

Amtron Technology, Inc.

Industrial Grade mSATA SSD AE Series Product Datasheet

V1.5

Table of Contents

| | | |
|-----------|--|-----------|
| 1. | Introduction | 4 |
| 1.1. | General Description | 4 |
| 1.2. | Product Features..... | 4 |
| 1.3. | Product Overview | 5 |
| 1.4. | Block Diagram | 6 |
| 2. | Product Specifications..... | 7 |
| 2.1. | Product Dimension..... | 7 |
| 2.2. | Capacity and Performance | 8 |
| 2.3. | Device Capacity | 9 |
| 2.4. | Performance | 10 |
| 2.5. | TBW (TeraBytes Written) and DWPD (Drive Write Per Day) | 11 |
| 2.6. | POR/SPOR Standby Ready Time | 12 |
| 2.7. | TCG Opal 2.0..... | 12 |
| 2.8. | UBER..... | 13 |
| 2.9. | MTBF..... | 13 |
| 2.10. | Compliance | 14 |
| 3. | Environmental Specifications | 15 |
| 3.1. | Environmental Conditions | 15 |
| 3.1.1. | Temperature Specification | 15 |
| 3.1.2. | High Temperature Test Condition | 15 |
| 3.1.3. | Low Temperature Test Condition..... | 15 |
| 3.1.4. | High Humidity Test Condition..... | 16 |
| 3.1.5. | Temperature Cycle Test..... | 16 |
| 3.1.6. | Mechanical Specification | 16 |
| 3.1.7. | Electrostatic Discharge (ESD) | 16 |
| 3.1.8. | EMI Compliance | 17 |
| 3.1.9. | Safety Certification | 17 |
| 3.2. | Package Qualification | 18 |
| 3.2.1. | High Temperature Storage Life Test (HTSL) | 18 |
| 3.2.2. | Solderability Test | 18 |
| 3.2.3. | Pre-condition Test | 18 |
| 3.2.4. | High Acceleration Stress Test (HAST/unbias)..... | 18 |

| | | |
|-----------|--|-----------|
| 3.2.5. | Temperature Cycling Test (TCT) | 18 |
| 3.3. | Certification | 19 |
| 4. | Electrical Specifications | 20 |
| 4.1. | Supply Voltage..... | 20 |
| 4.2. | Power Consumption..... | 20 |
| 5. | Interface..... | 21 |
| 5.1. | Pin Assignment and Descriptions | 21 |
| 6. | Supported Commands..... | 23 |
| 6.1. | ATA Command List..... | 23 |
| 6.2. | Identify Device Data | 25 |
| 6.3. | S.M.A.R.T. Attributes | 30 |
| 7. | Acronym | 31 |
| 8. | Part Number Decoder..... | 32 |

1. INTRODUCTION



1.1. General Description

Amtron industrial grade AE series mSATA solid-state drive (SSD) delivers all the advantages of flash disk technology with serial ATA I/II/III interface. The device is fully compliant with the standard mSATA form factor, known as JEDEC MO-300 standard.

Amtron AE series mSATA SSDs are available in a wide range from 16GB up to 2TB. It can reach high performance of up to 550MB/s read and 510MB/s write speed.

1.2. Product Features

- 3D TLC NAND flash
- Compliant with SATA Specification 3.2
- High speed:
Read: 550 MB/s max., Write: 510 MB/s max.
- Endure severe thermal and dynamic environments
 - Operation Temperature (Wide grade): -40°C to 85°C
 - Shock: 1500g
 - Vibration: 20g
- Very low power consumption
- MTBF: >2,500,000 hours
- Support S.M.A.R.T. Command
- Endure severe thermal and dynamic environments
 - Operation Temperature (Wide grade): -40°C to 85°C
 - Shock: 1500g
 - Vibration: 20g
- Compliant
 - CE including RoHS
 - FCC
 - ISO
- Controlled Bill of Materials (BOM)

