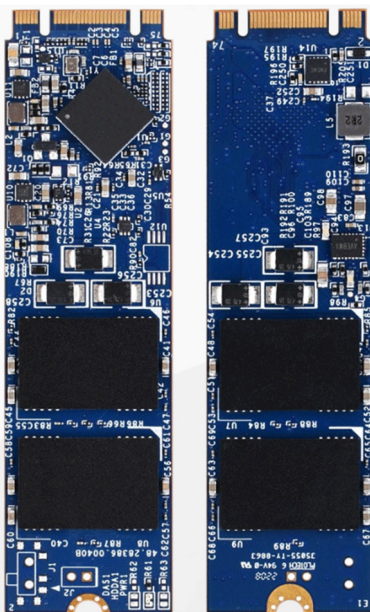*fortasa*
memory systems

RoHS Compliant

M.2 A-E - 2280 SATA Flash Module Series

Datasheet for M.2 A-E 2280 SATA 3 3D TLC based Flash Module with DataProtect capacitors

April 3, 2024

Revision 1.3

This Specification Describes the Features and Capabilities of the Standard and Industrial Temperature M.2 SATA Interface Modules

Please Contact Fortasa Memory Systems Sales for any Custom Features Required For Your Specific Application

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M.2 2280 SATA Flash Module
FMS-SM2A8xxxx-XED

Features:

- **Standard Serial SATA 3.2**
  - SATA 3.2 command set compatible
  - SATA 6.0 Gbps Interface
  - Backwards compatible with SATA 1.5 and 3.0 Gbps interfaces
  - ATA command set-4 (ACS-4)
- **Low power consumption (typical)**
  - Supply voltage: 3.3V±5%
    - Active mode: 425 mA (max)
    - Idle mode: 70 mA
- **NAND flash type: 3D NAND – BICS5 TLC**
- **MTBF (hours):** >3,000,000
- **Temperature ranges**
  - Operation:
    - Standard: 0°C to 70°C
    - Industrial: -40°C to 85°C
  - Storage: -40°C to 100°C
- **Performance**
  - Performance
    - Sustained Read: up to 560 MB/sec
    - Sustained Write: up to 510 MB/sec
    - Random read 4K: up to 55,000 IOPS
    - Random write 4K: up to 72,000 IOPS
- **Intelligent endurance design**
  - Built-in hardware LDPC based ECC algorithm
  - Global wear-leveling scheme together with dynamical block allocation to significantly increase the lifetime of a flash device and optimize the disk performance
  - Flash bad-block management
  - *Power Failure Management*
  - *ATA Secure Erase*
  - *SMART Command*
  - *Trim Command*
- **LED Indicators for Drive Behavior**
- **DataProtect Technology -** Implementation of Tantalum Capacitors to serve as backup power supply, capable of withstanding extended ambient temperature
- **AES-256 Hardware On-The-Fly Encryption Security**
- **Thermal Sensor for Temperature Management**
- **RoHS Recast compliant (complies with 2011/65/EU standard)**

- **Capacity**
  - 120GB, 240GB, 480GB, 960GB, 1920GB
- **Connector Type**
  - 75-pin SATA Based M.2 module pin-out
- **Form factor**
  - Double-sided M.2 2280-D5-B-M
  - 80.00 x 22.00 x 3.88(max), unit: mm
- **Endurance (in Drive Writes Per Day (DWPD))**
  - 120 GB: 2.13 DWPD
  - 240 GB: 1.99 DWPD
  - 480 GB: 2.02 DWPD
  - 960 GB: 1.35 DWPD
  - 1920 GB: 1.39 DWPD

Table of Contents

1 Product Description

1.1 General Description

Fortasa's M.2 2280 is a high-performance, SATA interface, solid state drive (SSD) designed to replace a conventional SATA hard disk drive. This module supports standard SATA protocol and can be plugged into a standard SATA connector commonly found in rugged laptops, military devices, thin clients, Point of Sale (POS) terminals, telecom, medical instruments, surveillance systems and industrial PCs.

