

# MLC

## M.2 PCIe NVMe Module

### MUSE-F Series

( 2242 / 2280 Form-factor )

( Gen-III x2 )

**Document No. :** 100-xBMDP-VFCTM

**Version No. :** 02V0 (A19094)

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ISO 9001 : 2015 CERTIFIED



### Product Features

#### ■ Flash IC

- TOSHIBA 15nm NAND Flash IC.
- Multi-Level Cell (MLC) management

#### ■ Compatibility

- NVMe Express™ 1.3 Standard.
- PCI Express® Base Specification Rev 3.0

#### ■ Additional Capabilities

- S.M.A.R.T.\*<sup>1</sup> (Self-Monitoring, Analysis and Reporting Technology) feature set support.
- Thermal Monitor for SSD's temperature.
- Static and Dynamic wear-leveling algorithm.
- Hardware Low Density Parity Check Code, LDPC support.

#### ■ Mechanical

- PCI Gen3 x 2 NVMe interface(2242/2280)
- M.2 keying notches in B and M positions.
- **Dimension:**
- **2242:** 42.0 mm x 22.0 mm
- **2280:** 80.0 mm x 22.0 mm
- **Weight:**
- **2242:** 8.00 g / 0.28 oz. (256GB max.)
- **2280:** 10.00 g / 0.35 oz. (512GB max.)

#### ■ Power

- Operating Voltage 3.3V(+/-) 5%
- **2242:**
- Read Mode: 755.0 mA (256GB max.)
- Write Mode: 830.0 mA (256GB max.)
- Idle Mode: 365.0 mA (256GB max.)
- **2280:**
- Read Mode: 845.0 mA (512GB max.)
- Write Mode: 1,130.0 mA (512GB max.)
- Idle Mode: 380.0 mA (512GB max.)

#### ■ Performance (Maximum value)<sup>2,3</sup>

- **2242:**
- Sequential Read: 1,300.0 MB/sec. (max.)
- Sequential Write: 340.0 MB/sec. (max.)
- 4KB Random Read (QD32): 51.0 K IOPS.
- 4KB Random Write (QD32): 47.0 K IOPS.
- **2280:**
- Sequential Read: 1,200.0 MB/sec. (max.)
- Sequential Write: 480.0 MB/sec. (max.)
- 4KB Random Read (QD32): 51.0 K IOPS.
- 4KB Random Write (QD32): 50.0 K IOPS.

#### ■ Capacity

- **2242:** 32GB, 64GB, 128GB and 256GB
- **2280:** 32GB, 64GB, 128GB, 256GB and 512GB

#### ■ Reliability

- **TBW:** Up to 390 TBW at 512GB 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:** 70Hz~2000Hz/20G.
- **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


### Order Information

#### I. Part Number List

##### ◆ APRO MLC M.2-2242 Form-factor PCIe NVMe Module MUSE-F Series

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Wide Temp Grade ( -40°C ~ +85°C )
	<b>32GB</b>	SBMDP032G-VFCTM-4BM	WBMDP032G-VFCTM-4BMC
	<b>64GB</b>	SBMDP064G-VFCTM-4BM	WBMDP064G-VFCTM-4BMC
	<b>128GB</b>	SBMDP128G-VFCTM-4BM	WBMDP128G-VFCTM-4BMC
	<b>256GB</b>	SBMDP256G-VFCTM-4BM	WBMDP256G-VFCTM-4BMC

##### ◆ APRO MLC M.2-2280 Form-factor PCIe NVMe Module MUSE-F Series

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Wide Temp Grade ( -40°C ~ +85°C )
	<b>32GB</b>	SBMDP032G-VFCTM-8BM	WBMDP032G-VFCTM-8BMC
	<b>64GB</b>	SBMDP064G-VFCTM-8BM	WBMDP064G-VFCTM-8BMC
	<b>128GB</b>	SBMDP128G-VFCTM-8BM	WBMDP128G-VFCTM-8BMC
	<b>256GB</b>	SBMDP256G-VFCTM-8BM	WBMDP256G-VFCTM-8BMC
	<b>512GB</b>	SBMDP512G-VFCTM-8BM	WBMDP512G-VFCTM-8BMC

