

2.5" SATA SSD

3IE7 Series

Ultra iSLC

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 & Wide-temperature
- Support Ultra iSLC technology
- iPower Guard
- iData Guard
- Dynamic Thermal Management
- Hybrid Write

Performance:

- Sequential Read up to 560 MB/s
- Sequential Write up to 510 MB/s

Power Requirements:

Input Voltage:	5V±5%
Max Operating Wattage:	1.6W
Idle Wattage:	1.1W

Reliability:

Capacity	TBW	DWPD
40GB	2500	34.2
80GB	5000	34.2
160GB	10000	34.2
320GB	20000	34.2
640GB	40000	34.2

Data Retention	10 Years
Warranty	5 Years

For warranty details, please refer to:

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

Table of contents

1. PRODUCT OVERVIEW	8
1.1 INTRODUCTION OF INNODISK 2.5" SATA SSD 3IE7.	8
1.2 PRODUCT VIEW AND MODELS	8
1.3 SATA INTERFACE.....	9
1.4 2.5-INCH 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 NAND FLASH MEMORY.....	14
3. THEORY OF OPERATION	15
3.1 OVERVIEW.....	15
3.2 SATA III 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.....	16
3.8 TRIM	16
3.9 iPOWER GUARD.....	17
3.10 DIE RAID	17

- 3.11 THERMAL THROTTLING..... 17**
- 4. INSTALLATION REQUIREMENTS 18**
 - 4.1 2.5" SATA SSD 3IE7 PIN DIRECTIONS 18**
 - 4.2 ELECTRICAL CONNECTIONS FOR 2.5" SATA SSD 3IE7 18**
 - 4.3 FORM FACTOR..... 18**
 - 4.4 DEVICE DRIVE 19**
- 5. SMART FEATURE SET 20**
 - 5.1 SMART ATTRIBUTES.....20**
- 6. PART NUMBER RULE 22**

REVISION HISTORY

Revision	Description	Date
Rev 1.0	Official Release	Oct., 2023
Rev 1.1	Rename the series to Ultra iSLC	Dec., 2023
Rev 1.2	Update Warranty Period	Jan., 2024

List of Tables

TABLE 1: DEVICE PARAMETERS.....10

TABLE 2 : PERFORMANCE - 112 LAYERS 3D TLC¹10

TABLE 3: INNODISK 2.5" SATA SSD 3IE7 WITH KIOXIA NAND POWER REQUIREMENT10

TABLE 4: TYPICAL POWER CONSUMPTION 11

TABLE 5: TEMPERATURE RANGE FOR 2.5" SATA SSD 3IE7 WITH KIOXIA NAND..... 11

TABLE 6: SHOCK/VIBRATION TESTING FOR 2.5" SATA SSD 3IE7 11

TABLE 7: 2.5" SATA SSD 3IE7 MTBF..... 11

TABLE 8: INNODISK 2.5" SATA SSD 3IE7 PIN ASSIGNMENT13

List of Figures

FIGURE 1: INNODISK 2.5" SATA SSD 3IE7	8
FIGURE 2: INNODISK 2.5" SATA SSD 3IE7 BLOCK DIAGRAM	15
FIGURE 3: SIGNAL SEGMENT AND POWER SEGMENT	18

1. Product Overview

1.1 Introduction of Innodisk 2.5" SATA SSD 3IE7.

Innodisk 2.5" SATA SSD 3IE7 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, achieves excellent performance up to 4CH standard by cost effective controller with 4CH.

With Innodisk L³ FW architecture, combining our signature 4K mapping algorithm L² FW architecture with powerful LDPC technology, 3IE7 series has outstanding high IOPS, better data integrity and extended lifespan through reducing the bad block number happening.

For real industrial application, 3IE7 series has built-in thermal sensor to monitor the environment temperature. iData Guard, the power loss management mechanism developed by Innodisk, ensures data integrity while power sudden loss happened.

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 3IE7 is available in follow capacities.

2.5" SATA SSD 3IE7 40GB

2.5" SATA SSD 3IE7 80GB

2.5" SATA SSD 3IE7 160GB

2.5" SATA SSD 3IE7 320GB

2.5" SATA SSD 3IE7 640GB



Figure 1: Innodisk 2.5" SATA SSD 3IE7

1.3 SATA Interface

Innodisk 2.5" SATA SSD 3IE7 supports SATA III(6.0Gb/s) interface, and compliant with SATA I (1.5Gb/s) and SATA II(3.0Gb/s).

