

# 3D-NAND Flash

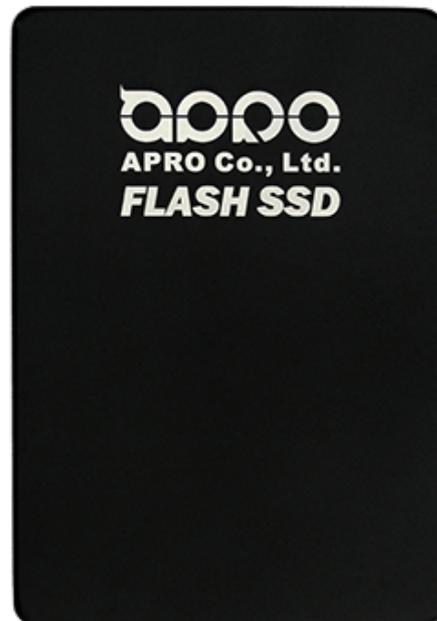
( TOSHIBA BiCS FLASH™ )

## 2.5" Rugged Metal SATA III SSD

### MUSE-ET Series

**Support power interrupts data protection**

**(7mm Thickness)**



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ISO 9001 : 2015 CERTIFIED



### Product Features

#### ■ Flash IC

- TOSHIBA **BICS FLASH**<sup>TM,3</sup>
- 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.<sup>\*1</sup> (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
- Power interrupts data protection technology by Tantalum Capacitors.

#### ■ Mechanical

- Standard 2.5" SATA Flash Disk form-factor (7mm)
- SATA 7-pin (data) + 15-pin (power connector) SATA Interface
- Dimension: 100.0 mm x 69.9 mm x 7.0 mm.
- Weight: 65.0 g / 2.29 oz.

#### ■ Power Operating Voltage 5V(+/-) 5%

- Read Mode: 480mA (max.)
- Write Mode: 620mA (max.)
- Idle Mode: 190mA (max.)

#### ■ Performance (Maximum value) \*2

- Sequential Read: 550.0 MB/sec. (max.)
- Sequential Write: 475.0 MB/sec. (max.)
- 4KB Random Read IOPS (QD32): 87.0K (max.)
- 4KB Random Write IOPS (QD32): 66.0K (max.)

#### ■ Capacity

- 128GB, 256GB, 512GB, 1TB & 2TB

#### ■ Reliability

- **TBW:** Up to 2,344 TBW at 2TB 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, 1,500G, 3 axes.

#### ■ Certifications and Declarations

- **Certifications:** CE & FCC
- **Declarations:** RoHS & REACH

#### Remarks:

1. Support official S.M.A.R.T. Utility.
2. Sequential performance is based on CrystalDiskMark 5.1.2 with file size 1000MB
3. **BICS** means Bit Cost Scalable Technology.  
**BICS FLASH** is a trademark of Toshiba Corporation.
4. Telcordia SR-332 GB, 25°C

### Order Information

#### I. Part Number List

##### ◆ APRO 2.5" Rugged Metal SATA III SSD (3D-NAND Flash) MUSE-ET Series

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Wide Temp. Grade ( -40°C ~ +85°C )
	128GB	SR7ST128G-VECT3	WR7ST128G-VECT3-C
	256GB	SR7ST256G-VECT3	WR7ST256G-VECT3-C
	512GB	SR7ST512G-VECT3	WR7ST512G-VECT3-C
	1TB	SR7ST001T-VECT3	WR7ST001T-VECT3-C
	2TB	SR7ST002T-VECT3	WR7ST002T-VECT3-C

#### Notes:

C : Special conformal coating treated on whole PCBA (Optional)

