innodisk

Total Solution For Industrial Flash Storage

CFast

3IE7 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
1.0	First Released	Nov, 2022
1.1	Add 20GB & 320GB	Dec, 2022

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1. Product Overview

1.1 Introduction of Innodisk CFast 3IE7

Innodisk CFast 3IE7 which is designed with CFast form factor by CFast 2.0, supporting SATA III standard (6.0Gb/s), achieves excellent performance up to 4CH standard by cost effective controller. Regarding of mechanical interference, Innodisk CFast 3IE7 featured as a small form factor, can be configured as a boot device or data storage and is suitable for most industrial application.

With Innodisk L^3 FW architecture, combining our signature 4K mapping algorithm L^2 FW architecture with powerful LDPC technology, 3IE7 series has outstanding high IOPS, better data integrity and extended lifespan through reducing the bad block number happening.

For real industrial application, 3IE7 series is built in thermal sensor to monitor the environment temperature. iData Guard, the power loss management mechanism developed by Innodisk, ensures data integrity while power sudden loss happened.

1.2 Product View and Models

Innodisk CFast 3IE7 is available in follow capacities within 3D TLC flash ICs.

CFast 3IE7 20GB

CFast 3IE7 40GB

CFast 3IE7 80GB

CFast 3IE7 160GB

CFast 3IE7 320GB



Figure 1: Innodisk CFast 3IE7

1.3 SATA Interface

Innodisk CFast 3IE7 supports SATA III(6.0Gb/s) interface, and compliant with SATA I (1.5Gb/s) and SATA II(3.0Gb/s).

1.4 CFast 2.0 Form Factor

CFast 3IE7 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 3IE7 mechanical dimensions: 42.8mm x 36.4mm x 3.6mm.

2. Product Specifications

2.1 Capacity and Device Parameters

CFast 3IE7 device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	Cylinders	Heads	Sectors	LBA	User Capacity(MB)
20GB	16383	16	63	35770291	17466
40GB	16383	16	63	78161328	38165
80GB	16383	16	63	156301488	76319
160GB	16383	16	63	312581808	152628
320GB	16383	16	63	625142448	305245

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance – 112 Layers 3D TLC

Capacity	Unit	20GB	40GB	80GB (2CH)	80GB (4CH)	160GB	320GB
Sequential Read (max.)	MB/s	260	430	420	550	550	550
Sequential Write (max.)		130	260	260	480	490	490
4KB Random Read (QD32)	IOPS	20000	36000	34,000	69,000	67,000	88,000
4KB Random Write (QD32)		34000	62000	61,000	77,000	76,000	77,000

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 3IE7 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	1.6
Write	2.0
Idle	0.9

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for CFast 3IE7

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 3IE7

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 3IE7 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 3IE7 MTBF

Product	Condition	MTBF (Hours)
Innodisk CFast 3IE7	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

CFast 3IE7 conforms to CE and FCC requirements.

2.6 RoHS Compliance

CFast 3IE7 is fully compliant with RoHS directive.

2.7 Reliability

Table 8: Reliability – 112 Layers 3D TLC (innodisk NAND)

Parameter	Value
Read Cycles	Unlimited Read Cycles
Flash endurance	100,000 P/E cycles
Wear-Leveling Algorithm	Support
Bad Blocks Management	Support
DIE RAID Recovery	Support
Error Correct Code	Support

TBW* (Total Bytes Written) Units: TB

Capacity	Sequential workload	Client workload
20GB	1700	1250
40GB	3400	2500
80GB	6800	5000
160GB	13600	10000
320GB	27200	20000

* 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 20GB client workload is not specified in JEDEC219A, the values are estimated.)
3. Based on out-of-box performance.

