innodisk

Total Solution For
Industrial Flash Storage

M.2 (P42)

3TE4 B+M Key Series

Customer: _____

Customer Part Number: _____

Innodisk Part Number: _____

Innodisk Model Name: _____

Date: _____

Innodisk Approver	Customer Approver

Features:

- PCIe Gen.3 x 2, NVMe SSD
- Kioxia 3D TLC NAND
- Standard & Wide-temperature for 112 Layers NAND
- With iPower Guard Design
- Thermal Management
- Hybrid Write Mode with SLC Cache Enable

Performance:

- Sequential Read up to 1,750 MB/s
- Sequential Write up to 1,400 MB/s

Power Requirements:

Input Voltage:	3.3V±5%
Max Operating Wattage:	3.3W
Idle Wattage:	0.6W

Reliability:

Capacity	TBW	DWPD
128GB	162.5	1.35
256GB	325	1.35
512GB	650	1.35

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
1.0	First Release	Jan., 2024
1.1	Revised Pin Assignment	Mar., 2024
1.2	Add 128GB	Mar., 2024

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1. Product Overview

1.1 Introduction of Innodisk M.2 (P42) 3TE4 B+M Key

Innodisk M.2 (P42) 3TE4 B+M Key is a NVM Express DRAM-less SSD designed with PCIe interface and industrial 3D TLC NAND Flash. M.2 (P42) 3TE4 B+M Key supports PCIe Gen III x 2 and it is compliant with NVM 1.3 providing excellent top and also sustained performance. With sophisticated error detection and correction (ECC) functions, the module can ensure full End-to-End data path protection that secures the data transmission between host system and NAND Flash.

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 (P42) 3TE4 B+M Key is available in follow capacities with industrial 3D TLC flash ICs.

M.2 (P42) 3TE4 128GB

M.2 (P42) 3TE4 256GB

M.2 (P42) 3TE4 512GB

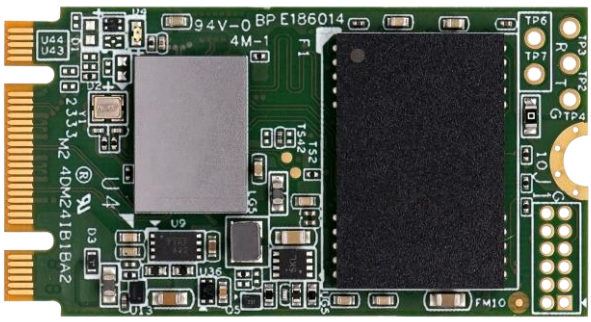

Figure 1: Innodisk M.2 (P42) 3TE4 B+M Key

1.3 PCIe Interface

Innodisk M.2 (P42) 3TE4 B+M Key supports PCIe Gen III interface and compliant with NVMe 1.3. M.2 (P42) 3TE4 can work under PCIe Gen 1, Gen 2 and Gen 3.

Most of operating system includes NVMe in-box driver now. For more information about the driver support in each OS, please visit https://nvmexpress.org/drivers/.

2. Product Specifications

2.1 Capacity and Device Parameters

M.2 (P42) 3TE4 B+M Key device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	Cylinders	Heads	Sectors	LBA	User Capacity(MB)
128GB	16383	16	63	234441648	114473
256GB				468862128	228937
512GB				937703088	457863

2.2 Performance

Burst Transfer Rate: 4 GB/s

Table 2: Performance –112 Layers 3D TLC

Capacity	Unit	128GB	256GB	512GB
Sequential** Read (Q8T1)	MB/s	1200	1750	1750
Sequential** Write (Q8T1)		570	1100	1400
Sustained Sequential Read (Avg.)***		980	1460	1460
Sustained Sequential Write (Avg.)***		180	370	470
4KB Random** Read (Q32T16)	IOPS	57,000	123,000	232,000
4KB Random** Write (Q32T16)		133,000	206,000	221,000

Note: * Performance results are measured in Room Temperature with Out-of-Box devices and may vary depending on overall system setup. In addition, 3TE4 series adopt hybrid mode which enables SLC Cache up to 30% of total user capacity followed by TLC direct write to strike balance between burst performance and steady overall stability.