The M.2 2280 module offers capacities of up to 2TB, providing full support for the SATA 6GBps high-speed interface standard. It can operate at sustained access rates of up to 500 megabytes per second, which is much faster than other solid-state or traditional HDD SATA drives currently available on the market. **Manufactured using 3D BICS3 TLC NAND-flash, this SSD offers cost effective solution to high capacity storage needs and withstand wide range of operating temperature from -40°C to +85°C.**

M.2 2280 offers high reliability global data wear-leveling scheme to allow uniform use of all storage blocks, increasing the lifetime of Flash media and optimizing drive performance. It also offers Self-Monitoring Analysis and Reporting Technology (S.M.A.R.T.) feature that follows the ATA/ATAPI specifications and uses the standard SMART command B0h to read data from the drive. This capability monitors the drive accesses and provides the host with vital information about drive condition to schedule maintenance and service times. Furthermore, M.2 2280 is equipped with a built-in thermal sensor to monitor the temperature of the SSD via S.M.A.R.T commands to prevent overheating.

1.2 Functional Block

The M.2 2280 drive incorporates a SATA 6.0 Gps Flash Controller and flash media. The Flash controller integrates the flash management unit to support multi-channel, multi-bank flash arrays.
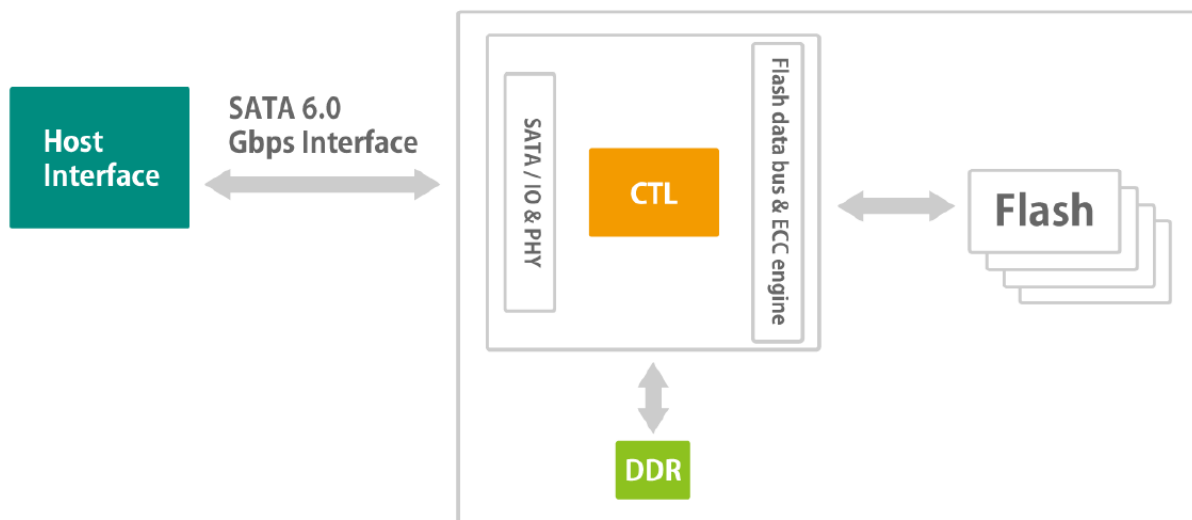
1.3 Capacity Specification

Standard capacity specification of the M.2 2280 Flash Drive product is shown in Table 1-1. The table lists the specific capacity and the default numbers of heads, sectors and cylinders (CHS).

Table 1-1: Capacity specifications

Capacity	Total Bytes	Cylinders	Heads	Sectors	Max LBA
120GB	120,034,123,776	16383[1]	16	63	234,441,648
240GB	240,057,409,536	16383[1]	16	63	468,862,128
480GB	408,103,981,056	16383[1]	16	63	937,703,088
960GB	960,197,124,096	16383[1]	16	63	1,875,385,008
1920GB	1,920,383,410,176	16383[1]	16	63	3,750,748,848

1. Cylinders, heads or sectors are not applicable for these capacities. Only LBA addressing applies.

1.4 Performance Specification

Performances of the M.2 2280 devices are listed in Table 1-2.

