innodisk

2.5" SATA SSD

3TG8-P Series

Customer: _____

Customer Part Number: _____

Innodisk Part Number: _____

Innodisk Model Name: _____

Date: _____

Innodisk Approver	Customer Approver

Total Solution For Industrial Flash Storage

Features:

- SATA III
- Kioxia 3D TLC NAND
- 2.5” SATA SSD
- Standard temperature
- Dynamic Thermal Management
- iDataguard
- PLP (iCell) Technology
- AES-256 Bits Encryption Engine (Optional)
- Support TCG OPAL Function (Optional)

Performance:

- Sequential Read up to 560 MB/s
- Sequential Write up to 530 MB/s

Power Requirements:

Input Voltage:	5V±5%
Max Operating Wattage (R/W):	5.2W
Idle Wattage:	1.2W

Reliability:

Capacity	TBW (Client)	DWPD
1TB	2,826	2.96
2TB	11,857	6.20
4TB	21,548	5.63
8TB	40,988	5.36

Data Retention	3 Months
Warranty	3 Years

3 months 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
V1.0	First Release	Mar., 2024
V1.1	Update Client Workload	Jun., 2024
V1.2	Revised NAND flash memory	Jun., 2024
V1.3	Remove WT information	Jun., 2024
V1.4	Update Client workload	Jul., 2024
V1.5	Update DWPD	Nov., 2024

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1. Product Overview

1.1 Introduction of Innodisk 2.5” SATA SSD 3TG8-P

Innodisk 2.5” SATA SSD 3TG8-P products provide high capacity and high performance flash memory Solid State Drive (SSD) that complies with Serial ATA (SATA) up to SATA III standard (6.0 Gb/s). The Innodisk 2.5” SATA SSD 3TG8-P is designed for industrial field and packs with several features like wear-leveling, garbage collection, AES and TCG OPAL.

With the outstanding performance, 3TG8-P has minimal latency, small seek time, and effectively reduces the booting time of operation system. With maximum capacity of 8TB, it is also qualified for most of the high data storage 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 2.5” SATA SSD 3TG8-P is available in follow capacities:

2.5” SATA SSD 3TG8-P 1TB
2.5” SATA SSD 3TG8-P 2TB
2.5” SATA SSD 3TG8-P 4TB
2.5” SATA SSD 3TG8-P 8TB

Figure 1: Innodisk 2.5” SATA SSD 3TG8-P

1.3 SATA Interface

Innodisk 2.5” SATA SSD 3TG8-P supports SATA III interface, and backward compliant with SATA SATA II and I.

1.4 2.5-inch Form Factor

The Industry-standard 2.5-inch form factor design with metal material case is easy for installation, which has a compact design 69.85mm (W) x 100.00mm (L) x 7.00mm (H)

2. Product Specifications

2.1 Capacity and Device Parameters

2.5" SATA SSD 3TG8-P device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	LBA	Cylinders	Heads	Sectors	User Capacity(MB)
1TB	1875385008	16383	16	63	915715
2TB	3750748848	16383	16	63	1831420
4TB	7501476528	16383	16	63	3662840
8TB	15002931888	16383	16	63	7325681

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance[1]

Capacity	Unit	1TB	2TB	4TB	8TB
Sequential[2] Read (max.)	MB/s	550	550	560	550
Sequential[2] Write (max.)		520	530	520	500
4KB Random[2] Read (Q32T1)	IOPS	83,000	84,000	78,000	90,000
4KB Random[2] Write (Q32T1)		79,000	79,000	75,000	85,000

Note: 1. Performance based on CrystalDiskMark 6.0.2 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 2.5" SATA SSD 3TG8-P Power Requirement

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

2.3.2 Power Consumption

Table 4: Typical Power Consumption

Mode	Power Consumption (W)
Read(RMS)	3.0
Write(RMS)	5.2
Idle	1.2
Power on peak	9.5

Target: 2.5" SATA SSD 3TG8-P 8TB

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range

Temperature	Range
Operating	Standard Grade: 0°C to +70°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 2.5" SATA SSD 3TG8-P

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 2.5" SATA SSD 3TG8-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: 2.5” SATA SSD 3TG8-P MTBF

Product	Condition	MTBF (Hours)
Innodisk 2.5” SATA SSD 3TG8-P	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

2.5” SATA SSD 3TG8-P conforms to CE and FCC requirements.

