APRO Co., Ltd.

3D-NAND Flash

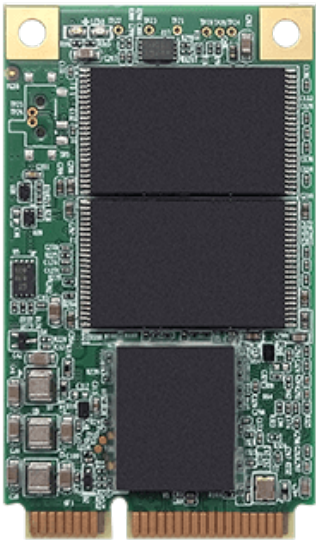
(KIOXIA BiCS5)

Mini SATA III Module

MUSE-ER Series

Supports DRAM Cache

(JEDEC MO-300A)



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Product Features

- **Flash IC**
  - **KIOXIA BiCS FLASH™.*4**
  - **BiCS-5** 3D-NAND Flash

- **Compatibility**
  - Compliant with SATA Revision 3.2
  - SATA 1.5Gb/s; SATA 3.0Gb/s & SATA 6.0Gb/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**
  - JEDEC MO-300A full size Solid State Drive
  - 52 pos. Edge Connector, PCI Express (PCIe) mini
  - Dimension: 50.8 mm x 29.8 mm.
  - Weight: 8.0 g / 0.30 oz.

- **Power Operating Voltage 3.3V(+/-) 5%**
  - Read Mode: 2.3W (max.)
  - Write Mode: 2.3W (max.)
  - Idle Mode: 0.9W (max.)

- **Performance (Maximum value) *2*3**
  - Sequential Read: 510.0 MB/sec. (2TB.)
  - Sequential Write: 460.0 MB/sec. (2TB.)
  - 4KB Random Read (QD32): 72.0K IOPS
  - 4KB Random Write (QD32): 57.0K IOPS

- **Capacity**
  - 128GB, 256GB, 512GB, 1TB and 2TB.

- **Reliability**
  - **TBW:** Up to 4,615 TBW at 2TB Capacity. (Client workload by JESD-219A)
  - **ECC:** Designed with hardware LDPC ECC engine with hard-decision and soft-decision decoding.
  - **MTBF**: > 3,000,000 hours
  - **Temperature:** (Operating)
    Standard Grade: 0ºC ~ +70ºC
    Industrial. Grade: -40ºC ~ +85ºC
  - **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

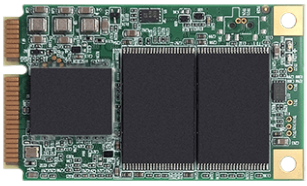
Remarks:

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 KIOXIA Corporation.

Order Information

I. Part Number List

◆ **APRO Mini SATA III Module (3D NAND FLASH) MUSE-ER Series**

Product Picture	Capacity	Standard grade (0ºC ~ 70ºC)	Industrial Grade (-40ºC ~ +85ºC)
	128GB	SBMSR128G-VECT5	WBMSR128G-VECT5-C
	256GB	SBMSR256G-VECT5	WBMSR256G-VECT5-C
	512GB	SBMSR512G-VECT5	WBMSR512G-VECT5-C
	1TB	SBMSR001T-VECT5	WBMSR001T-VECT5-C
	2TB	SBMSR002T-VECT5	WBMSR002T-VECT5-C

II. Part Number Decoder:

X1 X2 X3 X4 X5 X6 X7 X8 X9 – X11 X12 X13 X14 X15 – X17 X18

X1 : **Grade**

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

W: Industrial grade – operating temp. -40º C ~ +85 º C

X2 : **The material of case**

B : Bare

X3 X4 X5 : **Product category**

MSR : mini SATA Flash Module (mSATA) SDRAM Cache

X6 X7 X8 X9 : **Capacity**

128G:	128GB	**512G:**	512GB
256G:	256GB	**001T:**	1TB
		002T:	2TB

X11 : **Controller**

V : MUSE Series

X12 : **Controller version**

A, B, C.....

X13 : **Controller Grade**

C : Commercial grade

I : Industrial grade

X14 : **Flash IC**

T : KIOXIA NAND Flash IC

X15 : **Flash IC grade / Type**

5 : BiCS-5 3D-NAND Flash IC.

X17 X18: **Reserved for specific requirement**

C : Conformal coating (optional)

Revision History

Revision	Description	Date
1.0	Initial release	2022/11/24
1.1	Add 1TB/2TB Capacities	2022/12/01

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1. Introduction

APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series provides high capacity flash memory Solid State Drive (SSD) that electrically complies with Serial ATA 3.2 (SATA) standard and ATA-8 command set compatible. APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series support SATA 1.5Gbps/3.0Gbps/6.0Gbps data transfer rate with high performance and designed with a DRAM which is support 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, 1TB and 2TB.

