innodisk

Total Solution For Industrial Flash Storage

mSATA

3TG6-P 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
- Standard & Wide-temperature
- iPowerguard
- iDataguard
- Dynamic Thermal Management

Performance:

- Sequential Read up to 560 MB/s
- Sequential Write up to 420 MB/s

Power Requirements:

Input Voltage:	3.3V±5%
Max Operating Wattage:	3.2W
Idle Wattage:	2.8W

Reliability:

Capacity	TBW	DWPD
128GB	289	2.36
256GB	578	2.36
512GB	1154	2.36
1TB	2308	2.36
2TB	4615	2.41

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	Officially released	Mar., 2020
1.1	Add Industrial Grade & BICS4 solution	Jan., 2021
1.2	Add 1TB、2TB solution	May., 2021
1.3	Update TBW follow controller STD information	Aug., 2021
1.4	Modify to new TPS STD format	Dec., 2021
1.5	Add BiCS5 & Revised the LBA	Apr., 2022
1.6	Update SMART Attributes	Jul., 2022
1.7	Update 128GB LBA	Oct., 2022

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1. Product Overview

1.1 Introduction of Innodisk mSATA 3TG6-P with Innodisk NAND

Innodisk mSATA 3TG6-P 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. Innodisk mSATA 3TG6-P is designed for industrial field, and supports several standard features, including TRIM, NCQ, and S.M.A.R.T. The SSD have good performance, no latency time and small seek time. It effectively reduces the booting time of operation system and the power consumption is less than hard disk drive (HDD).

1.2 Product View and Models

Innodisk mSATA 3TG6-P is available in follow capacities:

mSATA 3TG6-P 128GB mSATA 3TG6-P 256GB
mSATA 3TG6-P 512GB mSATA 3TG6-P 1TB mSATA 3TG6-P 2TB

Figure 1: Innodisk mSATA 3TG6-P with Innodisk NAND

(Write protect is Optional)

1.3 SATA Interface

Innodisk mSATA 3TG6-P supports SATA III interface, and backward compliant with SATA I and SATA II.

2. Product Specifications

2.1 Capacity and Device Parameters

mSATA 3TG6-P 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	16383	16	63	468862128	228936
512GB	16383	16	63	937703088	457862
1TB	16383	16	63	1875385008	915715
2TB	16383	16	63	3750748848	1788000

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance- 64 Layers 3D TLC

	Capacity	Unit	128GB	256GB	512GB
64 Layers 3D TLC	Sequential* Read (Q32T1)	MB/s	560	560	510
	Sequential* Write (Q32T1)		120	255	420
	4KB Random** Read (QD32)	IOPS	46,000	77,000	77,000
	4KB Random** Write (QD32)		29,000	48,000	59,000

Note:

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

** Random performance based on IOmeter with Queue Depth 32

Table 3: Performance- 96 Layers 3D TLC

	Capacity	Unit	256GB	512GB	1TB	2TB
96 Layers 3D TLC	Sequential* Read (Q32T1)	MB/s	510	500	500	480
	Sequential* Write (Q32T1)		110	230	400	400
	4KB Random** Read (QD32)	IOPS	43,000	76,000	86,000	67,500

	4KB Random** Write (QD32)		27,000	54,000	56,000	52,500

Note:

* Sequential performance based on CrystalDiskMark 6.0.2 with file size 1000MB

** Random performance based on IOmeter with Queue Depth 32

Table 4: Performance- 112 Layers 3D TLC

	Capacity	Unit	128GB	256GB (4CH)	256GB (2CH)	512GB	1TB	2TB
112 Layers 3D TLC	Sequential* Read (Q32T1)	MB/s	390	510	370	510	500	500
	Sequential* Write (Q32T1)		80	170	70	150	300	450
	4KB Random** Read (QD32)	IOPS	26,000	49,000	24,000	44,000	67,000	76,000
	4KB Random** Write (QD32)		22,000	44,000	20,000	38,000	56,000	58,000

Note:

* Performance results are tested in Room Temperature with Out-of-Box devices and may vary depending on overall system setup.

