2.5" SATA SSD

InnoOSR 3TO7

Customer: _____

Customer Part Number: _____

Innodisk Part Number: _____

Innodisk Model Name: _____

Date: _____

Innodisk Approver	Customer Approver

Total Solution For Industrial Flash Storage

Features:

- The World's First SSD Dedicates to System Recovery
- Firmware Level Back Up to Prevent Compatibility Issue
- SATA III
- Kioxia 3D TLC NAND
- 2.5" SATA SSD
- Standard & Wide-temperature

Performance:

- Sequential Read up to 550 MB/s
- Sequential Write up to 510 MB/s

Power Requirements:

Input Voltage:	5V±5%
Max Operating Wattage:	2.5W
Idle Wattage:	1.4W

Reliability:

Capacity	TBW	DWPD
32GB	37	1.08
64GB	75	1.09
128GB	150	1.09
256GB	300	1.09
512GB	600	1.09
1TB	1200	1.09

Data Retention	10 Years
Warranty	3 Years

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	Official Release	Dec., 2020
V1.1	Add New Demo Cable	May. 2021
V1.2	Update Format & Add 112 Layers 3D TLC	Sep., 2022
V1.3	Update Performance	Apr., 2023

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1. Product Overview

1.1 Introduction of Innodisk 2.5" SATA SSD 3TO7.

Innodisk 2.5" SATA SSD 3TO7 provides high capacity flash memory Solid State Drive (SSD) that electrically complies with Serial ATA (SATA) standard supporting up to SATA III standard (6.0Gb/s) speed and capable of achieving excellent performance with its 4 channels 4CE Innodisk ID301 controller. Besides outstanding balance of performance, rich form factors, capacity and customization flexibility, the key feature of InnoOSR family is the single-device, Firmware LBA level OS & Data back-up capability which enables on-site recovery of operating system by simple procedure such as GPIO triggering or application commands.

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.

Product View and Models

Innodisk 2.5" SATA SSD 3TO7 is available in following capacities with 3D TLC flash ICs.

2.5" SATA SSD 3TO7 32GB   2.5" SATA SSD 3TO7 64GB

2.5" SATA SSD 3TO7 128GB   2.5" SATA SSD 3TO7 256GB

2.5" SATA SSD 3TO7 512GB   2.5" SATA SSD 3TO7 1TB

2.5" SATA SSD 3TO7 2TB

Figure 1: Innodisk 2.5" SATA SSD 3TO7

1.2 SATA Interface

Innodisk2.5″ SATA SSD 3TO7 supports SATA III(6.0Gb/s) interface, and compliant with SATA I (1.5Gb/s) and SATA II(3.0Gb/s).

2. Product Specifications

2.1 Capacity and Device Parameters

2.5″ SATA SSD 3TO7 device parameters are shown in Table 1

Table 1: Device parameters

64 Layers 3D TLC

Capacity	P/N	OS back-up capacity (GB)	LBA	User Capacity(GB)
32GB	DUS25-32GDK1E*[1]*[2]F10G	10	32768448	15.6
64GB	DUS25-64GDK1E*[1]*[2]F10G	10	96257328	45.9
	DUS25-64GDK1E*[1]*[2]F20G	20	75285808	35.9
128GB	DUS25-A28DK1E*[1]*[2]F10G	10	213467568	101.7
	DUS25-A28DK1E*[1]*[2]F20G	20	192496048	91.7
	DUS25-A28DK1E*[1]*[2]F30G	30	171524528	81.7
256GB	DUS25-B56DK1E*[1]*[2]F10G	10	447888048	213.5
	DUS25-B56DK1E*[1]*[2]F20G	20	426916528	203.5
	DUS25-B56DK1E*[1]*[2]F30G	30	405945008	193.5
512GB	DUS25-C12DK1E*[1]*[2]F10G	10	916729008	437.1
	DUS25-C12DK1E*[1]*[2]F20G	20	895757488	427.1
	DUS25-C12DK1E*[1]*[2]F30G	30	874785968	417.1
1TB	DUS25-01TDK1E*[1]*[2]F10G	10	1854410928	884.2
	DUS25-01TDK1E*[1]*[2]F20G	20	1833439408	874.2
	DUS25-01TDK1E*[1]*[2]F30G	30	1812467888	864.2
Note	*[1]: C: standard temperature (0′C to 70′C); W: wide temperature (-40′C to 85′C) *[2]: S: Single-channel; D: Dual-channels; Q: Quad-Channels			

