DELKIN DEVICES®

M.2 2280
PCIe Industrial
Solid State Drive

Engineering Specification

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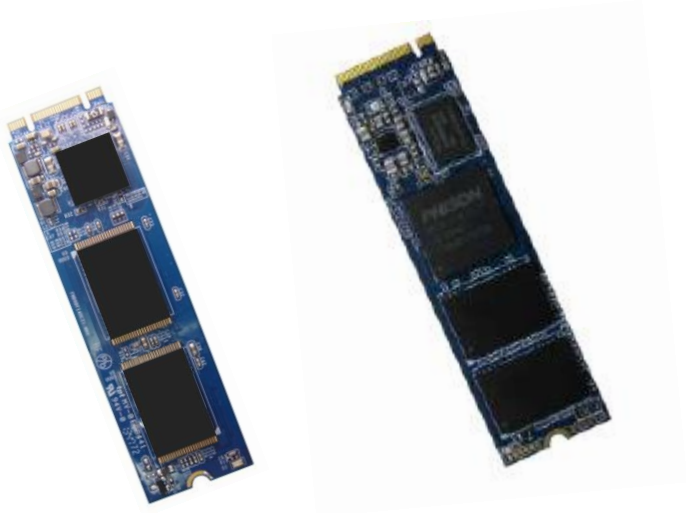
Revision: D



Product Overview

- **Capacity**
  - 128GB up to 1TB
- **Form Factor**
  - M.2 2280 D2 B+ M (128GB-512GB)
  - M.2 2280-D2-M (1TB)
- **PCIe Interface**
  - NVMe PCIe Gen 3 x 2 (128GB-512GB)
  - NVMe PCIe Gen 3 x 4 (1TB)
- **Compliance**
  - NVMe 1.3
  - PCI Express Base 3.1
- **Flash Interface**
  - Flash type: 3D TLC
- **Performance[1]**
  - Read: up to 2600 MB/s
  - Write: up to 1000 MB/s
- **Reliability**
  - Mean Time Between Failure (MTBF) More than 2,000,000 hrs
  - Uncorrectable Bit Error Rate (UBER) < 1 sector per 1016 bits read
- **Temperature Range[2]**
  - Operation: -40°C ~ 85°C
  - Storage: -40°C ~ 85°C
- **Features**
  - Static and Dynamic Wear Leveling
  - Bad Block Management
  - TRIM
  - SMART
  - Over-Provisioning
  - Firmware Update Capability
- **Power Management**
  - Support APST
  - Support ASPM
  - Support L1.2
- **Power Consumption[3]**
  - Active mode: < 1,620 mW
  - Idle mode: < 325 mW
- **RoHS compliant**
- **Features Support List:**
  - End to end data path protection
  - Thermal throttling
  - SmartECC™
  - SmartRefresh™
  - Drive log

Notes:

1. Refer to Chapter 2 for more details
2. Temperature is measured by SMART temperature. Active airflow is recommended within the system for maintaining proper device operating temperature on heavier workloads.

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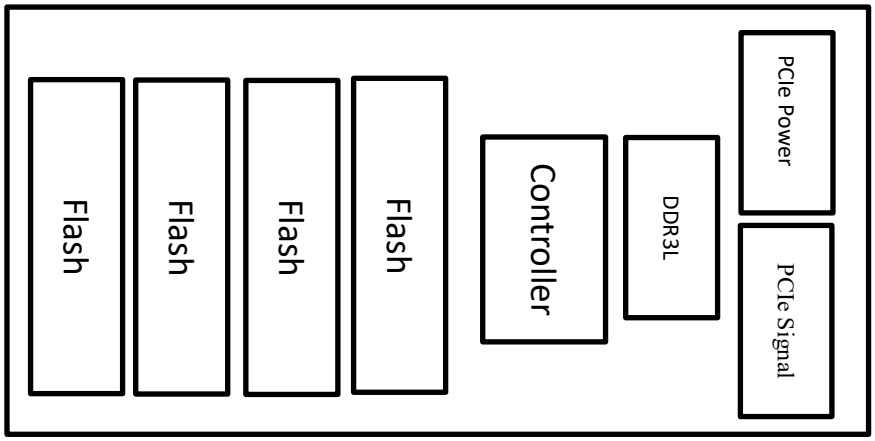
1. INTRODUCTION

1.1. General Description

Delkin Devices' M.2 2280 Industrial 3D TLC Solid State Drive (SSD) delivers all the advantages of flash disk technology with the performance of the Serial ATA III interface and is fully compliant with the standard Next Generation Form Factor (NGFF) or M.2. The Delkin M.2 is available in capacity range of 128GB to 1TB and can reach up to 1600 MB/s read, and 1000 MB/s write.

1.2. Product Block Diagram



Front Side

Figure 1-1 Product Block Diagram

1.3. Flash Management

1.3.1. Error Correction Code (ECC)

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, Delkin's M.2 2280 SSD utilizes a StongECC™ (SECC) algorithm, which can detect and correct data errors to ensure being read correctly and protects data from corruption.