** Performance results are based on CrystalDiskMark 6.0.2 with typical tolerance for range from 1% to 10%.

*** Performance results are based on AIDA 64 with block size 1MB of Linear Write Test Item

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 5: Innodisk mSATA 3TG6-P 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	3.0
Write	3.2
Idle	2.8
Peak	4.1

Target: 2TB mSATA 3TG6-P

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 7: Temperature range for mSATA 3TG6-P

Temperature	Range
Operating (Ta)	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 mSATA 3TG6-P

Reliability	Test Conditions	Reference Standards
Vibration	7 Hz to 2K Hz, 20G, 3 axes	IEC 68-2-6
Mechanical Shock	Duration: 0.5ms, 1500 G, 3 axes	IEC 68-2-27

2.4.4 Mean Time between Failures (MTBF)

Table 7 summarizes the MTBF prediction results for various mSATA 3TG6-P 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: mSATA 3TG6-P MTBF

Product	Condition	MTBF (Hours)
Innodisk mSATA 3TG6-P	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

mSATA 3TG6-P conforms to CE and FCC requirements.

2.6 RoHS Compliance

mSATA 3TG6-P is fully compliant with RoHS directive.

2.7 Reliability

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**
128GB	341	289
256GB	682	578
512GB	1364	1154
1TB	2663	2308
2TB	5327	4615

*Note:

1. Sequential: Mainly sequential write.
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

mSATA 3TG6-P support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

2.9 Pin Assignment

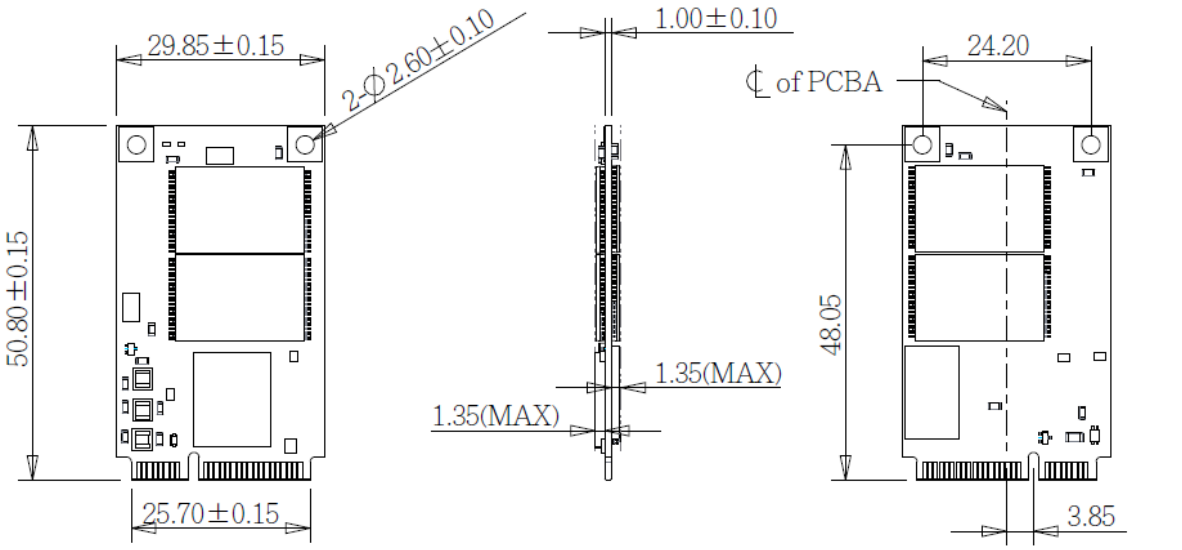
Innodisk mSATA 3TG6-P uses a standard SATA pin-out. See Table 8 for mSATA 3TG6-P pin assignment.

