

Cervoz Industrial Embedded Module

M.2 2280

Titan Series (3D TLC)

T376 Family

Product Datasheet



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Revision History

Date	Revision	Description
2020.09.01	1.0	First Released
2022.12.30	1.1	Ordering Information, MTBF and TBW Updated

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1. Product Overview

1.1 Introduction

Cervoz Industrial M.2 2280 Embedded Module T376 family is a Solid State Flash Disk product that is in compliance with the M.2 and SATA III standards. M.2 2280 T376 family fits in any M.2 2280 sockets in a PC or motherboard; it can be used for both booting and storage purposes. In addition, T376 family has a very unique function named Powerguard. The purpose of Powerguard is to protect data loss while encountering an improper power failure. Powerguard would complete the task of saving the boot files from the controller into the flash storage after sudden power loss. Cervoz designs these flash modules with additional tantalum capacitors to store these extra charges. With this special design, M.2 2280 is constantly charging the tantalum capacitors with 12V power during its operation.

T376 family uses SSD grade quality 3D TLC NAND flash memory from the industry leading manufacturer Micron. This product includes various capacities to choose from.

1.2 Application Fields

- Industrial PC and Thin Client
- Ticketing, Examining and Testing Machine
- Military, Health and Automatic Equipment
- Server, Cloud Computer

1.3 Features

- Compliant with SATA III 6.0Gb/s (backward compatible to 1.5Gb/s and 3Gb/s)
- 3D TLC NAND flash memory
- Capacity: 128GB ~ 2TB
- Powerguard Function (Power Loss Protection)
- Write Protect Function (Optional)
- Support AES 256-bit Encryption
- With DDR3 DRAM Buffer
- SLC write cache technology
- Operating as boot disk
- Product includes Standard Temperature range & Wide Temperature range
- Low power consumption
- Shock resistance and anti-vibration
- Static and dynamic wear leveling
- Bad block management
- S.M.A.R.T. & TRIM command
- Fully compatible with Windows 8.1, Windows 10, Windows 11, Mac OS, and Linux
- RoHS compliant

1.4 Product Appearance & Models

Cervoz Industrial M.2 2280 Module T376



T376 Family Standard Temp. (0°C ~ 70°C) Model No.	T376 Family Wide Temp. (-40°C ~ 85°C) Model No.	Capacity
CIE-M8T376MMF128GS	CIE-M8T376MMF128GW	128GB
CIE-M8T376MMF256GS	CIE-M8T376MMF256GW	256GB
CIE-M8T376M0F512GS	CIE-M8T376M0F512GW	512GB
CIE-M8T376M0F001TS	CIE-M8T376M0F001TW	1TB
CIE-M8T376M0F002TS	CIE-M8T376M0F002TW	2TB

Please Note:

Since certain storage capacity has to be reserved for firmware and controller management purposes; the physical capacity of the SATA flash module will be approximately 92.5% of the indicated capacity. If you need to install an image that has the exact (or close to) the indicated size of the flash module, please choose your flash module with a greater capacity.

2. Product Specifications

2.1 General Specifications

Form Factor	M.2 2280
Interface	SATA III 6.0Gb/s (backward compatible to 3.0Gb/s, 1.5Gb/s)
Connector	M.2 (B+M)
NAND Flash Type	3D TLC NAND
Capacity	128GB/256GB/512GB/1TB/2TB
Sequential Read	up to 555MB/s
Sequential Write	up to 475MB/s
DDR3 DRAM Buffer	Included
ECC Scheme	Applies the LDPC (Low Density Parity Check) of ECC algorithm
MTBF	>3,000,000 hours
Terabyte Written (TBW)	128GB : 219 256GB : 438 512GB : 875 1TB : 1750 2TB : 3500
Low Power Management	DIPM/HIPM mode
Supply Voltage	+3.3V DC \pm 5%
Power Consumption	Active mode: < 2140mW Idle mode: < 460mW
Dimension (LxWxH)	80.00*22.00*3.50mm

2.2 Performance

The performance was measured with below PC configuration:

- Platform: GIGABYTE_B150M-D3H
- RAM: Cervoz CIR-S3DUSPM1604G (DDR3 4G 1600MHz)
- Operation Systems: Windows 10
- Testing Utility: Crystal Disk Mark v5.1.0 x64
- SATAIII port (6.0 Gb/s) performance

