# 2.5” SATA SSD 650-D Datasheet

**(SQF-S25xx-xxxxDSDx)**

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## Revision History

| Rev. | Date | History |
|---|---|---|
| 0.1 | 2022/3/11 | 1. Draft |
| 1.0 | 2022/3/22 | 1. Preliminary |
| 1.1 | 2022/4/26 | 1. Add 64GB |
| 1.2 | 2022/6/13 | 1. Add sTLC items |
| 1.3 | 2022/8/3 | 1. Add sTLC endurance data |
| 1.4 | 2022/9/12 | 1. Update Sanitize command description and ATA Command Set |
| 1.5 | 2022/9/16 | 1. Update the description of NAND Endurance |
| 1.6 | 2022/9/21 | 1. Update sTLC Endurance (TeraByte Written) measured data |

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**Safety Instructions**

1. Read these safety instructions carefully.
2. Keep this User Manual for later reference.
3. Disconnect this equipment from any AC outlet before cleaning. Use a damp cloth. Do not use liquid or spray detergents for cleaning.
4. For plug-in equipment, the power outlet socket must be located near the equipment and must be easily accessible.
5. Keep this equipment away from humidity.
6. Put this equipment on a reliable surface during installation. Dropping it or letting it fall may cause damage.
7. The openings on the enclosure are for air convection. Protect the equipment from overheating. DO NOT COVER THE OPENINGS.
8. Make sure the voltage of the power source is correct before connecting the equipment to the power outlet.
9. Position the power cord so that people cannot step on it. Do not place anything over the power cord.
10. All cautions and warnings on the equipment should be noted.
11. If the equipment is not used for a long time, disconnect it from the power source to avoid damage by transient overvoltage.
12. Never pour any liquid into an opening. This may cause fire or electrical shock.
13. Never open the equipment. For safety reasons, the equipment should be opened only by qualified service personnel.
14. If one of the following situations arises, get the equipment checked by service personnel:
    - The power cord or plug is damaged.
    - Liquid has penetrated the equipment.
    - The equipment has been exposed to moisture.
    - The equipment does not work well, or you cannot get it to work according to the user's manual.
    - The equipment has been dropped and damaged.
    - The equipment has obvious signs of breakage.
15. DO NOT LEAVE THIS EQUIPMENT IN AN ENVIRONMENT WHERE THE STORAGE TEMPERATURE MAY GO BELOW -20° C (-4° F) OR ABOVE 60° C (140° F). THIS COULD DAMAGE THE EQUIPMENT. THE EQUIPMENT SHOULD BE IN A CONTROLLED ENVIRONMENT.
16. CAUTION: DANGER OF EXPLOSION IF BATTERY IS INCORRECTLY REPLACED. REPLACE ONLY WITH THE SAME OR EQUIVALENT TYPE RECOMMENDED BY THE MANUFACTURER, DISCARD USED BATTERIES ACCORDING TO THE MANUFACTURER'S INSTRUCTIONS.

**Consignes de sécurité**

1. Lisez attentivement ces instructions de sécurité.
2. Conservez ce manuel pour référence ultérieure.
3. Débranchez cet appareil de toute prise secteur avant le nettoyage. Utilisez un chiffon humide. Ne pas utiliser de détergents liquides ou en aérosol pour le nettoyage
4. Pour les équipements enfichables, la prise de courant doit être située près de l'équipement et doit être facilement accessible.
5. Gardez cet équipement à l'abri de l'humidité.
6. Placez cet équipement sur une surface fiable lors de l'installation. Le laisser tomber ou le laisser tomber peut causer des dommages.
7. Les ouvertures sur l'enceinte sont destinées à la convection de l'air. Protégez l'équipement de la surchauffe. NE COUVREZ PAS LES OUVERTURES.
8. Assurez-vous que la tension de la source d'alimentation est correcte avant de connecter l'équipement à la prise de courant.
9. Positionnez le cordon d'alimentation de sorte que personne ne puisse marcher dessus. Ne placez rien sur le cordon d'alimentation.
10. Toutes les mises en garde et avertissements sur l'équipement doivent être notés..
11. Si l'appareil n'est pas utilisé pendant une longue période, débranchez-le de la source d'alimentation pour éviter tout dommage dû à une surtension transitoire.
12. Ne jamais verser de liquide dans une ouverture. Cela pourrait provoquer un incendie ou un choc électrique.
13. N'ouvrez jamais l'équipement. Pour des raisons de sécurité, l'équipement ne doit être ouvert que par du personnel qualifié.
14. Si l'une des situations suivantes se produit, faites vérifier l'équipement par le personnel de service:l:
    - Le cordon d'alimentation ou la fiche est endommagé Liquid has penetrated the equipment.
    - L'équipement a été exposé à l'humidité.
    - L'équipement ne fonctionne pas bien ou vous ne pouvez pas le faire fonctionner conformément au manuel d'utilisation..
    - L'équipement est tombé et endommagé..
    - L'équipement présente des signes évidents de rupture.
15. NE PAS LAISSER CET APPAREIL DANS UN ENVIRONNEMENT O LA TEMPÉRATURE DE STOCKAGE PEUT ÊTRE INFÉRIEURE À -20 ° C (-4 ° F) OU SUPÉRIEURE À 60 ° C (140 ° F). CELA POURRAIT ENDOMMAGER L'ÉQUIPEMENT. L'ÉQUIPEMENT DOIT ÊTRE DANS UN ENVIRONNEMENT CONTRÔLÉ.
16. ATTENTION: DANGER D'EXPLOSION EN CAS DE REMPLACEMENT INCORRECT DE LA PILE. REMPLACEZ UNIQUEMENT AVEC LE MÊME TYPE OU LE TYPE ÉQUIVALENT RECOMMANDÉ PAR LE FABRICANT, DÉJETTEZ LES PILES UTILISÉES SELON LES INSTRUCTIONS DU FABRICANT.

# 1. Overview

Advantech SQF 650-D series 2.5” SSD (SQF-S25 650-D) delivers all the advantages of flash disk technology with the Serial ATA I/II/III interface and is fully compliant with 2.5” SSD specification. The SQF-S25 650-D is designed to operate at a maximum operating frequency of 177MHz with 25MHz external crystal. Its capacity could provide a wide range up to 2TB, and sTLC(Pseudo SLC) capacity up to 256GB(support customized 512GB). Moreover, it can reach up to 550MB/s read as well as 520MB/s write high performance based on 3D TLC flash (with 1.75MB SRAM enabled and measured by CrystalDiskMark v5.0). The power consumption of SQF-S25 650-D is much lower than traditional hard drives, making it the best embedded solution for new platforms.

