

M.2 (S80)

3TG6-P Series

Customer:

Customer

Part Number:

Innodisk

Part Number:

Innodisk

Model Name:

Date:

Innodisk Approver	Customer Approver

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REVISION HISTORY

Revision	Description	Date
V1.0	First Released	Jul., 2021
V1.1	Update Performance	Jul., 2022
V1.2	Update 128GB LBA	Oct., 2022
V1.3	Add 112-L 3D TLC	Oct., 2022

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1. Product Overview

1.1 Introduction of Innodisk M.2 (S80) 3TG6-P

Innodisk M.2 (S80) 3TG6-P 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 (S80) 3TG6-P 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 (S80) 3TG6-P is available in follow capacities within 3D TLC flash ICs.

M.2 (S80) 3TG6-P 128GB

M.2 (S80) 3TG6-P 256GB

M.2 (S80) 3TG6-P 512GB

M.2 (S80) 3TG6-P 1TB

M.2 (S80) 3TG6-P 2TB



Figure 1: Innodisk M.2 (S80) 3TG6-P (type 2280)

1.3 SATA Interface

Innodisk M.2 (S80) 3TG6-P 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 (S80) 3TG6-P 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 (S80) 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

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance- 64 Layers 3D TLC

Capacity	Unit	128GB	256GB	512GB	1TB
Sequential* Read (max.)	MB/s	560	550	560	530
Sequential* Write (max.)		150	300	490	450
4KB Random** Read (QD32)	IOPS	46,000	70,000	73,000	76,000
4KB Random** Write (QD32)		37,000	57,000	62,000	59,000

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- 112 Layers 3D TLC

Capacity	Unit	128GB	256GB	512GB	1TB	2TB
Sequential* Read (max.)	MB/s	410	520	510	510	510
Sequential* Write (max.)		80	140	340	380	390
4KB Random** Read (QD32)	IOPS	29,000	53,000	71,000	75,000	85,000
4KB Random** Write (QD32)		17,000	31,000	57,000	58,000	59,000

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

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 4: Innodisk M.2 (S80) 3TG6-P Power Requirement

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

2.3.2 Power Consumption

Table 5: Power Consumption

Mode	Power Consumption (W)
Read	2.6
Write	3.1
Idle	1.0

* Target: 1TB M.2 (S80) 3TG6-P

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 6: Temperature range for M.2 (S80) 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 7: Shock/Vibration Testing for M.2 (S80) 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 M.2 (S80) 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 8: M.2 (S80) 3TG6-P MTBF

Product	Condition	MTBF (Hours)
Innodisk M.2 (S80) 3TG6-P	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

M.2 (S80) 3TG6-P conforms to CE and FCC requirements.

2.6 RoHS Compliance

M.2 (S80) 3TG6-P is fully compliant with RoHS directive.

2.7 Reliability

Table 9: M.2 (S80) 3TG6-P TBW

Parameter		Value
Read Cycles		Unlimited Read Cycles
Flash endurance		3,000 P/E cycles
Wear-Leveling Algorithm		Support
Bad Blocks Management		Support
Error Correct Code		Support
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, tested by Vdbench. 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 (S80) 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 M.2 (S80) 3TG6-P uses a standard SATA pin-out. See Table 9 for M.2 (S80) 3TG6-P pin assignment.

Table 10: Innodisk M.2 (S80) 3TG6-P 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

