innodisk

Total Solution For
Industrial Flash Storage

OCuLinkDOM

3ME2 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	Nov. 2018

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1. Product Overview

1.1 Introduction of Innodisk OCuLinkDOM 3ME2

Innodisk OCuLinkDOM 3ME2 is an NVM Express DRAM-less SSD designed as the standard OCuLink pindefine with PCIe interface and MLC NAND Flash. OCuLinkDOM 3ME2 supports PCIe Gen III x2, and it is compliant with NVM 1.3 providing excellent performance. Moreover, it adopts MLC NAND Flash providing high endurance and reliability. With sophisticated error detection and correction (ECC) functions, the module can ensure full End-to-end Data Path Protection that secures the data transmission between host system and NAND Flash.

Innodisk OCuLinkDOM 3ME2 is integrated with Marvell controller which provide both low power consumption and efficient heat dissipation, making the SSD optimal for space-constrained IPCs and server boot-up applications.

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 OCuLinkDOM 3ME2 is available in follow capacities within MLC flash ICs.

OCuLinkDOM 3ME2 32GB

OCuLinkDOM 3ME2 64GB

OCuLinkDOM 3ME2 128GB

OCuLinkDOM 3ME2 256GB

Figure 1: Innodisk OCuLinkDOM 3ME2

1.3 PCIe Interface

Innodisk OCuLinkDOM 3ME2 supports PCIe Gen III interface and compliant with NVMe 1.3. OCuLinkDOM 3ME2 can work under PCIe Gen 1, Gen 2 and Gen 3.

Most of operating systems includes NVMe in-box driver now. For more information about the driver support in each OS, please visit http://nvmexpress.org/resources/drivers.

2. Product Specifications

2.1 Capacity and Device Parameters

OCuLinkDOM 3ME2 device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	Cylinders	Heads	Sectors	LBA	User Capacity(MB)
32GB	16383	16	63	62533296	30533
64GB	16383	16	63	125045424	61057
128GB	16383	16	63	250069680	122104
256GB	16383	16	63	500118192	244198

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance

Capacity	32GB	64GB	128GB	256GB
Sequential* Read (max.)	450MB/s	890 MB/s	1300 MB/s	1300 MB/s
Sequential* Write (max.)	50 MB/s	100 MB/s	190 MB/s	340MB/s
4KB Random** Read (QD32)	18000	36000	47000	51000
4KB Random** Write (QD32)	12000	22000	29000	47000

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 OCuLinkDOM 3ME2 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 (mA)
Read	755 (rms.)
Write	830 (rms.)
Idle	365 (rms.)

Target: 256GB OCuLinkDOM 3ME2

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for OCuLinkDOM 3ME2

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 OCuLinkDOM 3ME2

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 OCuLinkDOM 3ME2 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: OCuLinkDOM 3ME2 MTBF

Product	Condition	MTBF (Hours)
Innodisk OCuLinkDOM 3ME2	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

OCuLinkDOM 3ME2 conforms to CE and FCC requirements.

2.6 RoHS Compliance

OCuLinkDOM 3ME2 is fully compliant with RoHS directive.

2.7 Reliability

Table 8: OCuLinkDOM 3ME2 TBW

Parameter	**Value**	
Read Cycles	Unlimited Read Cycles	
Flash endurance	3,000 P/E cycles	
Wear-Leveling Algorithm	Support	
Bad Blocks Management	Support	
Error Correct Code	Support(LDPC)	
TBW* (Total Bytes Written) Unit: TB		
Capacity	**Sequential workload**	**Client workload**
32GB	93.6	38.7
64GB	187.2	77.40
128GB	374.4	135.49
256GB	748.8	202.85

* 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

OCuLinkDOM 3ME2 support following transfer mode:

PCIe Gen III 8Gbps

PCIe Gen II 4Gbps

PCIe Gen I 2Gbps

2.9 Pin Assignment

Innodisk OCuLinkDOM 3ME2 uses a standard OCuLink pin-out. See Table 9 for OCuLinkDOM 3ME2 pin assignment.