Capacity	128GB	256GB	512GB	1TB	2TB
Sequential Read (max.)	485MB/s	555MB/s	555MB/s	555MB/s	555MB/s
Sequential Write (max.)	425MB/s	475MB/s	465MB/s	440MB/s	470MB/s
4KB Random Read (QD32)	150MB/s	290MB/s	280MB/s	400MB/s	400MB/s
4KB Random Write (QD32)	345MB/s	350MB/s	345MB/s	330MB/s	350MB/s

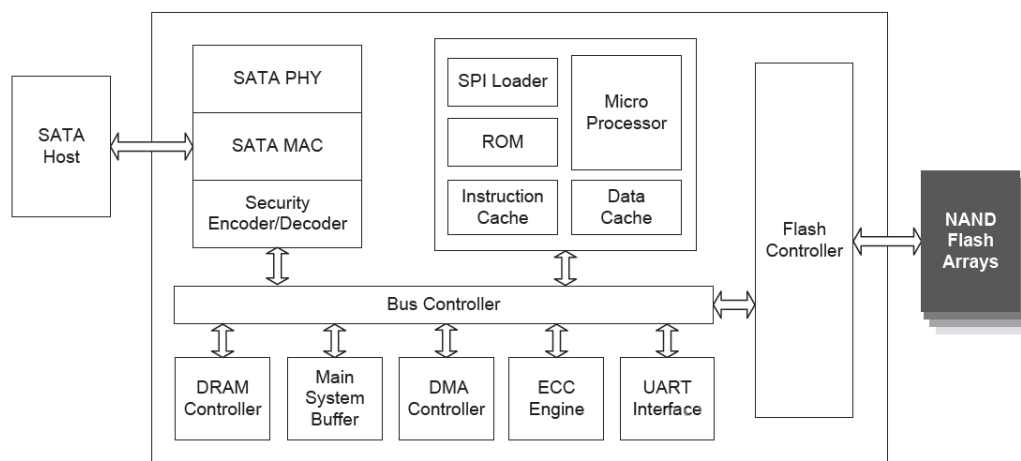
Actual performance might differ based on different using conditions and environment.

2.3 Drive Capacity

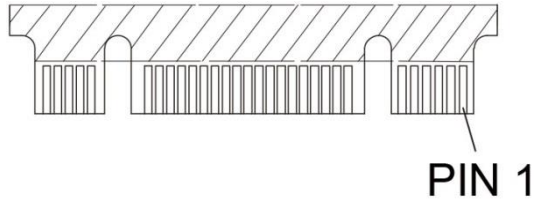
Capacity	Cylinders	Heads	Sectors	Max LBA
128GB	16,383	16	63	250,069,680
256GB	16,383	15	63	500,118,192
512GB	16,383	15	63	1,000,215,216
1TB	16,383	15	63	2,000,406,264
2TB	16,833	15	63	4,000,797,360

2.4 Electronic Specifications

2.4.1 Block Diagram



2.4.2 Pin Assignment



Pin #	Pin Description	Signal Name	Pin #	Pin Description	Signal Name
1	Ground	CONFIG_3 = GND	12	Module Key	Key
2	3.3V power in	+3.3V	13	Module Key	Key
3	Ground	GND	14	Module Key	Key
4	3.3V power in	+3.3V	15	Module Key	Key
5	Not Used	NC	16	Module Key	Key
6	Not Used	NC	17	Module Key	Key
7	Not Used	NC	18	Module Key	Key
8	Not Used	NC	19	Module Key	Key
9	Not Used or Ground	NC or GND ^{Note}	20	Not Used	NC
10	LED/DAS/DSS	DAS/DSS# (O) (OD)	21	Ground	CONFIG_0 = GND
11	Not Used	NC	22	Not Used	NC
Pin #	Pin Description	Signal Name	Pin #	Pin Description	Signal Name
23	Not Used	NC	50	Not Used	NC
24	Not Used	NC	51	Ground	GND
25	Not Used	NC	52	Not Used	NC
26	Not Used	NC	53	Not Used	NC
27	Ground	GND	54	Not Used	NC
28	Not Used	NC	55	Not Used	NC
29	Not Used	NC	56	MFG Data	NC
30	Not Used	NC	57	Ground	GND
31	Not Used	NC	58	MFG Clock	NC
32	Not Used	NC	59	Module Key	Key
33	Ground	GND	60	Module Key	Key
34	Not Used	NC	61	Module Key	Key
35	Not Used	NC	62	Module Key	Key
36	Not Used	NC	63	Module Key	Key
37	Not Used	NC	64	Module Key	Key
38	Enter/Exit Device Sleep	DEVSLP (I) (0/3.3V)	65	Module Key	Key
39	Ground	GND	66	Module Key	Key

