APRO Co., Ltd.

SLC

Industrial 2.5" Rugged Metal PATA SSD

HERCULES-Q Series

Document No. : 100-XR2IF-MQTS

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ISO 9001 : 2015 CERTIFIED

Product Features

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

- **Compatibility**
  - ATA/ATAPI-8 standard compatible in True-IDE mode.

- **Additional Capabilities**
  - S.M.A.R.T. (Self-Monitoring, Analysis and Reporting. Technology) feature set support.
  - Supports the following data transfer rate:
    PIO mode 0, 1, 2, 3, 4
    DMA mode 0, 1, 2
    Ultra DMA mode 0, 1, 2, 3, 4, 5, 6.
  - Customize C.H.S./Total LBAs capacity.
  - Support bad Block Management.
  - Support Power Loss Data Protection by low voltage detector.
  - Support both Global Wear Leveling Wear Leveling.

- **Mechanical**
  - Standard 44-Pin PATA (IDE) male connector
  - Dimension: 100.0mm x 70.1mm x 8.8mm.
  - Weight: 75.00 g / 2.64 oz.

- **Power Operating Voltage 5.0V(+/-) 5%**
  - Read Mode: 190.0 mA (max.)
  - Write Mode: 230.0 mA (max.)
  - Standby Mode: 5.7 mA (max.)

- **Performance (Maximum value) *1**
  - Sequential Read: 106.1 MB/sec. (max.)
  - Sequential Write: 98.3 MB/sec. (max.)

- **Capacity**
  - 8GB, 16GB, 32GB, 64GB and 128GB

- **Reliability**
  - **TBW:** Up to 628.0 TBW at 128GB Capacity.
  - (Client workload by JESD-219A)
  - **ECC:** Automatic 72 bits per 1024 bytes error correction (ECC) and retry capabilities.
  - **MTBF:** >3,000,000 hours
  - **Temperature:** (Operating)
    Standard Grade: 0ºC ~ +70ºC
    Industrial Grade: -40ºC ~ +85ºC
  - **Vibration:** 70 Hz to 2K Hz, 15G, 3 axes.
  - **Shock:** 0.5ms, 1500 G, 3 axes
  - **Erase counts:** 60K

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

Remarks:

1. Sequential performance is based on CrystalDiskMark

Order Information

I. Part Number List

◆ **APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series**

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Industrial Grade (-40°C ~ +85°C)
	8GB	SR2IF008G-MQCTC-U	WR2IF008G-MQITI-U
	16GB	SR2IF016G-MQCTC-U	WR2IF016G-MQITI-U
	32GB	SR2IF032G-MQCTC-U	WR2IF032G-MQITI-U
	64GB	SR2IF064G-MQCTC-U	WR2IF064G-MQITI-U
	128GB	SR2IF128G-MQCTC-U	WR2IF128G-MQITI-U

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 Temp Grade - operating temp. -40º C ~ +85 º C

X2 : **The material of case**

R : Rugged Metal

X3 X4 X5 : **Product category**

2IF : 2.5" PATA SSD

X6 X7 X8 X9 : **Capacity**

008G:	8GB	**064G:**	64GB
016G:	16GB	**128G:**	128GB
032G:	32GB		

X11 : **Controller**

M : HERCULES Series

X12 : **Controller version**

A, B, C.....

X13 : **Controller Grade**

C : Commercial grade

I : Industrial grade

X14 : **Flash IC**

T : Toshiba NAND Flash IC

X15 : **Flash IC grade / Type**

C : Commercial grade

I : Industrial grade

X17 : **Data transfer rate and disk type**

U: Defaulted as UDMA-6 mode / Fixed disk type

P: PIO-4 mode / Fixed disk type

A: Auto detect data transfer mode / Fixed disk type

X18 : **Reserved for specific requirement**

C : Conformal-coating (optional)

Revision History

Revision	Description	Date
1.0	Initial release	2015/7/3
1.1	Updated Version	2018/11/28
2.0	Updated Document form	2019/06/10

Contents

1. Introduction

APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series provides high capacity flash memory Solid State Drive (SSD) that electrically complies with ATA/ATAPI-8 standard. APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series support UDMA-6 with high performance. The available disk capacities are 8GB, 16GB, 32GB, 64GB and 128GB

The operating temperature grade is optional for standard grade 0°C ~ 70°C and industrial grade -40°C ~ +85°C. The data transfer performance by sequential read is up to 106.1 MB/sec, and sequential write is up to 98.3 MB/sec.