1.3.2. Wear Leveling

NAND flash devices can only undergo a limited number of program/erase cycles, and in most cases, the flash media are not used evenly. If some areas are updated more frequently than others, the lifetime of the device would be reduced significantly. Thus, Wear Leveling is applied to extend the

lifespan of NAND flash by evenly distributing write and erase cycles across the media.

Delkin utilizes advanced Wear Leveling algorithms, which can efficiently distribute flash usage through the whole flash media area. Moreover, by implementing both dynamic and static Wear Leveling algorithms, the life expectancy of the NAND flash is greatly improved.

1.3.3. Bad Block Management

Bad blocks are blocks that include one or more invalid bits, and their reliability is not guaranteed. Blocks that are identified and marked as bad by the manufacturer are referred to as “Initial Bad Blocks”. Bad blocks that are developed during usage of the flash are named “Later Bad Blocks”. Delkin implements an efficient bad block management algorithm to detect the factory-produced bad blocks and manages any bad blocks that appear with use. This practice further prevents data being stored into bad blocks and improves data reliability.

1.3.4. TRIM

TRIM is a feature which helps improve the read/write performance and speed of solid-state drives (SSD). Unlike hard disk drives (HDD), SSDs are not able to overwrite existing data, so the available space gradually becomes smaller with each use. With the TRIM command, the operating system can inform the SSD which blocks of data are no longer in use and can be removed permanently. Thus, the SSD will perform an erase action, which prevents unused data from occupying blocks.

1.3.5. SMART

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is an open standard that allows a drive to automatically detect its health and report potential failures. When a failure is recorded by SMART, users can choose to replace the drive to prevent unexpected outage or data loss. Moreover, SMART can inform users of impending failures while there is still time to perform proactive actions, such as copy data to another device.

1.3.6. Over-Provisioning

Over Provisioning refers to the inclusion of extra NAND capacity in a SSD, which is not visible or usable by users. With Over Provisioning, the performance and IOPS (Input/Output Operations per Second) are improved by providing the controller additional space to manage P/E cycles, which enhances the reliability and endurance as well. Moreover, the write amplification of the SSD becomes lower when the controller writes data to the flash.

1.3.7. Firmware Upgrades

Firmware can be considered as a set of instructions on how the device communicates with the host. Firmware can be upgraded when new features are added, compatibility issues are fixed, or read/write performance gets improved, as controlled by the user. It is possible to update firmware in the field, however, there are important factors to consider before attempting a firmware upgrade. Contact Delkin technical support for more information.

1.3.8. Thermal Throttling

The purpose of thermal throttling is to prevent any components in a SSD from over-heating during read and write operations. Delkin's Controller is designed with an on-die thermal sensor, and with, firmware can provide different levels of throttling to achieve protection efficiently and proactively via SMART reading.

1.4. Advanced Device Security Features

1.4.1. Secure Erase

Secure Erase is a standard ATA command and will write "0xFF" to all cells, to fully wipe all the data on hard drives and SSDs. When this command is issued, the SSD controller will erase its storage blocks and return to its factory default settings.

1.5. SSD Lifetime Management

1.5.1. Terabytes Written (TBW)

TBW (Terabytes Written) is a measurement of SSDs' expected lifespan, which represents the amount of data written to the device. To calculate the TBW of a SSD, the following equation is applied:

TBW = [(NAND Endurance) x (SSD Capacity) x (WLE)] / WAF

NAND Endurance: NAND endurance refers to the P/E (Program/Erase) cycle rating of NAND flash, per the manufacturer's specification.

SSD Capacity: The SSD capacity is the specific capacity in total of a SSD.

WLE: Wear Leveling Efficiency (WLE) represents the ratio of the average amount of erases on all the blocks to the erases on any block at maximum.

WAF: Write Amplification Factor (WAF) is a numerical value representing the ratio between the amount of data that a SSD controller writes to the flash and the amount of data that the host's flash controller writes. A better WAF, which is near 1, guarantees better endurance and lower frequency of data written to flash memory.

1.6. An Adaptive Approach to Performance Tuning

1.6.1. Throughput

Based on the available space of the disk, Delkin SSD controller will regulate the read/write speed and manage the throughput performance. When significant free space remains, the firmware will continuously perform read/write activity. At this stage, there is still no need to implement garbage collection to allocate and release memory, which will accelerate read/write processing to improve the performance. However, when free space is used up, the controller will slow down the read/write processing, and implement garbage collection to release memory blocks. Hence, read/write performance will become slower.

1.6.2. Predict & Fetch

Normally, when the host tries to read data from the SSD, the SSD will only perform one read action after receiving one command. However, Delkin's controller applies ***Predict & Fetch*** to improve the read speed. When the host issues sequential read commands to the SSD, the SSD will automatically expect that the following will also be read commands. Thus, before receiving the next command, flash has already prepared the data. Accordingly, this accelerates the data processing time, and the host does not need to wait as long to receive data.

