

# SanDisk®

## SanDisk® SSD U100

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### Product Manual

(Preliminary)

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## Revision History

Revision	Description	Date
0.90	<ul style="list-style-type: none"><li>• Fix 32GB sequential write (SATA-II) value.</li><li>• Update power consumption numbers with final product configuration.</li><li>• Add product weight for each form-factor.</li><li>• Changed Identify Data Word 235 to indicate maximum # of sectors per 'segmented' Download Microcode is 16 (10h).</li><li>• Changed DEVSLP -&gt; DEVSLP</li><li>• Change Power class levels</li><li>• Updated footnotes</li><li>• Removed Random Burst (Recovered) Write performance metric</li></ul>	August 25, 2011

## Table of Contents

<b>1.</b>	<b>INTRODUCTION .....</b>	<b>8</b>
1.1	GENERAL DESCRIPTION .....	8
1.2	KEY FEATURES .....	10
1.3	FUNCTIONAL DESCRIPTION .....	12
1.4	ADVANCED FLASH MANAGEMENT .....	13
1.4.1	<i>Non-Volatile Write Cache</i> .....	13
1.4.2	<i>Defect and Error Management</i> .....	14
1.4.3	<i>Wear Leveling</i> .....	14
1.4.4	<i>Bad Block Management</i> .....	14
1.5	ADVANCED LOW POWER MANAGEMENT .....	15
1.5.1	<i>Slumber SATA low power mode</i> .....	15
1.5.2	<i>DEVLSP SATA low power mode</i> .....	15
1.6	BACKGROUND GARBAGE COLLECTION .....	15
1.7	POWER CLASSES .....	16
1.8	PERFORMANCE THROTTLING .....	16
<b>2.</b>	<b>GENERAL PRODUCT SPECIFICATIONS .....</b>	<b>17</b>
2.1	INTERFACE .....	17
2.2	CAPACITY .....	17
2.3	PERFORMANCE .....	18
2.3.1	<i>Multi-level cell (MLC) Performance</i> .....	18
2.4	ENDURANCE .....	19
2.4.1	<i>Multi-level cell (MLC) Endurance</i> .....	19
<b>3.</b>	<b>POWER CHARACTERISTICS .....</b>	<b>20</b>
3.1	SUPPLY VOLTAGE .....	20
3.2	GRACEFUL POWER-OFF REQUIREMENTS .....	20
3.3	AVERAGE POWER CONSUMPTION .....	21
3.3.1	<i>Multi-level cell (MLC) Average Power Consumption</i> .....	21
3.4	ACTIVE POWER CONSUMPTION .....	22
3.4.1	<i>Multi-level cell (MLC) Active Power Consumption</i> .....	22
3.5	LOW POWER MODE CONSUMPTION .....	23
3.5.1	<i>Low Power Mode Consumption</i> .....	23
<b>4.</b>	<b>PHYSICAL SPECIFICATION .....</b>	<b>24</b>
4.1	HALF-SLIM SATA FORM FACTOR .....	24
4.1.1	<i>Standard SATA 8GB-64GB capacity</i> .....	24
4.1.2	<i>Half-Slim SATA 128GB-256GB capacity</i> .....	25
4.2	mSATA FORM FACTOR .....	26
4.2.1	<i>mSATA 8GB-64GB capacity</i> .....	26
4.2.2	<i>mSATA 128GB-256GB capacity</i> .....	27
4.3	MSATA MINI FORM FACTOR .....	28
4.3.1	<i>mSATA Mini 8GB capacity</i> .....	28
4.3.2	<i>mSATA Mini 16GB-128GB capacity</i> .....	28
<b>5.</b>	<b>ENVIRONMENTAL SPECIFICATIONS .....</b>	<b>29</b>
5.1	TEMPERATURE .....	29
5.2	HUMIDITY .....	29
5.3	VIBRATION .....	29
5.4	SHOCK .....	29
5.5	ALTITUDE .....	29
5.6	ELECTROSTATIC DISCHARGE (ESD) .....	30

5.7	ACOUSTICS.....	30
5.8	EMI/RFI COMPLIANCE .....	30
5.9	ROHS .....	30
5.10	REGULATIONS.....	31
<b>6.</b>	<b>RELIABILITY CHARACTERISTICS.....</b>	<b>32</b>
6.1	ERROR RATE.....	32
6.2	MTTF (MEAN-TIME-TO-FAILURE).....	32
<b>7.</b>	<b>INTERFACE .....</b>	<b>33</b>
7.1	SUPPORTED STANDARDS.....	33
7.2	PIN ASSIGNMENTS – HALF-SLIM SATA CONNECTOR .....	33
7.3	PIN ASSIGNMENTS – MSATA .....	34
<b>8.</b>	<b>SUPPORTED ATA COMMANDS.....</b>	<b>35</b>
8.1	IDENTIFY DATA .....	39
8.2	LOG PAGES .....	43
<b>9.</b>	<b>ORDERING INFORMATION .....</b>	<b>44</b>
9.1	SANDISK SSD U100 MLC PRODUCTS ORDERING INFORMATION .....	44
<b>10.</b>	<b>CONTACT INFORMATION .....</b>	<b>45</b>

## Table of Figures

FIGURE 1-1: SANDISK SSD U100 BLOCK DIAGRAM .....	8
FIGURE 1-2: SANDISK SSD U100 NCACHE™ TECHNOLOGY.....	13
FIGURE 4-1 : HALF-SLIM SATA 8-64GB TOP VIEW .....	24
FIGURE 4-2 : HALF-SLIM SATA 8-64GB SIDE VIEW.....	24
FIGURE 4-3 : MSATA 8-64GB TOP VIEW .....	26
FIGURE 4-4 : MSATA 8-64GB SIDE VIEW.....	26
FIGURE 4-5 : MSATA 128-256GB TOP VIEW .....	27
FIGURE 4-6 : MSATA 128-256GB SIDE VIEW.....	27
FIGURE 4-7 : MSATA MINI 16-128GB TOP VIEW .....	28
FIGURE 4-8 : MSATA MINI 16-128GB SIDE VIEW .....	28

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## Table of Tables

TABLE 1-1: SANDISK SSD U100 POWER CLASSES.....	16
TABLE 2-1: SANDISK SSD U100 CAPACITY SPECIFICATION .....	17
TABLE 2-2: SANDISK SSD U100 (MLC) PERFORMANCE .....	18
TABLE 2-3: SANDISK SSD U100 (MLC) ENDURANCE .....	19
TABLE 3-1: SANDISK SSD U100 SUPPLY VOLTAGE.....	20
TABLE 3-2: SANDISK SSD U100 (MLC) AVERAGE POWER CONSUMPTION .....	21
TABLE 3-3: SANDISK SSD U100 (MLC) ACTIVE POWER CONSUMPTION.....	22
TABLE 3-4: SANDISK SSD U100 POWER CONSUMPTION IN LOW POWER MODE.....	23
TABLE 4-1: MECHANICAL INFORMATION – HALF-SLIM SATA FORM FACTOR .....	24
TABLE 4-2: MECHANICAL INFORMATION - MSATA FORM FACTOR.....	26
TABLE 4-3: MECHANICAL INFORMATION - MSATA MINI FORM FACTOR .....	28
TABLE 5-1: SANDISK SSD U100 TEMPERATURE SPECIFICATION .....	29
TABLE 5-2: SANDISK SSD U100 HUMIDITY SPECIFICATION .....	29
TABLE 5-3: SANDISK SSD U100 VIBRATION SPECIFICATION .....	29
TABLE 5-4: SANDISK SSD U100 SHOCK SPECIFICATION .....	29
TABLE 5-5: SANDISK SSD U100 ALTITUDE SPECIFICATION .....	29
TABLE 5-6: SANDISK SSD U100 ESD SPECIFICATION .....	30
TABLE 5-7: SANDISK SSD U100 EMI/RFI COMPLIANCE .....	30
TABLE 5-8: SANDISK SSD U100 REGULATION STANDARDS .....	31
TABLE 6-1: SANDISK SSD U100 MTTF.....	32
TABLE 7-1: STANDARD SATA CONNECTOR PIN ASSIGNMENT.....	33
TABLE 7-2: MSATA CONNECTOR PIN ASSIGNMENT.....	34
TABLE 8-1: SUPPORTED ATA COMMANDS.....	38
TABLE 8-2: IDENTIFY DATA VALUES .....	42
TABLE 8-3: SUPPORTED SMART LOG PAGES .....	43
TABLE 9-1: SSD U100 MLC ORDERING INFORMATION .....	44
TABLE 9-2: EXAMPLES OF DECODED SKU FOR SSD U100 MLC PRODUCTS .....	44