## 2. Features

- **Standard SATA interface**
  - Support SATA 1.5/3.0/6.0 Gbps interface
  - SATA Revision 3.2 compliant
- **Operating Voltage：5V**
- **TRIM、AHCI supported**
- **Hardware write protect supported**
  - Pin header type: default on short position for write protect, and write protect function enabled by firmware.
- **Temperature Ranges**
  - Commercial Temperature
    - Tc 0℃ to 70℃ for operating[1]
    - Tc -40℃ to 85℃ for storage
  - Minus Temperature
    - Tc -20℃ to 85℃ for operating[1]
    - Tc -40℃ to 85℃ for storage
  - Industrial Temperature
    - -40℃ to 85℃ for operating[1]
    - -40℃ to 85℃ for storage

  *Note: 1. Based on SMART Attribute C2h, which measured by thermal sensor
- **Mechanical Specification**
  - Shock：1,500G / 0.5ms
  - Vibration：20G / 80~2,000Hz
- **Humidty**
  - Humidity：Up to 95% under 40℃
- **Acquired RoHS、WHQL、CE、FCC Certificate**
- **Acoustic：0 dB**
- **Dimension：100 mm x 69.85 mm x 7 mm**

# 3. Specification Table

## ■ Performance

| | | Sequential Performance (MB/sec) | | Random Performance (IOPS@4K) | |
|---|---|---|---|---|---|
| | | Read | Write | Read | Write |
| 3D TLC (BiCS5) | 64 GB | 375 | 264 | 35,000 | 55,000 |
| | 128 GB | 556 | 468 | 44,500 | 78,500 |
| | 256 GB | 555 | 492 | 75,500 | 82,500 |
| | 512 GB | 556 | 513 | 91,500 | 85,000 |
| | 1 TB | 557 | 523 | 96,500 | 86,000 |
| | 2 TB | 558 | 522 | 93,500 | 86,000 |
| 3D sTLC (BiCS5) | 32 GB | 558 | 472 | 47,000 | 75,000 |
| | 64 GB | 558 | 501 | 73,000 | 80,000 |
| | 128 GB | 558 | 518 | 91,000 | 81,000 |
| | 256 GB | 559 | 524 | 93,000 | 82,000 |

* All performance above are tested with AHCI mode.

* Tested by CrystalDiskMark 1GB workload.

## Endurance

JEDEC defined an endurance rating TBW (TeraByte Written), following by the equation below, for indicating the number of terabytes a SSD can be written which is a measurement of SSDs' expected lifespan, represents the amount of data written to the device.

**TBW = [(NAND Endurance) x (SSD Capacity)] / WAF**

- **NAND Endurance**: Program / Erase cycle of a NAND flash.
  - 3D TLC (BiCS5): 3,000 cycles
  - 3D sTLC (BiCS5): 50,000 cycles
- **SSD Capacity**: SSD physical capacity in total of a SSD.
- **WAF**: Write Amplification Factor (WAF), as the equation shown below, is a numerical value representing the ratio between the amount of data that a SSD controller needs to write and the amount of data that the host's flash controller writes. A better WAF, which is near to 1, guarantees better endurance and lower frequency of data written to flash memory.

**WAF = (Lifetime write to flash) / (Lifetime write to host)**

- **Endurance measurement is based on New JEDEC 219 Client Workload and verified with following workload conditions,**
  - Test duration: over 168hrs (=7 days)
  - File Size: Follow by JEDEC 219

| 3D TLC (BiCS5) | WAF | TBW | DWPD* |
|---|---|---|---|
| 64 GB | 2.90 | 65 | 0.93 |
| 128 GB | 4.20 | 90 | 0.64 |
| 256 GB | 3.20 | 230 | 0.82 |
| 512 GB | 2.70 | 550 | 0.98 |
| 1 TB | 2.50 | 1200 | 1.07 |
| 2 TB | 2.10 | 2900 | 1.29 |

| 3D sTLC (BiCS5) | WAF | TBW | DWPD* |
|---|---|---|---|
| 32 GB | 2 | 1000 | 28.54 |
| 64 GB | 1.4 | 3000 | 42.81 |
| 128 GB | 1.3 | 6400 | 45.66 |
| 256 GB | 1.3 | 13000 | 46.38 |

* The endura nce of SSD could be estimated based on users' behaviors, NAND endurance cycles, and write amplification factor. It is not guaranteed by the flash vendor. TBW may vary from flash configuration and platform.

* Endurance of 1 drive writes per day (DWPD) for 3 years

# 4. General Description

## Error Correction Code (ECC)

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, SQF 650-D series 2.5" SSD applies the LDPC (Low Density Parity Check) of ECC algorithm, which can detect and correct errors occur during read process, ensure data been read correctly, as well as protect data from corruption.

## Wear Leveling

NAND flash devices can only undergo a limited number of program/erase cycles, and in most cases, the flash media are not used evenly. If some areas get updated more frequently than others, the lifetime of the device would be reduced significantly. Thus, Wear Leveling is applied to extend the lifespan of NAND Flash by evenly distributing write and erase cycles across the media.

SQF provides advanced Wear Leveling algorithm, which can efficiently spread out the flash usage through the whole flash media area. Moreover, by implementing both dynamic and static Wear Leveling algorithms, the life expectancy of the NAND flash is greatly improved.

## Bad Block Management

Bad blocks are blocks that include one or more invalid bits, and their reliability is not guaranteed. Blocks that are identified and marked as bad by the manufacturer are referred to as "Initial Bad Blocks". Bad blocks that are developed during the lifespan of the flash are named "Later Bad Blocks". SQF implements an efficient bad block management algorithm to detect the factory-produced bad blocks and manages any bad blocks that appear with use. This practice further prevents data being stored into bad blocks and improves the data reliability.

## Power Loss Protection: Flush Manager

Power Loss Protection is a mechanism to prevent data loss during unexpected power failure. DRAM is a volatile memory and frequently used as temporary cache or buffer between the controller and the NAND flash to improve the SSD performance. However, one major concern of the DRAM is that it is not able to keep data during power failure. Accordingly, SQF SSD applies the Flush Manager technology, only when the data is fully committed to the NAND flash will the controller send acknowledgement (ACK) to the host. Such implementation can prevent false-positive performance and the risk of power cycling issues.

In addition, it is critical for a controller to shorten the time the in-flight data stays in the controller internal cache. Thus, SQF applies an algorithm to reduce the amount of data resides in the cache to provide a better performance. With Flush Manager, incoming data would only have a "pit stop" in the cache and then move to NAND flash directly. Also, the onboard DDR will be treated as an "organizer" to consolidate incoming data into groups before written into the flash to improve write amplification.

## TRIM

TRIM is a feature which helps improve the read/write performance and speed of solid-state drives (SSD). Unlike hard disk drives (HDD), SSDs are not able to overwrite existing data, so the available space gradually becomes smaller with each use. With the TRIM command, the operating system can inform the SSD which blocks of data are no longer in use and can be removed permanently. Thus, the SSD will perform the erase action, which prevents unused data from occupying blocks all the time.

## SMART

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is an open standard that allows a hard disk drive to automatically detect its health and report potential failures. When a failure is recorded by SMART, users can choose to replace the drive to prevent unexpected outage or data loss. Moreover, SMART can inform users of impending failures while there is still time to perform proactive actions, such as copy data to another device.

## Over-Provision

Over Provisioning refers to the inclusion of extra NAND capacity in a SSD, which is not visible and cannot be used by users. With Over Provisioning, the performance and IOPS (Input/Output Operations per Second) are improved by providing the controller additional space to manage P/E cycles, which enhances the reliability and endurance as well. Moreover, the write amplification of the SSD becomes lower when the controller writes data to the flash.

