innodisk

Total Solution For
Industrial Flash Storage

2.5" SATA SSD

3MR2-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
Rev 1.0	First Released	April, 2017
Rev 1.1	Update the drawing of housing	Sep., 2017
Rev 1.2	Add 2TB specification Update CF/FCC certification Update TBW	Mar., 2018
Rev 1.3	Correct 2TB LBA	Mar., 2018
Rev 1.4	Correct write protect command	June., 2018
Rev 1.5	Revise write protect command Feature	Sep., 2018
Rev 1.6	Correct Table 11: Identify Information	Jan, 2019
Rev 1.7	Update Power Consumption Information	Dec., 2020
Rev 1.8	Revise quick erase pin	Nov., 2022
Rev 1.9	Update the drawing of housing	Dec., 2022
Rev 2.0	Update Assembly Torque Information	Mar., 2023

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1. Product Overview

1.1 Introduction of Innodisk 2.5” SATA SSD 3MR2-P

Innodisk 2.5” SATA SSD 3MR2-P 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. Especially, it comes with several data security functions, including Quick Erase/ Security Erase/ FW Destroy and also Write Protect. All the security functions can be triggered both by hardware and software approaches. 2.5” SATA SSD 3MR2-P is compliant with MIL-STD-810G standards. The SSD is equipped ruggedized hardware design and thus it can perform well in the harsh environment. Furthermore, Innodisk 2.5” SATA SSD 3MR2-P supports TRIM for windows 7, which can improve performance when deleting files. 2.5” SATA SSD 3MR2-P is developed with Innodisk owned technical knowhow to ensure the data integrity and highest levels of reliability.

1.2 Product View and Models

Innodisk 2.5” SATA SSD 3MR2-P is available in follow capacities:

2.5” SATA SSD 3MR2-P 8GB
2.5” SATA SSD 3MR2-P 16GB
2.5” SATA SSD 3MR2-P 32GB
2.5” SATA SSD 3MR2-P 64GB
2.5” SATA SSD 3MR2-P 2TB
2.5” SATA SSD 3MR2-P 128GB
2.5” SATA SSD 3MR2-P 256GB
2.5” SATA SSD 3MR2-P 512GB
2.5” SATA SSD 3MR2-P 1TB

Figure 1: Innodisk 2.5” SATA SSD 3MR2-P

1.3 SATA Interface

Innodisk 2.5” SATA SSD 3MR2-P 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 2.5” SATA SSD 3MR2-P is compliant with Serial ATA Gen 1, Gen 2 and Gen 3 specification (Gen 3 supports 1.5Gbps /3.0Gbps/6.0Gbps data rate). SATA connector uses a 7-pin signal segment and a 15-pin power segment.

1.4 2.5-inch Form Factor

The Industry-standard 2.5-inch form factor design with metal material case is easy for installation, which has a compact design 69.85mm (W) x 100.00mm (L) x 9.50mm (H).

2. Product Specifications

2.1 Capacity and Device Parameters

2.5” SATA SSD 3MR2-P device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	LBA	Cylinders	Heads	Sectors	User Capacity(MB)
8GB	13695696	13587	16	63	6687
16GB	29323728	16383	16	63	14318
32GB	60579792	16383	16	63	29580
64GB	121138416	16383	16	63	59150
128GB	242255664	16383	16	63	118289
256GB	484490160	16383	16	63	236567
512GB	968959152	16383	16	63	473124
1TB	1937897136	16383	16	63	946238
2TB*	3958292478	16383	16	63	1932760

*2TB doesn’t support TCG OPAL 2.0

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance

	Capacity	8GB (1CH)	16GB (1CH)	16GB (2CH)	32GB (2CH)	32GB (4CH)	64GB (4CH)	128GB (4CH)	256GB (4CH)	512GB** (4CH)	1TB** (4CH)	2TB (4CH)
Toshiba 15nm	Sequential* Read (max.)	140 MB/s	140 MB/s	270 MB/s	270 MB/s	520 MB/s	520 MB/s	520 MB/s	520 MB/s	520 MB/s	520 MB/s	440 MB/s
	Sequential Write (max.)	25 MB/s	25 MB/s	45 MB/s	45 MB/s	90 MB/s	180 MB/s	350 MB/s	350 MB/s	450 MB/s	450 MB/s	420 MB/s
	4KB Random Read (QD32)	14,000 IOPS	14,000 IOPS	27,000 IOPS	27,000 IOPS	52,000 IOPS	75,000 IOPS	75,000 IOPS	75,000 IOPS	75,000 IOPS	75,000 IOPS	12,000 IOPS
	4KB Random Write (QD32)	6400 IOPS	6400 IOPS	11,500 IOPS	11,500 IOPS	23,000 IOPS	46,000 IOPS	80,000 IOPS	83,000 IOPS	76,000 IOPS	78,000 IOPS	15,600 IOPS

