APRO Co., Ltd.

SLC

Industrial 2.5" Rugged Metal SATA III SSD

PHANES-HR Series

Supports DRAM Cache

Document No. : 100-xR7SR-PHITI

Version No. : 02V1

Date : May, 2019

ISO 9001 : 2015 CERTIFIED

Product Features

- **Flash IC**
  - TOSHIBA NAND Flash IC.
  - Single-Level Cell (SLC) technology.

- **Compatibility**
  - SATA Revision 3.2
  - SATA 1.5Gb/s; SATA 3Gb/s & SATA 6Gb/s data transfer rate.
  - ATA-8 ACS2 command set

- **Additional Capabilities**
  - S.M.A.R.T.*[1] (Self-Monitoring, Analysis and Reporting Technology) feature set support.
  - Thermal Monitor for SSD's temperature.
  - Native Command Queuing (NCQ) support.
  - TRIM maintenance command support.
  - Static and Dynamic Wear Leveling
  - Power Loss Protection
  - Over-Provision
  - Bad Block Management
  - Support expanded register for SATA protocol 48 bits addressing mode

- **Mechanical**
  - Standard 2.5" SATA Flash Disk form-factor
  - SATA 7-pin (data) + 15-pin (power connector) SATA Interface
  - Dimension:
    R7SR: 100.0 mm x 69.9 mm x 7.0 mm.
    R2SR: 100.0 mm x 69.9 mm x 9.5 mm.
  - Weight:
    R7SR: (32GB~256GB) 65.00 g / 2.29 oz.
    R2SR: (512GB) 75.00 g / 2.64 oz.

- **Power Operating Voltage 5V(+/-) 5%**
  - Read Mode: 2,450 mW (max.)
  - Write Mode: 3,600 mW (max.)
  - Idle Mode: 450 mW (max.)

- **Performance (Maximum value) *[2]**
  - Sequential Read: 553.0 MB/sec. (max.)
  - Sequential Write: 532.3 MB/sec. (max.)
  - 4KB Random Read IOPS (QD32): 55K
  - 4KB Random Write IOPS (QD32): 53K
  - 4KB Random Read access time: 0.16ms
  - 4KB Random Write access time: 0.05ms

- **Capacity**
  - 32GB, 64GB, 128GB, 256GB and 512GB.

- **Reliability**
  - **TBW:** Up to 20,560 TBW by 512GB Capacity. (Test by sequential Write.)
  - **ECC Scheme:** Automatic 120 bits per 2K bytes error correction (ECC) and retry capabilities
  - **MTBF:** > 3,000,000 hours
  - **Temperature:** (Operating)
    Standard Grade: 0ºC ~ +70ºC
    Industrial. Grade: -40ºC ~ +85ºC
  - **Vibration:** 80 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

Order Information

I. Part Number List

◆ **APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series**

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Industrial Grade (-40°C ~ +85°C)
	32GB	SR7SR032G-PHCTC	WR7SR032G-PHITI
	64GB	SR7SR064G-PHCTC	WR7SR064G-PHITI
	128GB	SR7SR128G-PHCTC	WR7SR128G-PHITI
	256GB	SR7SR256G-PHCTC	WR7SR256G-PHITI
	512GB	SR2SR512G-PHCTC	WR2SR512G-PHITI

II. Part Number Decoder:

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

X1 : **Grade**

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

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

X2 : **The material of case**

R : Rugged Metal

X3 X4 X5 : **Product category**

7SR : 2.5" SATA SSD with SDRAM Cache

2SR: 2.5" SATA SSD with SDRAM Cache (512GB)

X6 X7 X8 X9 : **Capacity**

032G:	32GB	**256G:**	256GB
064G:	64GB	**512G**	512GB
128GB:	128GB		

X11 : **Controller**

P : PHANES Series

X12 : **Controller version**

A, B, C.....

