sales@imsolution.com.tw

Industrial Memory Specialist & Solution

M.2 2280 pSLC PCI-E 3.0 SSD Specification

Revision1.8

Product Overview

- **Capacity**
  - 120GB up to 960GB
- **PCI-E Interface**
  - PCI-E 3.0x4
  - Compatible to PCI-E 3x4
- **Flash Interface**
  - Flash Type: 3D pSLC
- **Performance**
  - Read: up to 2400 MB/s
  - Write: up to 1900 MB/s
- **NANDXtend™ ECC Technology**
  - 2KB codeword LDPC
  - Embedded programmable RAID
- **Power Consumption**
  - Active mode: < 1603mW
  - Idle mode: < 400mW
- **TBW (Terabyte Written) of MLC**
  - 1200TBW for 120GB
  - 2400TBW for 240GB
  - 4800TBW for 480GB/960GB
  - Equal to 5 DWPD/5yrs
- **MTBF**
  - More than 2,000,000 hours
- **Advanced Flash Management**
  - Static and Dynamic Wear Leveling
  - Bad Block Management
  - Firmware Update
- **Temperature Range**
  - Operation: 0°C ~ 70°C(C-Temp)
  - Operation: -40°C ~ 85°C(I-Temp)
  - Storage: -40°C ~ 85°C
- **RoHS compliant**

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Performance

M.2 2280	Capacity	Part Number	Performance			
			CrystalDiskMark		IOPS	
			Read (MB/s)	Write (MB/s)	4K QD32 Random Read	4K QD32 Random Write
	120GB	FP120GMP80P-MAN	2100	600	200K	300K
	240GB	FP240GMP80P-MAN	2400	1100	200K	300K
	480GB	FP480GMP80P-MAN	2400	1900	250K	410K
	960GB	FP960GMP80P-MAN	2400	1900	250K	410K

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1. INTRODUCTION

1.1. General Description

Imsolution's M.2 2280 delivers all the advantages of Flash Disk technology with the PCI-E 3.0x4 interface and is fully compliant with the standard *Next Generation Form Factor* (NGFF) called M.2 Card Format, which is generated by Intel. The M.2 2280 is designed to operate at a maximum operating frequency of state-of-art multi-cores ARM Cortex CPU. Its capacity could provide a wide range up to 960GB. Moreover, it can reach up to 2400MB/s read as well as 1900MB/s write high performance based on Toggle 2.0 flash (with 32MB SDR enabled and measured by CrystalDiskMark v3.0). The power consumption of the M.2 2280 is much lower than traditional Hard Drives, making it the best embedded solution for new plate forms.

