innodisk

Total Solution For Industrial Flash Storage

CFast

3TE7 Series

with Innodisk NAND

Customer: _____

Customer Part Number: _____

Innodisk Part Number: _____

Innodisk Model Name: _____

Date: _____

Innodisk Approver	Customer Approver

Features:

- SATA III
- Innodisk 3D TLC NAND
- CFast 3TE7
- Standard & Wide-temperature
- iPower Guard
- iData Guard
- Dynamic Thermal Management
- Hybrid Write

Performance:

- Sequential Read up to 550 MB/s
- Sequential Write up to 490 MB/s

Power Requirements:

Input Voltage:	3.3V±5%
Max Operating Wattage:	1.8W
Idle Wattage:	0.8W

Reliability:

Capacity	TBW	DWPD
32GB	38	1.08
64GB	75	1.09
128GB	150	1.09
256GB	300	1.09
512GB	600	1.09
1TB	1200	1.09

Data Retention	10 Years
Warranty	3 Years

For warranty details, please refer to:

https://www.innodisk.com/en/support_and_service/warranty

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Revision History

Revision	Description	Date
Rev 1.0	Official Release	May, 2021
Rev 2.0	Add 112 Layers 3D TLC information	Jan., 2022
Rev 2.1	Update LBA	Feb., 2022
Rev 2.2	Update Performance	Feb., 2022
Rev 2.3	Correct 1TB Performance	Apr., 2023
Rev 2.4	Update Boot Up Power Consumption	Dec., 2023

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1. Product Overview

1.1 Introduction of Innodisk CFast 3TE7

Innodisk CFast 3TE7 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 3TE7 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, 3TE7 series has outstanding high IOPS, better data integrity and extended lifespan through reducing the bad block number happening.

For real industrial application, 3TE7 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 3TE7 is available in follow capacities within 3D TLC flash ICs.

CFast 3TE7 64GB
CFast 3TE7 128GB
CFast 3TE7 256GB
CFast 3TE7 512GB
CFast 3TE7 1TB

Figure 1: Innodisk CFast 3TE7

1.3 SATA Interface

Innodisk CFast 3TE7 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 3TE7 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 3TE7 mechanical dimensions: 42.8mm x 36.4mm x 3.6mm.

2. Product Specifications

2.1 Capacity and Device Parameters

CFast 3TE7 device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	Cylinders	Heads	Sectors	LBA	User Capacity(MB)
64GB	16383	16	63	117231408	57241
				107463888(112-L)	52473
128GB	16383	16	63	234441648	114473
256GB	16383	16	63	468862128	228937
512GB	16383	16	63	937703088	457863
1TB	16383	16	63	1875385008	915715

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table2: Performance – 96 Layers 3D TLC

Capacity	Unit	128GB	256GB	512GB	1TB
Sequential Read (max.)	MB/s	440	530	550	550
Sequential Write (max.)		220	450	490	500
4KB Random Read (QD32)	IOPS	37,000	52,000	73,000	72,000
4KB Random Write (QD32)		14,000	28,000	53,000	59,000

Note: * Performance results are measured in Room Temperature with Out-of-Box devices and may vary depending on overall system setup. In addition, 3TE7 series adopt hybrid mode which enables SLC Cache followed by TLC direct write to strike balance between burst performance and steady overall stability.

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.

Note: *** Performance results are based on AIDA 64 v5.98 with block size 1MB of Linear Read & Write Test Item.

Table 3: Performance – 112 Layers 3D TLC

Capacity	Unit	64GB	128GB	256GB (4CH)	256GB (2CH)	512GB	1TB
Sequential** Read (Q32T1)	MB/s	260	440	550	420	560	550
Sequential** Write (Q32T1)		130	250	490	250	490	500
Sustained Sequential Read (Avg.)***		200	340	400	320	410	410
Sustained Sequential Write (Avg.)***		40	70	150	70	140	280
4KB Random** Read (Q32T1)	IOPS	20,000	33,000	71,000	32,000	67,000	85,000
4KB Random** Write (Q32T1)		10,000	20,000	39,000	34,000	48,000	72,000

Note: * Performance results are measured in Room Temperature with Out-of-Box devices and may vary depending on overall system setup. In addition, 3TE7 series adopt hybrid mode which enables SLC Cache followed by TLC direct write to strike balance between burst performance and steady overall stability.