2. PRODUCT SPECIFICATIONS

- ## Capacity
  - From 128GB up to 1TB

- ## Electrical/Physical Interface
  - PCIe Interface
    - Compliant with NVMe 1.3
    - PCIe Express Base Ver 3.1
    - PCIe Gen 3 x 2 lane & backward compatible to PCIe Gen 2 and Gen 1
    - Support up to QD 128 with queue depth of up to 64K
    - Supports power management

- ## ECC Scheme
  - StrongECC™ (SECC) of ECC algorithm

- ## Supports SMART and TRIM commands

- ## Performance

Capacity	Sequential Performance	
	CrystalDiskMark	
	Read (MB/s)	Write (MB/s)
128GB	1500	450
256GB	1600	850
512GB	1600	1000
1TB	2600	1000

Notes:

1. Performance is measured with the following conditions
   a. CrystalDiskMark 5.1.2, 1GB range, QD=32, Thread=1
   b. IOMeter, 8GB range, 4K data size, QD=32 (3) ATTO, transfer Size 8192 KB
2. Performance may vary with host platform.
3. Table above is for reference only.

- ## Endurance - TBW (Terabytes Written)

Capacity	TBW
128GB	>100
256GB	>200
512GB	>400
1TB	>900

NOTES:

1. Many factors affect drive endurance / TBW, including flash configuration, SDR configuration, host platform, usage model, write amplification factor, etc. The figures above are estimates and are not guarantees. The test followed JEDEC219A client endurance workload

- ## Part Numbers

M.2 2280 Industrial TLC SSD
Industrial Temperature (-40 to 85°C)

Capacity	Part Number
128GB	MB1HFRCFD-80000-2
256GB	MB2HFRCFD-80000-2
512GB	MB5HFQXFD-80000-2
1TB	MB1TFRAGA-80000-2

3. ENVIRONMENTAL SPECIFICATIONS

3.1. Environmental Conditions

3.1.1. Temperature and Humidity

- Temperature:
  - Storage: -40°C to 85°C
  - Operational: -40°C to 85°C

- Humidity:
  - RH 95% under 55°C (operational)

3.1.2. Shock & Vibration

- Shock Specification
  - 1500G, 0.5ms duration

- Vibration Specification
  - 20Hz ~80Hz/1.52mm displacement, 80Hz~2000Hz / 20G Acceleration, 3 axes

3.1.3. Electrostatic Discharge (ESD)

- +/- 4KV

3.1.4. EMI Compliance

- EN 55032, CISPR 32(CE)
- AS/NZS CISPR 32(CE)
- ANSI C63.4 (FCC)
- VCCI-CISPR 32 (VCCI)
- CNS 13438 (BSMI)

3.2. MTBF

MTBF, an acronym for Mean Time Between Failures, is a measure of a device's reliability. Its value represents the average time between a repair and the next failure. The measure is typically in units of hours. The higher the MTBF value, the higher the reliability of the device.

3.3. Certification & Compliance

- RoHS
- WHQL
- PCI Express Base 3.1
- UNH-IOL NVM Express Logo
- WARNING: This product may contain chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to www.p65warnings.ca.gov.

4. ELECTRICAL SPECIFICATIONS

4.1. Supply Voltage

Table 4-1 Supply Voltage

Parameter	Rating
Operating Voltage	Min = 3.14V Max = 3.47 V
Rise Time (Max/min)	100ms / 0.1ms
Fall Time (Max/min)	5s / 1ms
Min. Off Time[1]	1 s

NOTE:

1. Minimum time between power removed from SSD (Vcc < 100 mW) and power re-applied to the drive.

4.2. Power Consumption

Table 4-2 Power Consumption

Capacity	Read (Max)	Write (Max)	Read (Avg.)	Write (Avg.)
128GB	2900	2200	2800	2200
256GB	3300	2800	3200	2700
512GB	3500	3000	3400	2900
1TB	5000	4700	5000	5100

Unit: mW

NOTES:

a. Use CrystalDiskMark 5.1.2 with the setting of 1000MB. Sequentially read and write the disk for 5 times, and measure power consumption during sequential Read [1/5]~[5/5] or sequential Write [1/5]~[5/5]

b. Power Consumption may differ according to platform.

c. The measured power voltage is 3.3V.

5. INTERFACE

5.1. Pin Assignment and Descriptions

Table 5-1 defines the signal assignment of the internal NGFF connector for SSD usage, described in the PCI Express M.2 Specification, version 1.0 of the PCI-SIG.

