

SATA Slim

3TG6-P Series

Customer: _____
Customer
Part
Number: _____
Innodisk
Part
Number: _____
Innodisk
Model Name: _____
Date: _____

Innodisk Approver	Customer Approver

Features:

- SATA III
- Kioxia 3D TLC NAND
- Standard & Wide-temperature
- iPowerguard
- iDataguard
- Dynamic Thermal Management

Reliability:**Performance:**

- Sequential Read up to 560 MB/s
- Sequential Write up to 520 MB/s

Power Requirements:

Input Voltage:	5V±5%
Max Operating Wattage:	3.0W
Idle Wattage:	1.0W

Capacity	TBW	DWPD
128GB	289	2.1
256GB	578	2.1
512GB	1154	2.1

Data Retention	1 Year
Warranty	3 Years

For warranty details, please refer to:

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

Table of contents

LIST OF FIGURES	7
1. PRODUCT OVERVIEW	8
1.1 INTRODUCTION OF INNODISK SATA SLIM 3TG6-P	8
1.2 PRODUCT VIEW AND MODELS	8
1.3 SATA INTERFACE.....	9
1.4 MO-297 FORM FACTOR.....	9
2. PRODUCT SPECIFICATIONS	10
2.1 CAPACITY AND DEVICE PARAMETERS.....	10
2.2 PERFORMANCE	10
2.3 ELECTRICAL SPECIFICATIONS	10
2.3.1 Power Requirement.....	10
2.3.2 Power Consumption	11
2.4 ENVIRONMENTAL SPECIFICATIONS	11
2.4.1 Temperature Ranges	11
2.4.2 Humidity.....	11
2.4.3 Shock and Vibration	11
2.4.4 Mean Time between Failures (MTBF)	11
2.5 CE AND FCC COMPATIBILITY	12
2.6 RoHS COMPLIANCE	12
2.7 RELIABILITY	12
2.8 TRANSFER MODE	12
2.9 PIN ASSIGNMENT	13
2.10 MECHANICAL DIMENSIONS.....	14
2.11 ASSEMBLY WEIGHT	14
2.12 SEEK TIME	14
2.13 HOT PLUG.....	14
2.14 NAND FLASH MEMORY.....	14
3. THEORY OF OPERATION	15
3.1 OVERVIEW.....	15
3.2 SATA CONTROLLER	15
3.3 ERROR DETECTION AND CORRECTION.....	15
3.4 WEAR-LEVELING	16
3.5 BAD BLOCKS MANAGEMENT	16
3.6 iDATA GUARD.....	16
3.7 GARBAGE COLLECTION/TRIM	16
3.8 iPOWER GUARD.....	16
3.9 DIE RAID	16

3.10 QUICK ERASE (OPTIONAL)	17
3.10.1 Quick Erase Command	17
4. INSTALLATION REQUIREMENTS	19
4.1 SATA SLIM 3TG6-P PIN DIRECTIONS	19
4.2 ELECTRICAL CONNECTIONS FOR SATA SLIM 3TG6-P	19
4.3 DEVICE DRIVE	19
5. SMART FEATURE SET	20
5.1 SMART ATTRIBUTES	21
6. PART NUMBER RULE	22

REVISION HISTORY

Revision	Description	Date
Preliminary	First Released	Oct., 2018
Rev 1.0	Add TRIM note Modify Performance Table Modify Power Consumption Table Update RoHS report	Apr., 2019
Rev 1.1	Modify Performance Table Add Die RAID Add Quick Erase (optional) Modify SMART Attribute Table Update RoHS report to 2019 version Add CE/FCC report	May, 2019
Rev 1.2	Remove 1TB information	Nov., 2020
Rev 1.3	Update TBW	Aug., 2021
Rev 1.4	Update LBA	Nov., 2021
Rev 1.5	Update LBA	Apr., 2022

List of Tables

TABLE 1: DEVICE PARAMETERS	10
TABLE 2: PERFORMANCE - 64 LAYERS 3D TLC¹	10
TABLE 3: INNODISK SATA SLIM 3TG6-P POWER REQUIREMENT	10
TABLE 4: POWER CONSUMPTION –64 LAYERS 3D TLC	11
TABLE 5: TEMPERATURE RANGE FOR SATA SLIM 3TG6-P	11
TABLE 6: SHOCK/VIBRATION TESTING FOR SATA SLIM 3TG6-P	11
TABLE 7: SATA SLIM 3TG6-P MTBF	12
TABLE 8: INNODISK SATA SLIM 3TG6-P PIN ASSIGNMENT	13

List of Figures

FIGURE 1: INNODISK SATA SLIM 3TG6-P	8
FIGURE 2: INNODISK SATA SLIM 3TG6-P BLOCK DIAGRAM	15
FIGURE 3: SIGNAL SEGMENT AND POWER SEGMENT	19

1. Product Overview

1.1 Introduction of Innodisk SATA Slim 3TG6-P

Innodisk SATA Slim 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 SATA Slim 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).

