innodisk

Total Solution For
Industrial Flash Storage

2.5" SATA SSD

3TE7 Series

Customer: _____

Customer Part Number: _____

Innodisk Part Number: _____

Innodisk Model Name: _____

Date: _____

Innodisk Approver	Customer Approver

Features:

- SATA III
- Kioxia 3D TLC NAND
- 2.5” SATA SSD
- Standard & Wide-temperature
- iPower Guard
- iData Guard
- Dynamic Thermal Management
- Hybrid Write

Performance:

- Sequential Read up to 550 MB/s
- Sequential Write up to 520 MB/s

Power Requirements:

Input Voltage:	5V±5%
Max Operating Wattage:	2.1W
Idle Wattage:	1.0W

Reliability:

Capacity	TBW	DWPD
32GB	37	1.08
64GB	75	1.09
128GB	150	1.09
256GB	300	1.09
512GB	600	1.09
1TB	1200	1.09
2TB	2400	1.09

Data Retention	10 Years
Warranty	3 Years

For warranty details, please refer to:

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

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Revision History

Revision	Description	Date
Preliminary	First Released	June, 2018
Preliminary0.1	Revised Device parameters (LBA)	Sep.,2018
Rev 1.0	Update TBW information	Nov., 2018
Rev 1.1	Update Mechanical Dimensions	Jan., 2019
Rev 1.2	Update Power Consumption Test Result	Jan., 2019
Rev 1.3	Update Random Read/Write Result Update Power Consumption Test Result	Feb., 2019
Rev 1.4	Update Performance Update Trim Function Description	Apr., 2019
Rev 1.5	Update Power Consumption Test Result	May, 2019
Rev 1.6	Update Assembly Torque Information	Aug., 2019
Rev 1.7	Add SMART Feature Set	Sep., 2019
Rev 1.8	Add 64 Layers & 96 Layers 3D TLC Information	Oct., 2020
Rev 1.9	Modify 2TB information & TBW Information	Dec., 2020
Rev 2.0	Add 112L 3D TLC Information	Jul., 2021
Rev 2.1	Update Data Retention	Dec., 2021
Rev 2.2	Add 112 Layers 3D TLC wide temperature	Jul., 2022
Rev 2.3	Update Performance	Aug., 2022
Rev 2.4	Update Boot Up Power Consumption	Dec., 2023

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1. Product Overview

1.1 Introduction of Innodisk 2.5” SATA SSD 3TE7.

Innodisk 2.5” SATA SSD 3TE7 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 4CH standard by cost effective controller with 4CH.

With Innodisk L^3 FW architecture, combining our signature 4K mapping algorithm L^2 FW architecture with powerful LDPC technology, 3TE7 series has outstanding high IOPS, better data integrity and extended lifespan through reducing the bad block number happening.

For real industrial application, 3TE7 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 3TE7 is available in follow capacities within TLC flash ICs.

2.5” SATA SSD 3TE7 32GB
2.5” SATA SSD 3TE7 64GB
2.5” SATA SSD 3TE7 128GB
2.5” SATA SSD 3TE7 256GB
2.5” SATA SSD 3TE7 512GB
2.5” SATA SSD 3TE7 1TB
2.5” SATA SSD 3TE7 2TB

Figure 1: Innodisk 2.5” SATA SSD 3TE7

1.3 SATA Interface

Innodisk2.5” SATA SSD 3TE7 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 3TE7 device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	Cylinders	Heads	Sectors	LBA	User Capacity(MB)
32GB	16383	16	63	53742528	26241
64GB	16383	16	63	117231408	57241
				107463888(112-L)	52473
128GB	16383	16	63	234441648	114473
256GB	16383	16	63	468862128	228936
512GB	16383	16	63	937703088	457862
1TB	16383	16	63	1875385008	915715
2TB	16383	16	63	3750748848	1831420

Note: User capacity is different because of the Die RAID function.