Table 5-1 Pin Assignment and Descriptions for M.2

Pin #	PCIe Pin	Description
1	GND	CONFIG_3 = GND
2	3.3V	3.3V source
3	GND	Ground
4	3.3V	3.3V source
5	N/C	No Connect
6	N/C	No Connect
7	N/C	No Connect
8	N/C	No Connect
9	N/C	No Connect or Ground
10	LED1#	These signals are used to allow the add-in card to provide status indicators via LED devices that will be provided by the system. Behavior: Command in: ● 2Hz on/off cycle = blinking 2Hz (=250ms on / 250ms off time) No command: ● set low
11	N/C	No Connect
12	Module Key B	Module Key
13	Module Key B	Module Key
14	Module Key B	Module Key
15	Module Key B	Module Key
16	Module Key B	Module Key
17	Module Key B	Module Key
18	Module Key B	Module Key
19	Module Key B	Module Key
20	N/C	No Connect
21	GND	Ground

22	N/C	No Connect
23	N/C	No Connect
24	N/C	No Connect
25	N/C	No Connect
26	N/C	No Connect
27	GND	Ground
28	N/C	No Connect
29	PETn1	PCIe TX Differential signal defined by the PCI Express M.2 spec
30	N/C	No Connect
31	PETn1	PCIe TX Differential signal defined by the PCI Express M.2 spec
32	N/C	No Connect
33	GND	Ground
34	N/C	No Connect
35	PERn1	PCIe TX Differential signal defined by the PCI Express M.2 spec
36	N/C	No Connect
37	PERp1	PCIe TX Differential signal defined by the PCI Express M.2 spec
38	N/C	No Connect
39	GND	Ground
40	SMB_CLK (I/O)(0/1.8V)	SMBus Clock; Open Drain with pull-up on platform
41	PETn0	PCIe TX Differential signal defined by the PCI Express M.2 spec
42	SMB_DATA (I/O)(0/1.8V)	SMBus Data; Open Drain with pull-up on platform.
43	PETp0	PCIe TX Differential signal defined by the PCI Express M.2 spec
44	ALERT#(O) (0/1.8V)	Alert notification to master; Open Drain with pull-up on platform; Active low.
45	GND	Ground
46	N/C	No connect
47	PERn0	PCIe RX Differential signal defined by the PCI Express M.2 spec
48	N/C	No connect
49	PERp0	PCIe RX Differential signal defined by the PCI Express M.2 spec
50	PERST#(I)(0/3.3V)	PE-Reset is a functional reset to the card as defined by the PCIe Mini CEM specification.
51	GND	Ground
52	CLKREQ#(I/O)(0/3.3V)	Clock Request is a reference clock request signal as defined by the PCIe Mini CEM specification; Also used by L1 PM Sub-states.
53	REFCLKn	PCIe Reference Clock signals (100 MHz) defined by the PCI Express M.2 spec.

54	PEWAKE#(I/O)(0/3.3V)	PCIe PME Wake. Open Drain with pull up on platform; Active Low.
55	REFCLKp	PCIe Reference Clock signals (100 MHz) defined by the PCI Express M.2 spec.
56	Reserved for MFG Data	Manufacturing Data line. Used for SSD manufacturing only. Not used in normal operation. Pins should be left N/C in platform Socket.
57	GND	Ground
58	Reserved for MFG Clock	Manufacturing Clock line. Used for SSD manufacturing only. Not used in normal operation. Pins should be left N/C in platform Socket.
59	Module Key M	Module Key
60	Module Key M	Module Key
61	Module Key M	Module Key
62	Module Key M	Module Key
63	Module Key M	Module Key
64	Module Key M	Module Key
65	Module Key M	Module Key
66	Module Key M	Module Key
67	N/C	No Connect
68	SUSCLK (I) (0/3.3V) (I)(0/3.3V)	32.768 kHz clock supply input that is provided by the platform chipset to reduce power and cost for the module.
69	NC	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	GND	CONFIG_2 = Ground

6. SUPPORTED COMMANDS

6.1. NVMe Command List

Table 6-1 Admin Commands

Op Code	Command Description
00h	Delete I/O Submission Queue
01h	Create I/O Submission Queue
02h	Get Log Page
04h	Delete I/O Completion Queue
05h	Create I/O Completion Queue
06h	Identify
08h	Abort
09h	Set Features
0Ah	Get Features
0Ch	Asynchronous Event Request
10h	Firmware Activate
11h	Firmware Image Download

Table 6-2 Admin Commands – NVM Command Set Specific

Op Code	Command Description
00h	Format NVM
01h	Security Send
02h	Security Receive

Table 6-3 NVM Commands

Op Code	Command Description
00h	Flush
01h	Write
02h	Read
04h	Write Uncorrectable
08h	Write Zeroes
09h	Dataset Management

6.2. Identify Device Data

The following table details the sector data returned by the IDENTIFY DEVICE command.

