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PCI Express Flash Drive

AS228AP2 Product Specifications

Mar, 2019

Version 1.4

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Specifications Overview:

- **PCIe Interface**
  - Compliant with NVMe 1.2
  - Compatible with PCIe Gen3 x2 interface
- **Capacity**
  - 128GB, 256GB, 512GB

  Performance*
  - Interface burst read/write: 2 GB/sec
  - Sequential read: up to 1,600 MB/sec
  - Sequential write: up to 1,000 MB/sec
- **Flash Management**
  - Bad block management
  - S.M.A.R.T.
  - Power Failure Management
  - TRIM
  - Over-Provision
- **Endurance**
  - 128 GB: > 100TB
  - 256 GB: > 200TB
  - 512 GB: > 400TB
- **Temperature Range**
  - Operating: 0°C to 70°C
  - Storage: -40°C to 85°C
- **Supply Voltage**
  - 3.3 V ± 5%
- **Power Consumption***
  - Active mode: 3500 mW (max.)
  - Power State : <50mW (max.)
- **Connector Type**
  - 75-pin M.2 module pinout
- **NAND Flash Type:** 3D TLC
- **MTBF:** >1,500,000 hours
- **Form Factor**
  - M.2 2280-S3-B-M: 128, 256 GB
  - M.2 2280-D5-B-M: 512 GB
  - Dimensions:
    Single side: 80.00 x 22.00 x 2.38, unit: mm
    Double side: 80.00 x 22.00 x 3.88, unit: mm
  - Net Weight: 6.80 g
- **Shock & Vibration****
  - Shock: 1,500 G
  - Vibration:
    - Frequency/Displacement: 20Hz~80Hz/1.52mm
    - Frequency/Acceleration: 80Hz~2000Hz/20G
- **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.
**Non-operating

1. General Descriptions

Apacer AS228AP2 (M.2 2280) is the next generation modularized Solid State Drive (SSD) with the shape of all new M.2 form factor, aimed to be the more suitable for mobile and compact computers with standard width at only 22.00 mm. AS228AP2 appears in M.2 2280 mechanical dimensions and is believed to be the leading add-in storage solution for future host computing systems.

The M.2 SSD is designed with SATA-based connector pinouts, providing full compliance with the latest PCIe Gen3 x2 interface specifications. Aside from PCIe compliance, AS228AP2 delivers exceptional performance and power efficiency. On the other hand, the extreme thin and light form factor makes AS228AP2 the ideal choice for mobile computing systems, which appears to be the trend in near future.

Regarding reliability, AS228AP2 is built with a powerful PCIe controller that supports on-the-module ECC as well as efficient wear leveling scheme. In terms of power efficiency, AS228AP2 is compliant with PCIe Gen3 x2 interface standard so that it can operate on power management modes, which greatly save on power consumption.

2. Functional Block

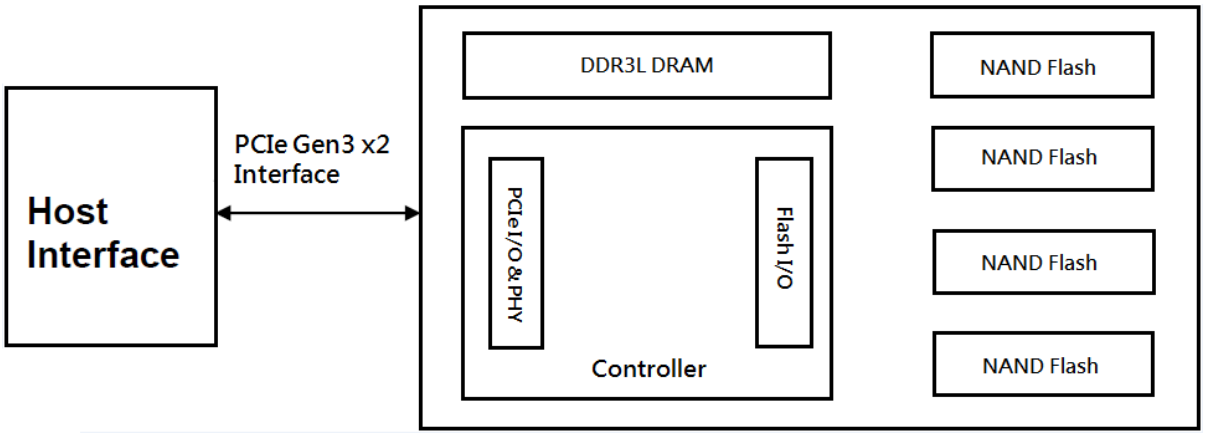


Figure 2-1 Functional Block Diagram

3. Pin Assignments

This connector does not support hot plug capability. There is 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.