Table 1-2: Performance specifications

Performance ╲ Capacity	120GB	240GB	480GB	960GB	1920GB
Sustained read (MB/s)	560	560	560	560	560
Sustained write (MB/s)	220	385	510	505	510
Random Read IOPS (4K)	16,000	35,000	55,000	51,000	52,000
Random Write IOPS (4K)	48,000	72,000	70,000	68,000	66,000

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

1.5 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.
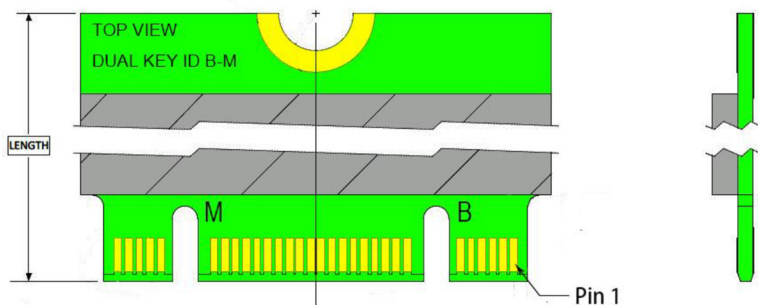
Figure 1-2: SATA connectors

Table 1-4: Signal Segment

Pin	Signal	Description
1	CONFIG_3	Ground (according to M.2 configurations for SSD-SATA definition)
2	3.3V	Supply Pin, 3.3V
3	GND	Ground
4	3.3V	Supply Pin, 3.3V
5	No Connect	No Connect
6	Not Available	Do Not Connect
7	Not Available	Do Not Connect
8	Not Available	Do Not Connect
9	No Connect	No Connect
10	DAS/DSS	Device Activity Signal/Disable Staggered Spin-up. Status indicators via LED devices enabled by the system Active Low. A pulled-up LED with a series current limiting resistor should allow for 9mA output when On.
11	No Connect	No Connect
12	Module key	
13	Module key	
14	Module key	
15	Module key	
16	Module key	
17	Module key	
18	Module key	
19	Module key	
20	Not Available	Do Not Connect
21	CONFIG_0	Ground (according to M.2 configurations for SSD-SATA definition)
22	Not Available	Do Not Connect
23	Not Available	Do Not Connect
24	Not Available	Do Not Connect

25	Not Available	Do Not Connect
26	Not Available	Do Not Connect
27	GND	Ground
28	Not Available	Do Not Connect
29	Not Available	Do Not Connect
30	Not Available	Do Not Connect
31	Not Available	Do Not Connect
32	Not Available	Do Not Connect
33	GND	Ground
34	Not Available	Do Not Connect
35	Not Available	Do Not Connect
36	Not Available	Do Not Connect
37	Not Available	Do Not Connect
38	Not Available	Do Not Connect
39	GND	Ground
40	Not Available	Do Not Connect
41	SATA-Rx+	Host receiver differential signal pair
42	Not Available	Do Not Connect
43	SATA-Rx-	Host receiver differential signal pair
44	Not Available	Do Not Connect
45	GND	Ground
46	Not Available	Do Not Connect
47	SATA-Tx-	Host transmitter differential pair
48	Not Available	Do Not Connect
49	SATA-Tx+	Host transmitter differential pair
50	Not Available	Do Not Connect
51	GND	Ground
52	Not Available	Do Not Connect
53	Not Available	Do Not Connect
54	Not Available	Do Not Connect
55	Not Available	Do Not Connect
56	Not Available	Do Not Connect
57	GND	Ground
58	Not Available	Do Not Connect
59	Not Available	Do Not Connect
60	Not Available	Do Not Connect
61	Not Available	Do Not Connect
62	Not Available	Do Not Connect
63	Not Available	Do Not Connect
64	Not Available	Do Not Connect

65	Not Available	Do Not Connect
66	Not Available	Do Not Connect
67	Not Available	Do Not Connect
68	SUSCLK	Not Used
69	CONFIG_1	Ground
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	Defines module type

2. Software Interface

2.1 Command Set

Table 2-1 summarizes the command set with the paragraphs that follow describing the individual commands and the task file for each.