Table 6-4 Controller Data Structure Identification

Bytes	O/M	Description	Default Value
01:00	M	PCI Vendor ID (VID)	0x1987
03:02	M	PCI Subsystem Vendor ID (SSVID)	0x1987
23:04	M	Serial Number (SN)	SN
63:24	M	Model Number (MN)	Model Number
71:64	M	Firmware Revision (FR)	FW Name
72	M	Recommended Arbitration Burst (RAB)	0x01
75:73	M	IEEE OUI Identifier (IEEE)	0x000000
76	O	Controller Multi-Path I/O and Namespace Sharing Capabilities (CMIC)	0x00
77	M	Maximum Data Transfer Size (MDTS)	0x09
79:78	M	Controller ID (CNTLID)	0x0000
83:80	M	Version (VER)	0x00010200
87:84	M	RTD3 Resume Latency (RTD3R)	0x00124F80
91:88	M	RTD3 Entry Latency (RTD3E)	0x0016E360
95:92	M	Optional Asynchronous Events Supported (OAES)	0x00000000
239:96	-	Reserved	0x0
255:240	-	Refer to the NVMe Management Interface Specification for definition	0x0
257:256	M	Optional Admin Command Support (OACS)	0x0017
258	M	Abort Command Limit (ACL)	0x00
259	M	Asynchronous Event Request Limit (AERL)	0x03
260	M	Firmware Updates (FRMW)	0x02
261	M	Log Page Attributes (LPA)	0x04
262	M	Error Log Page Entries (ELPE)	0x0F
263	M	Number of Power States Support (NPSS)	0x04
264	M	Admin Vendor Specific Command Configuration (AVSCC)	0x01
265	O	Autonomous Power State Transition Attributes (APSTA)	0x01
267:266	M	Warning Composite Temperature Threshold (WCTEMP)	0x016B
269:268	M	Critical Composite Temperature Threshold (CCTEMP)	0x016F
271:270	O	Maximum Time for Firmware Activation (MTFA)	0x0000
275:272	O	Host Memory Buffer Preferred Size (HMPRE)	0x00000000
279:276	O	Host Memory Buffer Minimum Size (HMMIN)	0x00000000
295:280	O	Total NVM Capacity (TNVMCAP)	0x0

311:296	O	Unallocated NVM Capacity (UNVMCAP)	0x0
315:312	O	Replay Protected Memory Block Support (RPMBS)	0x00000000
511:316	-	Reserved	0x0
NVM Command Set Attributes			
512	M	Submission Queue Entry Size (SQES)	0x66
513	M	Completion Queue Entry Size (CQES)	0x44
515:514	-	Reserved	0x0000
519:516	M	Number of Namespaces (NN)	0x00000001
521:520	M	Optional NVM Command Support (ONCS)	0x001E
523:522	M	Fused Operation Support (FUSES)	0x0000
524	M	Format NVM Attributes (FNA)	0x01
525	M	Volatile Write Cache (VWC)	0x01
527:526	M	Atomic Write Unit Normal (AWUN)	0x00FF
529:528	M	Atomic Write Unit Power Fail (AWUPF)	0x0000
530	M	NVM Vendor Specific Command Configuration (NVSCC)	0x00
531	M	Reserved	0x00
533:532	O	Atomic Compare & Write Unit (ACWU)	0x0000
535:534	M	Reserved	0x0000
539:536	O	SGL Support (SGLS)	0x00000000
703:540	M	Reserved	0x0
IO Command Set Attributes			
2047:704	M	Reserved	0x0
2048:2079	M	Power State 0 Descriptor	PSD0
2111:2080	O	Power State 1 Descriptor	PSD1
2143:2112	O	Power State 2 Descriptor	PSD2
2175:2144	O	Power State 3 Descriptor	PSD3
2207:2176	O	Power State 4 Descriptor	PSD4
…	-	(N/A)	0x0
3071:3040	O	Power State 31 Descriptor	PSD31
Vendor Specific			
4095:3072	O	Vendor Specific (VS)	Reserved

Table 6-5 Identify Namespace Data Structure & NVM Command Set Specific

Bytes	Description
7:0	Namespace Size (NSZE)
15:8	Namespace Capacity (NCAP)
23:16	Namespace Utilization (NUSE)
24	Namespace Features (NSFEAT)
25	Number of LBA Formats (NLBAF)
26	Formatted LBA Size (FLBAS)
27	Metadata Capabilities (MC)
28	End-to-end Data Protection Capabilities (DPC)
29	End-to-end Data Protection Type Settings (DPS)
30	Namespace Multi-path I/O and Namespace Sharing Capabilities (NMIC)
31	Reservation Capabilities (RESCAP)
119:32	Reserved
127:120	IEEE Extended Unique Identifier (EUI64)
131:128	LBA Format 0 Support (LBAF0)
135:132	LBA Format 1 Support (LBAF1)
139:136	LBA Format 2 Support (LBAF2)
143:140	LBA Format 3 Support (LBAF3)
147:144	LBA Format 4 Support (LBAF4)
151:148	LBA Format 5 Support (LBAF5)
155:152	LBA Format 6 Support (LBAF6)
159:156	LBA Format 7 Support (LBAF7)
163:160	LBA Format 8 Support (LBAF8)
167:164	LBA Format 9 Support (LBAF9)
171:168	LBA Format 10 Support (LBAF10)
175:172	LBA Format 11 Support (LBAF11)
179:176	LBA Format 12 Support (LBAF12)
183:180	LBA Format 13 Support (LBAF13)
187:184	LBA Format 14 Support (LBAF14)
191:188	LBA Format 15 Support (LBAF15)
383:192	Reserved
4095:384	Vendor Specific (VS)

