Apacer

RoHS Compliant

PCI Express Flash Drive

PM610-M280 Product Specifications

January 21, 2020

Version 1.0

Specifications Overview:

- **PCIe Interface**
  - Compliant with NVMe 1.2
  - Compatible with PCIe Gen3 x2 interface
- **Capacity**
  - 64, 128, 256, 512 GB
- **Performance***
  - Interface burst read/write: 2 GB/sec
  - Sequential read: up to 1,350 MB/sec
  - Sequential write: up to 1,005 MB/sec
  - Random read (4K): up to 112,000 IOPS
  - Random write (4K): up to 118,000 IOPS
- **Flash Management**
  - Built-in hardware ECC
  - Global Wear Leveling
  - Flash bad-block management
  - Flash Translation Layer: Page Mapping
  - S.M.A.R.T.
  - Power Failure Management
  - TRIM
  - Hyper Cache Technology
- **NAND Flash Type:** MLC
- **MTBF:** >1,000,000 hours
- **Reliability**
  - Thermal Sensor
  - Thermal Management Technique
  - End-to-End Data Protection
  - CoreGlacierTM**
- **Endurance (in Terabytes Written: TBW)**
  - 64 GB: 99 TBW
  - 128 GB: 175 TBW
  - 256 GB: 345 TBW
  - 512 GB: 563 TBW

- **Temperature Range**
  - Operating:
    - Standard: 0°C to 70°C
    - Wide: -40°C to 85°C
  - Storage: -40°C to 100°C
- **Supply Voltage**
  - 3.3 V ± 5%
- **Power Consumption***
  - Active mode: 1,310 mA
  - Idle mode: 145 mA
- **Connector Type**
  - 75-pin M.2 module pinout
- **Power Management**
  - Supports APST
  - Supports ASPM L1.2
- **Form Factor**
  - M.2 2280 single side, B+M key: 64, 128 GB
  - M.2 2280 double side, B+M key: 256, 512 GB
- **Dimensions**
  - Standard temp.:
    - 64, 128 GB: 80.00 x 22.00 x 2.38, unit: mm
    - 256, 512 GB: 80.00 x 22.00 x 3.38, unit: mm
  - Wide temp.:
    - 64,128 GB: 80.00 x 22.00 x 2.80, unit: mm
    - 256, 512 GB: 80.00 x 22.00 x 4.10, unit: mm
  - Net Weight:
    - Standard temp.: 7.3 g ± 5%
    - Wide temp.: 9.8 g ± 5%
- **Shock & Vibration***
  - Shock: 1,500 G
  - Vibration: 15 G
- **LED Indicators for Drive Behavior**
- **RoHS Compliant**

*Varies from capacities. The values for performances and power consumptions presented are typical and may vary depending on flash configurations or platform settings.
**Only supported on wide temperature series
***Non-operating

Table of Contents

1. General Descriptions

Apacer PM610-M280 is designed as M.2 2280 mechanical dimensions, providing full compliance with PCIe Gen3 x2 interface and NVMe 1.2 specifications. Aside from PCIe compliance, PM610-M280 delivers outstanding performance in data transfer, reaching up to 112,000/118,000 and 1,350/1,005 MB/s in IOPS and sequential read/write. This exceptional throughput indicates massive amounts of data can be processed at high speeds, proving that PM610-M280 is more suitable for high-performance compact computers and embedded computing systems.

This high-speed disk module uses two PCIe lanes, which greatly saves on power consumption compared with four lanes and delivers much higher performance than SATA SSDs. Moreover, by adopting MLC NAND Flash, PM610-M280 provides trustable endurance and reliability.