Note: ** Performance results are based on CrystalDiskMark 8.0.1 with file size 1000MB. Unit of 4KB items is I.O.P.S.

Note: *** Performance results are based on AIDA64 v5.98 with block size 1MB of Linear Read & Write Test Item.

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 3: Innodisk M.2 (P42) 3TE4 B+M Key Power Requirement

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

2.3.2 Power Consumption

Table 4: Power Consumption

Model	Power Consumption (W)
Read (RMS)	3.2
Write (RMS)	3.3
Idle (RMS)	0.6
Power-On Peak	3.8

Note: * Current results may vary depending on system components and power circuit design.

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for M.2 (P42) 3TE4 B+M Key

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 6: Shock/Vibration Testing for M.2 (P42) 3TE4 B+M Key

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 M.2 (P42) 3TE4 B+M Key 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: M.2 (P42) 3TE4 B+M Key MTBF

Product	Condition	MTBF (Hours)
Innodisk M.2 (P42) 3TE4 B+M Key	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

M.2 (P42) 3TE4 B+M Key conforms to CE and FCC requirements.

2.6 RoHS Compliance

M.2 (P42) 3TE4 B+M Key is fully compliant with RoHS directive.

2.7 Reliability

Table 8: M.2 (P42) 3TE4 B+M Key TBW

Parameter	Value
Read Cycles	Unlimited Read Cycles
Flash endurance	3,000 P/E cycles
Error Correct Code	Support(LDPC)
Data Retention	Under 40°C: 10 Years at Initial NAND Status; 1 Year at NAND Life End
TBW* (Total Bytes Written) Unit: TB	
Capacity	**Client workload**
128GB	162.5
256GB	325
512GB	650

* 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

M.2 (P42) 3TE4 B+M Key support following transfer mode:

PCIe Gen III 4 GB/s

PCIe Gen II 2 GB/s

PCIe Gen I 1 GB/s

2.9 Pin Assignment

Innodisk M.2 (P42) 3TE4 B+M Key follows standard M.2 spec, socket 2 key B+M PCIe-based SSD pinout. See Table 9 for M.2 (P42) 3TE4 B+M Key pin assignment.

Table 9: Innodisk M.2 (P42) 3TE4 B+M Key Pin Assignment

Signal Name	Pin #	Pin #	Signal Name
		75	GND
3.3V	74	73	GND
3.3V	72	71	GND
3.3V	70	69	NC
NC	68	67	NC
Notch	66	65	Notch
Notch	64	63	Notch
Notch	62	61	Notch
Notch	60	59	Notch
NC (Reserved)	58		
NC (Reserved)	56	57	GND
NC	54	55	REFCLKp
CLKREQ# (I/O)(0/3.3V)	52	53	REFCLKn
PERST# (I)(0/3.3V)	50	51	GND
NC	48	49	PERp0
NC	46	47	PERn0
NC	44	45	GND
NC (reserved for SMB_DATA)	42	43	PETp0
NC (reserved for SMB_CLK)	40	41	PETn0
NC	38	39	GND
NC	36	37	PERp1
NC	34	35	PERn1
NC	32	33	GND
NC	30	31	PETp1
NC	28	29	PETn1
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
LED1# (O) (OD)	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