Pin #	Description	Pin #	Description
A1	POWER 3.3 Vact RX	B1	N/C
A2	GROUND	B2	GROUND
A3	PERp0	B3	PETp0
A4	PERn0	B4	PETn0
A5	GND	B5	GND
A6	PERp1	B6	PETp1
A7	PERn1	B7	PETn1
A8	GND	B8	GND
A9	N/C	B9	N/C
A10	N/C	B10	N/C
A11	GND	B11	GND
A12	N/C	B12	PCLKP
A13	N/C	B13	PCLKN
A14	GND	B14	GND
A15	N/C	B15	N/C
A16	N/C	B16	N/C
A17	GND	B17	GND
A18	N/C	B18	N/C
A19	N/C	B19	N/C
A20	GND	B20	GND
A21	N/C	B21	POWER 3.3 Vact TX

Table 9: Innodisk OCuLinkDOM 3ME2 Pin Assignment

2.10 Mechanical Dimensions

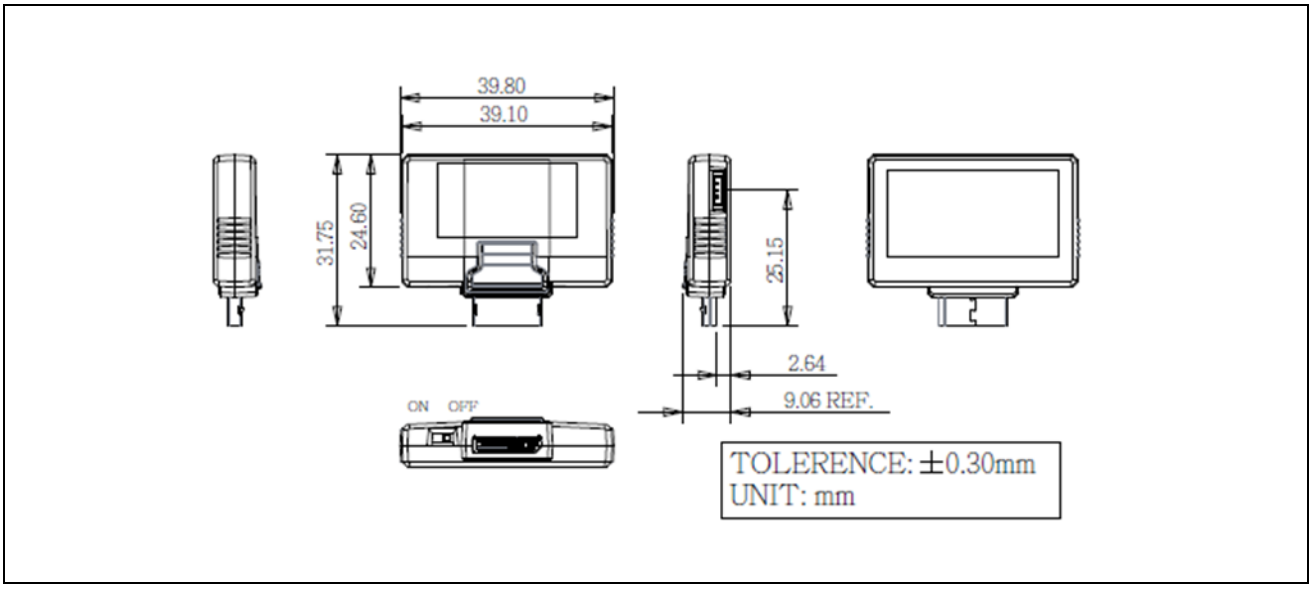

Figure 2: Innodisk OCuLinkDOM 3ME2 mechanical diagram

2.11 Assembly Weight

An Innodisk OCuLinkDOM 3ME2 within flash ICs, 32GB's weight is 7 grams approximately.

2.12 Seek Time

Innodisk OCuLinkDOM 3ME2 is not a magnetic rotating design. There is no seek or rotational latency required.

