innodisk

Total Solution For Industrial Flash Storage

2.5" SATA SSD

3IE6-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
Rev 1.0	First Released	Nov., 2020
Rev 1.1	Modify Performance Table	Jan., 2021
Rev 1.2	Add 112 Layers 3D TLC	July, 2023
Rev 1.3	Update TBW	Oct., 2023
Rev 1.4	Update P/E cycle Update TBW	Sep.,2025

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1. Product Overview

1.1 Introduction of Innodisk 2.5” SATA SSD 3IE6-P

Innodisk 2.5” SATA SSD 3IE6-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 2.5” SATA SSD 3IE6-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 2.5” SATA SSD 3IE6-P is available in follow capacities:

2.5” SATA SSD 3IE6-P 80GB
2.5” SATA SSD 3IE6-P 160GB
2.5” SATA SSD 3IE6-P 320GB
2.5” SATA SSD 3IE6-P 640GB
2.5” SATA SSD 3IE6-P 1280GB

Figure 1: Innodisk 2.5” SATA SSD 3IE6-P

1.3 SATA Interface

Innodisk 2.5” SATA SSD 3IE6-P supports SATA III interface, and backward compliant with SATA I and SATA II.

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 3IE6-P device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	LBA	Cylinders	Heads	Sectors	User Capacity(MB)
80GB	156301488	16383	16	63	76319
160GB	312581808	16383	16	63	152628
320GB	625142448	16383	16	63	305245
640GB	1250263728	16383	16	63	610480
1280GB	2500506288	16383	16	63	1220950

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance- 64 Layers 3D TLC[1]

Capacity	Unit	80GB	160GB	320GB	640GB
Sequential[2] Read (max.)	MB/s	540	550	550	500
Sequential[2] Write (max.)		470	510	500	460
4KB Random[2] Read (QD32)	IOPS	87,000	89,000	69,000	70,000
4KB Random[2] Write (QD32)		76,000	77,000	66,000	66,000

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]

Table 3: Performance - 112 Layers 3D TLC[1]

Capacity	Unit	160GB	320GB	640GB	1280GB
Sequential[2] Read (Q32T1)	MB/s	510	500	500	500
Sequential[2] Write (Q32T1)		490	500	490	500
4KB Random[2] Read (Q32T1)	IOPS	78,000	81,000	80,000	84,000
4KB Random[2] Write (Q32T1)		66,000	67,000	67,000	69,000

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 platform2

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 4: Innodisk 2.5” SATA SSD 3IE6-P Power Requirement

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

2.3.2 Power Consumption

Table 5: Typical Power Consumption

Mode	Power consumption (W)
Read	2.9
Write	2.9
Idle	1.5
Boot-Up	5.6

Target: 2.5” SATA SSD 3IE6-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 6: Temperature range for 2.5” SATA SSD 3IE6-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 2.5” SATA SSD 3IE6-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 3IE6-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: 2.5” SATA SSD 3IE6-P MTBF

Product	Condition	MTBF (Hours)
Innodisk 2.5” SATA SSD 3IE6-P	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

2.5” SATA SSD 3IE6-P conforms to CE and FCC requirements.

2.6 RoHS Compliance

2.5” SATA SSD 3IE6-P is fully compliant with RoHS directive.

2.7 Reliability

Parameter	Value	
Flash endurance	100,000 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**
80GB	7102	7440
160GB	14204	14881
320GB	28409	29762
640GB	56818	59524
1280GB	113636	119048
*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

2.5” SATA SSD 3IE6-P support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

