innodisk

Total Solution For Industrial Flash Storage

# M.2 (S42)

## 3IE4 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 |
|---|---|---|
| Pre 1.0 | First Release | Sep., 2016 |
| Pre 1.1 | Update 64GB performance | Dec., 2016 |
| Rev 1.0 | Official Release | Mar., 2017 |
| Rev 1.1 | Update performance | Mar., 2017 |
| Rev 1.2 | Update TBW<br>Modify pin assignment | Apr., 2017 |
| Rev 1.3 | Update mechanical drawing<br>Update REACH certification | Jul.,2017 |
| Rev 1.4 | Update seq. performance info (QD32) | Apr., 2018 |
| Rev 1.5 | Update RoHS & REACH 2020 | Jul., 2020 |
| Rev 1.6 | Update 4GB information | Aug., 2021 |

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# 1. Product Overview

## 1.1 Introduction of Innodisk M.2 (S42) 3IE4

Innodisk M.2 (S42) 3IE4 is characterized by $L^3$ architecture with the latest SATA III (6.0GHz) Marvell NAND controller. Innodisk's exclusive $L^3$ architecture is $L^2$ architecture multiplied LDPC (Low Density Parity Check). $L^2$ (Long Life) architecture is a 4K mapping algorithm that reduces WAF and features a real-time wear leveling algorithm to provide high performance and prolong lifespan with exceptional reliability. Innodisk M.2 (S42) 3IE4 is designed for industrial field, and supports several standard features, including TRIM, NCQ, and S.M.A.R.T. In addition, Innodisk's exclusive industrial-oriented firmware provides a flexible customization service, making it perfect for a variety of industrial applications.

## 1.2 Product View and Models

Innodisk M.2 (S42) 3IE4 is available in follow capacities within MLC flash ICs.

M.2 (S42) 3IE4 4GB M.2 (S42) 3IE4 8GB

M.2 (S42) 3IE4 16GB M.2 (S42) 3IE4 32GB

M.2 (S42) 3IE4 64GB M.2 (S42) 3IE4 128GB


**Figure 1: Innodisk M.2 (S42) 3IE4 (type 2242)**

## 1.3 SATA Interface

Innodisk M.2 (S42) 3IE4 supports SATA III interface, and compliant with SATA I and SATA II. SATA III interface can work with Serial Attached SCSI (SAS) host system, which is used in server computer. Innodisk M.2 (S42) 3IE4 is compliant with Serial ATA Gen 1, Gen 2 and Gen 3 specification (Gen 3 supports 1.5Gbps /3.0Gbps/6.0Gbps data rate).

# 2. Product Specifications

## 2.1 Capacity and Device Parameters

M.2 (S42) 3IE4 device parameters are shown in Table 1.

**Table 1: Device parameters**

| Capacity | Cylinders | Heads | Sectors | LBA | User Capacity(MB) |
|---|---|---|---|---|---|
| 4GB | 7773 | 16 | 63 | 7835184 | 3,825 |
| 8GB | 15525 | 16 | 63 | 15649200 | 7,641 |
| 16GB | 16383 | 16 | 63 | 31277232 | 15,272 |
| 32GB | 16383 | 16 | 63 | 62533296 | 30,533 |
| 64GB | 16383 | 16 | 63 | 125045424 | 61,057 |
| 128GB | 16383 | 16 | 63 | 250069680 | 122,104 |

## 2.2 Performance

Burst Transfer Rate: 6.0Gbps

**Table 2: Performance[1]**

| Capacity | 4GB | 8GB | | 16GB | 32GB | 64GB | 128GB |
|---|---|---|---|---|---|---|---|
| | | 1CH | 2CH | | | | |
| Sequential[2] Read (max.) | 145MB/s | 250 MB/s | 270 MB/s | 490MB/s | 520 MB/s | 520 MB/s | 520 MB/s |
| Sequential[2] Write (max.) | 90 MB/s | 80 MB/s | 190 MB/s | 160 MB/s | 240 MB/s | 360 MB/s | 370 MB/s |
| 4KB Random[2] Read (QD32) | 9600 IOPS | 12000 IOPS | 18000 IOPS | 23000 IOPS | 30000 IOPS | 31000 IOPS | 31000 IOPS |
| 4KB Random[2] Write (QD32) | 15000 IOPS | 14000 IOPS | 27000 IOPS | 27000 IOPS | 30000 IOPS | 31000 IOPS | 31000 IOPS |