X13 : **Controller Grade**

C : Commercial grade

I : Industrial grade

X14 : **Flash IC**

T : Toshiba SLC-NAND Flash IC

X15 : **Flash IC grade / Type**

C : Commercial grade

I : Industrial grade

X17 : **Reserved for specific requirement**

C : Conformal-coating (optional)

Revision History

Revision	Description	Date
1.0	Initial release	2016/04/20
1.1	Add capacity 512GB	2016/12/21
1.2	9.5mm thickness for 512GB capacity	2017/08/15
1.3	Updated Version	2018/11/28
2.0	Updated power consumption & performance	2019/05/15
2.1	Updated Mechanical information.	2019/05/29

Contents

1. Introduction

APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series provides high capacity flash memory Solid State Drive (SSD) that electrically complies with SATA Revision 3.2. APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series support SATA 1.5Gb/s; SATA 3Gb/s & SATA 6Gb/s data transfer rate with high performance. The available disk capacities are are 32GB, 64GB, 128GB, 256GB and 512GB.

The operating temperature grade is optional for Standard grade 0°C ~ 70°C and Industrial grade with conformal coating supports -40°C ~ +85°C. The data transfer performance by sequential read is up to 553.0 MB/sec, and sequential write is up to 532.3 MB/sec. The 4K random Read IOPS up to 55.0K and the 4K random Write IOPS up to 53.0K.

APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series products provide a high level interface to the host computer. This interface allows a host computer to issue commands to the APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series to read or write blocks of memory. Each sector is protected by a powerful 120 bits per 2K bytes error correction (ECC). APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series intelligent controller manages interface protocols, data storage and retrieval as well as ECC, defect handling and diagnostics, power management and clock control.

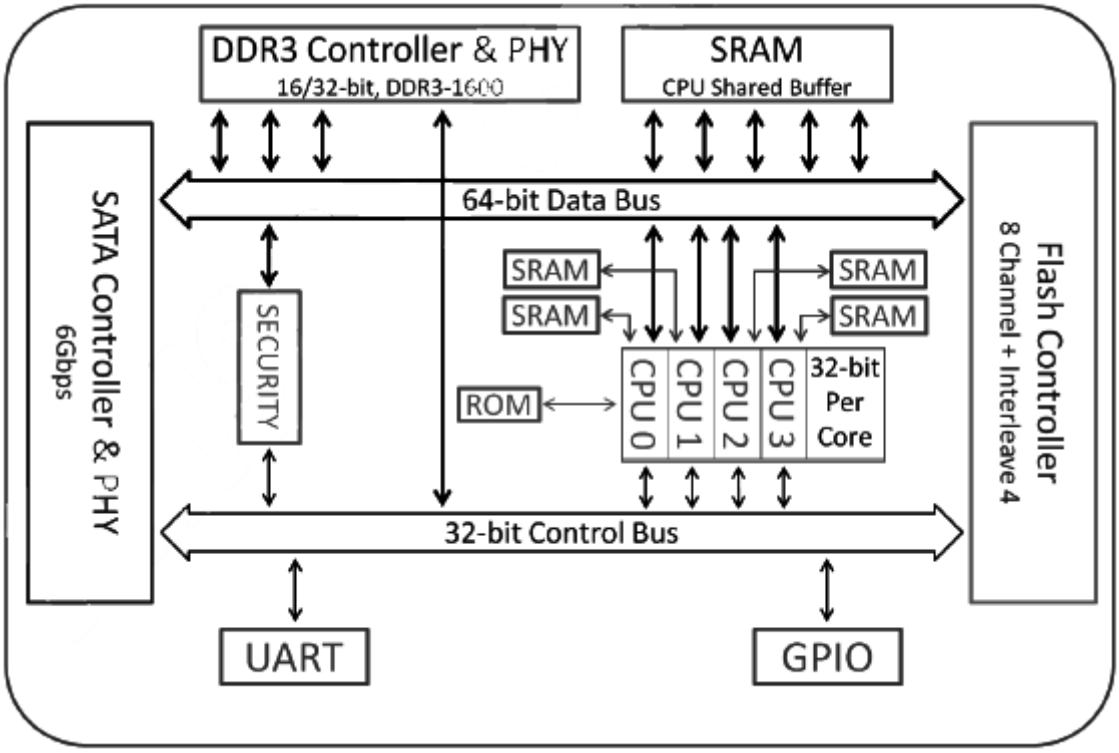

Figure 1: APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series block diagram