#### Notes:

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

### II. Part Number Decoder:

**X1 X2 X3 X4 X5 X6 X7 X8 X9** — **X11 X12 X13 X14 X15** — **X17 X17 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

**MDP**: M.2 PCIe NVMe Module

**X6 X7 X8 X9** : Capacity

**032G:** 32GB      **256GB:** 256GB

**064G:** 64GB      **512GB:** 512GB

**128GB:** 128GB

**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

**M** : MLC-NAND Flash IC

**X17 X18 X19** : 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

**X20** : Reserved for specific requirement

**C** : Conformal coating (optional)

### **Revision History**

Revision	Description	Date
1.0	Initial release.	2019/04/02
2.0	Updated document form & Some typo	2019/06/18

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### 1. Introduction

APRO MLC M.2-2242 & 2280 Form-factor PCIe NVMe Module MUSE-F Series provides high capacity flash memory Solid State Drive (SSD) that electrically complies with NVMe Express™ 1.3 Standard and support PCI Gen3 x 2 NVMe interface with high performance.

The MUSE-F Series M.2 2242 SSD available disk capacities are 32GB, 64GB,128GB and 256GB; the M.2 2280 SSD available disk capacities are 32GB, 64GB,128GB, 256GB and 512GB. Standard temperature range is from 0°C to +70°C with an optional wide temperature range from -40°C to +85°C. APRO MLC M.2 PCIe NVMe Module MUSE-F Series comes with two notches - B and M positions and supports up to two PCI Express lanes. Using both notches increase the compatibility for M/B socket mounting.

APRO's MUSE-F Series MLC M.2 PCIe NVMe 2242/2280 SSD provides the ultra-high random speed but in low power consumption. It is the most favorable solution for heavy-loading embedded systems or server computing with space limitation. The data transfer performance of 4K random read is 51,000 IOPS and the 4K random write is up to 50,000 IOPS; the sequential read is up to 1,200 MB/sec, and the sequential write is up to 480 MB/sec.

The powerful controller provides LDPC (Low Density Parity Check) to detect eventual errors while writing and increases the reliability in comparison to a standard ECC mechanism.

APRO's sophisticated S.M.A.R.T. tool is available for customers' request. It is able to monitor the health status of the MUSE-F Series MLC PCIe NVMe Module. The optional product with "Thermal Sensor" function, the user may detect its operating temperature by the S.M.A.R.T. tool whenever the SSD is operating. Currently, the S.M.A.R.T. tool is only for Windows OS based systems.