2.9 Pin Assignment

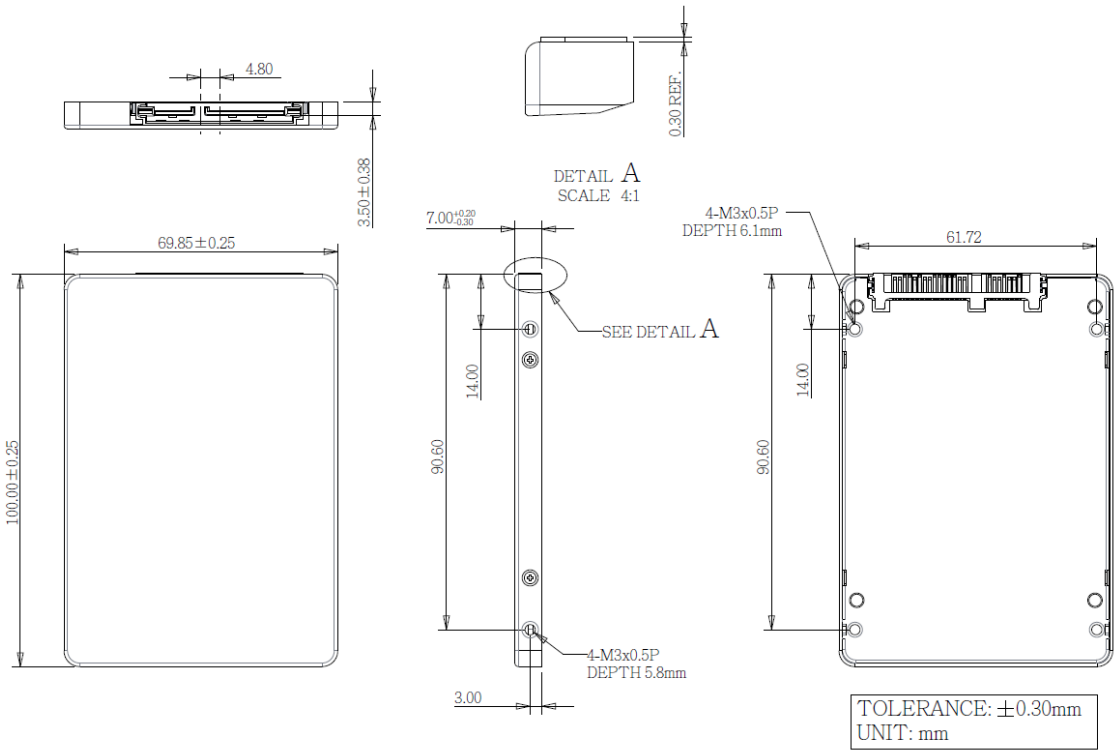
Innodisk 2.5” SATA SSD 3IE6-P uses a standard SATA pin-out. See Table 8 for 2.5” SATA SSD 3IE6-P pin assignment.

Table 9: Innodisk 2.5” SATA SSD 3IE6-P Pin Assignment

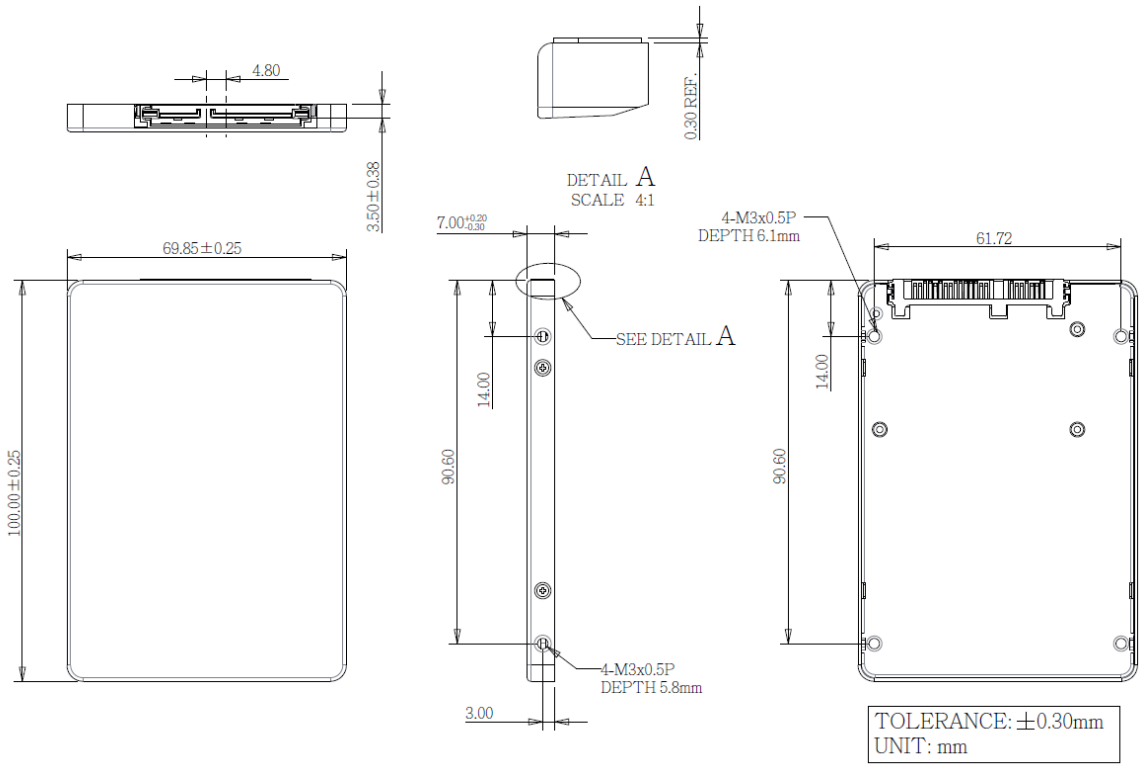
Name	Type	Description
S1	GND	NA
S2	A+	Differential Signal Pair A
S3	A-	
S4	GND	NA
S5	B-	Differential Signal Pair B
S6	B+	
S7	GND	NA
Key and Spacing separate signal and power segments		
P1	NC	NA
P2	NC	NA
P3	NC	NA
P4	GND	NA
P5	GND	NA
P6	GND	NA
P7	V5	5V Power, Pre-Charge
P8	V5	5V Power
P9	V5	5V Power
P10	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