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 SATA Slim is available in follow capacities:

[SATA Slim 3TG6-P 128GB](#) [SATA Slim 3TG6-P 256GB](#)

[SATA Slim 3TG6-P 512GB](#)



Figure 1: Innodisk SATA Slim 3TG6-P

1.3 SATA Interface

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

1.4 MO-297 Form Factor

The Industry-standard SATA Slim form factor design with metal material case is easy for installation, which has a compact design 54.0mm (W) x 39.0mm (L) x 4.0mm (H).

2. Product Specifications

2.1 Capacity and Device Parameters

SATA Slim 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	214906608	114473
256GB	16383	16	63	468862128	228936
512GB	16383	16	63	937703088	457862

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance - 64 Layers 3D TLC¹

Capacity	Unit	128GB	256GB	512GB
Sequential* Read (max.)	MB/s	560	550	560
Sequential* Write (max.)		130	280	510
4KB Random* Read (QD32)	IOPS	41000	71000	73000
4KB Random* Write (QD32)		37000	49000	65000

Note: 1. Performance based on CrystalDiskMark 5.1.2 with file size 1000MB of Queue Depth 32

2. Performance may vary based on various firmware version or test platform

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 3: Innodisk SATA Slim 3TG6-P Power Requirement

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

2.3.2 Power Consumption

Table 4: Power Consumption –64 Layers 3D TLC

Mode	Power Consumption (W)
Read	2.4
Write	3.0
Idle	1.0
Power-on Peak	1.9

Note: 1. The workload based on IOMeter with file size 1MBytes with Queue Depth 32 sequential read & write

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for SATA Slim 3TG6-P

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 SATA Slim 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 SATA Slim 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 7: SATA Slim 3TG6-P MTBF

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

2.5 CE and FCC Compatibility

SATA Slim 3TG6-P conforms to CE and FCC requirements.

2.6 RoHS Compliance

SATA Slim 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 Years at NAND Life End	
TBW* (Total Bytes Written) Unit:TB		
Capacity	Sequential workload	Client workload
128GB	341	289
256GB	682	578
512GB	1364	1154
*Note:		
1. Sequential: Mainly sequential write.		
2. Client: Follow JESD218 Test method and JESD219A Workload, tested by ULINK.		
3. Based on out-of-box performance.		