## Thermal Throttling

Thermal Throttling function is for protecting the drive and reducing the possibility of read / write error due to overheat. The temperature is monitored by the thermal sensor. As the operating temperature continues to increase to threshold temperature, the Thermal Throttling mechanism is activated. At this time, the performance of the drive will be significantly decreased to avoid continuous heating. When the operating temperature falls below threshold temperature, the drive can resume to normal operation.

## Advanced Device Security Features

- **Advanced Encryption Standard (AES)**
  An AES 256-bit encryption key is generated in the drive's security controller before the data gets stored on the NAND flash. When the controller or firmware fails, the data that is securely stored in the encryption key becomes inaccessible through the NAND flash.

- **TCG OPAL 2.0 support**
  SQFlash 650-D series supports standard TCG OPAL 2.0 function for advance Self-Encryption Drive (SED) feature sets. Advantech provides also user friendly interface for setting disk / system bonding to prevent SSD be used in non-authorized platforms, which is called Flash Lock function.

- **Write Protect Function**
  SQFlash 650-D series default support Write Protect function, when the write protect function enabled, all of the write command will carried to a buffer area without real programming to the Flash IC. Therefore, the data won't be saved in this mode and will be totally discarded upon power shutting down.

- **Hardware GPIO Write Protect (Default set)**

  HW GPIO Write Protection function is default set on SQF-S25 650. When the pins are opened (or jumper off), all of the write command will be carried to a buffer area without real programming to the Flash IC. So the data won't be saved in this mode and will be totally discarded upon power shutting down.

- **Secure Erase Function (SATA Command)**
  SQFlash 650-D series supports standard SATA command for secure erase function; when the SSD controller receive the secure erase command, the erase process will reset all blocks and erase all of the user data in the SSD.

- **Sanitize Function (SATA Command)**
  SQFlash 650-D series implements Sanitize command sets by default and supports Block Erase, Crypto Scramble, Overwrite and other related commands. With internal AES encryption support, Crypto Scramble starts with resetting AES key. In this way, the existing data will be scrambled within 10ms and can no longer be recovered. Also, the erase flag is set when the erase function is triggered, which will ensure the entire erase process can be 100% completed. Even if there's power outage, the erase operation will resume as soon as power is restored.
  (Note) Crypto Scramble needs to be done with the TCG OPAL 2.0 setting enabled.

- **Crypto Erase**

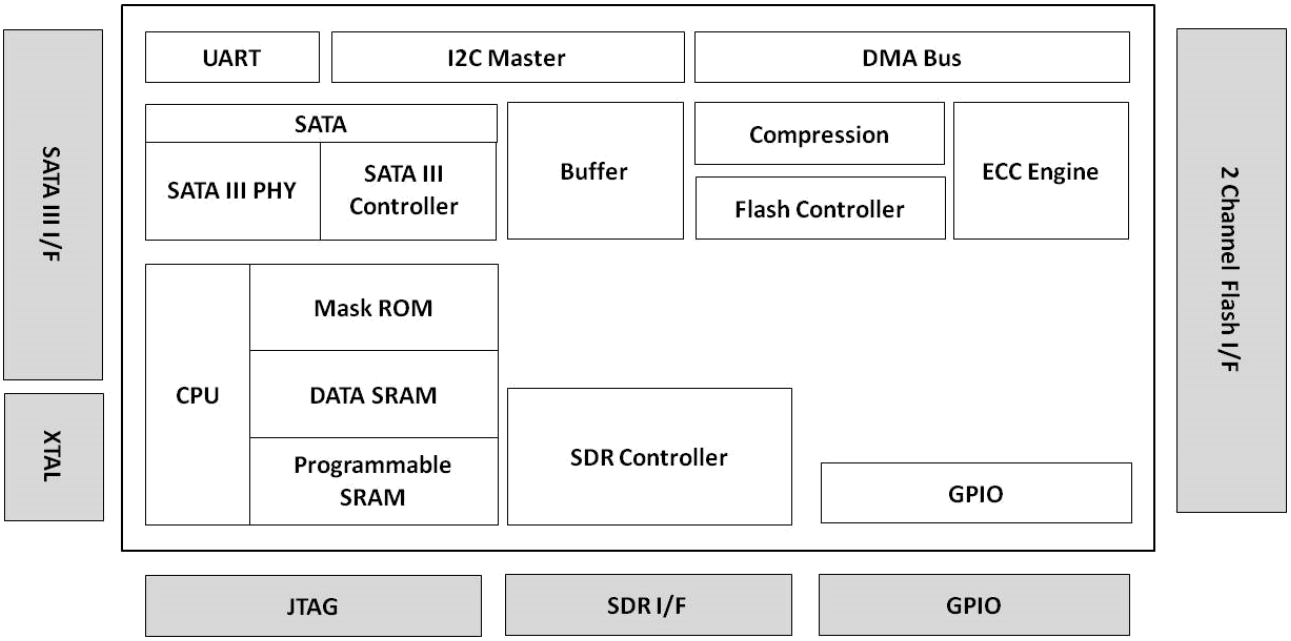
  SQFlash Crypto Erase is a security function based on vendor command which can be triggered by

sending ATA Command. When Crypto Erase is activated, it will trim logical to physical table, fill data in it, and then reset the AES key. With this Crypto Erase function, we can ensure original data in SSD inaccessible through the NAND flash.

- **Military Secure Erase**

  SQFlash Military Secure Erase is a series of security function based on vendor command which can be triggered by sending ATA Command. Please check Military Secure Erase Whitepaper for detail of each functions: AFSSI 5020, DoD 5220.22-M, USA NAVY NAVSO P-5239-26, NSA Manual 130-2, USA-ARMY 380-19, NISPOMUP Chap 8, Sect.8-501, NSA/CSS 9-12, AFSSI 8580.

## ■ Block Diagram




## ■ LBA value

| Density | LBA |
|---|---|
| 32 GB | 62,533,296 |
| 64 GB | 125,045,424 |
| 128 GB | 250,069,680 |
| 256 GB | 500,118,192 |
| 512 GB | 1,000,215,216 |
| 1 TB | 2,000,409,264 |
| 2 TB | 4,000,797,360 |

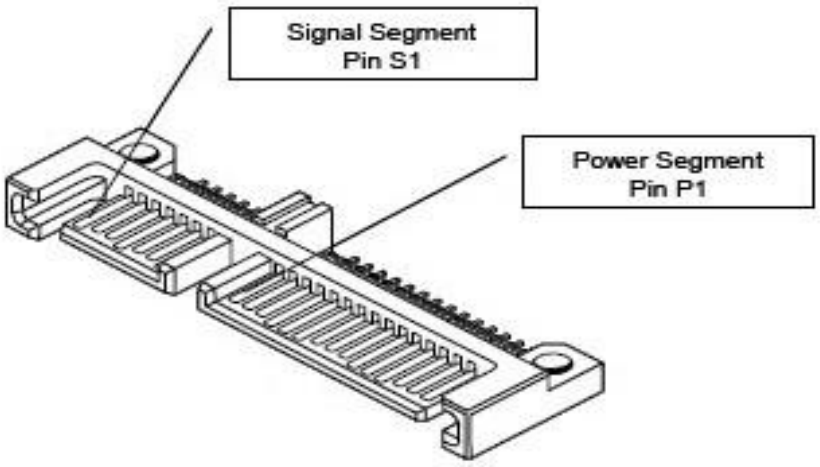
# 5. Pin Assignment and Description

## 5.1 2.5" SATA-SSD Interface Pin Assignments (Signal Segment)

| Pin # | Function | Description |
|---|---|---|
| S1 | GND | 2nd mate |
| S2 | A+ | Differential signal pair A |
| S3 | A- | |
| S4 | GND | 2nd mate |
| S5 | B- | Differential signal pair B |
| S6 | B+ | |
| S7 | GND | 2nd mate |

