innodisk

Total Solution For Industrial Flash Storage

SATA Slim

3IE7 Series

Ultra iSLC

with Innodisk NAND

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	Official Release (use Slim inside)	Jan., 2023
Rev 1.1	Add SATA Slim Form factor	Jun., 2023
Rev 1.2	Rename the series to Ultra iSLC	Dec., 2023

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1. Product Overview

1.1 Introduction of Innodisk SATA Slim SSD 3IE7.

Innodisk SATA Slim 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 L^3 FW architecture, combining our signature 4K mapping algorithm L^2 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 SATA Slim SSD 3IE7 is available in follow capacities.

SATA Slim SSD 3IE7 40GB
SATA Slim SSD 3IE7 80GB
SATA Slim SSD 3IE7 160GB
SATA Slim SSD 3IE7 320GB
SATA Slim SSD 3IE7 640GB

1.3 SATA Interface

InnodiskSATA Slim 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 MO-297 Form Factor

SATA Slim 3IE7 has a compact design 54.0mm (W) x 39.0mm (L) x 4.0mm (H) without metal material case, and is easy for installation.

2. Product Specifications

2.1 Capacity and Device Parameters

SATA Slim 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 TLC[1]

Capacity	Unit	40GB	80GB (2CH)	80GB (4CH)	160GB	320GB	640GB
Sequential[2] Read (Q32T1)	MB/s	420	420	550	550	550	550
Sequential[2] Write (Q32T1)		250	260	490	490	490	500
4KB Random[2] Read (Q32T1)	IOPS	36,000	34,000	70,000	67,000	88,000	88,000
4KB Random[2] Write (Q32T1)		61,000	61,000	76,000	76,000	76,000	77,000

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 SATA Slim SSD 3IE7 with innodisk 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]	2.2
Write (RMS)[1]	2.1
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 SATA Slim SSD 3IE7 with innodisk NAND

Temperature	Range
Operating (Ta)	Standard Grade: 0°C to +70°C
	Industrial Grade: -40℃ to +85℃
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 SATA Slim 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 SATA Slim 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: SATA Slim SSD 3IE7 MTBF

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

2.5 CE and FCC Compatibility

SATA Slim SSD 3IE7 conforms to CE and FCC requirements.

2.6 RoHS Compliance

SATA Slim 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:

1. Sequential: Mainly sequential write, tested by Vdbench.
2. 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.)
3. Based on out-of-box performance.

2.8 Transfer Mode

SATA Slim 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 SATA Slim SSD 3IE7 uses a standard SATA pin-out.

See Table 8 for SATA Slim SSD 3IE7 pin assignment.

Table 8: Innodisk SATA Slim 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

