innodisk

Total Solution For Industrial Flash Storage

SATADOM-ML

3IE2-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
Preliminary	First Released	Sep. 2016
V1.0	First released	Sep. 2016

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1. Product Overview

1.1 Introduction of Innodisk SATADOM-ML 3IE2-P

iSLC [3IE2-P series], designed to outdo the endurance, performance and reliability of MLC-based solutions. Through the use of flash management algorithms, iSLC improves SSD endurance up to 20,000 times, increasing lifespans up to 7 times longer than MLC-based solutions. In addition, iSLC improves the performance of solid state drives, with similar write performance of SLC-based solutions, and with data quality that is on par with SLC technologies. Innodisk iSLC series is cost efficient, boasting excellent benefits at only half the price of SLC-based solutions.

Innodisk Serial ATA Disk on Module (SATADOM) supports SATA III standard (6.0Gb/s) interface with excellent performance, and SATADOM-ML 3IE2-P is designed as the smallest form factor size that could enhance compatibility with various design applications. The innovative Pin8 uses the SATA connector itself as a power supply to drive the device without external cables. It could be connected directly to the SATA on-board socket on customers' system without additional power cable. Besides, the booting time for operation and the power consumption is less than hard disk drive (HDD), and can work under harsh environment compile with ATA protocol, no additional drives are required, and the SSD can be configured as a boot device.

1.2 Product View and Models

Innodisk SATADOM-ML 3IE2-P is available in follow capacities within iSLC flash ICs.

SATADOM-ML 3IE2-P 16GB

SATADOM-ML 3IE2-P 32GB

SATADOM-ML 3IE2-P 64GB

SATADOM-ML 3IE2-P 128GB

1.3 SATA Interface

Innodisk SATADOM-ML 3IE2-P supports SATA III interface, and compliant with SATA I and SATA II.

2. Product Specifications

2.1 Capacity and Device Parameters

SATADOM-ML 3IE2-P device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	LBA	Cylinders	Heads	Sectors	User Capacity(MB)
16GB	29323728	16383	16	63	14318
32GB	60579792	16383	16	63	29580
64GB	121138416	16383	16	63	59150
128GB	242255664	16383	16	63	118289

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance

Capacity	16GB	32GB	64GB	128GB
Sequential Read (max.)	300 MB/s	560 MB/s	560 MB/s	560 MB/s
Sequential Write (max.)	120 MB/s	240 MB/s	450 MB/s	220 MB/s
4KB Random Read (QD32)	34,000 IOPS	66,000 IOPS	75,000 IOPS	66,000 IOPS
4KB Random Write (QD32)	31,000 IOPS	61,000 IOPS	81,000 IOPS	57,000 IOPS

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

** Random performance is based on IO meter with Queue Depth 32

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 3: Innodisk SATADOM-ML 3IE2-P Power Requirement

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

2.3.2 Power Consumption

Table 4: Power Consumption

Mode	Power Consumption (mA)
Read	275 (max.)
Write	396 (max.)
Idle	96 (max.)
Initial	657(max.)
Pin 7 VCC Initial*	1000(max.)

Target: 128GB SATADOM-ML 3IE2-P

***To design in Pin7/8 VCC on motherboard, 5V with 1A power supply is requested.**

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for SATADOM-ML 3IE2-P

Temperature	Range
Operating	Standard Grade: 0°C to +70°C
	Industrial Grade: -40°C to +85°C
Storage	-55°C to +95°C

2.4.2 Humidity

Relative Humidity: 10-95%, non-condensing

2.4.3 Shock and Vibration

Table 6: Shock/Vibration Testing for SATADOM-ML 3IE2-P

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 SATADOM-ML 3IE2-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 7: SATADOM-ML 3IE2-P MTBF

Product	Condition	MTBF (Hours)
Innodisk SATADOM-ML 3IE2-P	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

SATADOM-ML 3IE2-P conforms to CE and FCC requirements.

2.6 RoHS Compliance

SATADOM-ML 3IE2-P is fully compliant with RoHS directive.