## 5.2 2.5" SATA-SSD Interface Pin Assignments (Power Segment)

| Pin # | Function |
|---|---|
| P1 | Not Used (3.3V) |
| P2 | Not Used (3.3V) |
| P3 | Not Used (3.3V Pre-Charge) |
| P4 | GND |
| P5 | GND |
| P6 | GND |
| P7 | 5V Pre-Charge |
| P8 | 5V |
| P9 | 5V |
| P10 | GND |
| P11 | LED pin |
| P12 | GND |
| P13 | Not Used (12V Pre-Charge) |
| P14 | Not Used (12V) |
| P15 | Not Used (12V) |




## 5.3 Hardware Jumper Feature Set

The SQFlash 650-D has a 4-pin jumper mounted on the PCB that controls the enable/disable of specific functions. The hardware jumper function setting supports Write Protection by default.

If you would like to set the jumper function as Crypto Erase function instead of Write Protect function, please contact Advantech sales representative.

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| Function | Pin | Open/Short | Enabled/Disabled |
|---|---|---|---|
| Write Protect (Default) | 2-3 | Open, jumper off or pull pin to 1.8V. | Enabled |
| | | Short, with jumper. | Disabled. |
| Crypto Erase (Customized) | 1-2 | Open, jumper off or pull pin to 1.8V. | Enabled |
| | | Short, with jumper. | Disabled. |






# 6. Identify Device Data

The Identity Device Data enables Host to receive parameter information from the device. The parameter words in the buffer have the arrangement and meanings defined in below table. All reserve bits or words are zero

| Word | ATA Identify Parameter | Value |
|---|---|---|
| 0 | General configuration bit-significant information | 0040h |
| 1 | Obsolete | *1 |
| 2 | Specific configuration | C837h |
| 3 | Obsolete | 0010h |
| 4-5 | Retired | 00000000h |
| 6 | Obsolete | 003Fh |
| 7-8 | Reserved for assignment by the Compact Flash Association | 00000000h |
| 9 | Retired | 0000h |
| 10-19 | Serial number (20 ASCII characters) | Varies |
| 20-21 | Retired | 00000000h |
| 22 | Obsolete | 0000h |
| 23-26 | Firmware revision (8 ASCII characters) | Varies |
| 27-46 | Model number (xxxxxxxx) | Varies |
| 47 | 7:0- Maximum number of sectors transferred per interrupt on MULTIPLE commands | 8010h |
| 48 | Trusted Computing feature set options(not support) | 4000h |
| 49 | Capabilities | 2F00h |
| 50 | Capabilities | 4000h |
| 51-52 | Obsolete | 000000000h |
| 53 | Words 88 and 70:64 valid | 0007h |
| 54 | Obsolete | *1 |
| 55 | Obsolete | 0010h |
| 56 | Obsolete | 003Fh |
| 57-58 | Obsolete | *2 |
| 59 | Sanitize and Number of sectors transferred per interrupt on MULTIPLE commands | 5D10h |
| 60-61 | Maximum number of sector ( 28bit LBA mode) | *3 |
| 62 | Obsolete | 0000h |
| 63 | Multi-word DMA modes supported/selected | 0407h |
| 64 | PIO modes supported | 0003h |
| 65 | Minimum Multiword DMA transfer cycle time per word | 0078h |
| 66 | Manufacturer's recommended Multiword DMA transfer cycle time | 0078h |
| 67 | Minimum PIO transfer cycle time without flow control | 0078h |
| 68 | Minimum PIO transfer cycle time with IORDY flow control | 0078h |
| 69 | Additional Supported (support download microcode DMA) | 0D00h |
| 70 | Reserved | 0000h |
| 71-74 | Reserved for the IDENTIFY PACKET DEVICE command | 0000000000000000h |
| 75 | Queue depth | 001Fh |
| 76 | Serial SATA capabilities | E70Eh |
| 77 | Serial ATA Additional Capabilities | 0086h |
| 78 | Serial ATA features supported | 014Ch |

| | | |
|---|---|---|
| 79 | Serial ATA features enabled | 0040h |
| 80 | Major Version Number | 0FF8h |
| 81 | Minor Version Number | 0000h |
| 82 | Command set supported | 706Bh |
| 83 | Command set supported | 7409h |
| 84 | Command set/feature supported extension | 6163h |
| 85 | Command set/feature enabled | 7069h |
| 86 | Command set/feature enabled | B401h |
| 87 | Command set/feature default | 6163h |
| 88 | Ultra DMA Modes | 007Fh |
| 89 | Time required for security erase unit completion | 0001h |
| 90 | Time required for Enhanced security erase completion | 001Eh |
| 91 | Current advanced power management value | 0000h |
| 92 | Master Password Revision Code | FFFEh |
| 93 | Hardware reset result. For SATA devices, word 93 shall be set to the value 0000h. | 0000h |
| 94 | Obsolete | 0000h |
| 95 | Stream Minimum Request Size | 0000h |
| 96 | Streaming Transfer Time – DMA | 0000h |
| 97 | Streaming Access Latency – DMA and PIO | 0000h |
| 98-99 | Streaming Performance Granularity | 0000h |
| 100-103 | Maximum user LBA for 48 bit Address feature set | *4 |
| 104 | Streaming Transfer Time – PIO | 0000h |
| 105 | Maximum number of 512-byte blocks per DATA SET MANAGEMENT command | 0008h |
| 106 | Physical sector size/Logical sector size | 4000h |
| 107 | Inter-seek delay for ISO-7779 acoustic testing in microseconds | 0000h |
| 108-111 | World Wide Name | Varies |
| 112-115 | Reserved | 0000000000000000h |
| 116 | Reserved | 0000h |
| 117-118 | Words per logical Sector | 00000000h |
| 119 | Supported settings | 411Ch |
| 120 | Command set/Feature Enabled/Supported | 401Ch |
| 121-126 | Reserved | 0h |
| 127 | Obsolete | 0h |
| 128 | Security status | 0021h |
| 129-140 | Vendor specific | Varies |
| 141 | Vendor specific | Varies |
| 142-159 | Vendor specific | Varies |
| 160 | Reserved for CFA | 0h |
| 161-167 | Reserved for CFA | 0h |
| 168 | Device Nominal Form Factor | Varies |
| 169 | DATA SET MANAGEMENT command is supported | 0001h |
| 170-173 | Additional Product Identifier | 0h |
| 174-175 | Reserved | 0h |
| 176-205 | Current media serial number | 0h |
| 206 | SCT Command Transport | 0h |