1.2. Controller Block Diagram

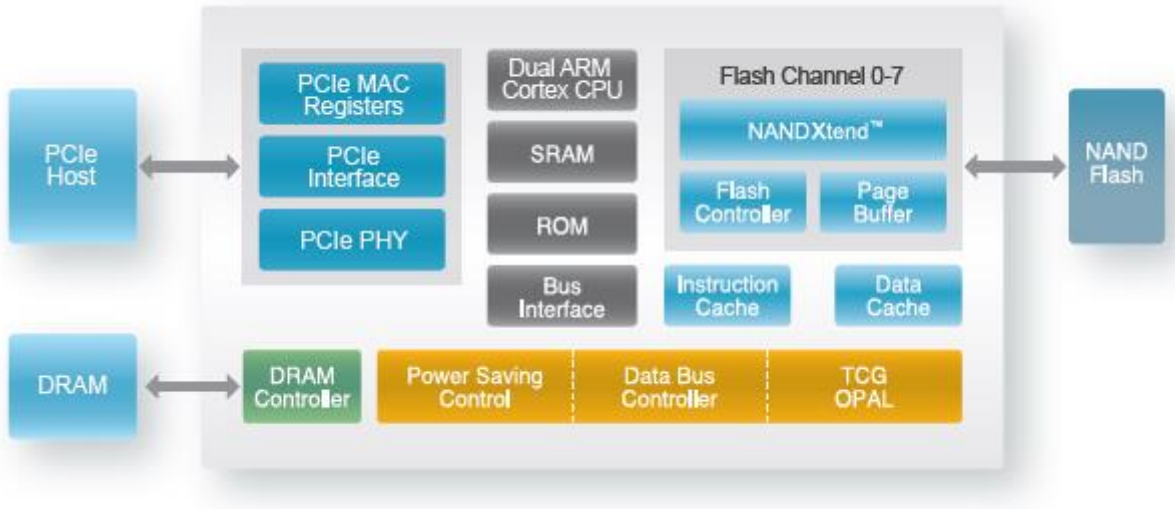


Figure 1-1 Imsolution M.2 2280 Controller Block Diagram

1.3. Product Block Diagram

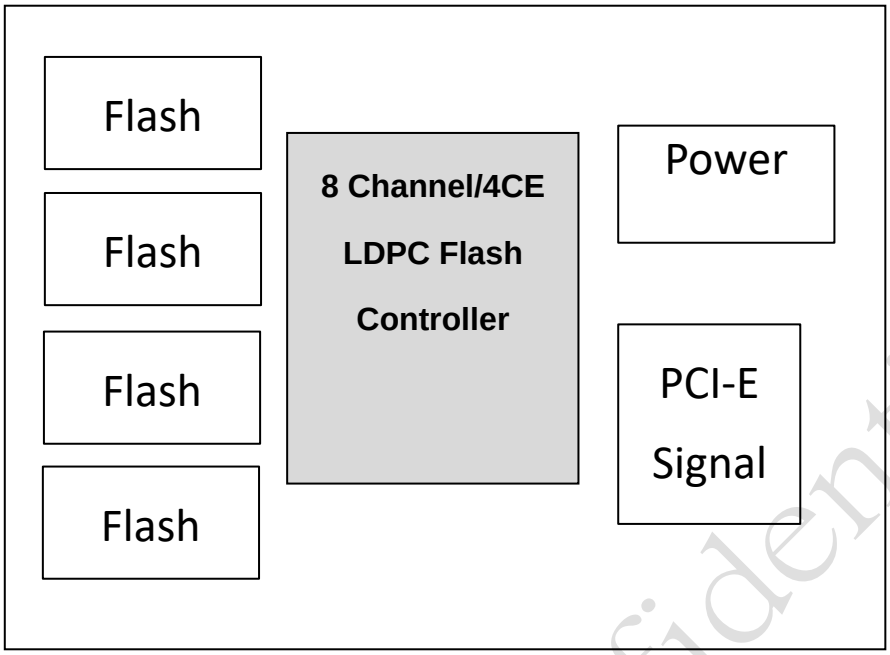


Figure 1-2 ImsolutionM.2 2280 Product Block Diagram

1.4. Flash Management

1.4.1. Error Correction Code (ECC)

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, Imsolution M.2 2280 applies the LDPC codeword ECC Algorithm, which can detect and correct errors occur during Read process, ensure data been read correctly, as well as protect data from corruption. It implements soft and hard error correction.

1.4.2. 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 get updated more frequently than others, the lifetime of the device would be reduced significantly. Thus, Wear Leveling technique is applied to extend the lifespan of NAND Flash by evenly distributing write and erase cycles across the media.

Imsolution provides advanced Wear Leveling algorithm, which can efficiently spread out the 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.

1.4.3. 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 the lifespan of the flash are named “Later Bad Blocks”. Imsolution 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 the data reliability.

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 of a NAND flash.

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 needs to write 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.