2.13 NAND Flash Memory

Innodisk OCuLinkDOM 3ME2 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 3 shows the operation of Innodisk OCuLinkDOM 3ME2 from the system level, including the major hardware blocks.

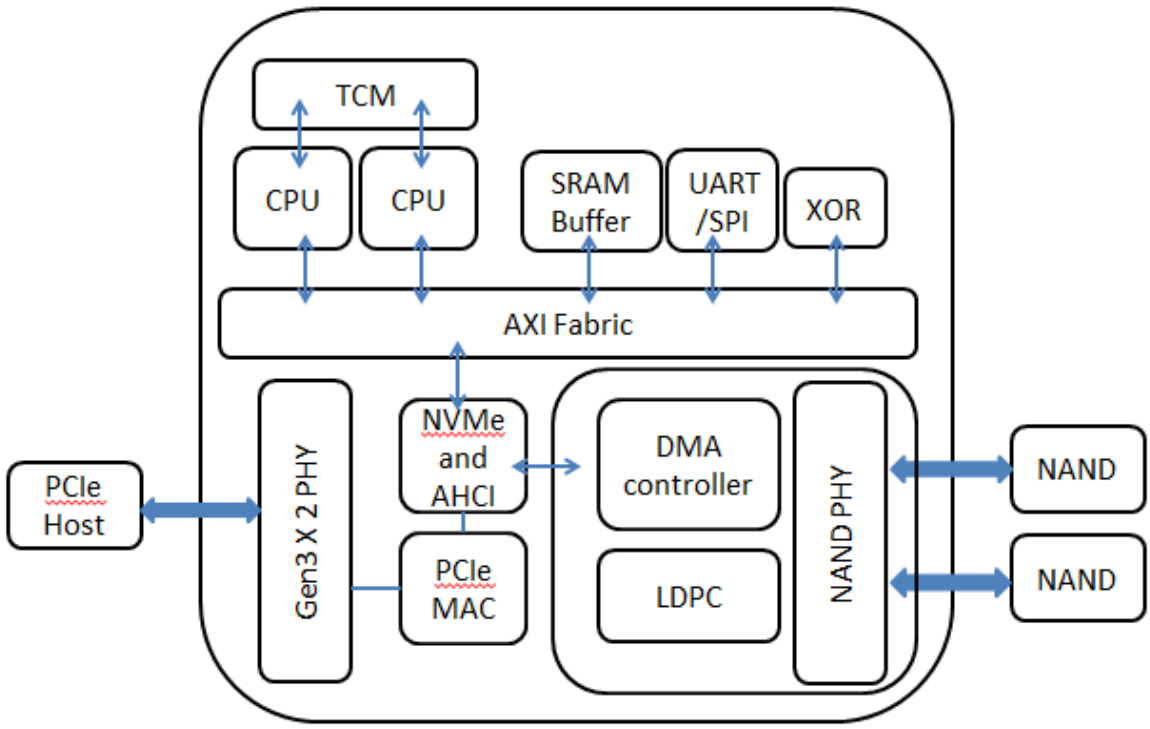

Figure 3: Innodisk OCuLinkDOM 3ME2 Block Diagram

Innodisk OCuLinkDOM 3ME2 integrates a PCIe Gen III x2 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 PCIe Gen III x2 Controller

Innodisk OCuLinkDOM 3ME2 is designed with 88NV1160, a PCIe Gen IIIx2 controller is compliant with NVMe 1.3, up to 16.0Gbps transfer speed. Also it is compliant with PCIe Gen 1, Gen 2 and Gen 3 specification. The controller supports up to 4 channels for flash interface.

3.3 Error Detection and Correction

Innodisk OCuLinkDOM 3ME2 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 OCuLinkDOM 3ME2 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 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.

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.