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 6.90mm (H)

2. Product Specifications

2.1 Capacity and Device Parameters

2.5" SATA SSD 3IE7 device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	LBA	Cylinders	Heads	Sectors	User Capacity(MB)
40GB	78161328	16383	16	63	38165
80GB	156301488	16383	16	63	76319
160GB	312581808	16383	16	63	152628
320GB	625142448	16383	16	63	305245
640GB	1250263728	16383	16	63	610480

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2 : Performance - 112 Layers 3D TLC¹

Capacity	Unit	40GB	80GB	160GB	320GB	640GB
Sequential ² Read (Q32T1)	MB/s	440	550	560	550	550
Sequential ² Write (Q32T1)		290	480	510	500	470
4KB Random ² Read (Q32T1)	IOPS	43,000	81,000	79,000	87,000	87,000
4KB Random ² Write (Q32T1)		60,000	75,000	58,000	76,000	73,000

Note:

1. Performance may vary based on various firmware version or test platform.
2. Performance results are based on CrystalDiskMark 6.0.2 with file size 1000MB of Queue Depth32.
3. Performance results are based on AIDA 64 v5.98 with block size 1MB of Linear Read & Write Test Item

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 3: Innodisk 2.5" SATA SSD 3IE7 with Kioxia NAND 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) ¹	1.5
Write (RMS) ¹	1.6
Idle	1.1
Boot Up	5.6

Target: 2.5" SSD 3IE7 640GB

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for 2.5" SATA SSD 3IE7 with Kioxia NAND

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 6: Shock/Vibration Testing for 2.5" SATA SSD 3IE7

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 3IE7 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 condition

Table 7: 2.5" SATA SSD 3IE7 MTBF

Product	Condition	MTBF (Hours)
Innodisk 2.5" SATA SSD 3IE7	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

2.5" SATA SSD 3IE7 conforms to CE and FCC requirements.

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

2.6 RoHS Compliance

2.5" SATA SSD 3IE7 is fully compliant with RoHS directive.

2.7 Reliability

Parameter		Value
Read Cycles		Unlimited Read Cycles
Flash endurance		100,000 P/E cycles
Wear-Leveling Algorithm		Support
Bad Blocks Management		Support
Die RAID Recovery		Support
Error Correct Code		Support
TBW* (Total Bytes Written) Units: TB		
Capacity	Sequential workload	Client workload
40GB	3400	2500
80GB	6800	5000
160GB	13600	10000
320GB	27200	20000
640GB	54400	40000
* Note: <ol style="list-style-type: none"> Sequential: Mainly sequential write, tested by Vdbench. Client: Follow JESD218 Test method and JESD219A Workload, tested by ULINK. (The capacity lower than 40GB client workload is not specified in JEDEC219A, the values are estimated.) Based on out-of-box performance. 		