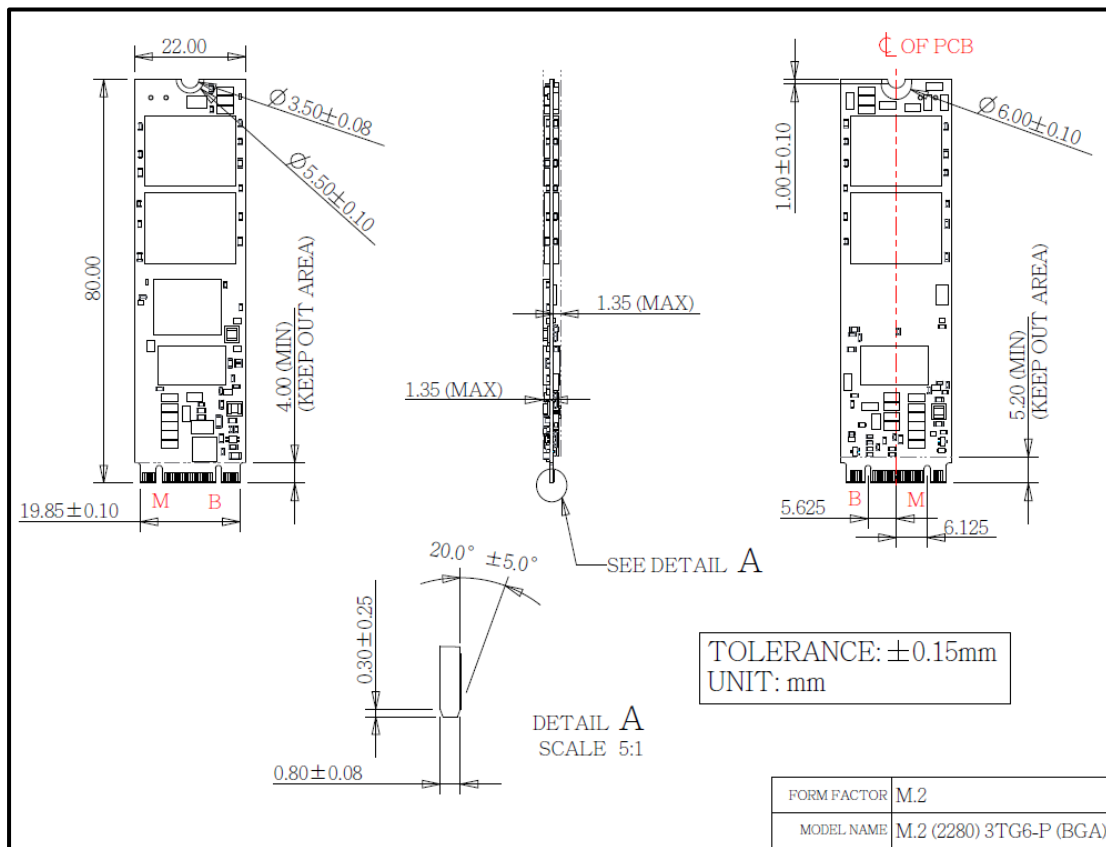


Figure 2: Innodisk M.2 (S80) 3TG6-P diagram (BGA)

2.11 Assembly Weight

An Innodisk M.2 (S80) 3TG6-P within flash ICs, 512GB's weight is 10 grams approximately.

2.12 Seek Time

Innodisk M.2 (S80) 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 M.2 (S80) 3TG6-P 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 (S80) 3TG6-P from the system level, including the major hardware blocks.

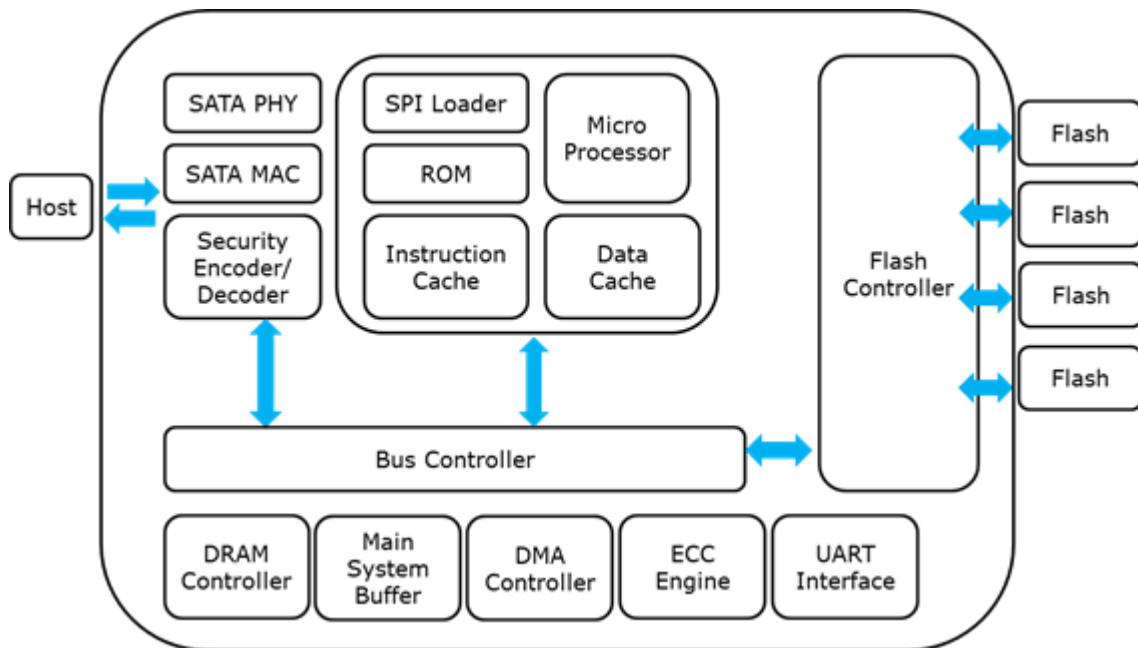


Figure 3: Innodisk M.2 (S80) 3TG6-P Block Diagram

Innodisk M.2 (S80) 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 III Controller

Innodisk M.2 (S80) 3TG6-P is designed with 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 4 channels for flash interface.

