

M.2 (S42)

3TE7 Series

Customer:

Customer

Part Number:

Innodisk

Part Number:

Innodisk

Model Name:

Date:

Innodisk Approver	Customer Approver

Total Solution For
Industrial Flash Storage

Features:

- SATA III
- Kioxia 3D TLC NAND
- M.2 2242-D2-B+M
- 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:	3.3V±5%
Max Operating Wattage:	1.7W
Idle Wattage:	0.8W

Reliability:

Capacity	TBW (Client)	DWPD (Client)
32GB	37	1.08
64GB	75	1.09
128GB	150	1.09
256GB	300	1.09
512GB	600	1.09
1TB	1200	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
V1.0	First Released	Feb. 2019
V1.1	Edited TRIM description & User Capacity	Apr. 2019
V1.2	Update Power Consumption	Oct., 2019
V1.3	Correct Controller Description	Feb., 2020
V1.4	Update Part number rule Description	Aug., 2020
V1.5	Update product picture and performance	Dec., 2020
V1.6	Add Kioxia 96 Layers 3D TLC	May., 2021
V1.7	Add Kioxia 112 Layers 3D TLC	Dec., 2021
V1.8	Add Kioxia 112 Layers 3D TLC wide temperature	Jul., 2022
V1.9	Update Performance	Aug., 2022
V2.0	Update boot-up power consumption	Dec., 2023

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1. Product Overview

1.1 Introduction of Innodisk M.2 (S42) 3TE7

Innodisk M.2 (S42) 3TE7 is characterized by L³ architecture with the latest SATA III (6.0GHz) Marvell NAND controller. Innodisk's exclusive L³ architecture is L² architecture multiplied LDPC (Low Density Parity Check). L² (Long Life) architecture is a 4K mapping algorithm that reduces WAF and features a real-time wear leveling algorithm to provide high performance and prolong lifespan with exceptional reliability. Innodisk M.2 (S42) 3TE7 is designed for industrial field, and supports several standard features, including TRIM, NCQ, and S.M.A.R.T. In addition, Innodisk's exclusive industrial-oriented firmware provides a flexible customization service, making it perfect for a variety of industrial applications.

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 M.2 (S42) 3TE7 is available in follow capacities within 3D TLC flash ICs.

M.2 (S42) 3TE7 32GB

M.2 (S42) 3TE7 64GB

M.2 (S42) 3TE7 128GB

M.2 (S42) 3TE7 256GB

M.2 (S42) 3TE7 512GB

M.2 (S42) 3TE7 1TB

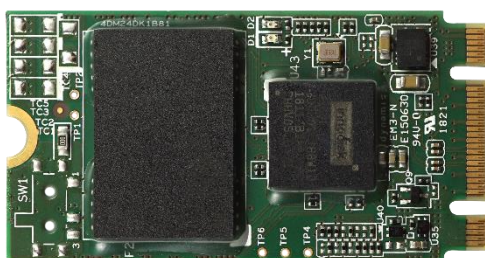


Figure 1: Innodisk M.2 (S42) 3TE7 (type 2242)

1.3 SATA Interface

Innodisk M.2 (S42) 3TE7 supports SATA III interface, and compliant with SATA I and SATA II. SATA III interface can work with Serial Attached SCSI (SAS) host system, which is used in server computer. Innodisk M.2 (S42) 3TE7 is compliant with Serial ATA Gen 1, Gen 2 and Gen 3 specification (Gen 3 supports 1.5Gbps /3.0Gbps/6.0Gbps data rate).

2. Product Specifications

2.1 Capacity and Device Parameters

M.2 (S42) 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

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

Capacity	Unit	32GB	64GB	128GB	256GB	512GB	1TB
Sequential* Read (Q32T1)	MB/s	170	350	540	540	550	510
Sequential* Write (Q32T1)		35	70	140	290	330	330
4KB Random** Read (QD32)	IOPS	11,800	22,800	43,400	74,800	81,600	80,000
4KB Random** Write (QD32)		9,100	18,400	36,300	67,300	74,300	70,000

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

Capacity	Unit	128GB	256GB	512GB	1TB
Sequential** Read (Q32T1)	MB/s	440	550	560	550
Sequential** Write (Q32T1)		300	480	490	520
Sustained*** Sequential Read (Avg.)		330	400	400	400
Sustained*** Sequential Write (Avg.)		80	150	290	320
4KB Random** Read (QD32)	IOPS	39,000	75,000	83,000	83,000
4KB Random** Write (QD32)		20,000	38,000	71,000	73,000

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 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.