2.8 Transfer Mode

2.5" SATA SSD 3IE7 support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

2.9 Pin Assignment

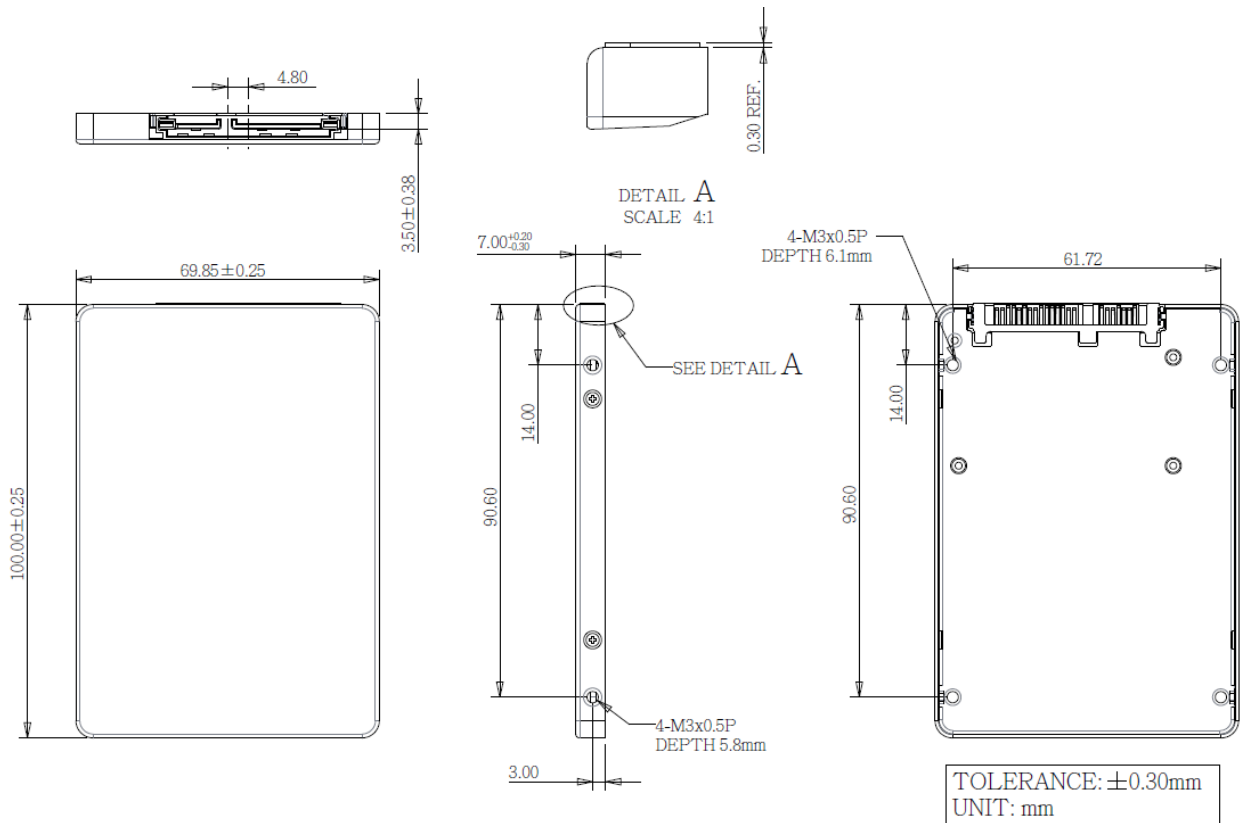
Innodisk 2.5" SATA SSD 3IE7 uses a standard SATA pin-out.

See Table 8 for 2.5" SATA SSD 3IE7 pin assignment.

Table 8: Innodisk 2.5" SATA SSD 3IE7 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 2.5" SATA SSD 3IE7 within flash ICs, 640GB's weight is 42 grams approximately.

2.12 Seek Time

Innodisk 2.5" SATA SSD 3IE7 is not a magnetic rotating design. There is no seek or rotational latency required.

2.13 NAND Flash Memory

Innodisk 2.5" SATA SSD 3IE7 uses 3D TLC NAND flash memory, with 100,000 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 3IE7 from the system level, including the major hardware blocks.