#### II. Part Number Decoder:

**X1 X2 X3 X4 X5 X6 X7 X8 X9** – **X11 X12 X13 X14 X15** - **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

R : Rugged Metal

#### **X3 X4 X5** : Product category

7ST : 2.5" SATA SSD w/DRAM cache & Tantalum Capacitors

#### **X6 X7 X8 X9** : Capacity

128G: 128GB      001T: 1TB

256G: 256GB      002T: 2TB

512G: 512GB

#### **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.

#### **X17 X18 X19 X20** : Reserved for specific requirement

C : Conformal coating (optional)

#### **X11** : Controller

M : MUSE Series

## *Revision History*

Revision	Description	Date
1.0	Initial release.	2019/03/07
2.0	Updated document form	2019/05/22

## Contents

Product Features .....	- 2 -
Order Information .....	- 3 -
<b>I. Part Number List</b> .....	- 3 -
<b>II. Part Number Decoder:</b> .....	- 3 -
Revision History .....	- 4 -
Contents .....	- 5 -
<b>1. Introduction</b> .....	- 6 -
<b>1.1. Scope</b> .....	- 7 -
<b>1.2. Flash Management Technology – Static Wear Leveling</b> .....	- 7 -
<b>1.3. Bad Block Management</b> .....	- 7 -
<b>1.4. DRAM Buffer</b> .....	- 7 -
<b>1.5. Power interrupts data protection Technology</b> .....	- 8 -
<b>1.6. Error Correcting Coding (ECC)</b> .....	- 8 -
<b>1.7. 3D-NAND Flash</b> .....	- 8 -
<b>2. Product Specifications</b> .....	- 9 -
<b>2.1. System Environmental Specifications</b> .....	- 9 -
<b>2.2. System Power Requirements</b> .....	- 9 -
<b>2.3. System Performance</b> .....	- 9 -
<b>2.4. System Reliability</b> .....	- 10 -
<b>2.5. Physical Specifications</b> .....	- 10 -
<b>2.6. Conformal coating</b> .....	- 12 -
<b>3. Interface Description</b> .....	- 12 -
<b>3.1. Rugged Metal 2.5" SATA III SSD interface</b> .....	- 12 -
<b>3.2. Pin Assignments</b> .....	- 13 -
<b>Appendix A: Limited Warranty</b> .....	- 14 -

### 1. Introduction

APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series provides high capacity flash memory Solid State Drive (SSD) that electrically complies with SATA Revision 3.2. APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series support SATA 1.5Gb/s; SATA 3Gb/s & SATA 6Gb/s data transfer rate and designed with a DRAM buffer which is support high transfer rate as a data buffer for the SSD; Also, the APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series applied with several tantalum capacitors to provide power buffering after host power interruption for data protection. The main used flash memories are BiCS 3D-NAND Flash memory chips. The available disk capacities are 128GB, 256GB, 512GB, 1TB and 2TB

The operating temperature grade is optional for standard grade 0°C ~ 70°C and Wide Temp. Grade -40°C ~ +85°C. The data transfer performance by sequential read is up to 550.0 MB/sec, and sequential write is up to 475.0 MB/sec.

APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series can be high speed booting SSD to varieties of IPC motherboards and PC structure system, and it is also suitable to handheld device embedded system, inventory recorder and particularly for serious environment monitor recorder system

APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series provides a high level interface to the host computer. This interface allows a host computer to issue commands to the APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET 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 Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series intelligent controller manages interface protocols, data storage and retrieval as well as ECC, bad block management and diagnostics, power management and clock control.

