

M.2 2280 PCIe/NVMe SSD 710 Datasheet

(SQF-CM8xx-xG-E8x)

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Revision History

Rev.	Date	History
0.1	2018/1/25	1. Preliminary release
0.2	2018/2/22	1. Adjust Features information
0.3	2018/3/9	1. Add TBW test result
0.4	2018/6/19	1. Add test result
0.5	2018/6/25	1. Add test result
0.6	2018/10/12	1. Add operation temperature information
0.7	2019/5/22	1. Updated product model
0.8	2020/1/9	1. Updated Pin Assignment and Description

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1. Overview

Advantech SQFlash 710 series M.2 2280 PCIe/NVMe SSD (Solid State Drive) follows NGFF M.2 2280 (B+M Key) standard form factor and supports PCIe Gen3 x2 interface with NVMe 1.2 compliance. The SSD offers a wide range of capacities up to 512GB and its performance can reach up to 1.6 GB/s read and 1.0 GB/s write sequential performance based on Toshiba BiCS3 3D TLC flash. Despite SQFlash 710 series M.2 2280 provides 3x more than SATA interface performance, but the power consumption is almost the same. This makes SQFlash 710 series suitable for embedded platforms which request compact design and low power consumption.

NOTES:

1. Achieved by 512GB SSD with external 1GB DDR3L at FOB (fresh-out-of-box) state on CrystalDiskMark v5.1.2.
2. The choice of DDR3L depends on drive capacity; DDR size = 0.1% of SSD capacity.

2. Features

■ PCIe Interface

- Compliant with NVMe1.2
- PCI Express Base 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
- Support power management

■ Operating Voltage : 3.3V

■ Support StrongECCTM (SECC) of ECC algorithm

■ Support SMART and TRIM commands

■ Temperature Ranges

- Commercial Temperature
 - 0°C to 70°C for operating¹
 - -40°C to 85°C for storage
- Industrial Temperature
 - -40°C to 85°C for operating
 - -40°C to 85°C for storage

*Note : 1. Based on SMART Attribute (Byte index [2 :1] of PCIe-SIG standard, which measured by thermal sensor

■ Mechanical Specification

- Shock : 1,500G / 0.5ms
- Vibration : 20G / 80~2,000Hz

■ Humidity

- Humidity : 5% ~ 95% under 55°C

■ Data Retention

- 10 years

■ Acquired RoHS 、 WHQL 、 CE 、 FCC Certificate

■ Acoustic : 0 dB

■ Dimension : 80.8 mm x 22.0 mm x 3.8 mm

3. Specification Table

■ Performance

		Sequential Performance (MB/sec)		Random Performance (IOPS @4K)	
		Read	Write	Read	Write
BiCS3 3D TLC	128 GB	1,501.00	485.90	92,218	117,020
	256 GB	1,581.00	916.40	180,105	186,579
	512 GB	1,599.00	1039.00	239,225	197,855

NOTES:

1. Performance is measured based on the following conditions:
 - A. CrystalDiskMark 5.1.2, 1GB range, QD=32, Thread=1
 - B. IOMeter, 8GB range, 4K data size, QD=32

■ Endurance

JEDEC defined an endurance rating TBW (TeraByte Written), following by the equation below, for indicating the number of terabytes a SSD can be written which is a measurement of SSDs' expected lifespan, represents the amount of data written to the device.

$$\text{TBW} = [(\text{NAND Endurance}) \times (\text{SSD Capacity})] / \text{WAF}$$

- **NAND Endurance:** Program / Erase cycle of a NAND flash.
 - SLC: 100,000 cycles
 - Ultra MLC: 30,000 cycles
 - MLC: 3,000 cycles
 - 3D TLC BiCS3: 3,000 cycles
- **SSD Capacity:** SSD physical capacity in total of a SSD.
- **WAF:** Write Amplification Factor (WAF), as the equation shown below, 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 to 1, guarantees better endurance and lower frequency of data written to flash memory.

$$\text{WAF} = (\text{Lifetime write to flash}) / (\text{Lifetime write to host})$$

Endurance measurement is based on JEDEC 218A/219A client workload and verified with following workload conditions,

- Test duration: over 168hrs (=7 days)
- File Size: Follow by JEDEC 218A & JEDEC 219A

• SQFlash 710 M.2 2280 TBW

	WAF	TBW
		3D TLC (BiCS3)
128 GB	2.52	152
256 GB	2.78	276
512 GB	2.59	593

4. General Description

■ Error Correction Code (ECC)

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, SQF-CM8 710 applies the StrongECCTM (SECC) algorithm, which can detect and correct data errors to ensure data being read correctly, and protects data from corruption.

■ 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.

Phison 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.

■ 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”. Phison 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.