Table 2-1: Command set

Command	Code	Command	Code
Check-Power-Mode	E5H	Security-Disable-Password	F6H
Data Set Management	06h	Security-Erase-Prepare	F3H
DCO	B1h	Security-Erase-Unit	F4H
Download Microcode PIO	92h	Security-Freeze-Lock	F5H
Download Microcode DMA	93h	Security-Set-Password	F1H
Execute-Drive-Diagnostic	90H	Security-Unlock	F2H
Flush-Cache	E7H	Seek	7XH
Identify-Drive	ECH	Set-Features	EFH
Idle	E3H	Set MAX Address	F9H
Idle-Immediate	E1H	Set MAX Address EXT	37H
Initialize-Drive-Parameters	91H	Set-Multiple-Mode	C6H
Read Buffer	E4	Set-Sleep-Mode	E6H
Read DMA (W retry)	C8H	SMART	B0H
Read DMA (W/O retry)	C9H	Stand-By	E2H
Read DMA EXT	25H	Stand-By-Immediate	E0H
Read FPDMA Queued	60H	Write Buffer	E8H
Read Log EXT	2FH	Write DMA	CAH or CBH
Read-Multiple	C4H	Write DMA EXT	35H
Read-Multiple EXT	29H	Write DMA FUA EXT	3DH
Read Native Max Address	F8H	Write FPDMA Queued	61H
Read Native Max Ext	27H	Write Log EXT	3FH
Read-Sector(s)	20H or 21H	Write-Multiple	C5H
Read-Sector(s) EXT	24H	Write-Multiple EXT	39H
Read-Verify-Sectors	40H or 41H	Write-Multiple FUA EXT	CEH
Read-Verify-EXT	42H	Write-Sector(s)	30H or 31H
Recalibrate	10H	Write-Sector(s) EXT	34H
		Write Uncorrectable	45H

3. Flash Management

3.1 Error Correction/Detection

The M.2 2280 Module 2280 Flash Module implements a hardware LDPC (Low Density Parity Check) based ECC scheme to ensure data has been read correctly, and protect critical stored information from corruption.

3.2 Wear Leveling

All NAND flash devices are limited by a finite number of write cycles. Under a standard file system, frequent file table updates are mandatory. As a painful side effect of OS file overhead, some areas of flash address space wear out faster than others. As these certain sections get a substantially higher write occurrence the whole drive can wear out very quickly. This uneven wear would significantly reduce the lifetime of the whole device, even if majority of the Flash sectors are far from the write cycle limit. Fortasa's SATA Flash Drive products offer advanced data wear leveling which distributes Flash writes evenly across the drive memory space. By utilizing this advanced wear leveling feature, the lifetime of the media can be significantly extended.

3.3 Power Failure Management

The Low Power Detection on the Flash controller initiates cached data saving before the power supply to the device drops too low for operation. This feature prevents the device from system crash and ensures data integrity during an unexpected brownout. This feature makes sure that there are no catastrophic failures of the drive due to system power glitches.

3.3 DataProtect Technology

As an additional layer of protection from sudden power disruptions or brown-outs, Fortasa has developed DataProtect hardware-based technology. The DataProtect consists of Tantallum electrolytic capacitors that can deliver emergency power current to enable the flash controller to flush cached data and essential metadata into NAND Flash blocks.