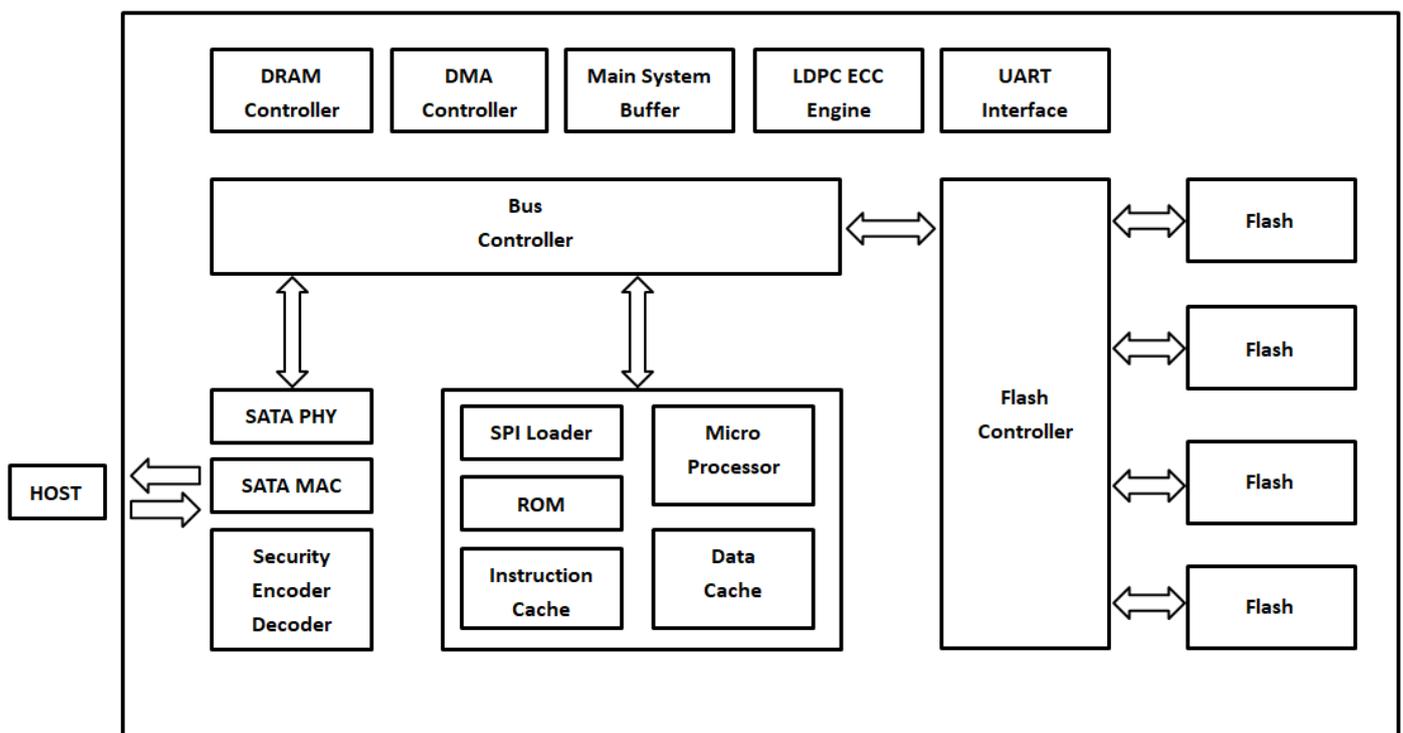


Figure 1: APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series block diagram

### 1.1. *Scope*

This document describes features, specifications and installation guide of APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET 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 Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET 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 Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET 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.
- 2TB Supports 16GBits DRAM Cache.

### 1.5. **Power interrupts data protection Technology**

In the event of an unstable power supply, SSD loses power before it can finish programming process from host to flash, this may cause data being written to the incorrect block and further leads to data corruption.

Power interrupt data protection technology is applied with several tantalum capacitors to provide power buffering after host power interruption. The Data Protection Technology provides enough time for the SSD controller can write all DRAM buffer data to flash, all data will be protected and without data loss. The ability of Power interrupt data protection technology is able to write 1.28MB of data within 60ms. This ensures all data in the DRAM buffer can be successfully written into flash.

Traditionally, super capacitors were applied in most SSD products, the advantages of tantalum capacitors over super capacitors are:

➤ **Tantalum capacitors are electrolyte free.**

It is able to maintain its designed capacitance for several years when used within design limits.