■ Power Loss Protection: Flush Manager

Power Loss Protection is a mechanism to prevent data loss during unexpected power failure. DRAM is a volatile memory and frequently used as temporary cache or buffer between the controller and the NAND flash to improve the SSD performance. However, one major concern of the DRAM is that it is not able to keep data during power failure. Accordingly, SQFlash SSD applies the Flush Manager technology, only when the data is fully committed to the NAND flash will the controller send acknowledgement (ACK) to the host. Such implementation can prevent false-positive performance and the risk of power cycling issues.

In addition, it is critical for a controller to shorten the time the in-flight data stays in the controller internal cache. Thus, SQFlash applies an algorithm to reduce the amount of data resides in the cache to provide a better performance. With Flush Manager, incoming data would only have a “pit stop” in the cache and then move to NAND flash directly. Also, the onboard DDR will be treated as an “organizer” to consolidate incoming data into groups before written into the flash to improve write amplification.

■ 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 so that blocks of data that are no longer in use can be removed permanently. Thus, the SSD will perform the erase action, which prevents unused data from occupying blocks at all time.

■ SMART

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is an open standard that allows a solid state 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 impending failures while there is still time to perform proactive actions, such as save data to another device.

■ Over-Provision

Over Provisioning refers to the preserving additional area beyond user capacity in a SSD, which is not visible to users and cannot be used by them. However, it allows a SSD controller to utilize additional space for better performance and WAF. 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.

■ Thermal Throttling

The purpose of thermal throttling is to prevent any components in a SSD from over-heating during read and write operations. Thermal Throttling function is for protecting the drive and reducing the possibility of read / write error due to overheat. The temperature is monitored by the thermal sensor. As the operating temperature continues to increase to threshold temperature, the Thermal Throttling mechanism is activated. At this time, the performance of the drive will be significantly decreased to avoid continuous heating. When the operating temperature falls below threshold temperature, the drive can resume to normal operation.

■ Security Features

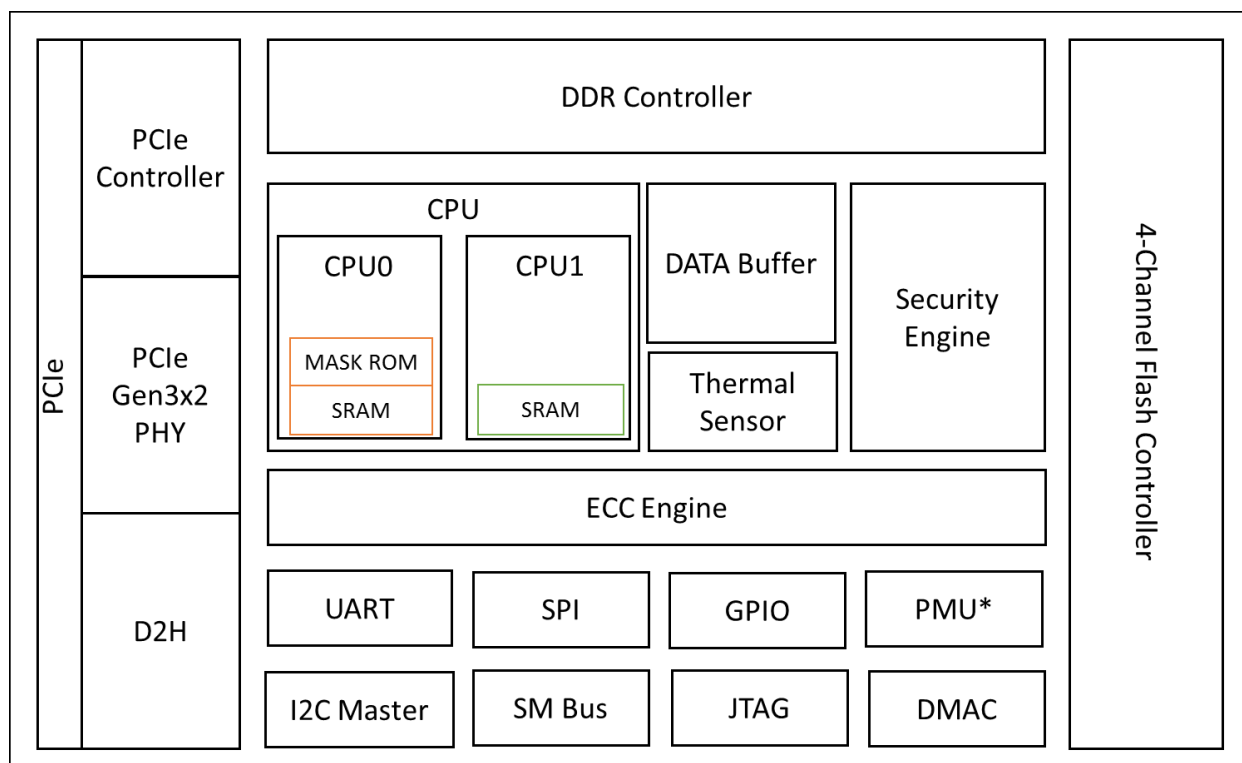
- Advanced Encryption Standard (AES)

An AES 256-bit encryption key is generated in the drive's security controller before the data gets stored on the NAND flash. When the controller or firmware fails, the data that is securely stored in the encryption key becomes inaccessible through the NAND flash.