Table 4 Performance - 112 Layers 3D TLC

Capacity	Unit	64GB	128GB	256GB	512GB	1TB
Sequential** Read (Q32T1)	MB/s	270	440	550	550	550
Sequential** Write (Q32T1)		160	290	510	510	450
Sustained*** Sequential Read (Avg.)		220	350	420	420	400
Sustained*** Sequential Write (Avg.)		40	80	170	310	270
4KB Random** Read (QD32)	IOPS	24,000	43,000	81,000	83,000	83,000
4KB Random** Write (QD32)		14,000	22,000	42,000	75,000	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 M.2 (S42) 3TE7 Power Requirement

Item	Symbol	Rating	Unit
Input voltage	V _{IN}	+3.3 DC +- 5%	V

2.3.2 Power Consumption

Table 6 Typical Power Consumption

Mode	Power Consumption (W)
Read	1.5
Write	1.7
Idle	0.8
Boot-Up Peak	3.1

Target: M.2 (S42) 3TE7

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 7: Temperature range for M.2 (S42) 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 M.2 (S42) 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
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2.4.4 Mean Time between Failures (MTBF)

Table 7 summarizes the MTBF prediction results for various M.2 (S42) 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: M.2 (S42) 3TE7 MTBF

Product	Condition	MTBF (Hours)
Innodisk M.2 (S42) 3TE7	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

M.2 (S42) 3TE7 conforms to CE and FCC requirements.

2.6 RoHS Compliance

M.2 (S42) 3TE7 is fully compliant with RoHS directive.

2.7 Reliability

Table 10: M.2 (S42) 3TE7 TBW

Parameter	Value	
Flash endurance	3,000 P/E cycles	
Error Correct Code	Support	
Data Retention	Under 40 C: 10 Years at Initial NAND Status; 1 Year at NAND Life End	
TBW* (Total Bytes Written) Unit: TB		
Capacity	Sequential workload	Client workload
32GB	85	38
64GB	170	75
128GB	341	150
256GB	682	300
512GB	1364	600
1TB	2727	1200
* Note:		
1. Sequential: Mainly sequential write, tested 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

M.2 (S42) 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 M.2 (S42) 3TE7 uses a standard SATA pin-out.

See following table for M.2 (S42) 3TE7 pin assignment.

Table 11: Innodisk M.2 (S42) 3TE7 Pin Assignment

Signal Name	Pin #	Pin #	Signal Name
		75	GND
3.3V	74	73	GND
3.3V	72	71	GND
3.3V	70	69	GND
NC	68	67	NC
Notch	66	65	Notch
Notch	64	63	Notch
Notch	62	61	Notch
Notch	60	59	Notch
NC	58		
NC	56	57	GND
NC	54	55	NC
NC	52	53	NC
NC	50	51	GND
NC	48	49	RX+
NC	46	47	RX-
NC	44	45	GND
NC	42	43	TX-
NC	40	41	TX+
DEVSLP	38	39	GND
NC	36	37	NC
NC	34	35	NC
NC	32	33	GND

NC	30	31	NC
NC	28	29	NC
NC	26	27	GND
NC	24	25	NC
NC	22	23	NC
NC	20	21	GND
Notch	18	19	Notch
Notch	16	17	Notch
Notch	14	15	Notch
Notch	12	13	Notch
DAS/DSS	10	11	NC
NC	8	9	NC
NC	6	7	NC
3.3V	4	5	NC
3.3V	2	3	GND
		1	GND