2.7 Reliability

Table 8: SATADOM-ML 3IE2-P TBW

Parameter	**Value**	
Read Cycles	Unlimited Read Cycles	
Flash endurance	20,000 P/E cycles	
Wear-Leveling Algorithm	Support	
BadBlocks Management	Support	
Error Correct Code	Support	
TBW* (Total Bytes Written) Unit: TB		
Capacity	**Sequential workload**	**Client workload**
16GB	284.1	156.3
32GB	568.2	312.5
64GB	1136	625
128GB	2273	1250
* 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

SATADOM-ML 3IE2-P support following transfer mode:

Serial ATA I 1.5Gbps

Serial ATA II 3.0Gbps

Serial ATA III 6.0Gbps

2.9 Pin Assignment

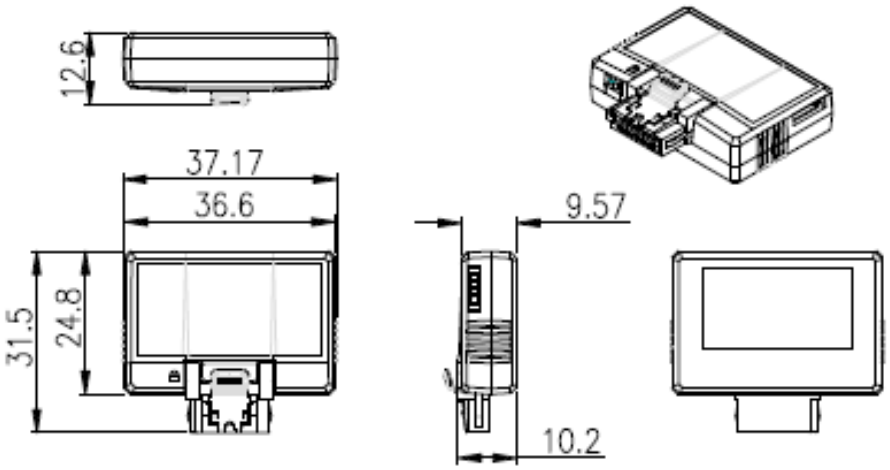
Innodisk SATADOM-ML 3IE2-P uses a standard SATA pin-out. See Table 8 for SATADOM-ML 3IE2-P pin assignment.

Table 9: Innodisk SATADOM-ML 3IE2-P Pin Assignment

Name	**Type**	**Description**
Pin 0	GND	Shielding
Pin 1	GND	Shielding
Pin 2	A+	Differential signal to A
Pin 3	A-	Differential signal to A-
Pin 4	GND	Shielding
Pin 5	B-	Differential signal to B-
Pin 6	B+	Differential signal to B
Pin 7	GND/ Vcc*	Shielding/ +5V Power*
Pin 8	Vcc	+5V Power

* SATADOM-ML 3IE2-P defaulted power supply is through pin 8 or extra power cable.
Pin 7 power supply is an optional function with separated PN ended with B.

2.10 Mechanical Dimensions



Dimension tolerance: ±0.2mm

2.11 Assembly Weight

An Innodisk SATADOM-ML 3IE2-P within flash ICs, 256GB's weight is 8 grams approximately.

2.12 Seek Time

Innodisk SATADOM-ML 3IE2-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 SATADOM-ML 3IE2-P uses Multi Level Cell (MLC) NAND flash memory, which is non-volatility, high reliability and high speed memory storage. Each cell stores 2 bits or holds four states per cell. Read or Write data to flash memory for SSD is control by microprocessor.

3. Theory of Operation

3.1 Overview

Figure 2 shows the operation of Innodisk SATADOM-ML 3IE2-P from the system level, including the major hardware blocks.