2.8 Transfer Mode

CFast 3IE7 support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

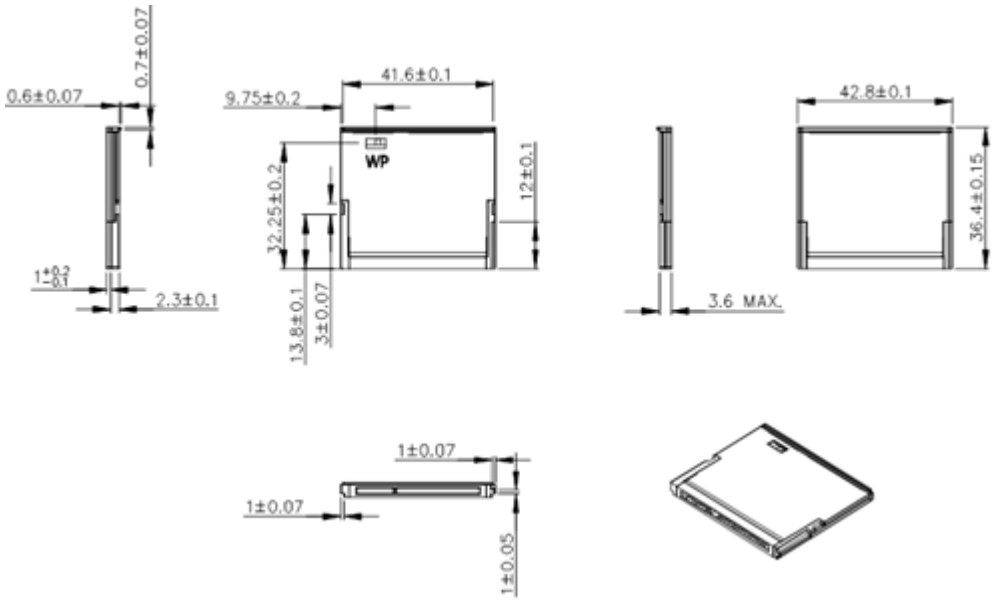
2.9 Pin Assignment

Innodisk CFast 3IE7 uses a standard SATA pin-out. See Table 8 for CFast 3IE7 pin assignment.

Table 9: Innodisk CFast 3IE7 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	Write protect pin of P10 and internal pull high 1M. Function enable when pin10 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.

(General tolerance: ±0.15mm)

2.11 Assembly Weight

An Innodisk CFast 3IE7 within flash ICs, 40GB's weight is 10 grams approximately.

2.12 Seek Time

Innodisk CFast 3IE7 is not a magnetic rotating design. There is no seek or rotational latency required.

2.13 NAND Flash Memory

Innodisk CFast 3IE7 uses 3D TLC NAND flash memory, with 100,000 program & erase cycles, 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 3IE7 from the system level, including the major hardware blocks.