2. PRODUCT SPECIFICATIONS

- **Capacity**
  - From 120GB up to 960GB
- **Electrical/Physical Interface**
  - PCI-E Interface
    - Compliant with PCI-E Revision 3.1
    - Compatible with PCI-E 3.0 8Gbps x 4 Lanes
    - Embedded BIST function for SATA PHY for low cost mass production
- **Supported NAND Flash**
  - 3D Flash pSLC, Toggle1.0 and Toggle2.0
  - Build-in hardware LDPC ECC (Codeword 2KB)
  - Support all types of MLC/MLC large block: 8KB/page and 16K/page NAND Flash
  - Support ONFI 2.3 interface: 8 channels at maximum
  - Bus Width: 8/16 bit
- **Cache Memory**
  - 8MB or 32MB SDRAM embedded
- **ECC Scheme**
  - SSD M.2 2280 can correct up to 144 bits error in 2K Byte data.
- **UART function**
- **GPIO**

3. ENVIRONMENTAL SPECIFICATIONS

3.1. Environmental Conditions

3.1.1. Temperature and Humidity

- Temperature:
  - Storage: -40°C to 85°C
  - Operational : 0°C to 70°C(C-Temp)
  - Operational : -40°C to 85°C(I-Temp)
- Humidity:
  - RH 90% under 40°C

Table 3- 1High Temperature Test Condition

	Temperature	Humidity	Test Time
Operation	70°C(CT)/ 85°C(IT)	0% RH	72 hours
Storage	85°C	0% RH	72 hours

Result: No any abnormality is detected.

Table 3- 2 Low Temperature Test Condition

	Temperature	Humidity	Test Time
Operation	0°C(CT)/ -40°C(IT)	0% RH	72 hours
Storage	-40°C	0% RH	72 hours

Result: No any abnormality is detected.

Table 3- 3High Humidity Test Condition

	Temperature	Humidity	Test Time
Operation	40°C	93% RH	24 hours
Storage	40°C	95% RH	72 hours

Result: No any abnormality is detected.

Table 3- 4Temperature Cycle Test

	Temperature	Test Time	Cycle
Operation	0°C	30 min	10 Cycles
	70°C	30 min	
Storage	-40°C	30 min	10 Cycles
	85°C	30 min	

Result: No any abnormality is detected.

3.1.2. Shock

Table 3- 5Imsolution M.2 2280 Shock Specification

	Acceleration Force	Half Sin Pulse Duration	Number of Shocks
Non-operational	1500G	0.5ms	6 faces, 5 times each
Operational	1500G	0.5ms	6 faces, 5 times each

Result: No any abnormality is detected when power on.

3.1.3. Vibration

Table 3- 6Imsolution M.2 2280 Vibration Specification

	Condition		Vibration Orientation
	Frequency/Displacement	Frequency/Acceleration	
Operational	20Hz~80Hz/1.52mm	80Hz~2000Hz/20G	X, Y, Z axis/60 min for each

Result: No any abnormality is detected when power on.

3.1.4. Drop

Table 3- 7Imsolution M.2 2280 Drop Specification

	Height of Drop	Number of Drop
Non-operational	80cm free fall	6 faces of each unit, 2 times

Result: No any abnormality is detected when power on.

3.1.5. Bending

Table 3- 8Imsolution M.2 2280 Bending Specification

	Force	Action
Non-operational	≥20N	Hold 1min/5times

Result: No any abnormality is detected when power on.

3.1.6. Torque

Table 3- 9Imsolution M.2 2280 Torque Specification

	Force	Action
Non-operational	0.5N-m or 2.5 deg	Hold 5min/5times

Result: No any abnormality is detected when power on.

3.1.7. Electrostatic Discharge (ESD)

Table 3- 10Imsolution M.2 2280 Contact ESD Specification

Device	Capacity	Temperature	Relative Humidity	+/- 4KV	Result
M.2 2280	120GB	24.0°C	49% (RH)	Device functions are affected, but EUT will be back to its normal or operational state automatically.	PASS

3.1.8. EMI Compliance

- FCC: CISPR22
- CE: EN55022
- BSMI 13438

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. The predicted result of Imsolution SSD M.2 2280 is more than 1,000,000 hours.