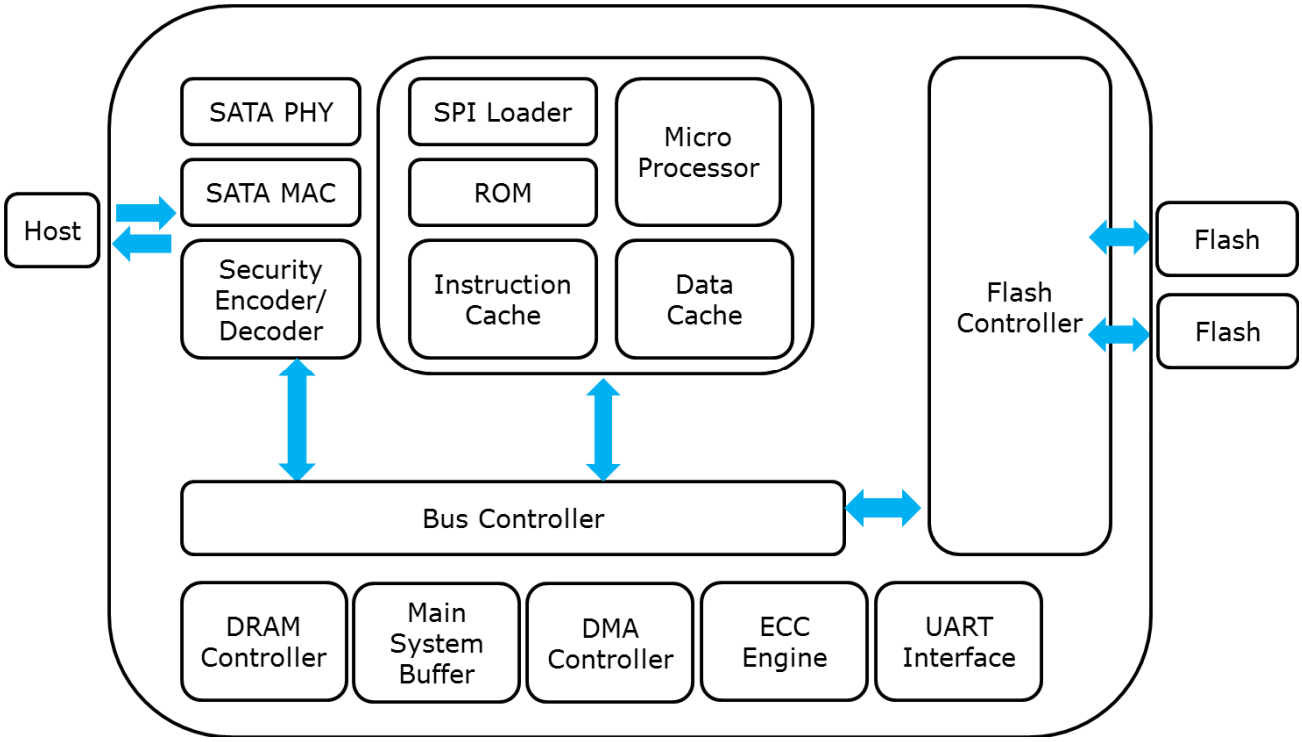


Figure 1: Innodisk SATADOM-ML 3IE2-P Block Diagram

Innodisk SATADOM-ML 3IE2-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.

3.2 SATA III Controller

Innodisk SATADOM-ML 3IE2-P is designed with ID 201, a SATA III 6.0Gbps (Gen. 3) controller, which supports external DDR3 DRAM. 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

Highly sophisticated Error Correction Code algorithms are implemented. The ECC unit consists of the Parity Unit (parity-byte generation) and the Syndrome Unit (syndrome-byte computation). This unit implements an algorithm that can correct 66 bits per 1024 bytes in an ECC block. Code-byte generation during write operations, as well as error detection during read operation, is implemented on the fly without any speed penalties.

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 SATADOM-ML 3IE2-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.

4. Installation Requirements

4.1 SATADOM-ML 3IE2-P Pin Directions

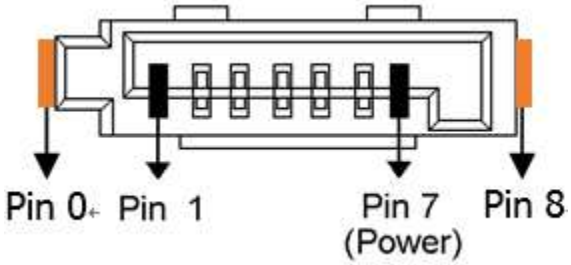


Figure 2: Signal Segment and Power Segment

* SATADOM-ML 3IE2-P default power supply through pin 8 or extra power cable.
Pin 7 power supply as an optional function with separate PN end of B.