2.8 Transfer Mode

SATA Slim 3TG6-P support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

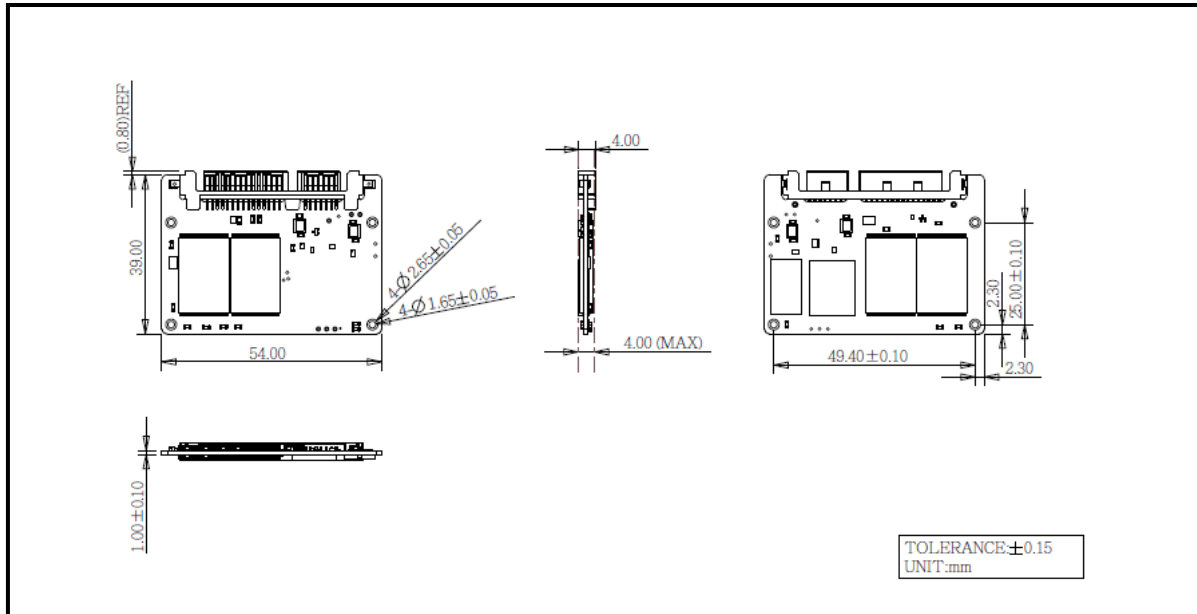
2.9 Pin Assignment

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

Table 8: Innodisk SATA Slim 3TG6-P 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



2.11 Assembly Weight

An Innodisk SATA Slim 3TG6-P within 3D TLC flash ICs, 2TB's weight is 90 grams approx.

2.12 Seek Time

Innodisk SATA Slim 3TG6-P 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 SATA Slim 3TG6-P 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 SATA Slim 3TG6-P from the system level, including the major hardware blocks.

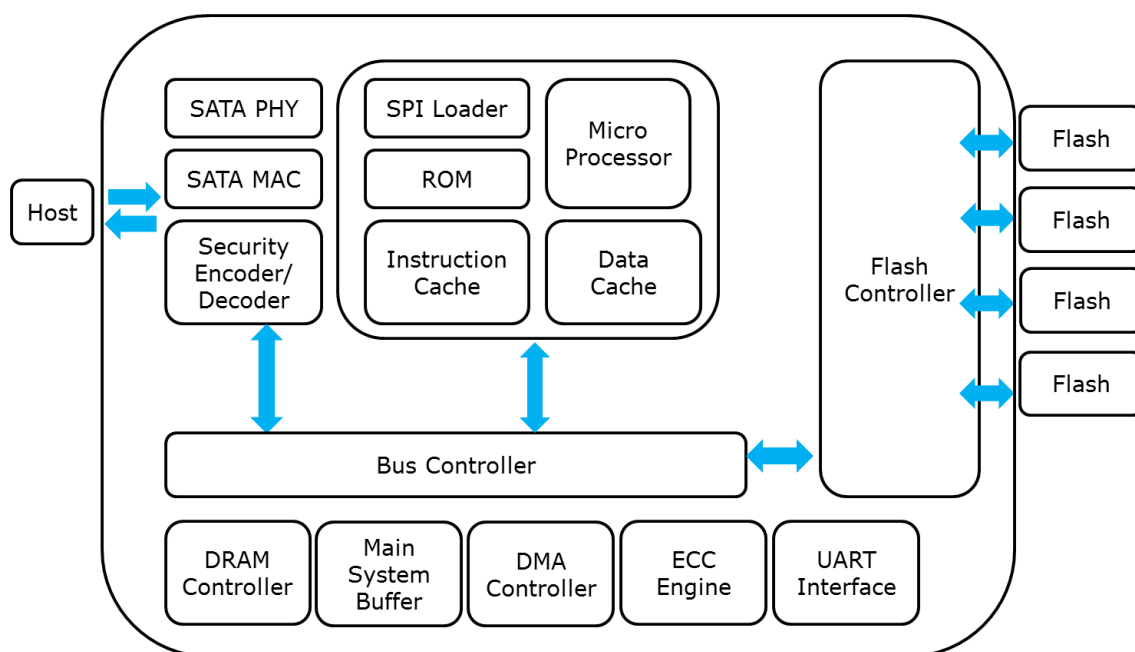


Figure 2: Innodisk SATA Slim 3TG6-P Block Diagram

Innodisk SATA Slim 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 SATA Slim 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 SATA Slim 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 SATA Slim 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 start-up and shut-down to maintain device performance and ensure data integrity.

3.9 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 3TG6-P series is default enable the Die RAID function for the industrial application.

3.10 Quick Erase (optional)

Quick Erase function is designed for emergency data erase in few seconds by providing ATA command.