Table 10: Innodisk mSATA 3TG6-P Pin Assignment

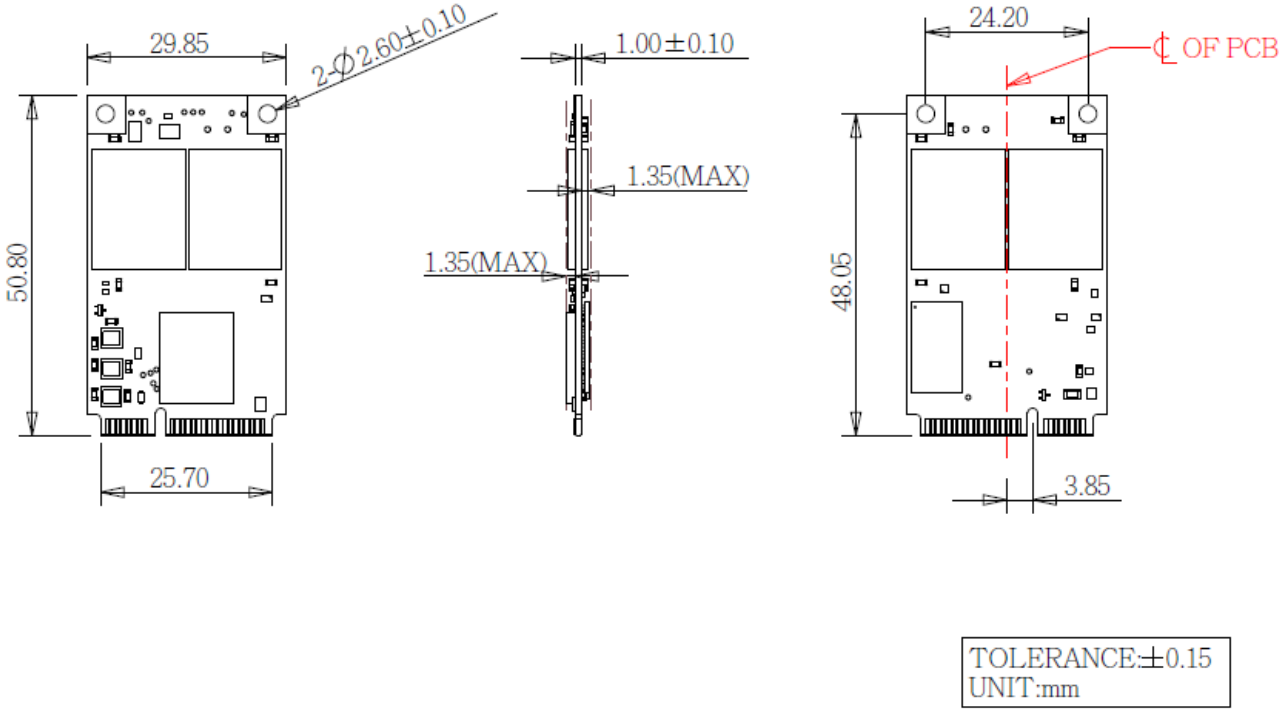
Signal Name	Pin #	Pin #	Signal Name
GND	51	52	+3.3V
DAS	49	50	GND
NC	47	48	NC
NC	45	46	NC
NC	43	44	DEVSLP
+3.3V	41	42	NC
+3.3V	39	40	GND
GND	37	38	NC
GND	35	36	NC
RX+	33	34	GND
RX-	31	32	NC
GND	29	30	NC
GND	27	28	NC
TX-	25	26	GND
TX+	23	24	+3.3V
GND	21	22	NC
NC	19	20	NC

NC	17	18	GND
GND	15	16	NC
NC	13	14	NC
NC	11	12	NC
GND	9	10	NC
NC	7	8	NC
NC	5	6	NC
NC	3	4	GND
NC	1	2	+3.3V

2.10 Mechanical Dimensions



TSOP Models: 128GB~256GB



BGA Model: 512GB~2TB

2.11 Assembly Weight

An Innodisk mSATA 3TG6-P within 3D NAND flash ICs, 256GB's weight is 8 grams approx.

2.12 Seek Time

Innodisk mSATA 3TG6-P is not a magnetic rotating design. There is no seek or rotational latency required.

2.13 NAND Flash Memory

Innodisk mSATA 3TG6-P uses 3D TLC NAND flash memory, with 3,000 programs & erases cycles, which is non-volatility, high reliability and high-speed memory storage.

2.14 Thermal Management

Innodisk mSATA 3TG6-P adopts optimized thermal management. In extreme temperature, disk will perform thermal throttling to ensure overall device stability. Disabling thermal throttling function may improve the performance but also expose device potential issues while operating under extreme environment conditions.

3. Theory of Operation

3.1 Overview

Figure 2 shows the operation of Innodisk mSATA 3TG6-P from the system level, including the major hardware blocks.