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 platform

## 2.3 Electrical Specifications

### 2.3.1 Power Requirement

**Table 3: Innodisk M.2 (S42) 3IE4 Power Requirement**

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

### 2.3.2 Power Consumption

**Table 4: Power Consumption[1]**

| Capcity | Seq. Read (mA) | Seq. Write (mA) | Idle (mA) |
|---|---|---|---|
| 4GB | 125 | 150 | 115 |
| 8GB | 145 | 180 | 120 |
| 16GB | 145 | 200 | 125 |
| 32GB | 155 | 215 | 125 |
| 64GB | 160 | 220 | 130 |
| 128GB | 170 | 270 | 140 |

Note: 1. The workload equates 128KB with Queue Depth 32 sequential read & write

## 2.4 Environmental Specifications

### 2.4.1 Temperature Ranges

**Table 5: Temperature range for M.2 (S42) 3IE4**

| 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 Testing for M.2 (S42) 3IE4**

| 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 M.2 (S42) 3IE4 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: M.2 (S42) 3IE4 MTBF**

| Product | Condition | MTBF (Hours) |
|---|---|---|
| Innodisk M.2 (S42) 3IE4 | Telcordia SR-332 GB, 25°C | >3,000,000 |

## 2.5 CE and FCC Compatibility

M.2 (S42) 3IE4 conforms to CE and FCC requirements.

## 2.6 RoHS Compliance

M.2 (S42) 3IE4 is fully compliant with RoHS directive.

## 2.7 Reliability

**Table 8: M.2 (S42) 3IE4 TBW**

| Parameter | | Value |
|---|---|---|
| Read Cycles | | Unlimited Read Cycles |
| Flash endurance | | 20,000 P/E cycles |
| Wear-Leveling Algorithm | | Support |
| Bad Blocks Management | | Support |
| Error Correct Code | | Support |
| **TBW* (Total Bytes Written)** Unit: TB | | |
| **Capacity** | **Sequential workload** | **Client workload** |
| 04GB | 78.1 | 52.1 |
| 08GB | 156.3 | 104.2 |
| 16GB | 312.5 | 208.3 |
| 32GB | 625.0 | 416.7 |
| 64GB | 1250.0 | 833.3 |
| 128GB | 2500.0 | 1388.9 |

* 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

M.2 (S42) 3IE4 support following transfer mode:

SATA III 6.0Gbps

SATA II 3.0Gbps

SATA I 1.5Gbps

## 2.9 Pin Assignment

Innodisk M.2 (S42) 3IE4 uses a standard SATA pin-out. See Table 9 for M.2 (S42) 3IE4 pin assignment.

**Table 9: Innodisk M.2 (S42) 3IE4 Pin Assignment**

| Signal Name | Pin # | Pin # | Signal Name |
|---|---|---|---|
| | | 75 | GND |
| 3.3V | 74 | 73 | GND |
| 3.3V | 72 | 71 | GND |
| 3.3V | 70 | 69 | GND |
| NC | 68 | 67 | NC |
| Notch | 66 | 65 | Notch |
| Notch | 64 | 63 | Notch |
| Notch | 62 | 61 | Notch |
| Notch | 60 | 59 | Notch |
| NC | 58 | | |
| NC | 56 | 57 | GND |
| NC | 54 | 55 | NC |
| NC | 52 | 53 | NC |
| NC | 50 | 51 | GND |
| NC | 48 | 49 | RX+ |
| NC | 46 | 47 | RX- |
| NC | 44 | 45 | GND |
| NC | 42 | 43 | TX- |
| NC | 40 | 41 | TX+ |
| DEVSLP | 38 | 39 | GND |
| NC | 36 | 37 | NC |
| NC | 34 | 35 | NC |
| NC | 32 | 33 | GND |
| NC | 30 | 31 | NC |
| NC | 28 | 29 | NC |
| NC | 26 | 27 | GND |
| NC | 24 | 25 | NC |
| NC | 22 | 23 | NC |
| NC | 20 | 21 | GND |
| Notch | 18 | 19 | Notch |
| Notch | 16 | 17 | Notch |
| Notch | 14 | 15 | Notch |
| Notch | 12 | 13 | Notch |