3.3. Certification & Compliance

- RoHS
- PCI-Express Base 3.0
- NVMe 1.2

4. ELECTRICAL SPECIFICATIONS

4.1. Supply Voltage

Table 4- 1 Supply Voltage of Imsolution M.2 2280/2.5inch/Add-In card

Parameter	Rating
Operating Voltage	3.3V(12V for Add-In card)

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.

Pin No.	PCIe Pin	Description
1	GND	Ground
2	3.3V	3.3V source
3	GND	Ground
4	3.3V	3.3V source
5	PETn3	PCIe TX Differential signal defined by the PCI Express M.2 spec
6	N/C	No connect
7	PETp3	PCIe TX Differential signal defined by the PCI Express M.2 spec
8	N/C	No connect
9	GND	Ground
10	LED1#(O)	Status indicators via LED devices
11	PERn3	PCIe RX Differential signal defined by the PCI Express M.2 spec
12	3.3V	3.3V source
13	PERp3	PCIe RX Differential signals defined by the PCI Express M.2 spec.
14	3.3V	3.3V source
15	GND	Ground
16	3.3V	3.3V source
17	PETn2	PCIe TX Differential signal defined by the PCI Express M.2 spec
18	3.3V	3.3V source
19	PETp2	PCIe TX Differential signal defined by the PCI Express M.2 spec
20	N/C	No connect
21	GND	Ground
22	N/C	No connect
23	PERn2	PCIe RX Differential signal defined by the PCI Express M.2 spec
24	N/C	No connect
25	PERp2	PCIe RX Differential signal defined by the PCI Express M.2 spec
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

Pin No.	PCIe Pin	Description
30	N/C	No connect
31	PETp1	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 RX Differential signal defined by the PCI Express M.2 spec
36	N/C	No connect
37	PERp1	PCIe RX Differential signal defined by the PCI Express M.2 spec
38	N/C	No connect
39	GND	Ground
40	N/C	No connect
41	PETn0	PCIe TX Differential signal defined by the PCI Express M.2 spec
42	N/C	No connect
43	PETp0	PCIe TX Differential signal defined by the PCI Express M.2 spec
44	N/C	No connect
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 Substates
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	Manufacturing Data line. Used for SSD manufacturing only. Not used in normal operation.
57	GND	Ground

Pin Number	PCIe Pin	Description
58	Reserved for	Manufacturing Clock line. Used for SSD manufacturing only. Not used in normal operation.
59	Module Key	Module Key
60	Module Key	
61	Module Key	
62	Module Key	
63	Module Key	
64	Module Key	
65	Module Key	
66	Module Key	
67	N/C	No connect
68	SUSCLK(32KHz) (I/O@3.3V)	32.768 kHz clock supply input that is provided by the platform chipset to reduce power and cost for the module
69	PEDET (NC-PCIe)	Host I/F Indication; No Connect for PCIe.
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	Ground