PM610-M280 is built with a powerful PCIe controller with advanced firmware technologies to achieve full-channel data protection. With End-to-End Data Protection technology, it ensures integrity and correctness of data transmission between the host and the NAND storage area, and greatly improves data reliability. PM610-M280 is believed to be the leading add-in storage solution for future computing systems.
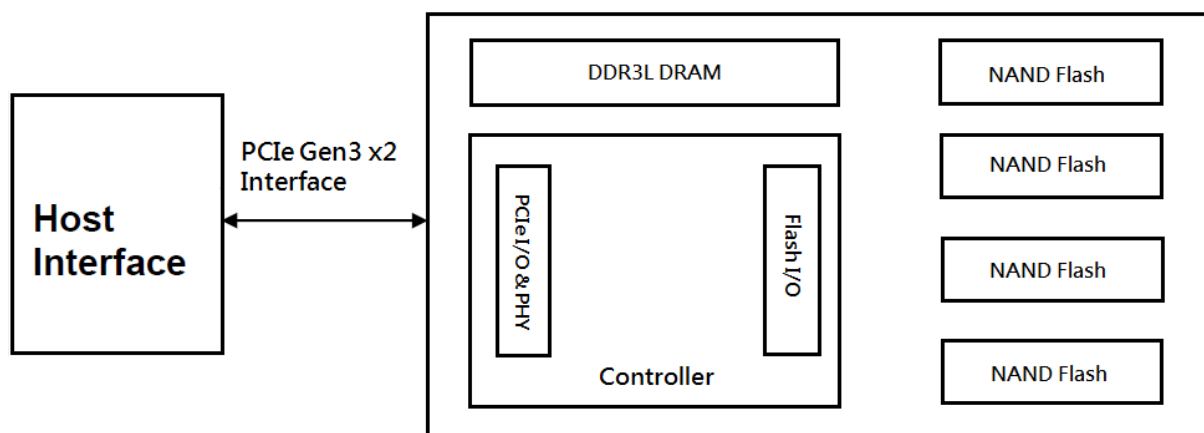
2. Functional Block

Figure 2-1 Functional Block Diagram

3. Pin Assignments

This connector does not support hot plug capability. There are a total of 75 pins. 12 pin locations are used for mechanical key locations; this allows such a module to plug into both Key B and Key M connectors.
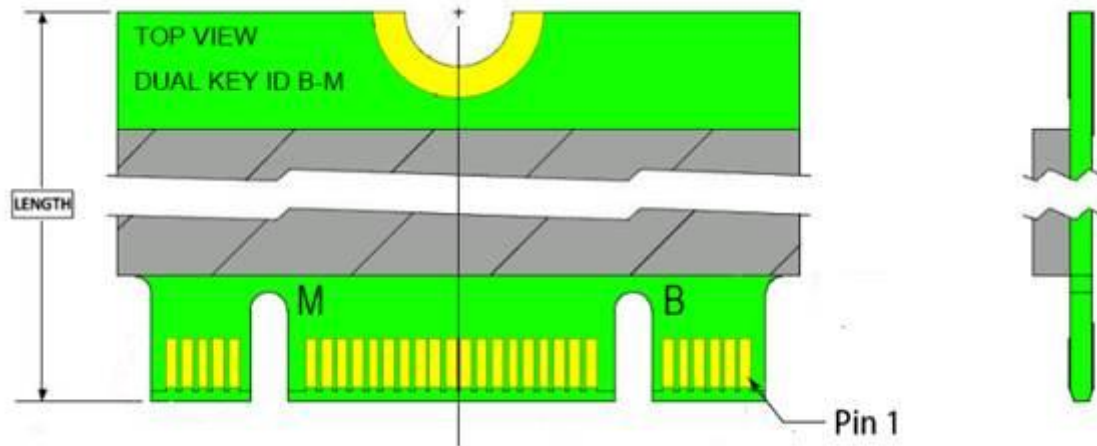
Table 3-1 Pin Assignments

Pin	Type	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
10	DAS/DSS	Device Activity Signal/Disable Staggered Spin-up
11	N/C	No connect
12	(removed for key)	Mechanical notch B
13	(removed for key)	Mechanical notch B
14	(removed for key)	Mechanical notch B
15	(removed for key)	Mechanical notch B
16	(removed for key)	Mechanical notch B
17	(removed for key)	Mechanical notch B
18	(removed for key)	Mechanical notch B
19	(removed for key)	Mechanical notch B
20	N/C	No connect
21	GND	CONFIG_0=GND
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	PETp1	PCIe TX Differential signal defined by the PCI Express M.2 spec

Table 3-1 Pin Assignments

Pin	Type	Description
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	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	(removed for key)	Mechanical notch M
60	(removed for key)	Mechanical notch M
61	(removed for key)	Mechanical notch M
62	(removed for key)	Mechanical notch M
63	(removed for key)	Mechanical notch M
64	(removed for key)	Mechanical notch M
65	(removed for key)	Mechanical notch M
66	(removed for key)	Mechanical notch M
67	NC	No connect (used for other purposes)
68	SUSCLK(32KHz) (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	Supply pin, 3.3V
71	GND	Ground
72	3.3V	Supply pin, 3.3V
73	GND	Ground
74	3.3V	Supply pin, 3.3V
75	CONFIG_2	Ground

4. Product Specifications

4.1 Capacity

Capacity specifications of PM610-M280 are available as shown in Table 4-1. It lists the specific capacity and the default numbers of heads, sectors and cylinders for each product line.

