Virtium
Solid State Storage and Memory

StorFly® M.2 Type 2280 Solid-State Drive

PCIe Gen3 x4 / NVMe 1.4 - Series 3 - Industrial

VTPM28CE

Datasheet - Rev. 1.0

1. Description

Virtium's StorFly Series 3 M.2 NVMe PCIe solid-state drive (SSD) technology is a performance-oriented solution designed for the unique storage demands and workload requirements of a broad range of industrial embedded systems, including communications equipment, industrial automation, medical imaging, transportation control, and data recorders where read and write demands are higher than typical boot or mixed workload solutions. StorFly Series 3 M.2 NVMe PCIe solid-state drives are mainstream productivity solutions designed to provide the ideal balance of power, performance, endurance, reliability, long ordering life, and cost all in a rugged industrial design suitable for environmental extremes.

Features

Capacity
- VTPM28CEXI: 40GB, 80GB, 160GB, 320GB
- VTPM28CECI: 120GB, 240GB, 480GB, 960GB

NAND: 3D TLC / pSLC

Sequential Performance[1]
- 128kB Sequential Read: up to 3,150 MB/s
- 128kB Sequential Write: up to 2,000 MB/s

Random Performance[1]
- 4kB IOPS Read: up to 170,000
- 4kB IOPS Write: up to 210,000

Power[1]: 3.3V±5%
- 128kB Sequential Read: 3.6 W
- 128kB Sequential Write: 3.1 W
- 4kB Random Read: 2.4 W
- 4kB Random Write: 2.2 W
- Idle: 1 W

Temperature Ranges
- Industrial: -40ºC to 85ºC
- Non-Operating: -40ºC to 85ºC

Reliability
- Advanced LDPC ECC
- MTBF: >2M hours

Endurance[1]
- JESD219A: 2,560 TBW
- Sequential: 9,750 TBW

vtGuard® Power Fail Protection
- Integrated power fail protection
- Preserves static data in the event of power failure
- Cache/buffer contents restored at power-on

SMART Attribute Reporting
- Monitors device health
- Anticipates and predicts failures

Mechanical Dimensions
- M.2 Type 2280-D2-M Form Factor
- Length x Width x Height mm (inches)
  80.00 (3.14) x 22.00 (0.866) x 2.20 (0.087)

Compliance
- PCIe Specification, Revision 3.1a
- NVMe Specification, Revision 1.4
- FCC, CE, UL, RoHS, WEEE

Environmental (Non-operating)
- Humidity (non-condensing): 5% to 95%
- Shock: 1500G, half-sine wave, 0.5ms duration
- Vibration: 20G, 20 Hz to 2000 Hz

Data Security
- Integrated AES-256 encryption (data-at-rest)
- Sanitize Block Erase
- TCG/Opal 2.0 compliant SEDs (Option)

(1)   Based on the VTPM28CEXI 320GB device

Electrostatic Discharge (ESD) can damage this device. When handling the device, always wear a grounded wrist strap and use a static dissipative surface.

Any damage to the unit that occurs after its removal from the shipping package and ESD protective bag is the responsibility of the user.

Part Numbering System

V T PM28CE X/C I xxx - yyyy

Where:	
V	= Virtium
T	= StorFly
PM28CE	= Form Factor / Interface: M.2 Type 2280-D2-M, NVMe / PCIe 3.1 High Performance Gen3 x4 NVMe 1.4
X/C	= Product Class: X = XE; C = CE
I	= Operating Temperature: I = Industrial (-40ºC to 85ºC)

xxx	= Capacity (1GB = 1,000,000,000 bytes)
	    040 = 40 GB
	    080 = 80 GB
	    120 = 120 GB
	    160 = 160 GB
	    240 = 240 GB
	    320 = 320 GB
	    480 = 480 GB
	    960 = 960 GB