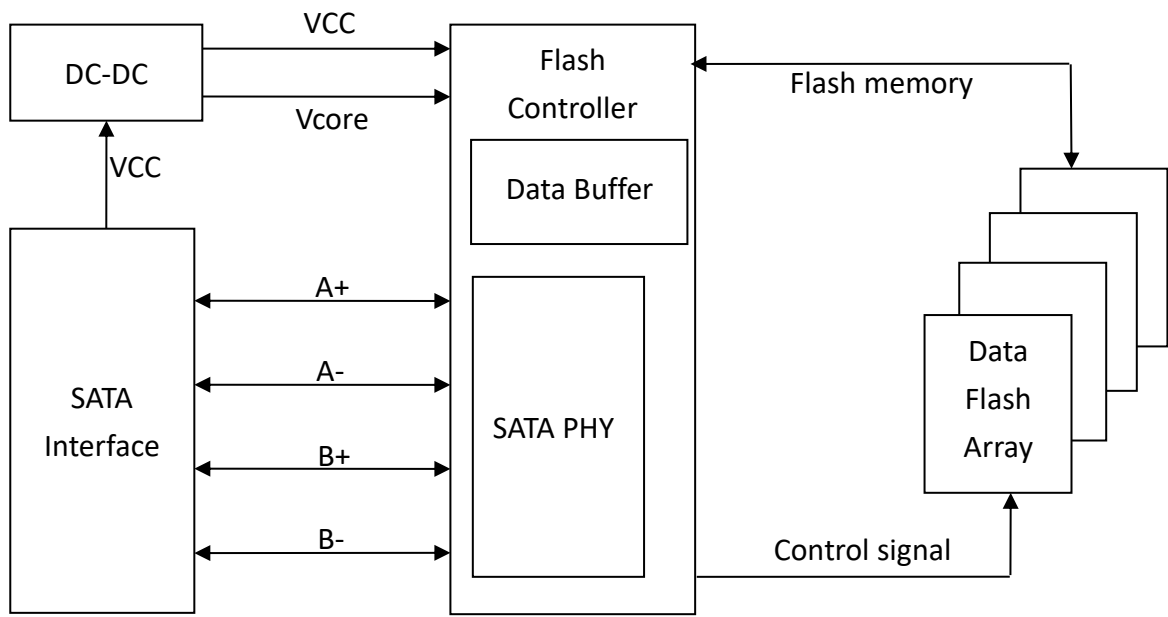
1.3. Product Overview

- **SATA Interface**
 - SATA Revision 3.2
 - SATA 1.5Gbps, 3Gbps, and 6Gbps interface
- **Flash Interface**
 - Flash Type: 3D TLC
- **Capacity**
 - TLC: 64GB up to 2TB
 - pSLC: 16GB up to 512GB
- **Performance**
 - Read up to 550 MB/s
 - Write up to 510 MB/s
- **Power Consumption ²**
 - Active mode: < 1,750 mW
 - Idle mode: < 210 mW
- **Low Power Management**
 - DEVSLP Mode (optional)
- **ECC**
 - LDPC / RAID ECC
 - Low density parity check code (>120bit/Kbytes)
- **EMI**
 - EN55032, CISPR 32 (CE)
 - ANSI C63.4 (FCC)
 - CNS 13438 (BSMI)
 - VCCI-CISPR 32 (VCCI)
- **Reliability**
 - MTBF ¹ > 2,500,000 hours
 - UBER < 1 sector per 10¹⁶ bits
 - TBW ³:
 - TLC: up to 3,000 TB
 - pSLC: up to 13,000 TB
- **Advanced Flash Management**
 - Advanced Wear Leveling
 - Bad Block Management
 - TRIM
 - SMART
 - Over-Provision
 - SmartZIP™
- **Temperature Range ⁴**
 - Operation (Standard): 0°C to 70°C
 - Operation (Wide): -40°C to 85°C
 - Storage: -40°C to 85°C
- **Safety Certification**
 - ISO 9001
 - ISO 14001
 - ISO 45001
 - ISO 27001
- **Compliant**
 - RoHS
 - CE & FCC

Notes:

1. MTBF, an acronym for Mean Time between Failures, is a measure of a device's reliability. Please refer Section 2.8 "MTBF" for details.
2. Please refer to Section 4.2 "Error! Reference source not found." for details.
3. Please refer to "2.5 TBW & DWPD" for details.
4. The operation temperature is the case temperature (T_c), in which can be detected via SMART.

1.4. Block Diagram

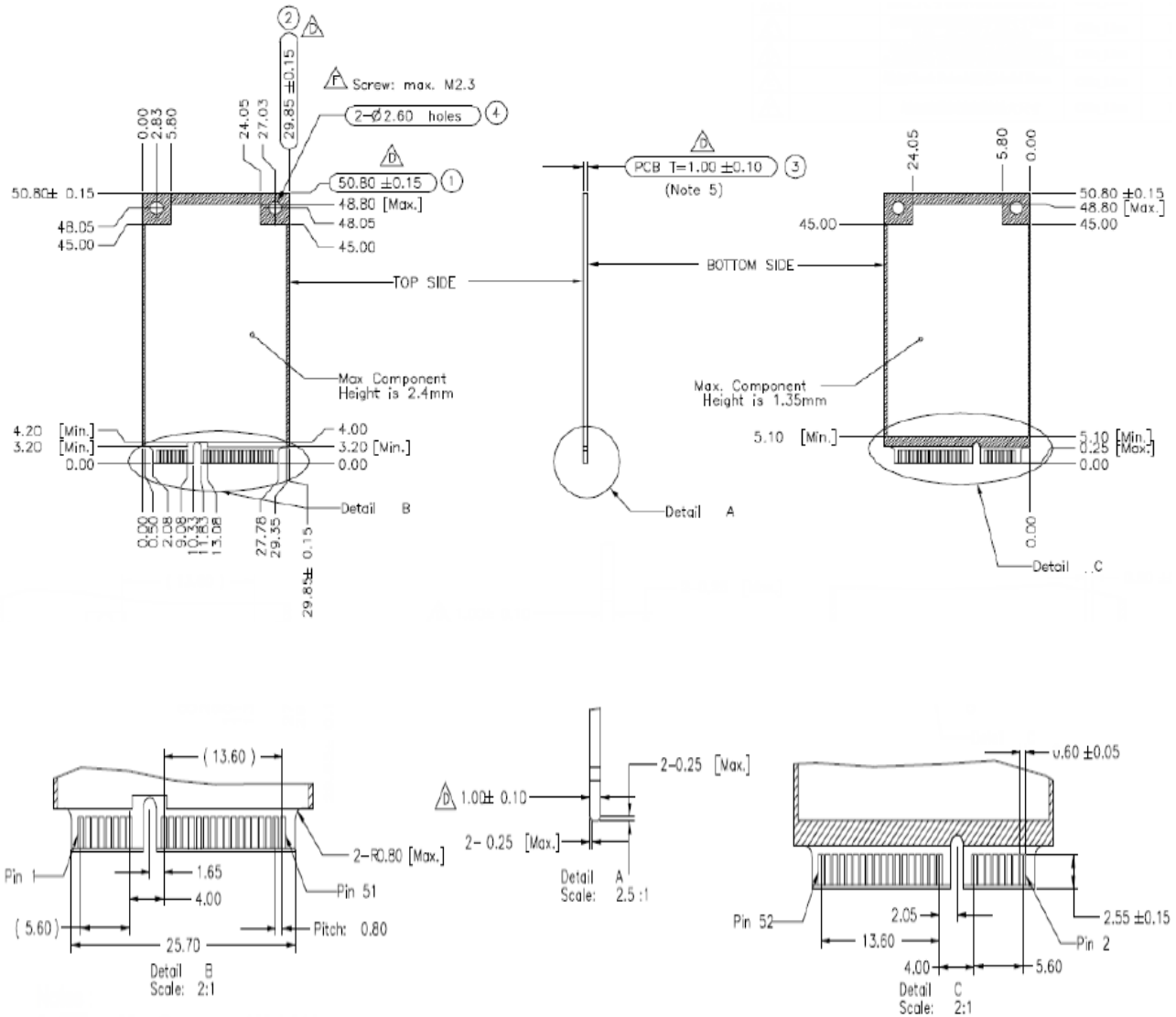


mSATA SSD Block Diagram

2. PRODUCT SPECIFICATIONS

2.1. Product Dimension

Dimension: 50.8mm (L) x 29.85mm (W) x 4.75mm (H)



Notes :

1. = Max Component Height is
2. = No Component
3. = No Component / Signal Vias / Signal Copper/Print
4. General Tolerance : ±0.1mm
5. Card Thickness applies across tab and includes plating and/or metalization
6. Check Point: ① ~ ④
7. Screw Max. Size M2.3

| COMMON TOLERANCE | | | | Finish | . | |
|------------------|-------|-------|-------|----------|---------------|------------|
| DIM | CLASS | A | (B) | Material | . | |
| L ≤ 3 | | ±0.05 | ±0.10 | ±0.20 | Scale : 1 / 1 | Unit : mm |
| 3 < L ≤ 6 | | ±0.05 | ±0.10 | ±0.20 | Drawing by | Otto_Lian |
| 6 < L ≤ 16 | | ±0.10 | ±0.15 | ±0.30 | Approval | Tom |
| 16 < L ≤ 30 | | ±0.10 | ±0.15 | ±0.30 | Date | 2014/11/03 |
| 30 < L ≤ 120 | | ±0.15 | ±0.20 | ±0.50 | Size : A4 | Rev:F |
| 120 < L ≤ 315 | | ±0.20 | ±0.50 | ±0.80 | | Page 1/1 |