6. SUPPORTED COMMANDS

6.1. NVMe Command List

Table 6-1 Admin Commands

Opcode	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

Opcode	Command Description
80h	Format NVM
81h	Security Send
82h	Security Receive

Table 6-3 NVM Commands

6.2. Identify DEVICE Data

Bytes	O/M	Description	Default Value
01:00	M	PCI Vendor ID (VID)	0x1987
315:312	O	Replay Protected Memory Block Support (RPMBS)	0
03:02	M	PCI Subsystem Vendor ID (SSVID)	0x1987
511:316	-	Reserved	0
23:04	M	Serial Number (SN)	SN
		NVM Command Set Attributes	
63:24	M	Model Number (MN)	Model Number
512	M	Submission Queue Entry Size (SQES)	0x66
71:64	M	Firmware Revision (FR)	FW Name
513	M	Completion Queue Entry Size (CQES)	0x44
72	M	Recommended Arbitration Burst (RAB)	0x01
515:514	-	Reserved	0
75:73	M	IEEE OUI Identifier (IEEE)	0
519:516	M	Number of Namespaces (NN)	0x01
76	O	Controller Multi-Path I/O and Namespace Sharing Capabilities (CMIC)	0x00
521:520	M	Optional NVM Command Support (ONCS)	0x001E
77	M	Maximum Data Transfer Size (MDTS)	0x09
523:522	M	Fused Operation Support (FUSES)	0
79:78	M	Controller ID (CNTLID)	0x0000
524	M	Format NVM Attributes (FNA)	0
83:80	M	Version (VER)	0x00010200
525	M	Volatile Write Cache (VWC)	0x01
87:84	M	RTD3 Resume Latency (RTD3R)	0x00124F80
527:526	M	Atomic Write Unit Normal (AWUN)	0x00FF
91:88	M	RTD3 Entry Latency (RTD3E)	0x0016E360
529:528	M	Atomic Write Unit Power Fail (AWUPF)	0x00
95:92	M	Optional Asynchronous Events Supported (OAES)	0
530	M	NVM Vendor Specific Command Configuration (NVSCC)	0x01
239:96	-	Reserved	0
531	M	Reserved	0
255:240	-	Refer to the NVMe Management Interface	
533:532	O	Atomic Compare & Write Unit (ACWU)	0x00
		Specification for definition	0
535:534	M	Reserved	0
257:256	M	Optional Admin Command Support (OACS)	0x0007
539:536	O	SGL Support (SGLS)	0x00
258	M	Abort Command Limit (ACL)	0x03
703:540	M	Reserved	0
259	M	Asynchronous Event Request Limit (AERL)	0x03
		IO Command Set Attributes	
260	M	Firmware Updates (FRMW)	0x02
2047:704	M	Reserved	0
261	M	Log Page Attributes (LPA)	0x03
2048:2079	M	Power State 0 Descriptor	PSD0
262	M	Error Log Page Entries (ELPE)	0x3F
2111:2080	O	Power State 1 Descriptor	PSD1
263	M	Number of Power States Support (NPSS)	0x04
2143:2112	O	Power State 2 Descriptor	PSD2
264	M	Admin Vendor Specific Command Configuration (AVSCC)	0x01
2175:2144	O	Power State 3 Descriptor	PSD3
265	O	Autonomous Power State Transition Attributes (APSTA)	0x01
2207:2176	O	Power State 4 Descriptor	PSD4
267:266	M	Warning Composite Temperature Threshold (WCTEMP)	0x0157
...	-	(N/A)	0
269:268	M	Critical Composite Temperature Threshold (CCTEMP)	0x0193
3071:3040	O	Power State 31 Descriptor	PSD31
271:270	O	Maximum Time for Firmware Activation (MTFA)	0x0000
		Vendor Specific	
275:272	O	Host Memory Buffer Preferred Size (HMPRE)	0
4095:3072	O	Vendor Specific (VS)	Phison Reserved
279:276	O	Host Memory Buffer Minimum Size (HMMIN)	0
295:280	O	Total NVM Capacity (TNVMCAP)	0
311:296	O	Unallocated NVM Capacity (UNVMCAP)	0