Table 6-6 List of Identify Namespace Data Structure for Each Capacity

Capacity (GB)	Byte[7:0]: Namespace Size (NSZE)
128	EE7C2B0
256	1DCF32B0
512	3B9E12B0
1024	TBD

6.3. SMART Attributes

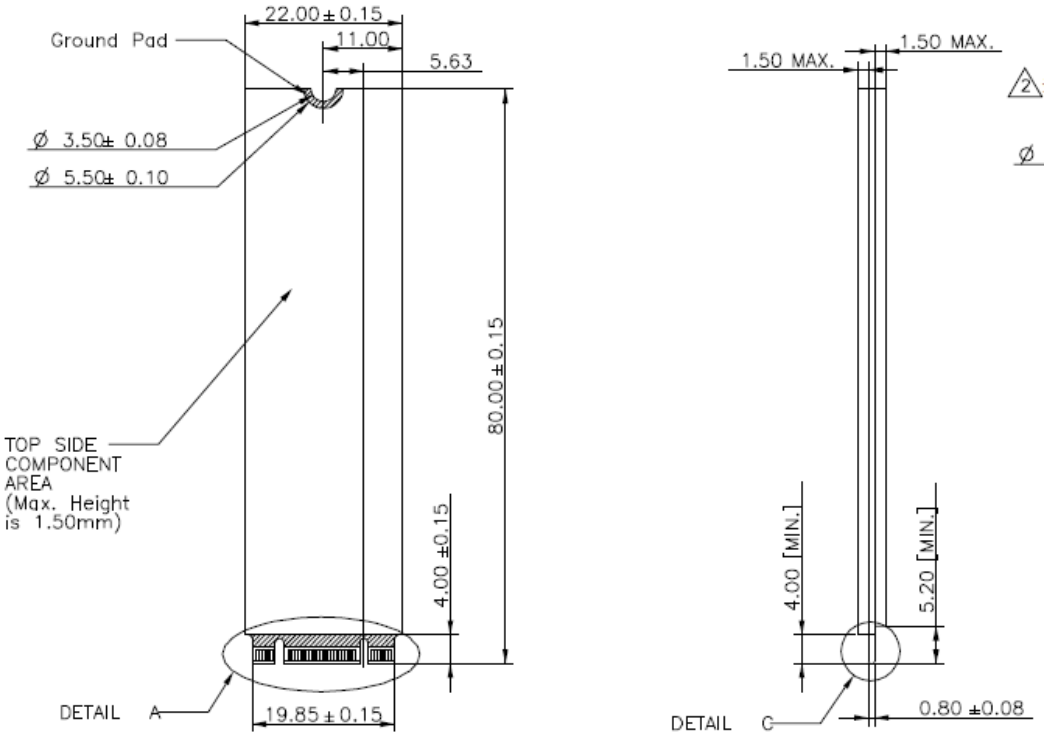
Table 6-7 SMART Attributes (Log Identifier 02h)

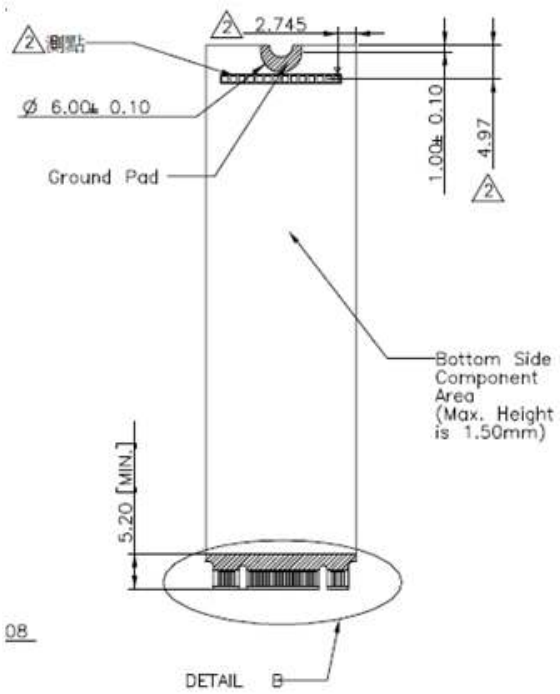
Bytes Index	Bytes	Description
[0]	1	Critical Warning
[2:1]	2	Composite Temperature
[3]	1	Available Spare
[4]	1	Available Spare Threshold
[5]	1	Percentage Used
[31:6]	26	Reserved
[47:32]	16	Data Units Read
[63:48]	16	Data Units Written
[79:64]	16	Host Read Commands
[95:80]	16	Host Write Commands
[111:96]	16	Controller Busy Time
[127:112]	16	Power Cycles
[143:128]	16	Power On Hours
[159:144]	16	Unsafe Shutdowns
[175:160]	16	Media and Data Integrity Errors
[191:176]	16	Number of Error Information Log Entries
[195:192]	4	Warning Composite Temperature Time
[199:196]	4	Critical Composite Temperature Time
[201:200]	2	Temperature Sensor 1
[203:202]	2	Temperature Sensor 2
[205:204]	2	Temperature Sensor 3
[207:206]	2	Temperature Sensor 4