Unit: mm

2.2. Capacity and Performance

- **Capacity**
 - TLC: From 64GB up to 2TB
 - pSLC: From 32GB up to 256GB
- **Electrical/Physical Interface**
 - SATA Interface
 - ◆ Compatible with SATA 1.5Gbps, 3Gbps and 6Gbps interface
 - ◆ AC coupling for transmitter and receiver
 - ◆ Self-calibrated and embedded termination resistor at transmitter
 - ◆ Support expanded register for SATA protocol 48 bits addressing mode
 - ◆ Support power management
- **Supported NAND Flash**
 - Kioxia BiCS5 3D-TLC, Toggle 3.0
- **ECC Scheme**
 - Applies the LDPC (Low Density Parity Check) of ECC algorithm
- **Operation Voltage Supply**
 - $3.3V \pm 5\%$
- **Power Saving Implementation**
 - Idle mode
 - Partial mode
 - Slumber mode
- **LBA Range**
 - IDEMA standard
- **UART / GPIO function**
- **Support SMART and TRIM commands**
- **Certification & Compliance**
 - RoHS
 - WHQL

2.3. Device Capacity

| Capacity | IDEMA Standard | | User Data Size |
|----------|---------------------|---------------------|-----------------------------|
| | 512Bytes/Sector | 4KBytes/Sector | |
| | Total Sectors (LBA) | Total Sectors (LBA) | |
| 32GB | 62,533,296 | 7,816,662 | Depended on file management |
| 60GB | 117,231,408 | 14,653,926 | |
| 64GB | 125,045,424 | 15,630,678 | |
| 120GB | 234,441,648 | 29,305,206 | |
| 128GB | 250,069,680 | 31,258,710 | |
| 240GB | 468,862,128 | 58,607,766 | |
| 256GB | 500,118,192 | 62,514,774 | |
| 480GB | 937,703,088 | 117,212,886 | |
| 512GB | 1,000,215,216 | 125,026,902 | |
| 960GB | 1,875,385,008 | 234,423,126 | |
| 1TB | 2,000,409,264 | 250,051,158 | |
| 1920GB | 3,750,748,848 | 468,843,606 | |
| 2TB | 4,000,797,360 | 500,099,670 | |

Notes:

1. 1 Gigabyte (GB) is equal to 1,000,000,000 Bytes; 1 sector is equal to 512 Bytes.
2. The calculation is following IDEMA Standard.
3. The total actual user data size of the SSD may be less than device capacity due to SSD format, SSD partition, operating system.
EX: OS shows 223.57GB (NTFS) with 240GB SSD.

2.4. Performance

| Capacity | Flash Structure | Sequential (MB/s) | | 4K Random (IOPS) | |
|-------------|----------------------------|-------------------|-------|------------------|--------|
| | | Read | Write | Read | Write |
| 60GB/64GB | 64GB x 1, BiCS5 TLC, BGA | 380 | 265 | 36,500 | 57,500 |
| 120GB/128GB | 64GB x 2, BiCS5 TLC, BGA | 550 | 450 | 44,500 | 78,500 |
| 240GB/256GB | 128GB x 2, BiCS5 TLC, BGA | 550 | 485 | 75,500 | 82,500 |
| 480GB/512GB | 256GB x 2, BiCS5 TLC, BGA | 550 | 500 | 91,500 | 83,500 |
| 960GB/1TB | 256GB x 4, BiCS5 TLC, BGA | 550 | 510 | 96,000 | 85,500 |
| 1920GB/2TB | 512GB x 4, BiCS5 TLC, BGA | 550 | 510 | 93,500 | 85,000 |
| 16GB | 64GB x 1, BiCS5 pSLC, BGA | 420 | 270 | 36,000 | 59,000 |
| 32GB | 64GB x 2, BiCS5 pSLC, BGA | 540 | 465 | 49,500 | 78,500 |
| 64GB | 128GB x 2, BiCS5 pSLC, BGA | 550 | 485 | 85,500 | 84,500 |
| 128GB | 256GB x 2, BiCS5 pSLC, BGA | 550 | 500 | 96,000 | 86,000 |
| 256GB | 256GB x 4, BiCS5 pSLC, BGA | 550 | 510 | 97,500 | 87,500 |
| 512GB | 512GB x 4, BiCS5 pSLC, BGA | 550 | 510 | 97,000 | 86,500 |

Notes:

- Performance may differ according to flash configuration and platform.
- The table above is for reference only.
- Performance is measured with the follow conditions
 - CrystalDiskMark 6.0, 1GB range, QD32T1 for sequential
 - IOmeter, QD32T8, 1GB range for 4K Random
 - Windows 10 professional (x64), Version 1809
- Measurement environment: Room temperature: 20~25°C, humidity: 40~60%RH, DC+3.3V condition.

2.5. TBW (TeraBytes Written) and DDPD (Drive Write Per Day)

| Capacity | Flash Type | TBW | DDPD |
|-------------|------------|--------|-------|
| 60GB/64GB | TLC | 65 | 0.92 |
| 120GB/128GB | TLC | 90 | 0.64 |
| 240GB/256GB | TLC | 220 | 0.78 |
| 480GB/512GB | TLC | 540 | 0.96 |
| 960GB/1TB | TLC | 1,200 | 1.07 |
| 1920GB/2TB | TLC | 3,000 | 1.29 |
| 16GB | pSLC | 480 | 28.05 |
| 32GB | pSLC | 1,000 | 28.53 |
| 64GB | pSLC | 3,000 | 42.81 |
| 128GB | pSLC | 6,400 | 45.66 |
| 256GB | pSLC | 13,000 | 46.37 |
| 512GB | pSLC | 25,800 | 46.01 |

Notes:

1. TBW is measured by JEDEC 219A Client workload.
2. TBW may differ according to flash configuration, platform and data written.
3. DDPD is calculated based on 3-year lifetime.
4. DDPD (Drive Write Per Day) = $TBW / [365 \times \text{years} \times \text{User Capacity(TB)}]$
5. The endurance of SSD could be estimated based on user behavior, NAND endurance cycles, and write amplification factor. It is not guaranteed by flash vendor.