Table 4-1 Capacity Specifications

Capacity	Total bytes*	Cylinders	Heads	Sectors	Max LBA
64 GB	64,016,302,080	16,383	16	63	125,031,840
128 GB	128,035,676,160	16,383	16	63	250,069,680
256 GB	256,060,514,304	16,383	16	63	500,118,192
512 GB	512,110,190,592	16,383	16	63	1,000,215,216

*Display of total bytes varies from file systems, which means not all of the bytes can be used for storage.
**Notes: 1 GB = 1,000,000,000 bytes; 1 sector = 512 bytes.
LBA count addressed in the table above indicates total user storage capacity and will remain the same throughout the lifespan of the device. However, the total usable capacity of the SSD is most likely to be less than the total physical capacity because a small portion of the capacity is reserved for device maintenance usages.

4.2 Performance

Performance of PM610-M280 is listed below in Table 4-2.

Table 4-2 Performance Specifications

Performance \ Capacity	64 GB	128 GB	256 GB	512 GB
Sequential Read* (MB/s)	990	1,335	1,350	1,345
Sequential Write* (MB/s)	220	555	865	1,005
Random Read IOPS (4K)**	63,000	103,000	112,000	110,000
Random Write IOPS (4K)**	32,000	86,000	112,000	118,000

Note:
Results may differ from various flash configurations or host system setting.
*Sequential performance is based on CrystalDiskMark 5.2.1 with file size 256MB.
**Random performance measured using IOMeter with Queue Depth 32.

4.3 Environmental Specifications

Environmental specifications of PM610-M280 are shown in Table 4-3.

Table 4-3 Environmental Specifications

Item	Specifications
Operating temp.	0°C to 70°C (Standard); -40°C to 85°C (Wide)
Non-operating temp.	-40°C to 100°C
Operating vibration	7.69 GRMS, 20~2000 Hz/random (compliant with MIL-STD-810G)
Non-operating vibration	4.02 GRMS, 15~2000 Hz/random (compliant with MIL-STD-810G)
Operating shock	50(G), 11(ms), half-sine wave
Non-operating shock	1,500(G), 0.5(ms), half-sine wave

Note: Shock and Vibration specifications are subject to change without notice.

4.4 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in PM610-M280. The prediction result for PM610-M280 is more than 1,000,000 hours.

Note: The MTBF is predicated and calculated based on "Telcordia Technologies Special Report, SR-332, Issue 3" method.

4.5 Certification and Compliance

PM610-M280 complies with the following standards:
- CE
- FCC
- RoHS
- MIL-STD-810

4.6 Endurance

The endurance of a storage device is predicted by TeraBytes Written based on several factors related to usage, such as the amount of data written into the drive, block management conditions, and daily workload for the drive. Thus, key factors, such as Write Amplifications and the number of P/E cycles, can influence the lifespan of the drive.

Table 4-4 Endurance Specifications

Capacity	TeraBytes Written
64 GB	99
128 GB	175
256 GB	345
512 GB	563

Note:
- This estimation complies with JEDEC random client workload.
- Flash vendor guaranteed MLC P/E cycle: 3K
- WAF may vary from capacity, flash configurations and writing behavior on each platform.
- 1 Terabyte = 1,024 GB

4.7 LED Indicator Behavior

The behavior of the PM610-M280 LED indicators is described in Table 4-5.

Table 4-5 LED Behavior

Location	LED	Description
LED A	DAS	LED blinks when the drive is being accessed

5. Flash Management

5.1 Error Correction/Detection

PM610-M280 implements a hardware ECC scheme, based on the BCH algorithm. It can detect and correct up to 80 bits error in 1K bytes.

5.2 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". Apacer 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.

5.3 Global Wear Leveling

Flash memory devices differ from Hard Disk Drives (HDDs) in terms of how blocks are utilized. For HDDs, when a change is made to stored data, like erase or update, the controller mechanism on HDDs will perform overwrites on blocks. Unlike HDDs, flash blocks cannot be overwritten and each P/E cycle wears down the lifespan of blocks gradually. Repeatedly program/erase cycles performed on the same memory cells will eventually cause some blocks to age faster than others. This would bring flash storages to their end of service term sooner. Global wear leveling is an important mechanism that levels out the wearing of all blocks so that the wearing-down of all blocks can be almost evenly distributed. This will increase the lifespan of SSDs.

