innodisk

Total Solution For Industrial Flash Storage

CFast

3IE2-P Series

Customer: _____

Customer Part Number: _____

Innodisk Part Number: _____

Innodisk Model Name: _____

Date: _____

Innodisk Approver	Customer Approver

Features:

- SATA III standard
- Innodisk MLC NAND
- Support iSLC technology
- CFast 3IE2-P
- Standard & Wide-temperature
- iPowerguard
- iDataguard
- Dynamic Thermal Management

Performance:

- Sequential Read up to 550 MB/s
- Sequential Write up to 460 MB/s

Power Requirements:

Input Voltage:	3.3V±5%
Max Operating Wattage:	2.09W
Idle Wattage:	0.42

Reliability:

Capacity	TBW	DWPD
16GB	156.3	5.4
32GB	312.5	5.4
64GB	625	5.4
128GB	1250	5.4

Data Retention	1 Year
Warranty	5 Years

For warranty details, please refer to:

https://www.innodisk.com/tw/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 3IE2-P

Innodisk CFast 3IE2-P is iSLC series which is 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. The InnoDisk iSLC series is cost efficient, boasting excellent benefits at only half the price of SLC-based solutions.

Innodisk CFast 3IE2-P is characterized by L^3 architecture with the latest SATA III (6.0GHz) SMI NAND controller. Innodisk's exclusive L^3 architecture is L^2 architecture multiplied LDPC (Low Density Parity Check). L^2 (Long Life) architecture is a 4K mapping algorithm that reduces WAF and features a real-time wear leveling algorithm to provide high performance and prolong lifespan with exceptional reliability.

Innodisk CFast 3IE2-P is designed for industrial field, and supports several standard features, including TRIM, NCQ, and S.M.A.R.T. In addition, Innodisk's exclusive industrial-oriented firmware provides a flexible customization service, making it perfect for a variety of industrial applications.

1.2 Product View and Models

Innodisk CFast 3IE2-P is available in follow capacities within MLC flash ICs.

CFast 3IE2-P 16GB
CFast 3IE2-P 32GB
CFast 3IE2-P 64GB
CFast 3IE2-P 128GB

Figure 1: Innodisk CFast 3IE2-P

1.3 SATA Interface

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

1.4 CFast 2.0 Form Factor

CFast 3IE2-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 3IE2-P mechanical dimensions: 42.8mm x 36.4mm x 3.6mm.

2. Product Specifications

2.1 Capacity and Device Parameters

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

Table 1: Device parameters

Capacity	LBA	Cylinders	Heads	Sectors	User Capacity(MB)
16GB	16383	16	63	29323728	14318
32GB	16383	16	63	60579792	29580
64GB	16383	16	63	121138416	59149
128GB	16383	16	63	242255664	118288

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance

Capacity	Units	16GB	32GB	64GB	128GB
Sequential* Read (QD32)	MB/s	300	550	550	550
Sequential* Write (QD32)		120	240	420	460
4KB Random** Read(QD32)	IOPS	34,000	66,000	75,000	76,000
4KB Random** Write(QD32)		31,000	62,000	67,000	67,000

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 3IE2-P 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 (W)
Read	1.10
Write	2.09
Idle	0.42
Current Peak	3.09

Target: 128GB CFast 3IE2-P

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 3IE2-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 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 CFast 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: CFast 3IE2-P MTBF

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

2.5 CE and FCC Compatibility

CFast 3IE2-P conforms to CE and FCC requirements.

2.6 RoHS Compliance

CFast 3IE2-P is fully compliant with RoHS directive.

2.7 Reliability

Table 8: CFast 3IE2-P TBW

Parameter	Value	
Read Cycles	Unlimited Read Cycles	
Flash endurance	20,000 P/E cycles	
Wear-Leveling Algorithm	Support	
Bad Blocks Management	Support	
Error Correct Code	Support	
TBW* (Total Bytes Written) Unit: TB		
Capacity	**Sequential workload**	**Client workload**
16GB	284.1	156.3
32GB	568.2	312.5
64GB	1136.4	625
128GB	2272.8	1250

* Note:

1. Sequential: Mainly sequential write are estimated by PassMark Burnin Test v8.1 pro.
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

CFast 3IE2-P support following transfer mode:

Serial SATA III 6.0Gbps

Serial SATA II 3.0Gbps

Serial SATA I 1.5Gbps

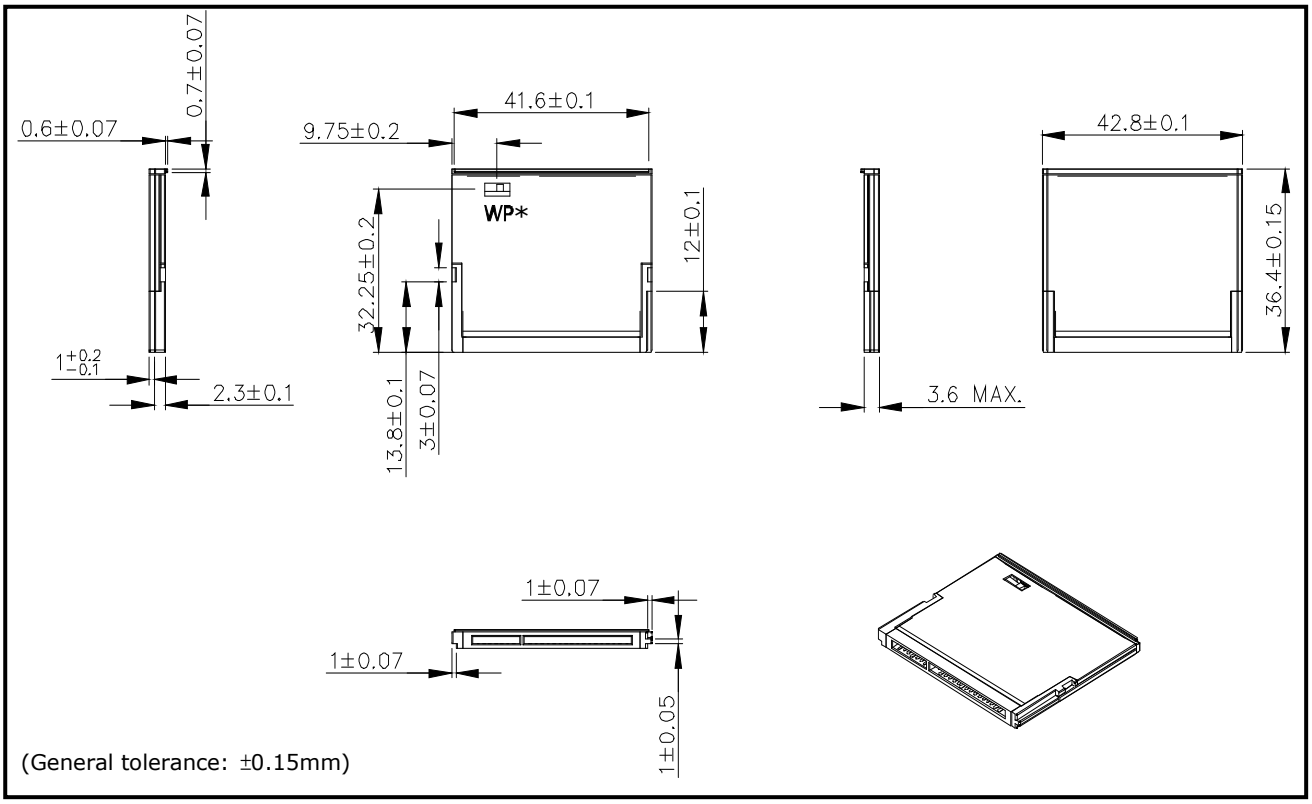
2.9 Pin Assignment

Innodisk CFast 3IE2-P uses a standard SATA pin-out. See Table 9 for CFast 3IE2-P pin assignment.

Table 9: Innodisk CFast 3IE2-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
Key and Spacing separate signal and power segments		
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	Write Protect	Customized Write Protect function. Function enable when pin 10 pull low(<0.8V). Function disable when pin10 pull high(>2.4V).
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 3IE2-P within MLC flash ICs, 256GB's weight is approximately 15 grams.

2.12 Seek Time

Innodisk CFast 3IE2-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 3IE2-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 3IE2-P from the system level, including the major hardware blocks.