2.6. POR/SPOR Standby Ready Time

- **POR/SPOR Ready Time**

| Capacity | POR ready time | | | | SPOR ready time | | | |
|-------------|----------------|------|----------|------|-----------------|-------|----------|-------|
| | Power On | | Identify | | Power On | | Identify | |
| | Typ. | Max. | Typ. | Max. | Typ. | Max. | Typ. | Max. |
| 60GB/64GB | 300 | 500 | 350 | 550 | 5,000 | 9,000 | 5,100 | 9,100 |
| 120GB/128GB | | | | | 5,000 | | 5,100 | |
| 240GB/256GB | | | | | 8,000 | | 8,100 | |
| 480GB/512GB | | | | | 8,000 | | 8,100 | |
| 960GB/1TB | | | | | 8,000 | | 8,100 | |
| 1920GB/2TB | | | | | 8,000 | | 8,100 | |
| 16GB | | | | | 5,000 | | 5,100 | |
| 32GB | | | | | 5,000 | | 5,100 | |
| 64GB | | | | | 8,000 | | 8,100 | |
| 128GB | | | | | 8,000 | | 8,100 | |
| 256GB | | | | | 8,000 | | 8,100 | |
| 512GB | | | | | 8,000 | | 8,100 | |

Unit: ms

Notes:

1. POR/SPOR stands for following:
 - (a) POR (Power On Ready): The ready time variation depends on data recover size.
 - (b) SPOR (Power On Ready after Sudden Power Off): The ready time variation depends on data recover size.
2. Power On/Identify ready time stands for following:
 - (a) Power on Time: From Power On to SSD response after drive ready.
 - (b) Identify Time: Power on Time + host issue Identify Command, response Ack.
3. Measurement environment: Room temperature: 20~25°C, humidity: 40~60%RH, DC+3.3V condition.

2.7. TCG Opal 2.0

The Opal specification is a set of specifications for self-encrypting drives published by the Trusted Computing Group (TCG), a non-profit organization that develops, defines, and promotes standards and specifications for secure computing. The Opal Security Subsystem Class (SSC) 2.0 defines the details of data management in storage devices and the classes authority for data access, and secures data from theft and tampering by unauthorized persons who are able to gain access to the storage device or host system.

TCG Opal 2.0 Main Features:

- AES 256-bit Hardware Self Encryption
- Deploy Storage Device & Take Ownership:

The Storage Device is integrated into its target system and ownership transferred by setting or changing the Storage Device’s owner credential.

- Activate or Enroll Storage Device:

LBA ranges are configured and data encryption and access control credentials (re)generated and/or set on the Storage Device. Access control is configured for LBA range unlocking.

- Lock & Unlock Storage Device:

Unlocking of one or more LBA ranges by the host and locking of those ranges under host control via either an explicit lock or implicit lock triggered by a reset event. MBR shadowing provides a mechanism to boot into a secure pre-boot authentication environment to handle device unlocking.

- Repurpose & End-of-Life:

Erasure of data within one or more.

- Physical Presence SID (PSID):

PSID is defined by TCG OPAL as a 32-character string and the purpose is to revert SSD back to its manufacturing setting when the drive is still OPAL-activated. PSID code can be printed on a SSD label when an OPAL-activated SSD supports PSID revert feature.

2.8. UBER

| Capacity | UBER |
|------------|---|
| 32GB ~ 2TB | < 1 sector per 10 ¹⁶ bits read |

Notes:

1. UBER (Uncorrectable Bit Error Rates) means the uncorrectable error per bits read.
2. UBER = FER (fail rate) / Data Size (user data bit).
3. FER = uncorrectable ECC frame number / total ECC frame number.
4. The LDPC capability > 120bit/KB.

2.9. MTBF

MTBF, an acronym for Mean Time between Failures, is a measure of reliability of a device. Its value represents the average time between a repair and the next failure. The unit of MTBF is in hours. The higher the MTBF value, the higher the reliability of the device.

The MTBF result is based on simulation software (Relex 7.3). Please note that a lower MTBF would be expected for higher capacity drives, and the following Table list the lowest MTBF for all capacities.

| Capacity | MTBF |
|------------|---------------------|
| 32GB ~ 2TB | > 2.5 million hours |

2.10. Compliance

- SATA III (SATA Rev. 3.2)
- Up to ATA/ATAPI-8 (Including S.M.A.R.T)

3. ENVIRONMENTAL SPECIFICATIONS



3.1. Environmental Conditions

3.1.1. Temperature Specification

| | Mode | Min. | Max. | Unit |
|----------------------------|----------------------|------|------|------|
| Temperature Ranges | Operation (Standard) | 0 | 70 | °C |
| | Operation (Wide) | -40 | 85 | °C |
| | Storage | -40 | 85 | °C |
| Humidity (non- condensing) | Operation | 5 | 90 | % |
| | Storage | 5 | 93 | % |
| Temperature Cycle Test | Operation (Standard) | 0 | 70 | °C |
| | Operation (Wide) | -40 | 85 | °C |
| | Storage | -40 | 85 | °C |

Notes:

1. The operation temperature means the case temperature, in which can be detected via the S.M.A.R.T. Airflow is suggested and it will allow device to be operated at appropriate temperature for each component during heavy workloads environment.

3.1.2. High Temperature Test Condition

| | | Temperature | Humidity | Test Time |
|-----------|----------------------|-------------|----------|-----------|
| Operation | Standard Temperature | 70°C | 0% RH | 72 hours |
| | Wide Temperature | 85°C | | |
| Storage | Standard Temperature | 85°C | 0% RH | 168 hours |
| | Wide Temperature | | | |

Test Reference: IEC 60068-2-2

3.1.3. Low Temperature Test Condition

| | | Temperature | Humidity | Test Time |
|-----------|----------------------|-------------|----------|-----------|
| Operation | Standard Temperature | 0°C | 0% RH | 72 hours |
| | Wide Temperature | -40°C | | |
| Storage | Standard Temperature | -40°C | 0% RH | 168 hours |
| | Wide Temperature | | | |

Test Reference: IEC 60068-2-1

3.1.4. High Humidity Test Condition

| | | Temperature | Humidity | Test Time |
|-----------|----------------------|-------------|----------|-----------|
| Operation | Standard Temperature | 40°C | 90% RH | 72 hours |
| | Wide Temperature | 55°C | | |
| Storage | Standard Temperature | 40°C | 93% RH | 96 hours |
| | Wide Temperature | 55°C | | |