| | | | |
|---|---|---|---|
| DAS/DSS | 10 | 11 | NC |
| NC | 8 | 9 | NC |
| NC | 6 | 7 | NC |
| 3.3V | 4 | 5 | NC |
| 3.3V | 2 | 3 | GND |
| | | 1 | GND |

## 2.10 Mechanical Dimensions

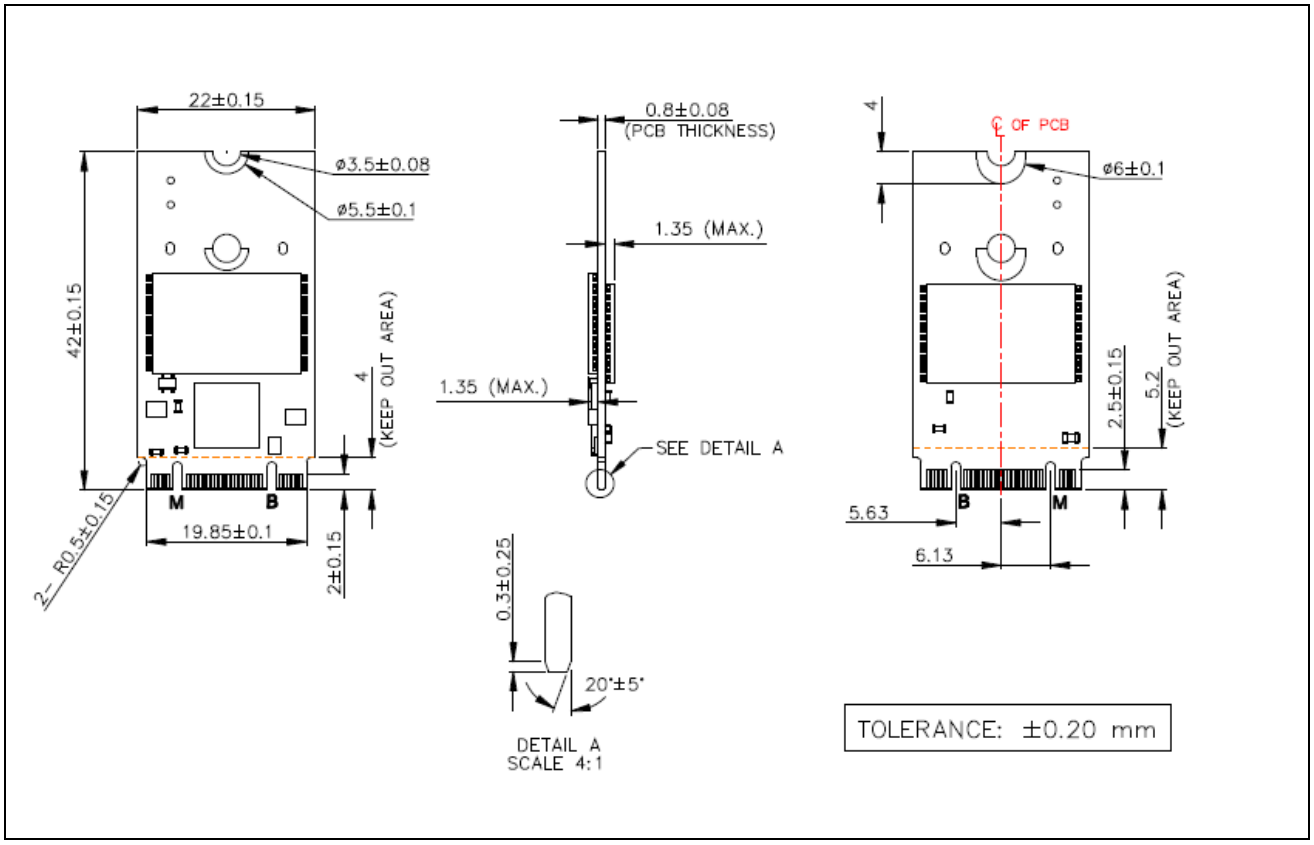


**Figure 2: Innodisk M.2 (S42) 3IE4 diagram (TSOP)**

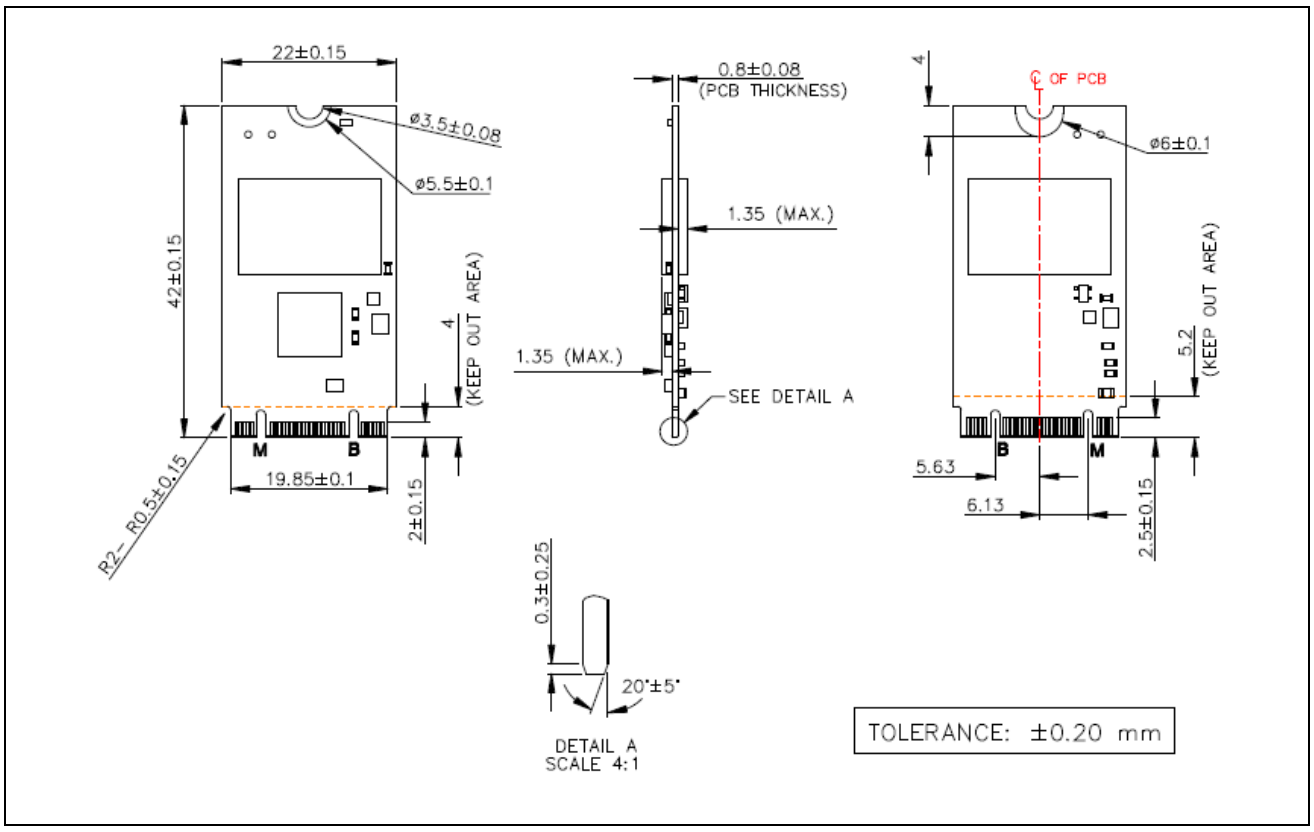


**Figure 3: Innodisk M.2 (S42) 3IE4 diagram (BGA)**

## 2.11 Assembly Weight

An Innodisk M.2 (S42) 3IE4 within flash ICs, 64GB's weight is 8 grams approximately.

## 2.12 Seek Time

Innodisk M.2 (S42) 3IE4 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 M.2 (S42) 3IE4 uses Multi Level Cell (MLC) NAND flash memory, 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 M.2 (S42) 3IE4 from the system level, including the major hardware blocks.