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.

Note: *** Performance results are based on AIDA 64 v5.98 with block size 1MB of Linear Read & Write Test Item.

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 4: Innodisk CFast 3TE7 Power Requirement

Item	Symbol	Rating	Unit
Input voltage	V_{IN}	+3.3 DC +- 5%	V

2.3.2 Power Consumption

Table 5: Power Consumption

Mode	Power Consumption (W)
Read	1.4
Write	1.8
Idle	0.8
Boot Up	3.2

* Target: CFast 3TE7 1TB

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 6: Temperature range for CFast 3TE7

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 7: Shock/Vibration Testing for CFast 3TE7

Reliability	Test Conditions	Reference Standards
Vibration	7 Hz to 2K Hz, 20G, 3 axes	IEC 60068-2-6
Mechanical Shock	Duration: 0.5ms, 1500 G, 3 axes	IEC 60068-2-27

2.4.4 Mean Time between Failures (MTBF)

The Following table summarizes the MTBF prediction results for various CFast 3TE7 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 8: CFast 3TE7 MTBF

Product	Condition	MTBF (Hours)
Innodisk CFast 3TE7	Telcordia SR-332 GB, 25°C	>3,000,000

2.5 CE and FCC Compatibility

CFast 3TE7 conforms to CE and FCC requirements.

2.6 RoHS Compliance

CFast 3TE7 is fully compliant with RoHS directive.

2.7 Reliability

Parameter	Value
Flash endurance	3,000 P/E cycles
Error Correct Code	Support
Data Retention	Under 40 C: 10 Years at Initial NAND Status; 1 Year at NAND Life End

TBW* (Total Bytes Written) Units: TB

Capacity	Sequential workload	Client workload
64GB	170	75
128GB	341	150
256GB	682	300
512GB	1364	600
1TB	2727	1200

* 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

CFast 3TE7 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 3TE7 uses a standard SATA pin-out. See following table for CFast 3TE7 pin assignment.

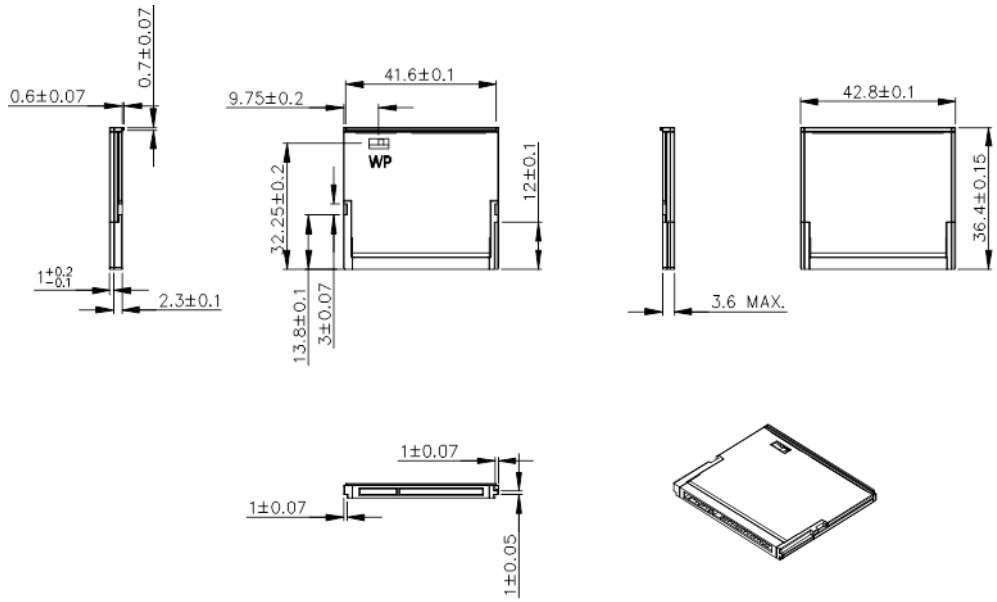
Table 9: Innodisk CFast 3TE7 Pin Assignment

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	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.

(General tolerance: ±0.15mm)



2.11 Assembly Weight

An Innodisk CFast 3TE7 within flash ICs, 128GB's weight is 10 grams approximately.