2.10 Mechanical Dimensions

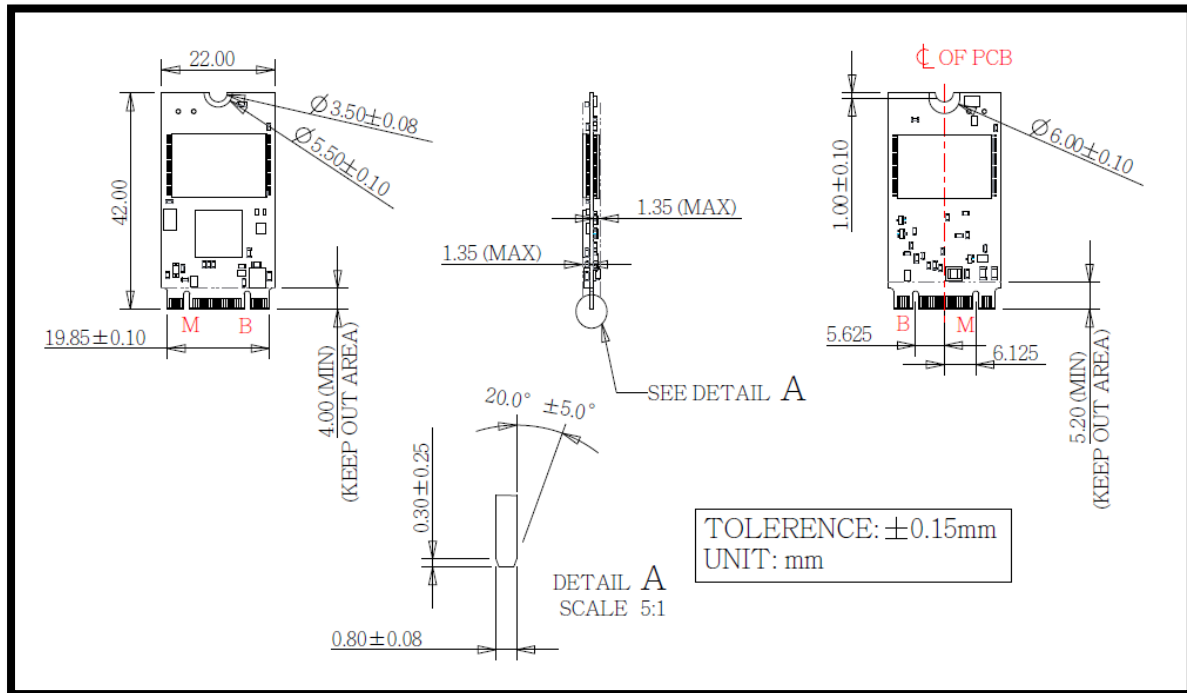


Figure 2: Innodisk M.2 (S42) 3TE7 diagram (TSOP)

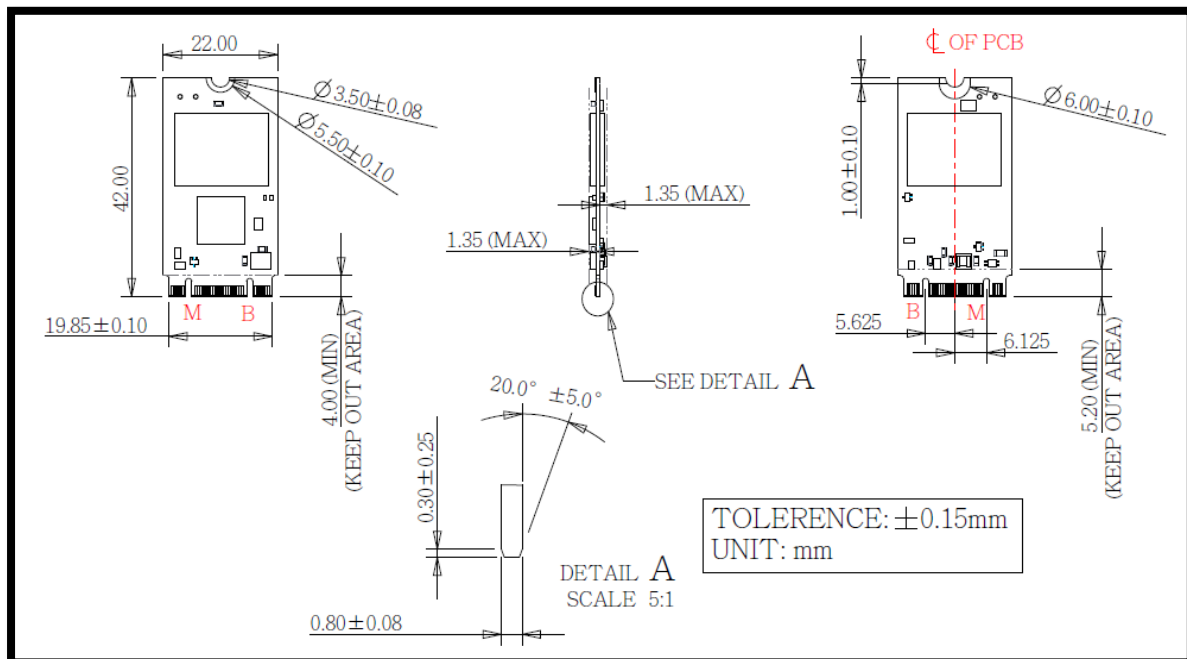


Figure 3: Innodisk M.2 (S42) 3TE7 diagram (BGA)

2.11 Assembly Weight

An Innodisk M.2 (S42) 3TE7 within flash ICs, 64GB's weight is 8 grams approximately.