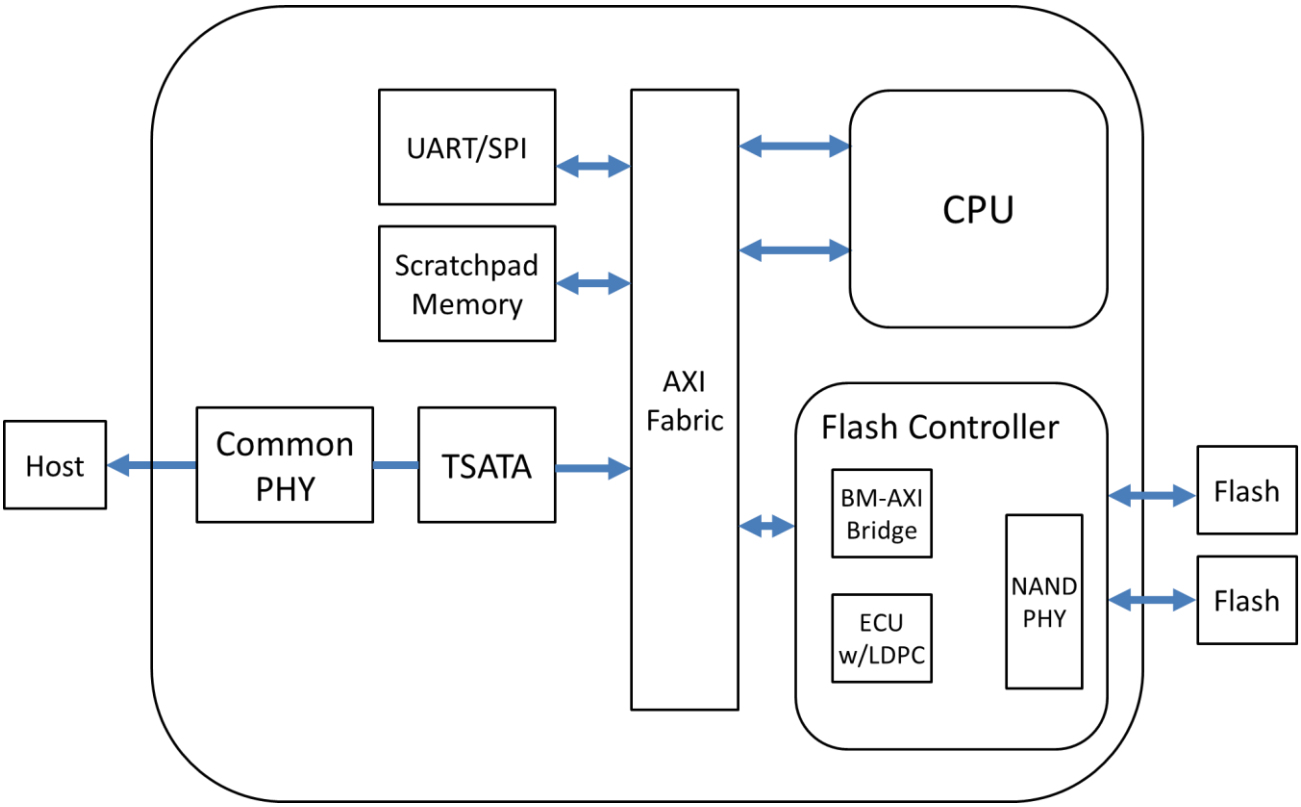


**Figure 4: Innodisk M.2 (S42) 3IE4 Block Diagram**

Innodisk M.2 (S42) 3IE4 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 M.2 (S42) 3IE4 is designed with ID 109, 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 2 channels for flash interface.

## 3.3 Error Detection and Correction

Innodisk 2.5”SATA SSD 3IE4 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 M.2 (S42) 3IE4 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 Power Cycling

Innodisk's power cycling management 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 power cycling 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.