40	Not Used	NC	67	Not Used	NC
41	SATA Txp	+B – TX+	68	32kHz clock supply	SUSCLK (I) (0/3.3V)
42	Not Used	NC	69	Defines module type	CONFIG_1 = GND
43	SATA Txn	-B – TX-	70	3.3V power in	+3.3V
44	Not Used	NC	71	Ground	GND
45	Ground	GND	72	3.3V power in	+3.3V
46	Not Used	NC	73	Ground	GND
47	SATA Rxn	-A – RX-	74	3.3V power in	+3.3V
48	Not Used	NC	75	Ground	CONFIG_2 = GND
49	SATA Rxp	+A – RX+			

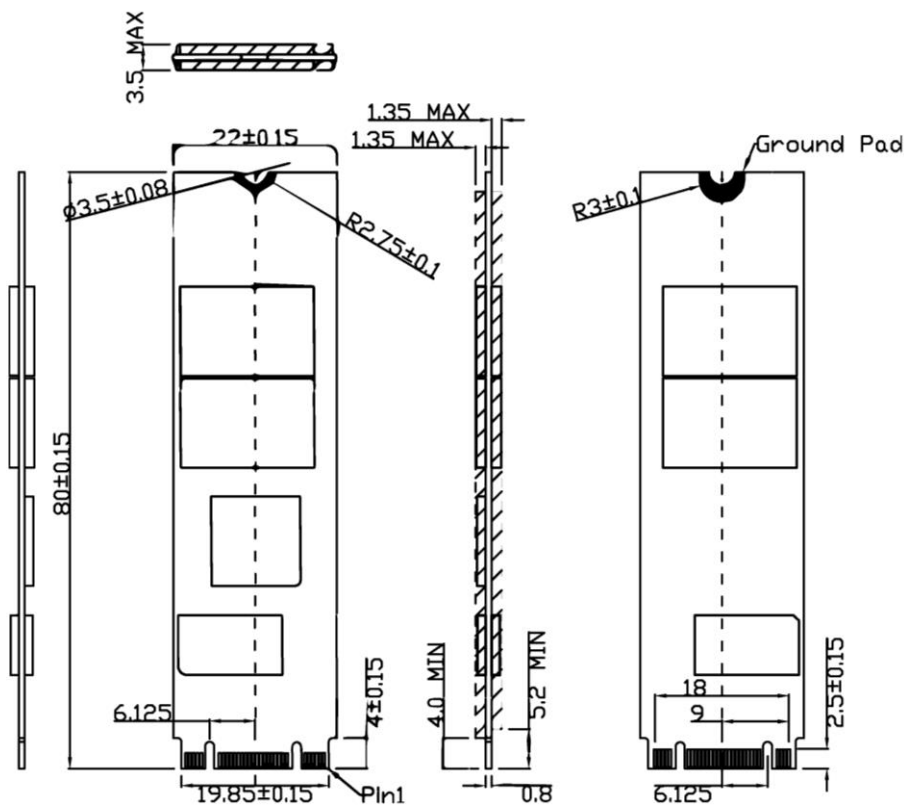
3 **Note:** NC for Socket 2, and GND for Socket 3.

2.5 Environmental Specifications

Type		Value
Temperature	Standard Temperature Operating:	0°C~70°C
	Standard Temperature Storage:	-40°C~85°C
	Wide Temperature Operating:	-40°C~85°C
	Wide Temperature Storage:	-50°C~95°C
Humidity	Operating & Storage	5~95%, Non-Condensing
Vibration	Non-Operating	20G, 10Hz~2000Hz
Shock	Non-Operating	1500G, 0.5ms

2.6 Mechanical Specifications

Type	Value
Form Factor	M.2 2280
Length	80.00mm +/-0.15mm
Width	22.00mm +/-0.15mm
Thickness	3.50mm +/-0.08mm