# 1. Introduction

## 1.1 General Description

The SanDisk® SSD U100 builds on the momentum of three generations of SSD P-Series and the overall trend in the market towards smaller, thinner computing machines that enable mobility, connectivity on the go and instant-on capability.

Designed and built on the philosophy of providing improved user-experience at affordable cost, SanDisk SSD U100 is a perfect replacement for HDD in the consumer market. The SanDisk SSD U100 beats HDD in every possible metric – size, weight, shock and vibration tolerance, power consumption, sequential and random read performances as well as sequential and random write performances.

The SanDisk SSD U100 houses a powerful SATA SSD controller that is fully compliant to SATA 6Gb/s (Revision 3.0) standards on the front-end. Matching the speed on the back-end side, the SSD controller is designed with 4 high-speed NAND Flash channels each operating at a maximum speed of 194MB/s. This allows the product to achieve superior performance up to 450MB/s and 350MB/s for sequential read and sequential write, respectively. It fulfills the market's ever increasing demand of seamless user-experience, improved multi-tasking capabilities and extreme responsiveness. The SATA interface aligns with the global transition in the industry, which is enforced by the platform's chipsets.

Using the advanced 24nm memory geometry provides for a low-cost product which beats the HDD's price in the capacity ranges of 8GB-32GB and provides a very competitive product at capacities ranging 64GB to 256GB. The SanDisk SSD U100 is offered in many small form factors, allowing SanDisk to maintain its leadership in this market. The small form factor enables further miniaturization of **Netbook**, **SmartBook** and **Tablet** designs and opens doors for a whole range of other applications such as **Ultrabooks (Ultrathin Notebooks)**.

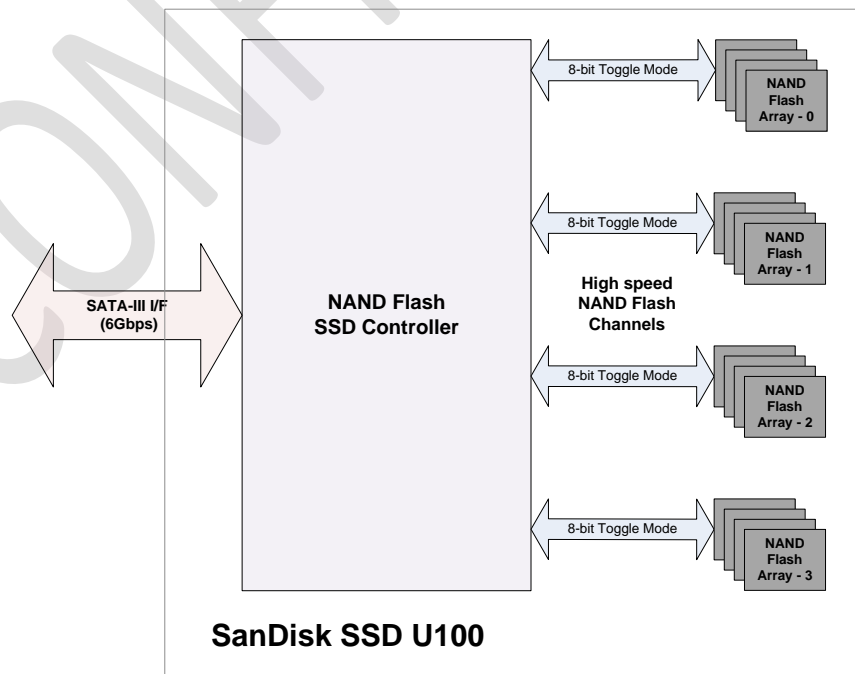


Figure 1-1: SanDisk SSD U100 Block Diagram



The SanDisk SSD U100 employs a low power architecture that significantly reduces the power consumed by the device in low power modes - allowing the users' to extend the charge cycles of the battery – highly-desired by mobility applications.

Built on the fundamentals of solid state technology, the SSD U100 has no moving parts, unlike an HDD, significantly improving the mechanical reliability of the device. The advanced flash management technology designed into the device firmware allows the SSD U100 to achieve superior sequential and random IO performance, and improves long-term data endurance (measure of device reliability) significantly. The device firmware also implements functions of Dynamic bad block management, dynamic and static wear-leveling, and robust error detection and correction code (EDC/ECC) to ensure data integrity. Once the SSD has been configured by the host, it appears to the host as a standard SATA disk drive.

## 1.2 Key Features

- High-capacity, ultra-small form factor supporting unformatted capacities<sup>1</sup> of 8GB, 16GB, 32GB, 64GB, 128GB and 256GB<sup>2</sup>:
  - Half-Slim SATA 2.5" standard connector, complies to JEDEC-297 standard
  - Standard mSATA form factor with a Mini-PCIe edge connector, complies to JEDEC MO-300A standard
  - mSATA Mini form factor with a Mini-PCIe edge connector, complies to JEDEC MO-300B standard
  
- Interface to host:
  - SATA 6Gb/s (Revision 3.0) compliant
  - Backwards compliant to SATA 3Gb/s & SATA 1.5Gb/s
  - ATA Command Set ACS-2
  - NCQ support up to queue depth = 32
  
- High performance<sup>3</sup>:
  - Maximum Host transfer rate: 6Gb/s
  - Sustained Sequential Read: 450 MB/s
  - Sustained Sequential Write: 350 MB/s
  - 4K Random Write (Sustained): 630 IOPS
  - 4K Random Read: 9400 IOPS
  
- Low power consumption:
  - Typical read/write<sup>4</sup>: 45mW
  - Slumber power mode<sup>5</sup>: 10mW
  - DEVSLP power mode<sup>6</sup>: TBD

---

<sup>1</sup> The logical capacity of the drive conforms to the IDEMA HDD Specification. See [www.idema.org](http://www.idema.org) for details. Some of the listed capacity is used for formatting and other functions, and thus is not available for data storage. 1 megabyte (MB) = 1 million bytes; 1 gigabyte (GB) = 1 billion bytes.

<sup>2</sup> 256GB availability in MLC flavor only.

<sup>3</sup> Performance for 128GB product on SATA 6Gb/s host, Queue Depth = 32. Based on internal testing; performance may vary.

<sup>4</sup> Average (typical) power while running MobileMark™ 2007 with Device Initiated Power Management (DIPM) enabled

<sup>5</sup> Based on Slumber Power mode of 128GB product

<sup>6</sup> Based on DEVSLP Power mode of 128GB product

- Advanced Flash Management:
  - nCache™ – Non Volatile Write Cache
  - Support for TRIM
  - Dynamic & Static Wear-leveling
  - Bad Block Management
  - Background Garbage Collection
  
- Support for Performance throttling and Power Classes:
  - Performance will be throttled in the event junction temperature of critical components is measured to be exceeding the maximum allowable for the product.
  - A Power Class feature is supported to allow the Host to define the maximum allowable power consumed by the device - honoring a power budget of the host.
  