In addition to electrolytic capacitors which guarantee SSD data integrity, an integrated voltage detector also serves the same purpose as well as ensures the stability of data transmission. The detector is designed to take proactive measures for the aforementioned disastrous scenario. When supply voltage drops below a minimum threshold, the detector will notify the flash controller to halt operation to prevent erratic operation. In parallel, to avoid potential data loss, the detector will also force DRAM to flush cached data into NAND Flash blocks using the additional energy stored in the Tantallum capacitors.

3.4 ATA Secure Erase

Accomplished by the Secure Erase (SE) command, which added to the open ANSI standards that control disk drives, "ATA Secure Erase" is built into the disk drive itself and thus far less susceptible to malicious software attacks than external software utilities. It is a positive easy-to-use data destroy command, amounting to electronic data shredding. Executing the command causes a drive to internally completely erase all possible user data. This command is carried out within disk drives, so no additional software is required. The erase process will not stop until it is completed. In case of power failure, the erase process will continue when the power is reapplied to the device.

3.5 S.M.A.R.T. Technology

S.M.A.R.T. is an acronym for Self-Monitoring, Analysis and Reporting Technology, an open standard allowing disk drives to automatically monitor their own health and report potential problems. It protects the user from unscheduled downtime by monitoring and storing critical drive performance and calibration parameters. Ideally, this should allow taking proactive actions to prevent impending drive failure.

Code	SMART Subcommand
D0h	READ DATA
D1h	READ ATTRIBUTE THRESHOLDS
D2h	Enable/Disable Attribute Autosave
D4h	Execute Off-line Immediate
D5h	Read Log (optional)
D6h	Write Log (optional)
D8h	Enable Operations
D9h	Disable operations
Dah	Return Status

General SMART attribute structure

Byte	Description
0	ID (Hex)
1 – 2	Status flag
3	Value
4	Worst
5*-11	Raw Data

*Byte 5: LSB

3.6 TRIM Command Support

Over time the performance of SSD degrades as user continually writes and erases data. The ATA-TRIM command "formats" the SSD to optimize the drive performance. A TRIM enabled SSD running an OS with TRIM support will stay closer to its peak performance without much performance variance.

3.7 SATA Power Management

The M.2 2280 Module supports the following SATA power saving modes:
- ACTIVE: PHY ready, full power, Tx & Rx operational
- PARTIAL: Reduces power, resumes in under 10 µs (microseconds)
- SLUMBER: Reduces power, resumes in under 10 ms (milliseconds)
- HIPM: Host-Initiated Power Management
- DIPM: Device-Initiated Power Management
- AUTO-SLUMBER: Automatic transition from partial to slumber.

Note:
1. The behaviors of power management features depend on host/device settings.

3.8 Thermal Sensor

M.2 2280 Module contains a Thermal Sensor that measures module temperature. The module temperature can be obtained by polling SMART Command attribute ID 194 (0xC2). When the device temperature reaches a pre-set temperature threshold, the module performance will be reduced to limit the power draw and prevent the module from overheating.

4. Environmental Specifications

4.1 Environments

Environmental specification of the M.2 2280 Flash Module series follows the MIL-STD-810F standard as shown in Table 4-1.

Table 4-1: Environmental specifications

Environment		Specification
Temperature	Operation	0°C to +70°C (Standard); -40°C to +85°C (Industrial)
	Storage	-55°C to +100°C
Vibration (Operating)		7.69 GRMS, 20~2000 Hz/random (compliant with MIL-STD-810G)
Vibration (Non Operating)		4.02 GRMS, 20~2000 Hz/random (compliant with MIL-STD-810G)
Shock (Operating)		Acceleration, 50(G)/11(ms)/half sine (compliant with MIL-STD-202G)
Shock (Non-Operating)		Acceleration, 1500(G)/0.5(ms)/half sine (compliant with MIL-STD-883K)

4.2 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in the Flash drive. Based on provided component data, M.2 2280 is rated at more than 3,000,000 hours.

 Notes about the MTBF:

The MTBF is predicated and calculated based on "Telcordia Technologies Special Report, SR-332, Issue 2" method.