Note: *Performance based on CrystalDiskMark 5.01with file size 1000M

** While enable AES function, the performance of 512GB, 1TB and 2TB is 360MB/s for sequential write

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 3: Innodisk 2.5” SATA SSD 3MR2-P Power Requirement

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

2.3.2 Power Consumption

Table 4: Power Consumption

Model	Power Consumption (mA)								
Capacity	8GB	16GB	32GB	64GB	128GB	256GB	512GB	1TB	2TB
Read (RMS)	165	180	240	170	185	185	185	210	750
Write (RMS)	190	195	235	390	590	610	720	730	1600
Idle (RMS)	145	145	150	155	170	170	170	200	390
Power-On Peak	1600	1600	1500	1550	1350	1500	1550	1100	1400

Note: Current results may vary depending on system components and power circuit design.

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for 2.5” SATA SSD 3MR2-P

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 2.5” SATA SSD 3MR2-P

Reliability	Test Conditions	Reference Standards
Vibration	7 Hz to 2K Hz, 20G, 3 axes	MIL-STD-810G/F 514.5
Mechanical Shock	Duration: 0.5ms, 1500 G, 3 axes	MIL-STD-810G/F 516.5

2.4.4 Mean Time between Failures (MTBF)

Table 7 summarizes the MTBF prediction results for various 2.5” SATA SSD 3MR2-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: 2.5” SATA SSD 3MR2-P MTBF

Product	Condition	MTBF (Hours)
Innodisk 2.5” SATA SSD 3MR2-P	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

2.5” SATA SSD 3MR2-P conforms to CE and FCC requirements.

2.6 RoHS Compliance

2.5” SATA SSD 3MR2-P is fully compliant with RoHS directive.

2.7 Reliability

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	
TBW* (Total Bytes Written) Unit:TB		
Capacity	**Sequential workload**	**Client workload**
08GB	21.3	9.4
16GB	42.6	18.8
32GB	85.2	37.5
64GB	170.5	75
128GB	340.9	150
256GB	681.8	300
512GB	1364	600
1TB	2663	1172
2TB	5327	2344

*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

2.5” SATA SSD 3MR2-P support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