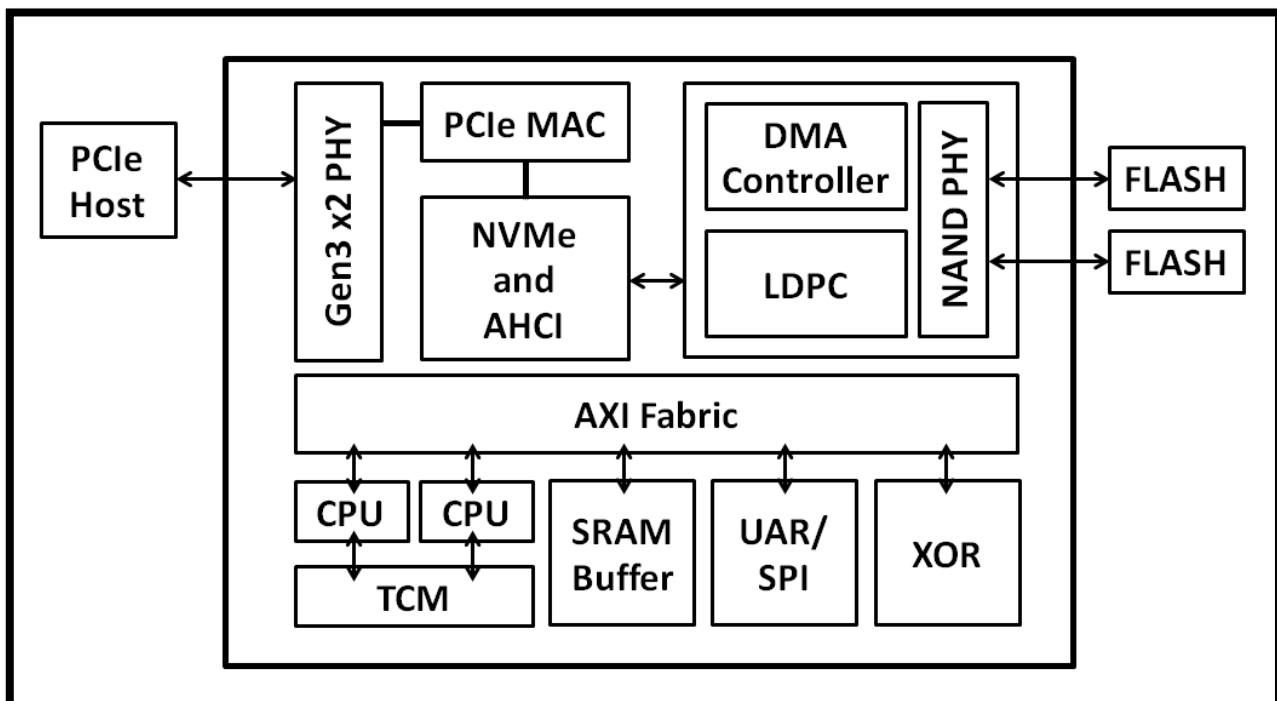


Figure 1: APRO MLC M.2 PCIe NVMe Module MUSE-F Series block diagram

### 1.1. Scope

This document describes features, specifications and installation guide of APRO MLC M.2 PCIe NVMe Module MUSE-F Series. In the appendix, there provides order information, warranty policy, RMA/DOA procedure for the most convenient reference.

### 1.2. Flash Management Technology – Static & Dynamic Wear Leveling

NAND flash devices can only undergo a limited number of program/erase cycles, and in most cases, the flash media are not used evenly. If some areas get updated more frequently than others, the lifetime of the 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.

APRO MLC M.2 PCIe NVMe Module MUSE-F Series provides advanced Wear Leveling algorithm, which can efficiently spread out the flash usage through the whole flash media area. Moreover, by implementing both wear-leveling algorithms, the life expectancy of the NAND flash are greatly improved, as dynamic and also static data is shifted, if necessary, in order to guarantee an evenly use of all flash cells.

### 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 MLC M.2 PCIe NVMe Module MUSE-F 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.



### 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 MLC M.2 PCIe NVMe Module MUSE-F Series		Standard Grade	Wide Temp Grade
		SBMDPxxxG-VFCTMxBM	WBMDPxxxG-VFCTMxBMC
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	
	Frequency/Acceleration:	70 Hz to 2K Hz, 20G, 3 axes (IEC 68-2-6)	
Shock	Operating & Non-operating:	0.5ms, 1500 G, 3 axes (IEC 68-2-27)	
Electrostatic Discharge (ESD)	Temperature:	24°C	
	Relative Humidity:	51%	
	+/-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 MLC M.2-2242 Form-factor PCIe NVMe Module MUSE-F Series		
DC Input Voltage (VCC)		3.3V±5%
Maximum average value	Reading Mode :	755.0 mA (256GB max.)
	Writing Mode :	830.0 mA (256GB max.)
	Idle Mode :	365.0 mA (256GB max.)

APRO MLC M.2-2280 Form-factor PCIe NVMe MUSE-F Series		
DC Input Voltage (VCC)		3.3V±5%
Maximum average value	Reading Mode :	845.0 mA (512GB max.)
	Writing Mode :	1,130.0 mA (512GB max.)
	Idle Mode :	380.0 mA (512GB max.)