# 4. Installation Requirements

## 4.1 M.2 (S42) 3IE4 Pin Directions

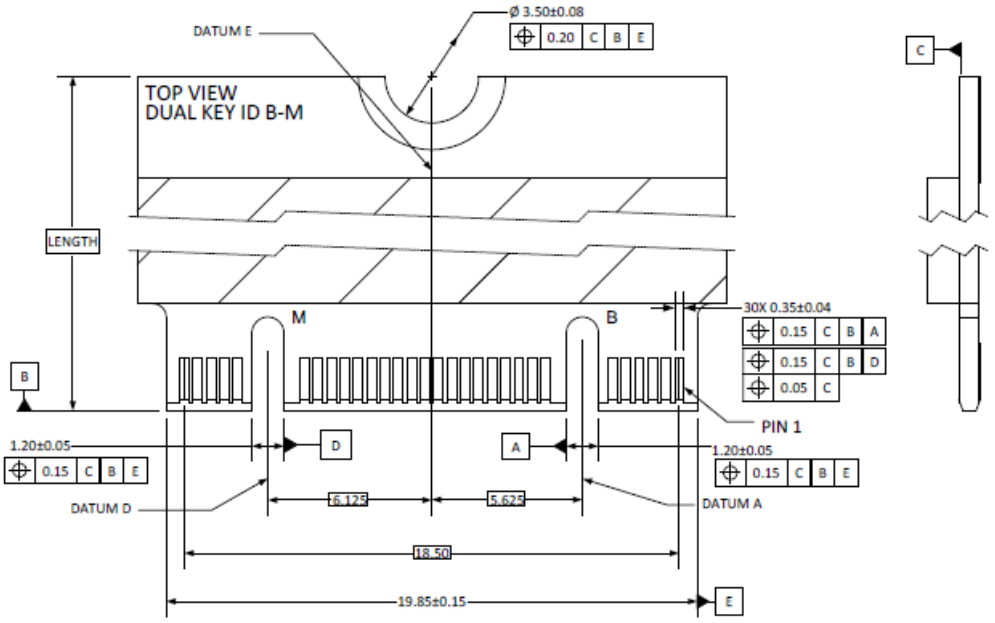


**Figure 5: Signal Segment and Power Segment**

## 4.2 Electrical Connections for M.2 (S42) 3IE4

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 Device Drive

No additional device drives are required. The Innodisk M.2 (S42) 3IE4 can be configured as a boot device.

# 5. 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** | **2** | **4** | **-** | **3** | **2** | **G** | **M** | **4** | **1** | **B** | **C** | **1** | **D** | **C** | **-** | **X** | **X** | **X** |