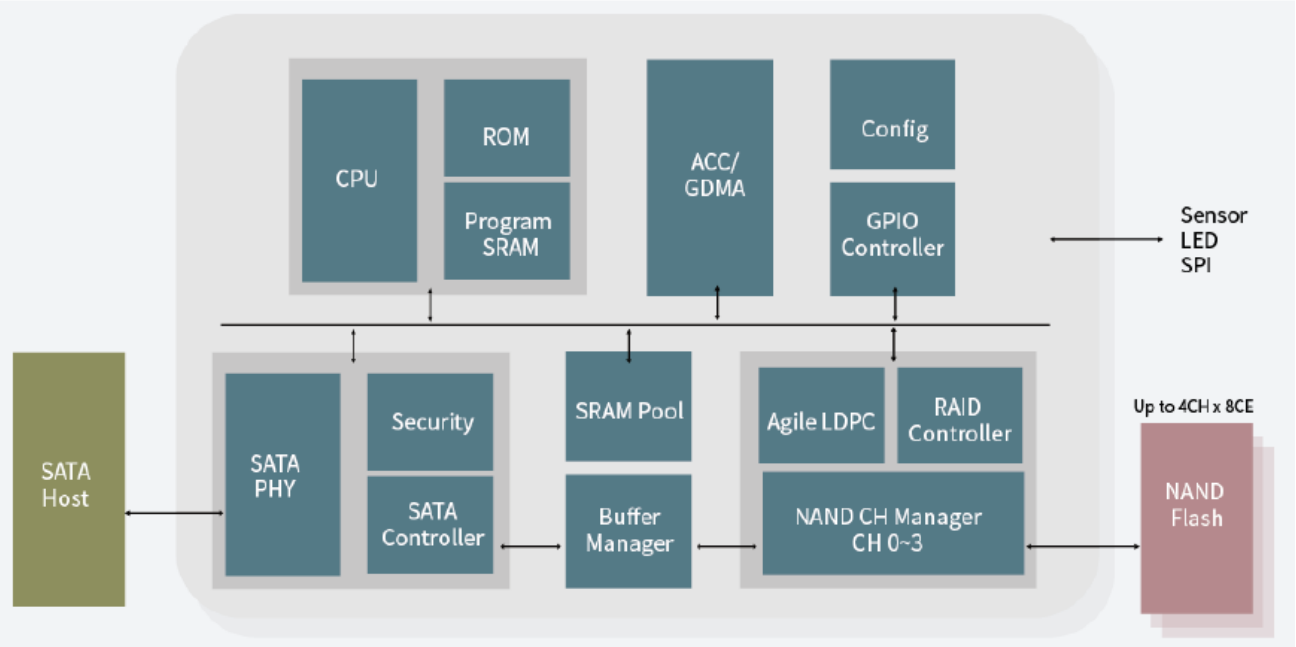


Figure 2: Innodisk CFast 3IE7 Block Diagram

Innodisk CFast 3IE7 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 3IE7 is designed with 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

Innodisk CFast 3IE7 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

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 3IE7 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

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.

3.9 iPower Guard

iPower Guard technology is a set of preventive measures that protect the SSD in an unstable power supply environment. This comprehensive package comprises safeguards for startup and shutdown to maintain device performance and ensure data integrity.

3.10 Write Protect (Optional)



Figure 3: Write Protect Hardware Mechanism

Write protect 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. 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 3IE7 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.

3.10.1 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 10: Execute Enable Write Protect command for inputs information

Register	7	6	5	4	3	2	1	0
Features	01h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	84h							

-Normal Outputs

Table 11: 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.

3.10.2 Disable Write Protect Command

This command disable SSD's write protect feature.

-Protocol: Non Data Command

-Inputs

Table 12: Execute Disable Write Protect command for inputs information

Register	7	6	5	4	3	2	1	0
Features	00h							
Sector Count	41h							
LBA Low	Na							
LBA Mid	Na							
LBA High	Na							
Device	1	1	1	0	Na			
Command	84h							

-Normal Outputs

Table 13: 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.

4. Installation Requirements

4.1 CFast 3IE7 Pin Directions

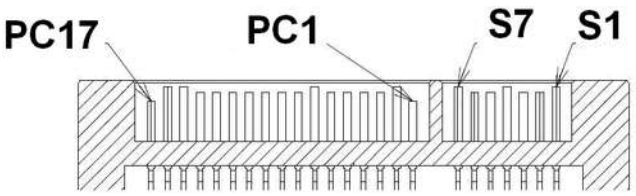


Figure 4: Signal Segment and Power Segment

4.2 Electrical Connections for CFast 3IE7

A Serial ATA device may be either directly connected to a host or connected to a host through an adaptor card. The SATA interface has a separate connector for the power supply. Please refer to the pin description for further details.

4.3 Device Drive

No additional device drives are required. The Innodisk CFast 3IE7 can be configured as a boot device.

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	**H**	**C**	**F**	**A**	**-**	**4**	**0**	**G**	**D**	**K**	**1**	**K**	**C**	**A**	**D**	**L**	**(W)**	**X**	**X**	**X**

Definition	
Code 1st (Disk)	**Code 13th (Flash Mode)**
D:Disk	K: 112 layers 3D TLC
Code 2st (Feature set)	**Code 14th (Operation Temperature)**
H:iSLC	C: Standard Grade (0℃~ +70℃)
	W: Industrial Grade (-40℃~ +85℃)
Code 3nd ~ 5th (Form Factor)	**Code 15th (Internal control)**
CFA: CFast	A-Z: BGA PCB version
Code 7th ~9th (Capacity)	**Code 16th (Channel of data transfer)**
20G: 20GB	S: Dual Channels
40G: 40GB	D: Dual Channels
80G: 80GB	Q: Quad Channels
A60: 160GB	
D2G: 320GB	**Code 17th (Flash Type)**
	L: Innodisk 3D TLC
	Q: Innodisk 3D TLC
Code 10th ~12th (Controller)	**Code 18th (Flash)**
DK1: SATA 3IE7	W: H/W Write Protect function (Switch)
	Code 19th~21th (Customized Code)