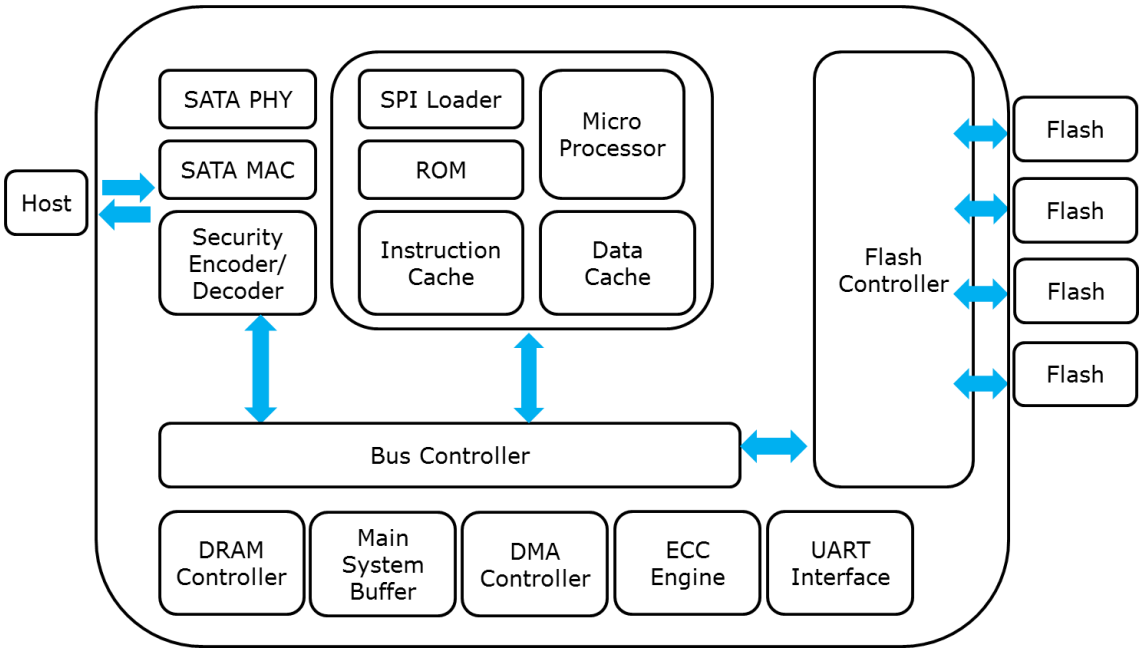


Figure 2: Innodisk mSATA 3TG6-P Block Diagram

Innodisk mSATA 3TG6-P 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 Controller

Innodisk mSATA 3TG6-P is designed with 88SS1080, a SATA III 6.0Gbps 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

Innodisk mSATA 3TG6-P 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 mSATA 3TG6-P 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

Innodisk's 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. Innodisk's 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 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.

3.9 AES Function (Optional)

In order to complete the physical security layer of protection, encryption needs to be paired with an ATA user password by ATA security command. After setting the authorized key by ATA security command, every time when you power on the system with SSD encrypted, you will be requested for a password to access the SSD. If the password is correct, the SSD will run well; if not, then you will not be able to access the SSD then.

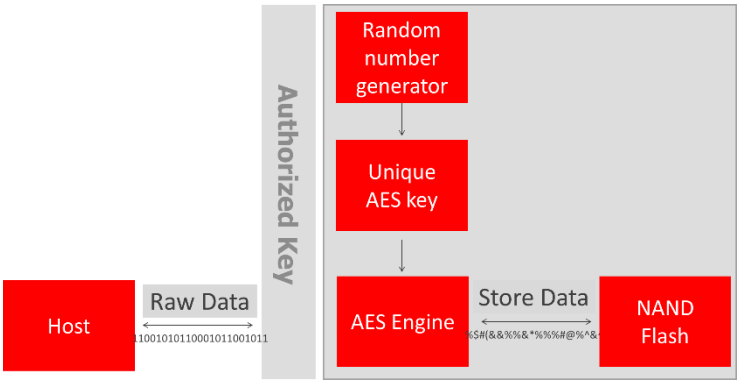


Figure 3: Innodisk mSATA 3TG6-P AES flow chart

3.9.1 Encrypted Key Management

Innodisk 3TG6-P SSD includes two methods of key management to apply to different applications. The first is a standard approach that allows the firmware to generate a random number and a unique key when it leaves the factory. This method ensures that the user can easily apply the SSD with the data encrypted key. Another approach is to meet unique customer requirements with an encrypted key generated by an SSD from the SATA interface host. The SSD must keep the encrypted key value when receiving the reset commands. This method works best for the SSD as a removable device in different systems. Innodisk provides the test tool to execute the AES hardware encryption. This user-friendly tool, developed by Innodisk Corporation, allows the customer to use/test encryption functions.

3.9.2 Authorized Key Management

In order to complete the physical security layer of protection, encryption needs to be bundled with an ATA user password provided by an ATA Security command. Unlike the AES key, the authorized key must be set by the user via the BIOS configuration. Every time you power on the system with SSD encryption, a password request prompt is sent to access the SSD. If the password is correct, the SSD will run well; if not, you will not be able to access the SSD.