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance - 64 Layers 3D TLC[1]

Capacity	Unit	32GB	64GB	128GB	256GB	512GB	1TB
Sequential** Read (Q32T1)	MB/s	180	350	550	550	560	550
Sequential** Write (Q32T1)		35	70	150	290	330	340
4KB Random** Read (Q32T1)	IOPS	12,000	22,000	44,000	77,000	83,000	80,000
4KB Random** Write (Q32T1)		9,000	18,000	36,000	67,000	74,000	71,000

Note:

*. Sequential performance is based on CrystalDiskMark 5.1.2 with file size 1000MB

**. Random performance is based on IO meter with Queue Depth 32

Table 3: Performance - 96 Layers 3D TLC[1]

Capacity	Unit	128GB	256GB	512GB	1TB	2TB
Sequential** Read (Q32T1)	MB/s	430	550	550	550	540
Sequential** Write (Q32T1)		210	440	510	490	500
Sustained*** Sequential Read (Avg.)		320	390	390	390	390
Sustained*** Sequential Write (Avg.)		70	140	280	310	310
4KB Random** Read (Q32T1)	IOPS	38,000	74,000	82,000	82,000	80,000
4KB Random** Write (Q32T1)		26,000	38,000	70,000	74,000	66,000

Note:

*. Performance results are 3TE7 with Kioxia BiCS4 NAND composition measured in Room Temperature with Out-of-Box devices and may vary depending on overall system setup. In addition, 3TE7 series adopt hybrid mode whicj enables SLC cache followed by TLC direct write to strike balance between burst performance and steady overall stability.

**. Performance results are based on CrystalDiskMark 6.0.2 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.

Table 4: Performance - 112 Layers 3D TLC[1]

Capacity	Unit	64GB	128GB	256GB	512GB	1TB	2TB
Sequential** Read (Q32T1)	MB/s	270	440	560	550	550	550
Sequential** Write (Q32T1)		160	290	500	510	520	520
Sustained*** Sequential Read (Avg.)		220	350	420	420	420	420
Sustained*** Sequential Write (Avg.)		40	80	170	310	320	320
4KB Random** Read (Q32T1)	IOPS	24,000	43,000	81,000	83,000	82,000	82,000
4KB Random** Write (Q32T1)		14,000	21,000	41,000	73,000	74,000	74,000

Note:

*. Performance results are 3TE7 with Kioxia BiCS5 NAND composition measured in Room Temperature with Out-of-Box devices and may vary depending on overall system setup. In addition, 3TE7 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 6.0.2 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 5: Innodisk 2.5” SATA SSD 3TE7 Power Requirement

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

2.3.2 Power Consumption

Table 6: Typical Power Consumption

Mode	Power Consumption (W)
Read (RMS)[1]	2.1
Write (RMS)[1]	2.0
Idle	1.0
Boot Up	5.5

* Target: 2.5” SATA SSD 3TE7 2TB

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 7: Temperature range for 2.5” SATA SSD 3TE7

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

2.4.2 Humidity

Relative Humidity: 10-95%, non-condensing

2.4.3 Shock and Vibration

Table 8: Shock/Vibration Testing for 2.5” SATA SSD 3TE7

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 3TE7 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 9: 2.5” SATA SSD 3TE7 MTBF

Product	Condition	MTBF (Hours)
Innodisk 2.5” SATA SSD 3TE7	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

2.5” SATA SSD 3TE7 conforms to CE and FCC requirements.

2.6 RoHS Compliance

2.5” SATA SSD 3TE7 is fully compliant with RoHS directive.

2.7 Reliability

Table 10: 2.5” SATA SSD 3TE7 TBW

Parameter	Value	
Flash endurance	3,000 P/E cycles	
Error Correct Code	Support	
Data Retention	Under 40℃: 10 Years at Initial NAND Status; 1 Year at NAND Life End	
TBW* (Total Bytes Written) Units: TB		
Capacity	**Sequential workload**	**Client workload**
32GB	85	37.5
64GB	170	75
128GB	341	150
256GB	682	300
512GB	1364	600

1TB	2727	1200
2TB	5455	2400

* 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. (The capacity lower than 64GB client workload is not specified in JEDEC219A, the values are estimated.)
3. Based on out-of-box performance.