3.10.1 Quick Erase Command

- Protocol: No Data

-Inputs

Table 9: Execute Quick Erase command for inputs information

Register	7	6	5	4	3	2	1	0
Features	21h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 10: Quick Erase command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

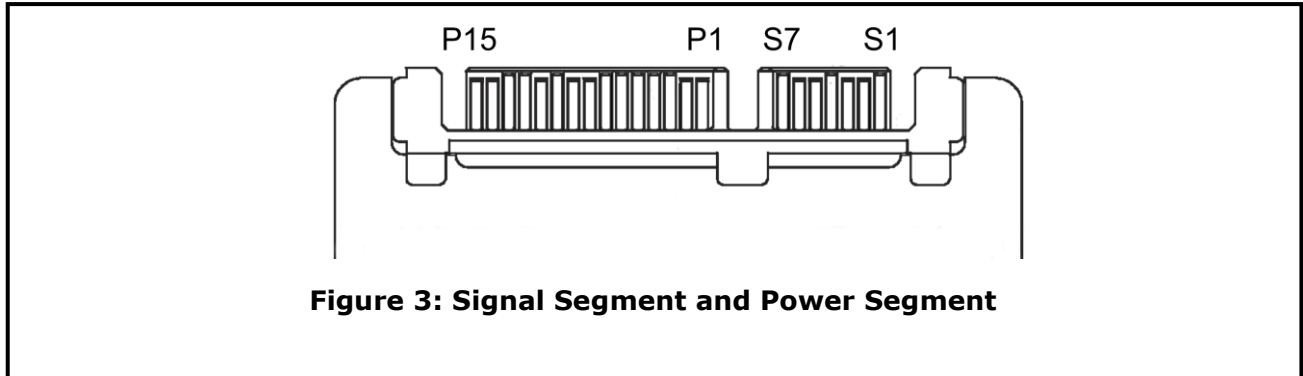
DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

4. Installation Requirements

4.1 SATA Slim 3TG6-P Pin Directions



4.2 Electrical Connections for SATA Slim 3TG6-P

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. Innodisk SATA Slim 3TG2-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)	Raw Attribute Value							Attribute Name
5 (05h)	LSB			MSB	00	00	00	Later Bad
9 (09h)	LSB			MSB	00	00	00	Power-On hours Count
12 (0Ch)	LSB			MSB	00	00	00	Drive Power Cycle Count
163 (A3h)	LSB					MSB	00	Total Bad Block Count
165 (A5h)	LSB			MSB	00	00	00	Max Erase count
167 (A7h)	LSB			MSB	00	00	00	Avg Erase count
169 (A9h)	LSB	00	00	00	00	00	00	Device Life
170 (AAh)	LSB					MSB	00	Spare Block Count
171 (ABh)	LSB					MSB	00	Program fail count
172 (ACh)	LSB					MSB	00	Erase fail count
184 (B8h)	LSB			MSB	00	00	00	Error Corrected Count
187 (BBh)	LSB			MSB	00	00	00	Reported Uncorrect Count
192 (C0h)	LSB			MSB	00	00	00	Unexpected Power Loss Count
194 (C2h)	Cur.*	00	MIN	00	MAX	03	Cur. *	Temperature
229 (E5h)	ID 0	ID 1	ID 2	ID 3	ID 4	ID 5	00	Flash ID
235 (EBh)		MSB	LSB	MSB	LSB	MSB	LSB	Later bad block info (Read/Write/Erase)
241 (F1h)	LSB					MSB	00	Total LBA written(LBA=32MB)
242 (F2h)	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
	D	G	S	L	M	-	A	2	8	M	7	1	E	C	1	Q	F	-	X	X
Description	Disk	SATA Slim					Capacity			Category			Flash mode	Operation Temp.	Internal Control	CH.	Flash		Customized Code	
Definition																				
Code 1 st (Disk)													Code 13 th (Flash mode)							
D : Disk													E: 64 layers 3D TLC							
Code 2 nd ~ 5 th (Form Factor)													Code 14 th (Operation Temperature)							
GSLM: SATA Slim													C: Standard Grade (0℃~ +70℃)							
Code 7 th ~9 th (Capacity)													W: Industrial Grade (-40℃~ +85℃)							
A28: 128GB													Code 15 th (Internal control)							
B56: 256GB													1: PCB version							
C12: 512GB																				
													Code 16 th (Channel of data transfer)							
Code 10 th ~12 th (Series)													Q: Quad Channels							
M71: SATA 3TG6-P																				
													Code 17 th (Flash Type)							
													F: Kioxia 3D TLC							
													Code 19 th ~20 th (Customized code)							