112 Layers 3D TLC

Capacity	P/N	OS back-up capacity (GB)	LBA	User Capacity(GB)
128GB	DUS25-A28DK1K*[1]A*[2]F10G	10	213470128	101.7
	DUS25-A28DK1K*[1]A*[2]F20G	20	192498608	91.7
	DUS25-A28DK1K*[1]A*[2]F30G	30	171527088	81.7
256GB	DUS25-B56DK1K*[1]A*[2]F30G	30	405947568	193.5
	DUS25-B56DK1K*[1]A*[2]F60G	60	343033008	163.5
	DUS25-B56DK1K*[1]A*[2]F90G	90	280118448	133.5
512GB	DUS25-C12DK1K*[1]A*[2]F30G	30	874788528	417.1
	DUS25-C12DK1K*[1]A*[2]F60G	60	811873968	387.1
	DUS25-C12DK1K*[1]A*[2]F90G	90	748959408	357.1
1TB	DUS25-01TDK1K*[1]A*[2]F30G	30	1812470448	864.2
	DUS25-01TDK1K*[1]A*[2]F60G	60	1749555888	834.2
	DUS25-01TDK1K*[1]A*[2]F90G	90	1686641328	804.2
2TB	DUS25-02TDK1K*[1]A*[2]F30G	30	3687834288	1758.5
	DUS25-02TDK1K*[1]A*[2]F60G	60	3624919728	1728.5
	DUS25-02TDK1K*[1]A*[2]F90G	90	3562005168	1698.5
Note	*[1]: C: standard temperature (0′C to 70′C); W: wide temperature (-40′C to 85′C) *[2]: S: Single-channel; D: Dual-channels; Q: Quad-Channels			

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance- 64 Layers 3D TLC

Capacity	Unit	32GB	64GB	128GB	256GB	512GB	1TB
Sequential * Read (max.)	MB/s	175	350	500	545	545	545
Sequential * Write (max.)		35	70	145	290	330	335
4KB Random** Read (QD32)	IOPS	11,500	22,500	31,000	75,500	78,500	79,000
4KB Random** Write (QD32)		8,900	18,500	35,500	67,000	71,000	69,500

Note: * Sequential performance results are based on CrystalDiskMark 5.1.2 with file size 1000MB

Note: ** Performance results are based on CrystalDiskMark 5.1.2 with file size 1000MB. Unit of 4KB items is I.O.P.S.

Table 3: Performance- 112 Layers 3D TLC

Capacity	Unit	128GB	256GB	512GB	1TB	2TB
Sequential** Read (Q32T1)	MB/s	440	550	550	550	550
Sequential** Write (Q32T1)		290	500	510	510	500
Sustained*** Sequential Read (Avg.)		350	410	420	420	420
Sustained*** Sequential Write (Avg.)		80	160	300	310	310
4KB Random** Read (Q32T1)	IOPS	40,000	79,000	82,000	80,000	80,000
4KB Random** Write (Q32T1)		25,000	41,000	70,000	70,000	73,000

Note:

*. Performance results are 3TO7 with Kioxia BiCS5 NAND composition measured in Room Temperature with Out-of-Box devices and may vary depending on overall system setup. In addition, 3TO7 series adopt hybrid mode which enables SLC cache followed by TLC direct write to strike balance between burst performance and steady overall stability.