### 2.3. System Performance

**Table 3: System Performances**

Data Transfer Mode supporting		PCI Gen3 x 2 NVMe interface			
Maximum Performance	Form-factor	2242			
	Capacity	32GB	64GB	128GB	256GB
	Sequential Read (MB/s)	450	890	1,300	1,300
	Sequential Write (MB/s)	50	100	190	340
	4KB Random Read IOPS (QD32)	18,000	36,000	47,000	51,000
	4KB Random Write IOPS (QD32)	12,000	22,000	29,000	47,000

Data Transfer Mode supporting		PCI Gen3 x 2 NVMe interface				
Maximum Performance	Form-factor	2280				
	Capacity	32GB	64GB	128GB	256GB	512GB
	Sequential Read (MB/s)	450	890	1,300	1,300	1,200
	Sequential Write (MB/s)	50	100	190	340	480
	4KB Random Read IOPS (QD32)	18,000	36,000	47,000	51,000	51,000
	4KB Random Write IOPS (QD32)	12,000	22,000	29,000	47,000	50,000

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

### 2.4. System Reliability

**Table 4: System Reliability**

<b>Wear-leveling Algorithms</b>	Static and Dynamic wear-leveling algorithms	
<b>Bad Block Management</b>	Supportive	
<b>ECC Technology</b>	Hardware design LDPC (Low Density Parity Check)	
<b>Erase counts</b>	NAND MLC Flash Cell Level : 3K P/E Cycles	
<b>TBW (Tera Bytes Written)</b>		
Capacity	32GB	38.0
	64GB	77.0
	128GB	135.0
	256GB	202.0
	512GB	390.0

Note:

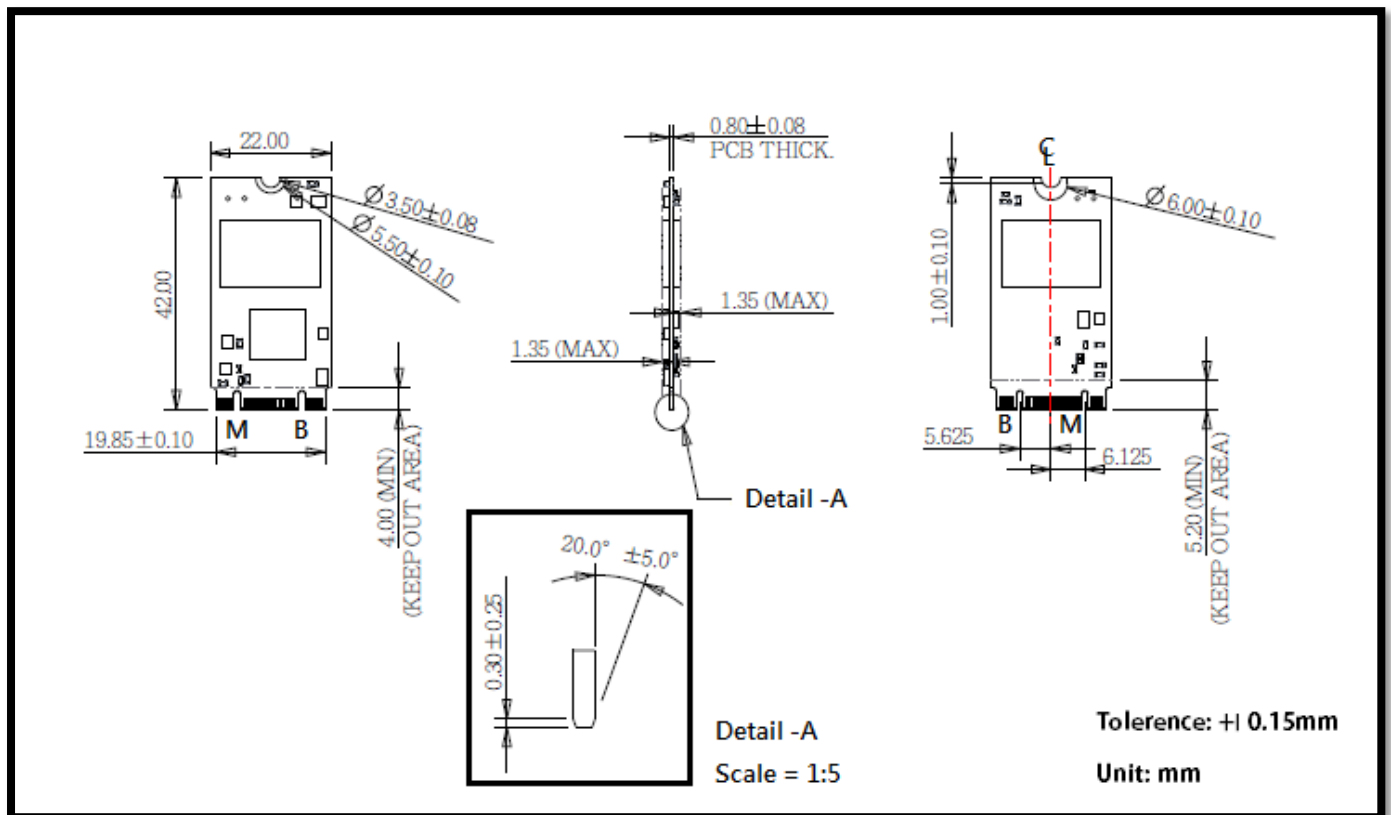
- Client workload by JESD-219A. (The capacity lower than 64GB client workload is not specified in JEDEC219A, the values are estimated.)
- The endurance of SSD could be varying based on user behavior, NAND endurance cycles, and write amplification factor. It is not guaranteed by flash vendor.