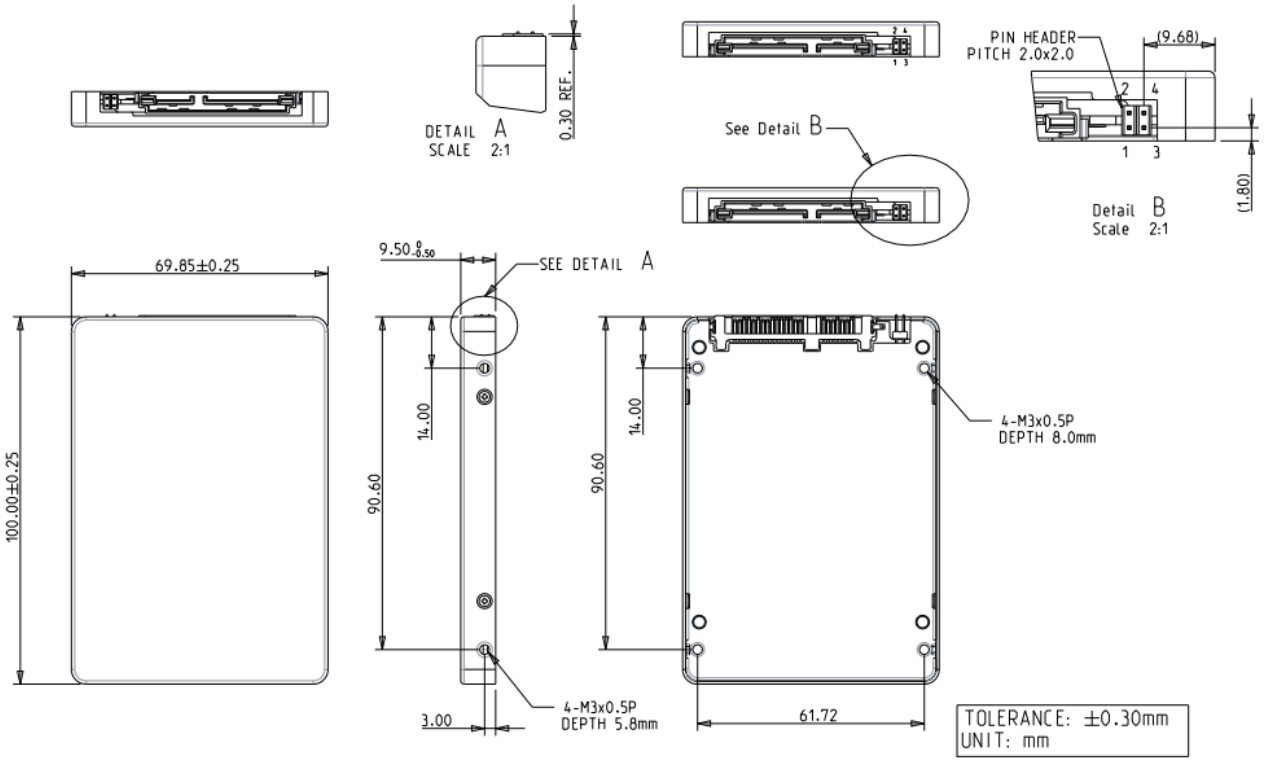
2.9 Pin Assignment

Innodisk 2.5” SATA SSD 3MR2-P uses a standard SATA pin-out. See Table 8 for 2.5” SATA SSD 3MR2-P pin assignment.

Table 8: Innodisk 2.5” SATA SSD 3MR2-P 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



2.11 Assembly Weight

An Innodisk 2.5” SATA SSD 3MR2-P within MLC flash ICs, 1TB’s weight is 90 grams approx.

2.12 Seek Time

Innodisk 2.5” SATA SSD 3MR2-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 2.5” SATA SSD 3MR2-P 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 2.5” SATA SSD 3MR2-P from the system level, including the major hardware blocks.

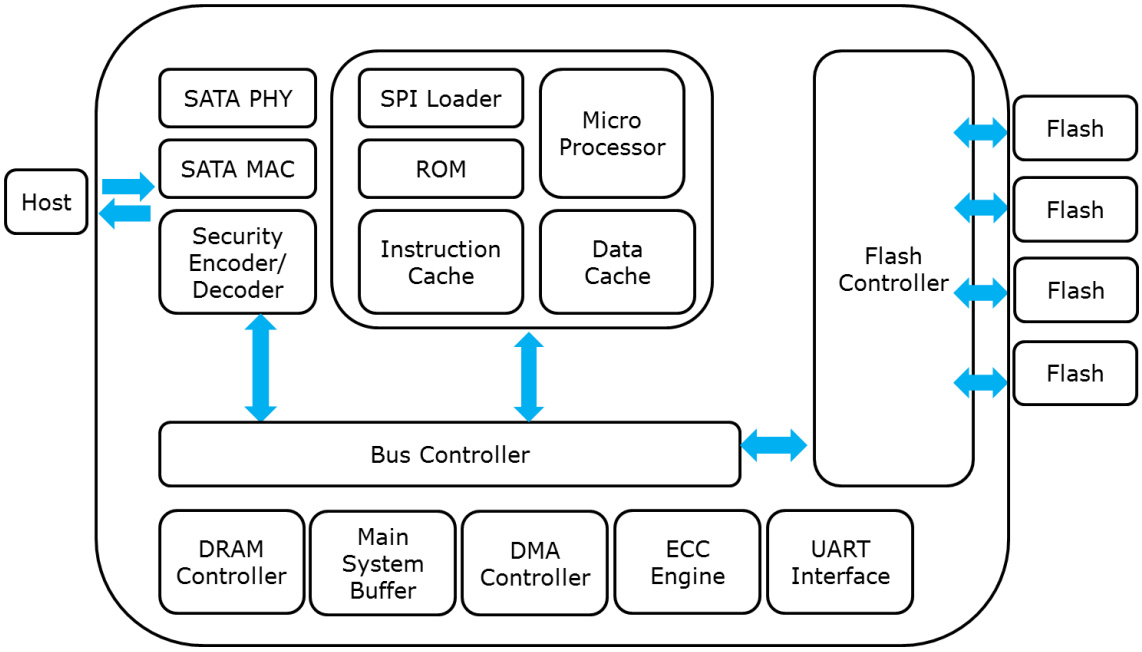


Figure 2: Innodisk FiD 2.5” SATA SSD 3MR2-P Block Diagram

Innodisk 2.5” SATA SSD 3MR2-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 2.5” SATA SSD 3MR2-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 2.5” SATA SSD 3MR2-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.

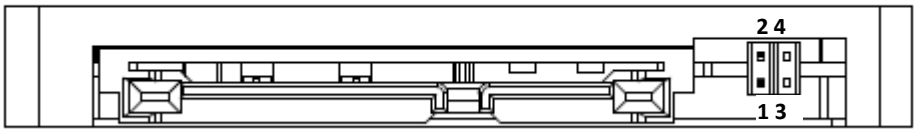
3.8 iCell Technology

iCell circuit is designed with several capacitors to be able to provide power after host power off. The SSD controller can write all DRAM buffer data to flash, so that is why 2.5” SATA SSD 3MR2-P can ensure all data can be written to disk without any data loss.