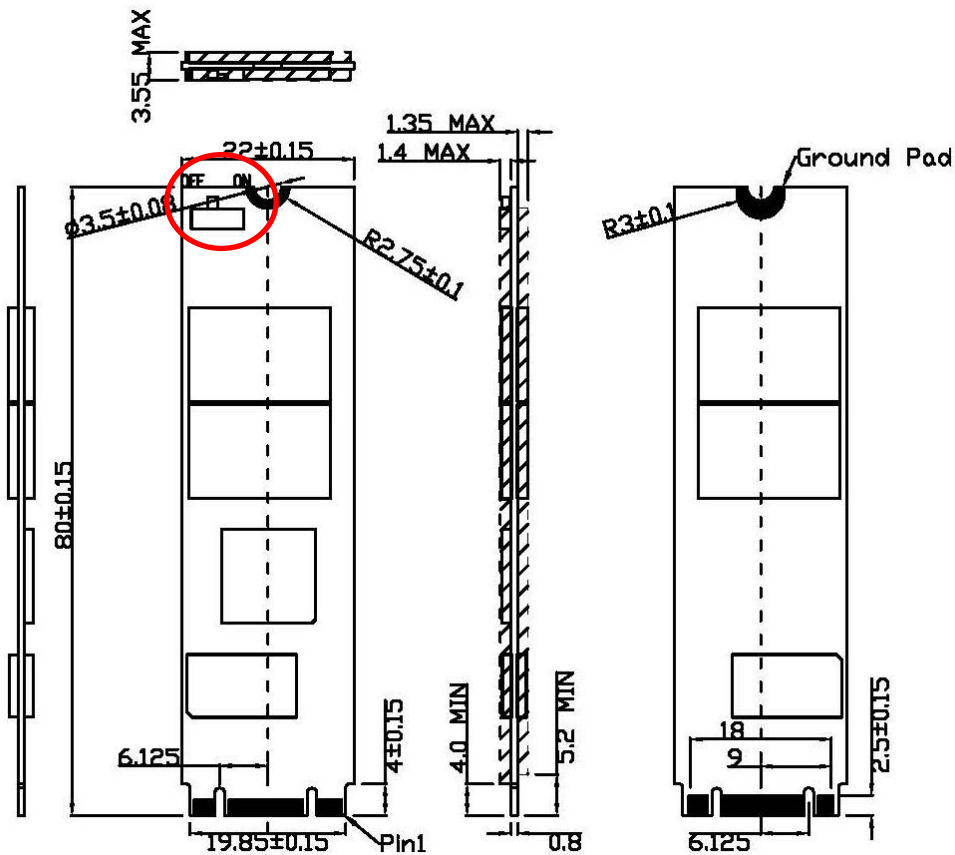


3. Powerguard Function(Power Loss Protection)

The Powerguard function provides additional power during an unexpected power outage to complete current flash write operation, moreover to protect firmware, mapping table integrity.

4. Write Protection (Optional)

Write protect function can be triggered by operating the write protection switch. Once write-protection activated, the M.2 2280 SSD will become read-only and the user will not be able to write or delete any data on the M.2 2280 SSD.



5. Supported Command

5.1 List of Command Sets

Code	Description	Code	Description
00h	NOP	C9h	Read DMA without Retry
06h	Data Set Management	CAh	Write DMA
10h-1Fh	Recalibrate	CBh	Write DMA without Retry
20h	Read Sectors	CEh	Write Multiple FUA EXT
21h	Read Sectors without Retry	E0h	Standby Immediate
24h	Read Sectors EXT	E1h	Idle Immediate
25h	Read DMA EXT	E2h	Standby
27h	Read Native Max Address EXT	E3h	Idle
29h	Read Multiple EXT	E4h	Read Buffer
2Fh	Read Log EXT	E5h	Check Power Mode
30h	Write Sectors	E6h	Sleep
31h	Write Sectors without Retry	E7h	Flush Cache
34h	Write Sectors EXT	E8h	Write Buffer
35h	Write DMA EXT	E9h	READ BUFFER DMA
37h	Set Native Max Address EXT	EAh	Flush Cache EXT
38h	CFA Write Sectors Without Erase	EBh	Write Buffer DMA
39h	Write Multiple EXT	ECh	Identify Device
3Dh	Write DMA FUA EXT	EFh	Set Features
3Fh	Write Long EXT	Efh/02h	Enable volatile write cache
40h	Read Verify Sectors	Efh/03h	Set transfer mode
41h	Read Verify Sectors without Retry	Efh/05h	Enable the APM feature set
42h	Read Verify Sectors EXT	Efh/10h	Enable use of SATA features et
44h	Zero EXT	Efh/10h/02h	Enable DMA Setup FIS Auto-Activate optimization
45h	Write Uncorrectable EXT	Efh/10h/03h	Enable Device-initiated interface power state (DIPM) transitions
47h	Read Log DMA EXT	Efh/10h/06h	Enable Software Settings Preservation (SSP)
57h	Write Log DMA EXT	Efh/10h/07h	Enable Device Automatic Partial to Slumber transitions
60h	Read FPDMA Queued	Efh/10h/09h	Enable Device Sleep
61h	Write FPDMA Queued	Efh/55h	Disable read look-ahead
70h-7Fh	Seek	Efh/66h	Disable reverting to power-on defaults
90h	Execute Device Diagnostic	Efh/82h	Disable volatile write cache

