innodisk

Total Solution For Industrial Flash Storage

M.2 (P42)

3TE9 Series

218-layer NAND

Customer: _____

Customer Part Number: _____

Innodisk Part Number: _____

Innodisk Model Name: _____

Date: _____

Innodisk Approver	Customer Approver

Features:

- PCIe Gen 3 x4, NVMe SSD
- Kioxia BiCS8 3D TLC NAND
- M.2 Type 2242-D2-M
- Standard temperature
- iDataguard
- iPowerguard
- Dynamic Thermal Management
- Hybrid Write Mode with SLC Cache Enable
- Support TCG OPAL function

Performance:

- Sequential Read up to 3,500 MB/s
- Sequential Write up to 3,050 MB/s

Power Requirements:

Input Voltage:	3.3V± 5%
Max Operating Wattage (R/W):	4.2W
Idle Wattage:	1.1W

Reliability (TBD):

Capacity	TBW	DWPD
256GB	301	1.2
512GB	478	0.9
1TB	1045	1.0
2TB	3034	1.5

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

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Revision History

Revision	Description	Date
Preliminary_V1.0	First Release	Apr., 2026
Preliminary_V1.1	Updated WAI information	Jun., 2026
V1.0	Official Release	Jun., 2026

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1. Product Overview

1.1 Introduction of Innodisk M.2 (P42) 3TE9

The Innodisk M.2 (P42) 3TE9 is a premium, DRAM-less NVMe SSD engineered specifically for the rigorous demands of edge computing and industrial embedded environments. Featuring a PCIe Gen3 x4 interface and full compliance with the NVMe 1.4 protocol, the 3TE9 utilizes high-endurance 3D TLC NAND Flash to deliver exceptional sequential throughput and sustained performance. With its compact, power-efficient design, the module integrates sophisticated error detection and correction (ECC) and comprehensive End-to-End Data Path Protection, ensuring robust system stability and the highest levels of data integrity between the host system and the NAND Flash.

1.2 Product View and Models

Innodisk M.2 (P42) 3TE9 is available in follow capacities with industrial 3D TLC flash ICs.

M.2 (P42) 3TE9 256GB
M.2 (P42) 3TE9 512GB
M.2 (P42) 3TE9 1TB
M.2 (P42) 3TE9 2TB

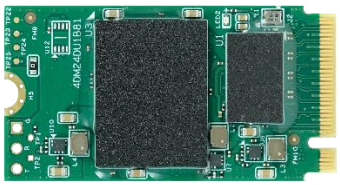

Figure 1: Innodisk M.2 (P42) 3TE9

1.3 PCIe Interface

Innodisk M.2 (P42) 3TE9 supports PCIe Gen 3 interface and compliant with NVMe 1.4. and it can work under PCIe Gen 1, Gen 2 and Gen 3.

2. Product Specifications

2.1 Capacity and Device Parameters

M.2 (P42) 3TE9 device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	LBA	User Capacity(MB)
256GB	468862128	228937
512GB	937703088	457863
1TB	1875385008	915715
2TB	3750748848	1831420

Note: * LBA size is 512byte

2.2 Performance

Burst Transfer Rate: 4 GB/s

Table 2: Performance- 218 Layers 3D TLC

Capacity	Unit	256GB	512GB	1TB	2TB
Sequential* Read (Q8T1)	MB/s	1,900	3,500	3,500	3,500
Sequential* Write (Q8T1)		1,450	2,750	3,000	3,050
Sustained Sequential Read (Avg.)***		1,100	1,450	1,500	1,200
Sustained Sequential Write (Avg.)***		590	970	1,050	1,200
4KB Random** Read (Q32T16)	IOPS	306,000	399,000	400,000	400,000
4KB Random** Write (Q32T16)		246,000	265,000	267,000	269,000

Note: * Performance results are 3TE9 with Kioxia BiCS8 NAND composition measured in Room Temperature with Out-of-Box devices and may vary depending on overall system setup. In addition, 3TE9 series adopt hybrid mode which enables SLC cache 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 item is IOPS.

Note: *** Performance results are based on AIDA 64 v7.3.0 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) 3TE9 Power Requirement

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

2.3.2 Power Consumption

Table 4: Power Consumption

Mode	Power Consumption (W)
Read	3.4
Write	4.2
Idle	1.1
Power-on peak	4.8

Target: M.2 (P42) 3TE9 2TB

Note: Current results may vary depending on system components and power circuit design. Please refer to the test report for other capacities.

