

# CFast

## 3MG2-P Series

## AES Function

**Customer:** \_\_\_\_\_

**Customer**

**Part**

**Number:** \_\_\_\_\_

**Innodisk**

**Part**

**Number:** \_\_\_\_\_

**Innodisk**

**Model Name:** \_\_\_\_\_

**Date:** \_\_\_\_\_

<b>Innodisk Approver</b>	<b>Customer Approver</b>

**Total Solution For  
Industrial Flash Storage**

**Features:**

- SATA III
- Innodisk MLC NAND
- CFAST 3MG2-P
- Standard & Wide-temperature
- iPowerguard
- iDataguard
- Dynamic Thermal Management
- Support AES function

**Performance:**

- Sequential Read up to 560 MB/s
- Sequential Write up to 340 MB/s

**Power Requirements:**

Input Voltage:	3.3V±5%
Max Operating Wattage:	2.66W
Idle Wattage:	0.42W

**Reliability:**

Capacity	TBW	DWPD
32GB	37.5	1.07
64GB	75	1.07
128GB	150	1.07
256GB	300	1.07

Data Retention	1 Year
Warranty	3 Years

For warranty details, please refer to:

[https://www.innodisk.com/en/support\\_and\\_service/warranty](https://www.innodisk.com/en/support_and_service/warranty)

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## REVISION HISTORY

Revision	Description	Date
V1.0	First released	Aug. 2021

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# 1. Product Overview

## 1.1 Introduction of Innodisk CFast 3MG2-P with AES function

Innodisk CFast 3MG2-P is SATA III 6Gb/s flash based disk, which delivers excellent performance, especially in random data transfer rate, and which offers reliability making it the ideal solution for a variety of applications, including embedded system, industrial computing, and enterprise field.

Innodisk CFast 3MG2-P supports several standard features, including TRIM, NCQ, and S.M.A.R.T. The CFast have good random Read/Write performance, no latency time and small seek time. It effectively reduces the booting time of operation system. CFast 3MG2-P not only performs unmatched performance, but also designed with Innodisk owned technical knowhow to ensure the data integrity and highest levels of reliability.

Innodisk CFast 3MG2-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.

**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 CFast 3MG2-P is available in follow capacities within MLC flash ICs.

CFast 3MG2-P 32GB

CFast 3MG2-P 64GB

CFast 3MG2-P 128GB

CFast 3MG2-P 256GB



**Figure 1: Innodisk CFast 3MG2-P**

## 1.3 SATA Interface

Innodisk CFast 3MG2-P supports SATA III interface, and compliant with SATA I and SATA II.

## 1.4 CFast 2.0 Form Factor

CFast 3MG2-P compliant with CFast 2.0 standard, it is designed with 7+17 pin connector and is SATA compatible. CFast 2.0 leverage the same connector interface as CFast 1.1 and the SATA-3 interface for higher performance. CFast 3MG2-P mechanical dimensions: 42.8mm x 36.4mm x 3.6mm.



## 2. Product Specifications

### 2.1 Capacity and Device Parameters

CFast 3MG2-P device parameters are shown in Table 1.

**Table 1: Device parameters**

Capacity	LBA	Cylinders	Heads	Sectors	User Capacity(MB)
32GB	61865984	16383	16	63	29932
64GB	123731968	16383	16	63	60140
128GB	247463936	16383	16	63	120556
256GB	494927872	16383	16	63	241388

### 2.2 Performance

Burst Transfer Rate: 6.0Gbps

**Table 2: Performance**

Capacity	Unit	32GB	64GB	128GB	256GB
Sequential* Read (QD32)	MB/s	280	550	560	560
Sequential* Write (QD32)		45	90	180	340
4KB Random** Read(Q8T8)	IOPS	27,000	52,000	73,000	75,000
4KB Random** Write(Q8T8)		11,000	23,000	47,000	75,000

Note: \* Performance results are measured in Room Temperature with Out-of-Box devices and may vary depending on overall system setup.

Note: \*\* Performance results are based on CrystalDiskMark 6.0.2 with typical tolerances for range from 1% to 10%. Unit of 4KB items is I.O.P.S.

### 2.3 Electrical Specifications

#### 2.3.1 Power Requirement

**Table 3: Innodisk CFast 3MG2-P Power Requirement**

Item	Symbol	Rating	Unit
Input voltage	V <sub>IN</sub>	+3.3 DC +- 5%	V

## 2.3.2 Power Consumption

**Table 4: Power Consumption**

Mode	Power Consumption (W)
Read	1.40
Write	2.66
Idle	0.42
Current Peak	2.57

Target: 256GB CFast 3MG2-P\_AES

Note: Current results may vary depending on system components and power circuit design. Please refer to the test report for other capacities.