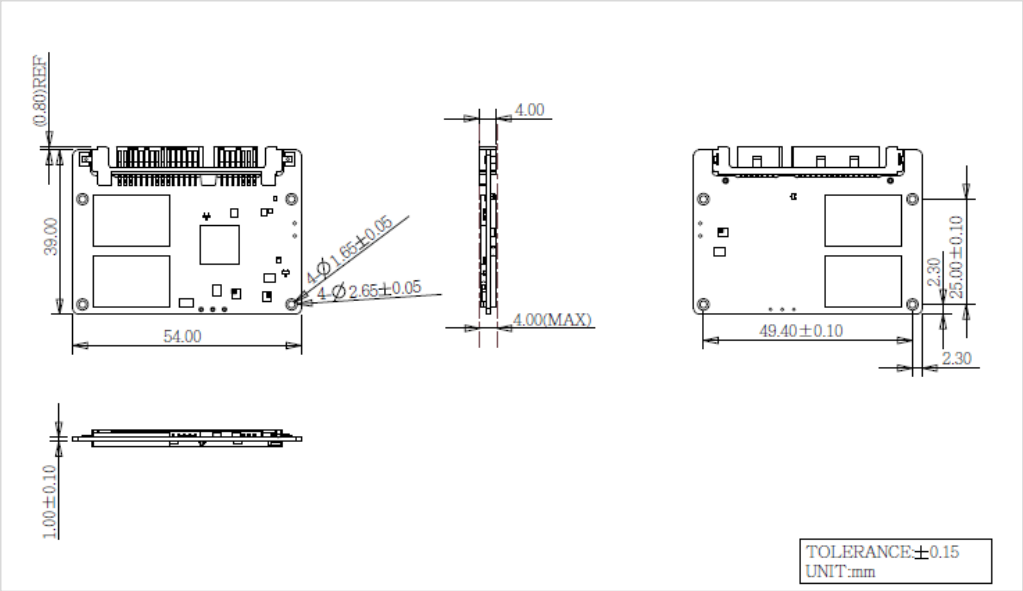

Figure 1 : SATA Slim PCBA diagram

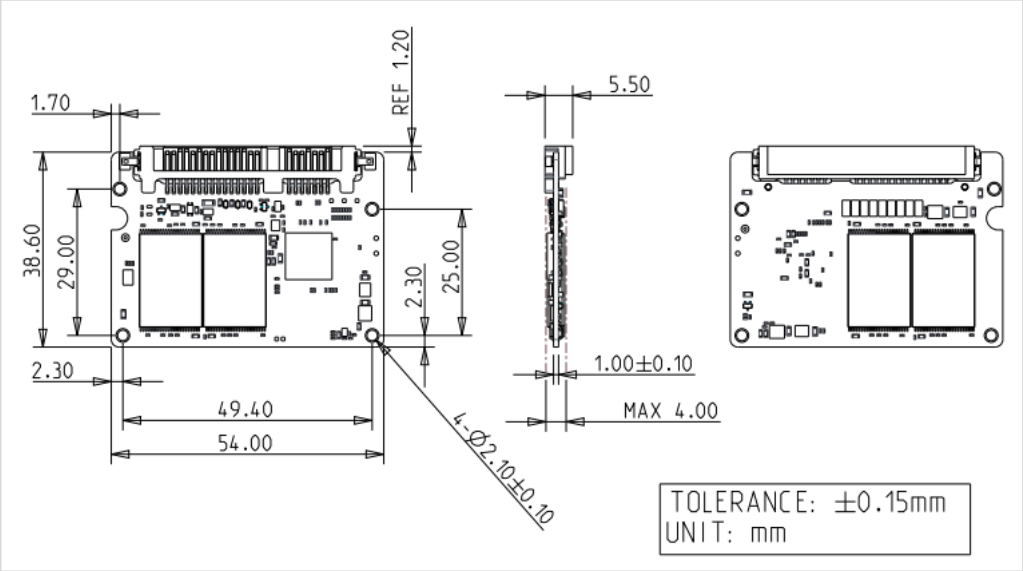

Figure 2 : SATA Slim (inside) PCBA diagram

2.11 Assembly Weight

An Innodisk SATA Slim SSD 3IE7 within flash ICs, 40GB's weight is 10 grams approximately.

2.12 Seek Time

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

2.13 NAND Flash Memory

Innodisk SATA Slim 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 3 shows the operation of Innodisk SATA Slim SSD 3IE7 from the system level, including the major hardware blocks.

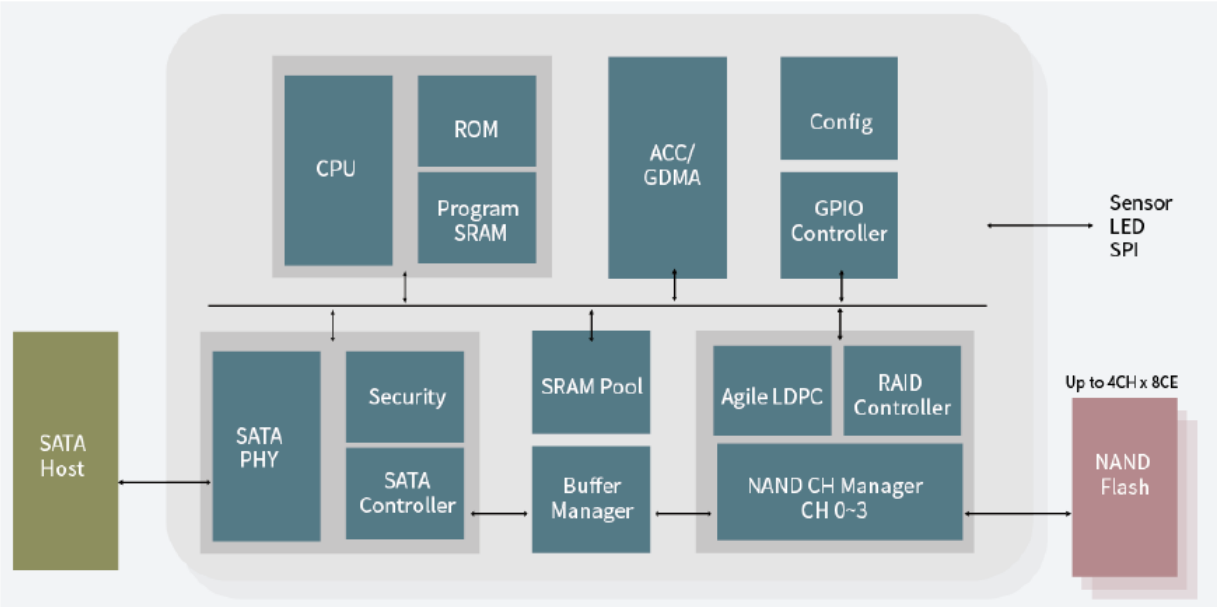

Figure 3: Innodisk SATA Slim SSD 3IE7 Block Diagram

Innodisk SATA Slim 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 SATA Slim 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

InnodiskSATA Slim 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 SATA Slim 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

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

4. Installation Requirements

4.1 SATA Slim SSD 3IE7 Pin Directions

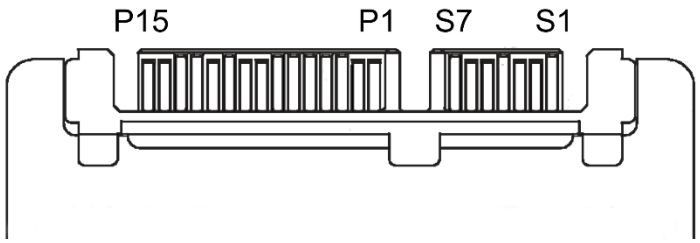

Figure 4: Signal Segment and Power Segment

4.2 Electrical Connections for SATA Slim 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 Device Drive

No additional device drives are required. Innodisk SATA Slim 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**	**L**	**M**	**-**	**4**	**0**	**G**	**D**	**K**	**1**	**K**	**C**	**C**	**Q**	**L**	-	**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℃~ +70℃)
	W: Industrial Grade (-40℃~ +85℃)
Code 3rd~ 5th (Form Factor)	**Code 15th (Internal control)**
SLM: SATA Slim	C: PCB 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)**
	L: Innodisk 3D TLC
Code 10th ~12th (Controller)	**Code 19th~21th (Customized Code)**
DK1: SATA 3IE7/3TE7	