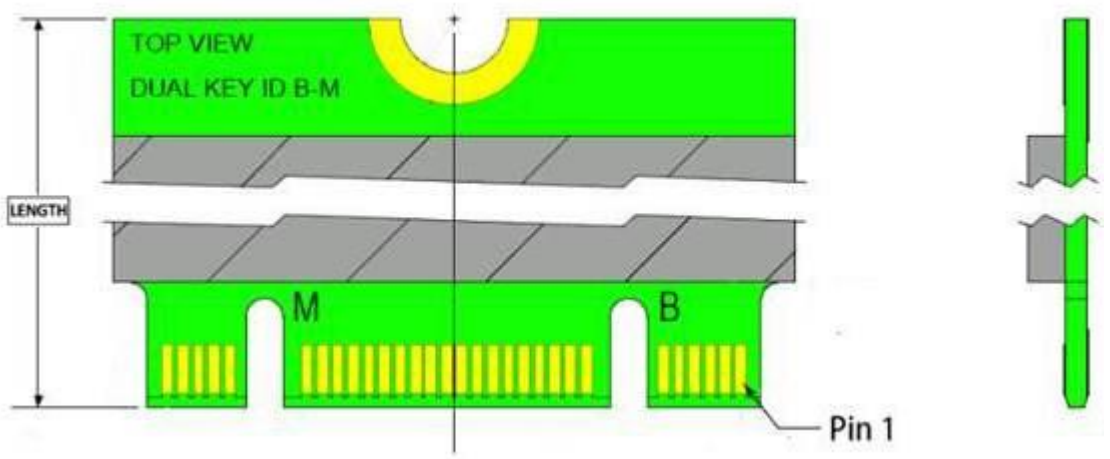


Table 3-1 Pin Assignments

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 Performance

Performance of AS228AP2 is listed below in Table 4-1.

Table 4-1 Performance Specifications

Capacity Performance	128 GB	256 GB	512 GB
Sequential Read* (MB/s)	1,500	1,600	1,600
Sequential Write* (MB/s)	450	850	1,000
Random Read IOPS (4K)**	90,000	180,000	230,000
Random Write IOPS (4K)**	100,000	150,000	160,000

Note:
Results may differ from various flash configurations or host system setting.
*Sequential performance is based on CrystalDiskMark 5.2.1 with file size 1,000MB.
**Random performance measured using IOMeter with Queue Depth 32.

4.2 Environmental Specifications

Environmental specifications of AS228AP2 are shown in Table 4-2.

Table 4-2 Environmental Specifications

Item	Specifications
Operating temp.	0°C to 70°C
Non-operating temp.	-40°C to 85°C
Non-operating vibration	– Frequency/Displacement: 20Hz~80Hz/1.52mm – Frequency/Acceleration: 80Hz~2000Hz/20G
Non-operating shock	1,500(G), 0.5(ms)

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

4.3 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in AS228AP2. The prediction result for AS228AP2 is more than 1,500,000 hours.

4.4 Certification and Compliance

AS228AP2 complies with the following standards:

- FCC
- CE
- RoHS

4.5 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 4-3 Endurance Specifications

Capacity	TeraBytes Written
128 GB	> 100TB
256 GB	> 200TB
512 GB	> 400TB

Note:

- The measurement assumes the data written to the SSD for test is under a typical and constant rate.
- The measurement follows the standard metric: 1 TB (Terabyte) = 1,000 GB.
- The estimated values are based on JEDEC endurance workload comprised of random data with the payload size distribution with sequential write behavior.

5. Flash Management

5.1 Error Correction/Detection

AS228AP2 implements a hardware ECC scheme, based on the Strongest (SECC) algorithm. SECC can detect and correct data errors to ensure data being read correctly and protects data from corruption.