Code	Description	Code	Description
91h	Initialize Device Parameters	Efh/85h	Disable the APM feature set
92h	Download Microcode	Efh/90h	Disable use of SATA feature set
93h	Download Microcode DMA	Efh/90h/02h	Disable DMA Setup FIS Auto-Activate optimization
B0h	SMART	Efh/90h/03h	Disable Device-initiated interface power state (DIPM) transitions
B0h/D0h	SMART READ DATA	Efh/90h/06h	Disable Software Settings Preservation (SSP)
B0h/D1h	SMART READ ATTRIBUTE THRESHOLDS	Efh/90h/07h	Disable Device Automatic Partial to Slumber transitions
B0h/D2h	SMART ENABLE/DISABLE ATTRIBUTE AUTOSAVE	Efh/90h/09h	Disable Device Sleep
B0h/D3h	SMART SAVE ATTRIBUTE VALUES	Efh/Aah	Enable read look-ahead
B0h/D4h	SMART EXECUTE OFF-LINE IMMEDIATE	Efh/CCh	Enable reverting to power-on defaults
B0h/D5h	SMART READ LOG	F1h	Security Set Password
B0h/D6h	SMART WRITE LOG	F2h	Security Unlock
B0h/D8h	SMART ENABLE OPERATIONS	F3h	Security Erase Prepare
B0h/D9h	SMART DISABLE OPERATIONS	F4h	Security Erase Unit
B0h/Dah	SMART RETURN STATUS	F5h	Security Freeze Lock
B0h/DBh	SMART ENABLE/DISABLE AUTOMATIC OFF-LINE	F6h	Security Disable Password
B1h	Device Configuration	F8h	Read Native Max Address
B4h	Sanitize	F9h	Set Max Address
C4h	Read Multiple	F9h/01h	SET MAX SET PASSWORD
C5h	Write Multiple	F9h/02h	SET MAXLOCK
C6h	Set Multiple Mode	F9h/03h	SET MAX UNLOCK
C8h	Read DMA	F9h/04h	SET MAX FREEZE LOCIK

5.2 Identify Device

Word	F/V	Default Value	Description
0	F	0040h	General configuration
1	X	XXXXh	Default number of cylinders
2	V	0000h	Reserved
3	X	00XXh	Default number of heads
4	X	0000h	Obsolete
5	X	0240h	Obsolete
6	F	XXXXh	Default number of sectors per track
7 - 8	V	XXXXh	Number of sectors per card (Word 7 = MSW, Word 8 = LSW)
9	X	0000h	Obsolete
10 - 19	F	XXXXh	Serial number in ASCII (Right justified)
20	X	0002h	Obsolete
21	X	0002h	Obsolete
22	X	0000h	Obsolete
23 - 26	F	XXXXh	Firmware revision in ASCII Big Endian Byte Order in Word
27 - 46	F	XXXXh	Model number in ASCII (Left justified) Big Endian Byte Order in Word
47	F	8001h	Maximum number of sectors on Read/Write Multiple command
48	F	0000h	Reserved
49	F	0F00h	Capabilities
50	F	4000h	Capabilities
51	F	0200h	PIO data transfer cycle timing mode
52	X	0000h	Obsolete
53	F	0007h	Field validity
54	X	XXXXh	Current numbers of cylinders
55	X	XXXXh	Current numbers of heads
56	X	XXXXh	Current sectors per track
57 - 58	X	XXXXh	Current capacity in sectors (LBAs) (Word 57 = LSW , Word 58 = MSW)
59	F	0101h	Multiple sector setting
60 - 61	F	XXXXh	Total number of user addressable logical sectors for 28-bit commands (DWord)