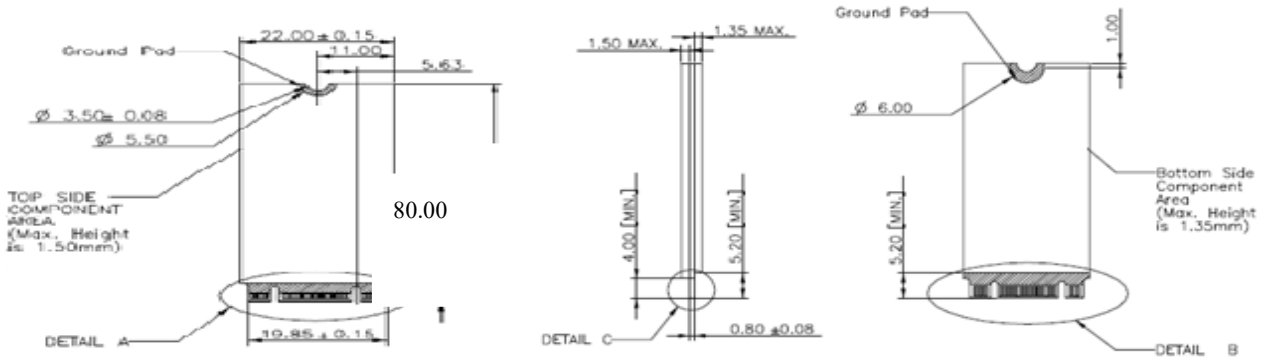
Table 6-4 Identify Controller Data Structure

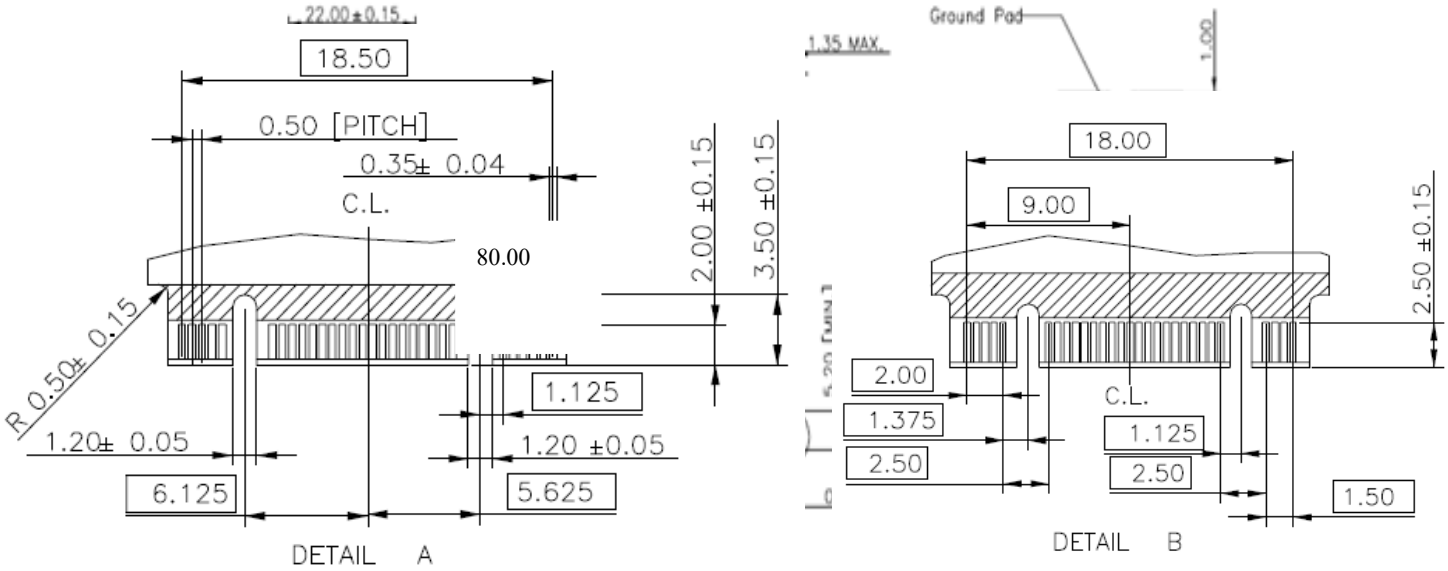
Table 6-5 Identify Namespace Data Structure & NVM Command Set Specific

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)

7. PHYSICAL DIMENSION

M.2 2280 Dimension: 80mm(L) x 22mm(W) x 3.75mm(H)





Unit : mm