➤ **Wide operating temperature range.**

Tantalum capacitors can operate from temperature range of -55C to +125C, which is very suitable for industrial and military usage.

➤ **Tantalum capacitors have an ultimate high volumetric efficiency (CV/cc).**

For example, a 50-microfarad tantalum capacitor can be equal and to properly replace a 500-microfarad aluminum capacitor.

### 1.6. **Error Correcting Coding (ECC)**

APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series provides a high level interface to the host computer. This interface allows a host computer to issue commands to the APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET 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 Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series intelligent controller manages interface protocols, data storage and retrieval as well as ECC, bad block management and diagnostics, power management and clock control.

### 1.7. **3D-NAND Flash**

3D NAND is a vertical implementation of the NAND flash cell memory array. The memory cell transistors forming the NAND string are connected in a series vertically and the memory transistors are changed from the floating-gate type to a trapped charge type.

In floating-gate technology, die density is increased by shrinking peripheral circuits and active circuits.

With 3D, holding the X/Y dimension of the die constant, die density is increased through multiple layers of the active circuits on the Z axis. Higher-density 3D NAND die enables applications needing high-density NAND chip solutions.

### 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 Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series		Standard Grade	Wide Temp. Grade
		SR7STxxxx-VECT3	WR7STxxxx-VECT3-C
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 Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series		
DC Input Voltage (VCC)		5V±5%
Maximum average value	Reading Mode :	480.0 mA (max.)
	Writing Mode :	620.0 mA (max.)
	Idle Mode :	190.0 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	1TB	2TB
	Sequential Read (MB/s)	560.0	560.0	560.0	530.0	550.0
	Sequential Write (MB/s)	135.0	285.0	525.0	460.0	475.0
	4KB Random Read IOPS (QD32)	42.0K	80.0K	87.0K	87.0K	87.0K
	4KB Random Write IOPS (QD32)	37.0K	56.0K	70.0K	70.0K	66.0K

Note:

1. The performance was measured using CrystalDiskMarkv5.0; 1GB data size test with SATA 6Gbps host.
2. Samples were built using Toshiba BiCS 3D-NAND Flash
3. Performance may differ according to flash configuration and platform.

### 2.4. System Reliability

**Table 4: System Reliability**

<b>Wear-leveling Algorithms</b>	Static wear-leveling algorithms	
<b>Bad Block Management</b>	Supportive	
<b>ECC Technology</b>	Hardware design LDPC (Low Density Parity Check)	
<b>Erase counts</b>	TOSHIBA <b>BiCS FLASH™</b> 3D NAND Flash: 3K P/E Cycles	
<b>TBW (Tera Bytes Written)</b>		
<b>Capacity</b>	128GB	150.0
	256GB	300.0
	512GB	600.0
	1TB	1,172.0
	2TB	2,344.0

Note:

- Client workload by JESD-219A.
- Samples were built using Toshiba BiCS 3D-NAND FLASH
- 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 Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series physical specifications and dimensions.

**Table 5: Physical Specifications of 2.5" SATA-III SSD-MUSE-ET Series**

<b>Length:</b>	100.0 mm
<b>Width:</b>	69.90 mm
<b>Thickness:</b>	7.0 mm
<b>Weight:</b>	65.0 g / 2.29 oz.