5.4 Flash Translation Layer – Page Mapping

Page mapping is an advanced flash management technology whose essence lies in the ability to gather data, distribute the data into flash pages automatically, and then schedule the data to be evenly written. Page-level mapping uses one page as the unit of mapping. The most important characteristic is that each logical page can be mapped to any physical page on the flash memory device. This mapping algorithm allows different sizes of data to be written to a block as if the data is written to a data pool and it does not need to take extra operations to process a write command. Thus, page mapping is adopted to increase random access speed and improve SSD lifespan, reduce block erase frequency, and achieve optimized performance and lifespan.

5.5 Power Failure Management

Power Failure Management plays a crucial role when experiencing unstable power supply. Power disruption may occur when users are storing data into the SSD. In this urgent situation, the controller would run multiple write-to-flash cycles to store the metadata for later block rebuilding. This urgent operation requires about several milliseconds to get it done. At the next power up, the firmware will perform a status tracking to retrieve the mapping table and resume previously programmed NAND blocks to check if there is any incompleteness of transmission.

5.6 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 the erase action, which prevents unused data from occupying blocks all the time.

5.7 Hyper Cache Technology

Apacer proprietary Hyper Cache technology uses a portion of the available capacity as SLC (1bit-per-cell) NAND flash memory, called Hyper cache mode. When data is written to SSD, the firmware will direct the data to Hyper Cache mode, providing excellent performance to handle various scenarios in industrial use.

6. Reliability Features

6.1 Thermal Sensor

Apacer Thermal Sensor is a digital temperature sensor with serial interface. By using designated pins for transmission, storage device owners are able to read temperature data.

6.2 Thermal Management Technique

Thermal management technique can monitor the temperature of the SSD equipped with a built-in thermal sensor via S.M.A.R.T. commands. This method can ensure the temperature of the device stays within temperature limits by drive throttling, i.e. reducing the speed of the drive when the device temperature reaches the threshold level, so as to prevent overheating, guarantee data reliability, and prolong product lifespan. When the temperature exceeds the maximum threshold level, thermal throttling will be triggered to reduce performance step by step to prevent hardware components from being damaged. Performance is only permitted to drop to the extent necessary for recovering a stable temperature to cool down the device's temperature. Once the temperature decreases to the minimum threshold value, transfer speeds will rise back to its optimum performance level.

6.3 End-to-End Data Protection

End-to-End Data Protection is a feature implemented in Apacer SSD products that extends error control to cover the entire path from the host computer to the drive and back, and that ensures data integrity at multiple points in the path to enable reliable delivery of data transfers. Unlike ECC which does not exhibit the ability to determine the occurrence of errors throughout the process of data transmission, End-to-End Data Protection allows SSD controller to identify an error created anywhere in the path and report the error to the host computer before it is written to the drive. This error-checking and error-reporting mechanism therefore guarantees the trustworthiness and reliability of the SSD.

6.4 CoreGlacier^{TM}

In many applications, SSDs are subject to challenging conditions. If the working environment is already hot, and the SSD's operation causes it to increase in temperature as well, the result could be damage to the hardware or corrupted data. In cases like this, leading industrial manufacturers know to turn to Apacer. Apacer developed CoreGlacier, a heatsink that distributes dissipation in isolated components with no thermal diffusion, to prevent heat-related damage from occurring.

7. Software Interface

7.1 Command Set

Table 7-1 summarizes the commands supported by PM610-M280.

Table 7-1 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 7-2 Admin Commands – NVM Command Set Specific

Opcode	Command Description
80h	Format NVM

Table 7-3 NVM Commands

Opcode	Command Description
00h	Flush
01h	Write
02h	Read
04h	Write Uncorrectable
05h	Compare
08h	Write Zeroes
09h	Dataset Management

7.2 S.M.A.R.T.

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is an open standard that allows a hard disk 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.

Table 7-4 SMART (02h)

Byte	Length	Description
0	1	Critical Warning
1-2	2	Composite Temperature
3	1	Available Spare
4	1	Available Spare Threshold
5	1	Percentage Used
6-31	26	Reserved
32-47	16	Data Units Read
48-63	16	Data Units Written
64-79	16	Host Read Commands
80-95	16	Host Write Commands
96-111	16	Controller Busy Time
112-127	16	Power Cycles
128-143	16	Power On Hours
144-159	16	Unsafe Shutdowns
160-175	16	Media and Data Integrity Errors
176-191	16	Number of Error Information Log Entries
192-195	4	Warning Composite Temperature Time
196-199	4	Critical Composite Temperature Time
200-201	2	Temperature Sensor 1
202-203	2	Temperature Sensor 2
204-205	2	Temperature Sensor 3
206-207	2	Temperature Sensor 4
208-209	2	Temperature Sensor 5
210-211	2	Temperature Sensor 6
212-213	2	Temperature Sensor 7
214-215	2	Temperature Sensor 8
216-511	296	Reserved

