

SATA Slim

3IE7 with

Innodisk NAND

Customer:

Customer

Part Number:

Innodisk

Part Number:

Innodisk

Model Name:

Date:

Innodisk Approver	Customer Approver

**Total Solution For
Industrial Flash Storage**

Table of contents

LIST OF FIGURES 6

1. PRODUCT OVERVIEW 7

1.1 INTRODUCTION OF INNODISK SATA SLIM 3IE7.7

1.2 PRODUCT VIEW AND MODELS7

1.3 SATA INTERFACE.....7

1.4 MO-297 FORM FACTOR.....8

2. PRODUCT SPECIFICATIONS..... 9

2.1 CAPACITY AND DEVICE PARAMETERS.....9

2.2 PERFORMANCE9

2.3.1 Power Requirement.....10

2.3.2 Power Consumption10

2.4 ENVIRONMENTAL SPECIFICATIONS10

2.4.1 Temperature Ranges10

2.4.2 Humidity.....10

2.4.3 Shock and Vibration10

2.4.4 Mean Time between Failures (MTBF)10

2.5 CE AND FCC COMPATIBILITY11

2.6 RoHS COMPLIANCE11

2.7 RELIABILITY12

2.8 TRANSFER MODE12

2.9 PIN ASSIGNMENT13

2.10 MECHANICAL DIMENSIONS.....14

2.11 ASSEMBLY WEIGHT14

2.12 SEEK TIME14

2.13 NAND FLASH MEMORY.....14

3. THEORY OF OPERATION 15

3.1 OVERVIEW.....15

3.2 SATA III CONTROLLER15

3.3 ERROR DETECTION AND CORRECTION.....15

3.4 WEAR-LEVELING16

3.5 BAD BLOCKS MANAGEMENT16

3.6 iDATA GUARD.....16

3.7 GARBAGE COLLECTION.....16

3.8 TRIM16

3.9 iPOWER GUARD.....17

3.10 DIE RAID17

3.11 QUICK ERASE (OPTIONAL)17

3.11.1 Quick Erase Command.....17

4. INSTALLATION REQUIREMENTS 19

4.1 SATA SLIM PIN DIRECTIONS..... 19

4.2 ELECTRICAL CONNECTIONS FOR SATA SLIM 3IE7 19

4.3 DEVICE DRIVE 19

5. SMART FEATURE SET 20

5.1 SMART ATTRIBUTES.....20

6. PART NUMBER RULE 22

REVISION HISTORY

Revision	Description	Date
Rev 1.0	First Released	Aug., 2021
Rev 1.1	Improve wording on NAND Flash & Part Number Rule	Mar., 2022

List of Tables

TABLE 1: DEVICE PARAMETERS	9
TABLE 2: PERFORMANCE- 96 LAYERS 3D TLC¹	9
TABLE 3: INNODISK SATA SLIM 3IE7 POWER REQUIREMENT	10
TABLE 4: POWER CONSUMPTION –96 LAYERS 3D TLC	10
TABLE 5: TEMPERATURE RANGE FOR SATA SLIM 3IE7	10
TABLE 6: SHOCK/VIBRATION TESTING FOR SATA SLIM 3IE7	10
TABLE 7: SATA SLIM 3IE7 MTBF	11
TABLE 8: INNODISK SATA SLIM 3IE7 PIN ASSIGNMENT	13
TABLE 9: EXECUTE QUICK ERASE COMMAND FOR INPUTS INFORMATION	17
TABLE 10: QUICK ERASE COMMAND FOR NORMAL OUTPUT INFORMATION	17
TABLE 11: SMART COMMAND	20
TABLE 12: SMART ATTRIBUTE	20

List of Figures

FIGURE 1: INNODISK SATA SLIM 3IE7	7
FIGURE 2: INNODISK SATA SLIM 3IE7 BLOCK DIAGRAM	15
FIGURE 3: SIGNAL SEGMENT AND POWER SEGMENT	19

1. Product Overview

1.1 Introduction of Innodisk SATA Slim 3IE7.

Innodisk SATA Slim 3IE7 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., achieves excellent performance up to 4CH standard by cost effective controller with 4CH.

With Innodisk L³ FW architecture, combining our signature 4K mapping algorithm L² 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.

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 SATA Slim 3IE7 is available in follow capacities within TLC flash ICs.