4.3 Certification and Compliance

The M.2 2280 complies with the following standards:
- CE
- FCC
- MIL-STD-810
- RoHS Recast

4.4 Endurance

The endurance of a storage device is predicted by a JEDEC approved test methodology. The data, reported in Drive Writes Per Day (DWPD), is based on several factors related to device architecture and product usage, such as the amount of data written into the drive, block management conditions, and daily workload for the drive. Please contact Sales to learn more about the DWPD analysis and calculations.

Table 4-2: TBW Values

Capacity	DWPW
120GB	2.13
240GB	1.99
480GB	2.02
960GB	1.35
1920GB	1.39

Notes:
- This estimation complies with JEDEC JESD-219, Enterprise endurance workload of random data with payload size distribution.
- Flash vendor guaranteed 3D NAND TLC P/E cycle: 3K
- WAF may vary from capacity, flash configurations and writing behavior on each platform.
- 1 Terabyte = 1,024GB
- DWPD (Drive Writes Per Day) is calculated based on the number of times that user overwrites the entire capacity of an SSD per day of its lifetime during the warranty period. (3D NAND TLC warranty: 3 years)

4.5 LED Indicator Behavior

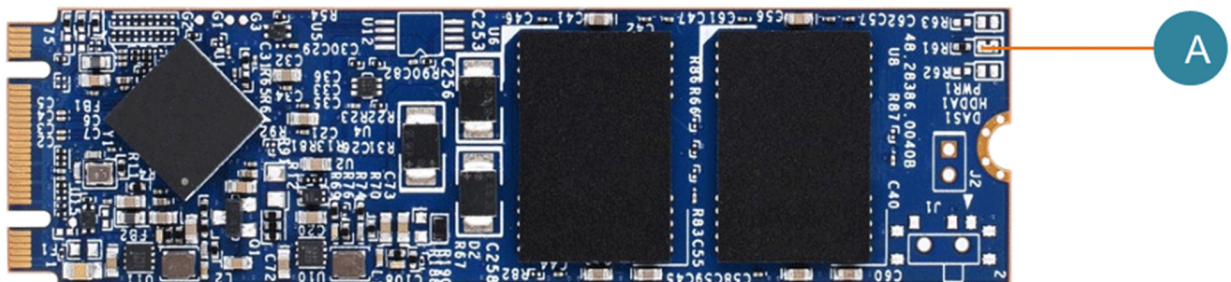The behavior of the M.2 2280 LED indicators is described in Table 4-3.

Table 4-3: LED Behavior

Location	LED	Description
LED A	HDDA1	LED blinks when the drive is being accessed

5. Electrical Specification

5.1 Operating Voltage

Caution: **Absolute Maximum Stress Ratings –** Applied conditions greater than those listed under "Absolute Maximum Stress Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these conditions or conditions greater than those defined in the operational sections of this data sheet is not implied. Exposure to absolute maximum stress rating conditions may affect device reliability.

Table 5-1: Operating range

Range	Ambient Temperature	Conditions
Standard	0°C to +70°C	3.3 V ±5% (3.135-3.465V)
Industrial	-40°C to +85°C	3.3 V ±5% (3.135-3.465V)

5.2 Power Consumption

Table 5-2 lists the M.2 2280 power consumption.

Table 5-2 Typical power consumption

Performance \ Capacity	120GB	240GB	480GB	960GB	1920GB
Active Mode (Max) (mA)	370	395	420	415	425
Idle Mode (mA)	65	70	70	70	70

Notes:
- 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.