Test Reference: IEC 60068-2-3

3.1.5. Temperature Cycle Test

| | | Temperature | Humidity | Test Time |
|-----------|----------------------|-------------|----------|-----------|
| Operation | Standard Temperature | 0°C | 30 min | 20 Cycles |
| | | 70°C | | |
| | Wide Temperature | -40°C | 30 min | 20 Cycles |
| | | 85°C | | |
| Storage | Standard Temperature | -40°C | 30 min | 30 Cycles |
| | | 85°C | | |
| | Wide Temperature | -40°C | 30 min | 50 Cycles |
| | | 85°C | | |

Test Reference: IEC 60068-2-14

3.1.6. Mechanical Specification

| Items | | | Condition |
|------------------|-----------------|------------------------|---------------------------------------|
| Shock | Non-operational | Acceleration Force | 1500G 0-p with half sine wave (0.5ms) |
| Vibration | Non-operational | Frequency/Displacement | 20Hz~80Hz/1.52mm |
| | | Frequency/Acceleration | 80Hz~2000Hz/20G p-p with sine wave |
| Drop | Non-operational | Height of Drop | 80cm free fall |
| | | Number of Drop | 6 face of each unit |
| | | Conflicting Material | Concrete floor |

3.1.7. Electrostatic Discharge (ESD)

| Specification | ± 4KV |
|---|---|
| EN 55024 CISPR 24 EN 61000-4-2 IEC 61000-4-2 | <ol style="list-style-type: none"> ± 4KV each 25 times, 1 second for 1 time. Contact discharge. Device functions are affected, EUT will be back to normal state. |

3.1.8. EMI Compliance

| Specification |
|------------------------|
| CE: EN 55032, CISPR 32 |
| FCC: ANSI C63.4 |
| VCCI: VCCI-CISPR 32 |
| BSMI: CNS 13438 |

3.1.9. Safety Certification

| Specification |
|---------------|
| ISO 9001 |
| ISO 14001 |
| ISO 45001 |
| ISO 27001 |

3.2. Package Qualification

3.2.1. High Temperature Storage Life Test (HTSL)

| Parameter | Test Condition | |
|-----------|----------------|----------------|
| Storage | Temperature | Test Duration |
| | 150°C | 168/1000 hours |

Test Reference: JESD22 A103

3.2.2. Solderability Test

| Parameter | Test Condition |
|-----------|--|
| Storage | <ol style="list-style-type: none"> 85°C/85% RH 16 hours, bake 1 hour at 125°C. Molten solder temperature: 245±5°C Dwell time: 5 seconds |

Note: Spec: > 95% of coating area, pinhole, voids, do not exceed 5% of total area.

3.2.3. Pre-condition Test

| Parameter | Test Method | Test Condition |
|-----------|-------------|---|
| Storage | JESD22-A113 | <ol style="list-style-type: none"> Temperature Cycle (-65°C/150°C, 5 cycles) Baking (125°C, 24 hours) Temp & Humidity Soaking (30°C/60% RH, 192 hours) IR Reflow 3 cycles |

Note: The parts passing this test will be used to do HAST and TCT.

3.2.4. High Acceleration Stress Test (HAST/unbias)

| Parameter | Test Method | Test Condition | | |
|-----------|-------------|---------------------|------------------|---------------|
| | | Ambient Temperature | Ambient Humidity | Test Duration |
| Storage | JESD22-A110 | 130°C | 85% RH | 96 hours |

3.2.5. Temperature Cycling Test (TCT)

| Parameter | Test Method | Test Condition | | |
|-----------|-------------|------------------|--------------|----------------|
| | | High Temperature | Low Humidity | Test Duration |
| Storage | JESD22-A104 | 150°C | -65% RH | 200/500 cycles |

3.3. Certification

- RoHS
- CE / FCC

4. ELECTRICAL SPECIFICATIONS



4.1. Supply Voltage

| Parameter | Rating |
|---------------------|---------------|
| Operating Voltage | 3.3V ± 5% |
| Rise Time (Max/Min) | 100ms / 0.1ms |
| Fall Time (Max/Min) | 5s / 10ms |
| Min. Off Time | 1s |

Notes:

1. Minimum time between power removed from SSD ($V_{cc} < 100$ mV) and power re-applied to the drive.
2. Ensure the voltage of each power domain in SSD has enough time to discharge less than 0.1V.
3. Rise Time during from 10% to 90% of 3.3V.
4. Fall Time during from 90% to 10% of 3.3V.

4.2. Power Consumption

| Capacity | Flash Structure | Read | Write | Partial | Slumber | Idle |
|----------|----------------------------|-------|-------|---------|---------|------|
| 64GB | 64GB x 1, BiCS5 TLC, BGA | 970 | 900 | 65 | 25 | 210 |
| 128GB | 64GB x 2, BiCS5 TLC, BGA | 1,150 | 1,250 | 65 | 25 | 210 |
| 256GB | 128GB x 2, BiCS5 TLC, BGA | 1,150 | 1,350 | 65 | 25 | 210 |
| 512GB | 256GB x 2, BiCS5 TLC, BGA | 1,250 | 1,600 | 65 | 27 | 210 |
| 1TB | 256GB x 4, BiCS5 TLC, BGA | 1,350 | 1,750 | 65 | 27 | 210 |
| 2TB | 512GB x 4, BiCS5 TLC, BGA | 1,450 | 1,750 | 65 | 27 | 210 |
| 16GB | 64GB x 1, BiCS5 pSLC, BGA | 1,000 | 1,000 | 65 | 25 | 175 |
| 32GB | 64GB x 2, BiCS5 pSLC, BGA | 1,100 | 1,100 | 65 | 25 | 175 |
| 64GB | 128GB x 2, BiCS5 pSLC, BGA | 1,100 | 1,150 | 65 | 25 | 175 |
| 128GB | 256GB x 2, BiCS5 pSLC, BGA | 1,150 | 1,150 | 65 | 25 | 175 |
| 256GB | 256GB x 4, BiCS5 pSLC, BGA | 1,200 | 1,150 | 65 | 25 | 175 |
| 512GB | 512GB x 4, BiCS5 pSLC, BGA | 1,350 | 1,300 | 65 | 25 | 175 |

Unit: mW

Notes:

1. It's average value of power consumption is achieved based on 100% conversion efficiency.
2. Sequential R/W is measured while testing 4000MB sequential R/W 5 times by CrystalDiskMark.
3. Power Consumption may differ according to flash configuration and platform.
4. Measurement environment: Room temperature: 20~25°C, humidity: 40~60%RH, DC+3.3V condition.