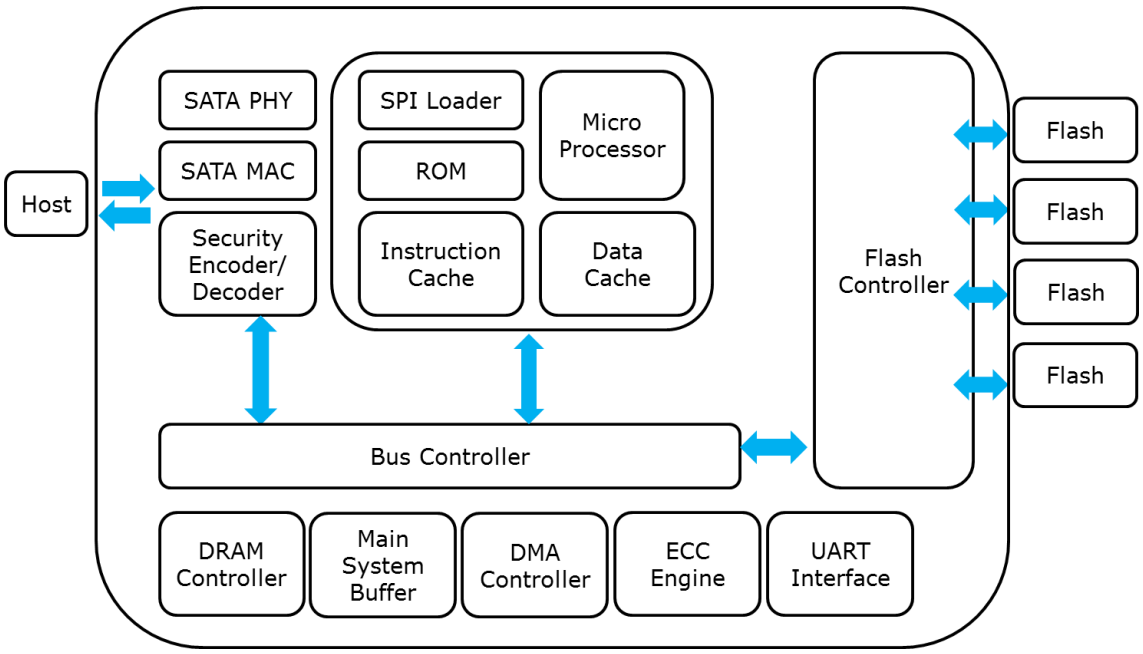


Figure 2: Innodisk CFast 3IE2-P Block Diagram

Innodisk CFast 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 CFast 3IE2-P is designed with ID201, 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 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 CFast 3IE2-P Pin Directions

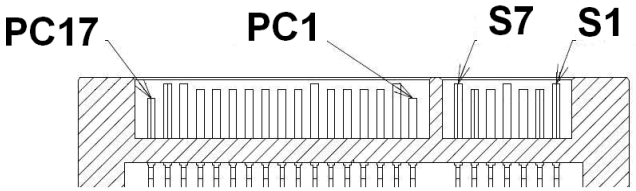


Figure 3: Signal Segment and Power Segment

4.2 Electrical Connections for CFast 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 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 3IE2-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 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.

4.4 Device Drive

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

5. SMART Feature Set

Innodisk 3IE2-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 3IE2-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
Attribute ID (hex)	**Attribute Name**
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. 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**	**C**	**F**	**A**	**-**	**A**	**2**	**8**	**D**	**8**	**1**	**B**	**C**	**A**	**Q**	**C**	**X**	**X**	**X**	**X**

Definition	
Code 1st (Disk)	**Code 13th (Flash Mode)**
D:Disk	B: Synchronous Flash Toshiba 15nm
Code 2st (Feature set)	**Code 14th (Operation Temperature)**
H: iSLC Series	C: Standard Grade (0℃~ +70℃)
	W: Industrial Grade (-40℃~ +85℃)
Code 3nd ~ 5th (Form Factor)	
CFA: CFast	**Code 15th (Internal control)**
	A~Z: BGA PCB version
Code 7th ~9th (Capacity)	
16G: 16GB	**Code 16th (Channel of data transfer)**
32G: 32GB	D: Dual Channels
64G: 64GB	Q: Quad Channels
A28: 128GB	
	Code 17th (Flash Type)
	C: Toshiba MLC
Code 10th ~12th (Controller)	**Code 18th (Optional Function)**
D81:ID201	W: H/W Write Protect function (Optional)
	Code 19th~21th (Customized Code)