APRO Co., Ltd.

3D-NAND Flash

(TOSHIBA **BiCS FLASH**^{TM})

M.2 SATA III Module

MUSE-ER Series

(2242 & 2280 Form factor)

Document No. : 100-xBMDS-VECT3

Version No. : 01V0

Date : October, 2019

ISO 9001 : 2015 CERTIFIED

Product Features

- **Flash IC**

  - TOSHIBA **BiCS FLASH^{TM}.**[4]

  - 3D-NAND Flash

- **Compatibility**

  - Compliant with SATA Revision 3.2

  - SATA 1.5Gb/s; SATA 3Gb/s & SATA 6Gb/s

  - Interface compatible.

  - ATA-8 ACS4 command set

- **Additional Capabilities**

  - S.M.A.R.T.[1] (Self-Monitoring, Analysis and Reporting Technology) feature set support.

  - Native Command Queuing (NCQ) support.

  - TRIM maintenance command support.

  - Support Static wear-leveling algorithm

  - Hardware Low Density Parity Check Code, LDPC support.

  - Support bad Block Management

  - Support DRAM buffer which is support high transfer rate as a data buffer for the SSD

- **Mechanical**

  - PCI Express^{TM} M.2(2242/2280)

  - M.2 keying notches in B and M positions.

  - **Dimension:**

  - **2242:** 42 mm x 22 mm.

  - **2280:** 80 mm x 22 mm.

  - **Weight:**

  - **2242:** 5.0 g / 0.17 oz.

  - **2280:** 8.0 g / 0.28 oz.

- **Power Operating Voltage 3.3V(+/-) 5%**

    2242:

  - Read Mode: 560.0 mA (max.)

  - Write Mode: 740.0 mA (max.)

  - Idle Mode: 220.0 mA (max.)

    2280:

  - Read Mode: 625.0 mA (max.)

  - Write Mode: 800.0 mA (max.)

  - Idle Mode: 220.0 mA (max.)

- **Performance (Maximum value)** [2, 3]

  - **2242:**

  - Sequential Read: 560.0 MB/sec. (max.)

  - Sequential Write: 510.0 MB/sec. (max.)

  - 4KB Random Read (QD32): 75.0K IOPS

  - 4KB Random Write (QD32): 66.6K IOPS

  - **2280:**

  - Sequential Read: 540.0 MB/sec. (max.)

  - Sequential Write: 470.0 MB/sec. (max.)

  - 4KB Random Read (QD32): 89.0K IOPS

  - 4KB Random Write (QD32): 62.5K IOPS

- **Capacity**

  - **2242:** 128GB, 256GB and 512GB

  - **2280:** 128GB, 256GB, 512GB and 1TB

- **Reliability**

  - **TBW:** Up to 1,172 TBW at 1TB Capacity. (Client workload by JESD-219A)

  - **ECC:** Designed with hardware LDPC ECC engine with hard-decision and soft-decision decoding.

  - **Temperature:** (Operating)

    Standard Grade: 0°C ~ +70°C

    Wide Temp. Grade: -40°C ~ +85°C

  - **Vibration:** 70 Hz to 2K Hz, 20G, 3 axes.

  - **Shock:** 0.5ms, 1500 G, 3 axes

- **Certifications and Declarations**

  - **Certifications**: CE & FCC

  - **Declarations**: RoHS & REACH

Remarks:

1. Support official S.M.A.R.T. Utility.

2. Typical I/O performance numbers as measured fresh-out-of-the-box (FOB) using IOmeter with a queue depth of 32

3. Sequential performance is based on CrystalDiskMark 5.1.2 with file size 1000MB

4. **BiCS** means Bit Cost Scalable Technology.

   BiCS FLASH is a trademark of Toshiba Corporation.