4.2 Electrical Connections for SATADOM-ML 3IE2-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 Device Drive

No additional device drives are required. The Innodisk SATADOM-ML 3IE2-P can be configured as a boot device.

4.4 Power supply for SATDOM

4.4.1 Power cable

A power cable is shipped with each SATADOM product, which has standard 4 pins power connector and special 3 pins power connector for SATADOM. The male and female power connector of SATADOM have foolproof design to avoid misconnection, please check it before power on. Innodisk also can customize the power connector for different host power socket design.

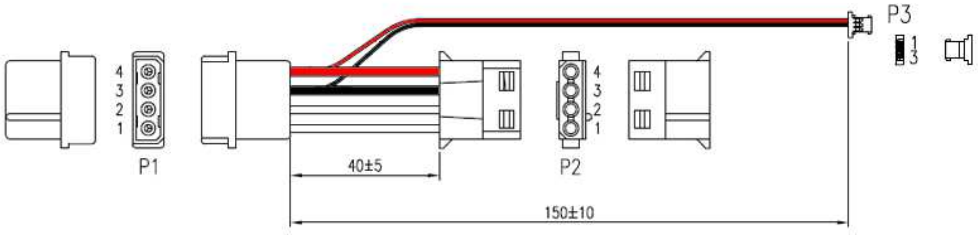


Figure 3: Standard power cable

4.4.2 Pin8 and Pin7 VCC

Innodisk's SATADOM SSDs provide an elegant, compact option for SSD storage in embedded systems, industrial PCs and server motherboards with their small form factor that connects directly to the SATA connector on the motherboard. This simplified SSD design not only frees up a precious drive bay for other storage options but eliminates messy, obtrusive SATA data cabling. Innodisk's patented Pin7 and Pin 8 SATA Power technologies take the cable-less concept to the next step by also eliminating the need for power cables for a 100% cable-less, shock resistant, space saving plug-and-play storage solution that optimizes airflow and makes the best use of limited board space in embedded and rackmount server systems.

SATADOM-ML 3IE2-P series with Pin8/Pin7 VCC, it is defined Pin8/Pin7 as VCC on the SATA connector. Thus the power would come from SATA connector Pin8/Pin7 VCC. Customers DO NOT have to use the power cable for power supply. Such a cable-less design of SATADOM-ML 3IE2-P series with Pin8/Pin7 VCC brings more convenience to customers' system. The followings are the points customers have to be careful of while designing in SATADOM-ML 3IE2-P series with Pin8/Pin7 VCC.

When customers use SATADOM with Pin8/Pin7 VCC and the host SATA socket does not have power on Pin8/Pin7, external power must be provided to the SATADOM from the 3pin connector on the side.To have the advantages of SATADOM-ML 3IE2-P series with Pin8/Pin7 VCC, and to avoid any potential damage on customer's board designed with VCC power supply. Innodisk suggests that customers MUST design their board with a fuse which should be designed before the SATA socket Pin8/Pin7 VCC. In other words, customers are suggested NOT TO layout 5V VCC to SATA socket on board directly. A circuit diagram example to explain this is shown as below.

