innodisk

Total Solution For Industrial Flash Storage

# 2.5" SATA SSD

## 3TEB Series

## with Innodisk NAND

**Customer:** _____

**Customer Part Number:** _____

**Innodisk Part Number:** _____

**Innodisk Model Name:** _____

**Date:** _____

| Innodisk Approver | Customer Approver |
|---|---|
| | |

**Features:**

- SATA III
- Innodisk 3D TLC NAND
- 2.5” SATA SSD
- Standard-temperature
- iPower Guard
- iData Guard
- Dynamic Thermal Management

**Performance:**

- Sequential Read up to 550 MB/s
- Sequential Write up to 500 MB/s

**Power Requirements:**

| | |
|---|---|
| Input Voltage: | 5V±5% |
| Max Operating Wattage: | 1.3W |
| Idle Wattage: | 0.4W |

**Reliability:**

| Capacity | TBW | DWPD |
|---|---|---|
| 64GB | 65 | 1.09 |
| 128GB | 150 | 1.26 |
| 256GB | 260 | 1.09 |
| 512GB | 582 | 1.22 |
| 1TB | 900 | 0.94 |

| | |
|---|---|
| Data Retention | 1 Year |
| Warranty | 3 Years |

1-year data retention is at NAND life end.

For warranty details, please refer to:

https://www.innodisk.com/en/support_and_service/warranty

# Table of contents

# Revision History

| Revision | Description | Date |
|---|---|---|
| 1.0 | First Released | Sep., 2023 |
| 1.1 | Add 64GB spec. | Jun., 2024 |
| 1.2 | Revise SMART Attributes<br>Update TBW | Aug., 2024 |
| 1.3 | Update Data Retention content | Jan., 2025 |

# List of Tables

# List of Figures

# 1. Product Overview

## 1.1 Introduction of Innodisk 2.5” SATA SSD 3TEB.

Innodisk 2.5” SATA SSD 3TEB products provide high capacity flash memory Solid State Drive (SSD) that electrically complies with Serial ATA (SATA) standard. It supports SATA III standard (6.0GHz) with high performance, achieves excellent performance up to 2CH standard by cost effective controller with 2CH.

With Innodisk $L^3$ FW architecture, combining our signature 4K mapping algorithm $L^2$ FW architecture with powerful LDPC technology, 3TEB series has outstanding high IOPS, better data integrity and extended lifespan through reducing the bad block number happening.

For real industrial application, 3TEB series has built-in thermal sensor to monitor the environment temperature. iData Guard, the power loss management mechanism developed by Innodisk, ensures data integrity while power sudden loss happened.

***CAUTION*** ***TRIM must be enabled.***

***TRIM enables SSD’s controller to skip invalid data instead of moving. It can free up significant amount of resources, extends the lifespan of SSD by reducing erase, and write cycles on the SSD. Innodisk’s handling of garbage collection along with TRIM command improves write performance on SSDs.***

## 1.2 Product View and Models

Innodisk 2.5” SATA SSD 3TEB is available in follow capacities within TLC flash ICs.

2.5” SATA SSD 3TEB 64GB  2.5” SATA SSD 3TEB 128GB

2.5” SATA SSD 3TEB 256GB  2.5” SATA SSD 3TEB 512GB

2.5” SATA SSD 3TEB 1TB


**Figure 1: Innodisk 2.5” SATA SSD 3TEB**

## 1.3 SATA Interface

Innodisk2.5” SATA SSD 3TEB supports SATA III(6.0Gb/s) interface, and compliant with SATA I (1.5Gb/s) and SATA II(3.0Gb/s).

## 1.4 2.5-inch Form Factor

The Industry-standard 2.5-inch form factor design with metal material case is easy for installation, which has a compact design 69.85mm (W) x 100.00mm (L) x 7.00mm (H)

# 2. Product Specifications

## 2.1 Capacity and Device Parameters

2.5” SATA SSD 3TEB device parameters are shown in Table 1.