- Ungraceful power loss handling:
  - Implements special hardware to detect the event of ungraceful power loss.
  - Ensures integrity of the data residing on the SSD<sup>7</sup>.
  
- Highly-reliable:
  - Mean time to failure (MTTF) – refer to Section 6.2 for capacity-specific values
  - Operating shock: 1,500G, 0.5msec half sine
  - Operating vibration: 5gRMS, 10-2000 Hz
  - Operating temperature: 0°C to 70°C
  - Non-operating temperature and storage: -55°C to +85°C

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<sup>7</sup> Requires the host to maintain an amount of power/current for ~2.5ms to allow outstanding flash programming sequences to complete.

### 1.3 Functional Description

The SSD U100 contains a high-level, intelligent storage subsystem. This intelligent (microcontroller) subsystem provides many capabilities not found in other types of memory devices.

These capabilities include the following:

- Compliant to SATA 6Gb/s (Revision 3.0) standard
- Supports ATA register and command set (ATA-8 / ACS2 standard)
- Support for NCQ, up to queue depth = 32
- Support for Trim command
- S.M.A.R.T. feature supported
- Advanced power management
- Implementation of dynamic and static wear-leveling to extend
- Sophisticated system for error recovery including a powerful error correction code (ECC)
- Host independence from details of erasing and programming flash memory
- Sophisticated system for managing defects (similar to systems found in magnetic disk drives)

## 1.4 Advanced Flash Management

### 1.4.1 Non-Volatile Write Cache

The fourth generation of modular SSD, the SSD U100 supports a unique feature to improve burst and sustained random write performance and ensure very positive user experience. Studies show that modern (client as well as mobile) operating systems (like Windows7, Windows Mobile, Android, ChromeOS) mostly access the storage device using small access blocks, with the majority being 4KB access blocks.

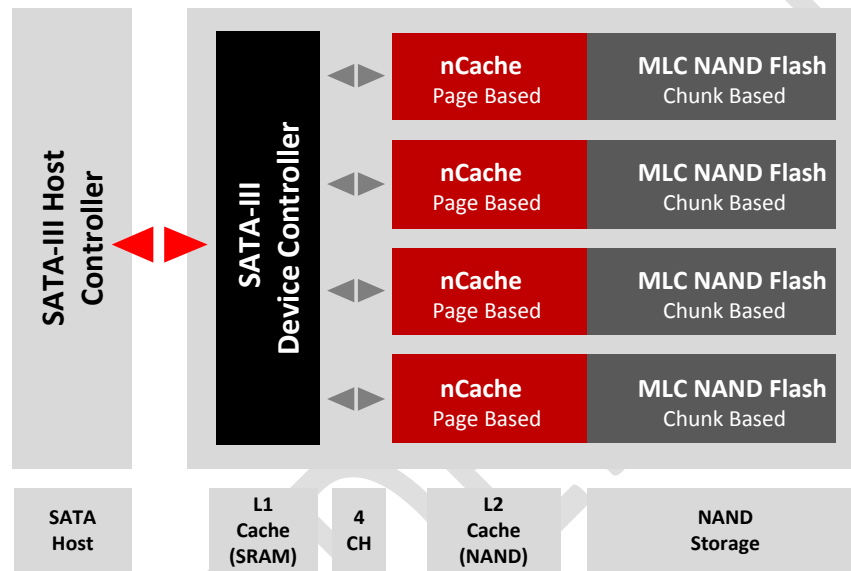


Figure 1-2: SanDisk SSD U100 nCache™ technology

These small logical access blocks conflict with the physical NAND block structure ( $\geq 2\text{MB}$ ) for the newer generation flash memory technology. Therefore, to bridge this difference, the SSD U100 employs a non-volatile NAND Flash write cache called the nCache™. The nCache™ is used to accumulate these small writes (called cache segments) at high-speed and then flush and consolidate them to a larger MLC section of the NAND Flash memory in the background during idle time.

The cache size of the SSD U100 is over  $500\text{MB}^8$  - an order of magnitude larger than other competing solutions that use DRAM based cache. Due to its large size, for most of the daily user activity, the nCache™ never overflows and the user experiences high-burst performance rather than the sustained performance. Once the nCache™ becomes full, the performance of SSD U100 drops to the steady state condition.

<sup>8</sup> The cache size scales with capacity. For 128GB product, the cache size is over 2GB.

## 1.4.2 Defect and Error Management

SSD U100 contains a sophisticated defect and error management system that is similar to the systems found in magnetic disk drives, and in many cases, offers enhancements. If necessary, the SSD device will rewrite data from a defective block to a good block. This action is completely transparent to the host and does not consume any user data space.

The SSD soft error rate specification is much better than the magnetic disk drive specification. In the extremely rare case that a read error does occur, the SSD U100 products have innovative algorithms to recover the data by using error detection code and error correction code (EDC/ECC). These defect and error management systems, coupled with the solid state construction, give SSD U100 unparalleled reliability.

## 1.4.3 Wear Leveling

Wear leveling is an intrinsic part of the erase pooling functionality of SSDs using NAND memory. Advanced features of dynamic and static wear-leveling, and automatic block management are used to ensure an even distribution of write/erase cycles throughout the entire device, regardless of how dynamic or static the data written is. This guarantees high data reliability and maximizes flash life expectancy.

## 1.4.4 Bad Block Management

Bad blocks are occasionally created during the life cycle of a flash component, in a phenomenon called dynamic bad-block accumulation. These bad blocks must be marked and replaced dynamically in order to prevent read/write failures. When a bad block is detected, the embedded Bad Block Mapping algorithm maps out the block, which will remove the block from future use.

## 1.5 Advanced Low Power Management

The SanDisk SSD U100 employs advanced low power architecture that reduces power consumption in low power modes. In particular, the SSD U100 supports the following SATA low power modes:

### 1.5.1 Slumber SATA low power mode

The SanDisk SSD U100 supports entering into Slumber SATA low power mode through DIPM (Device Initiated Power Management) as well as HIPM (Host Initiated Power Management). Upon completion of any command, in case of DIPM, the SSD will request the host to enter into Slumber power if there is no SATA bus activity for 20msec.

### 1.5.2 DEVLSP SATA low power mode

The SSD U100 employs the newest DEVLSP SATA low power mode that further reduces device power consumption in the IDLE state - thereby extending the time between charging of a battery, which is highly-desired in mobility applications. The standard SATA low power modes, Partial and Slumber, need SATA OOB (Out of Band) commands to return to normal operation. The SATA PHY has to be partially powered up to respond to the OOB command sequence, resulting in high Slumber mode current. DEVLSP enables the device, and optionally the host, to completely shut-off their SATA PHY, resulting in much lower power consumption compared to Slumber SATA low power mode.

## 1.6 Background Garbage Collection

Once the SATA PHY has entered into Slumber state, the flash management firmware can utilize the time the device is idle in order to perform internal house-keeping operations. These internal house-keeping activities include freeing up the space in the nCache by flushing and consolidating to the MLC storage. Performing internal house-keeping activities in background will significantly improve burst performance of the device, providing swift user experience and, at the same time, allowing for better utilization of the nCache. These operations are executed internally, while reporting device status READY to the host. Any time a new command is received from the host the internal operations will be terminated and the host command will be serviced with minimal delay. If no command is received by the device, the execution of the house-keeping activities will be limited to 30 seconds – designed to maintain low power consumption.

## 1.7 Power classes

The SanDisk SSD U100 targeted towards convergence market space characterized by stringent power budget originating from the objective to either extend battery charge cycle or due to power ICs limitation. In order to allow an adequate power-performance tradeoff, the SanDisk SSD U100 supports three power classes as define in the table below.