## 2.4 Environmental Specifications

### 2.4.1 Temperature Ranges

**Table 5: Temperature range for CFast 3MG2-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 CFast 3MG2-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 CFast 3MG2-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: CFast 3MG2-P MTBF**

Product	Condition	MTBF (Hours)
Innodisk CFast 3MG2-P	Telcordia SR-332 GB, 25°C	>3,000,000

## 2.5 CE and FCC Compatibility

CFast 3MG2-P conforms to CE and FCC requirements.

## 2.6 RoHS Compliance

CFast 3MG2-P is fully compliant with RoHS directive.

## 2.7 Reliability

**Table 8: CFast 3MG2-P 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
<b>TBW* (Total Bytes Written) Unit: TB</b>		
Capacity	Sequential workload	Client workload
32GB	85.	37.5
64GB	170.5	75
128GB	340.9	150
256GB	681.8	300
* Note:		
<ol style="list-style-type: none"> <li>1. Sequential: Mainly sequential write are estimated by PassMark Burnin Test v8.1 pro.</li> <li>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.)</li> <li>3. Based on out-of-box performance.</li> </ol>		

## 2.8 Transfer Mode

CFast 3MG2-P support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

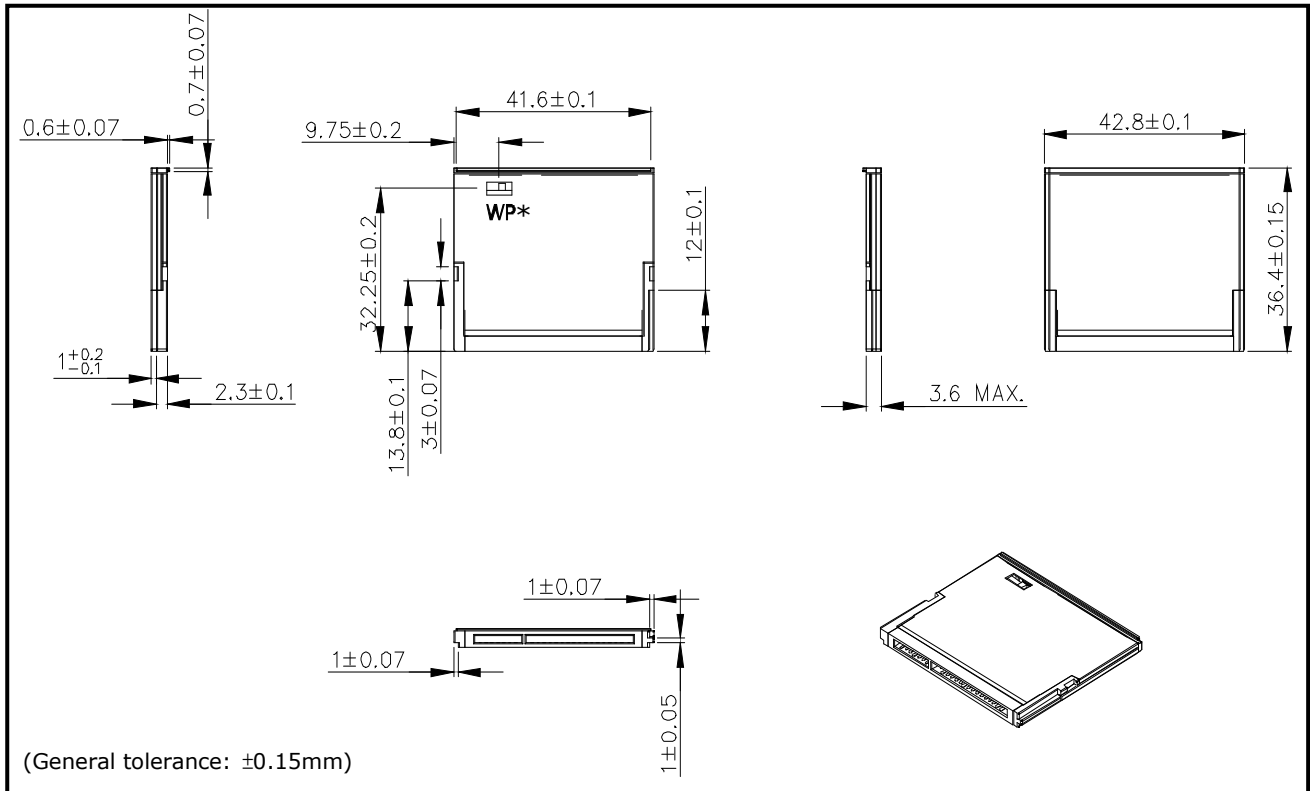
## 2.9 Pin Assignment

Innodisk CFast 3MG2-P uses a standard SATA pin-out. See Table 9 for CFast 3MG2-P pin assignment.