**Table 1: Device parameters**

| Capacity | Cylinders | Heads | Sectors | LBA | User Capacity(MB) |
|---|---|---|---|---|---|
| 64GB | 16383 | 16 | 63 | 117231408 | 57241 |
| 128GB | 16383 | 16 | 63 | 234441648 | 114473 |
| 256GB | 16383 | 16 | 63 | 468862128 | 228936 |
| 512GB | 16383 | 16 | 63 | 937703088 | 457862 |
| 1TB | 16383 | 16 | 63 | 1875385008 | 915715 |

## 2.2 Performance

Burst Transfer Rate: 6.0Gbps

**Table 2: Performance - 112 Layers 3D TLC***

| Capacity | Unit | 64GB | 128GB | 256GB | 512GB | 1TB |
|---|---|---|---|---|---|---|
| Sequential** Read (Q32T1) | MB/s | 500 | 550 | 550 | 550 | 550 |
| Sequential** Write (Q32T1) | | 270 | 490 | 500 | 500 | 500 |
| Sustained*** Sequential Read (Avg.) | | 240 | 450 | 510 | 510 | 510 |
| Sustained*** Sequential Write (Avg.) | | 30 | 250 | 310 | 280 | 340 |
| 4KB Random** Read (Q32T1) | IOPS | 15,000 | 38,000 | 75,000 | 70,000 | 68,000 |
| 4KB Random** Write (Q32T1) | | 12,000 | 71,000 | 72,000 | 72,000 | 73,000 |

Note:

*. Performance results are 3TEB with Innodisk BiCS5 NAND composition measured in Room Temperature with Out-of-Box devices and may vary depending on overall system setup. In addition, 3TEB series adopt hybrid mode which enables SLC cache followed by TLC direct write to strike balance between burst performance and steady overall stability.

**. Performance results are based on CrystalDiskMark 8.0.1 with file size 1000MB. Unit of 4KB item is IOPS.

***. Performance results are based on AIDA 64 v5.98 with block size 1MB of Linear Read & Write Test Item.

## 2.3 Electrical Specifications

### 2.3.1 Power Requirement

**Table 3: Innodisk 2.5” SATA SSD 3TEB Power Requirement**

| Item | Symbol | Rating | Unit |
|---|---|---|---|
| Input voltage | $V_{IN}$ | +5 DC +- 5% | V |

### 2.3.2 Power Consumption

**Table 4: Typical Power Consumption**

| Mode | Power Consumption (W) |
|---|---|
| Read (RMS)[1] | 1.2 |
| Write (RMS)[1] | 1.3 |
| Idle | 0.5 |
| Boot Up | 4.4 |

* Target: 2.5” SATA SSD 3TEB 1TB

## 2.4 Environmental Specifications

### 2.4.1 Temperature Ranges

**Table 5: Temperature range for 2.5” SATA SSD 3TEB**

| Temperature | Range |
|---|---|
| Operating | Standard Grade: 0°C to +70°C |
| Storage | -40°C to +85°C |

### 2.4.2 Humidity

Relative Humidity: 10-95%, non-condensing

### 2.4.3 Shock and Vibration

**Table 6: Shock/Vibration Testing for 2.5” SATA SSD 3TEB**

| Reliability | Test Conditions | Reference Standards |
|---|---|---|
| Vibration | 7 Hz to 2K Hz, 20G, 3 axes | IEC 60068-2-6 |
| Mechanical Shock | Duration: 0.5ms, 1500 G, 3 axes | IEC 60068-2-27 |

### 2.4.4 Mean Time between Failures (MTBF)

Table 7 summarizes the MTBF prediction results for various 2.5” SATA SSD 3TEB configurations. The analysis was performed using a RAM Commander™ failure rate prediction.

- **Failure Rate**: The total number of failures within an item population, divided by the total number of life units expended by that population, during a particular measurement interval under stated condition.
- **Mean Time between Failures (MTBF)**: A basic measure of reliability for repairable items: The mean number of life units during which all parts of the item perform within their specified limits, during a particular measurement interval under stated conditions.

**Table 7: 2.5” SATA SSD 3TEB MTBF**

| Product | Condition | MTBF (Hours) |
|---|---|---|
| Innodisk 2.5” SATA SSD 3TEB | Telcordia SR-332 GB, 25°C | >3,000,000 |

## 2.5 CE and FCC Compatibility

2.5” SATA SSD 3TEB conforms to CE and FCC requirements.