5. INTERFACE



5.1. Pin Assignment and Descriptions

| Pin # | mSATA Pin | Description |
|-------|-----------|---|
| 1 | NC | No Connect |
| 2 | +3.3V | 3.3V Source |
| 3 | NC | No Connect |
| 4 | DGND | Digital GND |
| 5 | NC | No Connect |
| 6 | NC | No Connect |
| 7 | NC | No Connect |
| 8 | NC | No Connect |
| 9 | DGND | Digital GND |
| 10 | NC | No Connect |
| 11 | NC | No Connect |
| 12 | NC | No Connect |
| 13 | NC | No Connect |
| 14 | NC | No Connect |
| 15 | DGND | Digital GND |
| 16 | NC | No Connect |
| 17 | NC | No Connect |
| 18 | DGND | Digital GND |
| 19 | NC | No Connect |
| 20 | NC | No Connect |
| 21 | SATA GND | SATA Ground Return Pin |
| 22 | NC | No Connect |
| 23 | TXP (out) | Host Receiver Differential Signal Pair |
| 24 | +3.3V | 3.3V Source |
| 25 | TXN (out) | Host Receiver Differential Signal Pair |
| 26 | SATA GND | SATA Ground Return Pin |
| 27 | SATA GND | SATA Ground Return Pin |
| 28 | NC | No Connect |
| 29 | SATA GND | SATA Ground Return Pin |
| 30 | NC | No Connect |
| 31 | RXN (in) | Host Transmitter Differential Signal Pair |
| 32 | NC | No Connect |
| | | |

| Pin # | mSATA Pin | Description |
|-------|-----------|---|
| 33 | RXP (in) | Host Transmitter Differential Signal Pair |
| 34 | DGND | Digital GND |
| 35 | SATA GND | SATA Ground Return Pin |
| 36 | NC | No Connect |
| 37 | SATA GND | SATA Ground Return Pin |
| 38 | NC | No Connect |
| 39 | +3.3V | 3.3V Source |
| 40 | DGND | Digital GND |
| 41 | +3.3V | 3.3V Source |
| 42 | NC | No Connect |
| 43 | NC | No Connect |
| 44 | DEVSLP | Enter/Exit DevSleep |
| 45 | NC | Reserved pin |
| 46 | NC | No Connect |
| 47 | NC | Reserved pin |
| 48 | NC | No Connect |
| 49 | DAS | Device Activity Signal |
| 50 | DGND | Digital GND |
| 51 | GND | Default connect to GND |
| 52 | +3.3V | 3.3V Source |

6. SUPPORTED COMMANDS



6.1. ATA Command List

| Op-Code | Command Description | Op-Code | Command Description | |
|---------|-----------------------------------|-----------------------------------|------------------------------|---|
| 00h | NOP | 60h | Read FPDMA Queued | |
| 06h | Data Set Management | 61h | Write FPDMA Queued | |
| 10h | Recalibrate | 70h | Seek | |
| 20h | Read Sectors | 90h | Execute Device Diagnostic | |
| 21h | Read Sectors without Retry | 91h | Initialize Device Parameters | |
| 24h | Read Sectors EXT | 92h | Download Microcode | |
| 25h | Read DMA EXT | 93h | Download Microcode DMA | |
| 27h | Read Native Max Address EXT | B0h | SMART | |
| 29h | Read Multiple EXT | B0h | D0h | SMART READ DATA |
| 2Fh | Read Log EXT | B0h | D1h | SMART READ DATA ATTRIBUTE THRESHOLD |
| 30h | Write Sectors | B0h | D2h | SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE |
| 31h | Write Sectors without Retry | B0h | D3h | SMART SAVE ATTRIBUTE VALUES |
| 34h | Write Sectors EXT | B0h | D4h | SMART EXECUTE OFF-LINE IMMEDIATE |
| 35h | Write DMA EXT | B0h | D5h | SMART READ LOG |
| 37h | Set Native Max Address EXT | B0h | D6h | SMART WRITE LOG |
| 39h | Write Multiple EXT | B0h | D8h | SMART ENABLE OPERATIONS |
| 3Dh | Write DMA FUA EXT | B0h | D9h | SMART DISABLE OPERATIONS |
| 3Fh | Write Long EXT | B0h | DAh | SMART RETURN STATUS |
| 40h | Read Verify Sectors | B0h | DBh | SMART ENABLE/DISABLE AUTOMATIC OFF-LINE |
| 41h | Read Verify Sectors without Retry | B1h | | DEVICE CONFIGURATION OVERLAY |
| 42h | Read Verify Sectors EXT | B1h | C0h | DEVICE CONFIGURATION RESTORE |
| 45h | Write Uncorrectable EXT | B1h | C1h | DEVICE CONFIGURATION FREEZE LOCK |
| 47h | Read Log DMA EXT | B1h | C2h | DEVICE CONFIGURATION IDENTIFY |
| 57h | Write Log DMA EXT | B1h | C3h | DEVICE CONFIGURATION SET |
| B1h | C4h | DEVICE CONFIGURATION IDENTIFY DMA | ECh | Identify Device |
| B1h | C5h | DEVICE CONFIGURATION SET DMA | EFh | Set Features |
| C4h | Read Multiple | EFh | 02h | Enable 8-bit PIO transfer mode |
| | | | | |