yyyy	= Virtium Proprietary

Order Information for Generic Parts

Part Number	Capacity (GB)	Product Class	NAND	Operating Temperature	From Factor	Interface /Protocol
VTPM28CEXI040-0011	40	XE	pSLC	-40ºC to 85ºC	M.2 2280-D2-M	PCIe/NVMe
VTPM28CEXI080-0011	80	XE	pSLC	-40ºC to 85ºC	M.2 2280-D2-M	PCIe/NVMe
VTPM28CEXI160-0011	160	XE	pSLC	-40ºC to 85ºC	M.2 2280-D2-M	PCIe/NVMe
VTPM28CEXI320-0011	320	XE	pSLC	-40ºC to 85ºC	M.2 2280-D2-M	PCIe/NVMe
VTPM28CECI120-0011	120	CE	3D TLC	-40ºC to 85ºC	M.2 2280-D2-M	PCIe/NVMe
VTPM28CECI240-0011	240	CE	3D TLC	-40ºC to 85ºC	M.2 2280-D2-M	PCIe/NVMe
VTPM28CECI480-0011	480	CE	3D TLC	-40ºC to 85ºC	M.2 2280-D2-M	PCIe/NVMe
VTPM28CECI960-0011	960	CE	3D TLC	-40ºC to 85ºC	M.2 2280-D2-M	PCIe/NVMe

2. Revision History

Date	Revision	Page(s)	Description
12/06/2022	0.01	All	Preliminary
12/19/2022	0.02	All	Add Table of contents Remove 20GB, 60GB Update performance, endurance and power consumption for all capacities. Remove '' Crypto Erase'' , add '' Sanitize Block Erase''
01/24/2022	0.03	5	Update the User-Addressable Capacity of 160GB device
02/13/2023	0.04	10,11	Update tables : Admin command set, I/O command set, Feature command set, Log pages
02/17/2023	1.0	All	Updated to the latest Format, added addendum, updated section 6 Final Release

Table of Contents

3. Specifications

Capacity

Unformatted Capacity (GB)[1]	User-Addressable LBA[2]	User-Addressable Capacity (Bytes)
40	78,161,328	40,018,599,936
80	156,301,488	80,026,361,856
120	234,441,648	120,234,441,648
160	312,581,808	160,041,885,696
240	468,862,128	240,057,409,536
320	625,142,448	320,072,933,376
480	937,703,088	480,103,981,056
960	1,875,385,008	960,197,124,096

(1) 1GB = 1,000,000,000 bytes. LBA: Logical Block Address; Logical Block Size = 512 Bytes/1 Sector.
(2) LBA: Logical Block Address; Logical Block Size = 512 Bytes/1 Sector.

Performance

Capacity (GB)	Performance Throughput[1] 128kB File, Queue Depth (QD) = 64		IOPS[1] 4kB File, Queue Depth (QD) = 64	
	Sequential Read MB/s	Sequential Write MB/s	100% Random Read	100% Random Write
VTPM28CEXIxxx-yyyy				
40	1,350	650	43,500	140,000
80	2,750	1,300	85,000	270,000
160	3,050	2,000	165,000	285,000
320	3,150	2,000	170,000	210,000
VTPM28CECIxxx-yyyy				
120	1,350	650	43,500	140,000
240	2,750	1,300	85,000	270,000
480	3,050	2,000	165,000	285,000
960	3,150	2,000	170,000	290,000

(1) Performance is based on fresh out-of-box condition formatted with NTFS filesystem and running CrystalDiskMark 8.0.0 with file size 1024MB. Actual results may vary depending on file system, workload, and SSD condition.

Power Consumption - 3.3V Supply

Capacity (GB)	Sequential Read[1] 128kB, QD = 64	Sequential Write[1] 128kB, QD = 64	Random Read[1] 4kB, QD = 64	Random Write[1] 4kB, QD = 64	Idle	Unit
VTPM28CEXIxxx-yyyy						
40	2.20	1.80	1.50	1.55	1.0	W
80	3.30	2.50	1.70	1.80	1.0	W
160	3.50	3.10	2.15	1.90	1.0	W
320	3.60	3.10	2.40	2.20	1.0	W
VTPM28CECIxxx-yyyy						
120	2.20	1.80	1.50	1.55	1.0	W
240	2.50	2.00	1.70	1.80	1.0	W
480	3.50	3.10	2.15	1.90	1.0	W
960	3.60	3.10	2.40	2.20	1.0	W