## 2.6 RoHS Compliance

2.5” SATA SSD 3TEB is fully compliant with RoHS directive.

## 2.7 Reliability

**Table 8: 2.5” SATA SSD 3TEB TBW**

| Parameter | Value | |
|---|---|---|
| Flash endurance | 3,000 P/E cycles | |
| Error Correct Code | Support | |
| Data Retention | Under 40℃:<br>1 Year at NAND Life End | |
| **TBW* (Total Bytes Written)** Units: TB | | |
| **Capacity** | **Sequential workload** | **Client workload** |
| 64GB | 170 | 65 |
| 128GB | 341 | 150 |
| 256GB | 682 | 260 |
| 512GB | 1364 | 582 |
| 1TB | 2727 | 900 |

* Note:

1. Sequential: Mainly sequential write are estimated by PassMark Burnin Test v8.1 pro.
2. Client: Follow JESD218 Test method and JESD219A Workload, tested by ULINK.
3. Based on out-of-box performance.

## 2.8 Transfer Mode

2.5” SATA SSD 3TEB support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

## 2.9 Pin Assignment

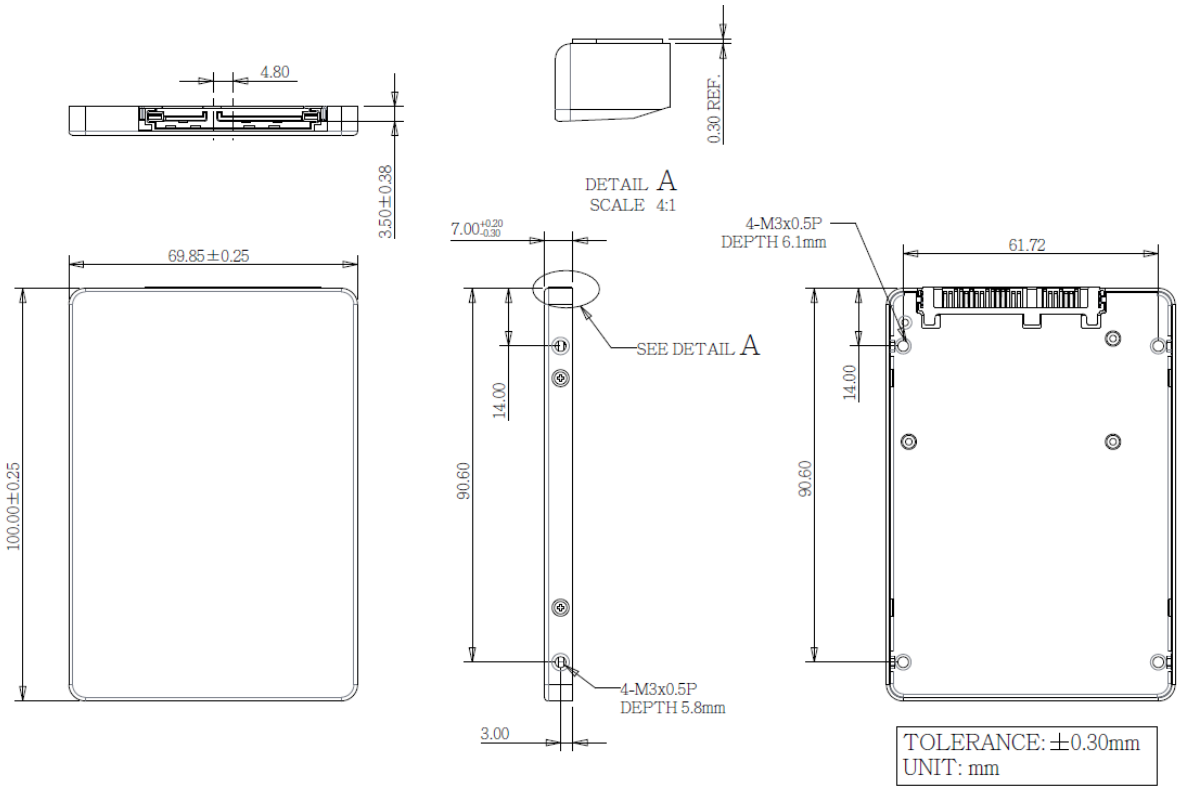
Innodisk 2.5” SATA SSD 3TEB uses a standard SATA pin-out.