Table 7-5 SMART (C0h)

Byte	Length	Description
2-3	2	SMART Version (0x3033)
4-7	4	P/E Cycle
8-9	2	Flash Type
10-255	246	Reserved
256-257	2	SSD Protect Mode
258-261	4	ECC Fail Count
262-265	4	PHY Error Count
266-269	4	CRC Error Count
274-277	4	Total Later Bad Block Count
278-281	4	Max Erase Count
282-285	4	Average Erase Count
286-289	4	Program Fail Count
290-293	4	Erase Fail Count
294-301	8	FlashWriteSector
302-511	210	Reserved

8. Electrical Specifications

8.1 Operating Voltage

Table 8-1 lists the supply voltage for PM610-M280.

Table 8-1 Operating Range

Item	Range
Supply Voltage	3.3V ± 5%

8.2 Power Consumption

Table 8-2 lists the power consumption for PM610-M280.

Table 8-2 Power Consumption

| Capacity / Mode	64 GB	128 GB	256 GB	512 GB
Active (mA)	875	1,015	1,060	1,310
Idle (mA)	140	140	140	145

Note:
*All values are typical and may vary depending on flash configurations or host system settings.
**Active power is an average power measurement performed using CrystalDiskMark with 128KB sequential read/write transfers.
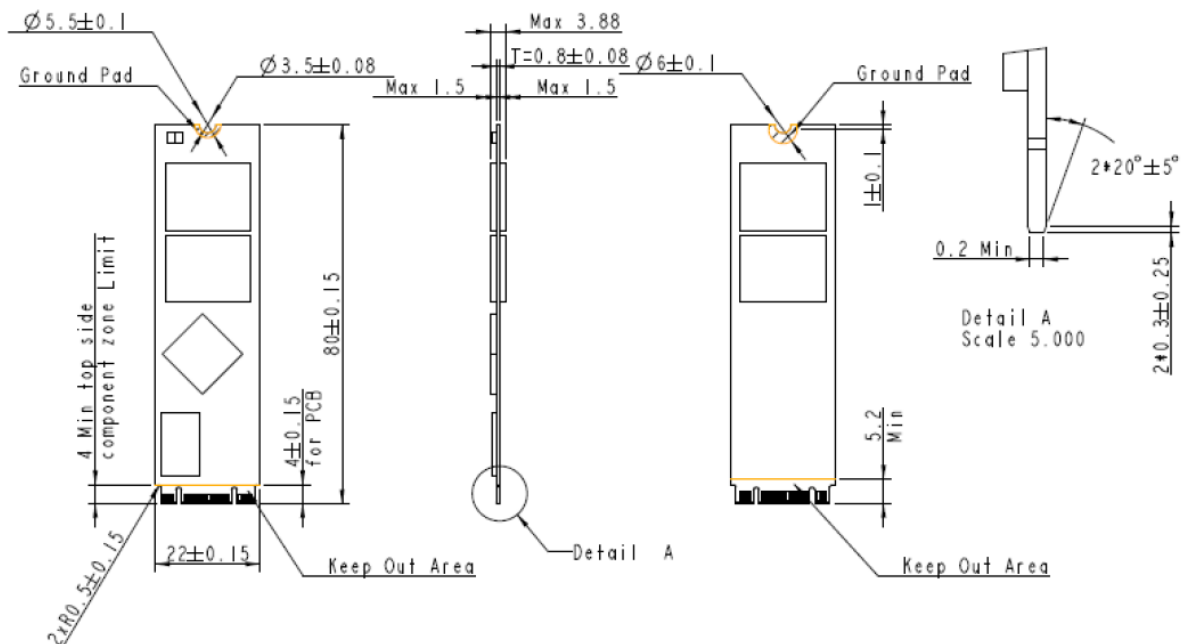
9. Physical Characteristics