**Table 9: Innodisk CFast 3MG2-P Pin Assignment**

Name	Type	Description
S1	SGND	Ground for signal integrity
S2	A+	Differential Signal Pair A
S3	A-	
S4	SGND	Ground for signal integrity
S5	B-	Differential Signal Pair B
S6	B+	
S7	SGND	Ground for signal integrity
<b>Key and Spacing separate signal and power segments</b>		
P1	CDI	Card Detect In
P2	PGND	Device Ground
P3	DEVSLP	Device sleep
P4	TBD	Reserved
P5	TBD	Reserved
P6	TBD	Reserved
P7	PGND	Device Ground
P8	TBD	Reserved
P9	LED2	HDDA LED (LED are lighted when P9 low active)
P10	TBD	Reserved
P11	TBD	Reserved
P12	IFDet	GND
P13	PWR	Device Power (3.3V)
P14	PWR	Device Power (3.3V)
P15	PGND	Device Ground
P16	PGND	Device Ground
P17	CDO	Card Detect Out

## 2.10 Mechanical Dimensions



\*Write Protect is optional.

## 2.11 Assembly Weight

An Innodisk CFast 3MG2-P within MLC flash ICs, 256GB's weight is approximately 15 grams.

## 2.12 Seek Time

Innodisk CFast 3MG2-P is not a magnetic rotating design. There is no seek or rotational latency required.

## 2.13 Hot Plug

The card support hot plug function and can be removed or plugged-in during operation. User has to avoid hot plugging the card 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.

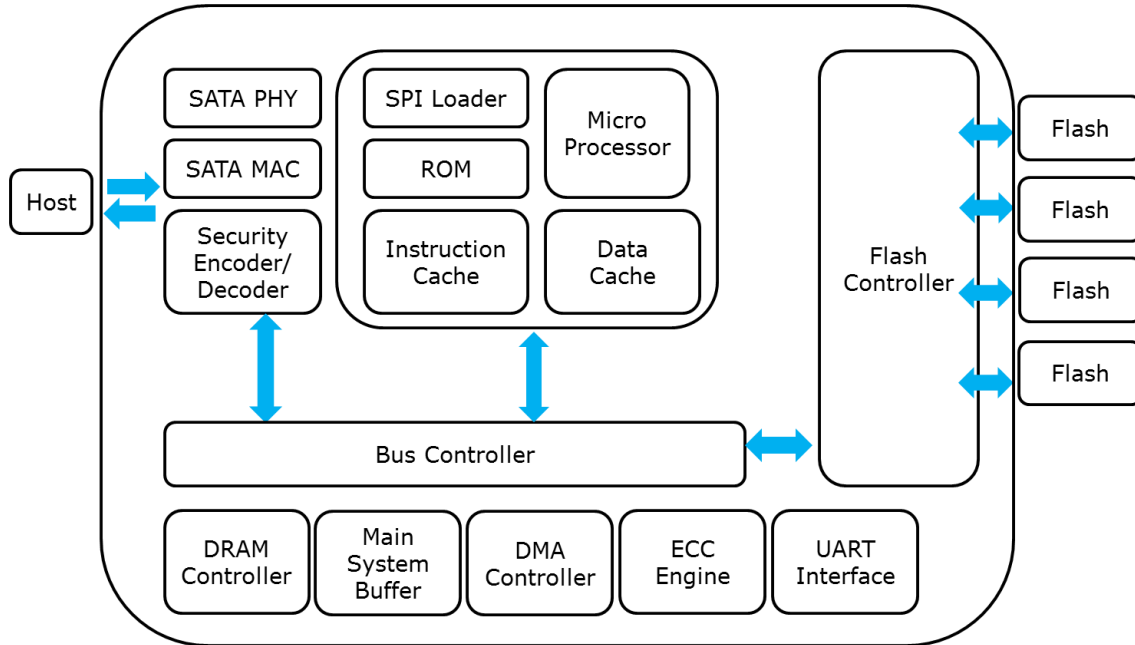
## 2.14 NAND Flash Memory

Innodisk CFast 3MG2-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 CFast 3MG2-P from the system level, including the major hardware blocks.