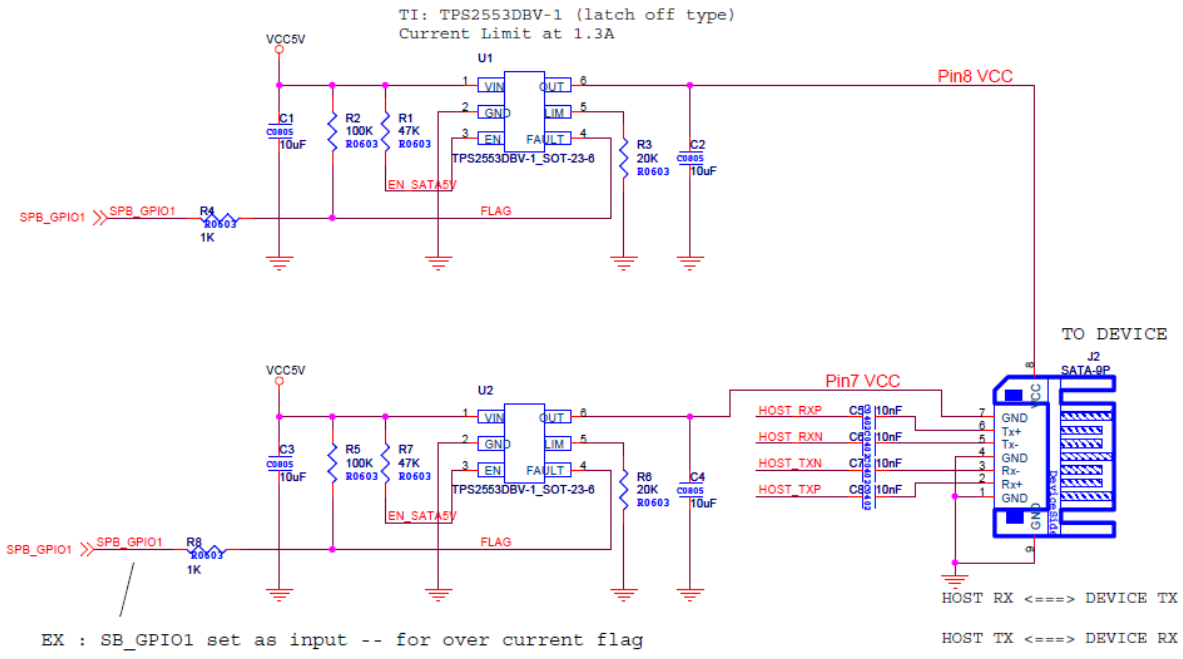


Figure 4: Pin 8 / Pin 7 host design in reference circuit

4.5 Write Protection

SATADOM-ML 3IE2-P within the hardware write-protect function could prevent the device from modification and deletion. Write-protected data could only be read, that is, users could not write to it, edit it, append data to it, or delete it. When users would like to make sure that neither themselves nor others could modify or destroy the file, users could switch on write-protection. Thus, SATADOM-ML 3IE2-P could process write-protect mechanism and disable flash memory to be written-in any data. Only while the system power-off, users could switch on write-protection. Write-protection could not be switched-on, after OS booting.

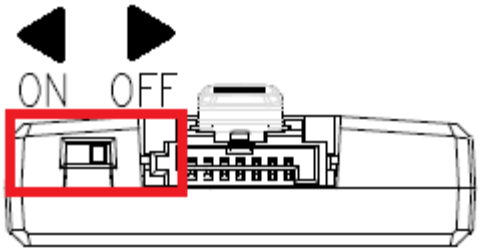


Figure 5: Hardware write protect position

5. SMART Feature Set

Innodisk 3IE2-P 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's 3IE2-P series SMART data attributes are listed in following table.

Attribute ID (hex)	Raw Attribute Value							Attribute Name
1 (01h)	MSB	00	00	00	00	00	00	Raw Read Error Rate
5 (05h)	LSB	MSB	00	00	00	00	00	Reallocated Sector Count
9 (09h)	LSB			MSB	00	00	00	Power-on Hours
12 (0Ch)	LSB			MSB	00	00	00	Power Cycle Count
160 (A0h)	LSB			MSB	00	00	00	Uncorrectable sector count when read/write
161 (A1h)	LSB	MSB	00	00	00	00	00	Number of valid spare block
163 (A3h)	LSB	MSB	00	00	00	00	00	Number of initial invalid block
164 (A4h)	LSB			MSB	00	00	00	Total erase count
165 (A5h)	LSB			MSB	00	00	00	Maximum erase count
166 (A6h)	LSB			MSB	00	00	00	Minimum erase count
167 (A7h)	LSB			MSB	00	00	00	Average erase count
168 (A8h)	LSB			MSB	00	00	00	Max erase count of spec
169 (A9h)	LSB			MSB	00	00	00	Remain Life (percentage)