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for M.2 (P42) 3TE9

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

2.4.2 Humidity

Relative Humidity: 10-95%, 40°C, non-condensing

2.4.3 Shock and Vibration

Table 6: Shock/Vibration Testing for M.2 (P42) 3TE9

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) 3TE9 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) 3TE9 MTBF

Product	Condition	MTBF (Hours)
Innodisk M.2 (P42) 3TE9	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

M.2 (P42) 3TE9 conforms to CE and FCC requirements.

Table 8: M.2 (P42) 3TE9 ESD

Reliability	Reference standards
Electrostatic Discharge (ESD)	IEC 61000-4-2 ESD

2.6 RoHS Compliance

M.2 (P42) 3TE9 is fully compliant with RoHS directive.

2.7 Reliability

Table 9: M.2 (P42) 3TE9 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: 1 Year at NAND Life End	
TBW* (Total Bytes Written) Unit: TB		
Capacity	**Sequential workload**	**Client workload**
256GB	682	301
512GB	1364	478
1TB	2727	1045
2TB	5455	3034

* 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 Innodisk. (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) 3TE9 support following transfer mode:

PCIe Gen 3: 4 GB/s

PCIe Gen 2: 2 GB/s

PCIe Gen 1: 1 GB/s

2.9 Pin Assignment

Innodisk M.2 (P42) 3TE9 follows standard M.2 spec, socket 3 key M PCIe-based SSD pinout. See Table 10 for M.2 (P42) 3TE9 pin assignment.

Table 10: Innodisk M.2 (P42) 3TE9 Pin Assignment

Signal Name	Pin #	Pin #	Signal Name
		75	GND
3.3V	74	73	VIO_CFG
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	58	57	GND
NC	56	55	REFCLKp
NC	54	53	REFCLKn
CLKREQ# (I/O)(0/3.3V)	52	51	GND
PERST# (I)(0/3.3V)	50	49	PERp0
NC	48	47	PERn0
NC	46	45	GND
NC	44	43	PETp0
SMB_DATA	42	41	PETn0
SMB_CLK	40	39	GND
NC	38	37	PERp1
NC	36	35	PERn1
NC	34	33	GND
NC	32	31	PETp1
PLA_S3#	30	29	PETn1
NC	28	27	GND
NC	26	25	PERp2
NC	24	23	PERn2
NC	22	21	GND
NC	20	19	PETp2
3.3V	18	17	PETn2
3.3V	16	15	GND
3.3V	14	13	PERp3

3.3V	12	11	PERn3
LED1#	10	9	GND
PLN#	8	7	PETp3
NC	6	5	PETn3
3.3V	4	3	GND
3.3V	2	1	GND

2.10 Device Activity Signal

A green LED on 3TE9 Series typically indicates power-on status and drive activity.