Table 8: Shock/Vibration Testing for 2.5” SATA SSD 3TG8-P

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

2.6 RoHS Compliance

2.5” SATA SSD 3TG8-P is fully compliant with RoHS directive.

2.7 Reliability

Parameter	Value		
Flash endurance	7,000 P/E cycles		
Error Correct Code	Support		
Data Retention	Under 40 °C: 3 Months at NAND Life End		
TBW* (Total Bytes Written) Unit:TB			
Capacity	**Sequential workload**	**Client workload**	**Enterprise workload**
1TB	6,363	2,826	842
2TB	12,727	11,857	2,741
4TB	25,454	21,548	6,211
8TB	50,909	40,988	12,035

*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

2.5” SATA SSD 3TG8-P support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

2.9 Pin Assignment

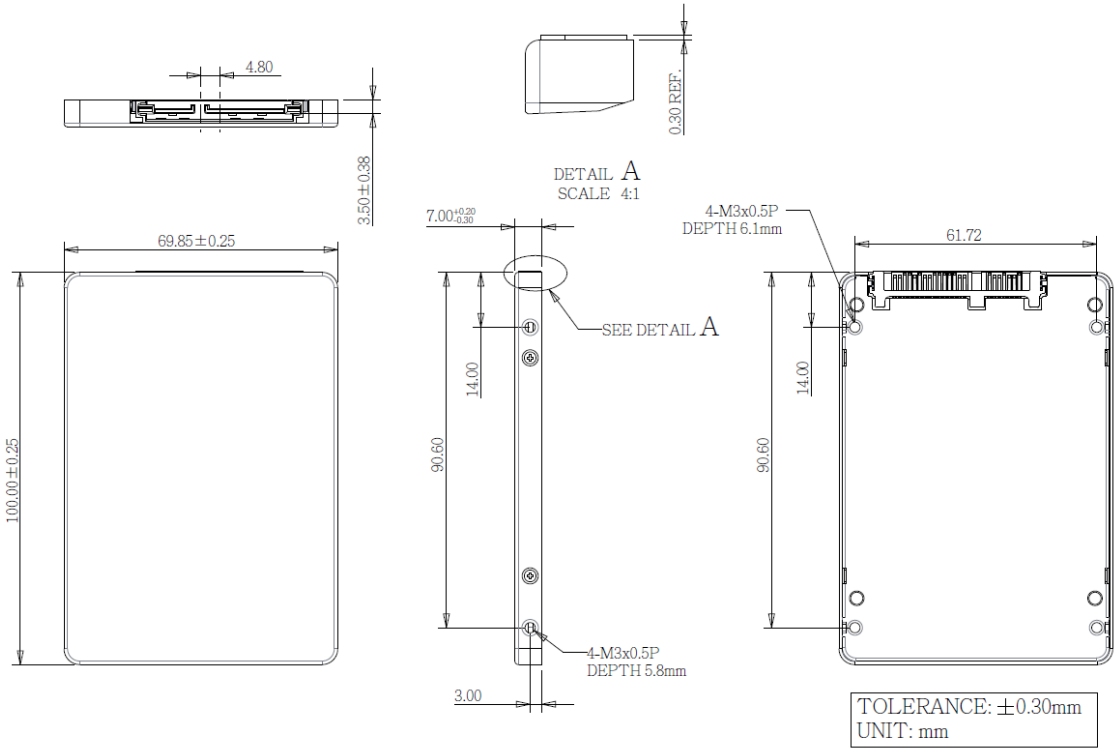
Innodisk 2.5” SATA SSD 3TG8-P uses a standard SATA pin-out. See Table 8 for 2.5” SATA SSD 3TG8-P pin assignment.

Table 9: Innodisk 2.5” SATA SSD 3TG8-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

* DGS25-XXXDEXKXAEFP



2.11 Assembly Weight

An Innodisk 2.5” SATA SSD 3TG8-P within 3D TLC flash ICs, 8TB’s weight is 65 grams approx.

2.12 Seek Time

Innodisk 2.5” SATA SSD 3TG8-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 2.5” SATA SSD 3TG8-P uses 3D TLC NAND flash memory, with 7,000 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 2.5" SATA SSD 3TG8-P from the system level, including the major hardware blocks.

