innodisk

Total Solution For Industrial Flash Storage

mSATA

3IE7 with

Innodisk 112-L 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
Preliminary 1.0	First Release	Nov., 2022
Preliminary 1.1	Correct LBA table	Nov., 2022
1.0	Official Release - Add 320GB, update power consumption table	Nov., 2022
1.1	Correct 20GB 4K random write Performance	Feb., 2023

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1. Product Overview

1.1 Introduction of Innodisk mSATA 3IE7

Innodisk mSATA 3IE7 which is designed with mSATA form factor by JEDEC MO-300/MO-300B, supporting SATA III standard (6.0Gb/s), achieves excellent performance up to 4CH standard by cost effective controller with 4CH. Regarding of mechanical interference, Innodisk mSATA 3IE7 absolutely replaces the traditional hard disk and makes personal computer, in any field, smaller and easier.For real industrial application, 3IE7 series is built in thermal sensor to monitor the environment temperature. iData Guard, the power loss management mechanism developed by Innodisk to 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 mSATA 3IE7 is available in follow capacities within 3D NAND flash ICs.

mSATA 3IE7 20GB mSATA 3IE7 40GB

mSATA 3IE7 80GB mSATA 3IE7 160GB

mSATA 3IE7 320GB

1.3 SATA Interface

Innodisk mSATA 3IE7 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

mSATA 3IE7 device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	LBA	Cylinders	Heads	Sectors	User Capacity(MB)
20GB	35770291	16383	16	63	17466
40GB	78161328	16383	16	63	38165
80GB	156301488	16383	16	63	76319
160GB	312581808	16383	16	63	152628
320GB	625142448	16383	16	63	305245

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table2: Performance - 112 Layers 3D TLC[1]

Capacity	Unit	20GB	40GB	80GB (2CH)	80GB (4CH)	160GB	320GB
Sequential ** Read (Q32T1)	MB/s	260	430	420	550	550	550
Sequential ** Write (Q32T1)		140	250	260	490	490	490
4KB Random*** Read (Q32T1)	IOPS	19,000	37,000	34,000	70,000	67,000	88,000
4KB Random*** Write (Q32T1)		34,000	60,000	61,000	77,000	76,000	76,000

Note: ** Performance results are based on CrystalDiskMark 6.0.2 with file size 1000MB.

Note: *** Performance results are based on Queue Depth 32

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 3: Innodisk mSATA 3IE7 Power Requirement

Item	Symbol	Rating	Unit
Input voltage	V_{IN}	+3.3 DC +- 5%	V

2.3.2 Power Consumption

Table 4: Power Consumption

Mode	Power Consumption (W)
Read	1.8
Write	1.9
Idle	0.8
Peak	3.8

Target: mSATA 3IE7

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for mSATA 3IE7

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 6: Shock/Vibration Test for mSATA 3IE7

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 mSATA 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 conditions.

Table 7: mSATA 3IE7 MTBF

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

2.5 CE and FCC Compatibility

mSATA 3IE7 conforms to CE and FCC requirements.

2.6 RoHS Compliance

mSATA 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
20GB	1700	1250
40GB	3400	2500
80GB	6800	5000
160GB	13600	10000
320GB	27200	20000

* 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 20GB client workload is not specified in JEDEC219A, the values are estimated.)
3. Based on out-of-box performance.