**. Performance results are based on CrystalDiskMark 6.0.2 with file size 1000MB. Unit of 4KB item is IOPS.

***. 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 4: Innodisk 2.5″ SATA SSD 3TO7 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(RMS)	2.0
Write(RMS)	2.5
Idle(RMS)	1.4
Peak	3.5

Target: 2.5″ SATA SSD 3TO7 2TB

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 6: Temperature range for 2.5″ SATA SSD 3TO7

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 3TO7

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 2.5″ SATA SSD 3TO7 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 3TO7 MTBF

Product	Condition	MTBF (Hours)
Innodisk 2.5″ SATA SSD 3TO7	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

2.5″ SATA SSD 3TO7 conforms to CE and FCC requirements.

2.6 RoHS Compliance

2.5″ SATA SSD 3TO7 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℃: 10 Years at Initial NAND Status; 1 Year at NAND Life End	
TBW* (Total Bytes Written) Units: TB		
Capacity	**Sequential workload**	**Client workload**
32GB	84.3	37.5
64GB	168.6	75
128GB	337.2	150
256GB	674.4	250
512GB	1348.8	500
1TB	2697.6	1000

2.8 Transfer Mode

2.5″ SATA SSD 3TO7 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 3TO7 uses a standard SATA pin-out.

See Table 8 for 2.5″ SATA SSD 3TO7 pin assignment.

Table 9: Innodisk 2.5″ SATA SSD 3TO7 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	InnoOSR LED Signaling Pin (GPIO 8), Default NC
P6	GND	InnOSR Recovery/Back-up Pin (GPIO 13), Default NC
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

* DUS25-XXXDK1XXXXFXXX
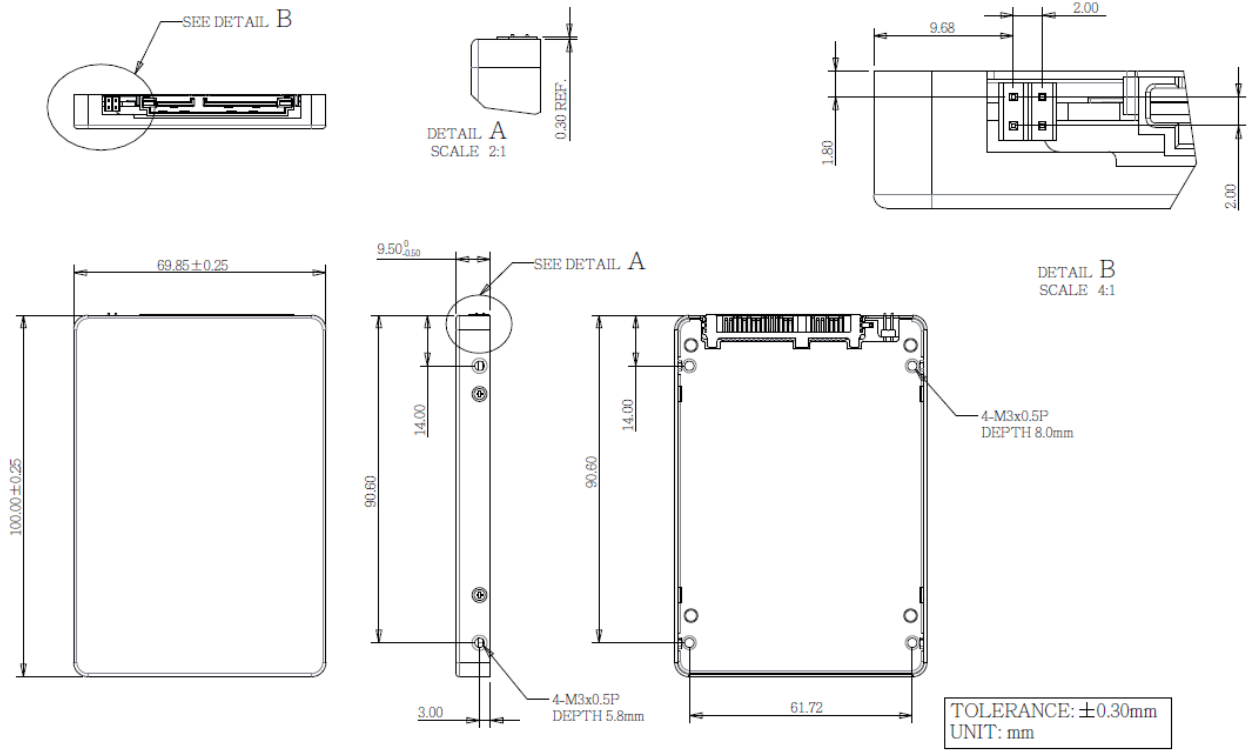
2.11 Assembly Weight

An Innodisk 2.5″ SATA SSD 3TO7 within flash ICs, 32GB's weight is 8 grams approximately.