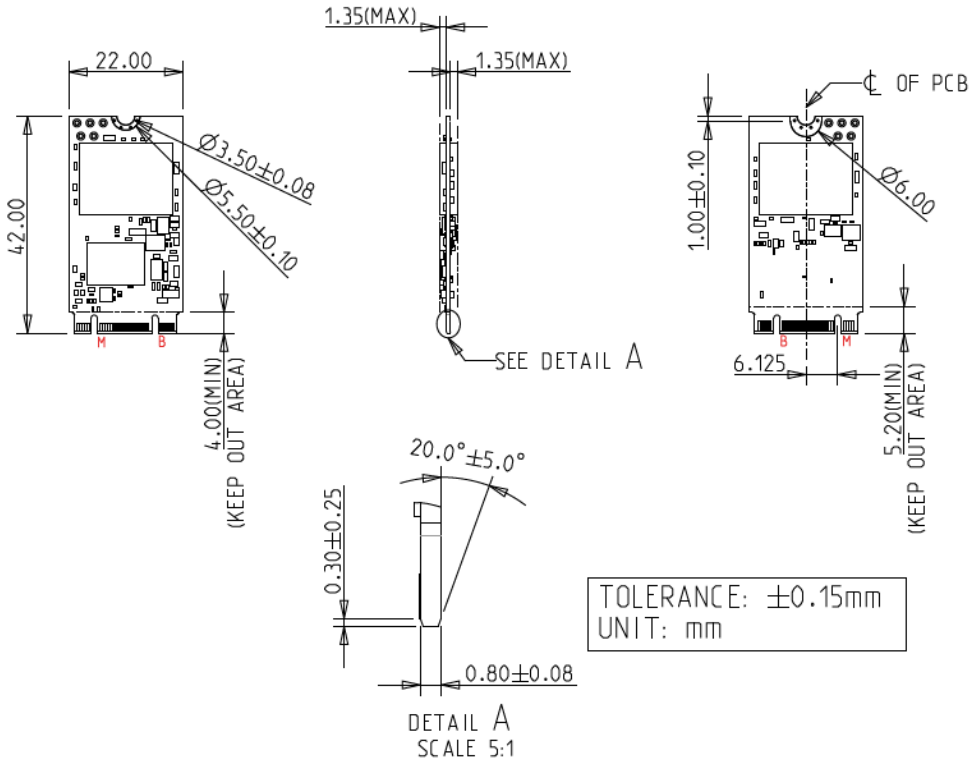

Figure 2: Innodisk M.2 (P42) 3TE4 B+M Key diagram

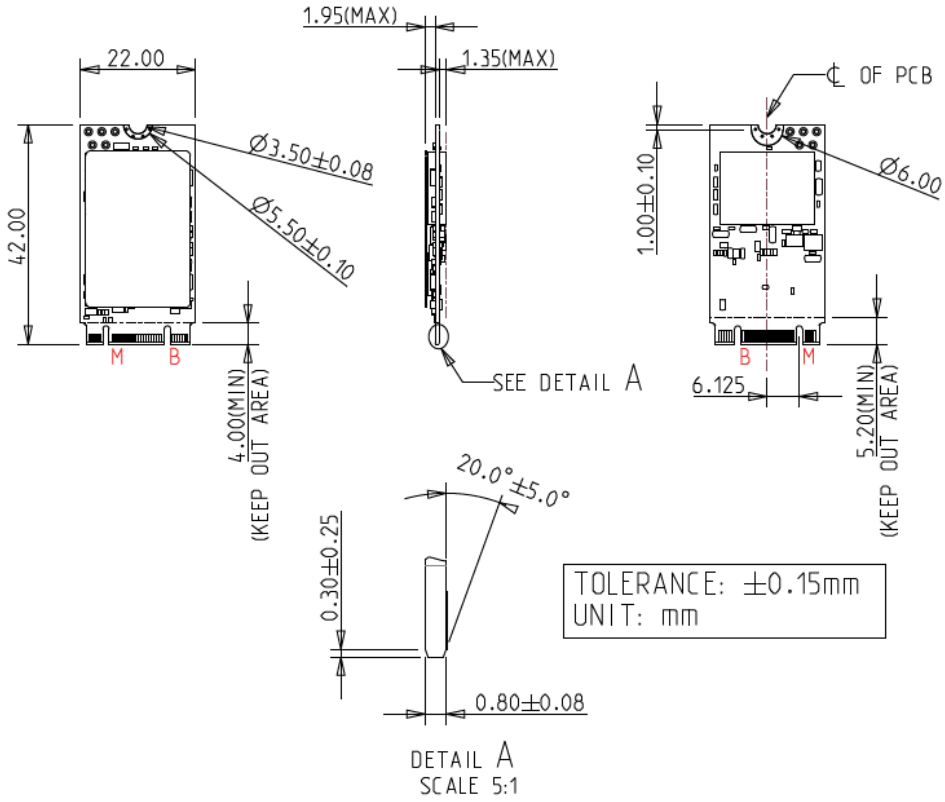

Figure 3: Innodisk M.2 (P42) 3TE4 B+M Key with heat spreading copper layer diagram

2.11 Assembly Weight

An Innodisk M.2 (P42) 3TE4 B+M Key 512GB standard temperature model weights 4.5 grams.