*2TB doesn’t support iCell

3.9 Quick Erase

Quick Erase function is designed for emergency data erase in few seconds by providing ATA command or shorting Quick Erase Pins (Pin 1 and Pin 2) with an external jumper to erase all of data block.



3.9.1 Quick Erase Command

- Protocol: No Data

-Inputs

Table 9: Execute Quick Erase command for inputs information

Register	7	6	5	4	3	2	1	0
Features	21h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 10: Quick Erase command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							

Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

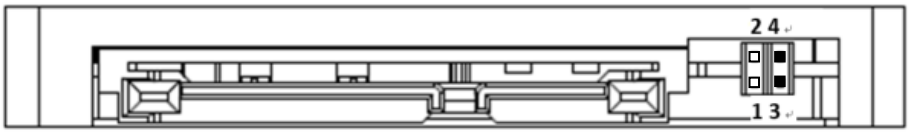
DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

3.10 Security Erase

Secure Erase function is designed for emergency data erase to comply with military standard. Erase functions can be triggered by shorting Secure Erase Pins (Pin 3 and Pin 4) or by sending ATA Command. All Data Block of flash chip will be erased by sending flash erase command. SE Pin can be set as one military Secure Erase standards.



Innodisk provides the following Security Erase for options:

(1) AFFSI 5020

(2) DoD 5220.22-M

(3) USA Navy NAVSO P-5239-26

(4) NSA Manual 130-2

(5) USA-Army 380-19

(6) NISPOMSUP Chap 8, Sect. 8-501

(7) NSA Manual 9-12

(8) IRIG 106

3.10.1 Secure Erase Command

Identify Information

Word 159 of Identify Table shows the SE pin’s function. Identify Table can be read by sending ECh ATA command.

Table 9: Identify Information

154	Secure Function Support 7-15 Reserved 6 1= Secure Erase ATA Vendor Command Supported 5 Reserved 4 1=Quick Erase ATA Vendor Command Supported 3 1=Destroy ATA Vendor Command Supported 2 1=Jumper Secure Erase Supported 1 1=Jumper Write Protect Supported 0 1=Jumper Quick Erase Supported	 0 X 0 X X X X X
155	Secure Function Status(Enable/Disable) 2-15 Reserved 1 1= Write Protect Enabled 0 Reserved	 X 0
156-158	Vendor Specific	
159	8~15 Function of Jumper “QE” 0x20: Destroy 0x21 or Others: Quick Erase 0~7 Secure Erase Function of Jumper “SE” **0x22: AFFSI 5020** **0x23: DoD 5220.22-M** **0x24: USA Navy NAVSO P-5239-26** **0x25: NSA Manual 130-2** **0x26: USA-Army 380-19**	 XXXXh

	0x27: NISPOMSUP Chap 8, Sect. 8-501 **0x28: NSA Manual 9-12** **0x29: IRIG106**	

1. AFFSI5020

This function is compliant with AFFSI 5020 specification.

Steps:

1. The whole disk is erased using Flash Erase Command.

2. The whole disk is filled with random data.

-Protocol: Non Data Command

-Inputs

Table 10: Execute AFFSI 5020 command for inputs information

Register	7	6	5	4	3	2	1	0
Features	22h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 11: AFFSI 5020 command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

2. DoD 5220.22-M

This function is compliant with DoD 5220.22-M specification.

Steps:

1. The whole disk is filled with fixed character pattern 0x55.

2. The whole disk is erased using Flash Erase Command.

-Protocol: Non Data Command

-Inputs

Table 12: Execute DoD 5220.22-M command for inputs information

Register	7	6	5	4	3	2	1	0
Features	23h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 13: DoD 5220.22-M command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

3. USA Navy NAVSO P-5239-26

This function is compliant with USA Navy NAVSO P-5239-26 specification.

Steps:

1. The whole disk is erased using Flash Erase Command.

2. The whole disk is filled with random data.

3. The whole disk is erased using Flash Erase Command.

-Protocol: Non Data Command

-Inputs

Table 14: Execute USA Navy NAVSO P-5239-26 command for inputs information

Register	7	6	5	4	3	2	1	0
Features	24h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 15: USA Navy NAVSO P-5239-26 command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							

LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

4. NSA Manual 130-2

This function is compliant with NSA Manual 130-2 specification.

Steps:

1. The whole disk is erased using Flash Erase Command.

2. The whole disk is filled with random data.

3. The whole disk is filled with random data again.

4. The whole disk is erased using Flash Erase Command. The whole disk is filled with fixed character pattern 0x55.

-Protocol: Non Data Command

-Inputs

Table 16: Execute NSA Manual 130-2 command for inputs information

Register	7	6	5	4	3	2	1	0
Features	25h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 17: NSA Manual 130-2 command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

5. USA-Army 380-19

This function is compliant with USA-Army 380-19 specification.