The operating Power Class is selected using user configurable or Operating System inputs.

Power Class	Unit	Power Class I	Power Class II	Power Class III
Maximum Active Power consumption	mW	800	1200	2000

Table 1-1: SanDisk SSD U100 Power Classes

## 1.8 Performance Throttling

In order to protect the integrity of the data and prevent excessive heat dissipation, the SSD U100 utilizes an on-board/on-chip thermal sensor to monitor the SSD's critical component junction temperature. If the temperature rises above the allowable limit, the performance will be reduced until the temperature decreases to an allowable level. This performance throttling technique acts as a safety measure as well as a means for achieving power class implementation described in the [previous section](#).



## 2. General Product Specifications

### 2.1 Interface

The SSD U100 interface complies with the Serial ATA standard published by ANSI. The device complies with the SATA 6Gb/s, Revision 3.0 specifications and supports ATA Command Set ACS-2.

For more information, refer to the American National Standard X3.221: AT Attachment for Interface for Disk Drives document. Documentation can be ordered from IHS by calling 1-800-854-7179 or accessing their Web site: <http://global.ihs.com>

### 2.2 Capacity

Unformatted Capacity <sup>9</sup>	Total Number of User-Addressable Sectors in LBA Mode <sup>10</sup>	Number of Logical Cylinders	Number of Logical Heads	Number of Logical Sectors per Track
8GB	15,649,200	15,525	16	63
16GB	31,277,232	16,383	16	63
32GB	62,533,296	16,383	16	63
64GB	125,045,424	65,535	16	63
128GB	250,069,680	65,535	16	63
256GB	500,118,192	65,535	16	63

**Table 2-1: SanDisk SSD U100 Capacity Specification**

<sup>9</sup> 1 gigabyte (GB) = 1 billion bytes. Some of the listed capacity is used for formatting and other functions, and thus is not available for data storage.

<sup>10</sup> 1 Sector = 512 bytes.

## 2.3 Performance<sup>11</sup>

### 2.3.1 Multi-level cell (MLC) Performance

Parameter	Unit	NCQ	8GB	16GB	32GB	64GB	128GB	256GB
<b>SATA 3Gb/s host interface</b>								
Sequential Read <sup>12</sup>	MB/s	NCQ=1	110	210	210	210	210	210
		NCQ=32	110	220	240	240	240	240
Sequential Write <sup>12</sup>	MB/s	NCQ=1	25	50	110	190	190	190
		NCQ=32	25	50	110	220	230	230
Random Read [4KB] <sup>13</sup>	IOPs	NCQ=1	4200	4200	4200	4200	4200	4200
		NCQ=32	5000	9200	9400	9400	9400	9400
Random Write – Sustained [4KB] <sup>13</sup>	IOPs	NCQ=1	40	100	190	300	530	600
		NCQ=32	40	100	190	300	530	600
Typical power-on ready time	msec		35 typical	55 typical	85 typical	125 typical	125 typical	125 typical
Parameter	Unit		8GB	16GB	32GB	64GB	128GB	256GB
<b>SATA 6Gb/s host interface</b>								
Sequential Read <sup>12</sup>	MB/s	NCQ=1	110	220	360	380	380	380
		NCQ=32	110	220	450	450	450	450
Sequential Write <sup>12</sup>	MB/s	NCQ=1	25	50	110	220	320	320
		NCQ=32	25	50	110	220	350	350
Random Read [4KB] <sup>13</sup>	IOPs	NCQ=1	4200	4200	4200	4200	4200	4200
		NCQ=32	5000	9200	9400	9400	9400	9400
Random Write – Sustained [4KB] <sup>13</sup>	IOPs	NCQ=1	40	100	200	300	530	630
		NCQ=32	40	100	200	300	530	630
Typical power-on ready time	msec		35 typical	55 typical	85 typical	125 typical	125 typical	125 typical

Table 2-2: SanDisk SSD U100 (MLC) Performance

<sup>11</sup> Measured using IOMETER 2006.07.27 on Intel® Core™ i7-2600 Processor based Windows 7™ PC, secondary drive configuration with host write cache enabled.

<sup>12</sup> Using 512KB aligned accesses across the entire capacity of the drive.

<sup>13</sup> The measurement is of 4KB aligned random accesses in the 8GB range of the drive's capacity with sequential precondition. For Random Write Sustained, card preconditioned with 4K Random write for 25 minutes followed by random write sustained performance averaged over 15 minutes.

## 2.4 Endurance

### 2.4.1 Multi-level cell (MLC) Endurance

Parameter	8GB	16GB	32GB	64GB	128GB	256GB
Long Term Data Endurance (LDE) <sup>14</sup>	5TBW	10TBW	20TBW	40TBW	80TBW	160TBW

Table 2-3: SanDisk SSD U100 (MLC) Endurance

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<sup>14</sup> LDE is calculated based on typical workload based on Windows OS. LDE is a direct function of user workload and access pattern. LDE is defined in terms of Terabytes Written, "TBW."

## 3. Power Characteristics

### 3.1 Supply Voltage

Parameter		Specifications
Input Voltage	Form Factor	
	Standard SATA connector	5V $\pm$ 5%
	mSATA / mSATA Mini	3.3V $\pm$ 5%
Maximum Ripple		70mV (peak to peak), 0 – 30MHz
Supply Rise Time		7msec to 500msec

Table 3-1: SanDisk SSD U100 Supply Voltage

### 3.2 Graceful Power-off Requirements

By default, most OS's operate with Host Write Cache 'enabled,' which more accurately means there can be data residing in the U100 that hasn't been successfully programmed into flash memory (this is a feature of ATA and not specific to SanDisk SSD products). To ensure this data is properly committed to flash memory, the U100 requires a Flush Cache command followed by a Standby Immediate command prior to power being removed. This command sequence allows the U100 to complete the programming of all data in its volatile data cache into flash memory, returning 'good' status to the host only after successful completion. This command sequence is handled transparently by most OS's during a standard shutdown sequence (e.g., hibernation, shutdown, standby, etc).

However, it is possible that in some applications (e.g., embedded systems without a typical user-interface providing graceful power-down options), power to the U100 could be removed, without warning, precluding the possibility of a graceful shutdown. To assist in the protection against data loss, the U100 utilizes an internal voltage sensor to detect the loss of power. In combination with residual power (i.e., current) from the host, the U100 will use the voltage sensor trigger to stop any outstanding flash programming operation that may lead to data loss. Please refer to the "Unexpected Power Loss Considerations" white paper available from SanDisk, which provides specific details relating to this topic.

### 3.3 Average Power Consumption

Average power consumption is defined as the blended read/write/idle power used by the SSD U100 while it is operating with a typical OS installed. The power consumption is being recorded while running MobileMark™ 2007 with Device Initiated Power Management (DIPM) enabled (allowing the SSD U100 to enter low power modes during host idle time). MobileMark™ 2007 simulates the usage of standard user applications in the Windows environment, providing a reproducible test platform for measuring average power consumption.

#### 3.3.1 Multi-level cell (MLC) Average Power Consumption

Input Voltage	Parameter	8GB	16GB	32GB	64GB	128GB	256GB
<b>SATA 3Gb/s host interface</b>							
5V ± 5%	Read/Write [mW]	43	43	45	52	55	55
3.3V ± 5%	Read/Write [mW]	40	40	42	50	52	52
<b>SATA 6Gb/s host interface</b>							
5V ± 5%	Read/Write [mW]	45	46	47	52	60	60
3.3V ± 5%	Read/Write [mW]	42	43	45	50	54	54

Table 3-2: SanDisk SSD U100 (MLC) Average Power Consumption

## 3.4 Active Power Consumption

Active power consumption is measured while the U100 is continuously processing sequential read and write commands (tested separately) with a transfer size of 256 sectors per command (128KB). Measurement of active power consumption is meant to demonstrate the worst-case continuous power required by the SSD U100 during long read or write command sequences.