2.8 Transfer Mode

2.5” SATA SSD 3TE7 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 3TE7 uses a standard SATA pin-out.

See following table for 2.5” SATA SSD 3TE7 pin assignment.

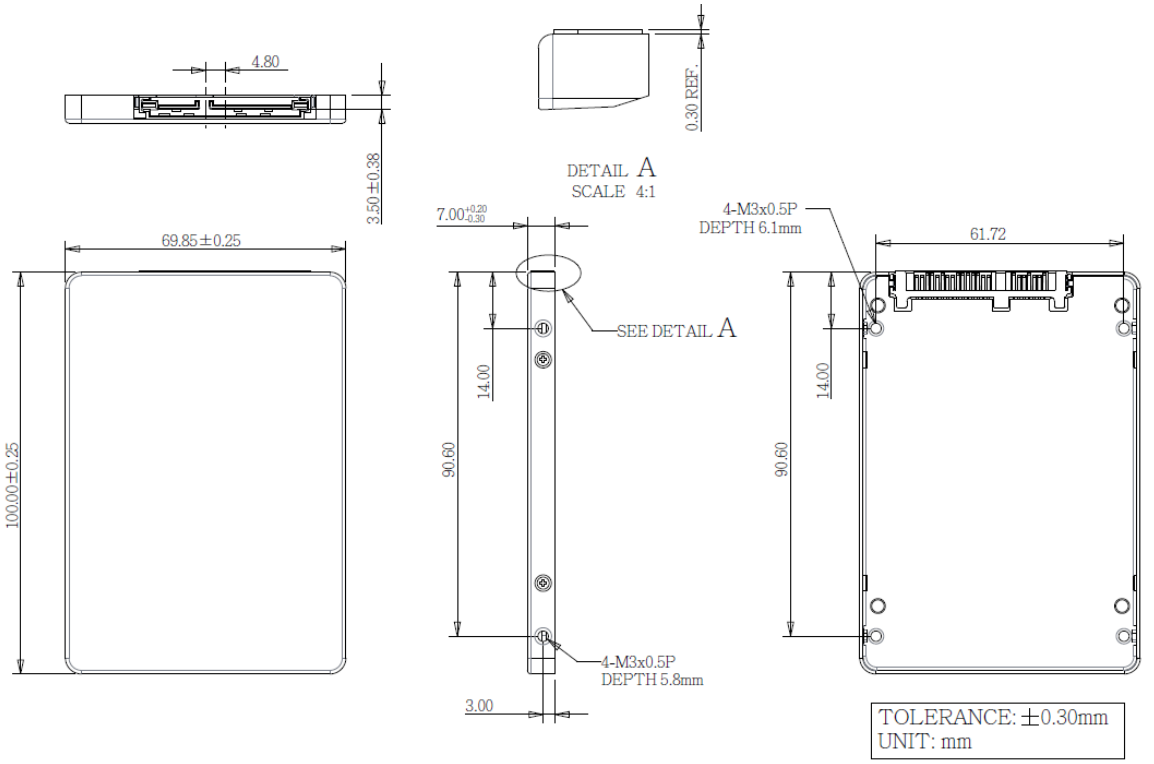
Table 11: Innodisk 2.5” SATA SSD 3TE7 Pin Assignment