2.12 Seek Time

Innodisk2.5″ SATA SSD 3TO7 is not a magnetic rotating design. There is no seek or rotational latency required.
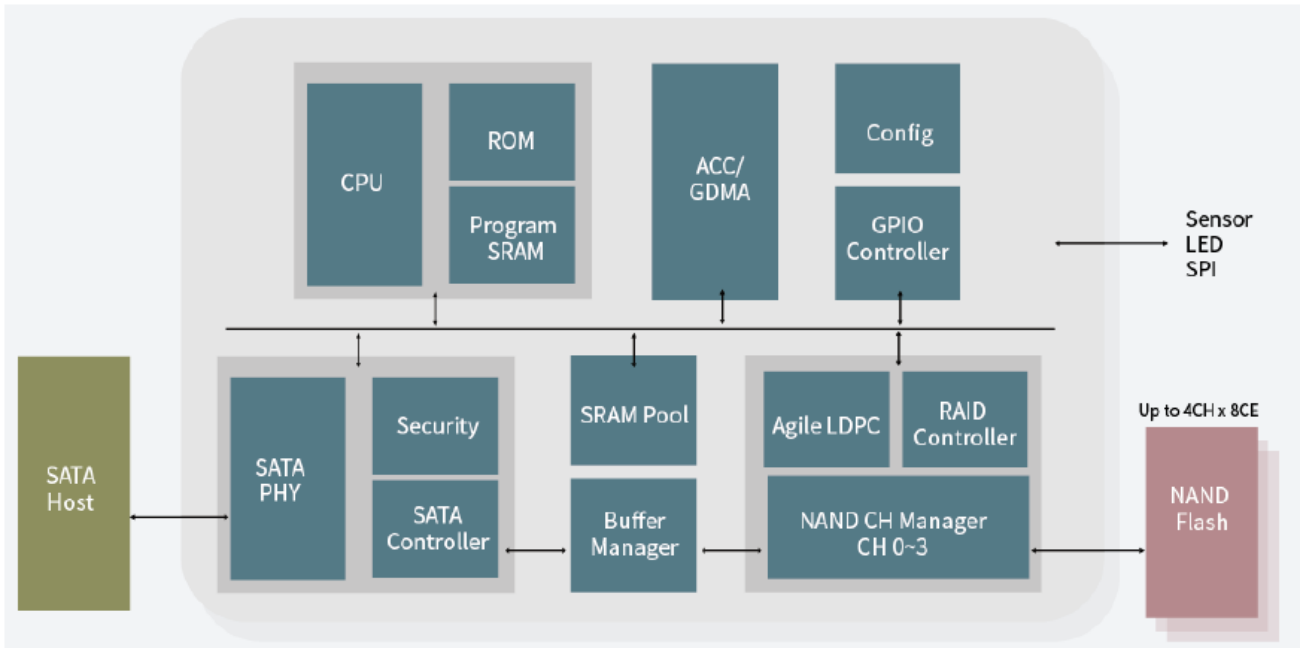
2.13 NAND Flash Memory

Innodisk 2.5″ SATA SSD 3TO7 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 2.5" SATA SSD 3TO7 from the system level, including the major hardware blocks.