5.2 Bad Block Management

Bad blocks are blocks that do not function properly or contain more invalid bits causing stored data unstable, and their reliability is not guaranteed. Blocks that are identified and marked as bad by the manufacturer are referred to as “Early 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 bad blocks that appear with use. This practice prevents data being stored into bad blocks and further improves the data reliability.

5.3 Wear Leveling

NAND flash devices can only undergo a limited number of program/erase cycles, when flash media is not used evenly, some blocks get updated more frequently than others and the lifetime of 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.

Apacer AS228AP2 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.

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 flush 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. Software Interface

6.1 Command Set

Table 6-1 summarizes the commands supported by AS228AP2.

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

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

6.2 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 6-4 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
[209:208]	2	Temperature Sensor 4
[211:210]	2	Temperature Sensor 5
[213:212]	2	Temperature Sensor 6
[215:214]	2	Temperature Sensor 7
[511:216]	296	Reserved

7. Electrical Specifications

7.1 Operating Voltage

Table 7-1 lists the supply voltage for AS228AP2

Table 7-1 Operating Range

Item	Range
Supply Voltage	3.3V ± 5%

7.2 Power Consumption

Table 7-2 lists the power consumption for AS228AP2.

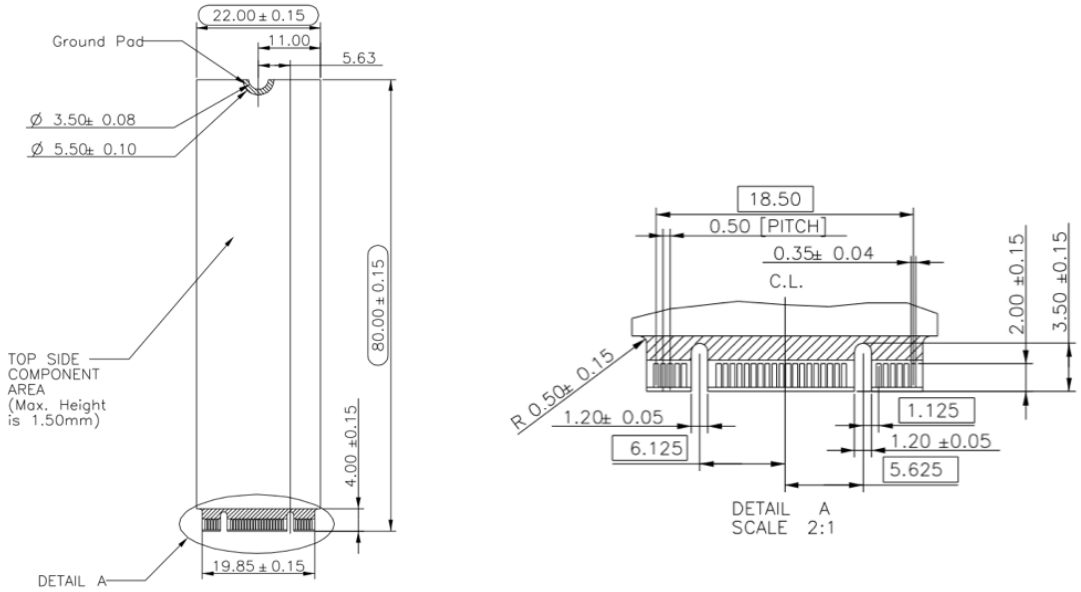
Table 7-2 Power Consumption

Capacity Mode	128 GB	256 GB	512 GB
Active (mW)	2900	3300	3500
Power State 3	35	40	45