**Definition**

| **Code 1st (Disk)** | | | **Code 14th (Operation Temperature)** |
|---|---|---|---|
| D : Disk | | | C: Standard Grade (0℃~ +70℃) |
| **Code 2nd (Feature set)** | | | W: Industrial Grade (-40℃~ +85℃) |
| H : iSLC Seies | | | |
| **Code 3rd ~5th (Form factor)** | | | **Code 15th (Internal control)** |
| M24: M.2 Type 2242-D2-B-M | | | 1~9: TSOP PCB version. |
| | | | A: BGA PCB version. |
| **Code 7th ~9th (Capacity)** | | | **Code 16th (Channel of data transfer)** |
| 04G: 4GB | 08G: 8GB | 16G: 16GB | S: Single Channel |
| 32G: 32GB | 64G: 64GB | A28: 128GB | D: Dual Channels |
| | | | |
| **Code 10th ~12th (Controller)** | | | **Code 17th (Flash Type)** |
| M41: 88NV1120 | | | C: Toshiba MLC |
| | | | |
| **Code 13th (Flash mode)** | | | **Code 19th ~21st (Customize code)** |
| B: Synchronous NAND for Toshiba 15nm | | | |
| | | | |

# 6. Appendix

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## 宜鼎國際股份有限公司
## Innodisk Corporation
## REACH Declaration

Tel:(02)7703-3000 Fax:(02) 7703-3555 Internet: https://www.innodisk.com/

Innodisk Corporation pursues its social responsibility for global environmental preservation by committing to be compliant with REACH regulation (REGULATION (EC) No 1907/2006). We hereby confirm that the product(s) delivered to

| Innodisk P/N | Description |
|---|---|
| All Innodisk EM FLASH Products | |

☐ contain(s) **no** hazardous substances or constituents exceeding the defined threshold 0.1 % by weight in homogenous material if not otherwise specified, as described in the candidate list table currently including 209 substances and shown on the ECHA website (http://echa.europa.eu/de/candidate-list-table).

☑ contain(s) one or more hazardous substances or constituents exceeding 0.1 % by weight in homogenous material if not otherwise specified in candidate list table. Where the threshold value is exceeded, the substances in question are to be declared in accompanying Appendix A .

☑ Comply with REACH Annex XVII.

**Guarantor**

Company name 公司名稱： Innodisk Corporation 宜鼎國際股份有限公司

Company Representative 公司代表人： *Randy Chien* 簡川勝

Company Representative Title 公司代表人職稱： Chairman 董事長

Date 日期： 2020 / 07/ 01

innodisk

# 宜鼎國際股份有限公司
# Innodisk Corporation



Tel:(02)7703-3000 Internet: https://www.innodisk.com/

## RoHS 自我宣告書(RoHS Declaration of Conformity)

**Manufacturer Products: All Innodisk EM FLASH, DRAM and EP products**

一、 宜鼎國際股份有限公司（以下稱本公司）特此保證售予貴公司之所有產品，皆符合歐盟 2011/65/EU 及(EU) 2015/863 關於 RoHS 之規範要求。
Innodisk Corporation declares that all products sold to the company, are complied with European Union RoHS Directive (2011/65/EU) and (EU) 2015/863 requirement.

二、 本公司同意因本保證書或與本保證書相關事宜有所爭議時，雙方宜友好協商，達成協議。
Innodisk Corporation agrees that both parties shall settle any dispute arising from or in connection with this Declaration of Conformity by friendly negotiations.

三、 本公司聲明我們的產品符合 RoHS 指令的附件中(7a)、(7c-I)允許豁免。
We declare, our products permitted by the following exemptions specified in the Annex of the RoHS directive.

※ (7a) Lead in high melting temperature type solders(i.e. lead-based alloys containing 85% by weight or more lead).