6. Physical Characteristics

6.1 Physical Dimensions

Figure 6-1 illustrates the overall physical dimensions of the M.2 2280 drive.
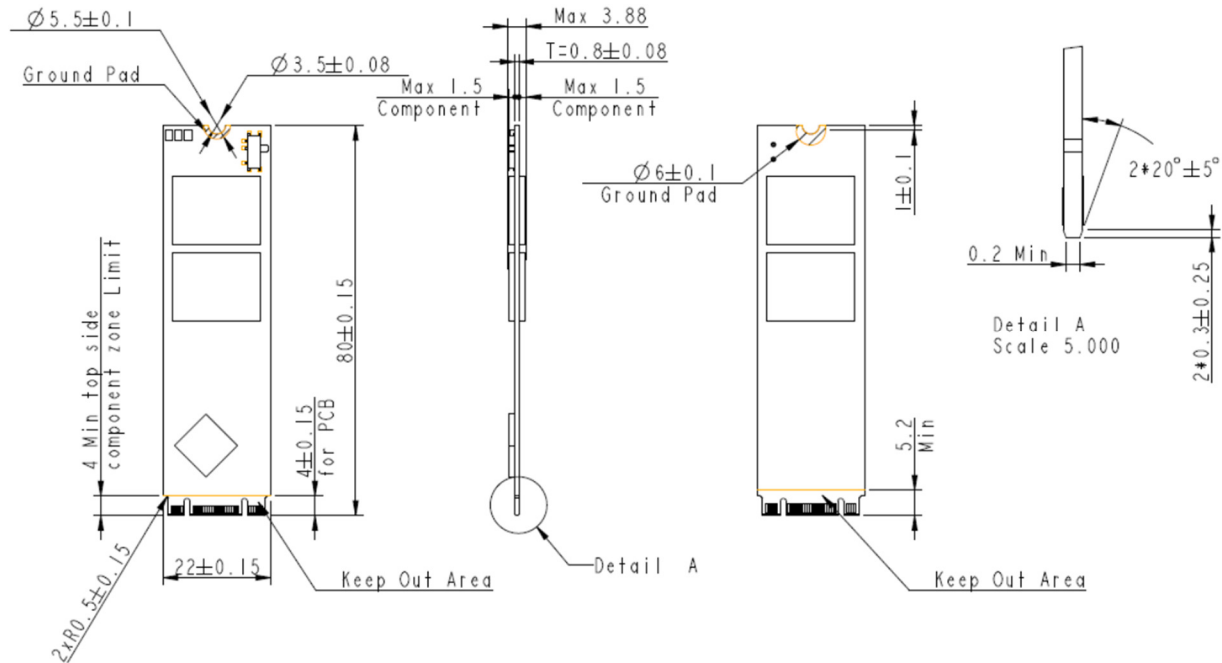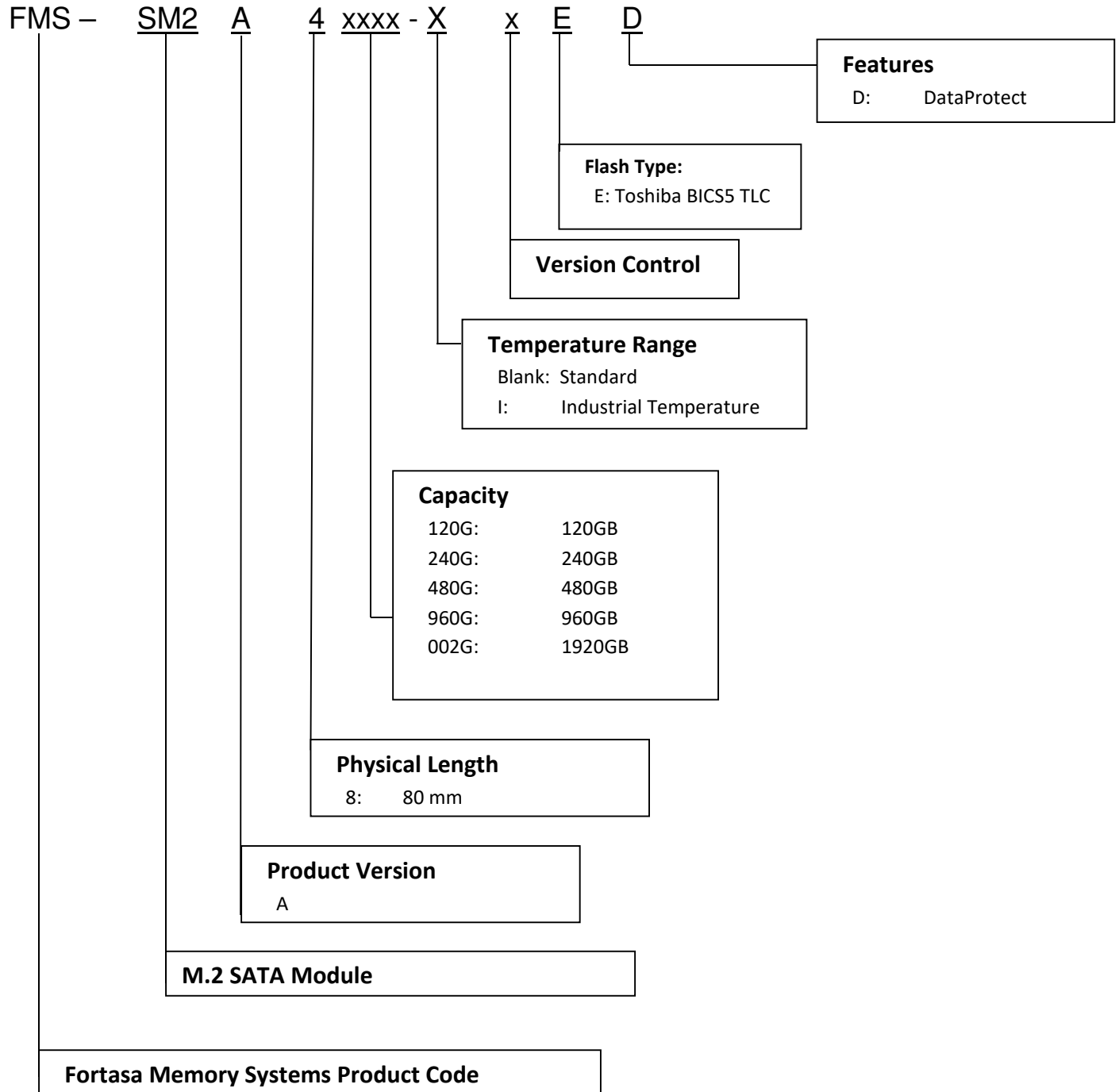