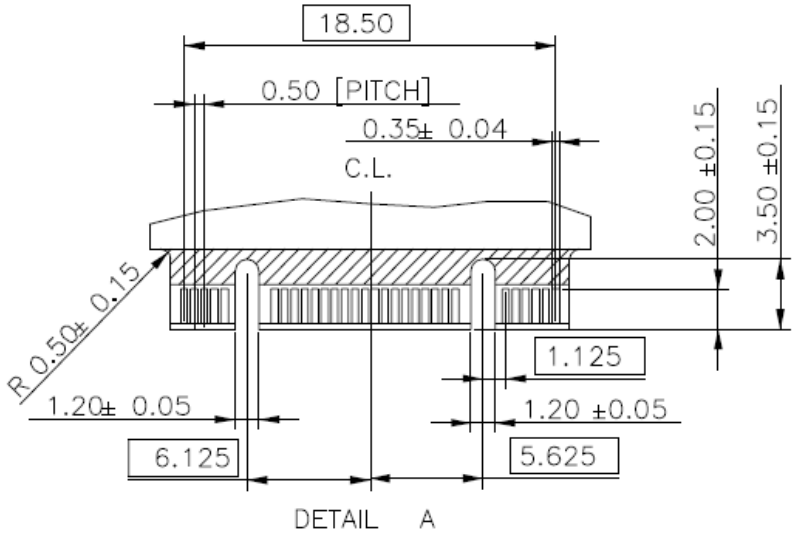
7. PHYSICAL DIMENSIONS

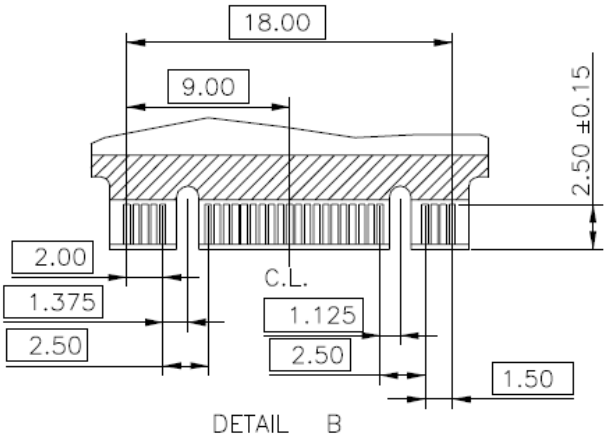
128GB – 512GB

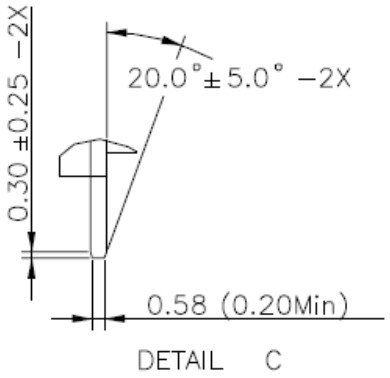
Dimension: 80mm (L) x 22mm (W) x 1.50mm (H)