Figure 2: Innodisk 2.5" SATA SSD 3TO7 Block Diagram

Innodisk 2.5" SATA SSD 3TO7 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 3TO7 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

Innodisk2.5" SATA SSD 3TO7 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 3TO7 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 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) 3TO7 series is default enable the Die RAID function for the industrial application

3.11 InnoOSR Back-up/Recovery
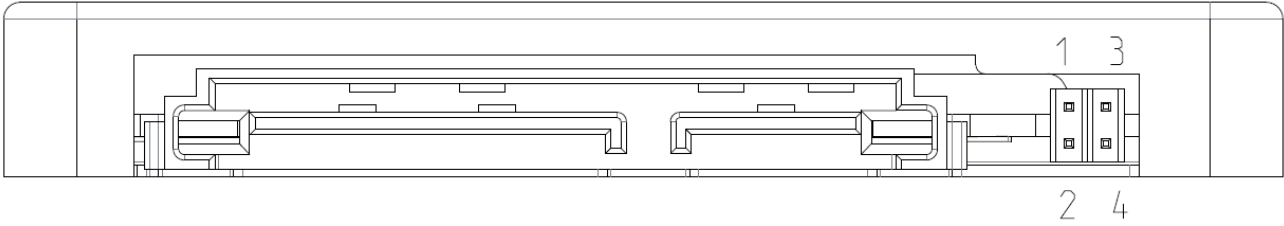
Pin Header Number	Pin Define	Installation for Innodisk Demo Cable (PN: 7W3000000870)	Rating
1	GPIO Pin8, Output for InnoOSR LED indication	Blue cable_0 that co-axis with red cable	3.3V ± 5%
2	GND	Red cable	NA
3	GPIO Pin13, Input for InnoOSR Recovery Trigger, Low active	Blue cable_1/2	3.3V ± 5%
4	GND	Blue cable_1/2	NA
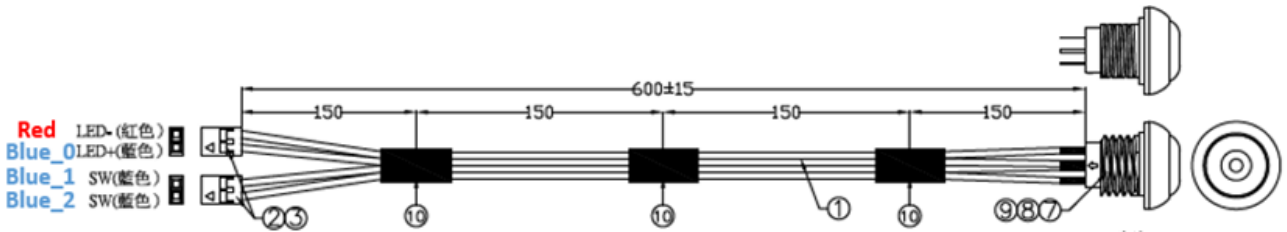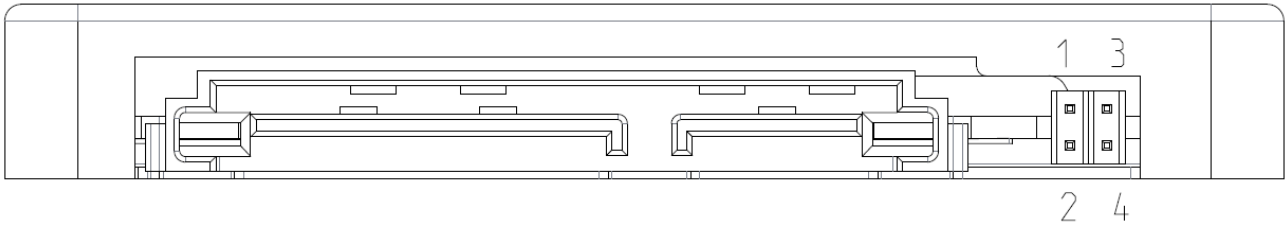
Pin Header Number	Pin Define	Installation for Innodisk Demo Cable (PN: 7W3000000920)	Rating
1	GPIO Pin8, Output for InnoOSR LED indication	Blue cable_1	3.3V ± 5%
2	GND	NA	NA
3	GPIO Pin13, Input for InnoOSR Recovery Trigger, Low active	Blue cable_2	3.3V ± 5%
4	GND	Red	NA
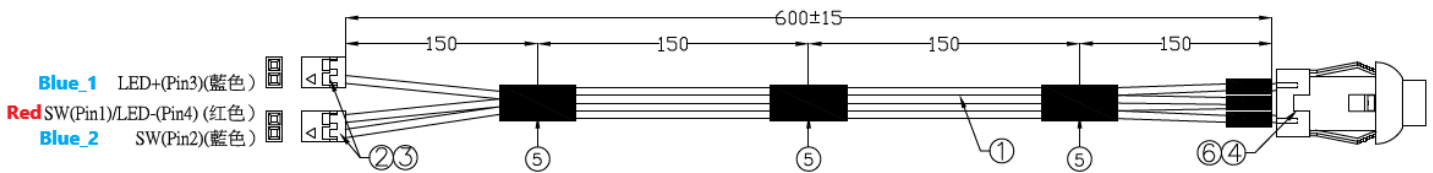
Main feature of InnoOSR family is the OS back up and swift recovery mechanism, which allow field repair easier than ever for malfunction systems with software level damages. As shown in above picture, 2 x 2 pin headers located on the side of standard 7 + 15 pins SATA connector can be used to interact with firmware of InnoOSR device to perform OS recovery process and provide LED signal which indicates the recovery status. In above picture, the push-button cable with green LED are with PN of 7W3000000870/7W3000000920 and are not included in standard InnoOSR product PN but can be order separately for trial purpose.