| Op-Code | | Command Description | Op-Code | | Command Description | |
|---------|-----|---------------------------------------|---------|-----|---|---|
| C5h | | Write Multiple | EFh | 03h | Set transfer mode based on value in Count field | |
| C6h | | Set Multiple Mode | EFh | 05h | Enable advanced power management | |
| C8h | | Read DMA | EFh | 10h | Enable use of Serial ATA feature | |
| C9h | | Read DMA without Retry | EFh | 10h | 02h | Enable DMA Setup FIS Auto-Activate optimization |
| CAh | | Write DMA | EFh | 10h | 03h | Enable Device-initiated interface power state (DIPM) transitions |
| CBh | | Write DMA without Retry | EFh | 10h | 06h | Enable Software Settings Preservation (SSP) |
| CEh | | Write Multiple FUA EXT | EFh | 10h | 07h | Enable Device Automatic Partial to Slumber transitions |
| E0h | | Standby Immediate | EFh | 10h | 09h | Enable Device Sleep |
| E1h | | Idle Immediate | EFh | 55h | | Disable read look-ahead feature |
| E2h | | Standby | EFh | 66h | | Disable reverting to power-on defaults |
| E3h | | Idle | EFh | 82h | | Disable write cache |
| E4h | | Read Buffer | EFh | 85h | | Disable advanced power management |
| E5h | | Check Power Mode | EFh | 90h | | Disable use of Serial ATA feature set |
| E6h | | Sleep | EFh | 90h | 02h | Disable DMA Setup FIS Auto-Activate optimization |
| E7h | | Flush Cache | EFh | 90h | 03h | Disable Device-initiated interface power state (DIPM) transitions |
| E8h | | Write Buffer | EFh | 90h | 06h | Disable Software Settings Preservation (SSP) |
| E9h | | Read Buffer DMA | EFh | 90h | 07h | Disable Device Automatic Partial to Slumber transitions |
| EAh | | Flush Cache EXT | EFh | 90h | 09h | Disable Device Sleep |
| EBh | | Write Buffer DMA | EFh | AAh | | Enable read look-ahead feature |
| EFh | CCh | Enable reverting to power-on defaults | F4h | | | Security Erase Unit |
| F1h | | Security Set Password | F5h | | | Security Freeze Lock |
| F2h | | Security Unlock | F6h | | | Security Disable Password |
| F3h | | Security Erase Prepare | F8h | | | Read Native Max Address |

6.2. Identify Device Data

The following table details the sector data returned by the IDENTIFY DEVICE command.

| Word | F: Fixed V: Variable X: retired/obsolete/ reserved | Default Value | Description |
|-------|--|---------------|---|
| 0 | F | 0040h | General configuration bit-significant information |
| 1 | X | *1 | Obsolete – Number of logical cylinders |
| 2 | F | C837h | Specific configuration |
| 3 | X | 0010h | Obsolete – Number of logical heads (16) |
| 4-5 | X | 00000000h | Retired |
| 6 | X | 003Fh | Obsolete – Number of logical sectors per logical track (63) |
| 7-8 | X | 00000000h | Reserved for assignment by the Compact Flash Association |
| 9 | X | 0000h | Retired |
| 10-19 | V | Varies | Serial number (20 ASCII characters) |
| 20-21 | X | 0000h | Retired |
| 22 | X | 0000h | Obsolete |
| 23-26 | V | Varies | Firmware revision (8 ASCII characters) |
| 27-46 | V | Varies | Model number (xxxxxxx) |
| 47 | F | 8010h | 7:0- Maximum number of sectors transferred per interrupt on MULTIPLE commands |
| 48 | F | 4000h | Reserved |
| 49 | F | 2F00h | Capabilities |
| 50 | F | 4000h | Capabilities |
| 51-52 | X | 00000000h | Obsolete |
| 53 | F | 0007h | Words 88 and 70:64 valid |
| 54 | X | *1 | Obsolete – Number of logical cylinders |
| 55 | X | 0010h | Obsolete – Number of logical heads (16) |
| 56 | X | 003Fh | Obsolete – Number of logical sectors per track (63) |
| 57-58 | X | *2 | Obsolete – Current capacity in sectors |
| 59 | F | 0110h | Number of sectors transferred per interrupt on MULTIPLE commands |
| 60-61 | V | *3 | Maximum number of sector (28bit LBA mode) |
| | | | |

| Word | F: Fixed V: Variable X: retired/obsolete/ reserved | Default Value | Description |
|-------|--|---------------|--|
| 62 | X | 0000h | Obsolete |
| 63 | F | 0407h | Multi-word DMA modes supported/selected |
| 64 | F | 0003h | PIO modes supported |
| 65 | F | 0078h | Minimum Multiword DMA transfer cycle time per word |
| 66 | F | 0078h | Manufacturer's recommended Multiword DMA transfer cycle time |
| 67 | F | 0078h | Minimum PIO transfer cycle time without flow control |
| 68 | F | 0078h | Minimum PIO transfer cycle time with IORDY flow control |
| 69 | F | 1F00h | Additional Supported |
| 70 | X | 0000h | Reserved |
| 71-74 | X | 0h | Reserved for the IDENTIFY PACKET DEVICE command |
| 75 | F | 001Fh | Queue depth |
| 76 | F | C50Eh | Serial SATA capabilities |
| 77 | F | 0006h | Supported Serial ATA Phy speed |
| 78 | F | 044Ch | Serial ATA features supported |
| 79 | F | 0040h | Serial ATA features enabled |
| 80 | F | 0FF8h | Major Version Number |
| 81 | F | 0000h | Minor Version Number |
| 82 | F | 746Bh | Command set supported |
| 83 | F | 7D09h | Command set supported |
| 84 | F | 4163h | Command set/feature supported extension |
| 85 | F | 7469h | Command set/feature supported or enabled |
| 86 | F | BC01h | Command set/feature supported or enabled |
| 87 | F | 4163h | Command set/feature supported or enabled |
| 88 | F | 007Fh | Ultra DMA Modes |
| 89 | F | 000Ah | Time required for Normal Erase mode SECURITY ERASE UNIT command |
| 90 | F | 001Eh | Time required for an Enhanced Erase mode SECURITY ERASE UNIT command |
| 91 | F | 0000h | Current advanced power management value |
| 92 | F | FFFEh | Master Password Revision Code |
| | | | |
| | | | |

| Word | F: Fixed V: Variable X: retired/obsolete/ reserved | Default Value | Description |
|---------|--|---------------|---|
| 93 | F | 0000h | Hardware reset result. The contents of the bits (12:0) of this word can be changed only during the execution of hardware reset. |
| 94 | X | 0000h | Vendor's recommended and actual acoustic management value |
| 95 | F | 0000h | Stream Minimum Request Size |
| 96 | F | 0000h | Streaming Transfer Time – DMA |
| 97 | F | 0000h | Streaming Access Latency – DMA and PIO |
| 98-99 | F | 00000000h | Streaming Performance Granularity |
| 100-103 | V | *4 | Maximum user LBA for 48 bit Address feature set |
| 104 | F | 0000h | Streaming Transfer Time – PIO |
| 105 | F | 0004h | Maximum number of 512-byte blocks per DATA SET MANAGEMENT command |
| 106 | F | 4000h | Physical sector size/Logical sector size |
| 107 | F | 0000h | Inter-seek delay for ISO-7779 acoustic testing in microseconds |
| 108-111 | F | Varies | Reserved |
| 112-115 | X | 0h | Reserved |
| 116 | X | 0000h | Reserved |
| 117-118 | F | 00000000h | Words per logical Sector |
| 119 | F | 4018h | Supported settings |
| 120 | F | 4018h | Command set/Feature Enabled/Supported |
| 121-126 | X | 0h | Reserved |
| 127 | X | 0000h | Obsolete |
| 128 | F | 0021h | Security status |
| 129-159 | V | Varies | Vendor specific |
| 160 | X | 0000h | Compact Flash Association (CFA) power mode 1 |
| 161-167 | X | 0h | Reserved for assignment by the CFA |
| 168 | V | Varies | Device Nominal Form Factor |
| 169 | F | 0001h | DATA SET MANAGEMENT command is supported |
| 170-173 | F | 0h | Additional Product Identifier |
| 174-175 | X | 0h | Reserve |
| | | | |