Order Information

I.   Part Number List

◆ **APRO M.2-2242 Form-factor SATA III Module (3D NAND) MUSE-ER Series**

Product Picture	*Grade*	*Standard grade (0°C ~ 70°C)*	*Wide Temp Grade (-40°C ~ +85°C)*
	128GB	SBMDS128G-VECT34BM(T)	WBMDS128G-VECT34BM(T)C
	256GB	SBMDS256G-VECT34BM(T)	WBMDS256G-VECT34BM(T)C
	512GB	SBMDS512G-VECT34BM(T)	WBMDS512G-VECT34BM(T)C

◆ **APRO M.2-2280 Form-factor SATA III Module (3D NAND) MUSE-ER Series**

Product Picture	*Grade*	*Standard grade (0°C ~ 70°C)*	*Wide Temp Grade (-40°C ~ +85°C)*
	128GB	SBMDS128G-VECT38BM(T)	WBMDS128G-VECT38BM(T)C
	256GB	SBMDS256G-VECT38BM(T)	WBMDS256G-VECT38BM(T)C
	512GB	SBMDS512G-VECT38BM(T)	WBMDS512G-VECT38BM(T)C
	1TB	SBMDS001T-VECT38BM(T)	WBMDS001T-VECT38BM(T)C

Notes:

C : Special conformal coating treated on whole PCBA which may support industrial grade operating temperature -40°C ~ +85°C

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II. Part Number Decoder:

| X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | — | X11 | X12 | X13 | X14 | X15 | X16 | X17 | X18 | X19 | X20 |

X1 : **Grade**

S: Standard Grade – operating temp. 0° C ~ 70 ° C

W: Wide Temp Grade- operating temp. -40° C ~ +85 ° C

X2 : **The material of case**

B : Bare PCBA w/o Casing

X3 X4 X5 : **Product category**

MDS : M.2 SATA III host interface

X6 X7 X8 X9 : **Capacity**

128GB:	128GB	**001:**	1TB
256GB:	256GB		
512GB:	512GB		

X11 : **Controller**

V : MUSE Series

X12 : **Controller version**

A, B, C.....

X13 : **Controller Grade**

C : Commercial grade

X14 : **Flash IC**

T : Toshiba NAND Flash IC

X15 : **Flash IC grade / Type**

3 : BiCS 3D-NAND Flash IC.

X16 X17 X18: **Form-Factor**

4: 2242 Type

8: 2280 Type

BM: with two notches in B and M positions use up to two PCI Express lanes and provide broader compatibility at the same time

X19 X20 : **Reserved for specific requirement**

Blank : Standard product w/o thermal sensor and conformal-coating

T : Thermal Sensor (optional)

C : Conformal coating (optional)

Revision History

Revision	Description	Date
1.0	Initial release.	2019/10/24

Contents

1. Introduction

APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series provides high capacity flash memory Solid State Drive (SSD) that electrically complies with SATA Revision 3.2 standard. APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series support SATA 1.5Gbps/3.0Gbps/6.0Gbps data transfer rate and designed with a DRAM buffer which is support high transfer rate as a data buffer for the SSD. The main used flash memories are BiCS 3D-NAND Flash memory chips. The available disk capacities are 128GB, 256GB, 512GB and 1TB. The operating temperature grade is optional for Standard grade 0°C ~ 70°C and wide temp grade with conformal coating supports -40°C ~ +85°C.

APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series provide the ultra-high random speed for heavy-loading embedded or server operations with space constraints for host computing systems; the data transfer performance by 4K random read is 75.0K IOPS and 4K random write is up to 66.0K IOPS; the sequential read is up to 560.0 MB/sec, and sequential write is up to 510.0 MB/sec. which is based on a Toshiba BiSC3 Flash™ (3D NAND) 512GB 2242 form-factor SSD.

APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series PCB design with two notches in B and M positions use up to two PCI Express lanes and provide broader compatibility at the same time for M/B socket mounting, while the M.2 modules with only one notch in the M position use up to four PCI Express lanes; both examples we provide APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series to be a SATA storage devices.

APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series provides a high level interface to the host computer. This interface allows a host computer to issue commands to the APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series to read or write blocks of memory. A powerful hardware design is architecture multiplied LDPC (Low Density Parity Check) for Error Correcting Coding (ECC). APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series intelligent controller manages interface protocols, data storage and retrieval as well as ECC, bad block management and diagnostics, power management and clock control.
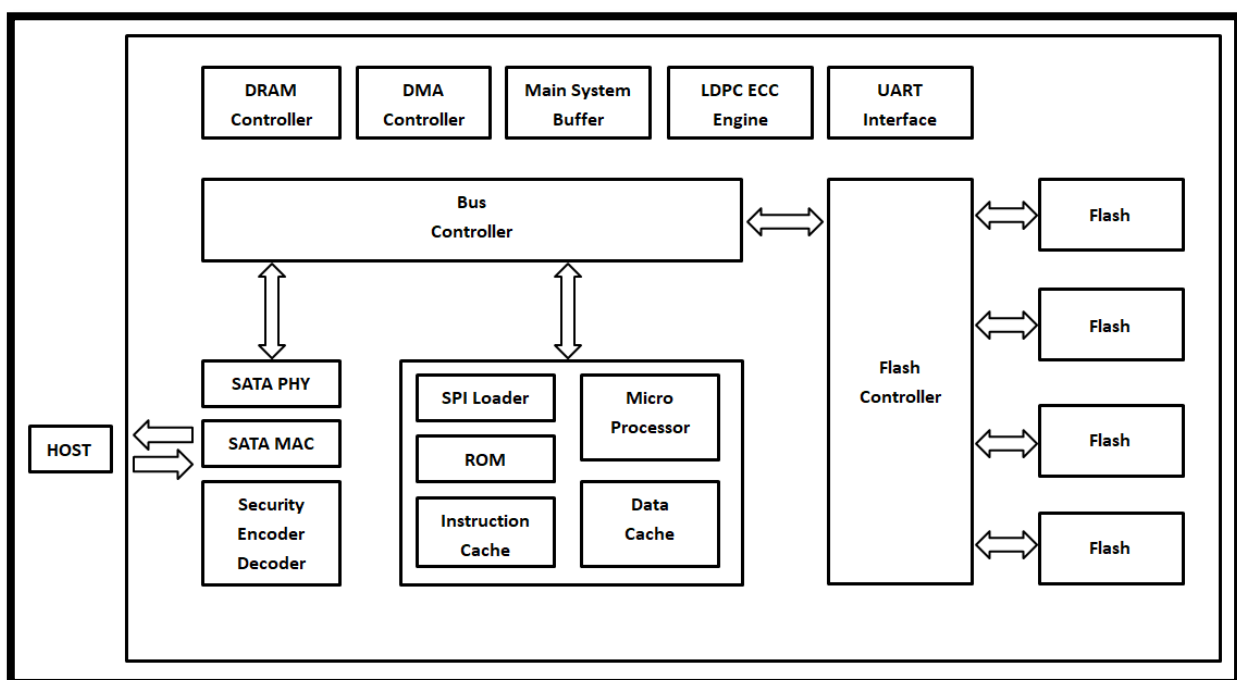

Figure 1: APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series block diagram

1.1. *Scope*

This document describes features, specifications and installation guide of APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series. In the appendix, there provides order information, warranty policy, RMA/DOA procedure for the most convenient reference..

1.2. *Flash Management Technology - Static Wear Leveling*

In order to gain the best management for flash memory, APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series supports Static Wear-leveling technology to manage the Flash system. The life of flash memory is limited; the management is to increase the life of the flash product.

A static wear-leveling algorithm evenly distributes data over an entire Flash cell array and searches for the least used physical blocks. The identified low cycled sectors are used to write the data to those locations. If blocks are empty, the write occurs normally. If blocks contain static data, it moves that data to a more heavily used location before it moves the newly written data. The static wear leveling maximizes effective endurance Flash array compared to no wear leveling or dynamic wear leveling.