The operating temperature grade is optional for Standard grade 0°C ~ 70°C and Industrial grade supports -40°C ~ +85°C. The data transfer performance by sequential read is up to 510.0 MB/sec, and sequential write is up to 460.0 MB/sec.

APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series with built-in DRAM provides a high level interface to the host computer. This interface allows a host computer to issue commands to the APRO Mini SATA III Module (3D-NAND BiCS5) 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 Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series intelligent controller manages interface protocols, data storage and retrieval as well as ECC, defect handling and diagnostics, power management and clock control.

Figure 1 shows a block diagram of the used high tech APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series.

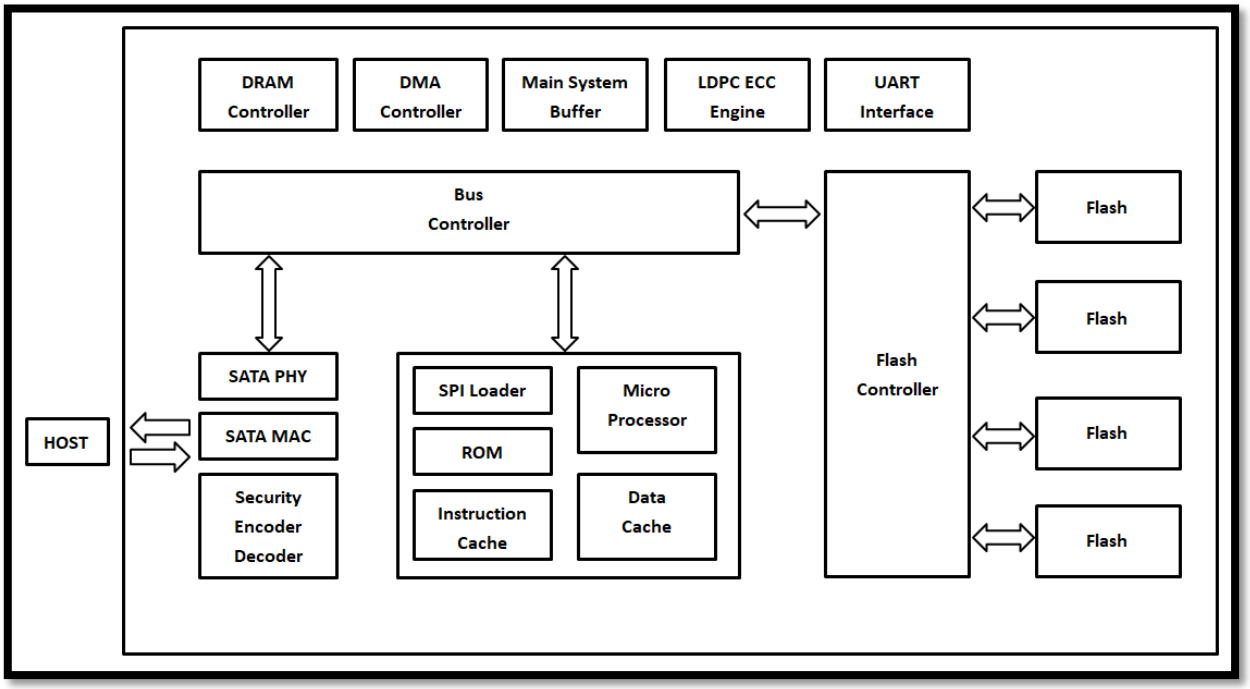

Figure 1: APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series block diagram

1.1. *Scope*

This document describes features, specifications and installation guide of APRO Mini SATA III Module (3D-NAND BiCS5) 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 Mini SATA III Module (3D-NAND BiCS5) 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 Latter 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 Mini SATA III Module (3D-NAND BiCS5) 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.

1.5. *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.

1.6. *Power Interrupt Data Protection*

Industrial market these days, often faces system failures due to power supply conditions. Over half of all fields encounter failures with data loss and corruption in applications due to power interruption. Data protection against sudden power interruption requires a unique feature in storage devices. Possibilities of this issue may occur on several conditions, such as disconnecting the device while operating, or unstable power supplies.

In order to mitigate the damage power interruption can cause to the storage device, APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series has designed a special technology to detect and eliminate the damage that power interruption generates and ensures data integrity. Flash will become write-protected to prevent data from being written into the wrong sector. Built-in voltage detect function alerts the host system of any unstable power supply and prevents the transmission of commands until power levels are once again stabilized. Storage devices can be damaged and data corrupted, product will need to be reformatted when this issue occurs, sometimes even have to reinstall O.S., or send back to supplier for repairmen. This shows direct influence on company's reputation, reliability of product itself, and most importantly, customer's faith. For most applications, storage devices normally work under power supplies lower than it should receive. Due to inefficient power levels, data corruption and damage of device can seriously influence ongoing business or deals, this may result in project loss due to the return and repair period of products.

APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series is designed to meet the highly standard of customer's requirements in industrial, military and medical markets, which included performances, reliability and longer lifetime.

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 Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series		Standard Grade	Industrial Grade
		SBMSRxxxG-VECT5	WBMSRxxxG-VECT5C
Temperature	Operating:	0ºC ~ +70ºC	-40ºC ~ +85ºC
	Non-operating:	-20ºC ~ +80ºC	-50ºC ~ +95ºC
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:	24ºC	
	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 Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series		
DC Input Voltage (VCC)		+3.3V±5%
Maximum average value	Reading Mode (max.) :	Read Mode: 2.30W
	Writing Mode (max.) :	Write Mode: 2.30W
	Idle Mode (max.) :	Idle Mode: 0.9W

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)	410.0	520.0	520.0	510.0	510.0
	Sequential Write(MB/s)	90.0	180.0	340.0	450.0	460.0
	4KB Random Read IOPS (QD32)	29.0K	54.0K	70.0K	71.0K	72.0K
	4KB Random Write IOPS (QD32)	23.0K	45.0K	57.0K	57.0K	57.0K

Note:

1. *The performance was measured using CrystalDiskMark by file size 1000MB (QD32).*
2. *Random performance based on IOmeter with Queue Depth 32*

2.4. *System Reliability*

Table 4: System Reliability

Wear-leveling Algorithms	Static wear-leveling algorithms	
Bad Blocks Management	Supportive	
ECC Technology	Hardware design LDPC (Low Density Parity Check)	
Erase counts	KIOXIA **BiCS FLASH™** 3D NAND Flash: 3K P/E Cycles	
Capacity / TBW(TB)	**Sequential workload**	**Client workload**
128GB	341	289
256GB	682	578
512GB	1,364	1,154
1TB	2,663	2,038
2TB	5,327	4,615

Note:

- *Sequential: Mainly sequential write.*
- *Client: Follow JESD218 Test method and JESD219A Workload, tested by ULINK. (The capacity lower than 64GB client workload is not specified in JEDEC219A, the values are estimated.)*
- *Based on out-of-box performance.*

2.5. *Physical Specifications*

Refer to Table 5 and see Figure 2 for APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series physical specifications and dimensions.

Table 5: Physical Specifications of APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series

Length:	50.8 mm
Width:	29.8 mm.
Weight:	8.0 g / 0.30 oz.