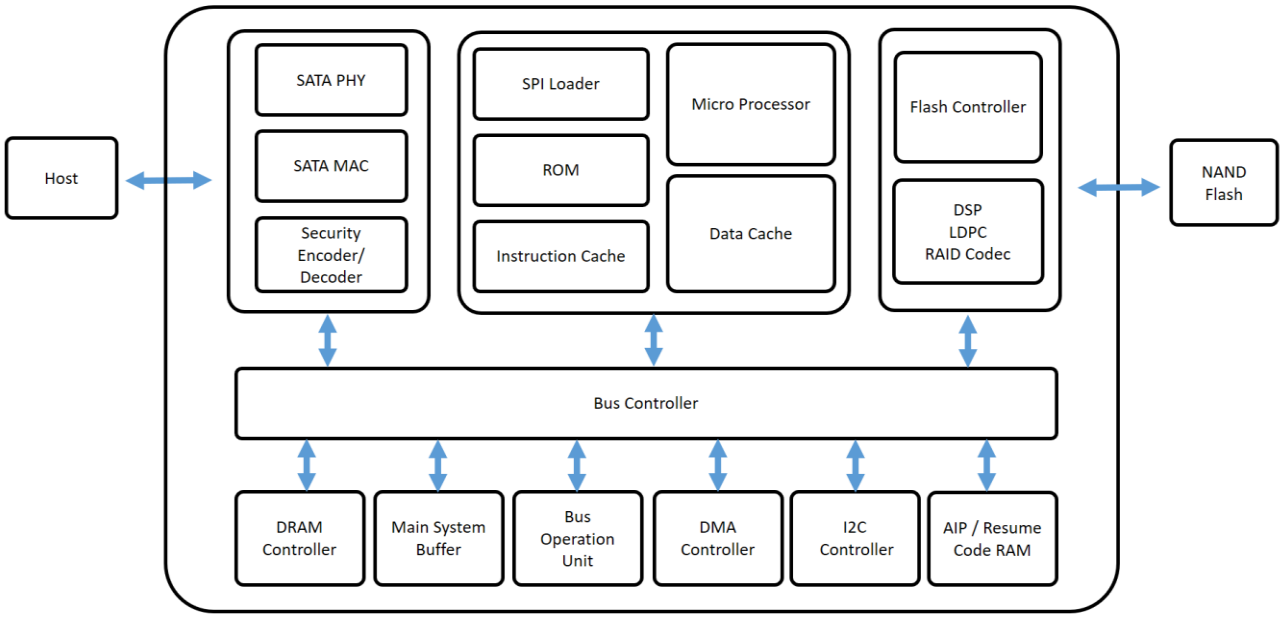


Figure 2: Innodisk 2.5" SATA SSD 3TG8-P Block Diagram

Innodisk 2.5" SATA SSD 3TG8-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 2.5" SATA SSD 3TG8-P is designed with 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 2.5"SATA SSD 3TG8-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 2.5" SATA SSD 3TG8-P 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 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 PLP (iCell) Technology

PLP (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 2.5” SATA SSD 3TG8-P can ensure all data can be written to disk without any data loss. Once the SSD controller receives this feedback signal, the SSD firmware triggers a mechanism to write the data into flash storage. As a result, PLP (iCell) is able to provide power during power outage, preventing any data loss from happening.

Figure 3: Diagram of 2.5” SATA SSD with iCell

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 3TG8-P series is default enable the Die RAID function for the industrial application.

3.10 TCG OPAL (Optional)

OPAL is a set of specifications for features of data storage devices that enhance security. These specifications are published by the Trusted Computing Group’s Storage Work Group. Innodisk 3TG8-P is compliant with TCG OPAL 2.0(*1). The capability of TCG OPAL Security mode allows multiple users with independent access control to read/write/erase independent data areas (LBA ranges). Each locking range adjusts by authenticated authority. Note that by default there is a single “Global Range” that encompasses the whole user data area. In TCG Opal Security Mode, Revert, Revert SP and GenKey command can erase all of data including global range and locking range; in the meantime generate the new encrypted key.

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

3.11 2.5” SATA SSD 3TG8-P 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.

