RoHS Compliant

M.2 - 2280 SATA Flash Module Series

Datasheet for M.2 2280 SATA 3 BICS3 TLC NAND based Flash Module

March 2, 2020

Revision 1.2

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

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

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Features:

- **Standard Serial SATA 3.2**
  - SATA 3.2 command set compatible
  - Serial SATA 6.0 Gbps Interface
  - Backwards compatible with SATA 1.5 and 3.0 Gbps interfaces
- **Low power consumption (typical)**
  - Supply voltage: 3.3V±5%
    - Active mode: <2100 mW
    - Idle mode: <900 mW
- **NAND flash type: 3D NAND – BICS3 TLC**
- **MTBF (hours):** >2,000,000
- **Temperature ranges**
  - Operation:
    Standard: 0°C to 70°C
    Industrial: -40°C to 85°C
  - Storage: -40°C to 100°C
- **Performance**
  - Burst transfer rate: 600 MB/sec
    - Sustained read: up to 550 MB/sec
    - Sustained write: up to 520 MB/sec
- **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*
- **Connector Type**
  - 75-pin SATA Based M.2 module pin-out
- **Form factor**
  - M.2 2280 SATA Module Form Factor
  - 80 (L) x 22 (W) x 3.5 (H), unit: mm
- **Thermal Sensor for Temperature Management**
- **RoHS Recast compliant (complies with 2011/65/EU standard)**
- **Capacity**
  240GB, 480GB, 960GB, 1920GB
- **Endurance in Terabytes Written (TBW)**
  - 240 GB: 376 TBW
  - 480 GB: 794 TBW
  - 960 GB: 1580 TBW
  - 1920 GB: 3136 TBW

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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 520 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.

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 Performance Specification

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

Table 1-2: Performance specifications

Capacity / Performance	240GB	480GB	960GB	1920GB
Sustained read (MB/s)	550	550	550	550
Sustained write (MB/s)	320	500	520	520

1.4 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: Micro-SATA connectors

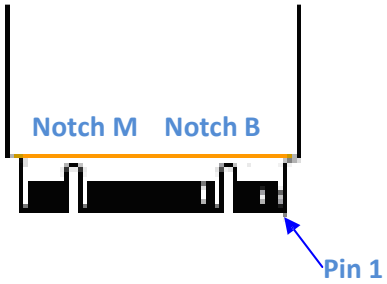


Table 1-4: Signal Segment

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 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 module 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.

3.4 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

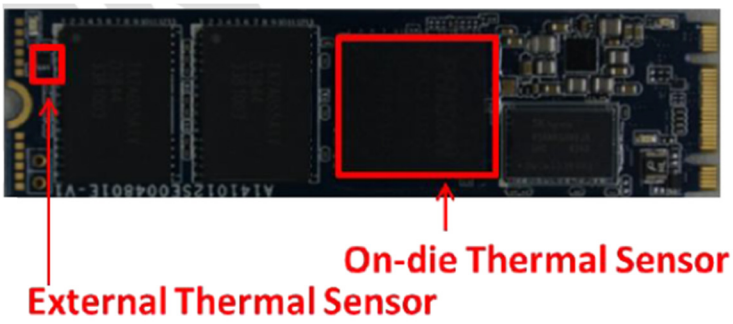
The M.2 2280 Module supports the following SATA power saving modes:

- 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.