3.11.1 InnoOSR Back-up Implementation Process

Process of InnoOSR Back-up / Recovery can be found in Independent "Innodisk InnoOSR Implementation Process" document.

### 3.11.2 InnoOSR Recovery Triggering Methods

There are two methods to trigger OS recovery process listed as follows:

Button triggering: With Pin 3 & 4 of the 2 x 2 pin headers located on the side of standard 7 + 15 pins SATA connector shorted for more than 5 seconds, the recovery process will start. OS image of which this process leads to can be established by our InnoOSR software tool.

Software triggering: Our InnoOSR software tool can also trigger the recovery process. However, due to the recovery process itself essentially means covering your operating OS up, you may experience system crash and progress bar can only be read via LED signal linked directly to InnoOSR device.

4. Installation Requirements

4.1 2.5″ SATA SSD 3TO7 Pin Directions

Figure 3: Signal Segment and Power Segment
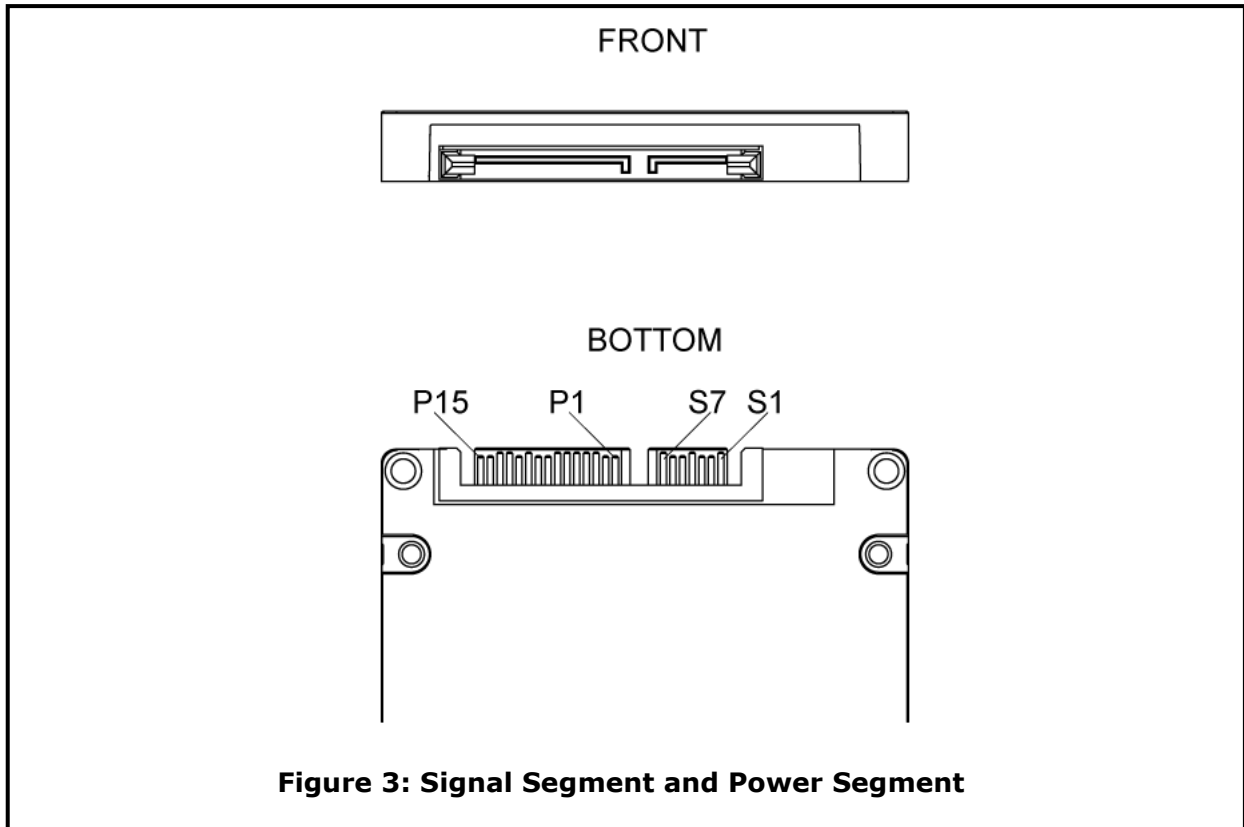
## 4.2 Electrical Connections for 2.5″ SATA SSD 3TO7