(1) Power consumption tests were done using Oakgate test system at 25ºC

Temperature and Humidity

Part Number	Operating Temperature	Non-Operating [1] Temperature	Humidity (Non-Condensing)
VTPM28CEXIxxx-yyyy	-40ºC to 85ºC	-40ºC to 85ºC	5% to 95%
VTPM28CECIxxx-yyyy	-40ºC to 85ºC	-40ºC to 85ºC	5% to 95%
(1) Maximum non-operating temperature assumes data is stored on the SSD. Temperatures above 85ºC are beyond NAND specification for data retention. Please see *Temperature Considerations for Industrial Embedded SSDs* whitepaper under the industrial SSD section of Virtium website (Virtium.com)			

Shock and Vibration

Reliability	Test Conditions	Reference Standards
Shock	1500G, half-sine wave, 0.5ms duration	JESD22-B110B.01
Vibration	20G, 20 Hz to 2000 Hz	JESD22-B103B.01

Interface

Interface	PCI Express Base Specification Rev 3.1a
Protocal	NVM Express Revision 1.4

4. Reliability

Endurance

VTPM28CEXIxxx-yyyy				
Capacity (GB)	JESD218A[1] & JESD219 Enterprise Workloads		100% Sequential Workloads	
	Total Bytes Written TBW (TB)	Drive Writes per day (5 years)	Total Bytes Written TBW (TB)	Drive Writes per day (5 years)
40	300	4.11	1,200	16.43
80	640	4.38	2,440	16.71
160	1,280	4.38	4,850	16.61
320	2,560	4.38	9,750	16.69
(1) JESD218A assumes an active temperature at 55ºC and a retention temperature at 40ºC				

VTPM28CECIxxx-yyyy				
Capacity (GB)	JESD218A[1] & JESD219 Enterprise Workloads		100% Sequential Workloads	
	Total Bytes Written TBW (TB)	Drive Writes per day (3 years)	Total Bytes Written TBW (TB)	Drive Writes per day (3 years)
120	96	0.73	360	2.74
240	192	0.73	730	2.78
480	384	0.73	1,460	2.78
960	768	0.73	2,920	2.78
(1) JESD218A assumes an active temperature at 55ºC and a retention temperature at 40ºC				

Mean Time Between Failures (MTBF)

The SSD achieves a MTBF of greater than 2,000,000 hours predicted and is derived from the component reliability data using Telcordia SR-332 methods at 40ºC and tested under standard environmental operating conditions.

## vtGuard® Power-Fail Protection

vtGuard is an integrated power failure protection technology that will preserve data on the SSD if a sudden power failure should occur. It will also transfer the write cache (metadata, mapping tables) contents to the non-volatile flash and restore the contents upon power restoration. This data will be preserved regardless of the duration of the power failure event. This technology also ensures that the SSD will be recoverable after sudden power failure events although a rebuild of the mapping tables may delay readiness of the SSD on the ensuing power cycle on larger capacities.