4. Installation Requirements

4.1 OCuLinkDOM 3ME2 Pin Directions

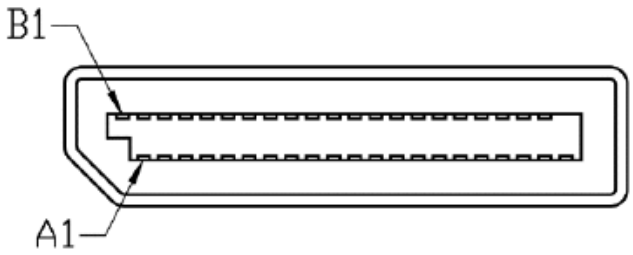

Figure 4: Signal Segment and Power Segment

4.2 Electrical Connections for OCuLinkDOM 3ME2

OCuLinkDOM interconnect is based on OCuLink socket which is a standard OCuLink specification V1.0 definition in PCI-SIG. OCuLink provided 4 channel and 8 channel socket in different dimension. For embedded purpose, we select 4 channel connector to design the OCuLinkDOM to optimize the dimension.

4.3 Device Drive

OCuLinkDOM 3ME2 is compliant with NVMe 1.3. To make sure NVMe storage devices can work in your system, both operation system and BIOS can support NVMe. Most of OS includes NVMe in-box driver now. For more information about the NVMe driver support in each OS, please visit the website http://nvmexpress.org/resources/drivers. For BIOS NVMe driver support please contact with your motherboard manufacturers.

4.4 Power supply for OCuLinkDOM

4.4.1 Power cable

A power cable is shipped with each OCuLinkDOM product, which has standard 4 pins power connector and special 3 pins power connector for OCuLinkDOM. The male and female power connector of OCuLinkDOM 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.

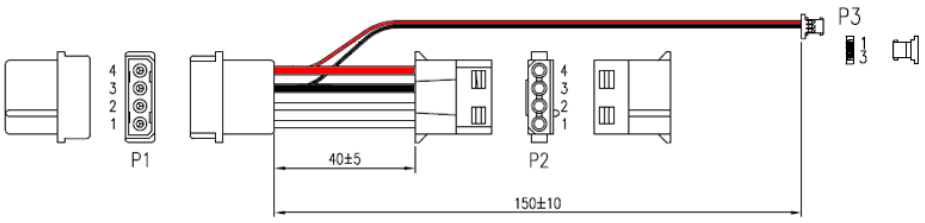

Figure 5: Standard power cable

4.5 Write Protection

OCuLinkDOM 3ME2 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, OCuLinkDOM 3ME2 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.

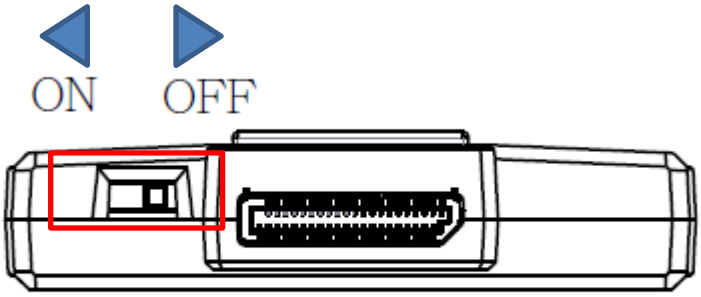

Figure 6: Hardware write protect position

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	**E**	**O**	**M**	**L**	**-**	**3**	**2**	**G**	**M**	**6**	**1**	**B**	**C**	**A**	**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℃)
E: Embedded series	**Code 15th (Internal control)**
Code 3rd ~5th (Form factor)	A~Z: BGA PCB version
OML: OCULINKDOM-ML type	**Code 16th (Channel of data transfer)**
Code 7th ~9th (Capacity)	D: Dual Channel
32G:32GB / 64G:64GB / A28:128GB / B56:256GB	
Code 10th ~12th (Controller)	**Code 17th (Flash Type)**
M61: Artemis Plus	C: Toshiba MLC
	Code 18th (Power supply config.)
Code 13th (Flash mode)	
B: Synchronous flash for Toshiba 15nm	
	Code 19th~21st (Customize code)

6. Appendix

REACH

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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

RoHS

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

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Innodisk Corporation declares that all products sold to the company, 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。

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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