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 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.
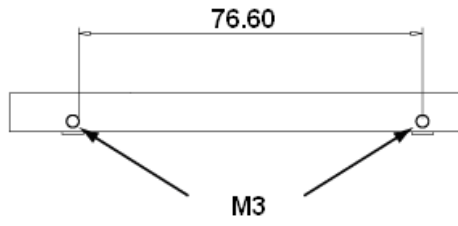
Figure 4: 2.5″ SATA SSD 3TO7 Mechanical Screw Hole

4.4 Device Drive

No additional device drives are required. Innodisk 2.5″ SATA SSD 3TO7 can be configured as a boot device.

5. SMART Feature Set

Innodisk 3TO7 series support the SMART command set and defines some vendor-specific data to report SMART attributes of SSD.

Table 10: 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 3TO7 series SMART data attributes are listed in following table.

Table 11: 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	U	S	2	5	-	3	2	G	D	K	1	E	C	1	D	F	1	0	G	

Definition	
Code 1ˢᵗ (Disk)	**Code 14ᵗʰ (Operation Temperature)**
D : Disk	C: Standard Grade (0℃~ +70℃)
Code 2ⁿᵈ (Feature set)	W: Industrial Grade (-40℃~ +85℃)
U : InnoOSR series	
Code 3ʳᵈ ~5ᵗʰ (Form factor)	**Code 15ᵗʰ (Internal control)**
S25: 2.5" SATA SSD	1~9: TSOP PCB version.
	A: BGA PCB version.
Code 7ᵗʰ ~9ᵗʰ (Capacity)	**Code 16ᵗʰ (Channel of data transfer)**

(continued)

32G: 32GB, 64G: 64GB, A28: 128GB, B56: 256GB, C12: 512GB, 01T: 1TB, 02T: 2TB

Code 16th: S: Single Channel, D: Dual Channels, Q: Quad Channels

Code 10th~12th (Controller): DK1: SATA 3TO7

Code 17th (Flash Type): F: Kioxia 3D TLC

Code 13th (Flash mode): E: 64 layers 3D TLC, K: 112 layers 3D TLC

Code 18th~20th (Hidden Area Size): 10G: 10GB Hidden, 20G: 20GB Hidden, 30G: 30GB Hidden, 60G: 60GB Hidden, 90G: 90GB Hidden

Code 21st~ (Customization Code)