1.3. *Bad Block Management*

➢ **Early Bad Block**

The fault block generated during the manufacturing process of NAND Flash is called Early Bad Block.

➢ **Later Bad Block**

In the process of use, as the number of operations of writing and erasing increases, a fault block is gradually generated, which is called a Later Bad Block.

Bad block management is a management mechanism for a bad block to be detected by the control IC and mark bad blocks in the NAND Flash and improve the reliability of data access. The bad block management mechanism of the control IC will establish a **Bad Block Table** when the NAND Flash is started for the first time, and will also record the errors found in the process of use in the bad block table, and data is ported to new valid blocks to avoid data loss.

In order to detect the initial bad blocks to handle run time bad blocks, APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series provides the **Bad Block Management** scheme. It remaps a bad block to one of the reserved blocks so that the data contained in one bad block is not lost and new data writes on a bad block is avoided.

1.4. *DRAM Buffer*

SSDs designed with a DRAM buffer which is support high transfer rate as a data buffer for the SSD; SSD with DRAM buffer is able to deliver excellent random data transfer speed.

➢ 128GB, 256GB Supports 2GBits DRAM Cache

➢ 512GB Supports 4GBits DRAM Cache

➢ 1TB Supports 8GBits DRAM Cache.

2. Product Specifications

For all the following specifications, values are defined at ambient temperature and nominal supply voltage unless otherwise stated.

2.1. System Environmental Specifications

Table 1: Environmental Specification

APRO M.2 SATA III Module MUSE-D Series		Standard Grade SBMDSxxxx-VECT3xBM	Wide Temp Grade WBMDSxxxx-VECT3xBMC
Temperature	Operating:	0°C ~ +70°C	-40°C ~ +85°C
	Non-operating:	-20°C ~ +80°C	-50°C ~ +95°C
Humidity	Operating & Non-operating:	10% ~ 95% non-condensing	
Vibration	Frequency/Acceleration:	70 Hz to 2K Hz, 20G, 3 axes	
Shock	Operating & Non-operating:	0.5ms, 1500 G, 3 axes	
Electrostatic Discharge (ESD)	Temperature:	24°C	
	Relative Humidity:	49% (RH)	
	+/-4KV:	Device functions are affected, but EUT will be back to its normal or operational state automatically.	

2.2. System Power Requirements

Table 2: Power Requirement

APRO M.2-2242 Form-factor SATA III Module (3D NAND) MUSE-ER Series		
DC Input Voltage (VCC)		3.3V±5%
Maximum average value	Reading Mode :	560.0 mA (max.)
	Writing Mode :	740.0 mA (max.)
	Idle Mode :	220.0 mA (max.)

APRO M.2-2280 Form-factor SATA III Module (3D NAND) MUSE-ER Series		
DC Input Voltage (VCC)		3.3V±5%
Maximum average value	Reading Mode :	625.0 mA (max.)
	Writing Mode :	800.0 mA (max.)
	Idle Mode :	220.0 mA (max.)

2.3. System Performance

Table 3: System Performances

Data Transfer Mode supporting		Serial ATA Gen-III (6.0Gb/s = 768MB/s)		
Maximum Performance	Capacity	128GB	256GB	512GB
	Form-factor	2242		
	Sequential Read (MB/s)	540.0	540.0	560.0
	Sequential Write (MB/s)	130.0	280.0	510.0
	4KB Random Read IOPS (QD32)	41.7K	73.9K	75.0K
	4KB Random Write IOPS (QD32)	34.3K	52.8K	66.6K

Data Transfer Mode supporting		Serial ATA Gen-III (6.0Gb/s = 768MB/s)			
Maximum Performance	Capacity	128GB	256GB	512GB	1TB
	Form-factor	2280			
	Sequential Read (MB/s)	560.0	560.0	560.0	540.0
	Sequential Write (MB/s)	130.0	280.0	510.0	470.0
	4KB Random Read IOPS (QD32)	41.8K	74.1K	76.2K	89.0K
	4KB Random Write IOPS (QD32)	34.0K	52.8K	66.2K	62.5K

Note: The performance was measured using CrystalDiskMark by file size 1000MB (QD32).