### 3.4.1 Multi-level cell (MLC) Active Power Consumption

Input Voltage	Parameter	8GB	16GB	32GB	64GB	128GB	256GB
<b>SATA 3Gb/s host interface</b>							
5V ± 5%	Read [mW]	550	770	840	875	950	1010
	Write [mW]	550	755	1090	1750	1890	2025
3.3V ± 5%	Read [mW]	500	700	775	815	885	955
	Write [mW]	500	680	1040	1710	1875	1995
<b>SATA 6Gb/s host interface</b>							
5V ± 5%	Read [mW]	575	795	1175	1210	1300	1400
	Write [mW]	575	775	1110	1775	2855	3040
3.3V ± 5%	Read [mW]	510	725	1090	1145	1240	1330
	Write [mW]	510	700	1058	1740	2815	3000

Table 3-3: SanDisk SSD U100 (MLC) Active Power Consumption

## 3.5 Low Power Mode Consumption

Low power mode consumption is defined as the mode where the SSD U100 has entered Slumber mode (SATA PHY state) and DPDM (SSD U100 specific 'deep power down mode' that is entered after a period of at least 20ms where no ATA commands are received from the host).

### 3.5.1 Low Power Mode Consumption

Input Voltage	Parameter	8GB	16GB	32GB	64GB	128GB	256GB
<b>SATA 3Gb/s host interface</b>							
5V ± 5%	Partial / Slumber Mode [mW]	10.00	10.40	12.10	13.50	13.70	13.70
3.3V ± 5%	Partial / Slumber Mode [mW]	8.00	8.02	10.20	10.43	10.60	10.60
	DEVSLP Power Mode [mW]	TBD	TBD	TBD	TBD	TBD	TBD
<b>SATA 6Gb/s host interface</b>							
5V ± 5%	Partial / Slumber Mode [mW]	10.20	10.45	12.15	13.70	13.75	13.75
3.3V ± 5%	Partial / Slumber Mode [mW]	8.20	8.45	10.39	10.56	10.75	10.75
	DEVSLP Power Mode [mW]	TBD	TBD	TBD	TBD	TBD	TBD

**Table 3-4: SanDisk SSD U100 Power Consumption in Low Power Mode**

## 4. Physical Specification

### 4.1 Half-Slim SATA Form Factor

Complies with SFF-8156/MO-297 standards

Parameter	Specifications
Width	54mm
Length	39mm
Thickness (max)	3.08mm (8-64GB), 2.88mm (128-256GB), Connector 4.00mm
Typical Weight	5.9g (8GB), 6.6g (16GB), 7.5g (32-64GB), 7.7g (128-256GB)

Table 4-1: Mechanical Information – Half-Slim SATA form factor

#### 4.1.1 Standard SATA 8GB-64GB capacity

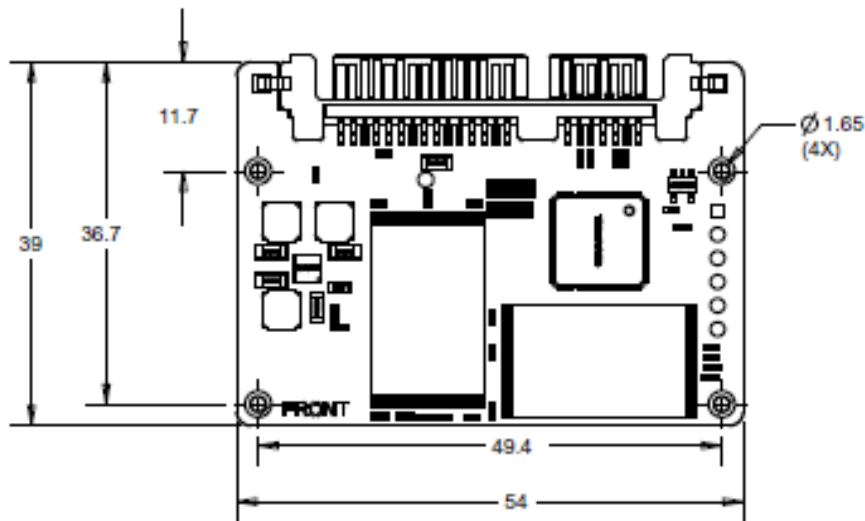


Figure 4-1 : Half-Slim SATA 8-64GB Top View

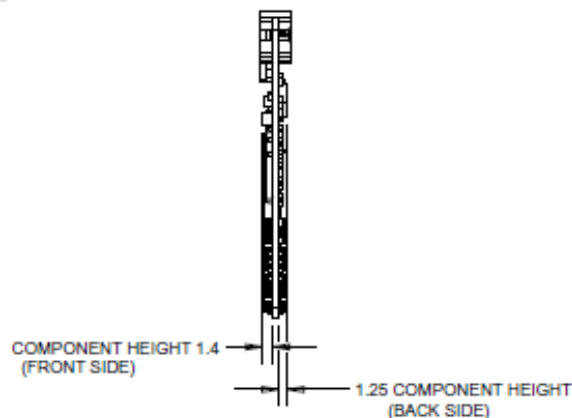


Figure 4-2 : Half-Slim SATA 8-64GB Side View



#### **4.1.2 Half-Slim SATA 128GB-256GB capacity**

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## 4.2 mSATA Form Factor

Complies with MO-300A Standard

Parameter	Specifications
Width	30mm
Length	50.95mm
Thickness (max)	3.4mm (8-64GB), 3.2mm (128-256GB)
Typical Weight	5.2g (8GB), 5.7g (16GB), 6.7g (32-64GB), 6.8g (128-256GB)