Step:

1. The whole disk is erased using Flash Erase Command.

2. The whole disk is filled with random data.

3. The whole disk is filled with fixed character pattern 0x55.

4. The whole disk is filled with fixed character pattern 0xAA.

-Protocol: Non Data Command

-Inputs

Table 18: Execute USA Army 380-19 command for inputs information

Register	7	6	5	4	3	2	1	0
Features	26h							

Sector Count	41h				
LBA Low	Na				
LBA Mid	Na				
LBA High	Na				
Device	1	1	1	0	Na
Command	82h				

-Normal Outputs

Table 19: USA Army 380-19 command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

6. NISPOMSUP Chap 8, Sect. 8-501

This function is compliant with NISPOMSUP Chap 8, Sect. 8-501 specification.

Steps:

1. The whole disk is filled with fixed character pattern 0x55.

2. The whole disk is filled with fixed character pattern 0xAA.

3. The whole disk is filled with random data.

-Protocol: Non Data Command

-Inputs

Table 20: Execute NISPOMSUP Chap 8, Sect. 8-501 command for inputs information

Register	7	6	5	4	3	2	1	0
Features	27h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 21: NISPOMSUP Chap 8, Sect. 8-501 command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

7. NSA Manual 9-12

This function is compliant with NSA Manual 9-12 specification.

Step:

1. The whole disk is erased using Flash Erase Command.

2. The whole disk is filled with unclassified pattern.

3. Verify the overwrite procedure by randomly rereading the overwritten information.

-Protocol: Non Data Command

-Inputs

Table 22: Execute NSA Manual 9-12 command for inputs information

Register	7	6	5	4	3	2	1	0
Features	28h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 23: NSA Manual 9-12 command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

8. IRIG1006

This function is compliant with IRIG106 specification.

Step:

1. The whole disk is erased using Flash Erase Command.

2. The whole disk is filled with pattern 0x55, and read back to verify.

3. The whole disk is erased using Flash Erase Command.

4. The whole disk is filled with pattern 0xAA, and read back to verify.

5. The whole disk is erased using Flash Erase Command.

6. Write 0x00 to all bad blocks. If there is any bit is still 1, the page is re-written 0 again. This procedure this repeated up to 16 times.

7. Erase all bad blocks and checked to determine if any zero are found. If any zeros are found, erase this block again. This procedure this repeated up to 16 times.

8. Write “Secure Erase” string to all blocks.

-Protocol: Non Data Command

-Inputs

Table 24: Execute IRIG160 command for inputs information

Register	7	6	5	4	3	2	1	0
Features	29h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 25: IRIG160 command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							

LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

3.11 Destroy (Firmware Destroy)

Innodisk Unrecoverable FW Destroy function implements an ultimate data erase of the SSD. Once Unrecoverable Destroy is triggered, beside all the user data and SSD information, also SSD firmware will be erased and which is unusable. Triggered pin definition is set for optional and available for customization (Pin 1/2 or Pin 3/4).

3.11.1 Unrecoverable Destroy Command

-Protocol: Non Data Command

-Inputs

Table 26: Execute Unrecoverable Destroy command for inputs information

Register	7	6	5	4	3	2	1	0
Features	20h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 27: Unrecoverable Destroy command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							

Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

3.12 Write Protect

When Write Protect pins are shorted, Write Protect function would be enabled, and ATA write command would be aborted, which can prevent the disk from data modification or data deletion. Write-protected data in disk is read-only, that is, users could not write to it, edit it, append data to it, or delete it. Write Protect pin definition is set for optional and available for customization (Pin 1/2 or Pin 3/4).

3.12.1 Enable Write Protect Command

This command enable SSD into write protect mode, which is read-only. The SSD under write protect will overpass any write command.

-Protocol: Non Data Command

-Inputs

Table 28: Execute Enable Write Protect command for inputs information

Register	7	6	5	4	3	2	1	0
Features	17h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			

Command	82h

-Normal Outputs

Table 29: Execute Enable Write Protect command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

ERR will be cleared to zero.

3.12.2 Disable Write Protect Command

This command disable SSD’s write protect feature.

-Protocol: Non Data Command

-Inputs

Table 30: Execute Disable Write Protect command for inputs information

Register	7	6	5	4	3	2	1	0
Features	18h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	82h							

-Normal Outputs

Table 31: Execute Disable Write Protect command for normal output information

Register	7	6	5	4	3	2	1	0
Error	Na							
Sector Count	Na							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	obs	Na	obs	DEV	Na	Na	Na	Na
Status	BSY	DRDY	DF	Na	DRQ	Na	Na	ERR

Device register-

DEV shall specify the selected device.

Status register

BSY will be cleared to zero indicating command completion

DRDY will be set to one.

DF (Device Fault) will be cleared to zero.