See following table for 2.5” SATA SSD 3TEB pin assignment.

**Table 9: Innodisk 2.5” SATA SSD 3TEB Pin Assignment**

| Name | Type | Description |
|---|---|---|
| S1 | GND | NA |
| S2 | A+ | Differential Signal Pair A |
| S3 | A- | |
| S4 | GND | NA |
| S5 | B- | Differential Signal Pair B |
| S6 | B+ | |
| S7 | GND | NA |
| **Key and Spacing separate signal and power segments** | | |
| P1 | NC | NA |
| P2 | NC | NA |
| P3 | NC | NA |
| P4 | GND | NA |
| P5 | GND | NA |
| P6 | GND | NA |
| P7 | V5 | 5V Power, Pre-Charge |
| P8 | V5 | 5V Power |
| P9 | V5 | 5V Power |
| P10 | GND | NA |
| P11 | DAS/DSS | Device Activity Signal / Disable Staggered |
| P12 | GND | NA |
| P13 | NC | NA |
| P14 | NC | NA |
| P15 | NC | NA |

## 2.10 Mechanical Dimensions




## 2.11 Assembly Weight

An Innodisk 2.5” SATA SSD 3TEB within flash ICs, 1TB’s weight is 45 grams approximately.

## 2.12 Seek Time

Innodisk2.5” SATA SSD 3TEB is not a magnetic rotating design. There is no seek or rotational latency required.

## 2.13 NAND Flash Memory

Innodisk 2.5” SATA SSD 3TEB uses 3D TLC NAND flash memory, with 3,000 program & erase cycles, which is non-volatility, high reliability and high speed memory storage.

# 3. Theory of Operation

## 3.1 Overview

Figure 2 shows the operation of Innodisk 2.5” SATA SSD 3TE8 from the system level, including the major hardware blocks.