2.12 Seek Time

Innodisk M.2 (S42) 3TE7 is not a magnetic rotating design. There is no seek or rotational latency required.

2.13 Hot Plug

The SSD support hot plug function and can be removed or plugged-in during operation. User has to avoid hot plugging the SSD which is configured as boot device and installed operation system.

Surprise hot plug : The insertion of a SATA device into a backplane (combine signal and power) that has power present. The device powers up and initiates an OOB sequence.

Surprise hot removal: The removal of a SATA device from a powered backplane, without first being placed in a quiescent state.

2.14 NAND Flash Memory

Innodisk M.2 (S42) 3TE7 uses 3D Triple Level Cell (TLC) NAND flash memory, which is non-volatility, high reliability and high speed memory storage.

3. Theory of Operation

3.1 Overview

Figure 4 shows the operation of Innodisk M.2 (S42) 3TE7 from the system level, including the major hardware blocks.

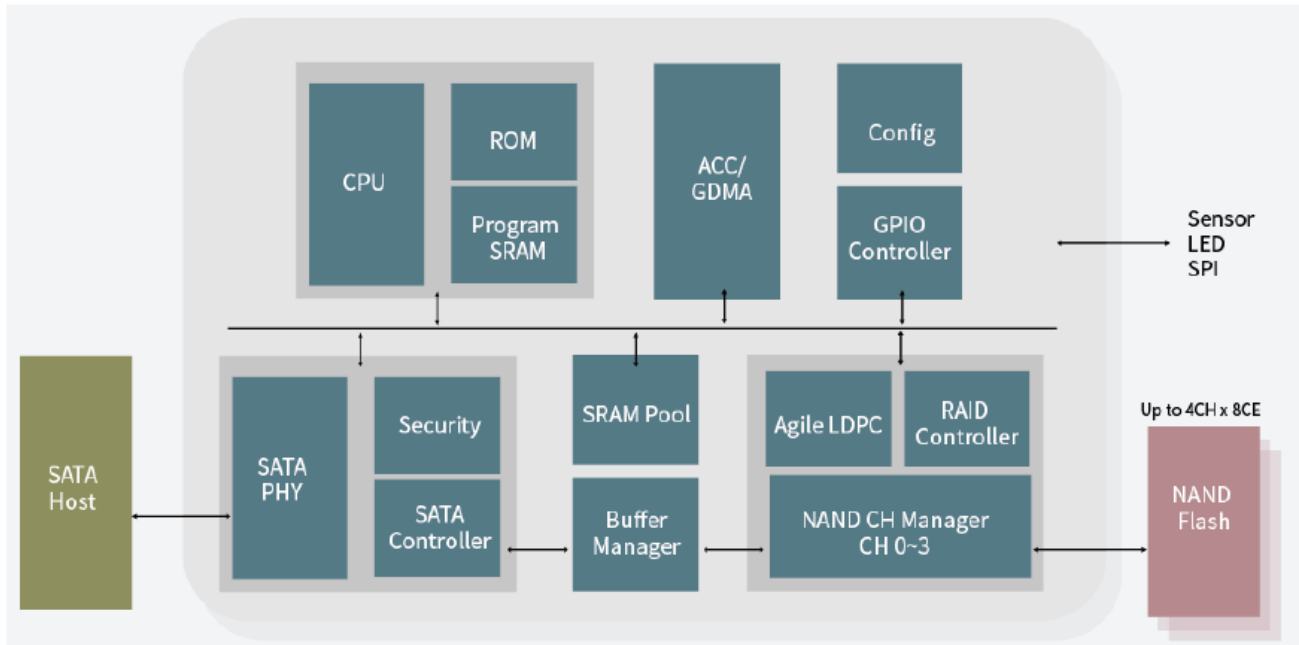


Figure 4: Innodisk M.2 (S42) 3TE7 Block Diagram

Innodisk M.2 (S42) 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 M.2 (S42) 3TE7 is designed with SATA III 6.0Gbps (Gen. 3) Controller, 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 2 channels for flash interface.