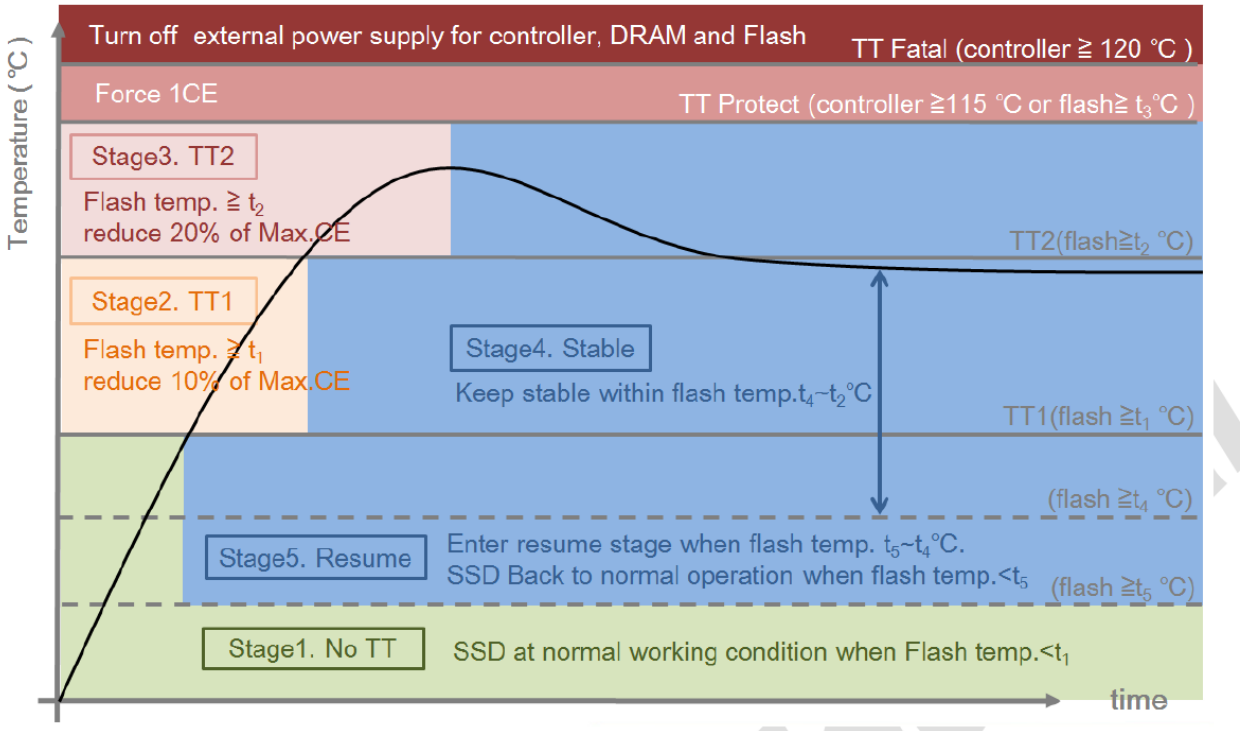
3.8 Thermal Sensor

M.2 2280 Module contains an on-die (embedded into Flash Controller) and off-die (Separate Component) Thermal Sensors that measure module and Flash Controller temperatures. The module temperature can also 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.



3.9 Thermal Throttling

Based on the measurement of the Thermal Sensor M.2 2280 Module adjusts the drive performance to reduce the heat generation and cool the drive. 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. After the drive temperature measurement drop below the pre-set temperature value the drive performance will adjust back to the maximum level.



Default Thermal Throttling Temperature Settings

	Operation temp of Standard temp grade: 0-70°C	Operation temp of Industrial temp grade: -40-+85°C
t_1	68°C	82°C
t_2	70°C	85°C
t_3	80°C	95°C
t_4	64°C	78°C
t_5	60°C	74°C

3.10 Read Only Mode (End of Life)

When drive becomes severely aged by repeated program/erase cycles, the spare block count will be reduced. When the number of usable good (spare) blocks falls below a defined threshold, the drive will notify Host through SMART read status command with an advanced Warning for the drive to enter Read Only Mode to prevent further data corruption. User should check SMART data frequently to identify drive end of life warning to gracefully replace the overused drive.

3.11 AES 256-bit Encryption

M.2 2280 Module incorporates Advanced Encryption Standard (AES) 256-bit which is an industry standard in data security and has been adopted by U.S. government and now widely used for symmetric-key data encrypting in order to meet higher level of data security requirements.

3.12 TCG OPAL SSC V1.0 Compliant

OPAL SSC (Security Subsystem Class) is specified by Trusted Computing Group. It is to define key management and access control features for self-encrypting drives. This specification uses a concept of pre-boot partition for user authentication. It is an optional authentication method in addition to ATA security. However, due to restriction on OPAL SSC specification, ATA security command will be disabled under OPAL SSC mode.

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	-40°C to +85°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)		50G,11ms
Shock (Non-Operating)		1500G, 0.5ms (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 2,000,000 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 TeraBytes Written (TBW), 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 TBW analysis and calculations.

Table 4-2: TBW Values

Capacity	TBW
240GB	376
480GB	794
960GB	1580
1920GB	3136

Notes:

- 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) = 1000 GB.
- This estimation adheres to JEDEC JESD-219, enterprise endurance workload of random data with payload size distribution.