### 2.5. Physical Specifications

Refer to Table 5 and see Figure 2 for MLC M.2-2242&2280 Form-factor PCIe NVMe Module MUSE-F Series physical specifications and dimensions.

**Table 5: Physical Specifications**

<b>Form-factor</b>	2242	2280
<b>Length:</b>	42.0 mm	80.0 mm
<b>Width:</b>	22.0 mm	22.0 mm
<b>Weight:</b>	8.00 g / 0.28 oz. (256GB max.)	10.00 g / 0.35 oz. (512GB max.)



**Figure 2: APRO MLC M.2-2242 Form-factor PCIe NVMe Module MUSE-F Series Dimension**

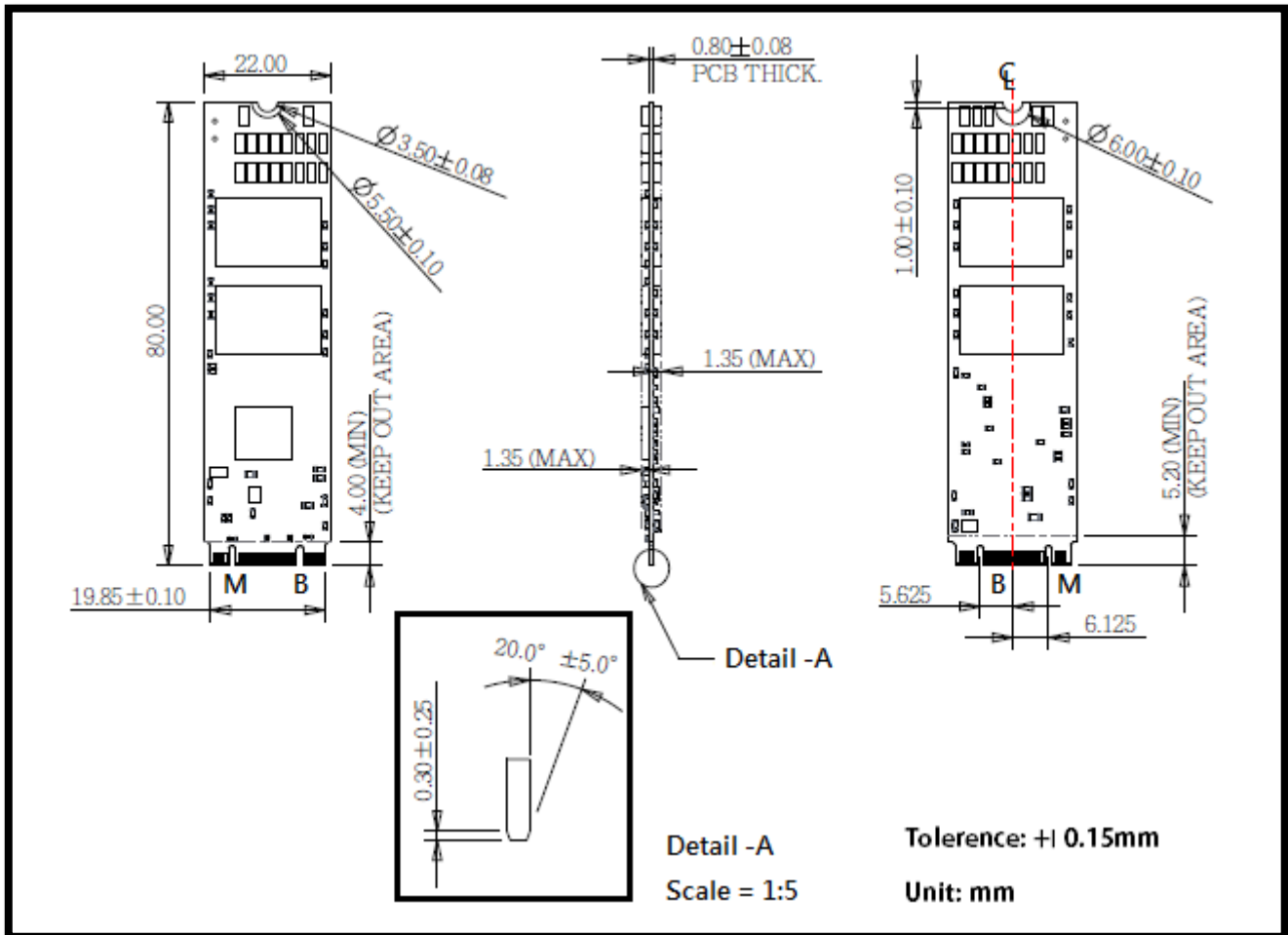