# 5. Physical Specifications

Pin Layout / Assignments

Pin	Signal	Description	Pin	Signal	Description
1	CONFIG_3	Ground	2	3.3V	3.3V Source
3	GND	Ground	4	3.3V	3.3V Source
5	PETn3	PCIe Lane 3 Tx-	6	N/C	No Connect
7	PETp3	PCIe Lane 3 Tx+	8	N/C	No Connect
9	GND	Ground	10	LED1#	Device Active Signal#
11	PERn3	PCIe Lane 3 Rx-	12	3.3V	3.3V Source
13	PERp3	PCIe Lane 3 Rx+	14	3.3V	3.3V Source
15	GND	Ground	16	3.3V	3.3V Source
17	PETn2	PCIe Lane 2 Tx-	16	3.3V	3.3V Source
19	PETp2	PCIe Lane 2 Tx+	20	N/C	No Connect
21	CONFIG_0	Ground	22	N/C	No Connect
23	PERn2	PCIe Lane 2 Rx-	24	N/C	No Connect
25	PERp2	PCIe Lane 2 Rx+	26	N/C	No Connect
27	GND	Ground	28	N/C	No Connect
29	PETn1	PCIe Lane 1 Tx-	30	N/C	No Connect
31	PETp1	PCIe Lane 1 Tx+	32	N/C	No Connect
33	GND	Ground	34	N/C	No Connect
35	PERn1	PCIe Lane 1 Rx-	36	N/C	No Connect
37	PERp1	PCIe Lane 1 Rx+	38	DEVSLP	No Connect
39	GND	Ground	40	N/C	No Connect
41	PETn0	PCIe Lane 0 Tx-	42	N/C	No Connect
43	PETp0	PCIe Lane 0 Tx+	44	N/C	No Connect
45	GND	Ground	46	N/C	No Connect
47	PERn0	PCIe Lane 0 Rx-	48	N/C	No Connect
49	PERp0	PCIe Lane 0 Rx+	50	PERST#	PCIe Reset#
51	GND	Ground	52	CLKREQ#	PCIe Device Clock Request#
53	REFCLKN	PCIe Reference Clock-	54	PEWake#	No Connect
55	REFCLKP	PCIe Reference Clock+	56	N/C	No Connect
57	GND	Ground	58	N/C	No Connect
Key			**Key**		
67	N/C	No Connect	68	SUSCLK	No Connect
69	CONFIG_1	No Connect	70	3.3V	3.3V Source
71	GND	Ground	72	3.3V	3.3V Source
73	GND	Ground	74	3.3V	3.3V Source
75	CONFIG_2	Ground	-	-	-
Note: Pins 59 - 66 are displaced by the connector key.					
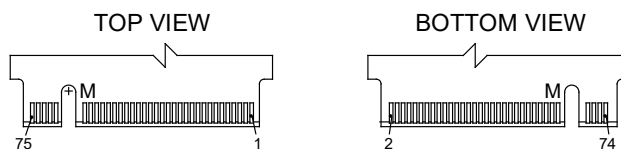
Pin Layout

Mechanical Dimensions

TOP VIEW

BOTTOM VIEW

Detail X
Scale 5:1

Detail Y
Scale 5:1
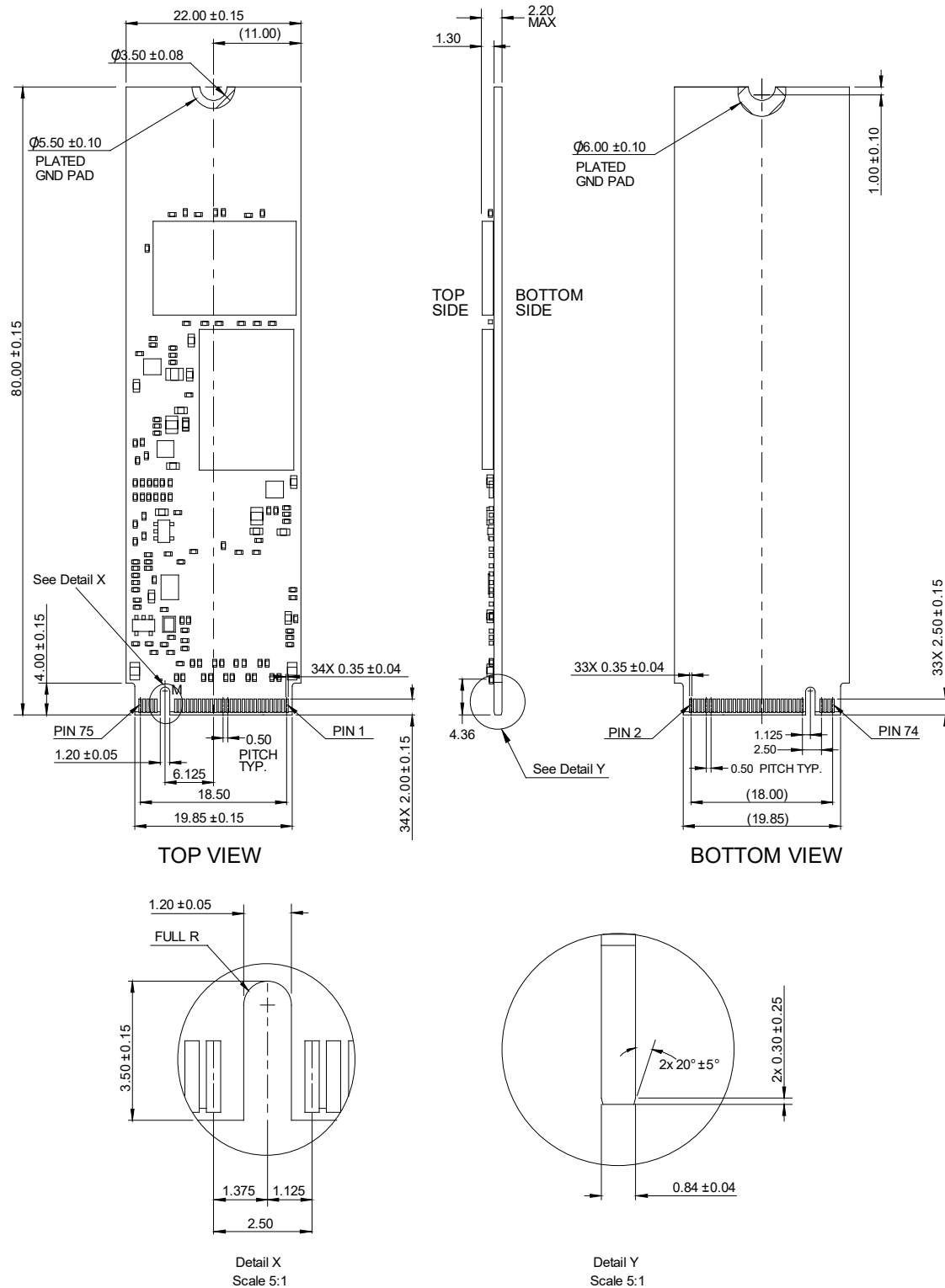
Note:

1. All dimensions are in millimeters
2. The dimensional diagram is for reference only
3. All components show as placed but actual placement will be based on product configuration

6. NVMe Command Set Specifications

Introduction

NVM Express, or NVMe, is a register level interface that is intended to simplify the configuration of NVMe devices. The standard is comprised of various terms that are important to know when implementing NVMe devices.

Note: This section is intended for informational purposes and presents an overview of the NVMe command set specification. The user should consult the cited NVMe Specification, Revision 1.4 for details.

Admin Command Set

Opcode (Hex)	Command
0x00	NVME_DEL_IO_SUBMISSION_QUEUE
0x01	NVME_CRT_IO_SUBMISSION_QUEUE
0x02	NVME_GET_LOG_PAGE
0x04	NVME_DEL_IO_COMPLETION_QUEUE
0x05	NVME_CRT_IO_COMPLETION_QUEUE
0x06	NVME_IDENTIFY
0x08	NVME_ABORT
0x09	NVME_GET_FEATURES
0x0A	NVME_SET_FEATURES
0x0C	NVME_ASYN_EVENT_REQUEST
0x10	NVME_FIRMWARE_ACTIVE
0x11	NVME_FIRMWARE_DOWNLOAD
0x14	NVME_DEVICE_SELF_TEST
0x18	NVME_KEEP_ALIVE
0x80	NVME_FORMAT_NVME
0x81	NVME_SECURITY_SEND
0x82	NVME_SECURITY_RECEIVE

NVMe I/O Command Set

Opcode (Hex)	Command
0x00	NVME_IO_FLUSH
0x01	NVME_IO_WRITE
0x02	NVME_IO_READ
0x08	NVME_IO_WRITE_ZEROS
0x09	NVME_IO_DATASET_MANAGEMENT

NVMe Feature Command Set

Opcode (Hex)	Command
0x01	FEATURE_ARBITRATION
0x02	FEATURE_PWR_MANAGEMENT
0x04	FEATURE_TEMPERATURE_THRESHOLD
0x05	FEATURE_ERR_RECOVERY
0x06	FEATURE_VOLATILE_WRITE_CACHE
0x07	FEATURE_NUM_OF_QUEUES
0x08	FEATURE_INT_COALESCING
0x09	FEATURE_INT_VECTOR_CONFIG
0x0A	FEATURE_WRITE_ATOMICITY
0x0B	FEATURE_ASYN_EVENT_CONFIG
0x0C	FEATURE_AUTO_PWR_STATE_TRANS
0x0D	FEATURE_HOST_MEMORY_BUFFER
0x0E	FEATURE_TIMESTAMP
0x0F	FEATURE_KEEP_ALIVE_TIMER
0x10	FEATURE_HOST_CONTROL_THERMAL_MANAGE
0x11	FEATURE_NON_OPERA_PS_CONFIG
0xD8	FEATURE_NVME_SYSTEM_CRASH_PROTECTION