- Secure / Quick Erase

SQFlash 710 series supports standard NVMe command secure erase. Also, with internal AES encryption support, the erase process will start with resetting AES key. By doing so, existing data will be scrambled within 10ms and cannot be recovered anymore. Moreover, erase flag is set when erase function is triggered, which will ensure the whole erase process can be 100% completed. Even there's power interrupt, after power resume, erase operation will be resume right away as well.

■ Block Diagram



■ LBA value

Density	LBA
128 GB	250,069,680
256 GB	500,118,192
512 GB	1,000,215,216

5. Pin Assignment and Description

Below table 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	CONFIG_3 = Ground
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	LED1#	Open drain, active low signal. These signals are used to allow the add-in card to provide status indicators via LED devices that will be provided by the system.
11	N/C	No connect
12	Module Key B	Module Key
13	Module Key B	
14	Module Key B	
15	Module Key B	
16	Module Key B	
17	Module Key B	
18	Module Key B	
19	Module Key B	
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	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 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 (Reserve)
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 (Reserve)

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43	PETp0	PCIe TX Differential signal defined by the PCIe 3.0 specification
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 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 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	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	N/C	No connect
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. NVMe Command List

■ 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
NVM Command Set Specific	
80h	Format NVM
81h	Security Send
82h	Security Receive

■ NVM commands

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

7. Identify Device Data

The Identify Device Data enables Host to receive parameter information from the device. The parameter words in the buffer have the arrangement and meanings defined in below table. All reserve bits or words are zero

■ Identify Controller Data Structure

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)	0
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)	0
239:96	-	Reserved	0
255:240	-	Refer to the NVMe Management Interface Specification for definition	0
257:256	M	Optional Admin Command Support (OACS)	0x0007
258	M	Abort Command Limit (ACL)	0x03
259	M	Asynchronous Event Request Limit (AERL)	0x03
260	M	Firmware Updates (FRMW)	0x02
261	M	Log Page Attributes (LPA)	0x03
262	M	Error Log Page Entries (ELPE)	0x3F
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)	0x0157
269:268	M	Critical Composite Temperature Threshold (CCTEMP)	0x0193
271:270	O	Maximum Time for Firmware Activation (MTFA)	0x0000
275:272	O	Host Memory Buffer Preferred Size (HMPRE)	0
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
315:312	O	Replay Protected Memory Block Support (RPMBS)	0
511:316	-	Reserved	0
NVM Command Set Attributes			
512	M	Submission Queue Entry Size (SQES)	0x66
513	M	Completion Queue Entry Size (CQES)	0x44
515:514	-	Reserved	0
519:516	M	Number of Namespaces (NN)	0x01
521:520	M	Optional NVM Command Support (ONCS)	0x001E
523:522	M	Fused Operation Support (FUSES)	0
524	M	Format NVM Attributes (FNA)	0
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)	0x00
530	M	NVM Vendor Specific Command Configuration (NVSCC)	0x01
531	M	Reserved	0

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533:532	O	Atomic Compare & Write Unit (ACWU)	0x00
535:534	M	Reserved	0
539:536	O	SGL Support (SGLS)	0x00
703:540	M	Reserved	0
IO Command Set Attributes			
2047:704	M	Reserved	0
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)	0
3071:3040	O	Power State 31 Descriptor	PSD31
Vendor Specific			
4095:3072	O	Vendor Specific (VS)	Phison Reserved

■ 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)