[SATA Slim 3IE7 40GB](#)

[SATA Slim 3IE7 80GB](#)

[SATA Slim 3IE7 160GB](#)



Figure 1: Innodisk SATA Slim 3IE7

1.3 SATA Interface

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

1.4 MO-297 Form Factor

SATA Slim 3IE7 has a compact design 54.0mm (W) x 39.0mm (L) x 4.0mm (H) without metal material case, and is easy for installation.

2. Product Specifications

2.1 Capacity and Device Parameters

SATA Slim 3IE7 device parameters are shown in Table 1.

Table 1: Device parameters

Capacity	Cylinders	Heads	Sectors	LBA	User Capacity(MB)
40GB	78,161,328	16383	16	63	38165
80GB	156,301,488	16383	16	63	76319
160GB	312,581,808	16383	16	63	152628

2.2 Performance

Burst Transfer Rate: 6.0Gbps

Table 2: Performance- 96 Layers 3D TLC¹

Capacity	40GB	80GB	160GB
Sequential Read (max.) ²	440 MB/s	550 MB/s	550 MB/s
Sequential Write (max.) ²	220 MB/s	445 MB/s	490 MB/s
4KB Random Read (QD32) ²	37,000 IOPS	70,000 IOPS	73,000 IOPS
4KB Random Write (QD32) ²	52,000 IOPS	61,000 IOPS	59,000 IOPS

Note: 1. Performance based on CrystalDiskMark 5.1.2 with file size 1000MB of Queue Depth 32

2. Performance may vary based on various firmware version or test platform

2.3 Electrical Specifications

2.3.1 Power Requirement

Table 3: Innodisk SATA Slim 3IE7 Power Requirement

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

2.3.2 Power Consumption

Table 4: Power Consumption –96 Layers 3D TLC

Mode	40GB (mA)	80GB (mA)	160GB (mA)
Read (RMS) ¹	267	304	307
Write (RMS) ¹	130	304	308
Idle	167	168	164
Boot Up	565	540	590

Note: 1. The workload based on IOMeter with file size 1MBytes with Queue Depth 32 sequential read & write

2.4 Environmental Specifications

2.4.1 Temperature Ranges

Table 5: Temperature range for SATA Slim 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 SATA Slim 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 SATA Slim 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: SATA Slim 3IE7 MTBF

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

2.5 CE and FCC Compatibility

SATA Slim 3IE7 conforms to CE and FCC requirements.

2.6 RoHS Compliance

SATA Slim 3IE7 is fully compliant with RoHS directive.

2.7 Reliability

Parameter	Value	
Flash endurance	30,000 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
40GB	1065	781
80GB	2130	1562
160GB	4260	3125
<p>* Note:</p> <ol style="list-style-type: none"> 1. Sequential: Mainly sequential write. 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

SATA Slim 3IE7 support following transfer mode:

Serial ATA III 6.0Gbps

Serial ATA II 3.0Gbps

Serial ATA I 1.5Gbps

2.9 Pin Assignment

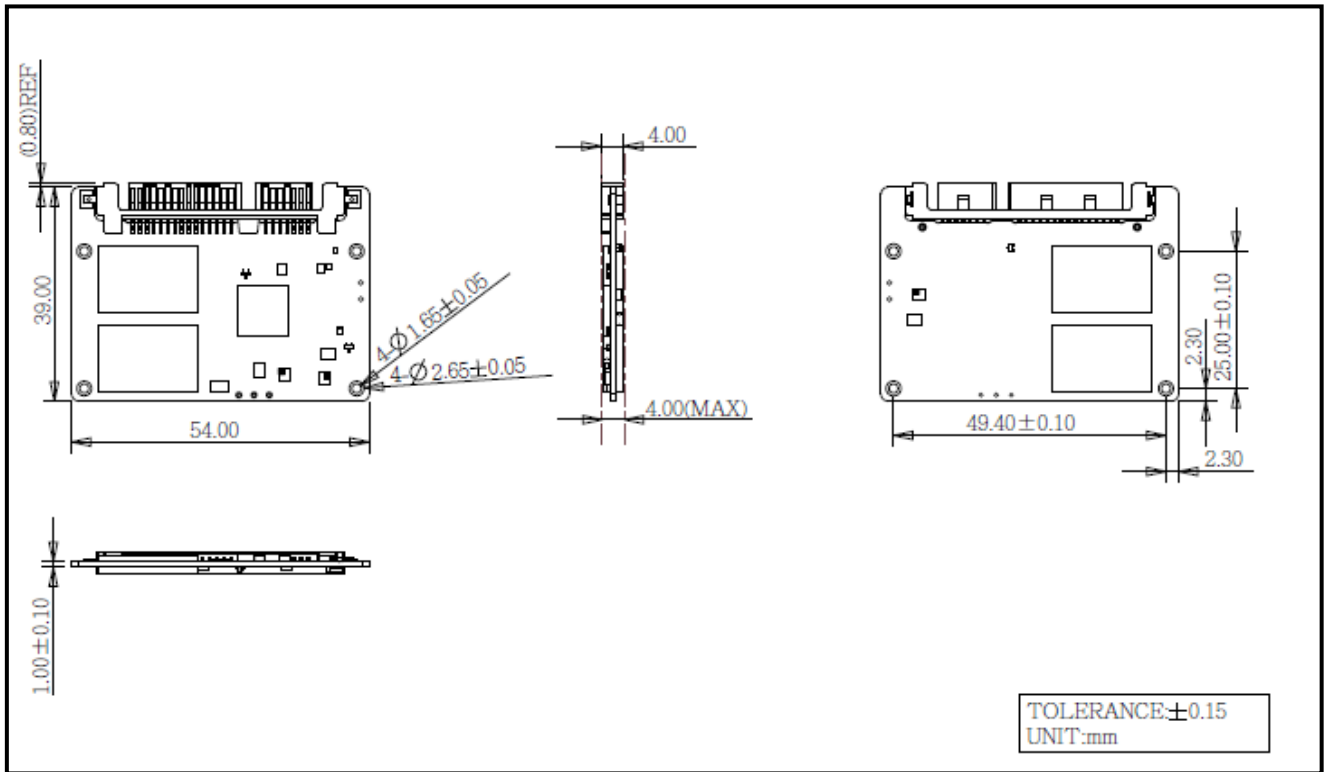
Innodisk SATA Slim 3IE7 uses a standard SATA pin-out.

See Table 8 for SATA Slim 3IE7 pin assignment.

Table 8: Innodisk SATA Slim 3IE7 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 SATA Slim 3IE7 within flash ICs, 32GB's weight is 8 grams approximately.

2.12 Seek Time

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

2.13 NAND Flash Memory

Innodisk SATA Slim SSD 3IE7 uses 3D TLC NAND flash memory, with 30,000 program & erase cycles based on iSLC mode, 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 SATA Slim 3IE7 from the system level, including the major hardware blocks.