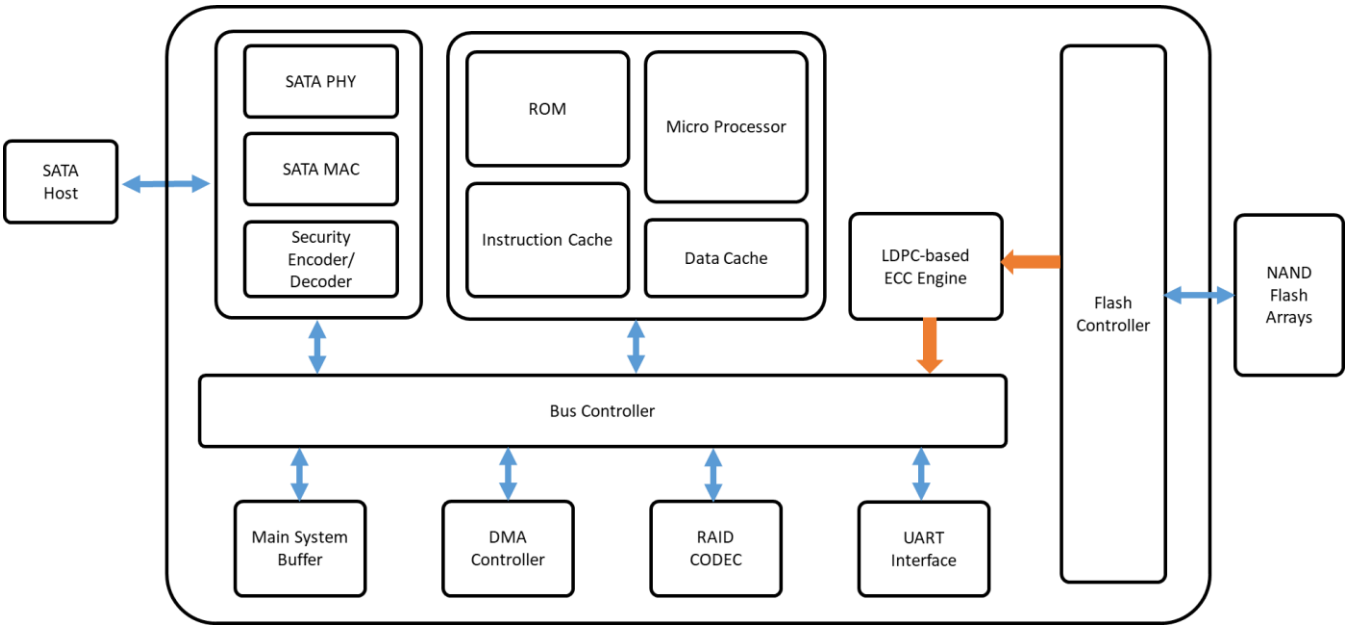



**Figure 2 : Innodisk 2.5” SATA SSD 3TEB Block Diagram**

Innodisk 2.5” SATA SSD 3TEB integrates a SATA III controller and NAND flash memories. Communication with the host occurs through the host interface, using the standard ATA protocol. Communication with the flash device(s) occurs through the flash interface.

## 3.2 SATA III Controller

Innodisk 2.5” SATA SSD 3TEB is designed with a SATA III 6.0Gbps (Gen. 3) controller. The Serial ATA physical, link and transport layers are compliant with Serial ATA Gen 1, Gen 2 and Gen 3 specification (Gen 3 supports 1.5Gbps/3.0Gbps/6.0Gbps data rate). The controller has four channels for flash interface.

## 3.3 Error Detection and Correction

Innodisk2.5” SATA SSD 3TEB is designed with hardware LDPC ECC engine with hard-decision and Soft-decision decoding. Low-density parity-check (LDPC) codes have excellent error correcting Performance close to the Shannon limit when decoded with the belief-propagation (BP) algorithm using soft-decision information.

## 3.4 Wear-Leveling

Flash memory can be erased within a limited number of times. This number is called the ***erase cycle limit*** or ***write endurance limit*** and is defined by the flash array vendor. The erase cycle limit applies to each individual erase block in the flash device.

Innodisk 2.5” SATA SSD 3TEB uses a static wear-leveling algorithm to ensure that consecutive writes of a specific sector are not written physically to the same page/block in the flash. This spreads flash media usage evenly across all pages, thereby extending flash lifetime.

## 3.5 Bad Blocks Management

Bad Blocks are blocks that contain one or more invalid bits whose reliability are not guaranteed. The Bad Blocks may be presented while the SSD is shipped, or may develop during the life time of the SSD. When the Bad Blocks is detected, it will be flagged, and not be used anymore. The SSD implement Bad Blocks management, Bad Blocks replacement, Error Correct Code to avoid data error occurred. The functions will be enabled automatically to transfer data from Bad Blocks to spare blocks, and correct error bit.

## 3.6 iData Guard

iData Guard is a comprehensive data protection mechanism that functions before and after a sudden power outage to SSD. Low-power detection terminates data writing before an abnormal power-off, while table-remapping after power-on deletes corrupt data and maintains data integrity. iData Guard provides effective power cycling management, preventing data stored in flash from degrading with use.

## 3.7 Garbage Collection/TRIM

Garbage collection and TRIM technology is used to maintain data consistency and perform continual data cleansing on SSDs. It runs as a background process, freeing up valuable controller resources while sorting good data into available blocks, and deleting bad blocks. It also significantly reduces write operations to the drive, thereby increasing the SSD’s speed and lifespan.

## 3.8 Trim

The Trim command is designed to enable the operating system to notify the SSD which pages no longer contain valid data due to erases either by the user or operating system itself. During a delete operation, the OS will mark the sectors as free for new data and send a Trim command to the SSD to mark them as not containing valid data. After that the SSD knows not to preserve the contents of the block when writing a page, resulting in less write amplification with fewer writes to the flash, higher write speed, and increased drive life.

## 3.9 iPower Guard

iPower Guard technology is a set of preventive measures that protect the SSD in an unstable power supply environment. This comprehensive package comprises safeguards for startup and shutdown to maintain device performance and ensure data integrity.