※ (7C-I) Electrical and electronic components containing lead in a glass or ceramic other than dielectric ceramic in capacitors, e.g. piezoelectric devices, or in a glass or ceramic matrix compound.

| Name of hazardous substance | Limited of RoHS ppm (mg/kg) |
|---|---|
| 鉛 (Pb) | < 1000 ppm |
| 汞 (Hg) | < 1000 ppm |
| 鎘 (Cd) | < 100 ppm |
| 六價鉻 (Cr 6+) | < 1000 ppm |
| 多溴聯苯 (PBBs) | < 1000 ppm |
| 多溴二苯醚 (PBDEs) | < 1000 ppm |
| 鄰苯二甲酸二(2-乙基己基)酯 (DEHP) | < 1000 ppm |
| 鄰苯二甲酸丁酯苯甲酯 (BBP) | < 1000 ppm |
| 鄰苯二甲酸二丁酯 (DBP) | < 1000 ppm |
| 鄰苯二甲酸二異丁酯 (DIBP) | < 1000 ppm |

**立 保 證 書 人 (Guarantor)**

Company name 公司名稱： Innodisk Corporation 宜鼎國際股份有限公司

Company Representative 公司代表人： Randy Chien 簡川勝

Company Representative Title 公司代表人職稱： Chairman 董事長

Date 日期： 2020 / 03 / 03

# Certificate

Issue Date: July 29, 2015
Ref. Report No. ISL-15LE321CE

| | | |
|---|---|---|
| Product Name | : | M.2 |
| Model(s) | : | M.2 (S42) 3$*#-& ($:Flash type: (S:SLC,I:iSLC,M:MLC); *:Product line: (E:Embedded, G:EverGreen, R:InnoRobust); #:Controller: ( empty:106/107/167/170, 2:201/ 202, 3:108/109); &:Product feature: (P:with DRAM, empty:without DRAM)) |
| Responsible Party | : | Innodisk Corporation |
| Address | : | 5F.No.237, Sec. 1, Datong Rd., Xizhi Dist., New Taipei City 221, Taiwan (R.O.C.) |

**We, International Standards Laboratory, hereby certify that:**

The device bearing the trade name and model specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in European Council Directive- EMC Directive 2004/108/EC. The device was passed the test performed according to :

CE

**Standards:**

EN 55022: 2010+AC2011 and CISPR 22: 2008 (modified)
EN 61000-3-2: 2006+A1:2009 +A2:2009 and IEC 61000-3-2: 2005+A1:2008 +A2:2009
EN 61000-3-3: 2013 and IEC 61000-3-3: 2013
EN 55024: 2010 and CISPR 24: 2010
EN 61000-4-2: 2009 and IEC 61000-4-2: 2008
EN 61000-4-3: 2006+A1: 2008 +A2: 2010 and
IEC 61000-4-3:2006+A1: 2007+A2: 2010
EN 61000-4-4:2012 and IEC 61000-4-4:2012

I attest to the accuracy of data and all measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

**International Standards Laboratory**

Jim Chu / Director

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☒ **Lung-Tan LAB:**
No. 120, Lane 180, Hsin Ho Rd., Lung-Tan Dist.,
Tao Yuan City 325, Taiwan
Tel: 886-3-407-1718; Fax: 886-3-407-1738

# Certificate

Issue Date: July 29, 2015
Ref. Report No. ISL-15LE321FB

| | | |
|---|---|---|
| Product Name | : | M.2 |
| Model(s) | : | M.2 (S42) 3$*#-& ($:Flash type: (S:SLC,I:iSLC,M:MLC); *:Product line: (E:Embedded, G:EverGreen, R:InnoRobust); #:Controller: ( empty:106/107/167/170, 2:201/ 202, 3:108/109); &:Product feature: (P:with DRAM, empty:without DRAM)) |
| Applicant | : | Innodisk Corporation |
| Address | : | 5F.No.237, Sec. 1, Datong Rd., Xizhi Dist., New Taipei City 221, Taiwan (R.O.C.) |

We, **International Standards Laboratory**, hereby certify that:

The device bearing the trade name and model specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified. (refer to Test Report if any modifications were made for compliance).

**Standards:**

FCC CFR Title 47 Part 15 Subpart B: 2014- Section 15.107 and 15.109
ANSI C63.4-2009
Industry Canada Interference-Causing Equipment Standard ICES-003 Issue 5: 2012

**Class B**

I attest to the accuracy of data and all measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

**International Standards Laboratory**

Jim Chu / Director

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