Figure 6-1 M.2 2280 physical dimensions

6.2 Physical Information

Parameter	Unit	120GB	240GB	480GB	960GB	1920GB
Length		80 ± 0.15	22 ± 0.15	22 ± 0.15	3.88	3.88
Width	mm	22 ± 0.15				
Height (Max.)		3.88				
Weight	g ± 5%	5.93	6.45	6.45	6.47	6.47

7. Product Ordering Information

7.1 Product Code Designations

FMS –   SM2   A   4 xxxx - X   x   E   D

Features
D: DataProtect

Flash Type:
E: Toshiba BICS5 TLC

Version Control

Temperature Range
Blank: Standard
I: Industrial Temperature

Capacity

120G:	120GB
240G:	240GB
480G:	480GB
960G:	960GB
002G:	1920GB

Physical Length
8:     80 mm

Product Version
A

M.2 SATA Module

Fortasa Memory Systems Product Code

7.2 Valid Combinations

Capacity	Standard Temperature Model Numbers	Industrial Temperature Model Numbers
120GB	FMS-SM2A8120G-ED	FMS-SM2A8120G-IED
240GB	FMS-SM2A8240G-ED	FMS-SM2A8240G-IED
480GB	FMS-SM2A8480G-ED	FMS-SM2A8480G-IED
960GB	FMS-SM2A8960G-ED	FMS-SM2A8960G-IED
1920GB	FMS-SM2A8002T-ED	FMS-SM2A8002T-IED

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

8. Revision History

Revision	Date	Description	Comments
1.0	8/3/2022	Initial Release	
1.1	9/8/2023	AddED DWPD Results	
1.2	2/2/2024	Updated Section 7-2 – Valid Combinations	
1.3	4/3/2024	Added 1920GB support	