Figure 2: APRO MLC M.2-2280 Form-factor PCIe NVMe Module MUSE-F Series Dimension

## 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 storage 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

#### 3.1. M.2 PCIe NVMe Module MUSE-F Series interface

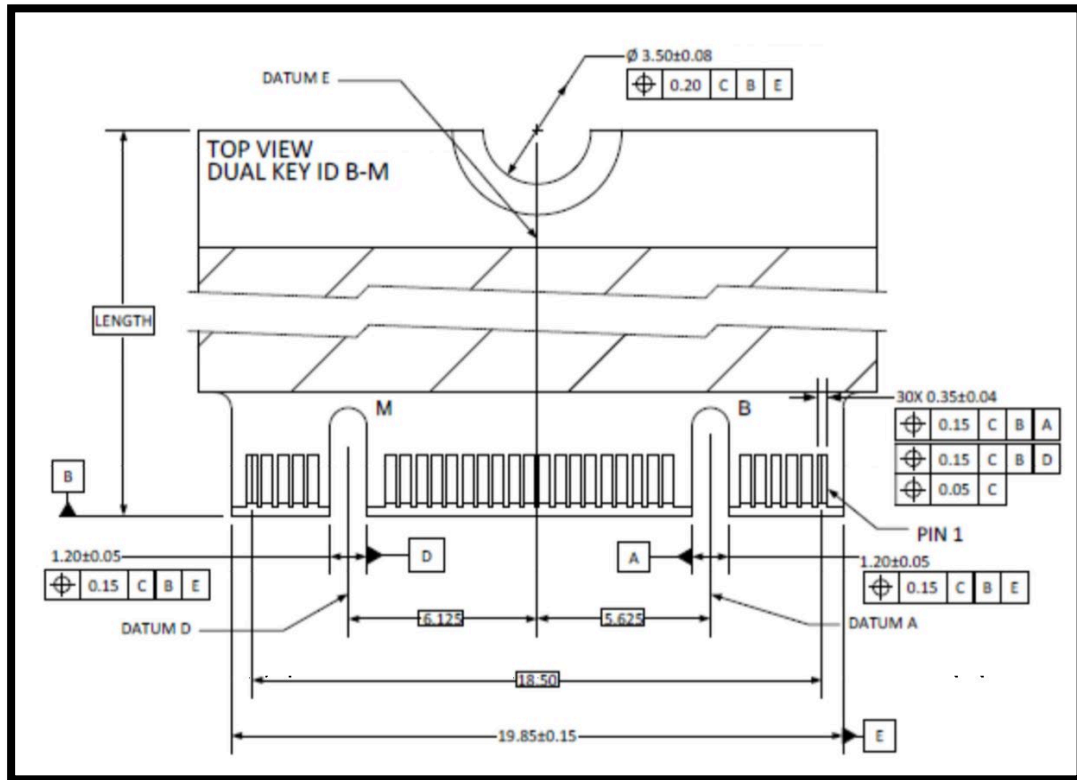


Figure 3: The connectors of Signal Segment and Power Segment

### 3.2. Pin Assignments

APRO MLC M.2 PCIe NVMe Module MUSE-F Series operates with standard SATA pin-out.