3.3 Error Detection and Correction

Innodisk 2.5" 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 M.2 (S42) 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

Garbage collection 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 M.2 (S42) 3TE7 series is default enable the Die RAID function for the industrial application.

3.11 SLC cache

Table 12: M.2 (S42) 3TE7 SLC cache

Capacity	64GB	128GB	256GB	512GB	1TB
SLC cache (GB)	3	3	5	9	18
SLC cache (%)	4.6	2.3	1.9	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 M.2 (S42) 3TE7 Pin Directions

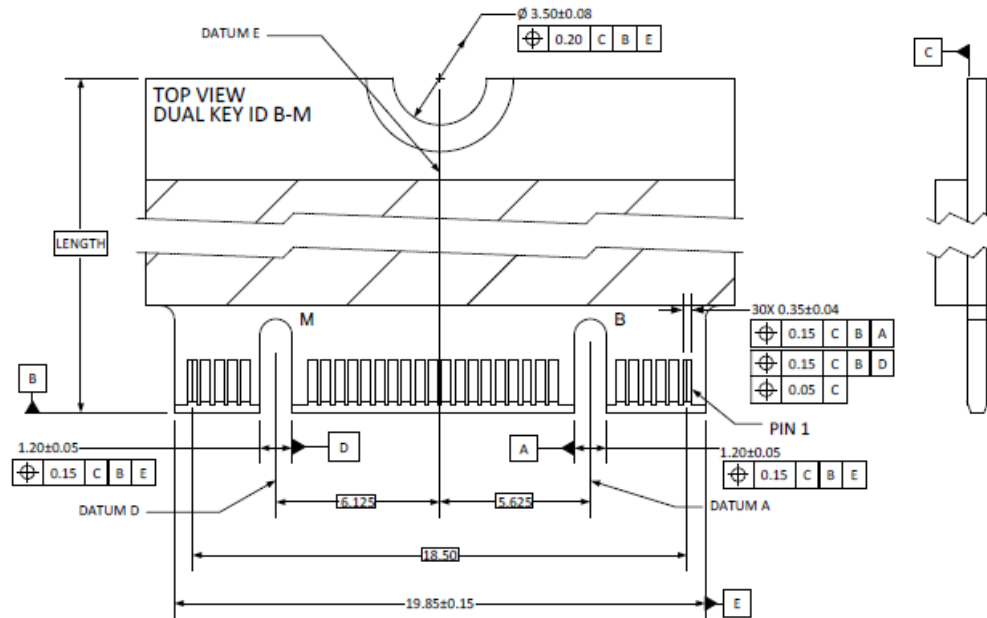


Figure 5: Signal Segment and Power Segment

4.2 Electrical Connections for M.2 (S42) 3TE7

A Serial ATA device may be either directly connected to a host or connected to a host through a cable. For connection via cable, the cable should be no longer than 1meter. The SATA interface has a separate connector for the power supply. Please refer to the pin description for further details.

4.3 Device Drive

No additional device drives are required. The Innodisk M.2 (S42) 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	M	2	4	-	3	2	G	D	K	1	E	C	1	D	F	-	X	X	X
Definition																					
Code 1 st (Disk)											Code 14 th (Operation Temperature)										
D : Disk											C: Standard Grade (0℃~ +70℃)										
Code 2 nd (Feature set)											W: Industrial Grade (-40℃~ +85℃)										
E : Embedded series																					
Code 3 rd ~5 th (Form factor)											Code 15 th (Internal control)										
M24: M.2 Type 2242-D2-B-M											1~9 、 A~Z: PCB version.										
Code 7 th ~9 th (Capacity)											Code 16 th (Channel of data transfer)										
32G: 32GB		64G: 64GB				A28: 128GB					S: Single Channel										
B56: 256GB		C12: 512GB				01T: 1TB					D: Dual Channels										
											Q: Quad Channels										
Code 10 th ~12 th (Controller)											Code 17 th (Flash Type)										
DK1: SATA 3TE7											F: Kioxia 3D TLC										
Code 13 th (Flash mode)											Code 19 th ~21 st (Customize code)										
E: 64 layers 3D TLC																					
G: 96 layers 3D TLC																					
K: 112 layers 3D TLC																					