* DHS25-XXXM71EXXQF (320GB ~ 640GB)
* DHS25-XXXM71KXAQFP



* DHS25-XXXM71EX3QF (80GB ~ 160GB)



2.11 Assembly Weight

An Innodisk 2.5” SATA SSD 3IE6-P within 3D TLC flash ICs, 640GB’s weight is 90 grams approx.

2.12 Seek Time

Innodisk 2.5” SATA SSD 3IE6-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 3IE6-P uses 3D TLC NAND flash memory, with 100,000 program & erase cycles based on iSLC mode, 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 3IE6-P from the system level, including the major hardware blocks.

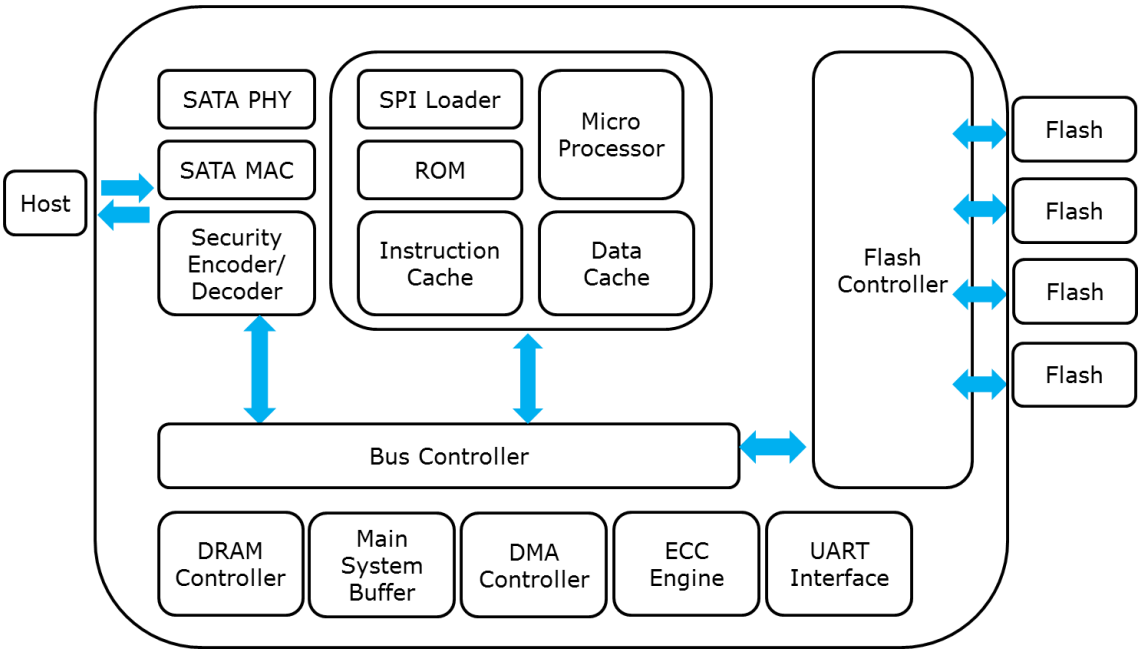


Figure 2: Innodisk 2.5” SATA SSD 3IE6-P Block Diagram

Innodisk 2.5” SATA SSD 3IE6-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.

* iCell is optional feature with different part number.

3.2 SATA Controller

Innodisk 2.5” SATA SSD 3IE6-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 2.5”SATA SSD 3IE6-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 3IE6-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 3IE6-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 10: 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 11: 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.

3.11 iCell Technology (Optional)

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 3IE6-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, 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

3.12 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.