2.4. System Reliability

Table 4: System Reliability

Wear-leveling Algorithms		Static wear-leveling algorithms
Bad Block Management		Supportive
ECC Technology		Hardware design LDPC (Low Density Parity Check)
Erase counts		TOSHIBA **BiCS FLASH**^{TM} 3D NAND Flash: 3K P/E Cycles
TBW (Tera Bytes Written)		
Capacity	128GB	150
	256GB	300
	512GB	600
	1TB	1,172

Note:

➢ *Client workload by JESD-219A.*

➢ *The endurance of SSD could be varying based on user behavior, NAND endurance cycles, and write amplification factor. It is not guaranteed by flash vendor.*

2.5. *Physical Specifications*

Refer to Table 5 and see Figure 2 for APRO M.2 SATA III Module (3D-NAND Flash) MUSE-ER Series physical specifications and dimensions.

Table 5: Physical Specifications of APRO M.2-2242&2280 Form-factor SATA III Module (3D NAND) MUSE-ER Series

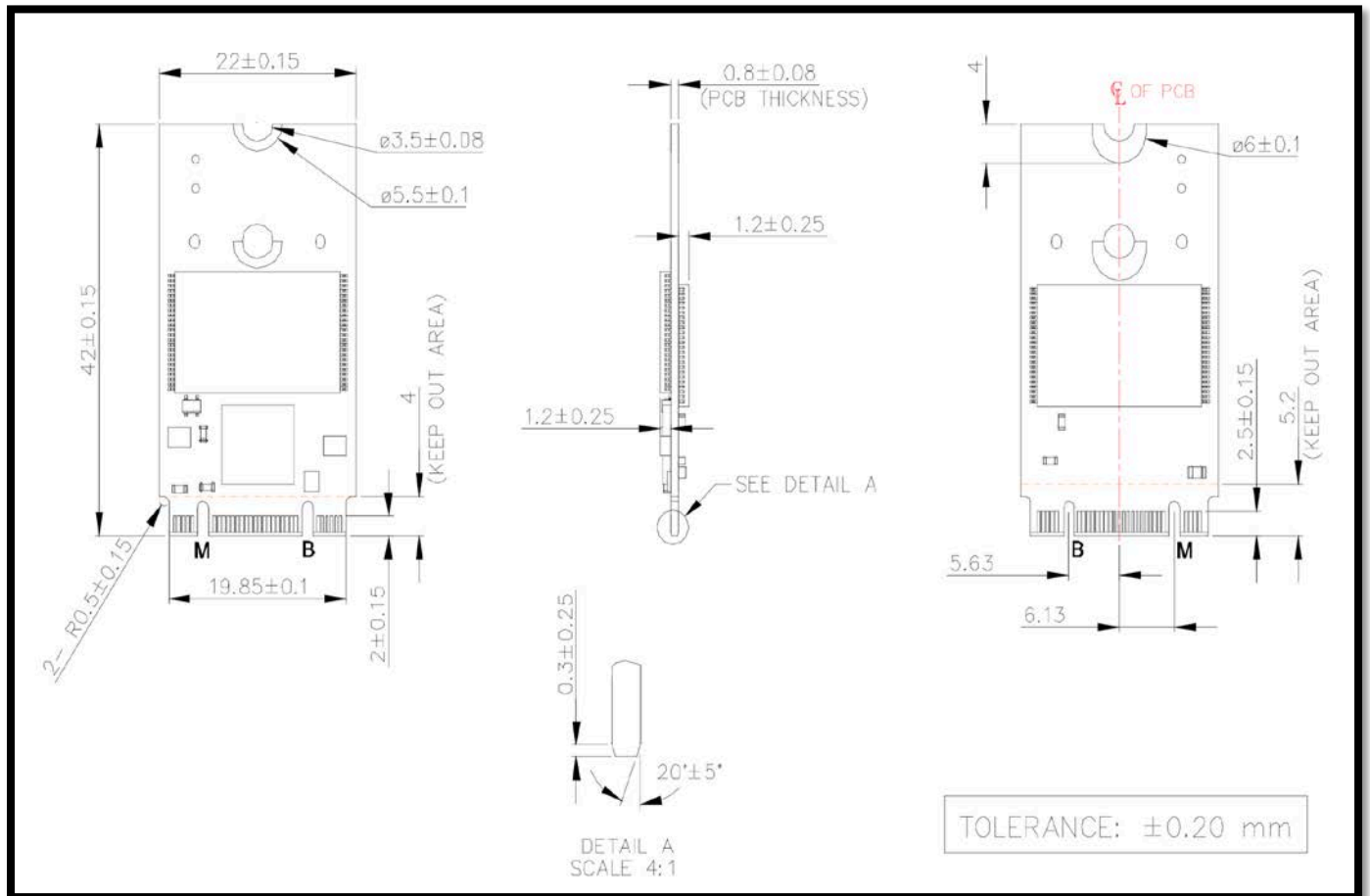| Form-factor	2242	2280
Length:	42.0 mm	80.0 mm
Width:	22.0 mm	22.0 mm
Weight:	5.0 g / 0.17 oz.	8.0 g / 0.28 oz.