# 4. Installation Requirements

## 4.1 2.5” SATA SSD 3TEB Pin Directions

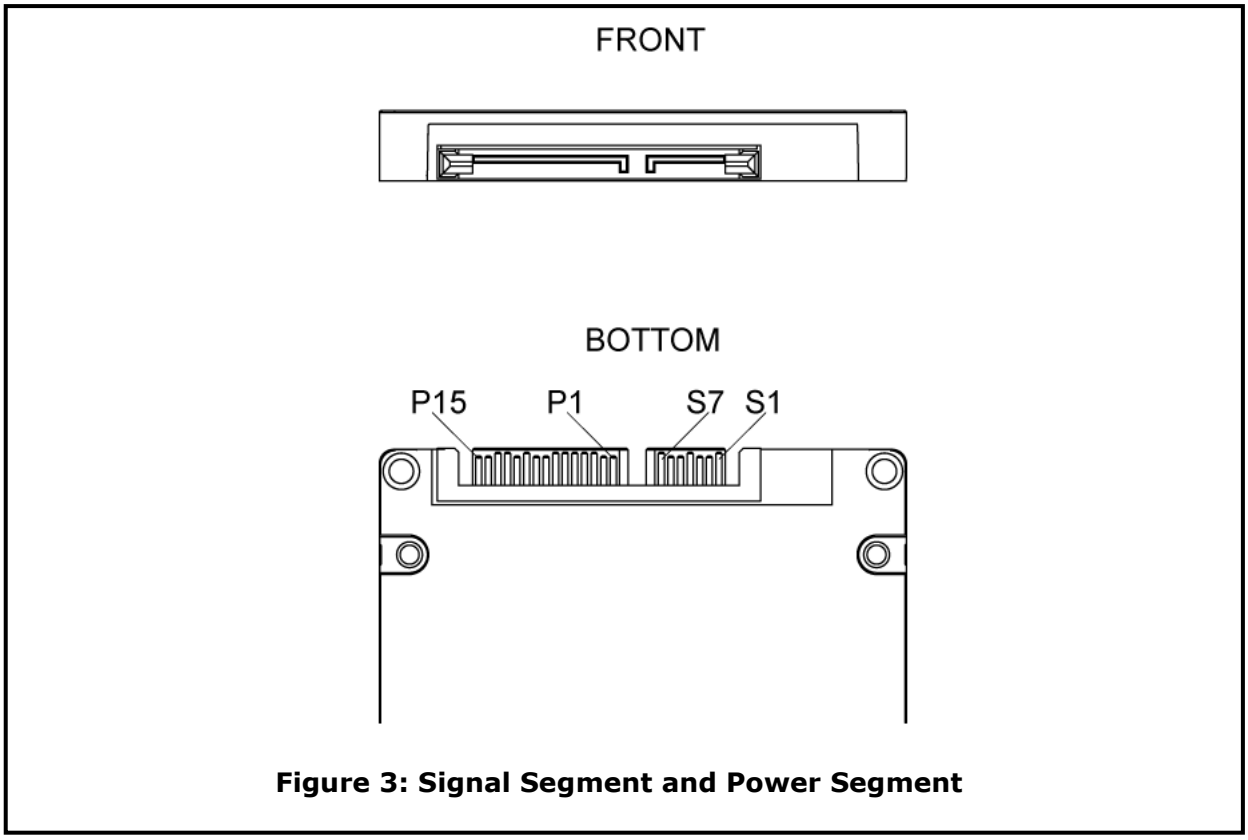



**Figure 3: Signal Segment and Power Segment**

## 4.2 Electrical Connections for 2.5” SATA SSD 3TEB

A Serial ATA device may be either directly connected to a host or connected to a host through an adaptor card. The SATA interface has a separate connector for the power supply. Please refer to the pin description for further details.

## 4.3 Form Factor

Please prepare following things:

- Screw driver.
- Four M3 screws. (Torque value 2.0 kgf-cm ~ 2.5 kgf-cm)
- SATA single cable (7-pin, Maximum length l meter).
- SATA power cable (15-pin).

Please turn off your computer, and open your computer’s case. Find one of available 2.5-inch slot, and plug the SSD in. To use the screws fix the SSD. Plug in the SATA single cable, and power cable.