**Figure 2: Innodisk CFast 3MG2-P with AES Block Diagram**

Innodisk CFast 3MG2-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. The AES engine was built-in the D82 controller. When CFast 3MG2-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.

\* iCell is optional feature with different part number.

## 3.2 SATA III Controller

Innodisk CFast 3MG2-P is designed with D82 controller built-in 256bits AES engine, a SATA III 6.0Gbps (Gen. 3) controller. The Serial ATA physical, link and transport layers are compliant with Serial ATA Gen 1, Gen 2 and Gen 3 specification (Gen 3 supports 1.5Gbps/3.0Gbps/6.0Gbps data rate). The controller has 4 channels for flash interface.

## 3.3 Error Detection and Correction

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 CFast 3MG2-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

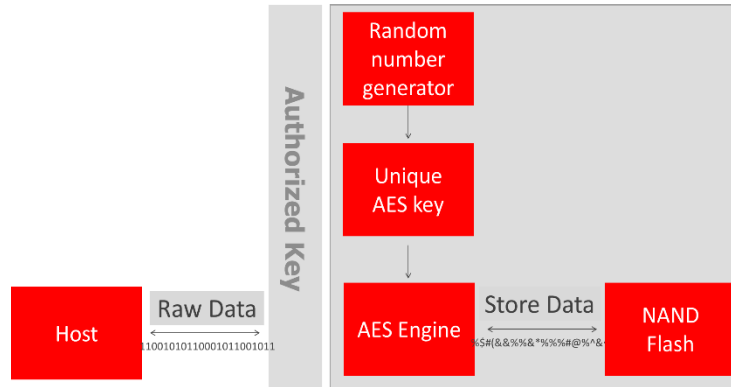
Innodisk's iData Guard is a comprehensive data protection mechanism that functions before and after a sudden power outage to SSD. Low-power detection terminates data writing before an abnormal power-off, while table-remapping after power-on deletes corrupt data and maintains data integrity. Innodisk's 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 AES function 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.



**Figure 3: 3MG2-P AES flow chart**

### 3.8.1 Encrypted Key Management

Innodisk 3MG2-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.

### 3.8.2 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



### 3.8.3 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 3MG2-P is compliant with TCG OPAL 2.0<sup>(\*1)</sup>. 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

### 3.9 Sanitize Device

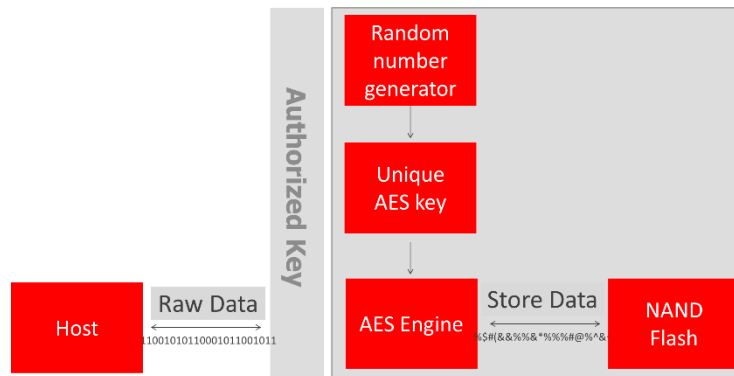
Innodisk’s CFast 3MG2-P support standard ATA Sanitize Command Set (B4h) <sup>(\*2)</sup>. Individual Sanitize Device feature set commands are identified by the value specified as below table.

\*2. The detail you could find in Technical Committee T13 Working Draft ATA Command Set

Value	Command
0000h	SANITIZE STATUS EXT
0001h..0010h	Reserved
0011h	CRYPTO SCRAMBLE EXT
0012h	BLOCK ERASE EXT
0013h	Reserved
0014h	OVERWRITE EXT
0015h..001Fh	Reserved
0020h	SANITIZE FREEZE LOCK EXT
0021h..003Fh	Reserved
0040h	SANITIZE ANTIFREEZE LOCK EXT
0041h..FFFFh	Reserved

### 3.10 CFast 3MG2-P AES function flow chart

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**Figure 3: Innodisk CFast 3MG2-P AES flow chart**

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SECURITY FREEZE LOCK	0XF5
SECURITY DISABLE PASSWORD	0XF6

### 3.10.3 TCG OPAL

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\*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 CFast 3MG2-P Pin Directions

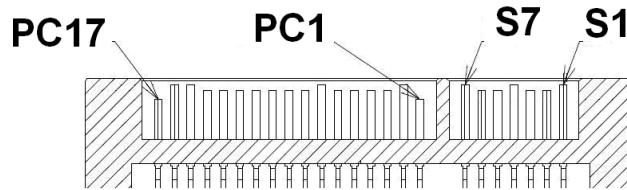


Figure 4: Signal Segment and Power Segment

### 4.2 Electrical Connections for CFast 3MG2-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 1 meter. The SATA interface has a separate connector for the power supply. Please refer to the pin description for further details.