Table 4-2: Mechanical Information - mSATA form factor

### 4.2.1 mSATA 8GB-64GB capacity

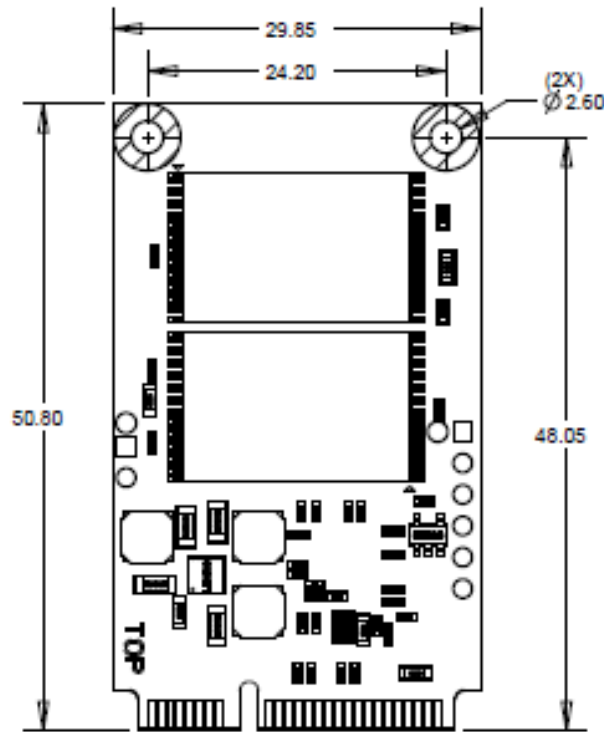


Figure 4-3 : mSATA 8-64GB Top View



Figure 4-4 : mSATA 8-64GB Side View

### 4.2.2 mSATA 128GB-256GB capacity

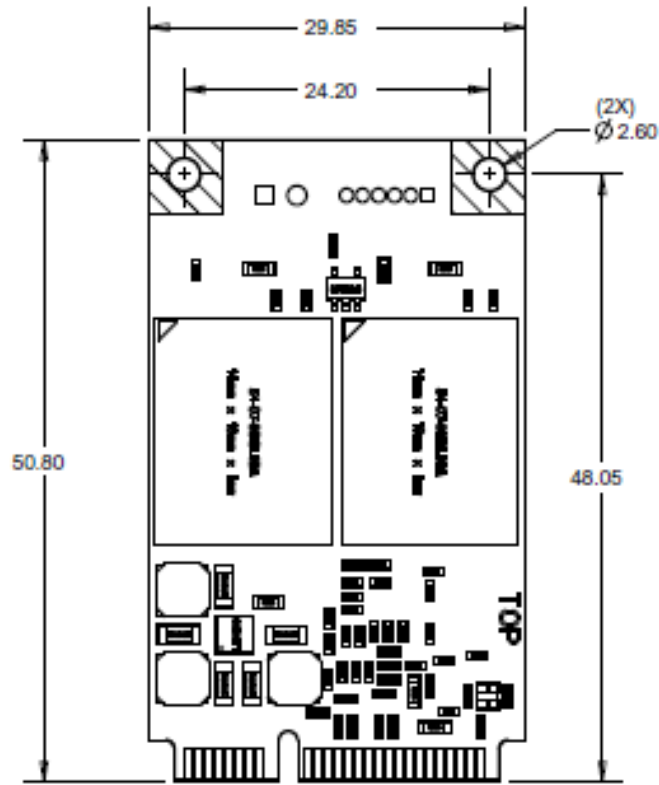


Figure 4-5 : mSATA 128-256GB Top View



Figure 4-6 : mSATA 128-256GB Side View

## 4.3 mSATA Mini Form Factor

Complies with MO-300B Standard

Parameter	Specifications
Width	30mm
Length	26.80mm
Thickness (max)	2.2mm (8GB), 3.2mm (16-128GB)
Typical Weight	3.0g (8GB), 3.3g (16GB), 3.4g (32GB), 3.5g (64-128GB)

Table 4-3: Mechanical Information - mSATA Mini form factor

### 4.3.1 mSATA Mini 8GB capacity

### 4.3.2 mSATA Mini 16GB-128GB capacity

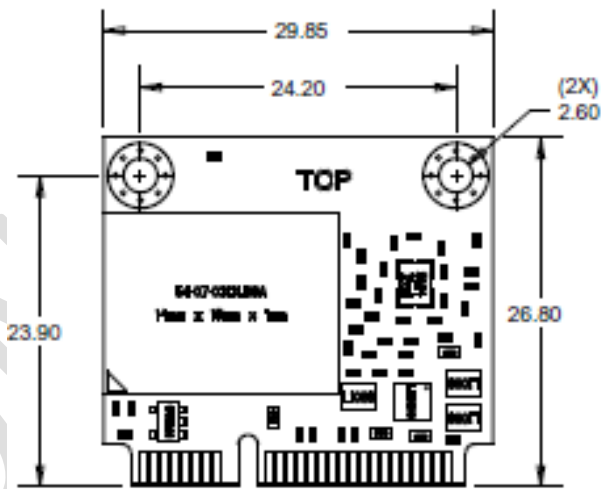


Figure 4-7 : mSATA Mini 16-128GB Top View

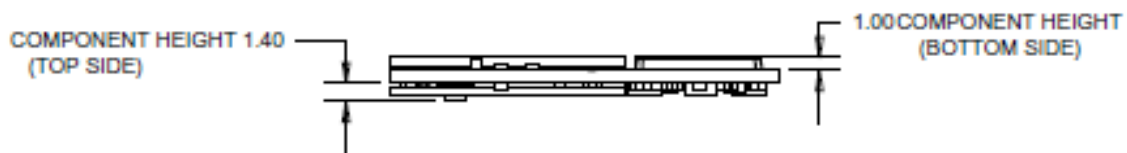


Figure 4-8 : mSATA Mini 16-128GB Side View

## 5. Environmental Specifications

### 5.1 Temperature

Parameter	Specifications
Operational	0°C to 70°C
Storage	-55°C to 85°C
Maximum temperature gradient	1°C per minute

Table 5-1: SanDisk SSD U100 Temperature Specification

### 5.2 Humidity

Parameter	Specifications
<b>Operational</b>	
Humidity (Non condensation)	5% to 95%
Maximum wet bulb	35°C
<b>Non-operational</b>	
Humidity (Non condensation)	5% to 95%
Maximum wet bulb	40°C
Maximum relative humidity gradient	20% per hour

Table 5-2: SanDisk SSD U100 Humidity Specification

### 5.3 Vibration

Parameter	Specifications
Operational / Non-operational	5gRMS, 10-2000 Hz, 3 axes

Table 5-3: SanDisk SSD U100 Vibration Specification

### 5.4 Shock

Parameter	Acceleration Force	Half Sine pulse duration
Operational /	1000G	1ms
Non operational	1500G	0.5ms

Table 5-4: SanDisk SSD U100 Shock Specification

### 5.5 Altitude

Parameter	Specifications
Non-Operational	-1500ft (-457m) to 40,000ft (12,192m)
Operational	-1500ft (-457m) to 10,000ft (3048m)

Table 5-5: SanDisk SSD U100 Altitude Specification

## 5.6 Electrostatic Discharge (ESD)

The SanDisk SSD U100's are ESD tested per IEC 61000-4-2 Standard.

Parameter	Test Voltage
Contact	2kV, 4kV
Air	4kV, 8kV

**Table 5-6: SanDisk SSD U100 ESD Specification**

## 5.7 Acoustics

The SSD U100 does not generate any acoustics noise (0dB).

## 5.8 EMI/RFI Compliance

The SanDisk SSD U100 is certified to comply with the following standards.

Standard
FCC Part 15 Class B
IECS-003 Class B
EN 55022 Class B
EN 55024
KCC No. 2008-39
KCC No. 2008-38
CNS 13438
VCCI: 2006
AS/NZS CISPR 22: 2006

**Table 5-7: SanDisk SSD U100 EMI/RFI Compliance**

## 5.9 RoHS

European union's restriction on use of hazardous substances in electrical and electronic equipment (EU RoHS) Directive 2002/95/EC. China's management methods for controlling pollution by electronic information products (China RoHS).

## 5.10 Regulations

The SanDisk SSD U100 is certified with the following certifications:

Standard
CE
UL (with file number)
CSA (or ULc)
CE
WEEE
TUV/SEMKO/UL/etc.
MIC (Korea) (with certification number)
BSMI (Taiwan) (with applicant code number)
VCCI (Japan)
C-Tick (Australia)
FCC
China RoHS
HF (Halogen Free)
EuP

**Table 5-8: SanDisk SSD U100 Regulation Standards**

## 6. Reliability Characteristics

### 6.1 Error Rate

Non-recoverable error rate is 1 error per  $10^{16}$  bits read.

### 6.2 MTTF (Mean-Time-To-Failure)

The reliability figure of merit most often used for electronic equipment is Mean-Time-To-Failure (MTTF). SanDisk estimates MTTF using a prediction methodology based in accordance with the Telcordia Special Report SR-332. The prediction is based on a Parts Stress Analysis.

Quality levels were defined as industrial grade (I) for all of the components. The detailed prediction for the system was performed at a temperature of 25°C in a GB environment.

The following table summarizes the estimated MTTF results for each capacity.