2.12 Seek Time

Innodisk CFast 3TE7 is not a magnetic rotating design. There is no seek or rotational latency required.

2.13 NAND Flash Memory

Innodisk CFast 3TE7 uses 3D TLC NAND flash memory, with 3,000 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 3TE7 from the system level, including the major hardware blocks.

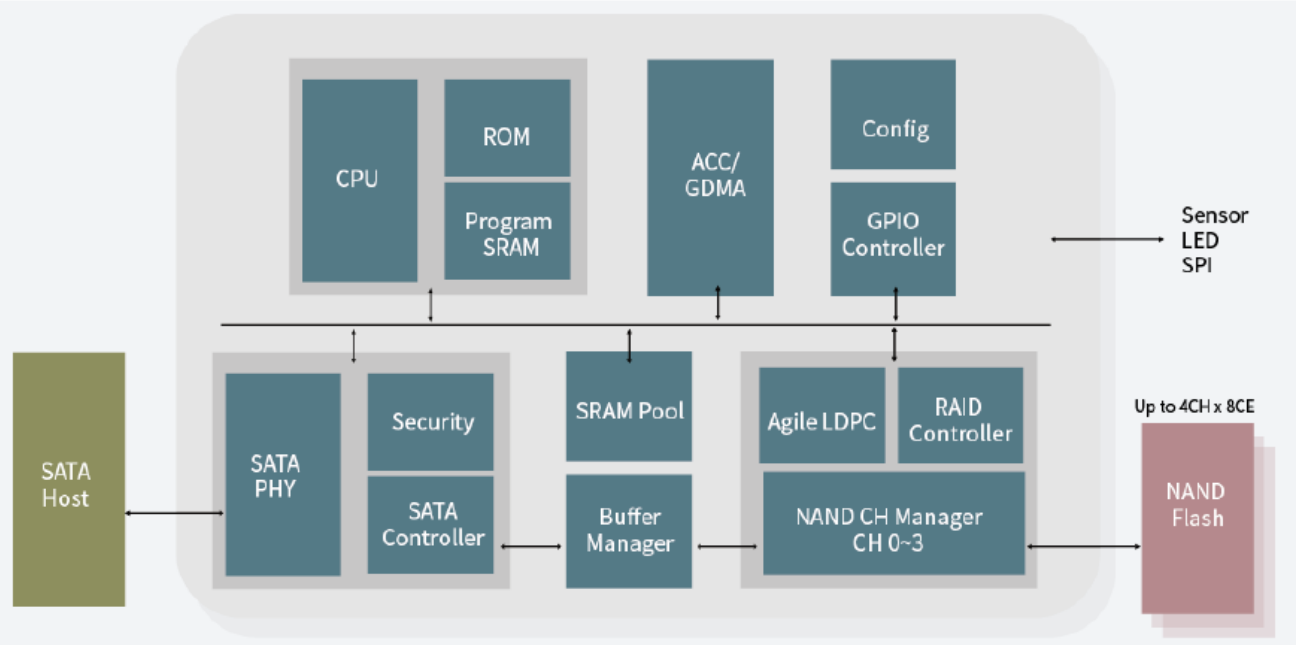


Figure 2: Innodisk CFast 3TE7 Block Diagram

Innodisk CFast 3TE7 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 3TE7 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 3TE7 is designed with hardware LDPC ECC engine with hard-decision and Soft-decision decoding. Low-density parity-check (LDPC) codes have excellent error correcting Performance close to the Shannon limit when decoded with the belief-propagation (BP) algorithm using soft-decision information.

3.4 Wear-Leveling

Flash memory can be erased within a limited number of times. This number is called the ***erase cycle limit*** or ***write endurance limit*** and is defined by the flash array vendor. The erase cycle limit applies to each individual erase block in the flash device.

Innodisk CFast 3TE7 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

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. 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 Die RAID

Die RAID is a controller function which leveraged user capacity to back up the data in NAND flash. Die RAID supported can ensure the user data in the NAND Flash more consistent in certain scenario. Innodisk CFast 3TE7 series is default enable the Die RAID function for the industrial application.