1.1. *Scope*

This document describes features, specifications and installation guide of APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series. In the appendix, there provides order information, warranty policy, RMA/DOA procedure for the most convenient reference.

1.2. *Flash Management Technology - Static and 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 SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series provides advanced Wear Leveling algorithm, which can efficiently spread out the flash usage through the whole flash media area. Moreover, by implementing both dynamic and static Wear Leveling algorithms, the life expectancy of the NAND flash is greatly improved.

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 SLC 2.5" Rugged Metal SATA III SSD PHANES-HR 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. *Power Loss Protection: Flushing Mechanism*

Power Loss Protection is a mechanism to prevent data loss during unexpected power failure. DRAM is a volatile memory and frequently used as temporary cache or buffer between the controller and the NAND flash to improve the SSD performance. However, one major concern of the DRAM is that it is not able to keep data during power failure. Accordingly, APRO's SLC SSD applies the Guaranteed Flush technology, which requests the controller to transfer data to the cache. Only when the data is fully committed to the NAND flash will the controller send acknowledgement (ACK) to the host.

Such implementation can prevent false-positive performance and the risk of power cycling issues.

Additionally, it is critical for a controller to shorten the time the in-flight data stays in the cache. Thus, APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series applies an algorithm to reduce the amount of data resides in the cache to provide a better performance. This SmartCacheFlush technology allows incoming data to only have a "pit stop" in the cache and then move to the NAND flash at once. If the flash is jammed due to particular file sizes (such as random 4KB data), the cache will be treated as an "organizer", consolidating incoming data into groups before written into the flash to improve write amplification.

1.5. *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.

- 32GB to 256GB Supports 4GBits DRAM Cache
- 512GB Supports 8GBits DRAM Cache.

1.6. *Mean Time Between Failure (MTBF)*

1.6.1. Definition

MTBF (Mean time between failures) is defined as failure or maintenance required for the average time including failure detection and maintenance for the device. For a simple and maintainable unit, MTBF = MTTF + MTTR.

MTTF (mean time to failure) is defined as the expectation of random variables for time to failure.

MTTR（**mean time to restoration**） is the expectation of random variables of time required for restoration which includes the time required for confirmation that a failure occurred, as well as the time required for maintenance.

1.6.2. Obtaining MTBF

There are two methods for obtaining MTBF:

A. MTBF software estimation method: by calculating all the MTBF data of all the components included in the bill of material, and the data of the completed products including actual parameters of voltage and electrical current using analysis software, the MTBF of the completed product is estimated.

B. MTBF sample test method: by determining a certain number of samples and a fixed time for testing, using a Arrhenius Model and Coffin-Manson Model to obtain parameters, and then using the formula with the parameters, the longevity and in so the reliability is proved.

Arrhenius Model: $\mathbf{Af = e\{ (1/k \times Ea (1/273+Tmax - 1/273+Ttest)\}}$

Coffin-Manson Model: $\mathbf{Af = (\Delta Ttest/\Delta Tuse)m}$

- **APRO uses the A method to Estimate MTBF**

MTBF is actually obtained by calculation which is just an estimation of future occurrences. The main reason to use the first method is that the data contains the analysis by all the parameters of components and actual parameters of voltage and electrical current of finished products, which is considered adequate and objective.

- **Interpretation of MTBF Analysis**

APRO estimates MTBF using a prediction methodology based on reliability data for the individual components in APRO products. The predicted MTBF based on Parts stress analysis Method of Telcordia Special Report SR-332, for components failure rates. Component data comes from several sources: device life tests, failure analysis of earlier equipment, device physics, and field returns.