### 4.3 Write Protection (Optional)



Innodisk CFast 3MG2-P within the 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, Innodisk CFast 3MG2-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.

### 4.4 Device Drive

No additional device drives are required. Innodisk CFast 3MG2-P can be configured as a boot device.

## 5. SMART Feature Set

Innodisk 3MG2-P series support the SMART command set and defines some vendor-specific data to report SMART attributes of SSD.

**Table 10: SMART command**

Value	Command	Value	Command
D0h	Read Data	D5h	Read Log
D1h	Read Attribute Threshold	D6h	Return Status
D2h	Enable/Disable Auto save	D8h	Enable SMART Operations
D3h	Save Attribute Values	D9h	Disable SMART Operations
D4h	Execute OFF-LINE Immediate	DAh	Return Status

### 5.1 SMART Attributes

Innodisk 3MG2-P series SMART data attributes are listed in following table.

**Table 11: SMART attribute**

Attribute ID (hex)	Attribute Name
1 (01h)	Raw Read Error Rate
5 (05h)	Reallocated Sector Count
9 (09h)	Power-on Hours
12 (0Ch)	Power Cycle Count
160 (A0h)	Uncorrectable sector count when read/write
161 (A1h)	Number of valid spare block
163 (A3h)	Number of initial invalid block
164 (A4h)	Total erase count
165 (A5h)	Maximum erase count
166 (A6h)	Minimum erase count
167 (A7h)	Average erase count
168 (A8h)	Max erase count of spec
169 (A9h)	Remain Life (percentage)
175 (AFh)	Program fail count in worst die
176 (B0h)	Erase fail count in worst die
177 (B1h)	Total wear level count
178 (B2h)	Runtime invalid block count
181 (B5h)	Total program fail count
182 (B6h)	Total erase fail count

<b>Attribute ID (hex)</b>	<b>Attribute Name</b>
187 (BBh)	Uncorrectable error count
192 (C0h)	Power-Off Retract Count
194 (C2h)	Controlled temperature
195 (C3h)	Hardware ECC recovered
196 (C4h)	Reallocation event count
198 (C6h)	Uncorrectable error count off-line
199 (C7h)	UltraDMA CRC error count
225 (E1h)	Total LBAs written (each write unit = 32MB)
232 (E8h)	Available reserved space
241 (F1h)	Total LBAs written (each write unit = 32MB)
242 (F2h)	Total LBAs read (each write unit = 32MB)

The temperature data on iSmart implies built-in or on-board thermal sensor value.

Notes: More detailed health info has been defined by innodisk and will be shown on iSMART V5.3.21 (or later version).

## 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	G	C	F	A	-	B	5	6	D	8	2	B	C	A	Q	C	(W)	X	X	X
Definition																					
Code 1 <sup>st</sup> (Disk)											Code 14 <sup>th</sup> (Operation Temperature)										
D: Disk											C: Standard Grade (0°C ~ +70°C)										
											W: Industrial Grade (-40°C ~ +85°C)										
Code 2 <sup>st</sup> (Feature set)											Code 15 <sup>th</sup> (Internal control)										
G: EverGreen Series											A~Z: BGA PCB version										
Code 3 <sup>rd</sup> ~ 5 <sup>th</sup> (Form Factor)											Code 16 <sup>th</sup> (Channel of data transfer)										
CFA: CFast											D: Dual Channels										
											Q: Quad Channels										
Code 7 <sup>th</sup> ~ 9 <sup>th</sup> (Capacity)											Code 17 <sup>th</sup> (Flash Type)										
32G: 32GB											C: Toshiba MLC										
64G: 64GB																					
A28: 128GB											Code 18 <sup>th</sup> (Optional Function)										
B56: 256GB											W: H/W Write Protect function										
Code 10 <sup>th</sup> ~ 12 <sup>th</sup> (Controller)											Code 19 <sup>th</sup> ~ 21 <sup>th</sup> (Customized Code)										
D82: SATA 3MG2-P with AES engine																					
Code 13 <sup>th</sup> (Flash Mode)																					
B: Synchronous Flash Toshiba 15nm																					