| | | |
|---|---|---|
| 207-208 | Reserved | 0h |
| 209 | Alignment of logical blocks within a physical block | 4000h |
| 210-211 | Write-Read-Verify Sector Count Mode 3 (not support) | 0000h |
| 212-213 | Write-Read-Verify Sector Count Mode 2 (not support) | 0000h |
| 214-216 | Obsolete | 0000h |
| 217 | Non-rotating media device | 0001h |
| 218 | Reserved | 0h |
| 219 | NV Cache relate (not support) | 0h |
| 220 | Write read verify feature set current mode | 0h |
| 221 | Reserved | 0h |
| 222 | Transport major version number | 10FFh |
| 223 | Transport minor version number | 0000h |
| 224-229 | Reserved | 0h |
| 230-233 | Extend number of user addressable sectors | 0h |
| 234 | Minimum number of 512-byte data blocks per DOWNLOAD MICROCODE command for mode 03h | 0001h |
| 235 | Maximum number of 512-byte data blocks per DOWNLOAD MICROCODE command for mode 03h | FFFEh |
| 236-254 | Reserved | 0h |
| 255 | Integrity word (Checksum and Signature) | XXA5h |

| Capacity (GB) | *1 (Word 1/Word 54) | *2 (Word 57 – 58) | *3 (Word 60 – 61) | *4 (Word 100 – 103) |
|---|---|---|---|---|
| 32 | 3FFFh | FBFC10h | 3BA2EB0h | 3BA2EB0h |
| 64 | 3FFFh | FBFC10h | 7740AB0h | 7740AB0h |
| 128 | 3FFFh | FBFC10h | EE7C2B0h | EE7C2B0h |
| 256 | 3FFFh | FBFC10h | FFFFFFFh | 1DCF32B0h |
| 512 | 3FFFh | FBFC10h | FFFFFFFh | 3B9E12B0h |
| 1024 | 3FFFh | FBFC10h | FFFFFFFh | 773BD2B0h |
| 2048 | 3FFFh | FBFC10h | FFFFFFFh | EE7752B0h |

# 7. ATA Command Set

## [Command Set List]

| Op-Code | Command Description |
|---|---|
| 00h | NOP |
| 06h | Data Set Management |
| 10h | Recalibrate |
| 20h | Read Sectors |
| 21h | Read Sectors without Retry |
| 24h | Read Sectors EXT |
| 25h | Read DMA EXT |
| 27h | Read Native Max Address EXT |
| 29h | Read Multiple EXT |
| 2Fh | Read Log EXT |
| 30h | Write Sectors |
| 31h | Write Sectors without Retry |
| 34h | Write Sectors EXT |
| 35h | Write DMA EXT |
| 37h | Set Native Max Address EXT |
| 39h | Write Multiple EXT |
| 3Dh | Write DMA FUA EXT |
| 3Fh | Write Long EXT |
| 40h | Read Verify Sectors |
| 41h | Read Verify Sectors without Retry |
| 42h | Read Verify Sectors EXT |
| 45h | Write Uncorrectable EXT |
| 47h | Read Log DMA EXT |
| 57h | Write Log DMA EXT |
| 5Bh | TRUSTED NON-DATA |
| 5Ch | TRUSTED RECEIVE |
| 5Dh | TRUSTED RECEIVE DMA |
| 5Eh | TRUSTED SEND |
| 5Fh | TRUSTED SEND DMA |
| 60h | Read FPDMA Queued |
| 61h | Write FPDMA Queued |
| 70h | Seek |
| 77h | SET DATE & TIME EXT |
| 90h | Execute Device Diagnostic |
| 91h | Initialize Device Parameters |
| 92h | Download Microcode PIO |
| 93h | Download Microcode DMA |
| B0h | D0h | SMART: READ DATA |
| B0h | D2h | SMART: ENABLE/DISABLE AUTOSAVE |
| B0h | D4h | SMART: EXECUTE OFF-LINE IMMEDIATE |
| B0h | D5h | SMART: READ LOG |
| B0h | D6h | SMART: WRITE LOG |
| B0h | D8h | SMART: ENABLE OPERATIONS |
| B0h | D9h | SMART: DISABLE OPERATIONS |
| B0h | DAh | SMART: RETURN STATUS |
| B1h | C0h | DEVICE CONFIGURATION: RESTORE |
| B1h | C2h | DEVICE CONFIGURATION: IDENTIFY |
| B1h | C3h | DEVICE CONFIGURATION: SET |
| B1h | C4h | DEVICE CONFIGURATION: IDENTIFY DMA |
| B1h | C5h | DEVICE CONFIGURATION: SET DMA |
| B4h | 00h | SANITIZE DEVICE: SANITIZE STATUS EXT |
| B4h | 11h | SANITIZE DEVICE: CRYPTO SCRAMBLE EXT |
| B4h | 12h | SANITIZE DEVICE: BLOCK ERASE EXT |
| B4h | 14h | SANITIZE DEVICE: OVERWRITE EXT |
| B4h | 20h | SANITIZE DEVICE: SANITIZE FREEZE LOCK EXT |

| | | |
|---|---|---|
| B4h | 40h | SANITIZE DEVICE: SANITIZE ANTIFREEZE LOCK EXT |
| C4h | | Read Multiple |
| C5h | | Write Multiple |
| C6h | | Set Multiple Mode |
| C8h | | Read DMA |
| C9h | | Read DMA without Retry |
| CAh | | Write DMA |
| CBh | | Write DMA without Retry |
| CEh | | Write Multiple FUA EXT |
| E0h | | Standby Immediate |
| E1h | | Idle Immediate |
| E2h | | Standby |
| E3h | | Idle |
| E4h | | Read Buffer |
| E5h | | Check Power Mode |
| E6h | | Sleep |
| E7h | | Flush Cache |
| E8h | | Write Buffer |
| E9h | | Read Buffer DMA |
| EAh | | Flush Cache EXT |
| EBh | | Write Buffer DMA |
| ECh | | IDENTIFY DEVICE |
| EFh | 02h | SET FEATURES: Enable volatile write cache |
| EFh | 03h | SET FEATURES: Set transfer mode |
| EFh | 05h | SET FEATURES: Enable the APM feature set |
| EFh | 55h | SET FEATURES: Disable read look-ahead feature |
| EFh | 82h | SET FEATURES: Disable volatile write cache |

| | | | |
|---|---|---|---|
| EFh | 85h | | SET FEATURES: Disable the APM feature set |
| EFh | 86h | | SET FEATURES: Disable the PUIS feature set |
| EFh | 90h | 02h | SET FEATURES: Disable DMA Setup FIS Auto-Activate optimization |
| EFh | 90h | 03h | SET FEATURES: Disable Device-initiated interface power state transitions |
| EFh | 90h | 06h | SET FEATURES: Disable Software Settings Preservation |
| EFh | 90h | 07h | SET FEATURES: Disable Device Automatic Partial to Slumber transitions |
| EFh | 10h | 03h | SET FEATURES: Enable Device-initiated interface power state transitions |
| EFh | 10h | 06h | SET FEATURES: Enable Software Settings Preservation |
| EFh | 10h | 07h | SET FEATURES: Enable Device Automatic Partial to Slumber transitions |
| EFh | AAh | | SET FEATURES: Enable read look-ahead feature |
| EFh | CCh | | SET FEATURES: Enable reverting to power-on defaults |
| F1h | | | Security Set Password |
| F2h | | | Security Unlock |
| F3h | | | Security Erase Prepare |
| F4h | | | Security Erase Unit |
| F5h | | | Security Freeze Lock |
| F6h | | | Security Disable Password |
| F8h | | | Read Native Max Address |
| F9h | | | Set Max: Address |
| F9h | 01h | | SET MAX: SET PASSWORD |
| F9h | 02h | | SET MAX: LOCK |
| F9h | 03h | | SET MAX: UNLOCK |
| F9h | 04h | | SET MAX: FREEZE LOCK |