175 (AFh)	LSB			MSB	00	00	00	Program fail count in worst die
176 (B0h)	LSB	MSB	00	00	00	00	00	Erase fail count in worst die
177 (B1h)	LSB			MSB	00	00	00	Total wear level count
178 (B2h)	LSB	MSB	00	00	00	00	00	Runtime invalid block count
181 (B5h)	LSB			MSB	00	00	00	Total program fail count
182 (B6h)	LSB	MSB	00	00	00	00	00	Total erase fail count
187 (BBh)	LSB			MSB	00	00	00	Uncorrectable error count
192 (C0h)	LSB	MSB	00	00	00	00	00	Power-Off Retract Count
194 (C2h)	MSB	00	00	00	00	00	00	Controlled temperature
195 (C3h)	LSB			MSB	00	00	00	Hardware ECC recovered
196 (C4h)	LSB			MSB	00	00	00	Reallocation event count
198 (C6h)	LSB			MSB	00	00	00	Uncorrectable error count off-line
199 (C7h)	LSB	MSB	00	00	00	00	00	UltraDMA CRC error count
225 (E1h)	LSB						MSB	Total LBAs written (each write unit = 32MB)
232 (E8h)	LSB	MSB	00	00	00	00	00	Available reserved space
241 (F1h)	LSB						MSB	Total LBAs written (each write unit = 32MB)
242 (F2h)	LSB						MSB	Total LBAs read (each write unit = 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	M	L	-	6	4	G	D	8	1	B	C	A	D	C	A	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 series	**Code 15th (Internal Control)**
Code 3rd ~5th (Form Factor)	A~Z: BGA PCB version
SML: SATADOM-ML	**Code 16th (Channel of Data Transfer)**
Code 7th ~9th (Capacity)	D: Dual channels
16G:16GB / 64G: 64GB	Q: Quad channels
32G: 32GB / A28: 128GB	
Code 10th ~12th (Controller)	**Code 17th (Flash Type)**
D81: ID201	C: Toshiba MLC
	Code 18th (Pin7 Type)
Code 13th (Flash Mode)	A: Pin8 version / standard version
B: Synchronous flash (Toshiba 15nm)	B: Pin8 & Pin7 version
	Code 19th~21st (Custom Code)

7. Appendix

宜鼎國際股份有限公司
Innodisk Corporation

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REACH Declaration of Conformity

Manufacturer Product: All Innodisk EM Flash and Dram products

1.宜鼎國際股份有限公司（以下稱本公司）特此保證此售予貴公司之產品，皆符合歐盟化學品法案(Registration , Evaluation and Authorization of Chemicals；REACH)之規定 (http://www.echa.europa.eu/de/candidate-list-table **last updated: 20/06/2016**)。所提供之產品包含：(1) 產品或產品所使用到的所有原物料；(2)包裝材料；(3)設計、生產及重工過程中所使用到的所有原物料。

We Innodisk Corporation hereby declare that our products are in compliance with the requirements according to the REACH Regulation (http://www.echa.europa.eu/de/candidate-list-table **last updated: 20/06/2016**). Products include： 1) Product and raw material used by the product： 2) Packaging material ；3) Raw material used in the process of design, production and rework

2.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.

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： 2016 / 06 / 23

innodisk

宜鼎國際股份有限公司
Innodisk Corporation

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RoHS 自我宣告書(RoHS Declaration of Conformity)

Manufacturer Product: All Innodisk EM Flash and Dram products

一、 宜鼎國際股份有限公司（以下稱本公司）特此保證售予新漢股份有限公司之所有產品，皆符合歐盟 2011/65/EU 關於 RoHS 之規範要求。

Innodisk Corporation declares that all products sold to Nexcom, are complied with European Union RoHS Directive (2011/65/EU) 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.

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

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： 2016 / 08 / 04