NVMe Log Pages

Opcode (Hex)	Command
0x01	LOG_ERR_INFO
0x02	LOG_SMART_HEALTH_INFO
0x03	LOG_FW_SLOT_INFO
0x05	LOG_CMD_EFFECTS
0X06	LOG_DEVICE_SELF_TEST
0x81	LOG_SANITIZE_STATUS (FW Version)

SMART / Health Log Information

Bytes	Description
0	**Critical Warning:** This field indicates critical warnings for the state of the controller. Each bit corresponds to a critical warning type; multiple bits may be set. If a bit is cleared to '0', then that critical warning does not apply. Critical warnings may result in an asynchronous event notification to the host. Bits in this field represent the current associated state and are not persistent. <table><tr><th>Bit</th><th>Definition</th></tr><tr><td>0</td><td>If set to '1', then the available spare space has fallen below the threshold.</td></tr><tr><td>1</td><td>If set to '1', then a temperature is above an over temperature threshold or below an under temperature threshold (refer to section 5.21.1.4).</td></tr><tr><td>2</td><td>If set to '1', then the NVM subsystem reliability has been degraded due to significant media related errors or any internal error that degrades NVM subsystem reliability.</td></tr><tr><td>3</td><td>If set to '1', then the media has been placed in read only mode.</td></tr><tr><td>4</td><td>If set to '1', then the volatile memory backup device has failed. This field is only valid if the controller has a volatile memory backup solution.</td></tr><tr><td>7:5</td><td>Reserved</td></tr></table>
2:1	**Composite Temperature:** Contains a value corresponding to a temperature in degrees Kelvin that represents the current composite temperature of the controller and namespace(s) associated with that controller. The manner in which this value is computed is implementation specific and may not represent the actual temperature of any physical point in the NVM subsystem.
3	**Available Spare:** Contains a normalized percentage (0 to 100%) of the remaining spare capacity available.
4	**Available Spare Threshold:** When the Available Spare falls below the threshold indicated in this field, an asynchronous event completion may occur. The value is indicated as a normalized percentage (0 to 100%).
5	**Percentage Used: T**he percentage of NVM subsystem life used based on the actual usage and the prediction of NVM life. A value of 100 indicates that the estimated endurance of the NVM in the NVM subsystem has been consumed, but may not indicate an NVM subsystem failure. The value is allowed to exceed 100. Percentages greater than 254 shall be represented as 255. This value shall be updated once per power-on hour (when the controller is not in a sleep state).
31:6	**Reserved**
47:32	**Data Units Read:** Contains the number of 512 byte data units the host has read from the controller; this value does not include metadata. This value is reported in thousands (i.e., a value of 1 corresponds to 1000 units of 512 bytes read) and is rounded up. When the LBA size is a value other than 512 bytes, the controller shall convert the amount of data read to 512 byte units.
63:48	**Data Units Written:** Contains the number of 512 byte data units the host has written to the controller; this value does not include metadata. This value is reported in thousands (i.e., a value of 1 corresponds to 1000 units of 512 bytes written) and is rounded up. When the LBA size is a value other than 512 bytes, the controller shall convert the amount of data written to 512 byte units.
79:64	**Host Read Commands:** Contains the number of read commands completed by the controller.
95:80	**Host Write Commands:** Contains the number of write commands completed by the controller.
111:96	**Controller Busy Time:** Contains the amount of time the controller is busy with I/O commands. The controller is busy when there is a command outstanding to an I/O Queue (specifically, a command was issued via an I/O Submission Queue Tail doorbell write and the corresponding completion queue entry has not been posted yet to the associated I/O Completion Queue). This value is reported in minutes.
127:112	**Power Cycles:** Contains the number of power cycles.
143:128	**Power On Hours:** Contains the number of power-on hours. This may not include time that the controller was powered and in a non-operational power state.
159:144	**Unsafe Shutdowns:** Contains the number of unsafe shutdowns. This count is incremented when a shutdown notification (CC.SHN) is not received prior to loss of power.
175:160	**Media and Data Integrity Errors:** Contains the number of occurrences where the controller detected an unrecovered data integrity error. Errors such as uncorrectable ECC, CRC checksum failure, or LBA tag mismatch are included in this field.
191:176	**Number of Error Information Log Entries:** Contains the number of Error Information log entries over the life of the controller.