The Telcordia model is based on the Telcordia document, Reliability Prediction Procedure for Electronic Equipment, Technical Reference SR-332. This standard basically modified the component models in MIL-HDBK-217 to better reflect the failure rates that AT&T Bell Lab equipment was experiencing in the field and was originally developed by AT&T Bell Lab as the Bellcore model.

This model supports different failure rate calculation methods in order to support the taking into account of stress, burn-in, laboratory, or field data. A Parts Count or Parts Stress analysis is included in Telcordia performance. Relex supports Telcordia Issues

1 and 2 and also Bellcore Issues 4, 5, and 6.Telcordia Issue 2, released in September 2006, are supported by Relex and Telcordia Issue 1, released in May 2001, is replaced with Relex. Refer to Telcordia Issue 2 Fields for information about the fields in Relex Reliability Studio specific to Telcordia Issue 2.

➢ **Purpose of the analyses**

The purpose of these analyses is to obtain early estimation of device reliability during engineering and customer validation stages. The prediction results will expose the reliability of whole assembly, viewed as a set of serially connected electronic components. Rating of the assembly electronic components will show the ratio between actual critical elements parameters and their specification limits. The purpose of component rating is to improve a product's inherent design reliability, increase its number of operating times, and to reduce warranty costs and to achieve a more robust design.

1.6.3. Definitions

Term	Definition
Failure	The event, or inoperable state, in which any item or part of an item does not, or would not, perform as previously specified.
Failure rate	The total number of failures within an item population, divided by the total number of life units expended by that population, during a particular measurement interval under stated condition.
FIT	Failures In Time: the number of failures in 1 billion hours.
PPM	Part per million: the number of failures in 1 million hours.
Mean Time Between Failures (MTBF)	A basic measure of reliability for repairable items: The mean number of life units during which all parts of the item perform within their specified limits, during a particular measurement interval under stated conditions..
GB	Ground, Fixed, Controlled: Nearly zero environmental stress with optimum engineering operation and maintenance. Typical applications are central office, environmentally controlled vaults, environmentally controlled remote shelters, and environmentally controlled customer premise area.
GF	Ground, Fixed, Uncontrolled: Some environmental stress with limited maintenance. Typical applications are manholes, poles, remote terminals, and customer premise areas subject to shock, vibration, temperature, or atmospheric variations.

➢ **Software & Database**

Analysis Software & Analysis Method

Software Name : Relex Reliability Studio 2008

Software Version : Relex Studio 2008

➢ **Analysis Method**

The prediction method used was Telcordia SR-332, Issue 2,

Parts Count

Failure rate (**λ**) = 10^9 hours (FITs)

MTBF=1/**λ**

$\lambda_{SSi} = \lambda_{Gi}\, TT_{Qi} TT_{Si} TT_{Ti}$

Where λ_{Gi} : Generic steady-state failure rate for device i

TT_{Qi} : Quality factor for device i

TT_{Si} : Stress factor for device i

TT_{Ti} : Temperature factor for device i

- **Calculation Parameter**

Operation Temperature : 25℃

Environment : Ground Benign, Controlled

Operation Stress : 50% (Voltage, Current, Power)

Method : Method I, Case 3

Products are advertised with MTBF up to 1 million hours in the market. Take one million hours as an example, the product's estimated life is 114 years. However, the current rapid progress of technology, advancement of flash storage device's manufacturing process research and development, and the supply period of former flash IC manufacturing processes are crucial to the actual life expectancy of flash products. In short, the MTBF of flash storage is for reference only. Good customer service and technical support provided by manufacturers is the most significant issue regarding to the life-span of products.

Remark:

All the details of testing and data are for reference only and do not imply any products performance as a result. MTBF is only an estimated date and is depends on both hardware and software. User shall not assume that all the products have the same MTBF as APRO estimates.