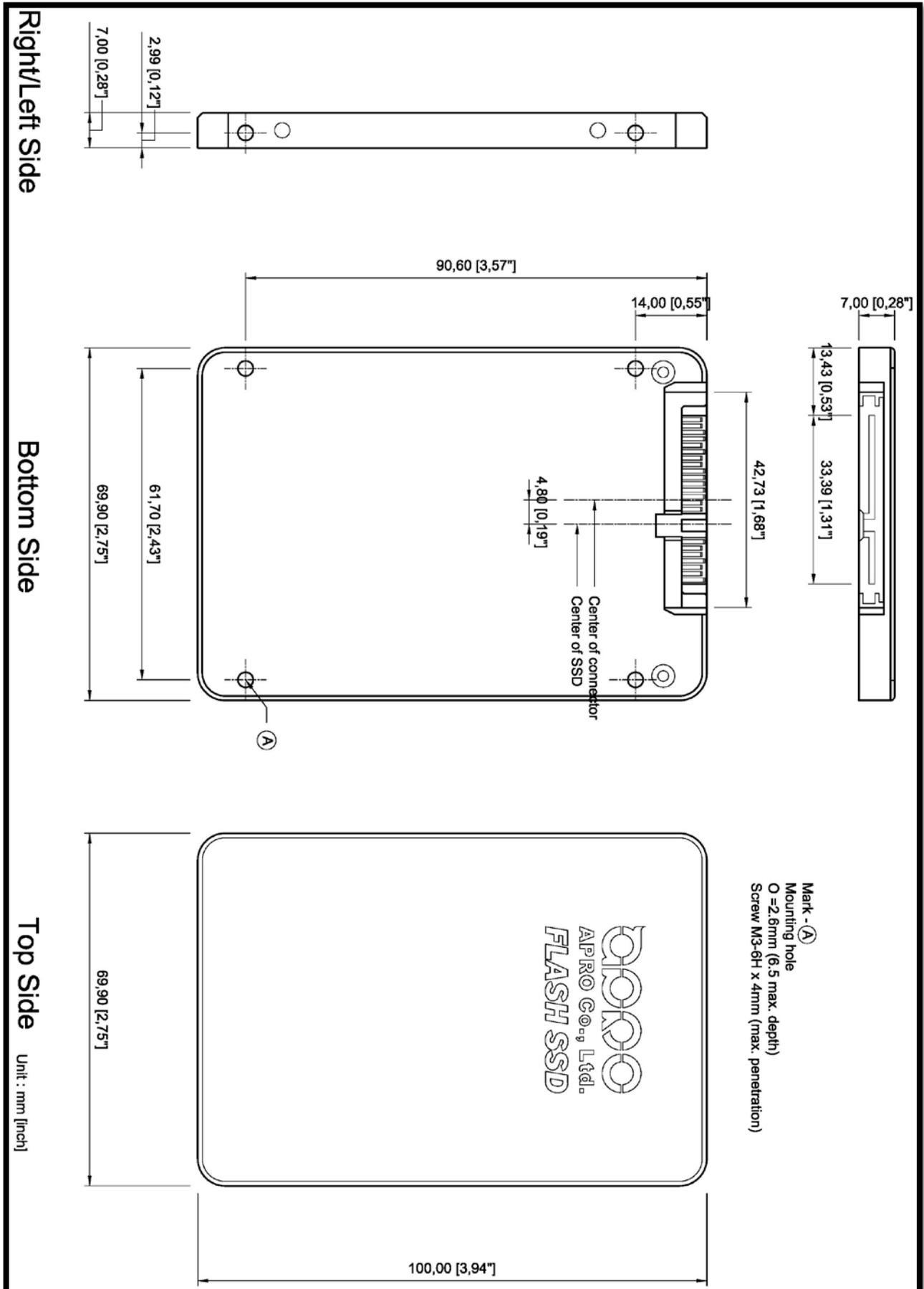


Figure 2: APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series Dimension