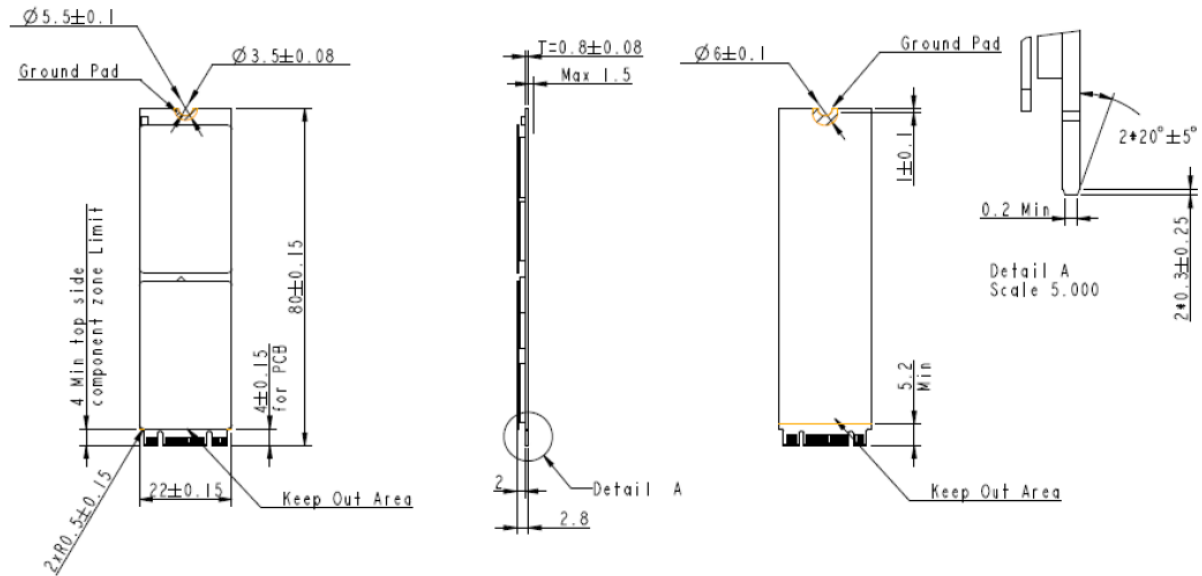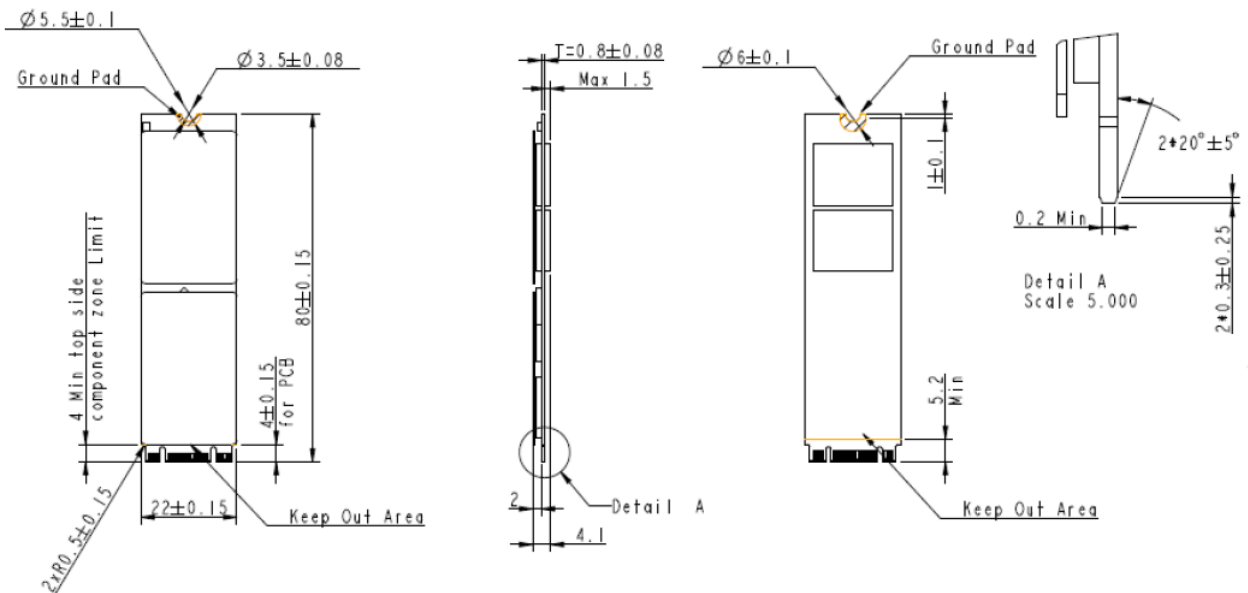## 9.1 Standard Temperature