2.8 Transfer Mode

mSATA 3IE7 support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

2.9 Pin Assignment

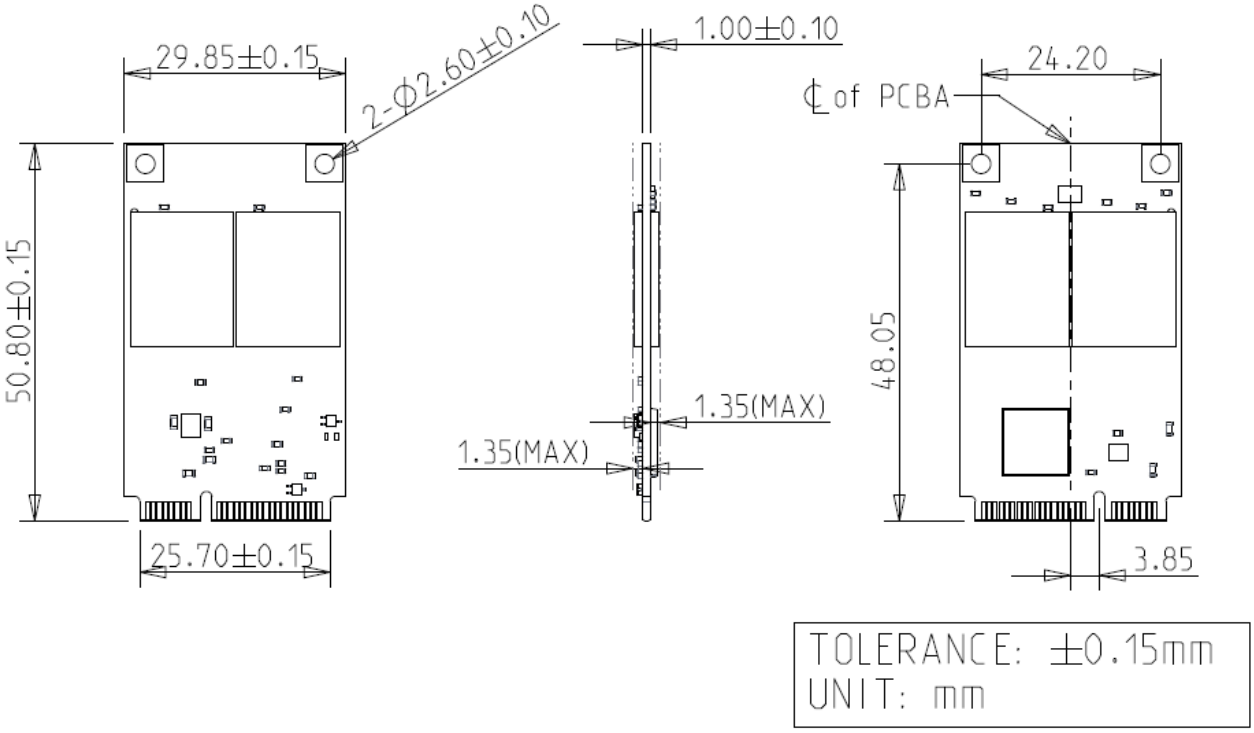
Innodisk mSATA 3IE7 uses a standard SATA pin-out. See Table 8 for mSATA 3IE7 pin assignment.

Table 8: Innodisk mSATA 3IE7 Pin Assignment

Signal Name	Pin #	Pin #	Signal Name
GND	51	52	+3.3V
DAS	49	50	GND

NC	47	48	NC
NC	45	46	NC
NC	43	44	DEVSLP
+3.3V	41	42	NC
+3.3V	39	40	GND
GND	37	38	NC
GND	35	36	NC
RX+	33	34	GND
RX-	31	32	NC
GND	29	30	NC
GND	27	28	NC
TX-	25	26	GND
TX+	23	24	+3.3V
GND	21	22	NC
NC	19	20	NC
NC	17	18	GND
GND	15	16	NC
NC	13	14	NC
NC	11	12	NC
GND	9	10	NC
NC	7	8	NC
NC	5	6	NC
NC	3	4	GND
NC	1	2	+3.3V

2.10 Mechanical Dimensions



2.11 Assembly Weight

An Innodisk mSATA 3IE7 within flash ICs, 20GB's weight is 8 grams approximately.

2.12 Seek Time

Innodisk mSATA 3IE7 is not a magnetic rotating design. There is no seek or rotational latency required. Innodisk mSATA 3IE7 uses 3D TLC NAND flash memory, with 100,000 program & erase cycles, which is non-volatility, high reliability and high speed memory storage.

2.13 NAND Flash Memory

Innodisk mSATA 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 mSATA 3IE7 from the system level, including the major hardware blocks.