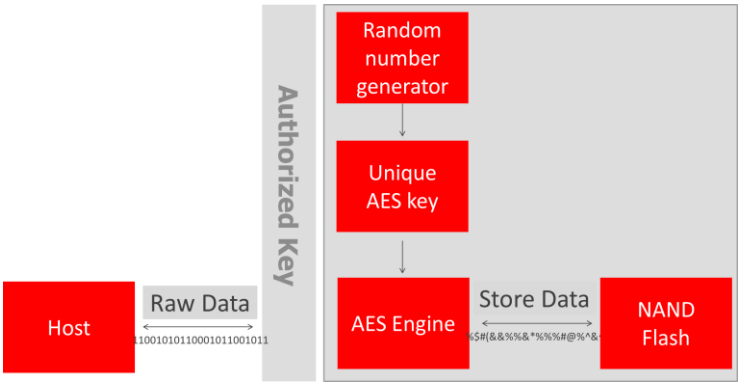


Figure 4: Innodisk 2.5” SATA SSD 3TG8-P AES flow chart

3.11.1 Encrypted Key Management

Innodisk 3TG8-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.

3.11.2 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 2.5” SATA SSD 3TG8-P Pin Directions

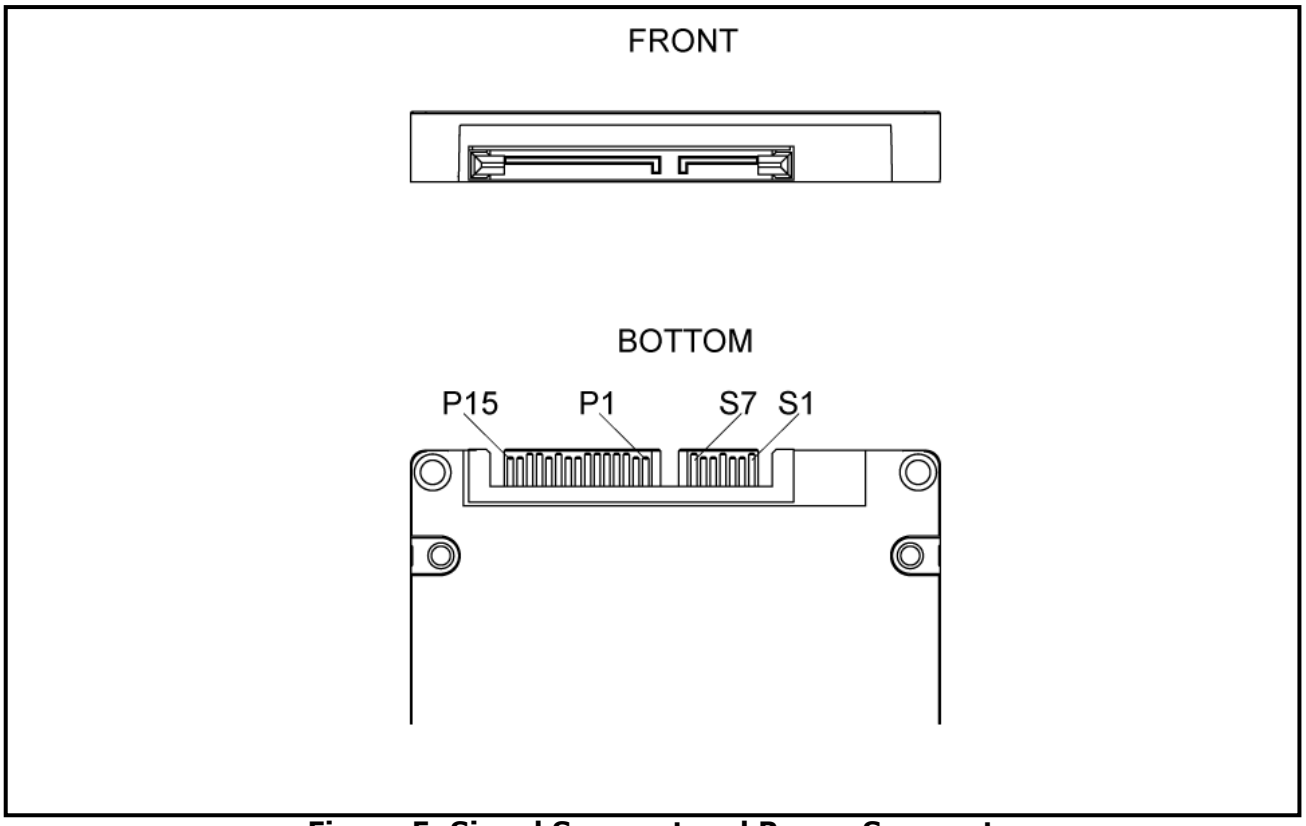


Figure 5: Signal Segment and Power Segment

4.2 Electrical Connections for 2.5” SATA SSD 3TG8-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 Form Factor

Please prepare following things:

- Screw driver.
- Four M3 screws. (Torque value is 2.0 ~ 2.5 Kgf.cm)
- SATA single cable (7-pin, Maximum length l meter).
- SATA power cable (15-pin).