3.11 SLC cache

Table 10: CFast 3TE7 SLC cache

Capacity	64GB	128GB	256GB	512GB	1TB	2TB
SLC cache (GB)	3	3	5	9	18	36
SLC cache (%)	4.6	2.3	1.9	1.7	1.7	1.7

3TE7 series adopt hybrid mode which enables SLC Cache up to 3% of total user capacity by TLC direct write to strike balance between burst performance and steady overall stability.

3.12 Thermal Throttling

Thermal throttling is a protective mechanism designed to safeguard components from potential damage caused by excessive temperatures. When an SSD approaches a critical temperature threshold, Innodisk firmware activates the thermal throttling mechanism to regulate the SSD's temperature. Thermal throttling is crucial for SSDs since it prevents drive damage, which could otherwise result in data loss. However, it's worth noting that when thermal throttling is activated, read and write tasks may experience a reduction in speed.

4. Installation Requirements

4.1 CFast 3TE7 Pin Directions

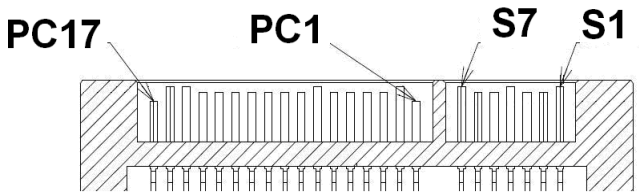


Figure 3: Signal Segment and Power Segment

4.2 Electrical Connections for CFast 3TE7

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 3TE7 can be configured as a boot device.

5. SMART Feature Set

Innodisk 3TE7 series support the SMART command set and defines some vendor-specific data to report SMART attributes of SSD.

Table 11: 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 3TE7 series SMART data attributes are listed in following table.

Table 12: SMART attribute

Attribute ID (hex)	Value	Raw Attribute Value						Rsv	Attribute Name
01	X								Read Error Rate
05	X	LSB	MSB	00	00	00	00	00	Later Bad
09	LSB	LSB	MSB	00	00	00	00	00	Power-On hours Count
0C	LSB	LSB	MSB	00	00	00	00	00	Drive Power Cycle Count
A3	X	LSB			MSB	00	00	00	Total Bad Block Count
A5	LSB	LSB			MSB	00	00	00	Max Erase count
A7	LSB	LSB			MSB	00	00	00	Avg Erase count
A9	LSB	LSB	00	00	00	00	00	00	Device Life
AA	X	LSB	MSB	00	00	00	00	00	Spare Block Count
AB	LSB	LSB	MSB	00	00	00	00	00	Program fail count
AC	LSB	LSB	MSB	00	00	00	00	00	Erase fail count
C0	LSB	LSB	MSB	00	00	00	00	00	Unexpected Power Loss Count
C2	LSB			MIN		MAX	00	00	Temperature

E5		ID 0	ID 1	ID 2	ID 3	ID 4	ID 5		Flash ID
EB			**MSB**	**LSB**	**MSB**	**LSB**	**MSB**	**LSB**	Later bad block info (**Read**/**Write**/**Erase**)
F1	00	LSB			MSB	00	00	00	Total LBA written(LBA=32MB)
F2	00	LSB			MSB	00	00	00	Total LBA read(LBA=32MB)

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	**E**	**C**	**F**	**A**	**-**	**C**	**1**	**2**	**D**	**K**	**1**	**G**	**C**	**A**	**Q**	**L**	**(W)**	**X**	**X**	**X**

Definition	
Code 1st (Disk)	**Code 13th (Flash Mode)**
D:Disk	G: 96 layers 3D TLC
	K: 112 layers 3D TLC
Code 2st (Feature set)	**Code 14th (Operation Temperature)**
E:Embedded series	C: Standard Grade (0℃~ +70℃)
	W: Industrial Grade (40℃~ +85℃)
Code 3nd ~ 5th (Form Factor)	**Code 15th (Internal control)**
CFA: CFast	A: BGA PCB version
Code 7th ~9th (Capacity)	**Code 16th (Channel of data transfer)**
64G: 64GB	D: Dual Channels
A28: 128GB	Q: Quad Channels
B56: 256GB	
C12: 512GB	**Code 17th (Flash Type)**
01T: 1TB	L/Q: Innodisk 3D TLC
Code 10th ~12th (Controller)	**Code 18th (Flash Type)**
DK1: SATA 3TE7	W: H/W Write Protect function
	Code 19th~21th (Customized Code)