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

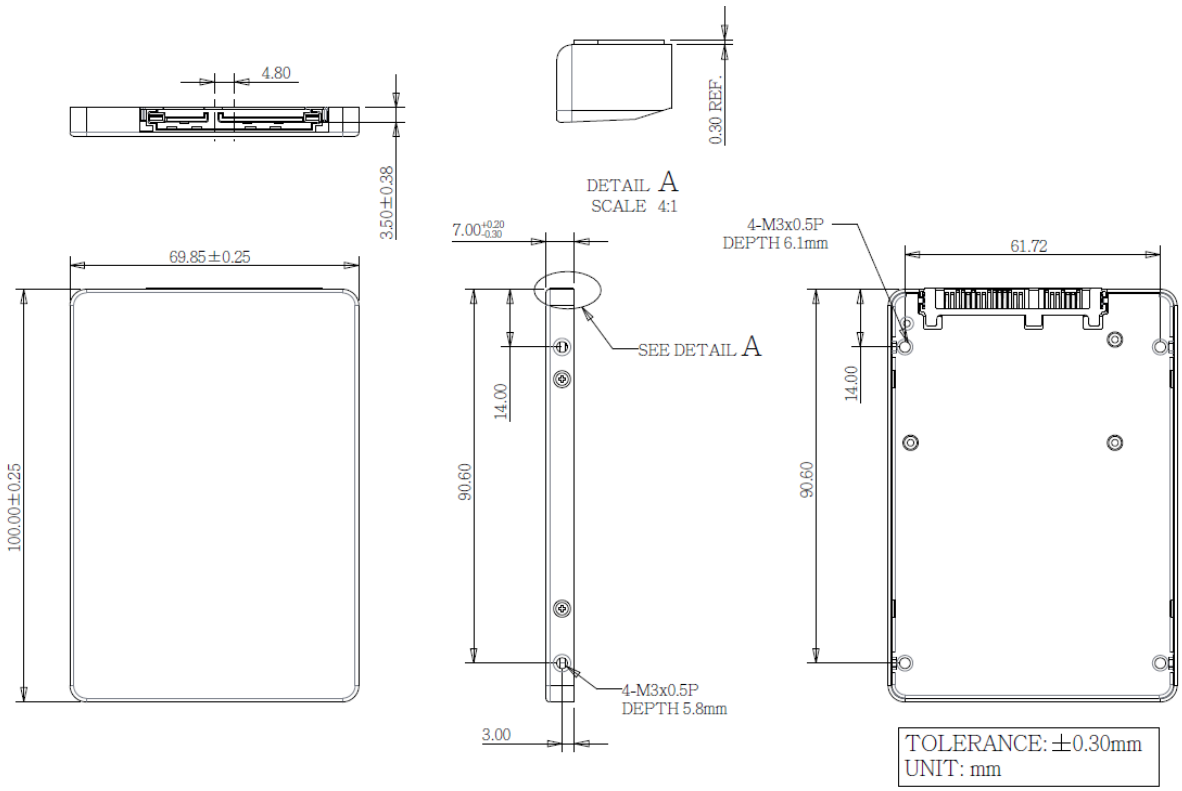
P10	GND	NA
P11	DAS/DSS	Device Activity Signal / Disable Staggered
P12	GND	NA
P13	NC	NA
P14	NC	NA
P15	NC	NA

2.10 Mechanical Dimensions

* Full PCB- DES25-XXXDK1XX%XF (% = 1 or A)



* Slim inside- DES25-XXXDK1XX%XF (% = 3 or C)



2.11 Assembly Weight

An Innodisk 2.5” SATA SSD 3TE7 within flash ICs, 2TB’s weight is 60 grams approximately.

2.12 Seek Time

Innodisk2.5” SATA SSD 3TE7 is not a magnetic rotating design. There is no seek or rotational latency required.

2.13 NAND Flash Memory

Innodisk 2.5” SATA SSD 3TE7 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 3TE7 from the system level, including the major hardware blocks.