■ List of Device Identification for Each Capacity

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

8. SMART Attributes

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

9. System Power Consumption

■ Supply Voltage

Parameter	Rating
Operating Voltage	3.3V

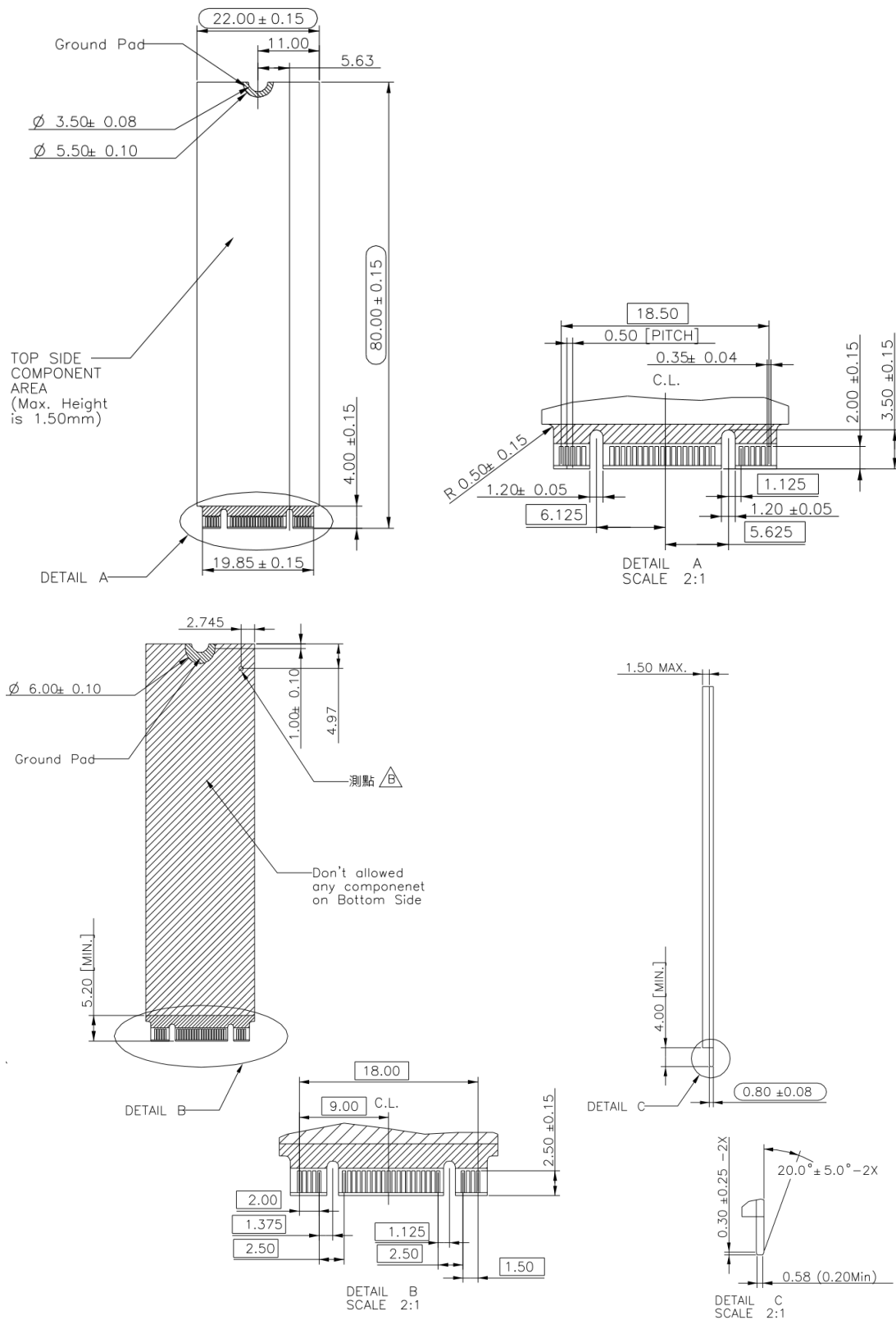
■ Power Consumption

mW		Read	Write	Idle
BiCS3 3D TLC	128 GB	2,734	2,223	35
	256 GB	3,249	2,776	40
	512 GB	3,346	2,913	45

1. The average value of power consumption is achieved based on 100% conversion efficiency.
2. Sample is measured under ambient temperature.
3. Power Consumption may differ according to flash configuration and platform.
4. Power consumption is measured during the sequential read and writes operations performed by CrystalDiskMark with the conditions described in 1(A).

10. Physical Dimension

M.2 2280 (B+M key) PCIe/NVMe SSD (Unit: mm)



Appendix: Part Number Table

BiCS3 3D TLC

Product	Advantech PN
SQF 710 PCIe/NVMe M.2 2280 128G 3D TLC (BiCS3) (0~70°C)	SQF-CM8V2-128G-E8C
SQF 710 PCIe/NVMe M.2 2280 256G 3D TLC (BiCS3) (0~70°C)	SQF-CM8V4-256G-E8C
SQF 710 PCIe/NVMe M.2 2280 512G 3D TLC (BiCS3) (0~70°C)	SQF-CM8V4-512G-E8C
SQF 710 PCIe/NVMe M.2 2280 128G 3D TLC (BiCS3) (-40~85°C)	SQF-CM8V2-128G-E8E
SQF 710 PCIe/NVMe M.2 2280 256G 3D TLC (BiCS3) (-40~85°C)	SQF-CM8V4-256G-E8E
SQF 710 PCIe/NVMe M.2 2280 512G 3D TLC (BiCS3) (-40~85°C)	SQF-CM8V4-512G-E8E