2.12 Seek Time

Innodisk M.2 (P42) 3TE4 B+M Key is not a magnetic rotating design. There is no seek or rotational latency required.

2.13 NAND Flash Memory

Innodisk M.2 (P42) 3TE4 B+M Key uses industrial 3D TLC NAND flash memory, which is non-volatility, high reliability and high speed memory storage.

3. Theory of Operation

3.1 Overview

Figure 3 shows the operation of Innodisk M.2 (P42) 3TE4 B+M Key from the system level, including the major hardware blocks.

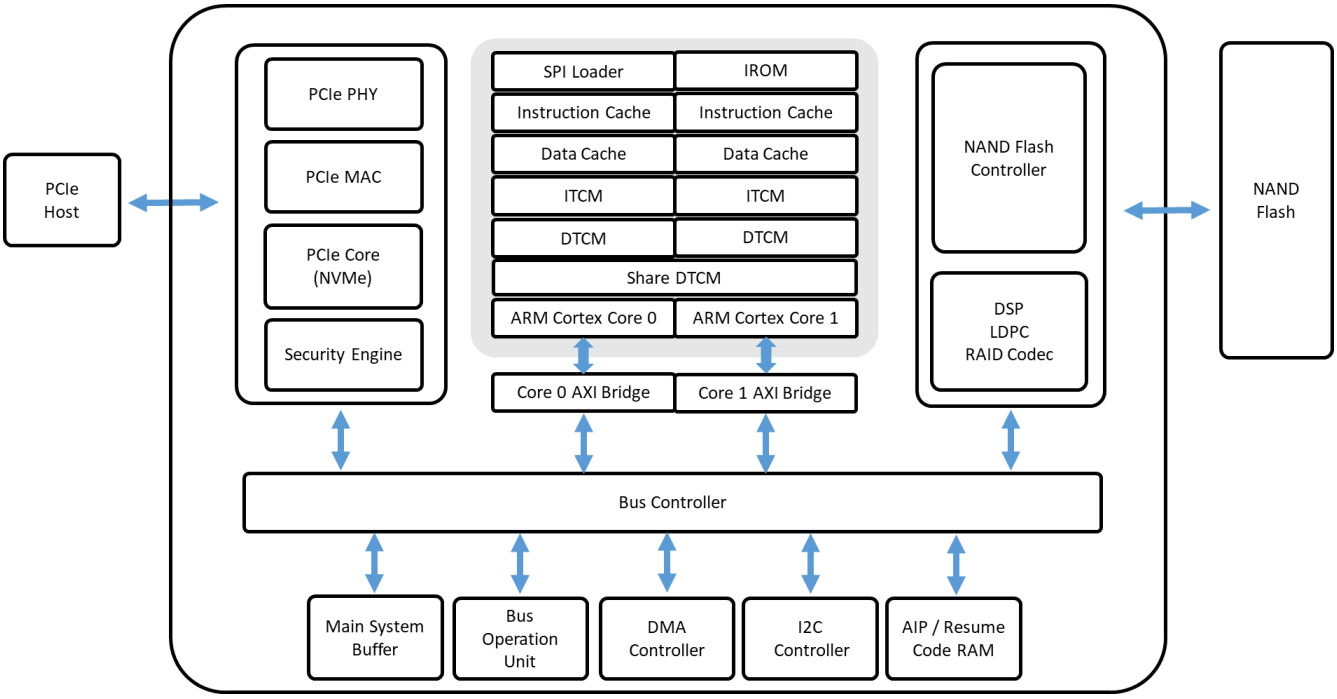

Figure 4: Innodisk M.2 (P42) 3TE4 B+M Key Block Diagram

Innodisk M.2 (P42) 3TE4 B+M Key integrates a PCIe Gen III x4 controller and NAND flash memories. Communication with the host occurs through the host interface, using the standard NVM protocol. Communication with the flash device(s) occurs through the flash interface.