7. Industry Standards

Reference Title	Date / Revision	Location
NVMe	NVMe 1.4	NVM Express Working Group. NVM Express (NVMe) Specification, Revision 1.4, May 1, 2017. http://www.nvmexpress.org.
PCI-SIG	Revision 3.1a	PCI Express Base Specification, Revision 3.1a, December 7, 2015. https://pcisig.com/
PCI-SIG	Revision 1.1	PCI Express M.2 Specification, Revision 1.1, December 15, 2016. https://pcisig.com/
JEDEC	JESD22-B110B.01	Mechanical Shock – Device and Subassembly, Revision of JESD22-B110B, June 2019, http://www.jedec.org
JEDEC	JESD22-B103B.01	Vibration, Variable Frequency, Minor revision to JESD22-B103-B, September 2016, http://www.jedec.org
JEDEC	JESD218A	Solid-State Drive (SSD) Requirements and Endurance Test Method, February 2011, http://www.jedec.org
JEDEC	JESD219	Solid-State Drive (SSD) Endurance Workloads, September 2010, http://www.jedec.org

8. Certifications and Compliance

Compliance / Certification	Description
CE and FCC Compliant	Class: FCC Part 15 Subpart B Class B:2011 Declaration of Conformity registration No. STE120607699
RoHS Compliant	Restriction of Hazardous Substance Directive
UL Certified	Underwriters Laboratories, Inc. 94V-0
WEEE Certified	Waste, Electrical and Electronic Equipment Directive

9. Contact Information

Corporate Headquarters and Manufacturing Location:
30052 Tomas, Rancho Santa Margarita, CA 92688 USA

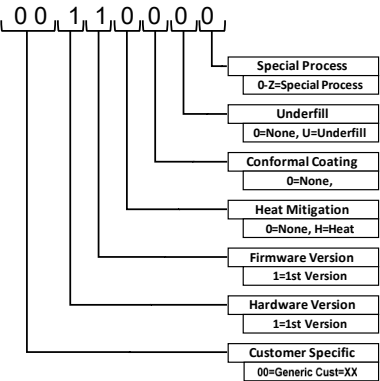|	
Main Website:	www.virtium.com
Contacts / Sales:	http://www.virtium.com/contacts-sales/
Toll Free:	(888) VIRTIUM / (888) 847.8486
Telephone:	+1 (949) 888.2444
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Customer Support	custserv@virtium.com
	https://www.linkedin.com/company/virtium/mycompany/
	https://twitter.com/Virtium
	https://www.facebook.com/virtium

10.   ADDENDUM Deviations from Generic Product

Product Name: Virtium

Customer Name: Virtium Generic

Requested Changes to Generic Product: None

- These are standard parts, no changes requested

```
0 0  1 1 0 0 0 0
```

Special Process	
0-Z=Special Process	
Underfill	
0=None, U=Underfill	
Conformal Coating	
0=None,	
Heat Mitigation	
0=None, H=Heat	
Firmware Version	
1=1st Version	
Hardware Version	
1=1st Version	
Customer Specific	
00=Generic Cust=XX	

Part Number	VTPM28CECIxxx-0011	Additional Notes: N/A
Part Number	VTPM28CEXIxxx-0011	Additional Notes: N/A

Virtium is a leading designer and manufacturer of industrial-grade SSD Storage and Memory Module solutions. Our 25+ years of successful innovation, high-quality production, and customer commitment, differentiate us from our competitors and have earned us many notable customers service awards. Virtium solutions offer many benefits to our customers, including high-volume production of the most reliable industrial-grade solid-state drives and memory modules with the greatest durability, highest consistency, and extended product life beyond the fast-moving industry changes - our product availability is up to 10 years. Virtium has consistently provided product solutions to the world's largest Networking, Telecom, Industrial OEM, and other key industries that require the highest levels of data-storage integrity. We design, manufacture and support our products in the USA