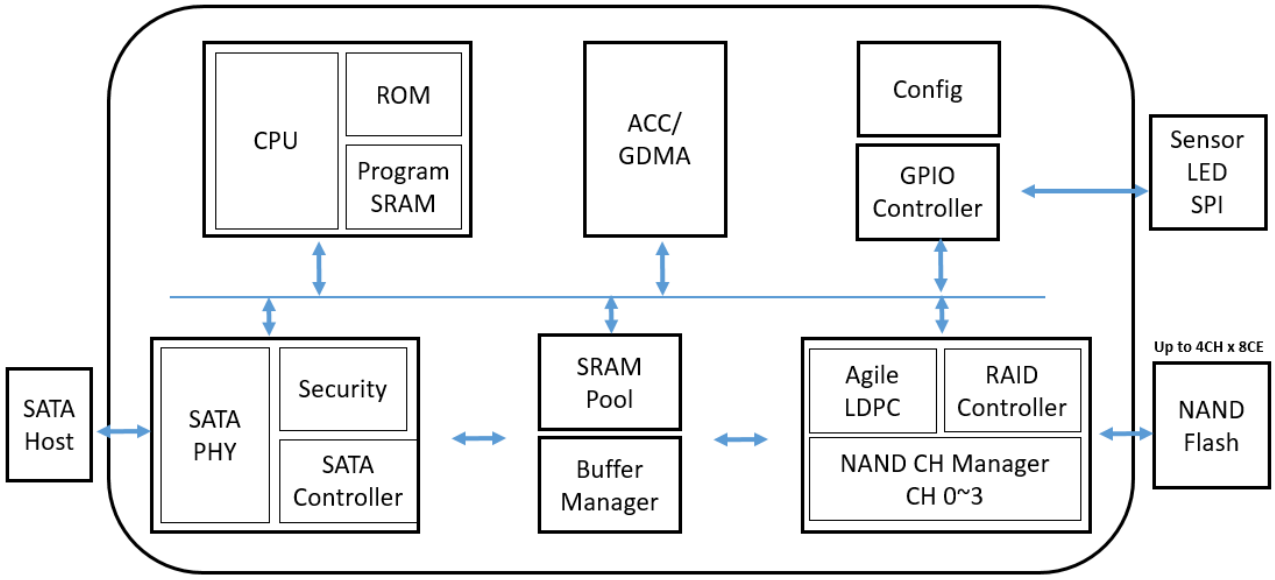


Figure 2: Innodisk 2.5” SATA SSD 3TE7 Block Diagram

Innodisk 2.5” SATA SSD 3TE7 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 3TE7 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 4 channels for flash interface.

3.3 Error Detection and Correction

Innodisk2.5” SATA SSD 3TE7 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 3TE7 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.

3.10 Die RAID

Die RAID is a controller function which leveraged user capacity to back up the data in NAND flash. Die RAID supported can ensure the user data in the NAND Flash more consistent in certain scenario. Innodisk 2.5” SATA SSD 3TE7 series is default enable the Die RAID function for the industrial application.

3.11 SLC cache

Table 12: 2.5” SATA SSD 3TE7 SLC cache

Capacity	64GB	128GB	256GB	512GB	1TB	2TB
SLC cache (GB)	3	3	5	9	18	36
SLC cache (%)	4.6	2.3	1.9	1.7	1.7	1.7

3TE7 series adopt hybrid mode which enables SLC Cache up to 3% of total user capacity by TLC direct write to strike balance between burst performance and steady overall stability.

3.12 Thermal Throttling

Thermal throttling is a protective mechanism designed to safeguard components from potential damage caused by excessive temperatures. When an SSD approaches a critical temperature threshold, Innodisk firmware activates the thermal throttling mechanism to regulate the SSD's temperature. Thermal throttling is crucial for SSDs since it prevents drive damage, which could otherwise result in data loss. However, it's worth noting that when thermal throttling is activated, read and write tasks may experience a reduction in speed.