Please turn off your computer, and open your computer’s case. Find one of available 2.5-inch slot, and plug the SSD in. To use the screws fix the SSD. Plug in the SATA single cable, and power cable. Please boot the installation Operation System from CD-ROM, and install Operation System into SSD.

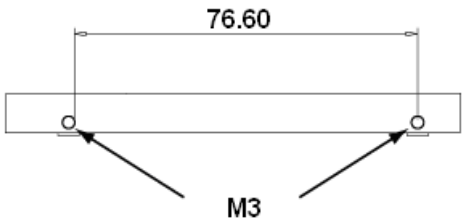


Figure 6: 2.5” SATA SSD 3TG8-P Mechanical Screw Hole

4.4 Device Drive

No additional device drives are required. Innodisk 2.5” SATA SSD 3TG8-P can be configured as a boot device.

5. SMART Feature Set

5.1 SMART Attributes

Innodisk 3TG8-P series SMART data attributes are listed in following table.

Attribute ID (hex)	**Attribute Name**						
1 (01h)	LSB	00	00	00	00	00	Read Error Rate
5 (05h)	LSB	MSB	00	00	00	00	Reallocated Sector Count
9 (09h)	LSB			MSB	00	00	Power-on Hours
12 (0Ch)	LSB			MSB	00	00	Power Cycle Count
160 (A0h)	LSB			MSB	00	00	On-line Uncorrectable Sector Count
161 (A1h)	LSB	MSB	00	00	00	00	Number of Valid Spare Block
163 (A3h)	LSB	MSB	00	00	00	00	Number of Initial Invalid Block
164 (A4h)	LSB			MSB	00	00	Total Erase Count
165 (A5h)	LSB			MSB	00	00	Maximum Erase Count
166 (A6h)	LSB			MSB	00	00	Minimum Erase Count
167 (A7h)	LSB			MSB	00	00	Average Erase Count
177 (B1h)	LSB			MSB	00	00	Wear Leveling Count
181 (B5h)	LSB			MSB	00	00	Program Fail Count
182 (B6h)	LSB			MSB	00	00	Erase Fail Count
192 (C0h)	LSB			MSB	00	00	Sudden Power-off Count
194 (C2h)	LSB						Current Temperature
			LSB				Minimum Temperature in Lifetime
					LSB		Maximum Temperature in Lifetime
195 (C3h)	LSB			MSB	00	00	Hardware ECC recovered
198 (C6h)	LSB			MSB	00	00	Uncorrectable Error Count Off-Line
199 (C7h)	LSB			MSB	00	00	SATA CRC error count
231 (E7h)	LSB	00	00	00	00	00	Remain Life Percentage
241 (F1h)	LSB					MSB	Total LBAs Written
242 (F2h)	LSB					MSB	Total LBAs Read

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**	**S**	**2**	**5**	**-**	**0**	**8**	**T**	**D**	**E**	**1**	**N**	**C**	**A**	**E**	**F**	**P**	**-**	**X**	**X**
	Disk	2.5″ SATA SSD				-	Capacity			Series			Flash mode	Op. Temp	Int. Control	CH.	Flash	iCell	-	Customized Code	

Definition	
Code 1st (Disk)	**Code 14th (Operation Temperature)**
D : Disk	C: Standard Grade (0℃~ +70℃)
Code 2nd ~ 5th (Form Factor)	**Code 15th (Internal control)**
GS25: 2.5″ SATA SSD	A: PCB type
Code 7th ~9th (Capacity)	**Code 16th (Channel of data transfer)**
01T: 1TB	E: Eight Channels
02T: 2TB	
04T: 4TB	**Code 17th (Flash Type)**
08T: 8TB	F: Kioxia 3D TLC
Code 10th ~12th (Series)	**Code 18th (iCell)**
DE1: SATA 3TG8-P	P: PLP (iCell)
DE2: SATA 3TG8-P with AES +TCG OPAL Function	
Code 13th (Flash mode)	**Code 20th ~ (Customized code)**
N: 112 layers 3D TLC (P/E cycle: 7K)	