Note: ND = Non-Data Command
PI = PIO Data-In Command
PO = PIO Data-Out Command
DM = DMA Command
DD = Execute Diagnostic Command

## [Command Set Descriptions]

**1. CHECK POWER MODE (code: E5h)**;
This command allow host to determine the current power mode of the device.

**2. DOWNLOAD MICROCODE (code: 92h);**
This command enables the host to alter the device's microcode. The data transferred using the DOWNLOAD MICROCODE command is vendor specific.
All transfers shall be an integer multiple of the sector size. The size of the data transfer is determined by the content of the LBA Low register and the Sector Count register.
This allows transfer sizes from 0 bytes to 33,553,920 bytes, in 512bytes increments.

**3. EXECUTE DEVICE DIAGNOSTIC (code: 90h);**
This command performs the internal diagnostic tests implemented by the module.

**4. FLUSH CACHE (code: E7h);**
This command used by the host to request the device to flush the write cache.

**5. FLUSH CACHE EXT (code: EAh);**
This command is used by the host to request the device to flush the write cache. If there is data in the write cache, that data shall be written to the media.

**6. IDENTIFY DEVICE (code: ECh);**
The IDENTIFY DEVICE command enables the host to receive parameter information from the module.

**7. IDLE (code: 97h or E3h);**
This command allows the host to place the module in the IDLE mode and also set the Standby timer. INTRQ may be asserted even through the module may not have fully transitioned to IDLE mode. If the Sector Count register is non-"0", then the Standby timer shall be enabled. The value in the Sector Count register shall be used to determine the time programmed into the Standby timer. If the Sector Count register is "0" then the Standby timer is disabled.

**8. IDLE IMMEDIATE (code: E1h);**
This command causes the module to set BSY, enter the Idle (Read) mode, clear BSY and generate an interrupt.

**9. INITIALIZE DEVICE PARAMETERS (code: 91h);**
This command enables the host to set the number of sectors per track and the number of heads per cylinder.

**10. NOP (code: 00h);**
If this command is issued, the module respond with command aborted.

**11. READ BUFFER (code: E4h);**
This command enables the host to read the current contents of the module's sector buffer.

**12. READ DMA (code: C8h or C9h);**
This command reads from "1" to "256" sectors as specified in the Sector Count register using the DMA data transfer protocol. A sector count of "0" requests "256" sectors transfer. The transfer begins at the sector specified in the Sector Number register.

**13. READ DMA Ext (code: 25h);**
This command allows the host to read data using the DMA data transfer protocol.

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**14. READ MULTIPLE (code: C4h);**

This command performs similarly to the READ SECTORS command. Interrupts are not generated on each sector, but on the transfer of a block which contains the number of sector per block is defined by the content of word 59 in the IDENTIFY DEVICE response.

**15. READ MULTIPLE EXT (code: 29h);**

This command performs similarly to the READ SECTORS command. The number of sectors per block is defined by a successful SET MULTIPLE command. If no successful SET MULTIPLE command has been issued, the block is defined by the device's default value for number of sectors per block as defined in bits (7:0) in word 47 in the IDENTIFY DEVICE information.

**16. READ NATIVE MAX ADDRESS (code: F8h);**

This command returns the native maximum address. The native maximum address is the highest address accepted by the device in the factory default condition.

**17. READ NATIVE MAX ADDRESS EXT (code: 27h);**

This command returns the native maximum address.

**18. READ SECTOR(S) (code: 20h or 21h);**

This command reads from "1" to "256" sectors as specified in the Sector Count register. A sector count of "0" requests "256" sectors transfer. The transfer begins at the sector specified in the Sector Number register.

**19. READ SECTOR(S) EXT (code: 24h);**

This command reads from "1" to "65536" sectors as specified in the Sector Count register. A sector count of "0" requests "65536" sectors transfer. The transfer begins at the sector specified in the Sector Number register.

**20. READ VERIFY SECTOR(S) (code: 40h or 41h);**

This command is identical to the READ SECTORS command, except that DRQ is never set and no data is transferred to the host.

**21. READ VERIFY SECTOR(S) EXT (code: 42h);**

This command is identical to the READ SECTORS command, except that DRQ is never set and no data is transferred to the host.

**22. RECALIBRATE (code: 1Xh);**

This command return value is select address mode by the host request.

**23. SECURITY DISABLE PASSWORD (code: F6h);**

This command transfers 512 bytes of data from the host. Table defines the content of this information. If the password selected by word 0 match the password previously saved by the device, the device shall disable the Lock mode. This command shall not change the Master password. The Master password shall be reactivated when a User password is set.

**24. SECURITY ERASE PREPARE (code: F3h);**

This command shall be issued immediately before the SECURITY ERASE UNIT command to enable device eraseing and unlocking.

**25. SECURITY ERASE UNIT (code: F4h);**

This command transfer 512 bytes of data from the host. Table## defines the content of this information. If the password does not match the password previously saved by the device, the device shall reject the command with command aborted.

The SECURITY ERASE PREPARE command shall be completed immediately prior to the SECURITY

ERASE UNIT command.

**26. SECURITY FREEZE LOCK (code: F5h);**

This command shall set the device to frozen mode. After command completion any other commands that update the device Lock mode shall be command aborted. Frozen shall be disabled by power-off or hardware reset.

If SECURITY FREEZE LOCK is issued when the drive is in frozen mode, the drive executes the command and remains in frozen mode.

**27. SECURITY SET PASSWORD (code: F1h);**

This command transfer 512 bytes of data from the host. Table defines the content of this information. The data transferred controls the function of this command. Table defines the interaction of the identifier and security level bits.

**28. SECURITY UNLOCK (code: F2h);**

This command transfer 512 bytes of data from the host. Table (as Disable Password) defines the content of this information.

If the Identifier bit is set to Master and the device is in high security level, then the password supplied shall be compared with the stored Master password. If the device is in maximum security level then the unlock shall be rejected.

If the identifier bit is set to user then the device shall compare the supplied password with the stored User password.

If the password compare fails then the device shall return command aborted to the host and decrements the unlock counter. This counter shall be initially set to five and shall be decremented for each password mismatch when SECURITY UNLOCK is issued and the device is locked. When this counter reachs zero then SECURITY UNLOCK and SECURITY ERASE UNIT command shall be aborted unitl a power-on or a hardware reset.