4. Installation Requirements

4.1 2.5” SATA SSD 3TE7 Pin Directions

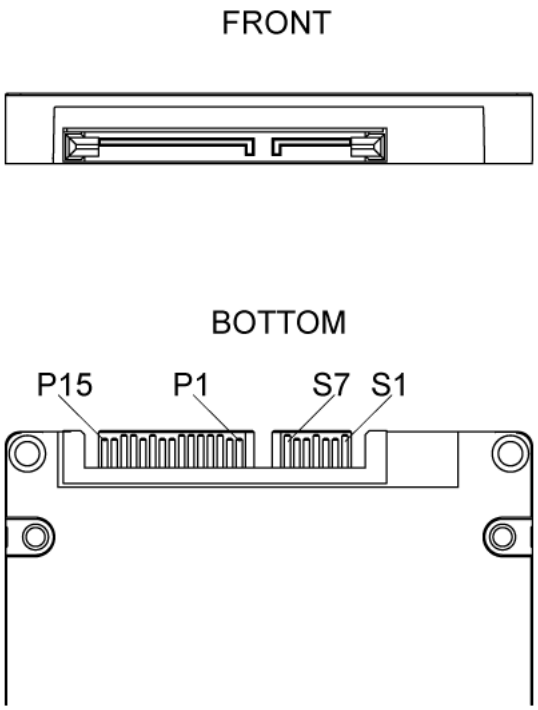


Figure 3: Signal Segment and Power Segment

4.2 Electrical Connections for 2.5” SATA SSD 3TE7

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 SSD.

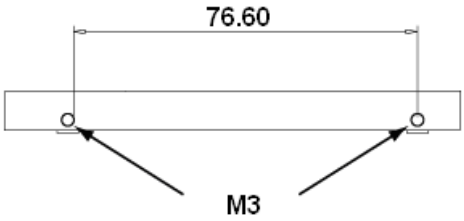


Figure 4: 2.5” SATA SSD 3TE7 Mechanical Screw Hole

4.4 Device Drive

No additional device drives are required. Innodisk 2.5” SATA SSD 3TE7 can be configured as a boot device.

5. SMART Feature Set

Innodisk 3TE7 series support the SMART command set and defines some vendor-specific data to report SMART attributes of SSD.

Table 13: 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 3TE7 series SMART data attributes are listed in following table.

Table 14: SMART attribute

Attribute ID (hex)	Value	Raw Attribute Value						Rsv	Attribute Name
05	X	LSB	MSB	00	00	00	00	00	Later Bad
09	LSB	LSB	MSB	00	00	00	00	00	Power-On hours Count
0C	LSB	LSB	MSB	00	00	00	00	00	Drive Power Cycle Count
A3	X	LSB			MSB	00	00	00	Total Bad Block Count
A5	LSB	LSB			MSB	00	00	00	Max Erase count
A7	LSB	LSB			MSB	00	00	00	Avg Erase count
A9	LSB	LSB	00	00	00	00	00	00	Device Life
AA	X	LSB	MSB	00	00	00	00	00	Spare Block Count
AB	LSB	LSB	MSB	00	00	00	00	00	Program fail count
AC	LSB	LSB	MSB	00	00	00	00	00	Erase fail count
C0	LSB	LSB	MSB	00	00	00	00	00	Unexpected Power Loss Count
C2	LSB			MIN		MAX	00	00	Temperature

E5		ID 0	ID 1	ID 2	ID 3	ID 4	ID 5		Flash ID
EB			**MSB**	**LSB**	**MSB**	**LSB**	**MSB**	**LSB**	Later bad block info (**Read**/**Write**/**Erase**)
F1	00	LSB			MSB	00	00	00	Total LBA written(LBA=32MB)
F2	00	LSB			MSB	00	00	00	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**	**-**	**0**	**2**	**T**	**D**	**K**	**1**	**K**	**C**	**C**	**Q**	**F**	**-**	**X**	**X**	**X**

Definition	
Code 1st (Disk)	**Code 13th (Flash Mode)**
D : Disk	E: 64 layers 3D TLC
	G: 96 layers 3D TLC
	K: 112 layers 3D TLC
Code 2nd ~ 5th (Form Factor)	**Code 14th (Operation Temperature)**
ES25: 2.5” SATA SSD	C: Standard Grade (0℃~ +70℃)
	W: Industrial Grade (-40℃~ +85℃)
Code 7th ~9th (Capacity)	**Code 15th (Internal control)**
32G: 32GB	1/A: Full size PCBA version
64G: 64GB	3/C: Slim PCBA version
A28: 128GB	**Code 16th (Channel of data transfer)**
B56: 256GB	S: Single Channel
C12: 512GB	D: Dual Channels
01T: 1TB	Q: Quad Channels
02T: 2TB	**Code 17th (Flash Type)**
Code 10th ~12th (Controller)	F: Kioxia 3D TLC
DK1: SATA 3TE7	**Code 19th~21th (Customized Code)**