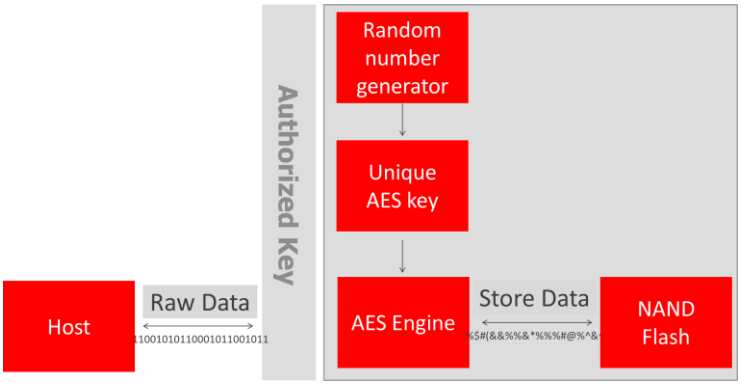


Figure 4: Innodisk 2.5” SATA SSD 3IE6-P AES flow chart

3.12.1 Encrypted Key Management

Innodisk 3IE6-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.

3.12.2 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 3IE6-P Pin Directions

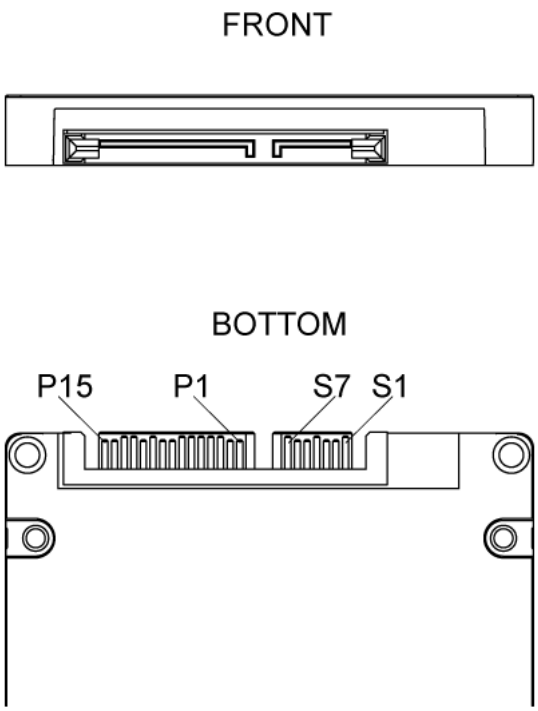


Figure 5: Signal Segment and Power Segment

4.2 Electrical Connections for 2.5” SATA SSD 3IE6-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.

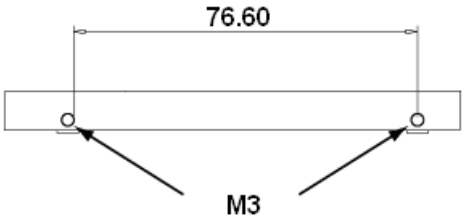


Figure 6: 2.5” SATA SSD 3IE6-P Mechanical Screw Hole

4.4 Device Drive

No additional device drives are required. Innodisk 2.5” SATA SSD 3IE6-P can be configured as a boot device.

5. SMART Feature Set

Innodisk 3IE6-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 3IE6-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
175(AFh)	LSB	MSB	LSB	MSB	LSB	MSB	00	iCell Health status (Total number of tests/Minutes since last test/last test result(ms))
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)

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
	D	**H**	**S**	**2**	**5**	**-**	**1**	**T**	**2**	**M**	**7**	**1**	**K**	**C**	**A**	**Q**	**F**	**(P)**	**-**	**X**	**X**
Description	Disk	2.5” SATA SSD					Capacity			Category			Flash mode	Operation Temp.	Internal Control	CH.	Flash	icell		Customized Code	

Definition	
Code 1st (Disk)	**Code 13th (Flash mode)**
D : Disk	E: 64 layers 3D TLC
	K: 112 layers 3D TLC
Code 2nd ~ 5th (Form Factor)	**Code 14th (Operation Temperature)**
HS25: 2.5” SATA SSD with iSLC Mode	C: Standard Grade (0℃~ +70℃)
Code 7th ~9th (Capacity)	W: Industrial Grade (-40℃~ +85℃)
80G: 80GB	**Code 15th (Internal control)**
A60: 160GB	1/A: Full PCB
D2G: 320GB	3: Slim inside
F4G: 640GB	
1T2: 1280GB	**Code 16th (Channel of data transfer)**
	Q: Quad Channels
Code 10th ~12th (Series)	
M71: 3IE6-P Series	
	Code 17th (Flash Type)
	F: Kioxia 3D TLC
	Code 18th (iCell)
	P: iCell (Optional)
	Code 20th ~21th (Customized code)