Command	Command Code
SECURITY SET PASSWORD	0XF1
SECURITY UNLOCK	0XF2
SECURITY ERASE PREPARE	0XF3
SECURITY ERASE UNIT	0XF4
SECURITY FREEZE LOCK	0XF5
SECURITY DISABLE PASSWORD	0XF6

4. Installation Requirements

4.1 mSATA 3TG6-P Pin Directions

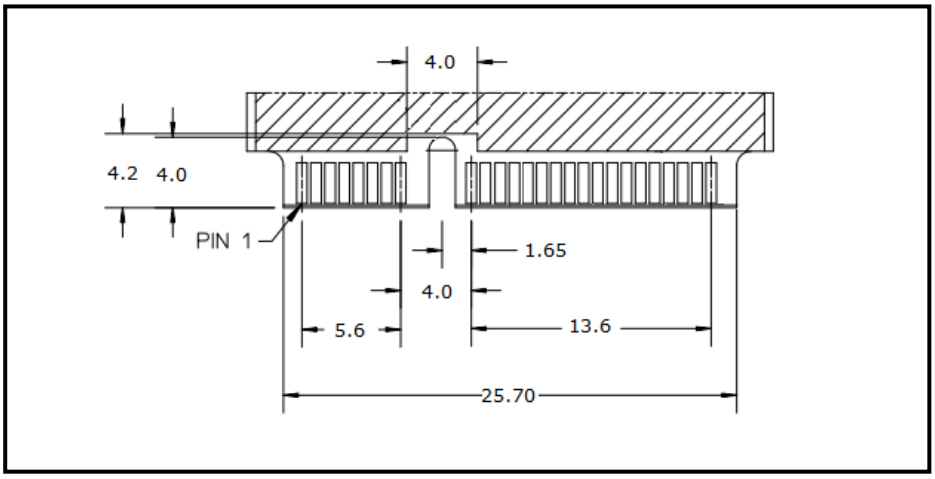


Figure 4: Signal Segment and Power Segment

4.2 Electrical Connections for mSATA 3TG6-P

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 Device Drive

No additional device drives are required. Innodisk mSATA 3TG6-P can be configured as a boot device.

5. SMART Feature Set

Innodisk 3TG6-P series support the SMART command set and defines some vendor-specific data to report SMART attributes of SSD.

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

5.1 SMART Attributes

Innodisk 3TG6-P series SMART data attributes are listed in following table.

Attribute ID (hex)	**Value**	**Raw Attribute Value**						**Rsv**	**Attribute Name**
05	64_{hex}	LSB			MSB	00	00	00	Later Bad
09	LSB	LSB			MSB	00	00	00	Power-On hours Count
0C	LSB	LSB			MSB	00	00	00	Drive Power Cycle Count
A3	LSB	LSB					MSB	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	64_{hex}	LSB	00	00	00	00	00	00	Device Life
AA	64_{hex}	LSB					MSB	00	Spare Block Count
AB	LSB	LSB					MSB	00	Program fail count

AC	LSB	LSB					MSB	00	Erase fail count
B8	00	LSB			MSB	00	00	00	Error Corrected Count
BB	00	LSB			MSB	00	00	00	Reported Uncorrected Count
C0	LSB	LSB			MSB	00	00	00	Unexpected Power Loss Count
C2	Cur. *	Cur.*	00	MIN	00	MAX	03	Cur. *	Temperature
E5	64_{hex}	ID 0	ID 1	ID 2	ID 3	ID 4	ID 5	00	Flash ID
EB	00		MSB	LSB	MSB	LSB	MSB	LSB	Later bad block info (Read/Write/Erase)
F1	64_{hex}	LSB					MSB	00	Total LBA writ-ten(LBA=32MB)
F2	64_{hex}	LSB					MSB	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	**G**	**M**	**S**	**R**	**-**	**A**	**2**	**8**	**M**	**7**	**1**	**E**	**C**	**1**	**Q**	**L**	**-**	**X**	**X**	**X**
Description	Disk	mSATA					Capacity			Category			Flash mode	Operation Temp.	Internal Control	CH.	Flash		Customized Code		

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)**
GMSR: mSATA regular	C: Standard Grade (0℃~ +70℃)
	W: Standard Grade (-45℃~ +85℃)
Code 7th ~9th (Capacity)	**Code 15th (Internal control)**
A28: 128GB	1/A: PCB version
B56: 256GB	**Code 16th (Channel of data transfer)**
C12: 512GB	S: Single Channel
01T: 1TB	D: Duo Channels
02T: 2TB	Q: Quad Channels
Code 10th ~12th (Series)	**Code 17th (Flash Type)**
M71: mSATA 3TG6-P	L: Innodisk 3D TLC
	Q: WD 3D TLC
	Code 20th ~21th (Customized code)