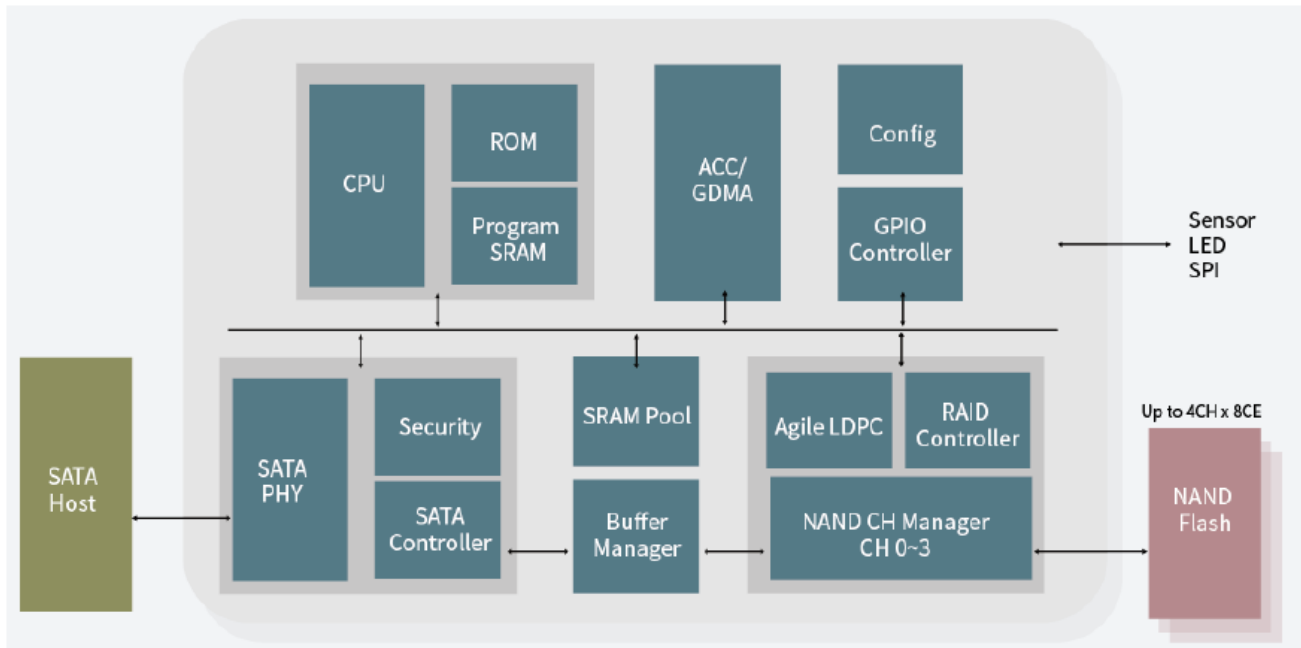


Figure 2: Innodisk SATA Slim 3IE7 Block Diagram

Innodisk SATA Slim 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 SATA Slim 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 SATA Slim 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 SATA Slim 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 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 SATA Slim 3IE7 series is default enable the Die RAID function for the industrial application.

3.11 Quick Erase (optional)

Quick Erase function is designed for emergency data erase in few seconds by providing ATA command.

3.11.1 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.

4. Installation Requirements

4.1 SATA Slim Pin Directions

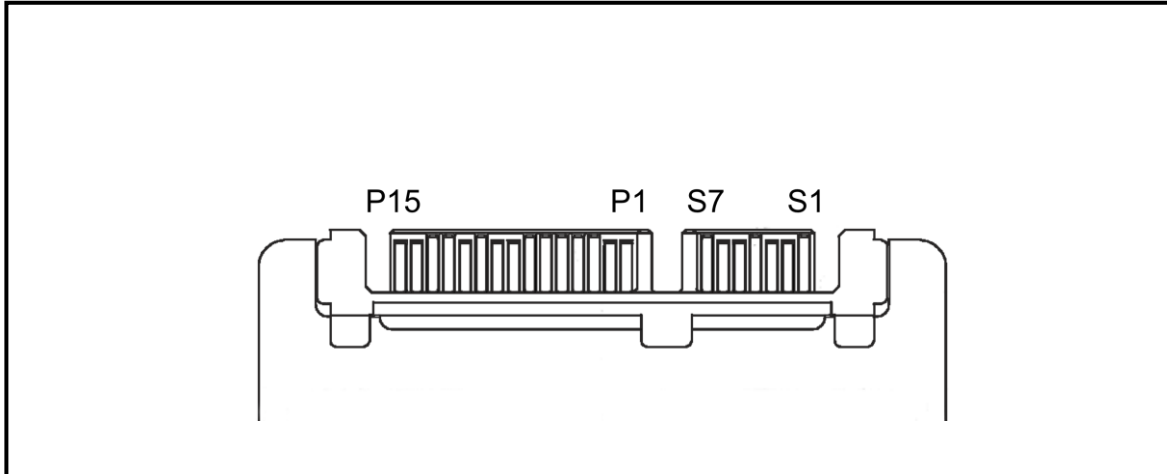


Figure 3: Signal Segment and Power Segment

4.2 Electrical Connections for SATA Slim 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 SATA Slim 3IE7 can be configured as a boot device.

5. SMART Feature Set

Innodisk 3IE7 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 3IE7 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	H	S	L	M	-	4	0	G	D	K	1	G	C	A	Q	L	-	X	X	X
Definition																					
Code 1 st (Disk)											Code 13 th (Flash Mode)										
D : Disk											G: 96 layers 3D TLC										
Code 2 nd (Feature Set)											Code 14 th (Operation Temperature)										
H: iSLC series											C: Standard Grade (0°C~ +70°C)										
											W: Industrial Grade (-40°C~ +85°C)										
Code 3 rd ~ 5 th (Form Factor)											Code 15 th (Internal control)										
SLM: SATA Slim											A: PCBA version										
Code 7 th ~9 th (Capacity)											Code 16 th (Channel of data transfer)										
40G: 40GB											S: Single Channel										
80G: 80GB											D: Dual Channels										
A60: 160GB											Q: Quad Channels										
Code 10 th ~12 th (Controller)											Code 17 th (Flash Type)										
DK1: SATA 3IE7											L: Innodisk 3D TLC										
											Code 19 th ~21 th (Customized Code)										