DRQ will be cleared to zero

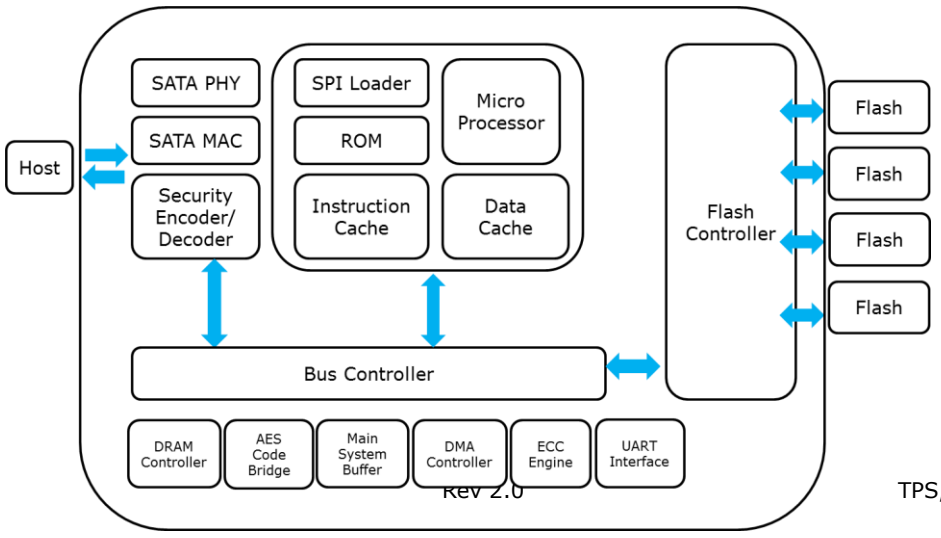
ERR will be cleared to zero.

3.13 Hardware-based AES 256bit function (Optional)

Innodisk 2.5” SATA SSD 3MR2-P is designed with AES engine, which is built-in the controller. When controller receives the data package from host, AES engine encrypts the data package and save the encrypted data into NAND flash. Thus, unauthorized personal has no access to decrypt the data in NAND flash.

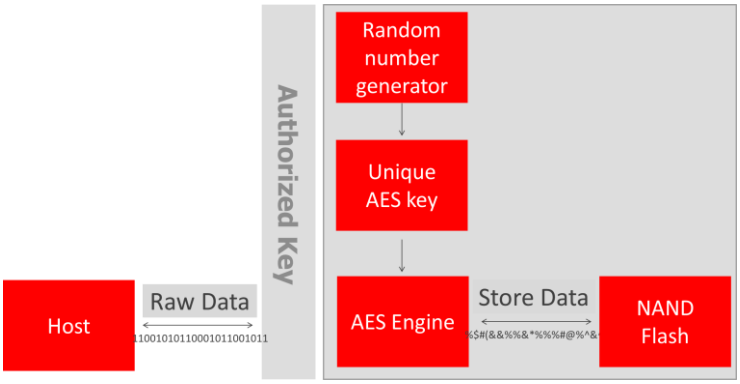
3.13.1 AES Block Diagram

The AES engine was built-in the ID201 controller. When 2.5” SATA SSD 3MR2-P is initiated with Firmware, AES engine will generate a random number to be an AES key. Each SSD has a unique AES key when it leaves the factory.



3.13.2 2.5” SATA SSD 3MR2-P with AES Flow Chart

In order to complete the physical security layer of protection, encryption needs to be paired with an ATA user password by ATA security command. After setting the authorized key by ATA security command, every time when you power on the system with SSD encrypted, you will be requested for a password to access the SSD. If the password is correct, the SSD will run well; if not, then you will not be able to access the SSD then.



3.13.3 Encrypted Key Management

Innodisk 3MR2-P SSD includes two methods of key management to apply to different applications. The first is a standard approach that allows the firmware to generate a random number and a unique key when it leaves the factory. This method ensures that the user can easily apply the SSD with the data encrypted key. Another approach is to meet unique customer requirements with an encrypted key generated by an SSD from the SATA interface host. The SSD must keep the encrypted key value when receiving the reset commands. This method works best for the SSD as a removable device in different systems. Innodisk provides the test tool to execute the AES hardware encryption. This user-friendly tool, developed by Innodisk Corporation, allows the customer to use/test encryption functions.

3.13.4 Authorized Key Management

In order to complete the physical security layer of protection, encryption needs to be bundled with an ATA user password provided by an ATA Security command. Unlike the AES key, the authorized key must be set by the user via the BIOS configuration. Every time you power on the system with SSD encryption, a password request prompt is sent to access the SSD. If the password is correct, the SSD will run well; if not, you will not be able to access the SSD.