Table 11: Innodisk M.2 (P42) Device Activity Signal

LED Color	Function
Green	Power-On

2.11 Mechanical Dimensions

M.2 Type 2242-D2-M

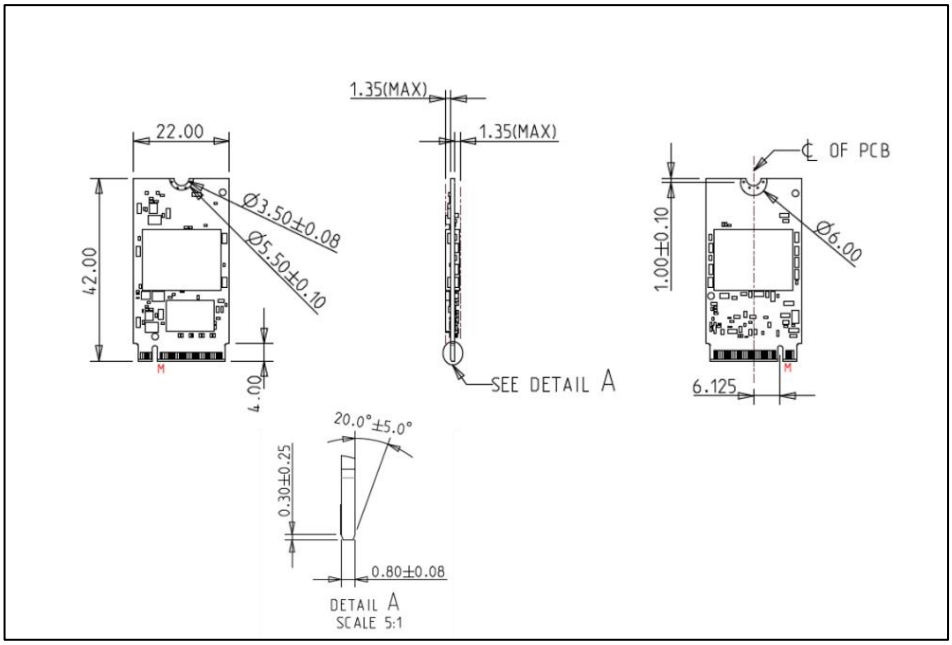

Figure 2: Innodisk M.2 (P42) 3TE9 mechanical drawing

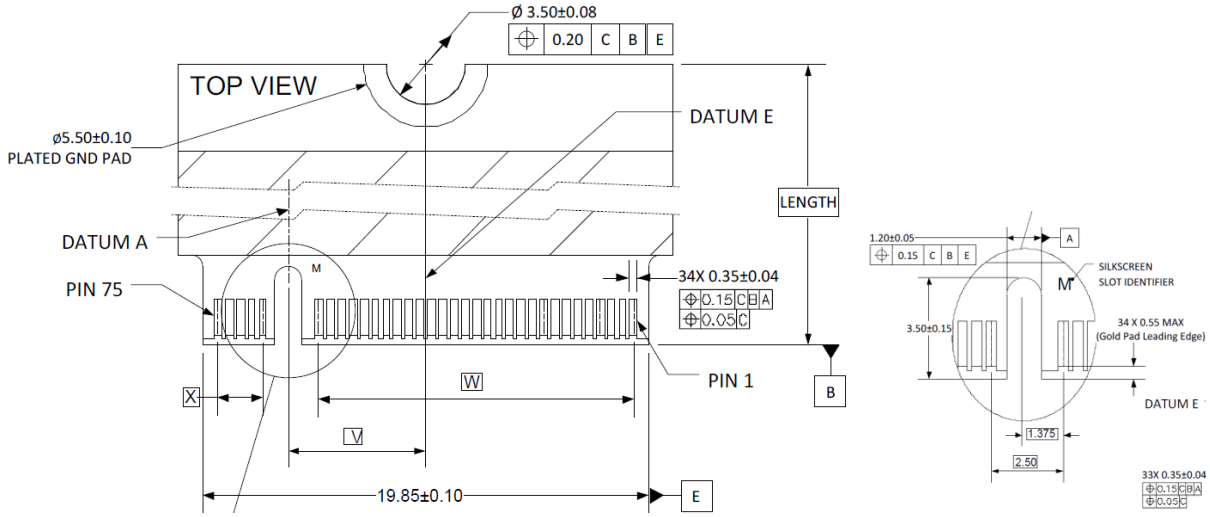

Figure 3: Signal Segment and Power Segment

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) 3TE9 is compliant with M.2 Socket 3 key M.

2.12 Assembly Weight

An Innodisk M.2 (P42) 3TE9 within NAND flash ICs, 256GB's weight is 6.2 grams approximately.

3. Theory of Operation

3.1 Overview

Innodisk M.2 (P42) 3TE9 integrates a PCIe Gen 3 x4 controller and NAND flash memories. Communication with the host occurs through the host interface, using the standard NVMe 1.4 protocol. Communication with the flash device(s) occurs through the flash interface.

Figure 4 shows the operation of Innodisk M.2 (P42) 3TE9 from the system level, including the major hardware blocks.