Word	F/V	Default Value	Description
62	X	0000h	Reserved
63	F	0207h	Multiword DMA transfer Supports MDMA mode 0, 1 and 2
64	F	0003h	Advanced PIO modes supported
65	F	0078h	Minimum Multiword DMA transfer cycle time per word
66	F	0078h	Recommended Multiword DMA transfer cycle time
67	F	0078h	Minimum PIO transfer cycle time without flow control
68	F	0078h	Minimum PIO transfer cycle time with IORDY flow control
69	F	4000h	Additional supported
70 - 74	F	0000h	Reserved
75	F	001Fh	Queue depth
76	F	070Eh	Serial ATA capabilities <ul style="list-style-type: none"> • Supports Serial ATA Gen3 • Supports Serial ATA Gen2 • Supports Serial ATA Gen1 • Supports Phy event counters log • Supports receipt of host initiated power management requests • Supports Native Command Queuing
77	F	0080h	Serial ATA additional capability <ul style="list-style-type: none"> • DevSleep to Reduced Power State
78	F	0148h	Serial ATA features supported <ul style="list-style-type: none"> • Supports Device Sleep • Supports software settings preservation
79	V	0040h	Reserved
80	F	03F0h	Major version number (ACS-2)
81	F	0000h	Minor version number
82	F	742Bh	Command sets supported 0
83	F	7500h	Command sets supported 1
84	F	4023h	Command sets supported 2
85 - 87	V	XXXXh	Command set/feature enabled
88	V	007Fh	Ultra DMA mode supported and selected
89	F	0003h	Time required for a Normal Erase mode Security Erase Unit command
90	F	0001h	Time required for an Enhanced Erase mode Security Erase Unit
91	V	0000h	Current advanced power management value
92	V	FFFEh	Master password identifier

Word	F/V	Default Value	Description
93 - 99	V	0000h	Reserved
100 - 103	V	XXXXh	Maximum user LBA for 48-bit address feature set
104	V	0000h	Reserved
105	F	0100h	Maximum number of 512-byte blocks per Data Set Management
106 - 127	V	0000h	Reserved
128	V	0001h	Security status
129 - 159	X	XXXXh	Vendor specific
160	F	0000h	Power requirement description
161	X	0000h	Reserved
162	F	0000h	Key management schemes supported
163	F	0000h	CF Advanced True IDE Timing mode capability and setting
164 - 168	V	0000h	Reserved
169	F	0001h	Data Set Management supported
170 - 216	V	XXXXh	Reserved
217	F	0001h	Non-rotating media (SSD)
218 - 221	X	0000h	Reserved
222	F	107Fh	Transport major revision (SATA Rev 3.1)
223 - 254	X	0000h	Reserved
255	X	XXXXh	Integrity word

Notes:

1. F = content (byte) is fixed and does not change.
2. V = content (byte) is variable and may change depending on the state of the device or the commands executed by the device.
3. X = content (byte) is vendor specific and may be fixed or variable.

5.3 Identify Device SMART Feature Set

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

If the reserved size is below the threshold, the status can be read from the Cylinder Register using the Return Status command (DAh).

5.4 SMART Data Feature

The following 512 bytes make up the device SMART data structure. Users can obtain the data using the “Read Data” command (D0h).

Byte	F / V	Description
0 - 1	X	Revision code
2 - 361	X	Vendor specific (see 4.3.2)
362	V	Off-line data collection status
363	X	Self-test execution status byte
364 - 365	V	Total time in seconds to complete off-line data collection activity
366	X	Vendor specific
367	F	Off-line data collection capability
368 - 369	F	SMART capability
370	F	Error logging capability <ul style="list-style-type: none"> • 7-1 Reserved • 0 1 = Device error logging supported
371	X	Vendor specific
372	F	Short self-test routine recommended polling time (in minutes)
373	F	Extended self-test routine recommended polling time (in minutes)
374	F	Conveyance self-test routine recommended polling time (in minutes)
375 - 385	R	Reserved
386 - 395	F	Firmware version/date code
396 - 399	F	Reserved
400 - 405	F	‘SM2246’
406 - 510	X	Vendor specific
511	V	Data structure checksum

5.5 SMART Attributes

The following table defines the vendor specific data in byte 2 to 361 of the 512-byte SMART data.