| Word | F: Fixed V: Variable X: retired/obsolete/ reserved | Default Value | Description |
|---------|--|-------------------------|--|
| 176-205 | F | 0h | Current media serial number |
| 206 | F | 0000h | SCT Command Transport{ |
| 207-208 | X | 00000000h | Reserved |
| 209 | F | 4000h | Alignment of logical blocks within a physical block |
| 210-211 | F | 0000h | Write-Read-Verify Sector Count Mode 3 (not support) |
| 212-213 | F | 0000h | Write-Read-Verify Sector Count Mode 2 (not support) |
| 214-216 | X | 0000h | NV Cache relate (not support) |
| 217 | F | 0001h | Non-rotating media device |
| 218 | X | 0000h | Reserved |
| 219 | X | 0000h | NV Cache relate (not support) |
| 220 | V | 0000h | Write read verify feature set current mode |
| 221 | X | 0000h | Reserved |
| 222 | F | 107Fh | Transport major version number |
| 223 | F | 0000h | Transport minor version number |
| 224-229 | X | 0h | reserved |
| 230-233 | F | 0h | Extend number of user addressable sectors |
| 234 | F | 0001h | Minimum number of 512-byte data blocks per DOWNLOAD MICROCODE command for mode 03h |
| 235 | F | FFFEh | Maximum number of 512-byte data blocks per DOWNLOAD MICROCODE command for mode 03h |
| 236-242 | X | 0h | Reserved |
| 243 | X | 0000h | Reserved |
| 244-254 | X | 0h | Reserved |
| 255 | F | XXA5h XX is variable | Integrity word (Checksum and Signature) |

■ List of Device Identification for Each Capacity

| Capacity (GB) | *1 (Word 1/Word 54) | *2 (Word 57–58) | *3 (Word 60–61) | *4 (Word 100–103) |
|------------------|------------------------|--------------------|--------------------|----------------------|
| 16 | 3FFFh | FBFC10h | 1DD40B0h | 1DD40B0h |
| 32 | 3FFFh | FBFC10h | 3BA2EB0h | 3BA2EB0h |
| 60 | 3FFFh | FBFC10h | 6FCCF30h | 6FCCF30h |
| 64 | 3FFFh | FBFC10h | 7740AB0h | 7740AB0h |
| 120 | 3FFFh | FBFC10h | DF94BB0h | DF94BB0h |
| 128 | 3FFFh | FBFC10h | EE7C2B0h | EE7C2B0h |
| 240 | 3FFFh | FBFC10h | 0FFFFFFFh | 1BF244B0h |
| 256 | 3FFFh | FBFC10h | 0FFFFFFFh | 1DCF32B0h |
| 480 | 3FFFh | FBFC10h | 0FFFFFFFh | 37E436B0 |
| 512 | 3FFFh | FBFC10h | 0FFFFFFFh | 3B9E12B0h |
| 960 | 3FFFh | FBFC10h | 0FFFFFFFh | 6FC81AB0h |
| 1024 | 3FFFh | FBFC10h | 0FFFFFFFh | 773BD2B0h |
| 1920 | 3FFFh | FBFC10h | 0FFFFFFFh | DF8FE2B0h |
| 2048 | 3FFFh | FBFC10h | 0FFFFFFFh | EE7752B0h |

6.3. S.M.A.R.T. Attributes

| Entry | ID | Description |
|-------|------|--|
| 0 | 0x01 | Number of Uncorrectable Errors Accumulated. |
| 1 | 0x09 | Power on Hours Count. |
| 2 | 0x0C | Power Cycle Count (number of power on/off cycles accumulated) |
| 3 | 0xA8 | SATA PHY Error Count (Only record from power on, when power off this value will clear to zero. These values include all PHY error count, ex data FIS CRC, code error, disparity error, command FIS CRC.....) |
| 4 | 0xAA | Bad Block Count (early bad count and later bad count) |
| 5 | 0xAD | Erase Count (max. erase count and average erase count) |
| 6 | 0xC0 | Unexpected Power Loss Count |
| 7 | 0xC2 | Temperature (show 33°C if no thermal sensor) |
| 8 | 0xDA | Number of Accumulation CRC Error (read/write data FIS CRC error) |
| 9 | 0xE7 | SSD Life Remaining |
| 10 | 0xF1 | Host Write (GB) |

7. ACRONYM



| Acronym | Definition |
|------------|--|
| ATTO | Commercial performance benchmark application |
| DEVSLP | Device Sleep Mode |
| DDR | Double data rate (SDRAM) |
| DIPM | Device initiated power management |
| HIPM | Host initiated power management |
| LBA | Logical block addressing |
| MTBF | Mean time between failures |
| NCQ | Native command queue |
| PLP | Power Loss Protection |
| SATA | Serial advanced technology attachment |
| S.M.A.R.T. | Self-monitoring, analysis and reporting technology |
| SSD | Solid state drive |

8. PART NUMBER DECODER



MSS-AEX¹X²X³X⁴X⁵X⁶X⁷X⁸

| Item | Series | Capacity (Byte) | NAND Flash | Option |
|--|--------|--|--|-------------------------------|
| | | X ¹ X ² X ³ X ⁴ X ⁵ | X ⁶ | X ⁷ X ⁸ |
| MSS | AE | 0016G 0032G 0060G 0064G 0120G 0128G 0240G 0256G 0480G 0512G 0960G 0001T 1920G 0002T | A : 3D TLC Standard (0°C to +70°C) B : 3D TLC Industrial (-40°C to +85°C) V : 3D pSLC Standard (0°C to +70°C) W : 3D pSLC Industrial (-40°C to +85°C) | |
| <p>X⁷X⁸</p> <p>Blank: Standard</p> | | | | |