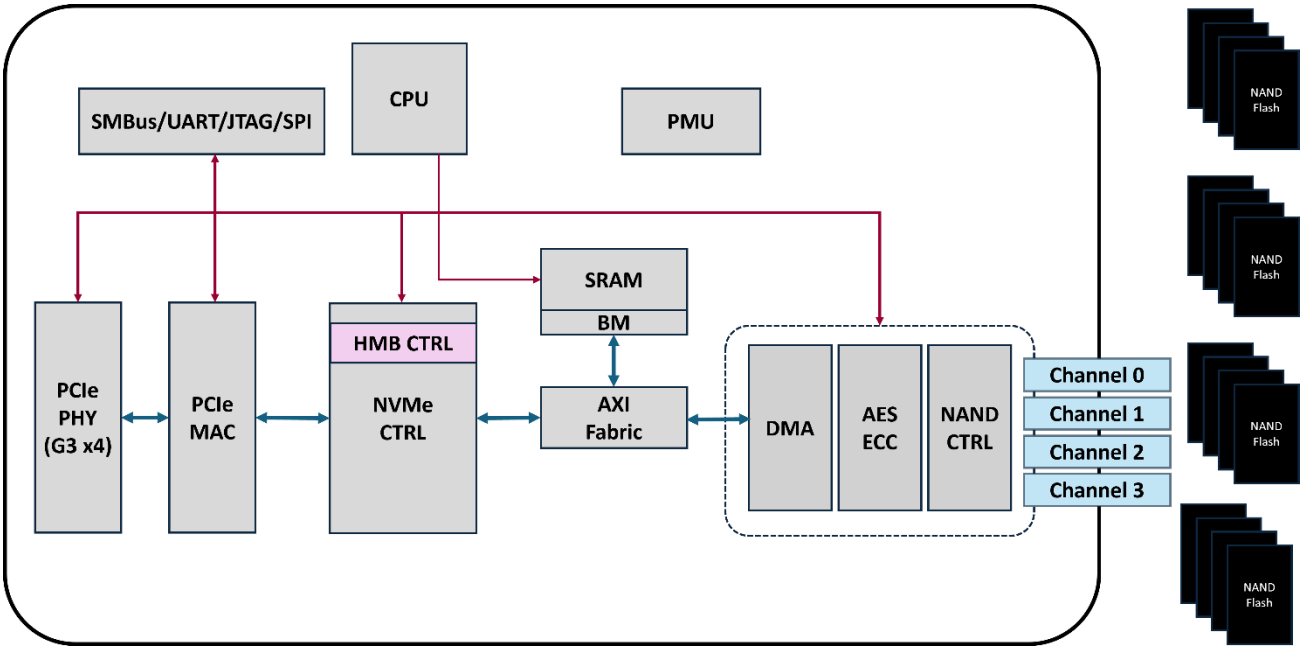

Figure 4: Innodisk M.2 (P42) 3TE9 Block Diagram

3.2 Error Detection and Correction

Innodisk M.2 (P42) 3TE9 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.

3.3 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.

3.4 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.

Wear-leveling is a controller background process that minimize the accumulation of erase and write cycle by distributes data across different memory blocks, spreading the workload evenly to ensure SSD’s longevity.

3.5 Garbage Collection (GC)

The Garbage Collection mechanism is designed to maintain optimal SSD performance by reclaiming storage blocks occupied by invalid data. It is a background process that scans, consolidates, and relocates valid data to fresh blocks, allowing obsolete blocks to be erased and reused. This ensures a steady supply of free blocks for the host, enhancing both the overall response time and the drive's reliability.

3.6 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.

3.7 Thermal Management

M.2 (P42) 3TE9 has has built-in thermal sensor which can detect the 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.

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, the firmware regulates the SSD's temperature by adjusting the data processing speed. This mechanism is crucial for SSDs since it prevents drive damage, which could otherwise result in data loss. It is worth noting that when thermal throttling is involved, read and write operation may experience a reduction in speed.

3.8 iDataGuard

iDataGuard is a comprehensive data protection mechanism that functions before and after a sudden power outage to the 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. Innodisk's iData Guard provides effective power cycling management, preventing data stored in flash from degrading with use.

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 TCG OPAL

The Innodisk 3TE9 adheres to the TCG Opal 2.0(*1) specifications, enhancing data security through advanced hardware-based encryption. This allows for the creation of independent LBA ranges, each with its own access control and authentication authority. While the drive begins with a single 'Global Range,' administrators can configure multiple locking ranges for granular data management. Furthermore, the feature allows cryptographic erasure via Revert, Revert SP, and GenKey commands; these operations purge all stored data and refresh the internal encryption key, ensuring that data remains irrecoverable.

*1. You need to install TCG OPAL software to implement OPAL function, which is supplied by TCG OPAL software developed company

5. SMART / Health Information

This log page is used to provide SMART and general health information. The information provided is over the life of the controller and is retained across power cycles. More details about Set Features command; please refer to NVM Express 1.4

5.1 Get Log Page (Log Identifier 02h)

Innodisk 3TE9 series SMART / Health Information Log are listed in following table.