Command	Command Code
SECURITY SET PASSWORD	0XF1
SECURITY UNLOCK	0XF2
SECURITY ERASE PREPARE	0XF3
SECURITY ERASE UNIT	0XF4
SECURITY FREEZE LOCK	0XF5

SECURITY DISABLE PASSWORD	0XF6

3.13.5 TCG OPAL

OPAL is a set of specifications for features of data storage devices that enhance security. These specifications are published by the Trusted Computing Group’s Storage Work Group. Innodisk 3MR2-P is compliant with TCG OPAL 2.0(*1). The capability of TCG OPAL Security mode allows multiple users with independent access control to read/write/erase independent data areas (LBA ranges). Each locking range adjusts by authenticated authority. Note that by default there is a single “Global Range” that encompasses the whole user data area. In TCG Opal Security Mode, Revert, Revert SP and GenKey command can erase all of data including global range and locking range; in the meantime generate the new encrypted key.

*1. You need to install TCG OPAL software to implement OPAL function, which is supplied by TCG OPAL software developed company 2. 2TB doesn’t support TCG OPAL

4. Installation Requirements

4.1 2.5” SATA SSD 3MR2-P Pin Directions

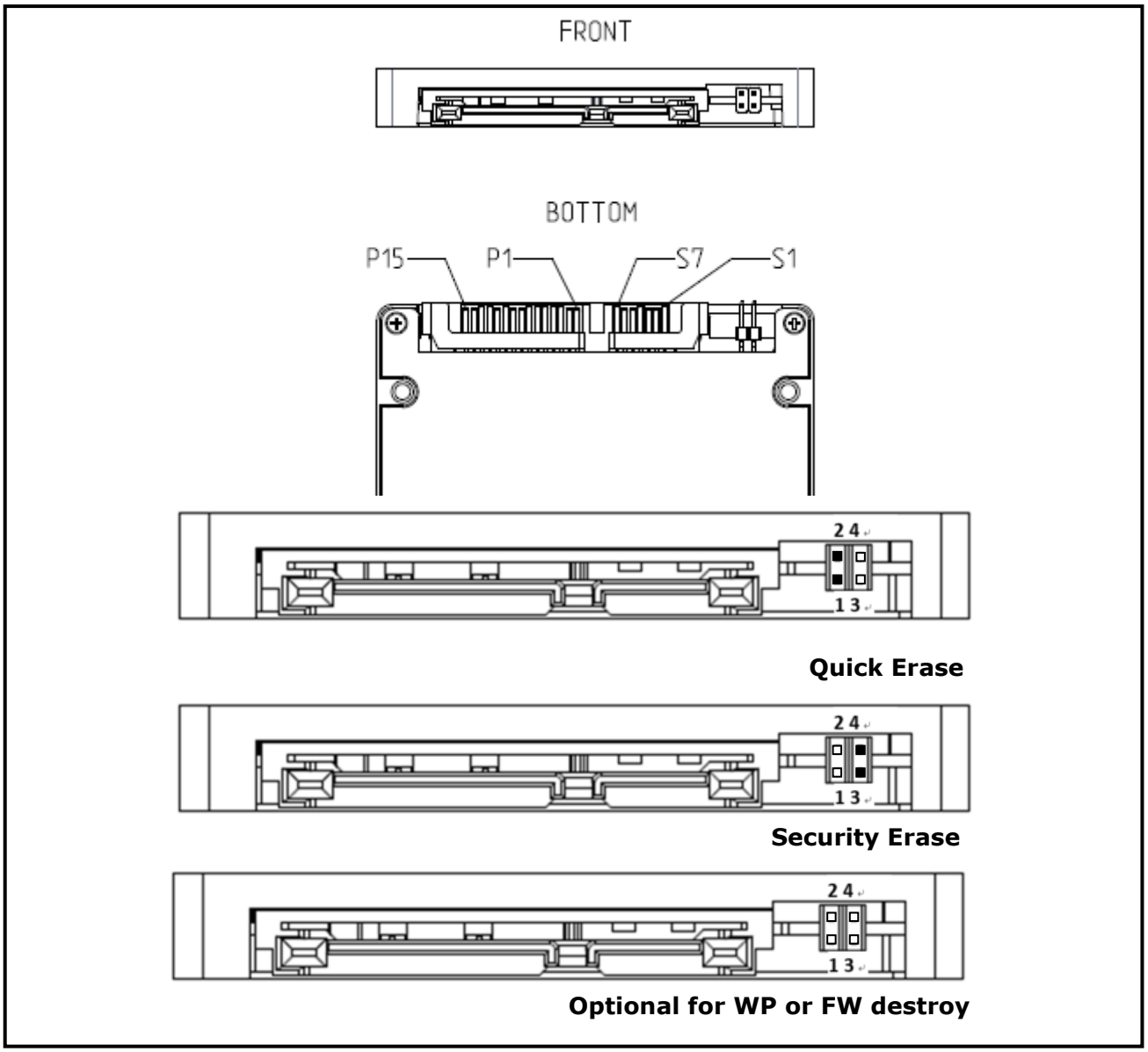


Figure 3: Signal Segment and Power Segment

4.2 Electrical Connections for 2.5” SATA SSD 3MR2-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 Form Factor

Please prepare following things:

- Screw driver.
- Four M3 screws. (Torque value is 2.0 ~ 2.5 Kgf.cm)
- SATA single cable (7-pin, Maximum length l meter).
- SATA power cable (15-pin).