**Table 6 - Pin Assignments**

<b>Signal Name</b>	<b>Pin Number</b>		<b>Signal Name</b>
		<b>75</b>	GND
3.3V	<b>74</b>	<b>73</b>	GND
3.3V	<b>72</b>	<b>71</b>	GND
3.3V	<b>70</b>	<b>69</b>	NC
NC	<b>68</b>	<b>67</b>	NC
Notch	<b>66</b>	<b>65</b>	Notch
Notch	<b>64</b>	<b>63</b>	Notch
Notch	<b>62</b>	<b>61</b>	Notch
Notch	<b>60</b>	<b>59</b>	Notch
NC (Reversed)	<b>58</b>		
NC (Reversed)	<b>56</b>	<b>57</b>	GND
NC	<b>54</b>	<b>55</b>	REFCLKp
CLKREQ# (I/O)(0/3.3V)	<b>52</b>	<b>53</b>	REFCLKn
PERST# (I)(0/3.3V)	<b>50</b>	<b>51</b>	GND
NC	<b>48</b>	<b>49</b>	PERp0
NC	<b>46</b>	<b>47</b>	PERn0
NC	<b>44</b>	<b>45</b>	GND
SMB_DATA (I/O)(0/1.8V)	<b>42</b>	<b>43</b>	PETp0
SMB_CLK (I/O)(0/1.8V)	<b>40</b>	<b>41</b>	PETn0
NC	<b>38</b>	<b>39</b>	GND
NC	<b>36</b>	<b>37</b>	PERp1
NC	<b>34</b>	<b>35</b>	PERn1
NC	<b>32</b>	<b>33</b>	GND
NC	<b>30</b>	<b>31</b>	PETp1
NC	<b>28</b>	<b>29</b>	PETn1
NC	<b>26</b>	<b>27</b>	GND
NC	<b>24</b>	<b>25</b>	NC
NC	<b>22</b>	<b>23</b>	NC
NC	<b>20</b>	<b>21</b>	GND
Notch	<b>18</b>	<b>19</b>	Notch
Notch	<b>16</b>	<b>17</b>	Notch
Notch	<b>14</b>	<b>15</b>	Notch
Notch	<b>12</b>	<b>13</b>	Notch
NC	<b>10</b>	<b>11</b>	NC
NC	<b>8</b>	<b>9</b>	GND
NC	<b>6</b>	<b>7</b>	NC
3.3V	<b>4</b>	<b>5</b>	NC
3.3V	<b>2</b>	<b>3</b>	GND
		<b>1</b>	GND

### **3.3. Electrical connectors of M.2**

APRO MLC M.2 PCIe NVMe Module MUSE-F Series interconnection is based on a 75 positions Edge Card connector. The 75 positions connector is intended to be keyed so as to distinguish between families of host interfaces and the various Sockets used in general Platforms.

APRO MLC M.2 PCIe NVMe Module MUSE-F Series is compliant with M.2 Socket 2 key B-M.

### **3.4. Driver**

APRO MLC M.2 PCIe NVMe Module MUSE-F Series is compliant with NVMe Express™ 1.3 Standard.

The application's O.S. and BIOS should include NVMe driver to compatible with NVMe storage device. Most of O.S. includes NVMe in-box driver now.

**O.S. Driver:** Please visit the website <http://nvmeexpress.org/resources/drivers> for more information about the driver for each O.S

**BIOS Driver:** NVMe driver for BIOS support, please contact with motherboard manufacturers.

### **Appendix A: Limited Warranty**

APRO warrants your MLC M.2-2242 & 2280 Form-factor PCIe NVMe Module MUSE-F 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:**

- **MLC ( Standard grade / Wide temp. grade )    2 years / Within 3K Erasing Counts**

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