9.1.1 64-128GB
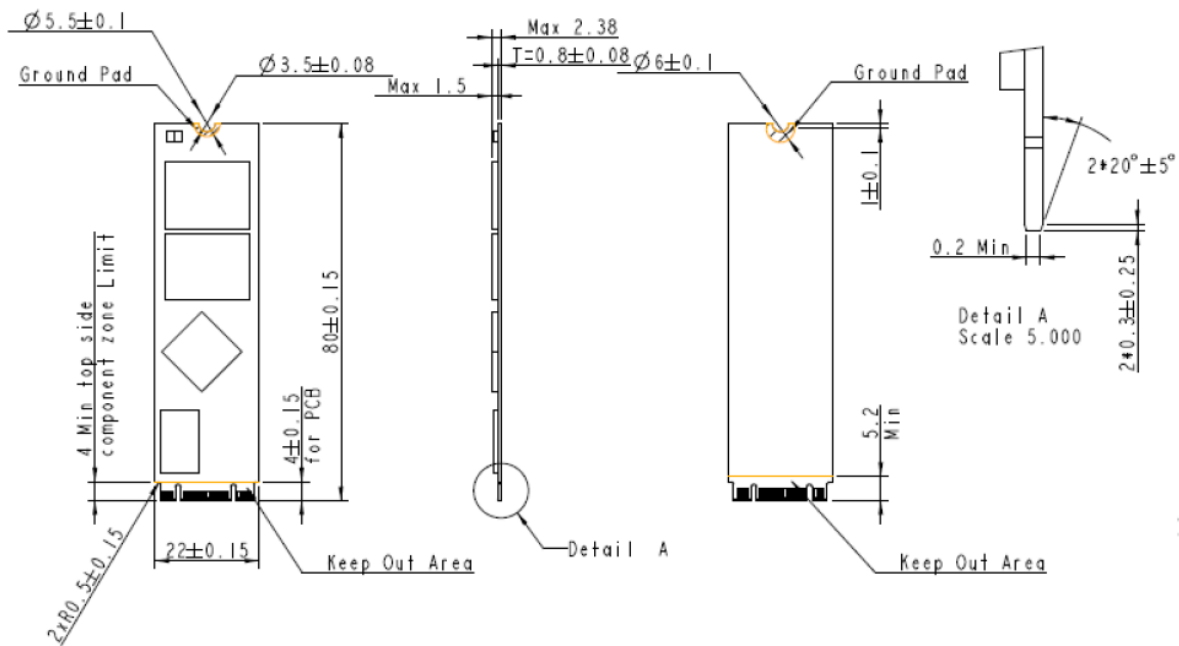
9.1.2 256-512GB

9.2 Wide Temperature

9.2.1 64-128GB

9.2.2 256-512GB

9.3 Net Weight

Table 9-1 Net Weight

Standard Temperature	
Capacity	**Net Weight (g ± 5%)**
64GB	5.4
128GB	5.5
256GB	6.3
512GB	7.3
Wide Temperature	
Capacity	**Net Weight (g ± 5%)**
64GB	8.0
128GB	8.0
256GB	8.8
512GB	9.8