Please boot the installation Operation System from CD-ROM, and install Operation System into

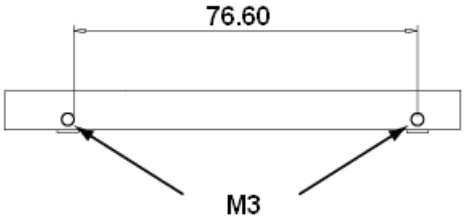



**Figure 4: 2.5” SATA SSD 3TEB Mechanical Screw Hole**

## 4.4 Device Drive

No additional device drives are required. Innodisk 2.5” SATA SSD 3TEB can be configured as a boot device.

# 5. SMART Feature Set

Innodisk 3TEB series support the SMART command set and defines some vendor-specific data to report SMART attributes of SSD.

**Table 10: SMART command**

| Value | Command | Value | Command |
|---|---|---|---|
| D0h | Read Data | D5h | Read Log |
| D1h | Read Attribute Threshold | D6h | Return Status |
| D2h | Enable/Disable Auto save | D8h | Enable SMART Operations |
| D3h | Save Attribute Values | D9h | Disable SMART Operations |
| D4h | Execute OFF-LINE Immediate | DAh | Return Status |

## 5.1 SMART Attributes

Innodisk 3TEB series SMART data attributes are listed in following table.

**Table 11: SMART attribute**

| Attribute ID (hex) | Raw Attribute Value | | | | | | | Attribute Name |
|---|---|---|---|---|---|---|---|---|
| 01 | MSB | 00 | 00 | 00 | 00 | 00 | 00 | Read error rate |
| 05 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Reallocated sectors count |
| 09 | LSB | | | MSB | 00 | 00 | 00 | Power on hours |
| 0C | LSB | | | MSB | 00 | 00 | 00 | Power cycle count |
| A0 | LSB | | | MSB | 00 | 00 | 00 | Online Uncorrectable sector count |
| A1 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Number of valid spare blocks |
| A3 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Number of initial invalid block |
| A4 | LSB | | | MSB | 00 | 00 | 00 | Total erase count |
| A5 | LSB | | | MSB | 00 | 00 | 00 | Max. erase count |
| A6 | LSB | | | MSB | 00 | 00 | 00 | Min. erase count |
| A7 | LSB | | | MSB | 00 | 00 | 00 | Average erase count |
| A9 | LSB | | | MSB | 00 | 00 | 00 | Remain Life (percentage) |
| B1 | LSB | | | MSB | 00 | 00 | 00 | Wearleveling count |
| B5 | LSB | | | MSB | 00 | 00 | 00 | Total program fail count |
| B6 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Total erase fail count |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| C0 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Sudden Power Count |
| C2 | MSB | 00 | 00 | 00 | 00 | 00 | 00 | Enclosure Temperature |
| C3 | LSB | | | MSB | 00 | 00 | 00 | Hardware ECC recovered |
| C6 | LSB | MSB | 00 | 00 | 00 | 00 | 00 | Uncorrectable error count Off Line |
| C7 | LSB | | | | | | MSB | Ultra DMA CRC Error Count |
| F1 | LSB | | | | | | MSB | Total LBA written(LBA=32MB) |
| F2 | LSB | | | | | | MSB | Total LBA read(LBA=32MB) |

# 6. Part Number Rule

| CODE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **D** | **E** | **S** | **2** | **5** | **-** | **A** | **2** | **8** | **I** | **C** | **1** | **K** | **C** | **C** | **D** | **L** | **-** | **X** | **X** | **X** |

| **Definition** | |
|---|---|
| **Code 1st (Disk)** | **Code 13th (Flash Mode)** |
| D : Disk | K: 112 layers 3D TLC |
| | |
| **Code 2nd ~ 5th (Form Factor)** | **Code 14th (Operation Temperature)** |
| ES25: 2.5” SATA SSD | C: Standard Grade (0℃~ +70℃) |
| | |
| **Code 7th ~9th (Capacity)** | **Code 15th (Internal control)** |
| 64G: 64GB | C: Slim PCBA version |
| A28: 128GB | |
| B56: 256GB | |
| C12: 512GB | **Code 16th (Channel of data transfer)** |
| 01T: 1TB | S: Single Channel |
| | D: Dual Channels |
| **Code 10th ~12th (Controller)** | **Code 17th (Flash Type)** |
| IC1: SATA 3TEB | L: Innodisk 3D TLC |
| | **Code 19th~21th (Customized Code)** |
| | |