Capacity	Condition	MTTF (Hours)	Estimated FITs
8GB	Telcordia SR-332, GB, 25°C	TBD	TBD
16GB	Telcordia SR-332, GB, 25°C	TBD	TBD
32GB	Telcordia SR-332, GB, 25°C	TBD	TBD
64GB	Telcordia SR-332, GB, 25°C	TBD	TBD
128GB	Telcordia SR-332, GB, 25°C	TBD	TBD
256GB	Telcordia SR-332, GB, 25°C	TBD	TBD

**Table 6-1: SanDisk SSD U100 MTTF**



## 7. Interface

### 7.1 Supported Standards

The SSD U100 complies with the following standards:

- SATA 6Gb/s, Revision 3.0
- ATA Command Set ACS-2

### 7.2 Pin Assignments – Half-Slim SATA connector

#### SIGNAL Connector Pinout:

Pin #	Signal Name	Description
S1	GND	2nd mate
S2	A+	RxP
S3	A-	RxM
S4	GND	2nd mate
S5	B-	TxM
S6	B+	TxP
S7	GND	2nd mate

#### POWER Connector Pinout:

Pin #	Signal Name	Description
P1	V33	Not connected
P2	V33	Not connected
P3	V33	Not connected
P4	GND	1st mate
P5	GND	2nd mate
P6	GND	2nd mate
P7	V5	5V power input, pre-charge, 2nd mate
P8	V5	5V power input
P9	V5	5V power input
P10	GND	2nd mate
P11	DAS/RSS	Device Activity Signal
P12	GND	1st mate
P13	V12	Not connected
P14	V12	Not connected
P15	V12	Not connected

**Table 7-1: Standard SATA Connector Pin Assignment**

## 7.3 Pin Assignments - mSATA

Pin #	Assignment	Description	Pin #	Assignment	Description
1		No Connect	2	+3.3V	3.3V Source
3		No Connect	4	GND	Return Current Path
5		No Connect	6		No Connect
7		No Connect	8		No Connect
9	GND	Return Current Path	10		No Connect
11		No Connect	12		No Connect
13		No Connect	14		No Connect
15	GND	Return Current Path	16		No Connect
17		No Connect	18	GND	Return Current Path
19		No Connect	20		No Connect
21	GND	Return Current Path	22		No Connect
23	+B - TXP	Transmitter Differential Signal Pair	24	+3.3V	3.3V Source
25	-B - TXN	Transmitter Differential Signal Pair	26	GND	Return Current Path
27	GND	Return Current Path	28		No Connect
29	GND	Return Current Path	30		No Connect
31	-A - RXN	Receiver Differential Signal Pair	32		No Connect
33	+A - RXP	Receiver Differential Signal Pair	34	GND	Return Current Path
35	GND	Return Current Path	36		No Connect
37	GND	Return Current Path	38		No Connect
39	+3.3V	3.3V Source	40	GND	Return Current Path
41	+3.3V	3.3V Source	42	PWR_LOSS	Power Loss Indicator
43		No Connect	44	DEVSLP	SATA PHY Power Control
45		No Connect	46		No Connect
47		No Connect	48		No Connect
49	DA/DSS	Device Activity	50	GND	Return Current Path
51	Presence Detection	Pulled low by the device	52	+3.3V	3.3V Source

**Table 7-2: mSATA Connector Pin Assignment**

## 8. Supported ATA Commands

The following table defines some of the common ATA commands supported by the SSD U100. Specifics of each ATA command's operation can be found in the ATA/ATAPI Command Set ACS-2 document.

Command Name		ATA8	Code
Check Power Mode		M	E5h
Data Set Management		O	06h
	Trim		01h
Device Configuration Overlay		O	B1h
<b>DCO sub-commands:</b>	Restore		C0h
	Freeze Lock		C1h
	Identify		C2h
	Set		C3h
	Identify DMA		C4h
	Set DMA		C5h
Download Microcode		O	92h
	Download (with offsets) and save microcode.		03h
	Download (without offsets) and save microcode.		07h
Execute Device Diagnostic		M	90h
Flush Cache		M	E7h
Flush Cache Ext		O	EAh
Identify Device		M	Ech
Idle		M	E3h
Idle Immediate		M	E1h
Initialize Drive Parameters		Obs	91h
NOP		O	00h
Read Buffer		O	E4h
Read DMA		M	C8h
Read DMA Ext		O	25h
Read DMA w/o Retry		Obs	C9h
Read FPDMA Queued		O	60h
Read Log Ext		O	2Fh
Read Multiple		M	C4h
Read Multiple Ext		O	29h
Read Native Max Address		O	F8h
Read Native Max Addr Ext		O	27h

Read Sectors		M	20h	
Read Sectors Ext		O	24h	
Read Sectors w/o Retry		Obs	21h	
Read Verify Sectors		M	40h	
Read Verify Sectors Ext		O	42h	
Read Verify Sectors w/o Retry		Obs	41h	
Recalibrate		Obs	1Xh	
Sanitize		O	B4h	
<b>Sanitize sub-commands:</b>	Sanitize Status Ext		00h	
	Block Erase Ext		12h	
	Sanitize Freeze Lock Ext		20h	
Security Disable Password		O	F6h	
Security Erase Prepare		O	F3h	
Security Erase Unit		O	F4h	
Security Freeze Lock		O	F5h	
Security Set Password		O	F1h	
Security Unlock		O	F2h	
Seek		Obs	7Xh	
Set Features		M	EFh	
<b>Set Features sub-commands:</b>	Enable write cache		02h	
	Set transfer mode		03h	
	Enable Advanced Power Management (APM)		05h	
	Enable SATA features		10h	
		DMA Setup FIS Auto-Activate Optimization		02h
		Device-Initiated Interface Power Management		03h
		Software Setting Preservation		06h
	Disable read look-ahead		55h	
	Disable reverting to power-on defaults		66h	
	Disable write cache		82h	
	Disable Advanced Power Management (APM)		85h	
	Disable SATA features		90h	
		DMA Setup FIS Auto-Activate Optimization		02h
		Device-Initiated Interface Power Management		03h
		Software Setting Preservation		06h
	Enable read look-ahead		AAh	
	Enable reverting to power-on defaults		CCh	

Set Max Address		O	F9h	
<b>Security Extension sub-commands:</b>	Set Max Set Password		01h	
	Set Max Lock		02h	
	Set Max Unlock		03h	
	Set Max Freeze Lock		04h	
	Set Max Set Password DMA		05h	
	Set Max Unlock DMA		06h	
Set Max Address Ext		O	37h	
Set Multiple Mode		M	C6h	
Sleep		M	E6h	
Smart		O	B0h	
<b>Smart sub-commands:</b>	Read Attribute Values (Read Data)		D0h	
	Read Attribute Thresholds		Obs D1h	
	Enable/Disable Attribute Autosave		O D2h	
	Save Attribute Values		D3h	
	<b>Execute Offline Immediate:</b>	LBA Low	D4h	
		Execute off-line immediate routine		00h
		Execute Short Self-test routine (Offline)		01h
		Execute Extended Self-test routine (Offline)		02h
		Abort off-line immediate routine		7Fh
		Execute Short Self-test routine (Captive)		81h
		Execute Extended Self-test routine (Captive)		82h
	Read Log		D5h	
	Write Log		D6h	
	Enable Operations		D8h	
	Disable Operations		D9h	
	Read Status		DAh	
	Disable Auto Offline		Obs DBh	
Standby		M E2h		
Standby Immediate		M E0h		
Write Buffer		O E8h		
Write DMA		M CAh		
Write DMA Ext		O 35h		
Write DMA w/o Retry		Obs CBh		
Write FPDMA Queued		O 61h		

Write Log Ext	O	3Fh
Write Multiple	M	C5h
Write Multiple Ext	O	39h
Write Sectors	M	30h
Write Sectors Ext	O	34h
Write Sectors w/o Retry	Obs	31h
Write Uncorrectable Ext	O	45h
Pseudo-UECC with Logging		55h

M = Mandatory. O = Optional. Obs = Obsolete, But Supported

**Table 8-1: Supported ATA Commands**

## 8.1 Identify Data

The following table defines the specifics of the Identify Data returned by the SSD U100.