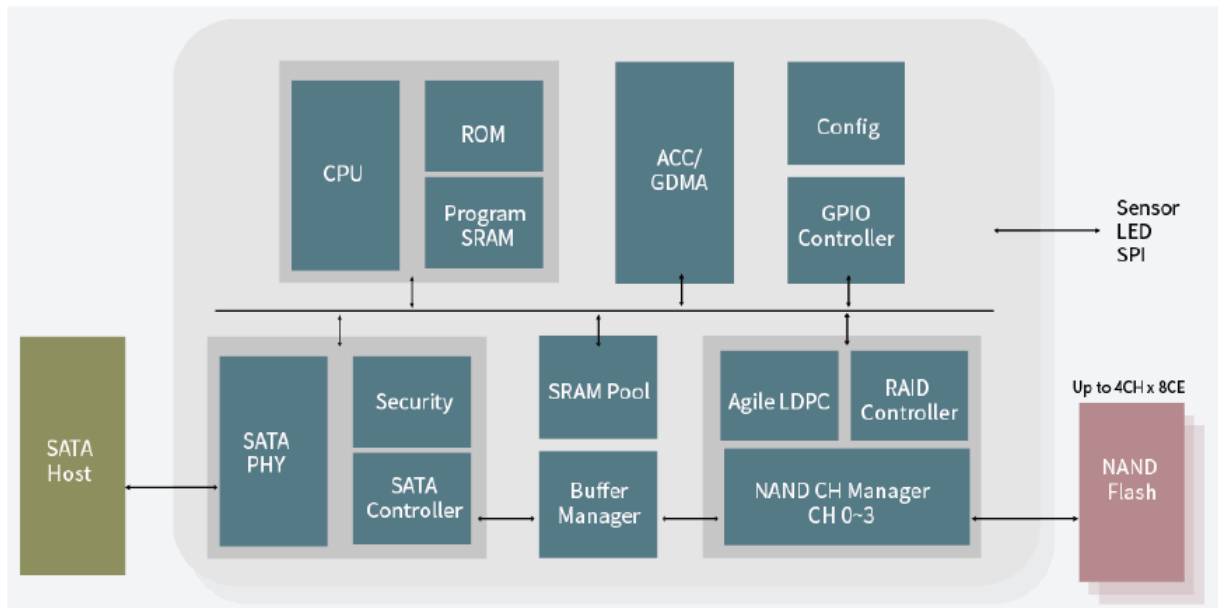


Figure 2: Innodisk 2.5" SATA SSD 3IE7 Block Diagram

Innodisk 2.5" SATA SSD 3IE7 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 2.5" SATA SSD 3IE7 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 2.5" SATA SSD 3IE7 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 3IE7 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 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 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 2.5" SATA SSD 3IE7 series is default enable the Die RAID function for the industrial application.

3.11 Thermal Throttling

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, Innodisk firmware activates the thermal throttling mechanism to regulate the SSD's temperature. Thermal throttling is crucial for SSDs since it prevents drive damage, which could otherwise result in data loss. However, it's worth noting that when thermal throttling is activated, read and write tasks may experience a reduction in speed.