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

Capacity / Performance	240GB	480GB	960GB	1920GB
Active Mode (mW)	1500	1800	2000	2100
Idle Mode (mW)	800	800	900	900

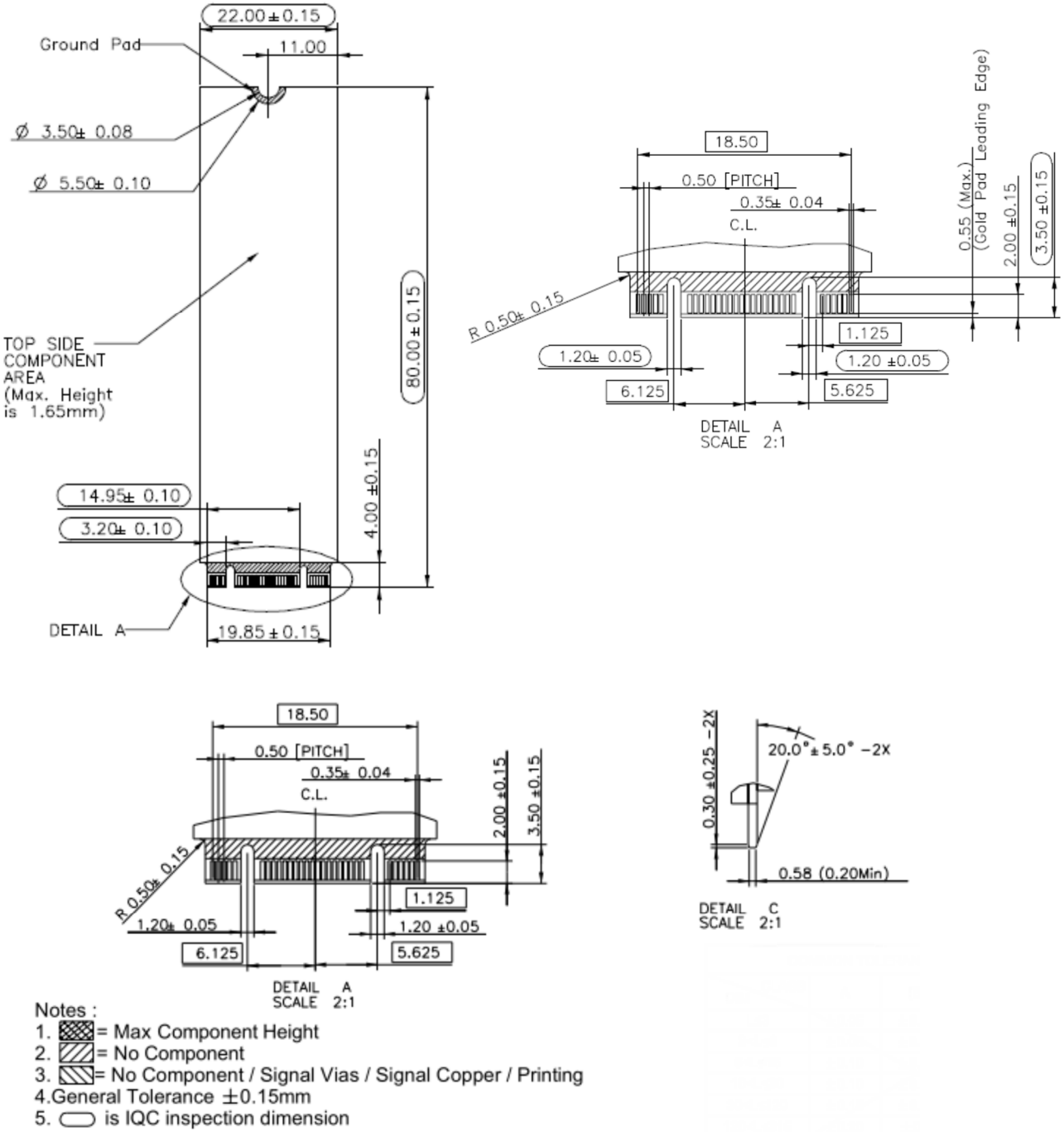
6. Physical Characteristics

6.1 Physical Dimensions - 80±0.15mm (L) x 22±0.15mm (W) x 3.5±0.08mm (H)

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

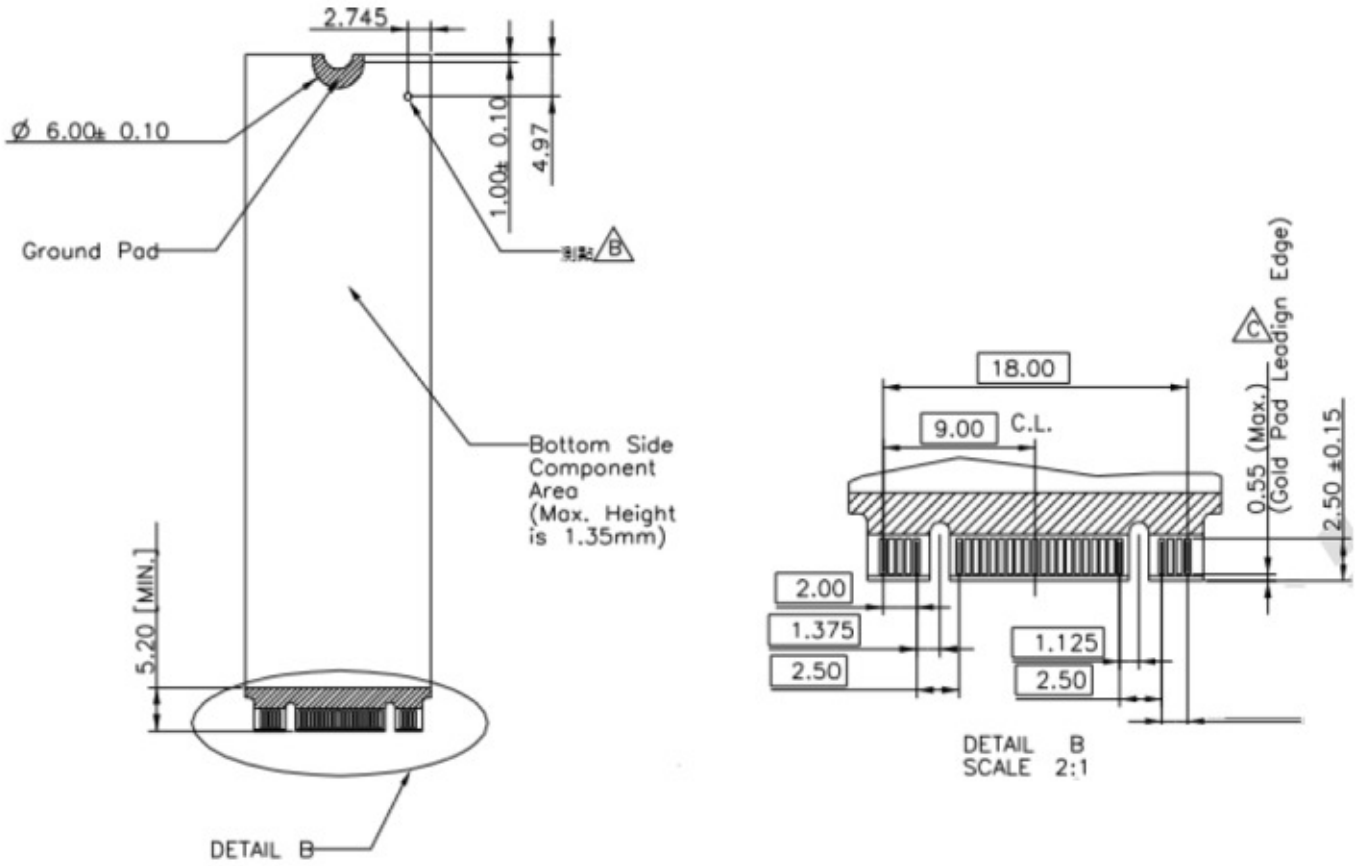
Figure 6-1 M.2 2280 physical dimensions

Top View