Attribute ID (hex)	Raw Attribute Value							Attribute Name
01	MSB	00	00	00	00	00	00	Read error rate
05	LSB	MSB	00	00	00	00	00	Reallocated sectors count
09	LSB			MSB	00	00	00	Power-on hours
0C	LSB			MSB	00	00	00	Power cycle count
A0	LSB			MSB	00	00	00	Uncorrectable sector count when read/write
A1	LSB	MSB	00	00	00	00	00	Number of valid spare block
A3	LSB	MSB	00	00	00	00	00	Number of initial invalid block
A4	LSB			MSB	00	00	00	Total erase count
A5	LSB			MSB	00	00	00	Maximum erase count
A6	LSB			MSB	00	00	00	Minimum erase count
A7	LSB			MSB	00	00	00	Average erase count
A8	LSB			MSB	00	00	00	Max erase count of spec
A9	LSB			MSB	00	00	00	Remain Life (percentage)
AF	LSB			MSB	00	00	00	Program fail count in worst die
B0	LSB	MSB	00	00	00	00	00	Erase fail count in worst die
B1	LSB			MSB	00	00	00	Total wear level count
B2	LSB	MSB	00	00	00	00	00	Runtime invalid block count
B5	LSB			MSB	00	00	00	Total program fail count
B6	LSB	MSB	00	00	00	00	00	Total erase fail count
BB	LSB			MSB	00	00	00	Uncorrectable error count
C0	LSB	MSB	00	00	00	00	00	Power-off retract count
C2	MSB	00	00	00	00	00	00	Controlled temperature
C3	LSB			MSB	00	00	00	Hardware ECC recovered
C4	LSB			MSB	00	00	00	Reallocation event count
C6	LSB			MSB	00	00	00	Uncorrectable error count off-line
C7	LSB	MSB	00	00	00	00	00	Ultra DMA CRC error count
E1	LSB						MSB	Total LBAs written (each write unit = 32MB)
E8	LSB	MSB	00	00	00	00	00	Available reserved space
F1	LSB						MSB	Total LBAs written (each write unit = 32MB)
F2	LSB						MSB	Total LBAs read (each read unit = 32MB)

6. Part No. Decoder

1	-	2	3	4	5	6	7	8	9	10
Product Line	-	Form Factor	Product Series	Cervoz Family Code (Bus / Internal Control)	NAND Flash	Flash Capacity	Flash Mode	Module Capacity	Operating Temp.	Customize Code
XXX	-	XX	X	XXX	X	X	X	XXXX	X	XX

1. Product Line

CIS	Cervoz Industrial SSD
CIM	Cervoz Industrial Memory Card
CIE	Cervoz Industrial Embedded Module

2. Form Factor

2S	2.5" SATA
2P	2.5" PATA
CF	CompactFlash
CA	CFast
MS	mSATA
HM	Half Size mSATA
HS	Half Slim
M4	M.2 2242
M6	M.2 2260
M8	M.2 2280
0V	PATA Disk 40pin Vertical
4V	PATA Disk 44pin Vertical
4L	PATA Disk 44pin Horizontal Left
7T	SATA Disk 7pin Vertical Tall
7S	SATA Disk 7pin Vertical Short
7L	SATA Disk 7pin Horizontal Left
7R	SATA Disk 7pin Horizontal Right

3. Product Series

S	Supreme Series (SLC)
R	Reliance Series (RO-MLC)
M	Momentum Series (MLC)
T	Titan Series (TLC)

4. Cervoz Family Code

Bus and Internal Control for Cervoz Product Families

5. NAND Flash

M	Micron
T	Toshiba

6. Flash Capacity

A	256Mb
B	512Mb

C	1Gb
D	2Gb
E	4Gb
F	8Gb
G	16Gb
H	32Gb
I	64Gb
J	128Gb
K	256Gb
L	512Gb
M	1Tb
N	2Tb
O	4Tb

7. Flash Mode

Internal Control for Flash Mode

8. Module Capacity

128M	128MB
256M	256MB
512M	512MB
001G	1GB
002G	2GB
004G	4GB
008G	8GB
016G	16GB
032G	32GB
064G	64GB
128G	128GB
256G	256GB
512G	512GB
001T	1TB
002T	2TB

9. Operating Temperature

S	Standard Grade (0~ +70°C)
W	Wide Temperature Grade (-40 ~ +85°C)

10. Customize Code

WP	Write Protect Function
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