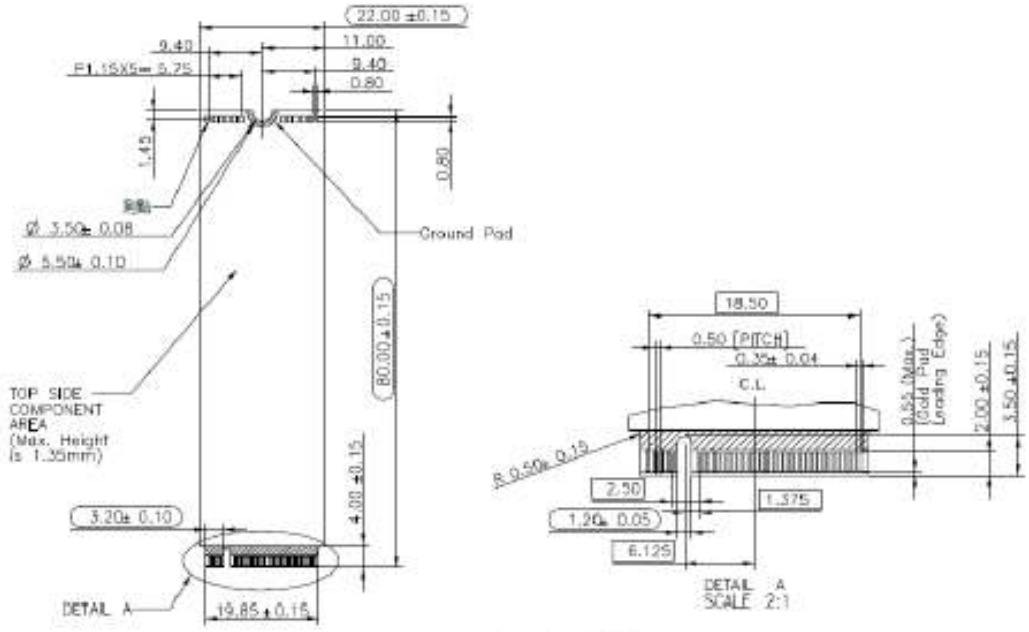


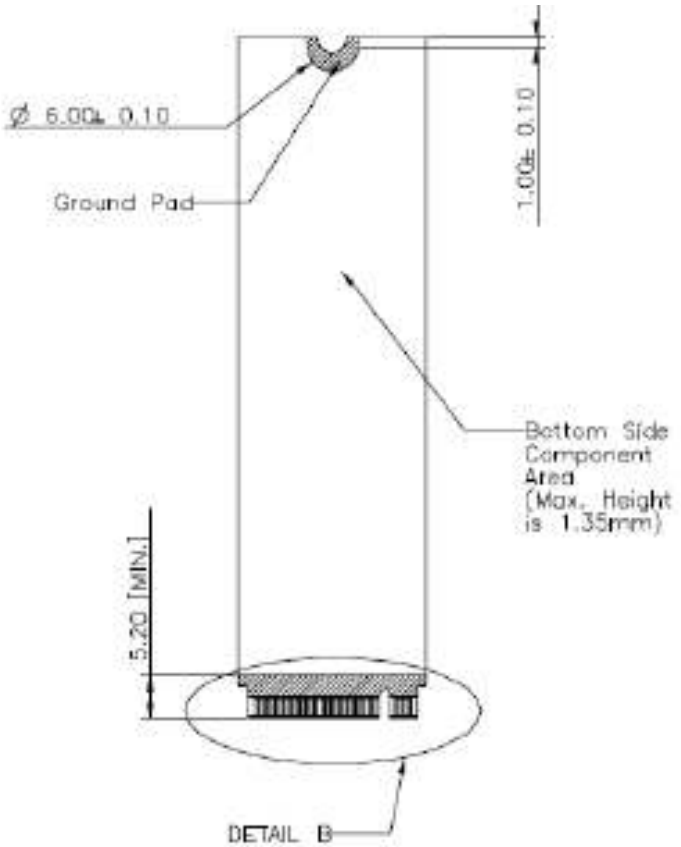


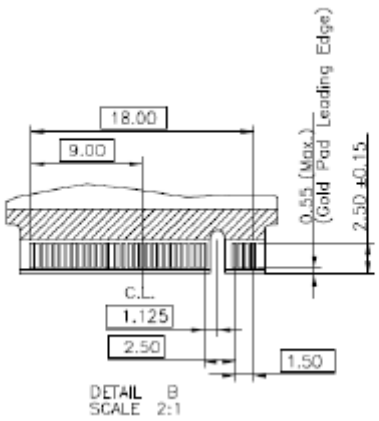


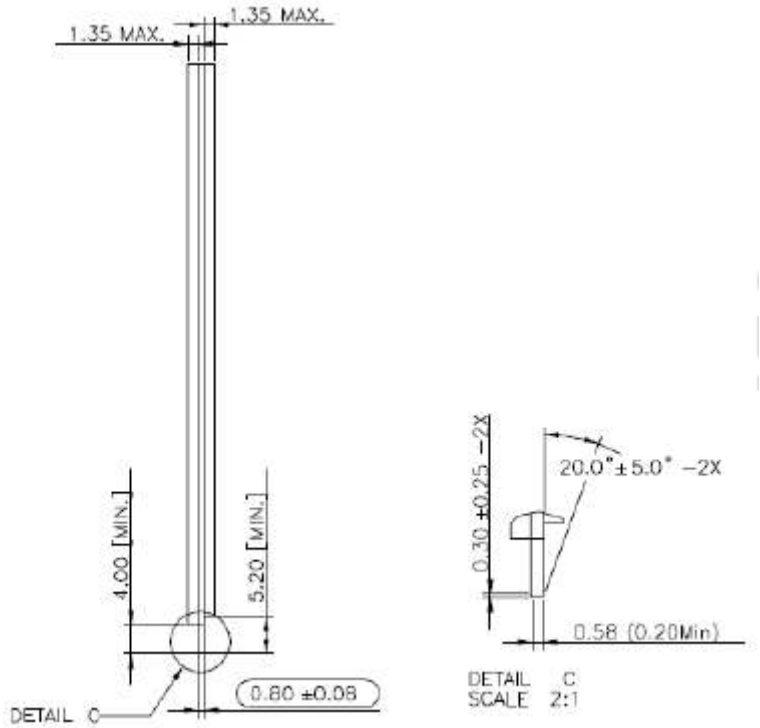
1TB

Dimension: 80mm (L) x 22mm (W) x 1.35mm (H)






18.00
9.00
0.55 (Max.)
(Gold Pad Leading Edge)
2.50 ±0.15
C.L.
1.125
2.50
1.50
DETAIL B
SCALE 2:1


1.35 MAX.
1.35 MAX.
4.00 [MIN.]
5.20 [MIN.]
0.80 ±0.08
DETAIL C
0.30 ±0.25 -2X
20.0° ±5.0° -2X
0.58 (0.20Min)
DETAIL C
SCALE 2:1