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 SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series		Standard Grade	Industrial Grade
		SR7SRxxxG-PHCTC	WR7SRxxxG-PHITI
Temperature	Operating:	0ºC ~ +70ºC	-40ºC ~ +85ºC
	Non-operating:	-20ºC ~ +80ºC	-50ºC ~ +95ºC
Humidity	Operating & Non-operating:	10% ~ 95% non-condensing	
Vibration	Frequency / Acceleration:	80 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 SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series		
DC Input Voltage (VCC)		5V±5%
Maximum average value	**Reading Mode :**	2,450.0 mW (max.)
	Writing Mode :	3,600.0 mW (max.)
	Idle Mode :	450.0 mW (max.)

2.3. System Performance

Table 3: System Performances

Data Transfer Mode supporting		Serial ATA Gen-III (6.0Gb/s = 768MB/s)				
4KB Random access time	**Read:**	0.16 ms.				
	Write:	0.05 ms.				
Maximum Performance	**Capacity**	**32GB**	**64GB**	**128GB**	**256GB**	**512GB**
	Sequential Read (MB/s)	550.0	538.9	550.0	550.0	553.0
	Sequential Write(MB/s)	320.0	512.0	490.0	530.0	532.3
	4KB Random Read IOPS (QD32)	52.0K	55.1K	55.0K	55.0K	55.0K
	4KB Random Write IOPS (QD32)	24.9K	50.4K	50.0K	53.0K	53.0K

Note: The performance was measured using CrystalDiskMark with SATA 6Gbps host.

2.4. System Reliability

Table 4: System Reliability

Wear-leveling Algorithms		Static and Dynamic wear-leveling algorithms
Bad Blocks Management		Supportive
ECC Technology		120 bits per 2K bytes
Erase counts		NAND SLC Flash Cell Level : 3K P/E Cycles
TBW (Tera Bytes Written)		
Capacity	**32GB**	1,280
	64GB	2,560
	128GB	5,140
	256GB	10,280
	512GB	20,560

Note:

- *Samples were built using Toshiba 15nm Toggle SLC NAND flash.*
- *Test by sequential Write.*
- *The endurance of SSD could be estimated 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 3 for APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series physical specifications and dimensions.

Table 5: Physical Specifications of APRO SLC 2.5" SATA III SSD-PHANES-HR Series

Length:	100.0 mm
Width:	69.90 mm
Thickness:	7.0 mm (32GB~256GB) / 9.5mm (512GB)
Weight:	R7SR: (32GB~256GB) 65.00 g / 2.29 oz. R2SR: (512GB) 75.00 g / 2.64 oz.