3.2 PCIe Gen III x 4 Controller

Innodisk M.2 (P42) 3TE4 B+M Key is designed with a PCIe Gen III x4 controller which is compliant with NVMe 1.3, up to 32.0Gbps transfer speed. In addition, it is compliant with PCIe Gen. 1, Gen. 2 and Gen. 3 specification. The controller supports up to four channels for flash interface.

3.3 Error Detection and Correction

Innodisk M.2 (P42) 3TE4 B+M Key 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 with a limited number of cycles. This number is called the ***erase cycle limit*** or ***write endurance limit*** and is defined by the flash NAND vendor. The erase cycle limit applies to each individual erase block in the flash device.

Innodisk M.2 (P42) 3TE4 B+M Key uses a combination of two types of wear leveling- dynamic and static wear leveling- to distribute write cycling across an SSD and balance erase count of each block, thereby extending device 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 lifetime of the SSD. When a Bad Block is detected, it will be flagged as unusable block by firmware. The SSD implement Bad Blocks management that consists of Bad Blocks replacement and Error Correcting 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 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.

3.7 End to End Data Path Protection

End-to-end Data Path Protection that secures the data transmission between host system and NAND Flash. In the transmission path, no matter in or out, all buffer and storage implement Error Code Correction that optimizes the data integrity in the whole transmission of SSD.

3.8 Thermal Management

M.2 (P42) 3TE4 B+M Key has built-in thermal sensor which can detect environment temperature of SSD. In the meantime, firmware will monitor the thermal sensor to prevent any failure of overheating. During extreme temperature, firmware will adjust the data transfer behavior to maintain the SSD’s reliable operation.

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 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 (P42) 3TE4 B+M Key Pin Directions

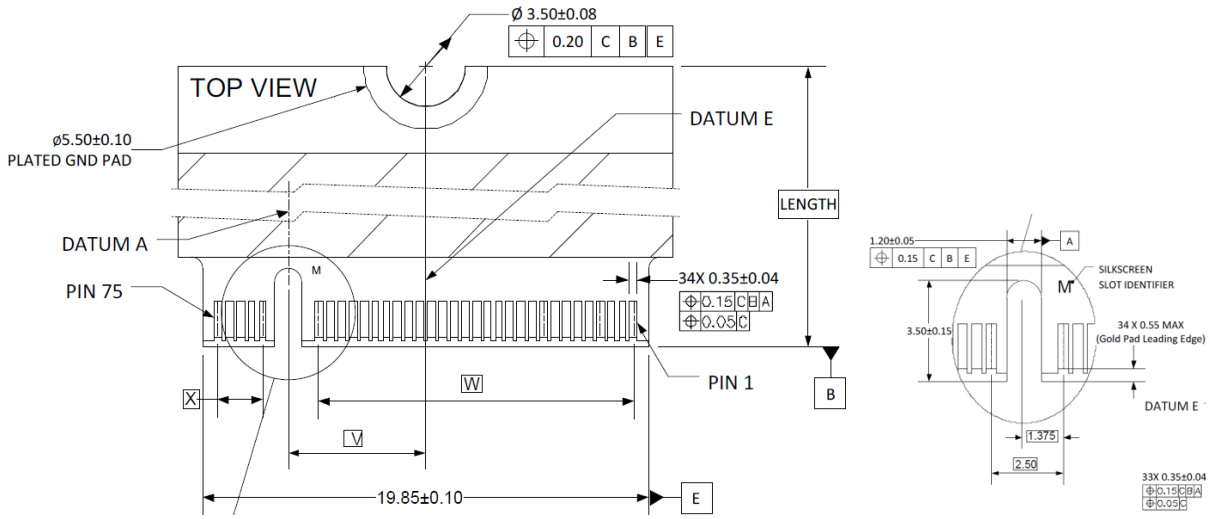

Figure 5: Signal Segment and Power Segment

4.2 Electrical Connections for M.2 (P42) 3TE4 B+M Key

M.2 interconnect is based on a 75 position Edge Card connector. The 75 position connector is intended to be keyed so as to distinguish between families of host interfaces and the various Sockets used in general Platforms. M.2 (P42) 3TE4 B+M Key is compliant with M.2 Socket 2 key B + M.