10. Product Ordering Information

10.1 Product Code Designations

AP P xxxG 1 CX – 02 T X X

Blank: Single Side
D: Double Side

Operating Temperature Range
T: 0°C to 70°C
W: -40°C to 85°C

Flash Type

Version Control

Product Spec
CN: Standard
CC: With Metal Pad

M.2 2280

Capacity
64G = 64GB
128G= 128GB
256G = 256GB
512G= 512GB

PCIe

Apacer Product Code
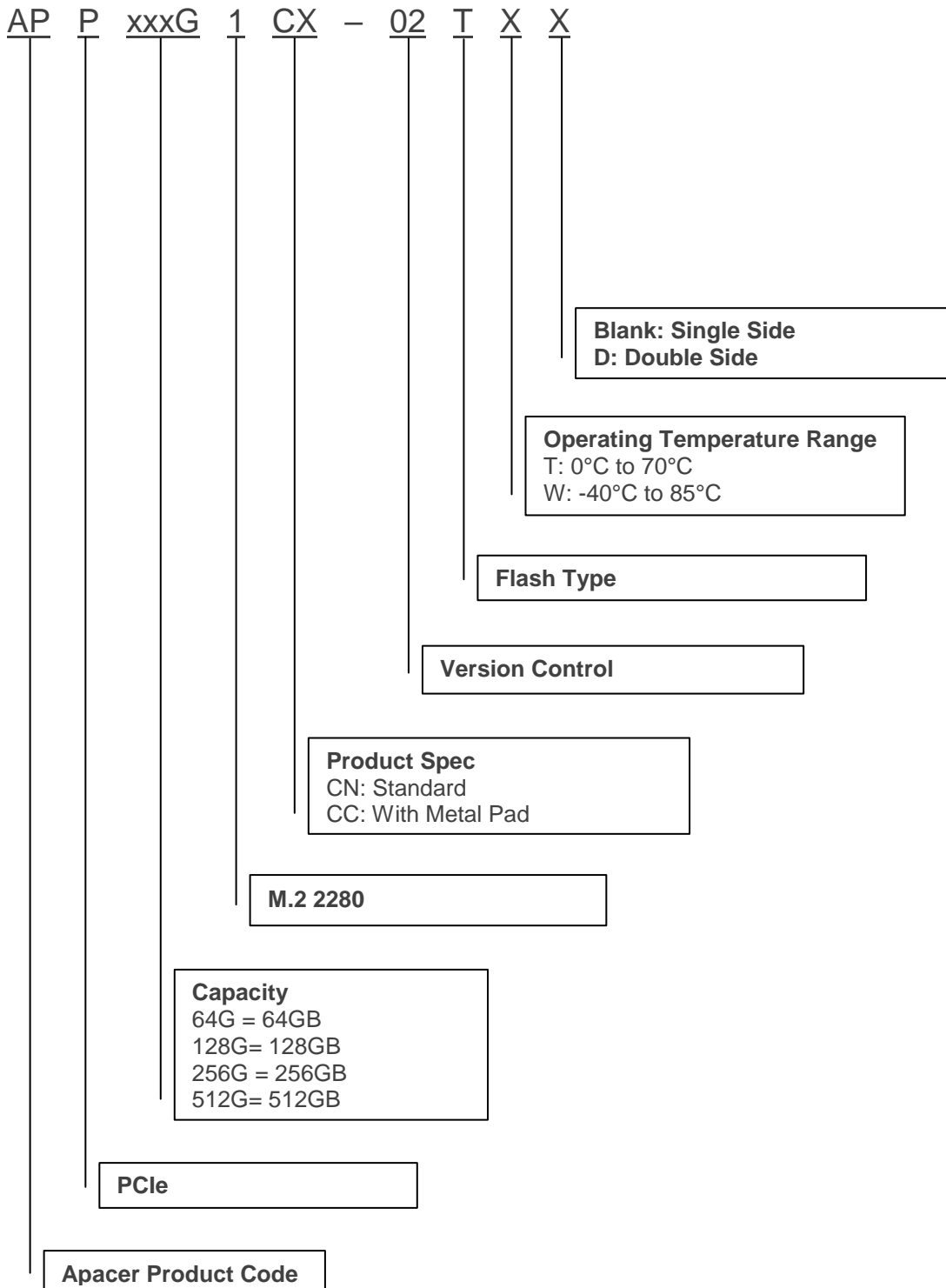
10.2 Valid Combinations

Capacity	Standard Temperature	Wide Temperature
64GB	APP064G1CN-02TT	APP064G1CC-02TW
128GB	APP128G1CN-02TT	APP128G1CC-02TW
256GB	APP256G1CN-02TTD	APP256G1CC-02TWD
512GB	APP512G1CN-02TTD	APP512G1CC-02TWD

Note: Valid combinations are those products in mass production or will be in mass production. Consult your Apacer sales representative to confirm availability of valid combinations and to determine availability of new combinations.

Revision History

Revision	Description	Date
1.0	Initial release	1/21/2020

Global Presence

Taiwan (Headquarters)
Apacer Technology Inc.
1F., No.32, Zhongcheng Rd., Tucheng Dist.,
New Taipei City 236, Taiwan R.O.C.
Tel: 886-2-2267-8000
Fax: 886-2-2267-2261
amtsales@apacer.com

Japan
Apacer Technology Corp.
6F, Daiyontamachi Bldg., 2-17-12, Shibaura, Minato-Ku,
Tokyo, 108-0023, Japan
Tel: 81-3-5419-2668
Fax: 81-3-5419-0018
jpservices@apacer.com

China
Apacer Electronic (Shanghai) Co., Ltd
Room D, 22/FL, No.2, Lane 600, JieyunPlaza,
Tianshan RD, Shanghai, 200051, China
Tel: 86-21-6228-9939
Fax: 86-21-6228-9936
sales@apacer.com.cn

U.S.A.
Apacer Memory America, Inc.
46732 Lakeview Blvd., Fremont, CA 94538
Tel: 1-408-518-8699
Fax: 1-510-249-9551
sa@apacerus.com

Europe
Apacer Technology B.V.
Science Park Eindhoven 5051 5692 EB Son,
The Netherlands
Tel: 31-40-267-0000
Fax: 31-40-290-0686
sales@apacer.nl

India
Apacer Technologies Pvt Ltd,
1874, South End C Cross, 9th Block Jayanagar,
Bangalore-560069, India
Tel: 91-80-4152-9061/62
Fax: 91-80-4170-0215
sales_india@apacer.com