**29. SEEK (code: 7Xh);**

This command performs address range check.

**30. SET MAX ADDRESS (code: F9h);**

After successful command completion, all read and write access attempts to address greater than specified by the successful SET MAX ADDRESS command shall be rejected with an IDNF error. IDENTIFY DEVICE response words (61:60) shall reflect the maximum address set with this command.

**31. SET MAX ADDRESS EXT (code: 37h);**

After successful command completion, all read and write access attempts to address greater than specified by the successful SET MAX ADDRESS command shall be rejected with an IDNF error. IDENTIFY DEVICE response words (61:60) shall reflect the maximum address set with this command.

**32. SET FEATURE (code: EFh);**

This command is used by the host to establish parameters that affect the execution of certain device features.

**33. SET MULTIPLE MODE (code: C6h);**

This command enables the device to perform READ and Write Multiple operations and establishes the block count for these commands.

**34. SLEEP (code: 99h or E6h);**

This command causes the module to set BSY, enter the Sleep mode, clear BSY and generate an interrupt.

**35. SMART READ DATA (code: B0h with Feature register value of D0h);**

This command returns the Device SMART data structure to the host.

**36. SMART ENABLE/DISABLE AUTO SAVE (code: B0h with Feature register value of D2h);**
This command enables and disables the optional attribute autosave feature of the device.

**37. SMART EXECUTE OFF_LINE (code: B0h with Feature register value of D4h);**
This command cause the device to immediately initiate the optional set of activities that collect SMART data in an off-line mode and then save this data to the device's non-volatile memory, or execute a self-diagnostic test routine in either captive or off-line mode.

**38. SMART READ LOG (code: B0h with Feature register value of D5h);**
This command returns the specified log data to the host.

**39. SMART ENABLE OPERATION (code: B0h with Feature register value of D8h);**
This command enables access to all SMART capabilities within the device. Prior to receipt of this command SMART data are neither monitored nor saved by the device.

**40. SMART DISABLE OPERATION (code: B0h with Feature register value of D9h);**
This command disables all SMART capabilities within the device including any and all timer and event count functions related exclusively to this feature. After command acceptance the device shall disable all SMART operations.
After receipt of this command by the device, all other SMART commands including SMART DISABLE OPERATION commands, with exception of SMART ENABLE OPERATIONS, are disabled and invalid and shall be command aborted by the device.

**41. SMART RETURN STATUS (code: B0h with Feature register value of DAh);**
This command causes the device to communicate the reliability status of the device to the host.

**42. STANDBY (code: E2h);**
This command causes the module to set BSY, enter the Standby mode, clear BSY and return the interrupt immediately.

**43. STANDBY IMMEDIATE (code: E0h);**
This command causes the module to set BSY, enter the Standby mode, clear BSY and return the interrupt immediately.

**44. WRITE BUFFER (code: E8h);**
This command enables the host to overwrite contents of the module's sector buffer with any data pattern desired.

**45. WRITR DMA (code: CAh or CBh);**
This command writes from "1" to "256" sectors as specified in the Sector Count register using the DMA data transfer protocol. A sector count of "0" requests "256" sectors transfer. The transfer begins at the sector specified in the Sector Number register.

**46. WRITR DMA EXT (code: 35h);**
This command writes from "1" to "65536" sectors as specified in the Sector Count register using the DMA data transfer protocol. A sector count of "0" requests "65536" sectors transfer. The transfer begins at the sector specified in the Sector Number register.

**47. WRITE MULTIPLE (code: C5h);**
This command is similar to the WRITE SECTORS command. Interrupts are not presented on each sector, but on the transfer of a block which contains the number of sectors defined by Set Multiple command.

**48. WRITE MULTIPLE EXT (code: 39h);**
This command is similar to the WRITE SECTORS command. Interrupts are not presented on each sector, but on the transfer of a block which contains the number of sectors defined by Set Multiple command.

**49. WRITE SECTOR(S) (code: 30h);**

This command writes from "1" to "256" sectors as specified in the Sector Count register. A sector count of "0" requests "256" sectors transfer. The transfer begins at the sector specified in the Sector Number register.

**50. WRITE SECTOR(S) EXT (code: 34h);**

This command writes from "1" to "65536" sectors as specified in the Sector Count register. A sector count of "0" requests "65536" sectors transfer. The transfer begins at the sector specified in the Sector Number register.

**51. WRITE SECTOR(S) W/O ERASE (code: 38h);**

This command writes from "1" to "256" sectors as specified in the Sector Count register. A sector count of "0" requests "256" sectors transfer. The transfer begins at the sector specified in the Sector Number register.

**52. WRITE VERIFY (code: 3Ch);**

This command is similar to the WRITE SECTOR(S) command, except that each sector is verified before the command is completed.

# 8. System Power Consumption

## 8.1 Supply Voltage

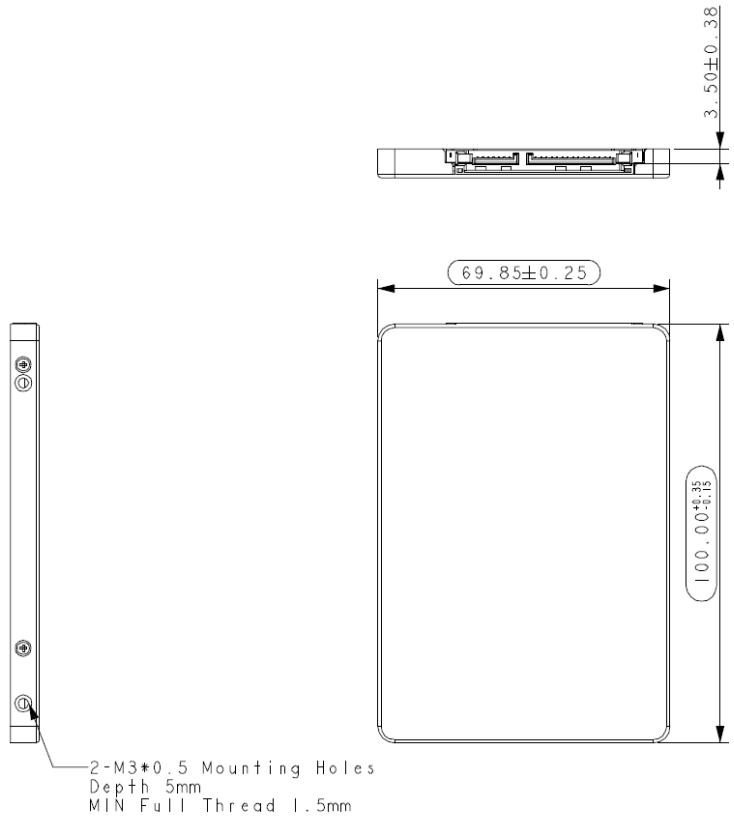
| Parameter | Rating |
|---|---|
| Operating Voltage | 5V |