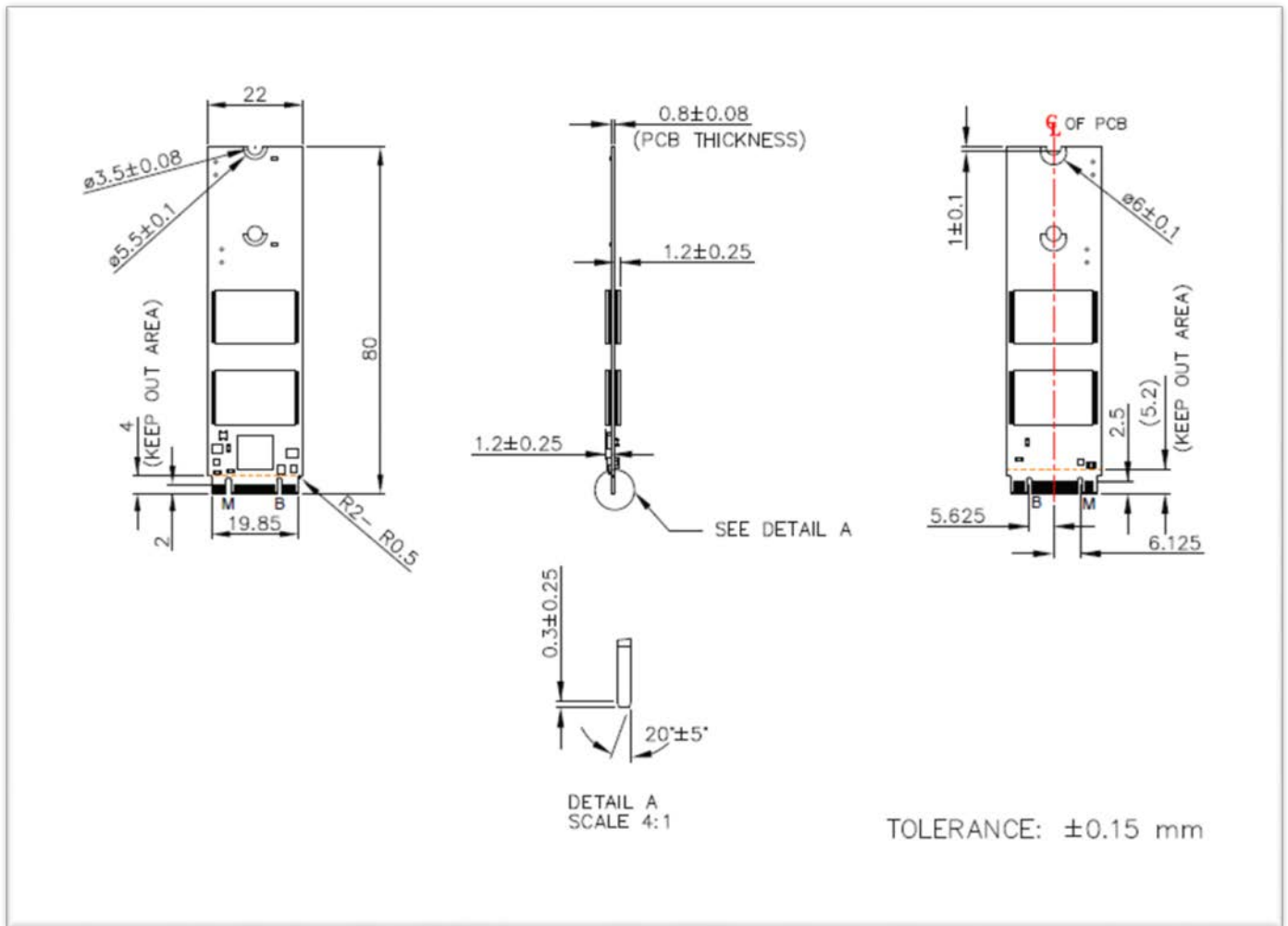*Figure 2: APRO M.2-2242 Form-factor SATA III Module Dimension*