Table 11: Get Log Page – SMART / Health Information Log

<table>
<tr><th>Bytes</th><th>Description</th></tr>
<tr><td>00</td><td>Critical Warning: This field indicates critical warnings for the state of the controller. Each bit corresponds to a critical warning type; multiple bits may be set to ‘1’. If a bit is cleared to ‘0’, then that critical warning does not apply. Critical warnings may result in an asynchronous event notification to the host. Bits in this field represent the state at the time the Get Log Page command is processed and may not reflect the state at the time a related asynchronous event notification, if any, occurs or occurred.
<table>
<tr><th>Bit</th><th>Definition</th></tr>
<tr><td>0</td><td>If set to ‘1’, then the available spare capacity has fallen below the threshold.</td></tr>
<tr><td>1</td><td>If set to ‘1’, then a temperature is:
a) greater than or equal to an over temperature threshold.
b) less than or equal to an under temperature threshold.</td></tr>
<tr><td>2</td><td>If set to ‘1’, then the NVM subsystem reliability has been degraded due to significant media related errors or any internal error that degrades NVM subsystem reliability.</td></tr>
<tr><td>3</td><td>If set to ‘1’, then all of the media has been placed in read only mode. The controller shall not set this bit to '1' if the read-only condition on the media is a result of a change in the write protection state of a namespace.</td></tr>
<tr><td>4</td><td>If set to ‘1’, then the volatile memory backup device has failed. This field is only valid if the controller has a volatile memory backup solution.</td></tr>
<tr><td>5</td><td>Reserved</td></tr>
<tr><td>7:6</td><td>Reserved</td></tr>
</table></td></tr>
<tr><td>02:01</td><td>Composite Temperature: Current temperature in degrees Kelvin. Represents the controller and namespace(s).</td></tr>
</table>

03	**Available Spare:** Normalized percentage (0 to 100%) of the remaining spare capacity.
04	**Available Spare Threshold:** Threshold (0 to 100%) below which an asynchronous event may occur.
05	**Percentage Used:** Vendor-specific estimate of device life used (100 = endurance consumed). Updated once per power-on hour.
06	**Reserved**
31:07	**Reserved**
47:32	**Data Units Read:** Number of 512-byte data units read, reported in thousands (e.g., 1 = 1,000 units).
63:48	**Data Units Written:** Number of 512-byte data units written, reported in thousands. Refer to the specific I/O Command Set specification for the list of User Data Out Commands that affect this field.
79:64	**Host Read Commands:** Total number of read commands (including Compare) completed by the controller.
95:80	**Host Write Commands:** Total number of write commands completed by the controller.
111:96	**Controller Busy Time:** Amount of time the controller is busy with I/O commands, reported in minutes.
127:112	**Power Cycles:** Number of power cycles recorded.
143:128	**Power On Hours:** Number of power-on hours (may exclude non-operational states).
159:144	**Unsafe Shutdowns:** Number of unsafe shutdowns.
175:160	**Media and Data Integrity Errors:** Number of unrecovered data integrity errors (ECC, CRC, LBA mismatch).
191:176	**Number of Error Information Log Entries:** Total number of Error Information log entries over the life of the controller.
195:192	**Warning Composite Temperature Time:** Time in minutes spent at or above the Warning Temp Threshold (WCTEMP).

196:199	**Critical Composite Temperature Time:** Time in minutes spent at or above the Critical Temp Threshold (CCTEMP).
201:200	**Temperature Sensor 1:** Contains the current temperature reported by the embedded thermal sensor in the controller.
203:202	**Reserved**
205:204	**Temperature Sensor 3:** Contains the current temperature reported by the embedded thermal sensor in the NAND Flash TJ.
207:206	**Reserved**
209:208	**Temperature Sensor 5:** Reserved.
211:210	**Temperature Sensor 6:** Reserved.
213:212	**Temperature Sensor 7:** Reserved.
215:214	**Temperature Sensor 8:** Reserved.
219:216	**Thermal Mgmt Temp 1 Count:** Number of times the controller transitioned to lower power states due to Temp 1.
223:220	Thermal Mgmt Temp 2 Count: Number of times the controller transitioned to lower power states due to Temp 2 (Heavy Throttling).
227:224	**Total Time For Thermal Mgmt 1:** Total duration in seconds spent in Thermal Management Temp 1 state.
231:228	**Total Time For Thermal Mgmt 2:** Total duration in seconds spent in Thermal Management Temp 2 state.
511:232	**Reserved for Innodisk SMART tool.**

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**	**D**	**U**	**2**	**P**	**C**	**A**	**D**	**F**	**-**	**X**	**X**	**X**

Definition	
Code 1st (Disk)	**Code 14th (Operation Temperature)**
D : Disk	C: Standard Grade (0°C ~ +70°C)
Code 2nd (Feature set)	**Code 15th (Internal control)**
E : Embedded series	A~Z: BGA PCB version.
Code 3rd ~5th (Form factor)	**Code 16th (Channel of data transfer)**
M24: M.2 Type 2242-D2-M	D: Dual Channels
	Q: Quad Channels
Code 7th ~9th (Capacity)	**Code 17th (Flash Type)**
B56: 256GB	F: Kioxia 3D TLC
C12: 512GB	
01T: 1TB	
02T: 2TB	
Code 10th ~12th (Controller)	**Code 19th ~ (Customize code)**
DU2: PCIe 3TE9 series with TCG OPAL function	
Code 13th (Flash mode)	
P: 218 Layers 3D TLC	