## 8.2 Power Consumption

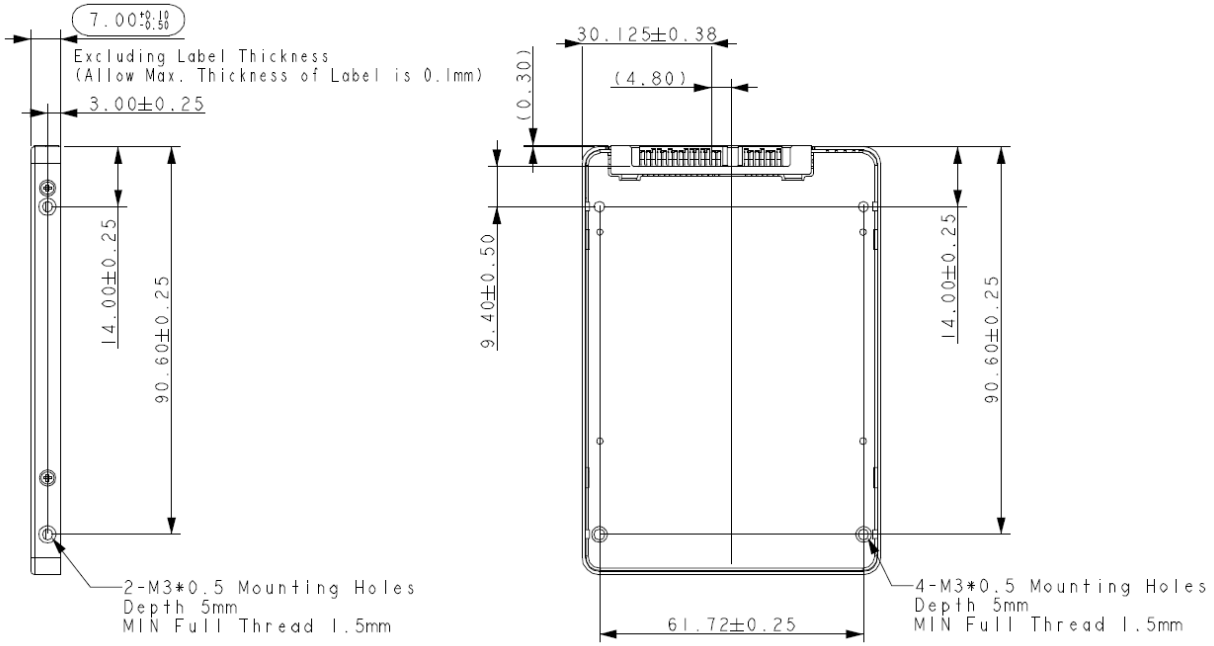
| (mW) | | Read | Write | Idle | Slumber |
|---|---|---|---|---|---|
| 3D TLC (BiCS5) | 64 GB | 970 | 900 | 200 | 30 |
| | 128 GB | 1150 | 1200 | 250 | 30 |
| | 256 GB | 1150 | 1350 | 250 | 30 |
| | 512 GB | 1250 | 1550 | 250 | 30 |
| | 1 TB | 1350 | 1750 | 250 | 30 |
| | 2 TB | 1500 | 1750 | 250 | 30 |
| 3D sTLC (BiCS5) | 32 GB | 1150 | 1150 | 250 | 20 |
| | 64 GB | 1200 | 1200 | 250 | 20 |
| | 128 GB | 1200 | 1250 | 250 | 20 |
| | 256 GB | 1350 | 1250 | 250 | 20 |

# 9. Physical Dimension

**2.5" SSD (Unit: mm)**




**(Top View)**




**(Bottom View)**

## Appendix: Part Number Table

| Product | Advantech PN |
|---|---|
| SQF 2.5" SSD 650-D 64G 3D TLC (BiCS5) (0~70°C) | SQF-S25V1-64GDSDC |
| SQF 2.5" SSD 650-D 128G 3D TLC (BiCS5) (0~70°C) | SQF-S25V1-128GDSDC |
| SQF 2.5" SSD 650-D 256G 3D TLC (BiCS5) (0~70°C) | SQF-S25V1-256GDSDC |
| SQF 2.5" SSD 650-D 512G 3D TLC (BiCS5) (0~70°C) | SQF-S25V2-512GDSDC |
| SQF 2.5" SSD 650-D 1T 3D TLC (BiCS5) (0~70°C) | SQF-S25V4-1TDSDC |
| SQF 2.5" SSD 650-D 2T 3D TLC (BiCS5) (0~70°C) | SQF-S25V4-2TDSDC |
| SQF 2.5" SSD 650-D 64G 3D TLC (BiCS5) (-20~85°C) | SQF-S25V1-64GDSDM |
| SQF 2.5" SSD 650-D 128G 3D TLC (BiCS5) (-20~85°C) | SQF-S25V1-128GDSDM |
| SQF 2.5" SSD 650-D 256G 3D TLC (BiCS5) (-20~85°C) | SQF-S25V1-256GDSDM |
| SQF 2.5" SSD 650-D 512G 3D TLC (BiCS5) (-20~85°C) | SQF-S25V2-512GDSDM |
| SQF 2.5" SSD 650-D 1T 3D TLC (BiCS5) (-20~85°C) | SQF-S25V4-1TDSDM |
| SQF 2.5" SSD 650-D 2T 3D TLC (BiCS5) (-20~85°C) | SQF-S25V4-2TDSDM |
| SQF 2.5" SSD 650-D 64G 3D TLC (BiCS5) (-40~85°C) | SQF-S25V1-64GDSDE |
| SQF 2.5" SSD 650-D 128G 3D TLC (BiCS5) (-40~85°C) | SQF-S25V1-128GDSDE |
| SQF 2.5" SSD 650-D 256G 3D TLC (BiCS5) (-40~85°C) | SQF-S25V1-256GDSDE |
| SQF 2.5" SSD 650-D 512G 3D TLC (BiCS5) (-40~85°C) | SQF-S25V2-512GDSDE |
| SQF 2.5" SSD 650-D 1T 3D TLC (BiCS5) (-40~85°C) | SQF-S25V4-1TDSDE |
| SQF 2.5" SSD 650-D 2T 3D TLC (BiCS5) (-40~85°C) | SQF-S25V4-2TDSDE |
| SQF 2.5" SSD 650-D 32G 3D sTLC (BiCS5) (0~70°C) | SQF-S25Z1-32GDSDC |
| SQF 2.5" SSD 650-D 64G 3D sTLC (BiCS5) (0~70°C) | SQF-S25Z1-64GDSDC |
| SQF 2.5" SSD 650-D 128G 3D sTLC (BiCS5) (0~70°C) | SQF-S25Z2-128GDSDC |
| SQF 2.5" SSD 650-D 256G 3D sTLC (BiCS5) (0~70°C) | SQF-S25Z4-256GDSDC |
| SQF 2.5" SSD 650-D 32G 3D sTLC (BiCS5) (-40~85°C) | SQF-S25Z1-32GDSDE |
| SQF 2.5" SSD 650-D 64G 3D sTLC (BiCS5) (-40~85°C) | SQF-S25Z1-64GDSDE |
| SQF 2.5" SSD 650-D 128G 3D sTLC (BiCS5) (-40~85°C) | SQF-S25Z2-128GDSDE |
| SQF 2.5" SSD 650-D 256G 3D sTLC (BiCS5) (-40~85°C) | SQF-S25Z4-256GDSDE |