Word Address	Default Value	Total Bytes	Data Field Type Information
0	0040h	2	ATA General configuration: bit-significant information
1	3FFFh	2	ATA Default number of cylinders (depends on capacity)
2	C837h	2	Reserved
3	0010h	2	Default number of heads
4-5	0000h	4	Obsolete
6	003Fh	2	Default number of sectors per track
7-9	0000h	6	Obsolete
10-19	ASCII	20	Serial number in ASCII (left-justified)
20-22	0000h	6	Obsolete
23-26	MJ.MN.XX	8	Firmware revision in ASCII
27-46	SanDisk SSD U100 XXXGB	40	Model number in ASCII (left-justified) for SSD U100 MLC
47	8001h	2	Maximum No. of sectors in Read/Write Multiple command
48	0000h	2	Reserved
49	2F00h	2	LBA and MWDMA modes supported
50	4000h	2	Capabilities
51	0200h	2	PIO data transfer cycle timing mode
52	0000h	2	Obsolete
53	0007h	2	Field validity
54	XXXXh	2	Current number of cylinders (depends on capacity)
55	0010h	2	Current number of heads
56	003Fh	2	Current sectors per track
57-58	XXXXh	4	Current capacity in sectors (LBAs)
59	9101h	2	Sanitize options and Multiple sector setting (Multiple = 1)
60-61	XXXXh	4	Total number of sectors addressable in LBA Mode
62	0000h	2	Obsolete
63	0007h	2	Bits:15-8: Multiword DMA mode active Bits: 0-7: Multiword DMA modes supported
64	0003h	2	Advanced PIO modes supported
65	0078h	2	Minimum multiword DMA transfer cycle time per word (ns)
66	0078h	2	Recommended multiword DMA transfer cycle time per word in ns
67	0078h	2	Minimum PIO transfer without flow control

Word Address	Default Value	Total Bytes	Data Field Type Information
68	0078h	2	Minimum PIO transfer with IORDY flow control
69	5200h	2	ACS2 Additional Supported – Deterministic Trim
70-74	0000h	10	Reserved
75	001Fh	2	Queue Depth
76	050Eh	2	SATA capabilities
77	000Xh	2	SATA Additional capabilities (0002=1.5Gb/s, 0004=3Gb/s, 0006=6Gb/s)
78	004Ch	2	SATA Features Supported
79	0040h	2	SATA Features Enabled
80	03F0h	2	Major Version number
81	0110h	2	Minor Version number
82	746Bh	2	Command set supported
83	7D01h	2	Command sets supported
84	4123h	2	Command set/feature supported extension
85	7469h	2	Command set/feature enabled
86	BD01h	2	Command set/feature enabled
87	4123h	2	Command set/feature default
88	007Fh	2	Ultra DMA Mode supported and selected
89	0001h	2	Time required for security erase-unit completion (all capacities complete < 2 minutes)
90	0001h	2	Time required for Enhanced security erase completion (all capacities complete < 2 minutes)
91	0000h	2	Current advanced power management value
92	FFFEh	2	Master Password Identifier
93	0000h	2	Hardware Reset Result
94	0000h	2	Current AAM Value
95	0000h	2	Stream Min Request Size
96	0000h	2	Streaming Transfer Time-DMA
97	0000h	2	Streaming Access Latency
98-99	0000h	4	Streaming Performance Granularity
100-103	XXXXh	8	48-bit # of LBA's
104	0000h	2	Streaming Transfer Time-PIO
105	0008h	2	Max # 512-byte Blocks in LBA Range Entries
106	4000h	2	Physical Sector Size/Logical
107	0000h	2	Inter-Seek Delay for ISO7779



Word Address	Default Value	Total Bytes	Data Field Type Information
108-111	5001B440XXXXXXXXh	8	WWN
112-115	0000h	8	Reserved
116	0000h	2	Reserved for TLC
117-118	0000h	4	Logical Sector Size
119	4014h	2	Command/Feature Sets Supported #4
120	4014h	2	Command/Feature Sets Enabled
121-126	0000h	12	Reserved
127	0000h	2	Obsolete
128	0021h	2	Security Status
129-159	0000h	62	Reserved vendor-unique bytes
160-167	0000h	16	Reserved
168	0004h	2	Device Nominal Form Factor
169	0001h	2	ATA8-ACS2 Data Set Management Support
170-175	0000h	12	Reserved
176-205	0000h	60	Current Media Serial Number (not supported)
206	0000h	2	SCT Command Transport
207-208	0000h	4	Reserved for CE-ATA
209	4000h	2	Alignment-Logical within Physical Block
210-211	0000h	4	Wr/Rd/Vfy Sector Count Mode 3
212-213	0000h	4	Wr/Rd/Vfy Sector Count Mode 2
214	0000h	2	NV Cache Capabilities
215-216	0000h	4	NV Cache Size in Logical Blocks
217	0001h	2	Nominal Media Rotation Rate
218	0000h	2	Reserved
219	0000h	2	NV Cache Options
220	0000h	2	Wr/Rd/Vfy Feature Set-Current Mode
221	0000h	2	Reserved
222	1031h	2	Transport Major Version Number
223	0000h	2	Transport Minor Version Number
224-233	0000h	20	Reserved for CE-ATA

Word Address	Default Value	Total Bytes	Data Field Type Information
234	0008h	2	Min Sector Count for Download Microcode Mode 3
235	0010h	2	Max Sector Count for Download Microcode Mode 3
236-254	0000h	38	Reserved for CE-ATA
255	XXXXh	2	Integrity Word-Checksum

**Table 8-2: Identify Data Values**

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## 8.2 Log Pages

The following table defines the list of supported Log Pages accessible through SMART Write Log, SMART Read Log, Read Log Ext and Write Log Ext commands.

Log Address	Total Pages	Log Address Description
0x00	1	General Purpose Log Directory
0x01	1	Summary SMART Error Log
0x03	'n'	Ext Comprehensive SMART Error Log
0x04	'n'	Device Statistics Log – SSD Statistics
0x06	1	SMART Self-Test Log
0x10	1	NCQ Error Log
0x11	1	SATA PHY Event Counters Log
80h-9Fh	16	Host Vendor-specific Logs

**Table 8-3: Supported SMART Log Pages**

## 9. Ordering information

### 9.1 SanDisk SSD U100 MLC Products Ordering Information

SDSA5XK-CCCG-YYYY	
SD	SanDisk
SA	SATA
5	Generation: 4
X	Form factor: A – Half 1.8" form factor, Standard SATA connector D – mSATA form factor F – mSATA Mini form factor G – 2.5" 7mm cased form factor
K	Flash Memory used: 24nm 64Gb MLC ABL
CCC	Capacity: 008 016 032 064 128 256
G	Units: GB
YYYY	Customer code reference

**Table 9-1: SSD U100 MLC Ordering Information**

Refer to the examples below as reference for ordering SKUs.

SKU #	Details
SDSA5AK-032G-YYYY	32GB SSD U100 MLC in Half 1.8" form factor, Standard SATA connector
SDSA5DK-064G-YYYY	64GB SSD U100 MLC in mSATA form factor
SDSA5FK-128G-YYYY	128 GB SSD U100 MLC in mSATA Mini form factor

**Table 9-2: Examples of decoded SKU for SSD U100 MLC Products**

## 10. Contact information

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### Korea

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