### 2.6. Conformal coating

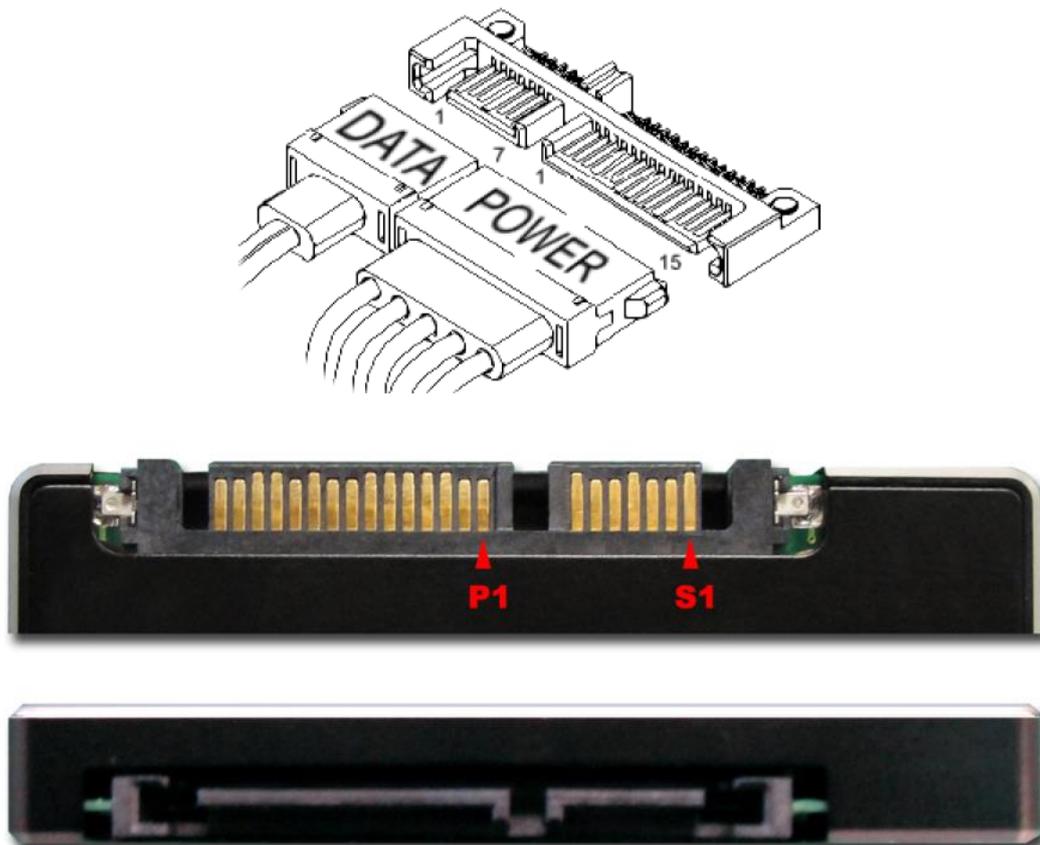
Conformal coating is a protective, dielectric coating designed to conform to the surface of an assembled printed circuit board. Commonly used conformal coatings include silicone, acrylic, urethane and epoxy. APRO applies only silicone on APRO storage products upon requested especially by customers. The 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. Rugged Metal 2.5" SATA III SSD interface

APRO Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET Series is equipped with 7 pins in the signal segment and 15 pins in the power segment.



**Figure 3: The connectors of Signal Segment and Power Segment**

### 3.2. Pin Assignments

There are total of 7 pins in the signal segment and 15 pins in the power segment.

The pin assignments are listed in below table 6.

Name	Type	Description
S1	GND	NA
S2	A+	Differential Signal Pair A
S3	A-	
S4	GND	NA
S5	B-	Differential Signal Pair B
S6	B+	
S7	GND	NA

Key and Spacing separate signal and power segments		
P1	NC	NA
P2	NC	NA
P3	NC	NA
P4	GND	NA
P5	GND	NA
P6	GND	NA
P7	V5	5V Power, Pre-Charge
P8	V5	5V Power
P9	V5	5V Power
P10	GND	NA
P11	DAS/DSS	Device Activity Signal / Disable Staggered
P12	GND	NA
P13	NC	NA
P14	NC	NA
P15	NC	NA

**Table 6 - Pin Assignments**

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

APRO warrants your Rugged Metal 2.5" SATA III SSD (3D-NAND Flash) MUSE-ET 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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