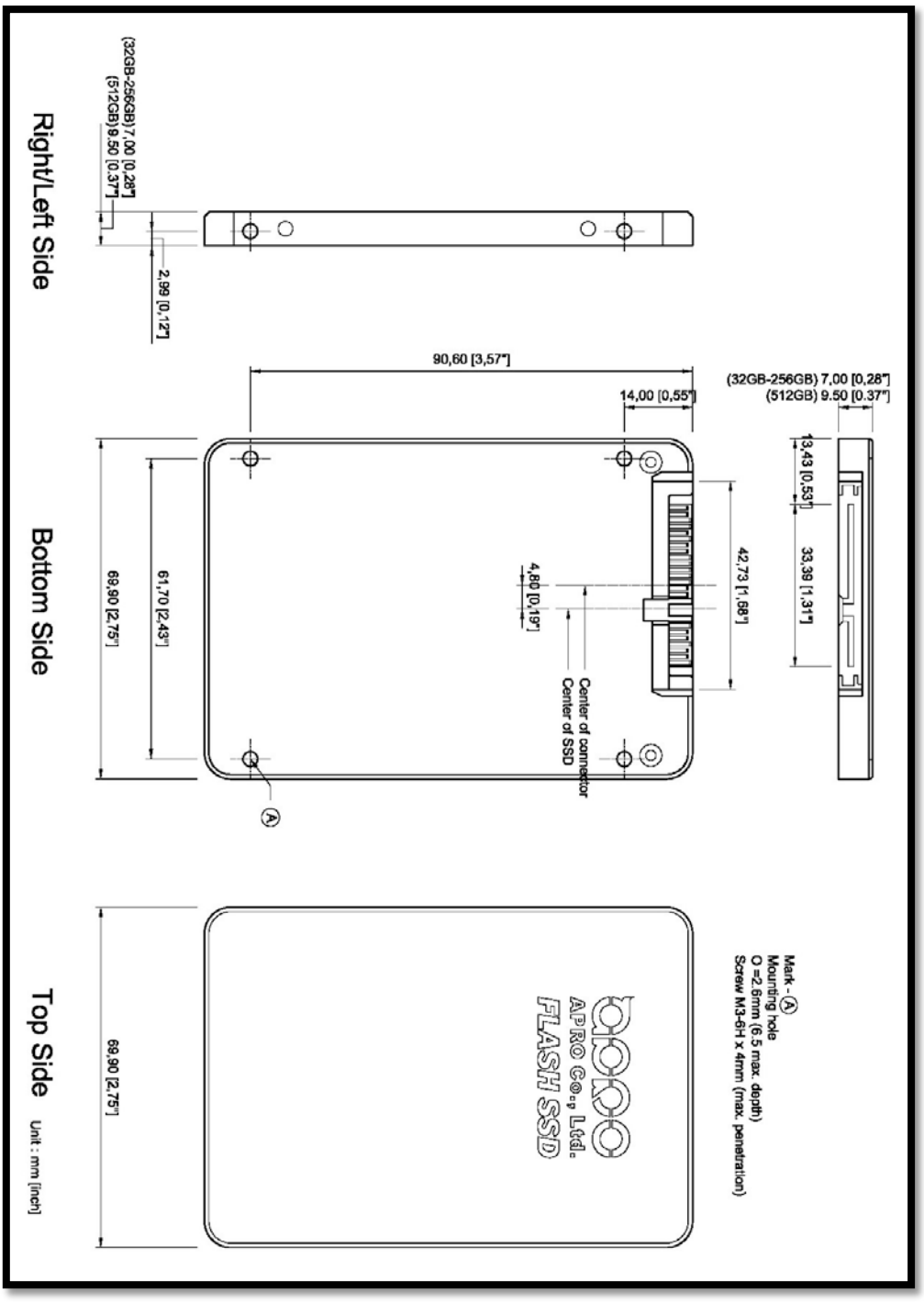

Figure 3: APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series Dimension

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 uses MIL-I-46058C silicon conformal coating

3. Interface Description

3.1. *SLC 2.5" SATA III SSD interface*

APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series is equipped with standard 7 pins + 15 pins Serial ATA connector.