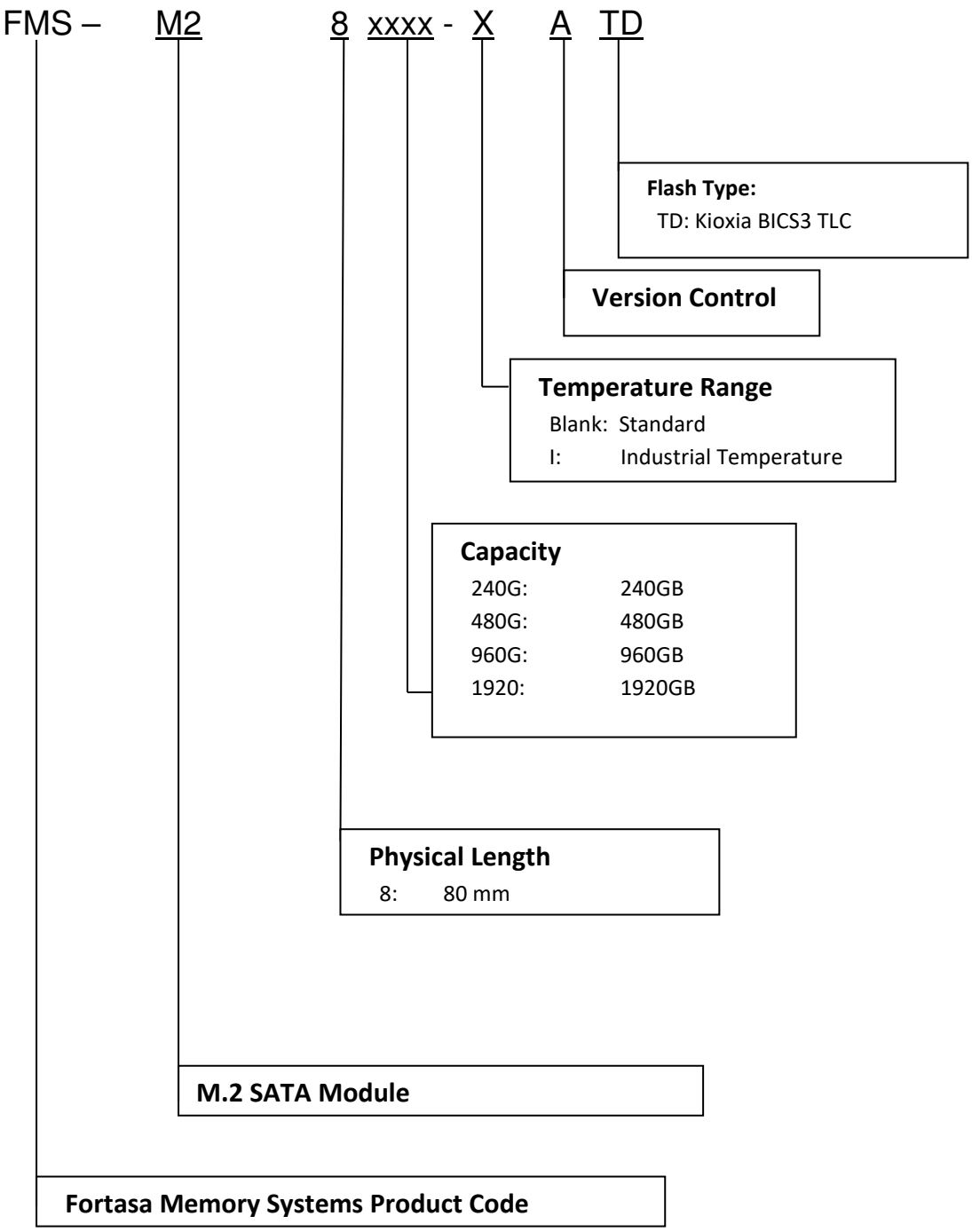
Notes :
1. ▨ = Max Component Height
2. ▨ = No Component
3. ▨ = No Component / Signal Vias / Signal Copper / Printing
4. General Tolerance ±0.15mm
5. ⬭ is IQC inspection dimension

Bottom View


2.745
Ø 6.00± 0.10
1.00± 0.10
4.97
Ground Pad
B
Bottom Side Component Area (Max. Height is 1.35mm)
5.20 [MIN.]
DETAIL B
18.00
9.00
C.L.
C
0.55 (Max.) (Gold Pad Leadign Edge)
2.50 ±0.15
2.00
1.375
2.50
1.125
2.50
DETAIL B
SCALE 2:1

7. Product Ordering Information

7.1 Product Code Designations



7.2 Valid Combinations

Capacity	Standard Temperature Model Numbers	Industrial Temperature Model Numbers
240GB	FMS-M28240G-TD	FMS-M28240G-ITD
480GB	FMS-M28480G-TD	FMS-M28480G-ITD
960GB	FMS-M28960G-TD	FMS-M28960G-ITD
1920GB	FMS-M281920-TD	FMS-M281920-ITD

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	1/17/2018	Initial Release	
1.1	7/23/2018	Add TBW Results	
1.2	3/2/20	Add 1920GB capacity	