4.3 Device Drive

M.2 (P42) 3TE4 B+M Key is compliant with NVMe 1.3. Both Operation System and BIOS should include NVMe driver to compatible with NVMe device. Nowadays, most of OS includes NVMe in-box driver now. For more information about the driver support in each OS, please visit the website https://nvmexpress.org/drivers/. For BIOS NVMe driver support please contact with motherboard manufacturers.

5. SMART Attribute

Innodisk 3TE4 series SMART data attributes are listed in following table.

Table 10: SMART Attribute

BYTE	Raw Attribute Value								Attribute Name
BYTE 00	LSB								Critical Warning
BYTE 01 - 02	LSB	MSB							Composite Temperature (external sensor)
BYTE 03	LSB								Available Spare
BYTE 04	LSB								Available Spare Threshold
BYTE 05	LSB								Percentage Used
BYTE 06 - 31	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00	Reserved
BYTE 32 - 39	Data Units Read L								Data Units Read
BYTE 40 - 47	Data Units Read H								
BYTE 48 - 55	Data Units Written L								Data Units Written
BYTE 56 - 63	Data Units Written H								
BYTE 64 - 71	Host Read Commands L								Host Read Commands
BYTE 72 - 79	Host Read Commands H								
BYTE 80 - 87	Host Write Commands L								Host Write Commands
BYTE 88 - 95	Host Write Commands H								
BYTE 96 - 103	Controller Busy Time L								Controller Busy Time
BYTE 104 - 111	Controller Busy Time H								
BYTE 112 - 119	the number of power cycles L								The Number of power cycles
BYTE 120 - 127	the number of power cycles H								
BYTE 128 - 135	Power On Hours L								Power On Hours
BYTE 136 - 143	Power On Hours H								
BYTE 144 - 151	Unsafe Shutdowns L								Unsafe Shutdowns
BYTE 152 - 159	Unsafe Shutdowns H								
BYTE 160 - 167	Media and Data Integrity Errors L								Media and Data Integrity Errors
BYTE 168 - 175	Media and Data Integrity Errors H								
BYTE 176 - 183	Number of Error Information Log Entries L								Number of Error Information Log Entries
BYTE 184 - 191	Number of Error Information Log Entries H								
BYTE 192 - 195	LSB			MSB					Warning Composite Temperature Time
BYTE 196 - 199	LSB			MSB					Critical Composite Temperature Time
BYTE 200 - 201	LSB	MSB							Temperature Sensor 1

									(Controller)
BYTE 202 - 203	LSB	MSB							Temperature Sensor 2 (NAND Flash CH0 CE0)
BYTE 204 - 205	LSB	MSB							Temperature Sensor 3 (NAND Flash CH0 CE0)
BYTE 206 - 207	LSB	MSB							Temperature Sensor 4 (Flash Last CHx CE0)
BYTE 208 - 209	LSB	MSB							Temperature Sensor 5 (Flash Max. CH0-3)
BYTE 210 - 211	LSB	MSB							Temperature Sensor 6 (Flash Max. CH4-7)
BYTE 212 - 213	LSB	MSB							Temperature Sensor 7 (Flash Min. CH0-3)
BYTE 214 - 215	LSB	MSB							Temperature Sensor 8 (Flash Min. CH4-7)

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**	**-**	**B**	**5**	**6**	**I**	**B**	**1**	**K**	**W**	**C**	**Q**	**F**	**-**	**X**	**X**	**X**

Definition			
Code 1st (Disk)			**Code 14th (Operation Temperature)**
D : Disk			C: Standard Grade (0℃~ +70℃)
Code 2nd (Feature set)			W: Industrial Grade (40℃~ +85℃)
E : Embedded series			
Code 3rd ~5th (Form factor)			**Code 15th (Internal control)**
M24: M.2 Type 2242-S2-M			C: B+M key
Code 7th ~9th (Capacity)			**Code 16th (Channel of data transfer)**
A28: 128GB	B56: 256GB	C12: 512GB	D: Dual Channels
			Q: Quad Channels
Code 10th ~12th (Controller)			**Code 17th (Flash Type)**
IB1: 3TE4 Series			K: Kioxia 3D TLC
Code 13th (Flash mode)			**Code 19th ~21th (Customize code)**
K: 112 Layers 3D TLC			