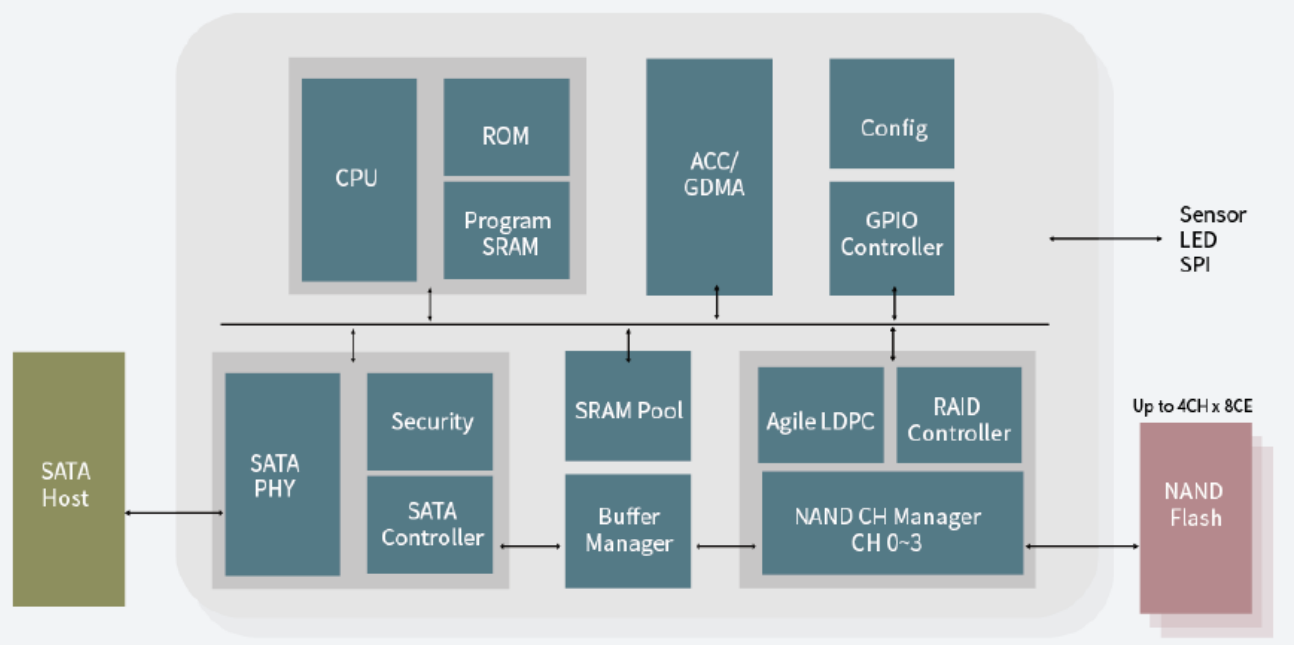


Figure 1: Innodisk mSATA 3IE7 Block Diagram

Innodisk mSATA 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 mSATA 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 mSATA 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 mSATA 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'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

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 mSATA 3IE7 series is default enable the Die RAID function for the industrial application.

4. Installation Requirements

4.1 mSATA 3IE7 Pin Directions

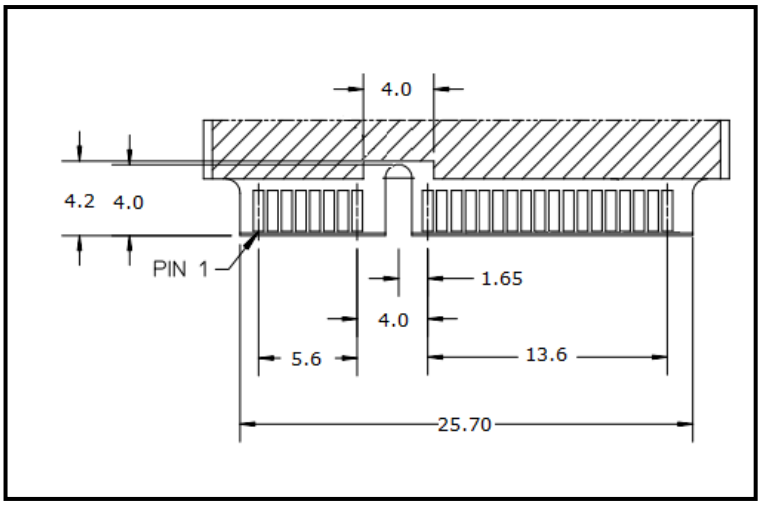


Figure 2: Signal Segment and Power Segment

4.2 Electrical Connections for mSATA 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. The Innodisk mSATA 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 9: 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 10: 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**	**M**	**S**	**R**	**-**	**8**	**0**	**G**	**D**	**K**	**1**	**K**	**C**	**A**	**Q**	**L**	**-**	**X**	**X**	**X**

Definition	
Code 1st (Disk)	**Code 14th (Operation Temperature)**
D : Disk	C: Standard Grade (0℃~ +70℃)
Code 2nd ~5th (Form Factor)	W: Industrial Grade (-40℃~ +85℃)
HMSR: mSATA Regular	**Code 15th (Internal control)**
	A: PCB version
Code 7th ~9th (Capacity)	**Code 16th (Channel of data transfer)**
20G: 20GB	S: Single Channel
40G: 40GB	D: Dual Channels
80G: 80GB	Q: Quad Channels
A60: 160GB	
D2G: 320GB	
Code 10th ~12th (Controller)	**Code 17th (Flash Type)**
DK1: SATA 3IE7	L: Innodisk 3D TLC
Code 13th (Flash Mode)	**Code 19th~21th (Customized Code)**
K: 112 layers 3D TLC	