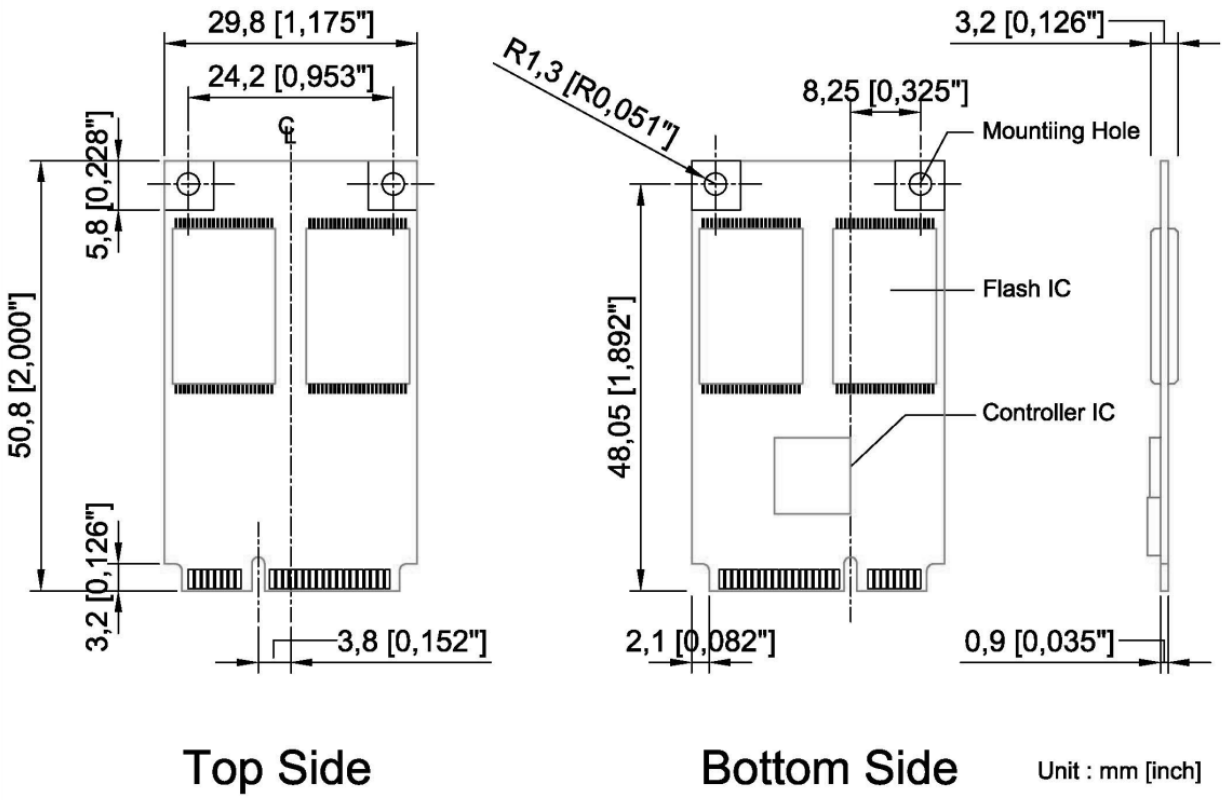

Figure 2: APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series Dimension

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 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

3.1. Mini SATA III Module (3D-NAND Flash) MUSE-ER Series interface

APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series is equipped with 52 pos. Edge Connector

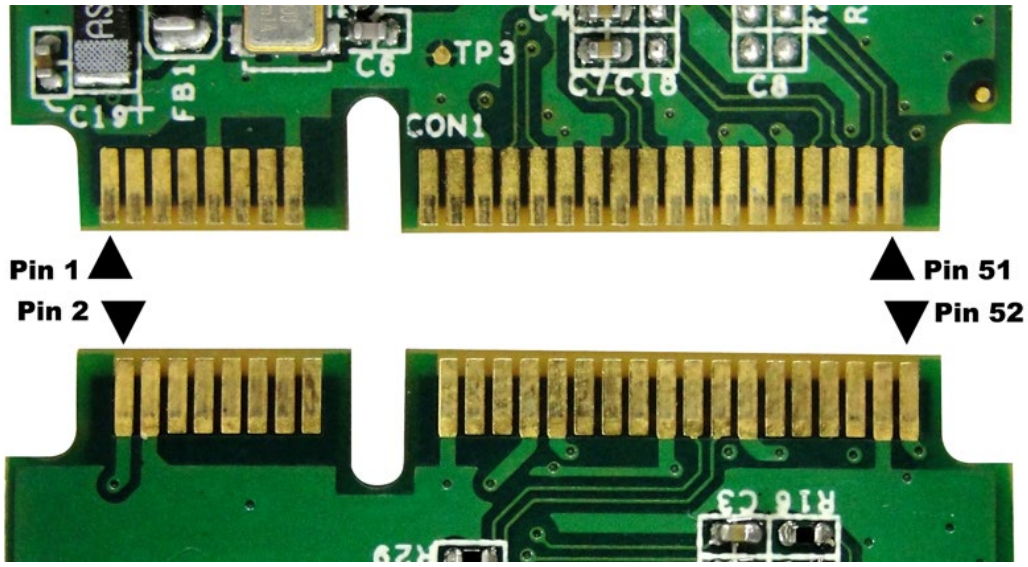

Figure 3: The connectors of APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series

3.2. Pin Assignments

APRO Mini SATA III Module (3D-NAND BiCS5) MUSE-ER Series operates with standard SATA pin-out.

The pin assignments are listed in below table 6.

Signal Name	Pin #	Pin #	Signal Name
NC	1	2	**+3.3V**
NC	3	4	**GND**
NC	5	6	**NC**
NC	7	8	**NC**
GND	9	10	**NC**
NC	11	12	**NC**
NC	13	14	**NC**
GND	15	16	**NC**
NC	17	18	**GND**
NC	19	20	**NC**
GND	21	22	**NC**
TX+	23	24	**+3.3V**
TX-	25	26	**GND**
GND	27	28	**NC**
GND	29	30	**NC**
RX-	31	32	**NC**
RX+	33	34	**GND**
GND	35	36	**NC**
GND	37	38	**NC**
+3.3V	39	40	**GND**
+3.3V	41	42	**NC**
NC	43	44	**DEVSLP**
NC	45	46	**NC**
NC	47	48	**NC**
DAS	49	50	**GND**
GND	51	52	**+3.3V**

Table 6 - Pin Assignments

Appendix A: Limited Warranty

APRO warrants your Mini SATA III Module (3D-NAND BiSC5) 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 / Industrial grade): 2 years / Within 3K Erasing Counts**

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