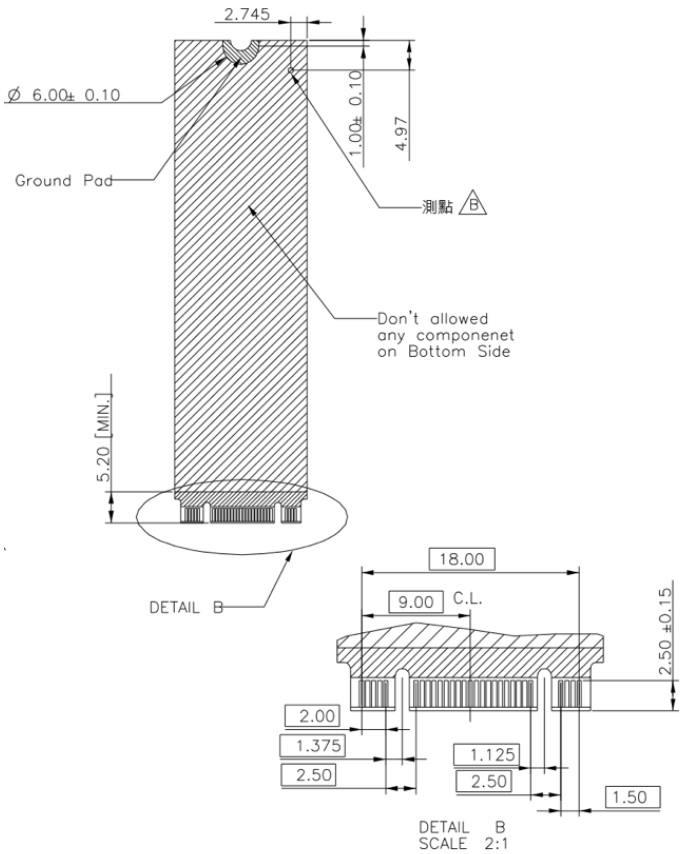
Note:
*All values are typical and may vary depending on flash configurations or host system settings.
**Active power is an average power measurement performed using CrystalDiskMark with 128KB sequential read/write transfers.

8. Physical Characteristics

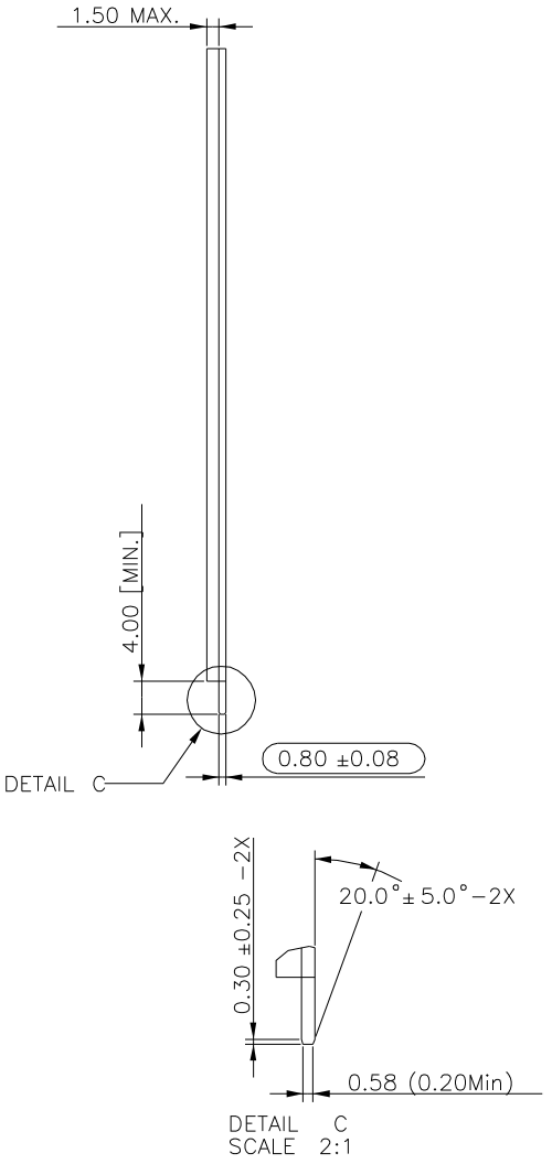
8.1 Physical Dimensions



Top View



Bottom View



Side View

Notes :
1. ▨ = Max Component Height
2. ▨ = No Component
3. ▨ = No Component / Signal Vias / Signal Copper / Printing
4.General Tolerance ±0.15mm
5. ⬭ is IQC inspection dimension

8.2 Part Number Listing

Capacity	Bulk P/N
128GB	85.DCD60.B011C
256GB	85.DCDA0.B011C
512GB	85.DCDE0.B011C

Revision History

Revision	Description	Date
1.0	Preliminary release	11/23/2018
1.1	Update power consumption	11/26/2018
1.2	Add part number listing	12/20/2018
1.3	Change PCIe interface compliant with NVMe 1.2	01/24/2019
1.4	Modify flash management feature	03/20/2019

Global Presence

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