Please turn off your computer, and open your computer’s case. Find one of available 2.5-inch slot, and plug the SSD in. To use the screws fix the SSD. Plug in the SATA single cable, and power cable. Please boot the installation Operation System from CD-ROM, and install Operation System into SSD.

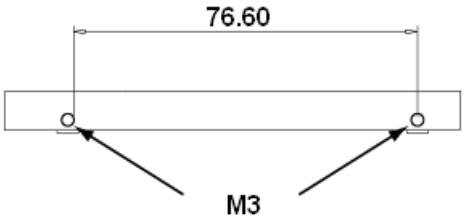


Figure 4: 2.5” SATA SSD 3MR2-P Mechanical Screw Hole

4.4 Device Drive

No additional device drives are required. Innodisk 2.5” SATA SSD 3MR2-P can be configured as a boot device.

5. SMART Feature Set

Innodisk 3MR2-P series 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	Write Log
D8h	Enable SMART Operations
D9h	Disable SMART Operations
DAh	Return Status

5.1 SMART Attributes

Innodisk 3MR2-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	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	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. AES Algorithm Certification

The following provides technical information about controller implementations that have been validated as confirming to the Advanced Encryption Standard (AES) Algorithm, Deterministic Random Bit Generator (DRBG) Algorithm, and Secure Hash Standard (SHS).

6.1 AES Algorithm

Val. No	Operational Environment	Val. Date	Modes/States/Key sizes/Description/Notes
2474	Cadence NC-verilog hardware simulator v10.20	May/24/2013	Using the tests found in The Advanced Encryption Standard Algorithm Validation Suite (AESAVS). This testing is performed by NVLAP accredited Cryptographic And Security Testing (CST) Laboratories. ECB (e/d; 128, 192, 256) XTS (KS: XTS_128) KS: XTS_256

6.2 DRBG Algorithm

Val. No	Operational Environment	Val. Date	Modes/States/Key sizes/Description/Notes
337	Cadence NC-verilog hardware simulator v10.20	May/24/2013	Using the tests found in The DRBG Validation Suite (DRBGVS). This testing is performed by NVLAP accredited Cryptographic And Security Testing (CST) Laboratories. HashBased DRBG: Prediction Resistance Tested: enabled and not enabled (SHA-256)

6.3 SHS Algorithm

Val. No	Operational Environment	Val. Date	Modes/States/Key sizes/Description/Notes
2093	Cadence NC-verilog hardware simulator v10.20	May/24/2013	Has been validated as confirming to the Secure Hash Algorithm specified in Federal Information Processing Standard (FIPS) 180-3, Secure Hash Standard (SHS), using tests described in the

			Secure Hash Algorithm Validation System (SHAVS). This testing is performed by NVLAP accredited Cryptographic And Security Testing (CST) Laboratories. SHA-256

7. 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	**R**	**S**	**2**	**5**	**-**	**3**	**2**	**G**	**D**	**8**	**1**	**B**	**C**	**1**	**Q**	**C**	**P**	**-**	**X**	**X**
Description	Disk	2.5” SATA SSD 3MR2-P					Capacity			Category			Flash mode	Operation Temp.	Internal Control	CH.	Flash	icell		Customized Code	

Definition	
Code 1st (Disk)	**Code 13th (Flash mode)**
D : Disk	B: Synchronous Flash for Toshiba 15nm
Code 2nd ~ 5th (Form Factor)	**Code 14th (Operation Temperature)**
RS25: 2.5” SATA SSD 3MR2-P	C: Standard Grade (0℃~ +70℃)
Code 7th ~9th (Capacity)	W: Industrial Grade (-40℃~ +85℃)
08G: 8GB	**Code 15th (Internal control)**
16G: 16GB	Compliant with 9mm height housing
32G: 32GB	
64G: 64GB	
A28: 128GB	
B56: 256GB	**Code 16th (Channel of data transfer)**
C12:512GB	S: Single Channel
01T: 1TB	D: Dual Channels
	Q: Quad Channels
Code 10th ~12th (Series)	
D81: 2.5” SATA SSD 3MR2-P	**Code 17th (Flash Type)**
D82: 2.5” SATA SSD 3MR2-P with AES	C: Toshiba MLC
	Code 18th (iCell)
	Code 20th ~21th (Customized code)