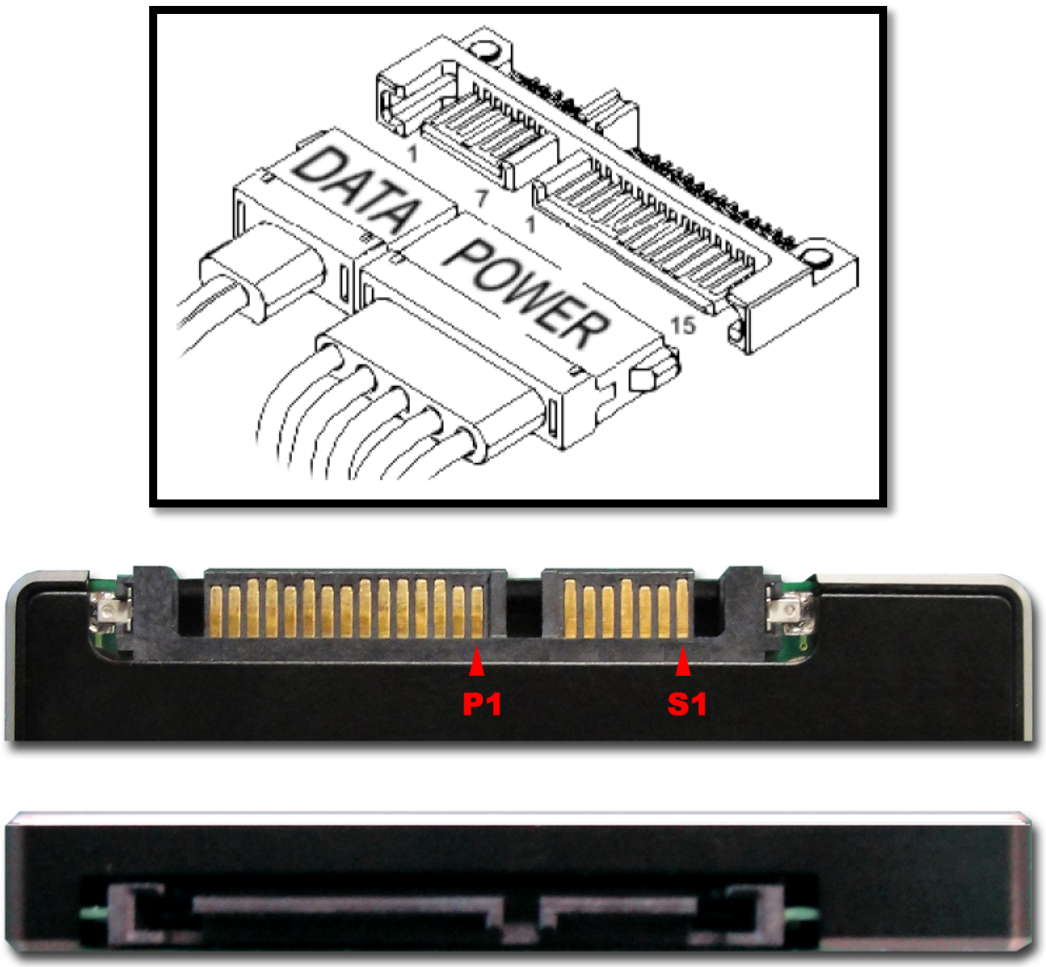

Figure 4: The connectors of APRO SLC 2.5" Rugged Metal SATA III SSD PHANES-HR Series

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.

Table 6 - Pin Assignments

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	DEVSLP	NA
P4	GND	NA
P5	GND	NA
P6	GND	NA
P7	5V	5V Power, Pre-Charge
P8	5V	5V Power
P9	5V	5V Power
P10	GND	NA
P11	Reserved	Device Activity Signal / Disable Staggered Spin up
P12	GND	NA
P13	Not Used (12V pre-charge)	NA
P14	Not Used (12V)	NA
P15	Not Used (12V)	NA

Notes:

- *All pins are in a signal row with a 1.27 mm (0.050" pitch).*
- *The commands on the mating sequence in forward table apply to the case of backplane blind mate connector only. In this case, the mating sequences are:*
- *(1) The pre-charge power pins and other ground pins.*
- *(2) The signal pins and the rest of the power pin*

Appendix A: Limited Warranty

APRO warrants your SLC 2.5" Rugged Metal SATA III SSD PHANES-HR 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:

- **SLC STD. Grade 3 years / Within 60K Erasing Counts**
- **SLC IND. Grade 5 years / Within 60K Erasing Counts**

This document is for information use only and is **subject to change without prior notice**. APRO Co., Ltd. assumes no responsibility for any errors that may appear in this document, nor for incidental or consequential damages resulting from the furnishing, performance or use of this material. No part of this document may be reproduced, transmitted, transcribed, stored in a retrievable manner or translated into any language or computer language, in any form or by any means, electronic, mechanical, magnetic, optical, chemical, manual or otherwise, without the prior written consent of an officer of APRO Co., Ltd.