4. Installation Requirements

4.1 2.5" SATA SSD 3IE7 Pin Directions

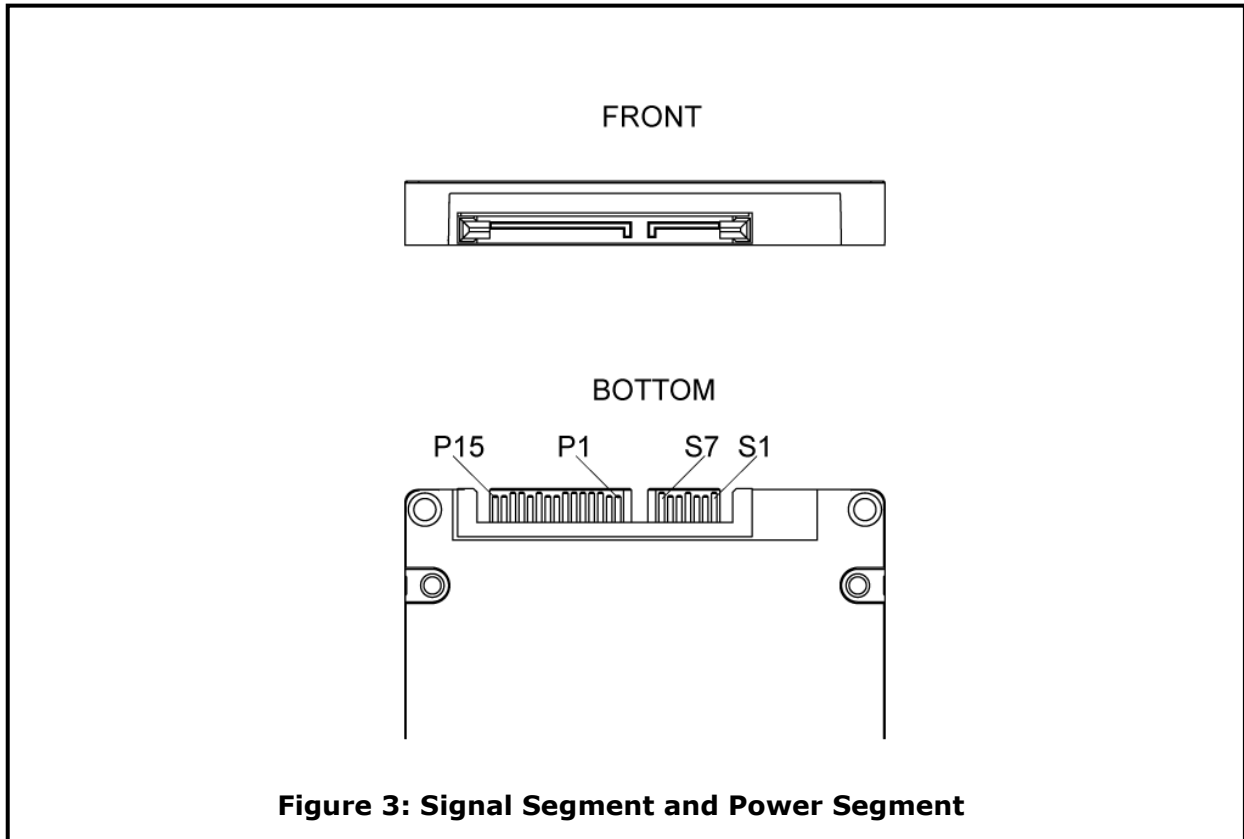


Figure 3: Signal Segment and Power Segment

4.2 Electrical Connections for 2.5" SATA SSD 3IE7

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 Form Factor

Please prepare following things:

- Screw driver.
- Four M3 screws. (Torque value 2.0 kgf-cm ~ 2.5 kgf-cm)
- SATA single cable (7-pin, Maximum length 1 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.

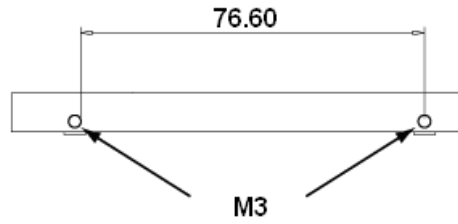


Figure 4: 2.5" SATA SSD 3IE7 Mechanical Screw Hole

4.4 Device Drive

No additional device drives are required. Innodisk 2.5" SATA SSD 3IE7 can be configured as a boot device.

5. SMART Feature Set

Innodisk 3IE7 series support the SMART command set and defines some vendor-specific data to report SMART attributes of SSD.

Table 1: 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 3IE7 series SMART data attributes are listed in following table.

Table 2: SMART attribute

Attribute ID (hex)	Value	Raw Attribute Value						Rsv	Attribute Name
01	X								Read Error Rate
05	X	LSB	MSB	00	00	00	00	00	Later Bad
09	LSB	LSB	MSB	00	00	00	00	00	Power-On hours Count
0C	LSB	LSB	MSB	00	00	00	00	00	Drive Power Cycle Count
A3	X	LSB			MSB	00	00	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	LSB	LSB	00	00	00	00	00	00	Device Life
AA	X	LSB	MSB	00	00	00	00	00	Spare Block Count
AB	LSB	LSB	MSB	00	00	00	00	00	Program fail count
AC	LSB	LSB	MSB	00	00	00	00	00	Erase fail count

C0	LSB	LSB	MSB	00	00	00	00	00	Unexpected Power Loss Count
C2	LSB			MIN		MAX	00	00	Temperature
E5		ID 0	ID 1	ID 2	ID 3	ID 4	ID 5		Flash ID
EB			MSB	LSB	MSB	LSB	MSB	LSB	Later bad block info (Read/Write/Erase)
F1	00	LSB			MSB	00	00	00	Total LBA written(LBA=32MB)
F2	00	LSB			MSB	00	00	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	H	S	2	5	-	4	0	G	D	K	1	K	C	C	D	F	-	X	X	X
Definition																					
Code 1st (Disk)											Code 13th (Flash Mode)										
D : Disk											K: 112 Layers 3D TLC										
Code 2nd (Feature Set)											Code 14th (Operation Temperature)										
H: iSLC series											C: Standard Grade (0°C~ +70°C)										
											W: Industrial Grade (-40°C~ +85°C)										
Code 3rd ~ 5th (Form Factor)											Code 15th (Internal control)										
S25: 2.5" SATA SSD											A: Full size PCBA version										
											C: Slim PCBA version										
Code 7th ~9th (Capacity)											Code 16th (Channel of data transfer)										
40G: 40GB											S: Single Channel										
80G: 80GB											D: Dual Channels										
A60: 160GB											Q: Quad Channels										
D2G: 320GB																					
F4G: 640GB											Code 17th (Flash Type)										
Code 10th ~12th (Controller)											F: Kioxia 3D TLC										
DK1: SATA 3IE7 series											Code 19th~21th (Customized Code)										