Figure 2: APRO M.2-2280 Form-factor SATA III Module Dimension

2.6. *Conformal coating*

Conformal coating is a protective, dielectric coating designed to conform to the surface of an assembled printed circuit board. Commonly used conformal coatings include silicone, acrylic, urethane and epoxy. APRO applies only silicone on APRO storages products upon requested especially by customers. The type of silicone coating features good thermal shock resistance due to flexibility. It is also easy to apply and repair.

Conformal coating offers protection of circuitry from moisture, fungus, dust and corrosion caused by extreme environments. It also prevents damage from those Flash storages handling during construction, installation and use, and reduces mechanical stress on components and protects from thermal shock. The greatest advantage of conformal coating is to allow greater component density due to increased dielectric strength between conductors.

APRO use MIL-I-46058C silicon conformal coating

3. Interface Description

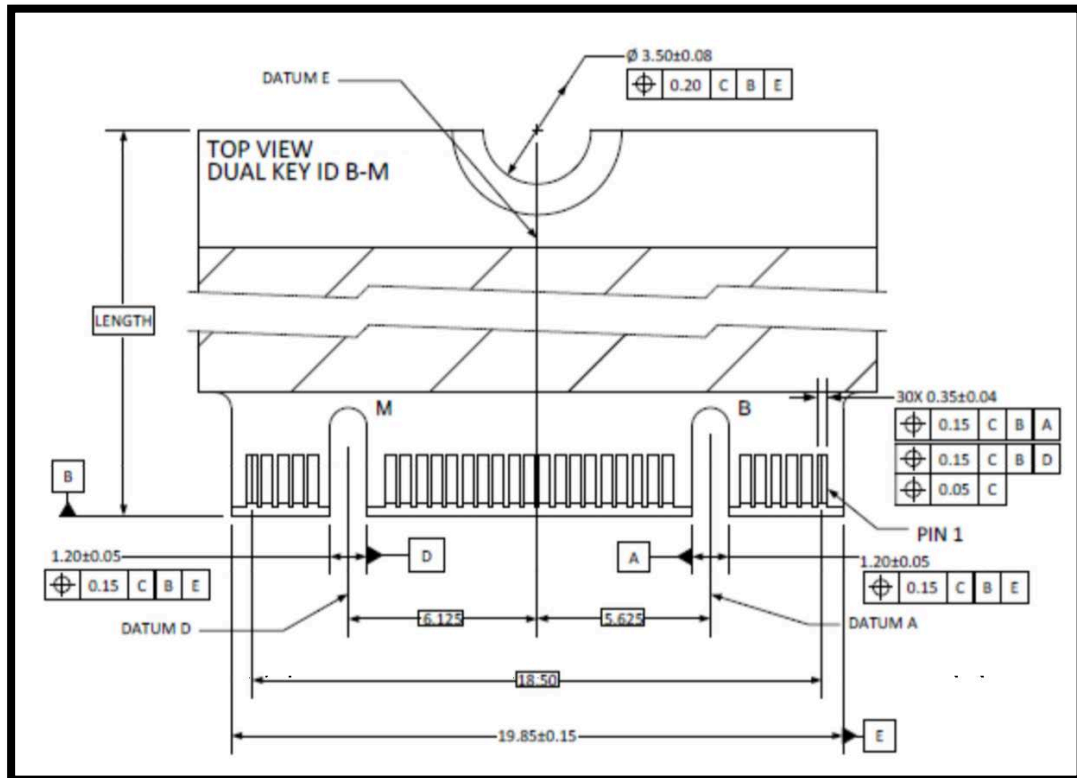## 4.1. M.2 SATA III Module interface

Figure 3: The connectors of Signal Segment and Power Segment

4.2. Pin Assignments

APRO M.2 SATA III Module operates with standard SATA pin-out. The pin assignments are listed in below table 6.

Table 6 - Pin Assignments

Signal Name	Pin #	Pin #	Signal Name
		75	GND
3.3V	74	73	GND
3.3V	72	71	GND
3.3V	70	69	GND
NC	68	67	NC
Notch	66	65	Notch
Notch	64	63	Notch
Notch	62	61	Notch
Notch	60	59	Notch
NC	58		
NC	56	57	GND
NC	54	55	NC
