up to) (100% Span)	IOPS	300	300	400	600	400	150
Random Write (up to) (8GB Span)	IOPS	3,700	10,000	14,000	21,000	23,000	23,000

Table 2 details the sequential bandwidth performance of the Intel SSD 320 Series while using 64 KB (65,536 bytes) transfer size with a queue depth of 32.

Table 2. Sequential Read/Write Bandwidth

Performance	Unit	Intel SSD 320 Series					
		40 GB	80 GB	120 GB	160 GB	300 GB	600 GB
Sequential Read (up to)	MB/s	200	270	270	270	270	270
Sequential Write (up to)	MB/s	45	90	130	165	205	220

2.2 Power Consumption

This section details the power consumption of the Intel SSD 320 Series using a simulated enterprise workload.

The workload equates 64 KB (65,536 bytes) QD=32 sequential writes. Root Mean Squared (RMS) power is measured using scope trigger over a 100 ms sample period.

Table 3. Typical Power Consumption

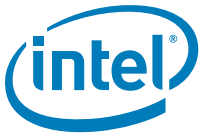
Intel SSD 320 Series	Mode	Typ Value	Unit
40 GB	Active	2.0	Watts
80 GB	Active	2.5	Watts
120 GB	Active	3.0	Watts
160 GB	Active	3.0	Watts
300 GB	Active	3.5	Watts
600 GB	Active	4.0	Watts

2.3 Reliability

This section details the write endurance of the Intel SSD 320 Series in an enterprise environment. Write endurance is measured while running 100% random 4 KB (4,096 bytes) writes spanning 100% of the drive using Iometer.

Table 4. Write Endurance Specifications

Intel SSD 320 Series	Value (Terabytes)
40 GB	5
80 GB	10
120 GB	15
160 GB	15
300 GB	30
600 GB	60



3.0 SMART Attributes

Table 5 summarizes the SMART attributes supported by the Intel SSD 320 Series in an enterprise environment to measure media wear during a timed workload.

Table 5. Supported SMART Attributes

ID	Attribute	Status Flag						Threshold
		PW	OC	PE	ER	EC	SP	
E2h	Timed Workload Media Wear Indicator	0	1	0	0	1	1	0 (none)
E3h	Timed Workload Host Read/Write Ratio	0	1	0	0	1	1	0 (none)
E4h	Workload Timer	0	1	0	0	1	1	0 (none)

Status flags key:

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

3.1 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.

3.2 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.

3.3 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.

3.4 Example Use Cases

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

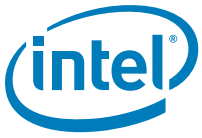
Ideally, the system that the drive is being used in should be capable of issuing S.M.A.R.T. commands. Otherwise, provisions have been provided to allow the media wear attributes to be persistent so the drive can be moved to a S.M.A.R.T.-capable system to read out the drive wear attribute values.

3.4.1 Use Case 1 – With a System Capable of S.M.A.R.T. Commands

1. Make sure DIPM (Device Initiated Power Management) is disabled to ensure data collected is accurate.
2. Issue the S.M.A.R.T. EXECUTE OFF-LINE IMMEDIATE (D4h) sub-command 40h to reset the drive wear attributes.
3. Run the workload to be evaluated for at least 60 minutes (otherwise the drive wear attributes will not be available).
4. Read out the drive wear attributes with the S.M.A.R.T. READ DATA (D0h) command.

3.4.2 Use Case 2 – With a System Not Capable of S.M.A.R.T. Commands

1. Make sure DIPM is disabled to ensure data collected is accurate.
2. On a S.M.A.R.T. capable system, issue the S.M.A.R.T. EXECUTE OFF-LINE IMMEDIATE (D4h) sub-command 40h to reset the E4h (workload timer) attribute.
3. Move the drive to the system where the workload will be measured (and not capable of S.M.A.R.T. commands).
4. Run the workload to be evaluated for at least 60 minutes (otherwise the drive wear attributes will not be available).
5. 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 S.M.A.R.T. attributes to persistent memory within the drive.
6. Move the drive to a S.M.A.R.T.-capable system.
7. Read out the drive wear attributes with the S.M.A.R.T. READ DATA (D0h) command within 60 minutes after power-up.



3.5 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 S.M.A.R.T. 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 Section 3.4 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:

- 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.

4.0 Additional Product Information

For more information on the Intel SSD 320 Series, see the documentation listed in Table 6.

Table 6. Standards References

Title	Order Number
Intel® Solid-State Drive 320 Series Product Specification	325152

5.0 Terms and Acronyms

Table 7 defines the terms and acronyms used in this document.

Table 7. Glossary of Terms and Acronyms

Term	Definition
ATA	Advanced Technology Attachment
DIPM	Device Initiated Power Management
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.
KB	Kilobyte
LBA	Logical Block Address
IOPS	Input/Output Operations Per Second
SATA	Serial Advanced Technology Attachment
SSD	Solid-State Drive
TB	Terabyte

6.0 Revision History

Date	Revision	Description
April 2011	002	Added “100% LBA range” to Random 4 KB writes on cover page.
March 2011	001	Initial release.