3.3 Error Detection and Correction

Innodisk M.2 (S80) 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 M.2 (S80) 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

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 (S80) 3TG6-P series is default enable the Die RAID function for the industrial application.

3.11 iCell Technology

iCell circuit is designed with several capacitors to be able to provide power after host power off. The SSD controller can write all DRAM buffer data to flash, so that is why M.2 (S80) 3TG6-P can ensure all data can be written to disk without any data loss.

4. Installation Requirements

4.1 M.2 (S80) 3TG6-P Pin Directions

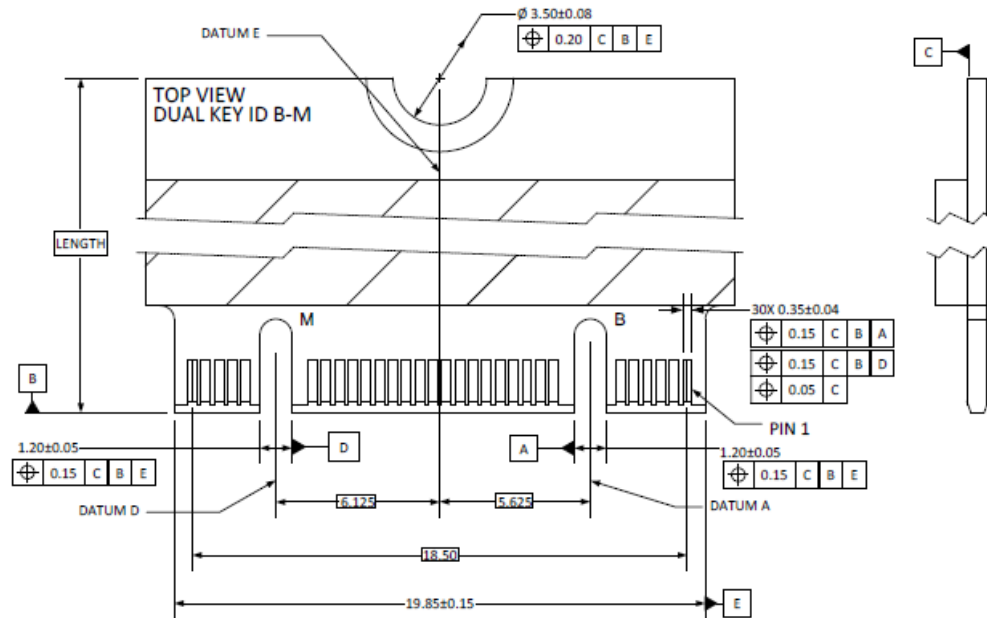


Figure 4: Signal Segment and Power Segment

4.2 Electrical Connections for M.2 (S80) 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. The Innodisk M.2 (S80) 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.

Table 11: 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 3TG6-P series SMART data attributes are listed in following table.

Table 12: SMART attribute

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 written(LBA=32MB)
F2	64 _{hex}	LSB					MSB	00	Total LBA read(LBA=32MB)

Cur.* =Current

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	22
	D	G	M	2	8	-	0	1	T	M	7	1	E	C	A	Q	F	P	-	X	X	X
Definition																						
Code 1 st (Disk)											Code 14 th (Operation Temperature)											
D : Disk											C: Standard Grade (0℃~ +70℃)											
											W: Industrial Grade (-40℃~ +85℃)											
Code 2 nd (Feature set)											Code 15 th (Internal control)											
G : EverGreen series											A~Z: BGA PCB version.											
Code 3 rd ~5 th (Form factor)											Code 16 th (Channel of data transfer)											
M28: M.2 Type 2280-D2-B-M											D: Dual Channels											
											Q: Quad Channels											
Code 7 th ~9 th (Capacity)											Code 17 th (Flash Type)											
A28: 128GB		B56:256GB				C12:512GB					F: Kioxia 3D TLC											
01T: 1TB		02T: 2TB																				
Code 10 th ~12 th (Controller)											Code 18 th (iCell)											
M71: 3TG6-P											P: iCell feature											
Code 13 th (Flash mode)											Code 19 th ~21 st (Customize code)											
E: 64 layers 3D TLC																						
K: 112 layers 3D TLC																						