NC	52	53	NC
NC	50	51	GND
NC	48	49	RX+
NC	46	47	RX-
NC	44	45	GND
NC	42	43	TX-
NC	40	41	TX+
DEVSLP	38	39	GND
NC	36	37	NC
NC	34	35	NC
NC	32	33	GND
NC	30	31	NC
NC	28	29	NC
NC	26	27	GND
NC	24	25	NC
NC	22	23	NC
NC	20	21	GND
Notch	18	19	Notch
Notch	16	17	Notch
Notch	14	15	Notch
Notch	12	13	Notch
DAS/DSS	10	11	NC
NC	8	9	NC
NC	6	7	NC
3.3V	4	5	NC
3.3V	2	3	GND
		1	GND

Appendix A: Limited Warranty

APRO warrants your M.2-2242 & 2280 Form-factor SATA III Module (3D NAND) MUSE-ER Series against defects in material and workmanship for the life of the drive. The warranty is void in the case of misuse, accident, alteration, improper installation, misapplication or the result of unauthorized service or repair. The implied warranties of merchantability and fitness for a particular purpose, and all other warranties, expressed or implied, except as set forth in this warranty, shall not apply to the products delivered. In no event shall APRO be liable for any lost profits, lost savings or other incidental or consequential damages arising out of the use of, or inability to use, this product.

BEFORE RETURNING PRODUCT, A RETURN MATERIAL AUTHORIZATION (RMA) MUST BE OBTAINED FROM APRO.

Product shall be returned to APRO with shipping prepaid. If the product fails to conform based on customers' purchasing orders, APRO will reimburse customers for the transportation charges incurred.

WARRANTY PERIOD:

- **3D-NAND Flash (Standard grade / Wide Temp. Grade): 2 years / Within 3K Erasing Counts**

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