APRO Industrial SLC 2.5" PATA SSD products provide a high level interface to the host computer. This interface allows a host computer to issue commands to the Rugged Metal 2.5" PATA SLC SSD to read or write blocks of memory. Each sector is protected by a powerful 72 bits per 1024 bytes error correction (ECC).

APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q 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 APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series.

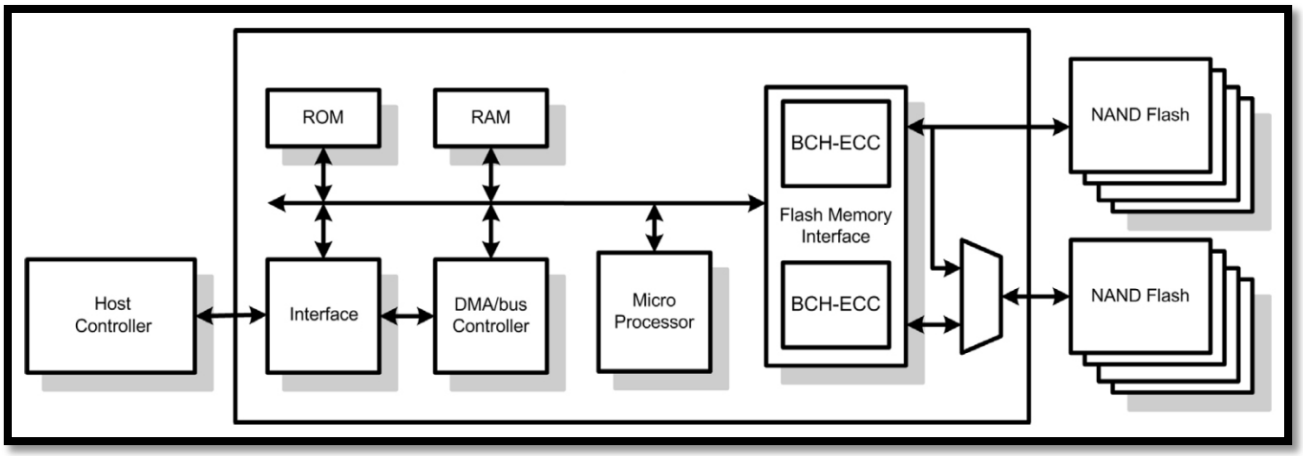

Figure 1: APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series block diagram

1.1. *Scope*

This document describes features, specifications and installation guide of APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series. The appendix provides order information, warranty policy, RMA/DOA procedure for the most convenient reference.

1.2. *Flash Management Technology - Global Wear Leveling*

In order to gain the best management for flash memory, APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series applies Global 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. The objective of global wear leveling is to prevent any frequently updated data from staying at the static area so that wear leveling could be evenly applied to all blocks. Static areas contain any data that does not change, and are ignored by dynamic wear leveling. Such static data may include operating system files, table look-ups, executable files, and etc. Global wear leveling frequently replaces blocks in this area with block in the hot area, and thus each block in all areas has the same probability to be used.

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 data, it moves that data to a more heavily used location before it moves the newly written data. Wear leveling maximizes effective endurance Flash array compared to no wear leveling products.

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 Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q 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 Data Protection by Low Voltage Detector*

APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series has built-in Low Voltage Detector; it becomes active when detecting voltage threshold near 50% of the power it should receive from host. In this scenario, storage will take precedence for the data that host has already completed its command to write into flash at the same time whenever low voltage is detected.

APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series utilizes host and device-initiated power fail protection mechanisms to guarantee data integrity. When encountering sudden power interruption, device will check the last programmed page for any uncorrectable error, if errors were found, all data written prior of the error will be moved to a new block while old block will be erased and corrected during the next power on.

1.5. *Mean Time Between Failure (MTBF)*

1.5.1. 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.

1.5.2. 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.

1.5.3. 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 ($\boldsymbol{\lambda}$) = 10^9 hours (FITs)

MTBF=1/$\boldsymbol{\lambda}$

$\boldsymbol{\lambda}_{SSi} = \boldsymbol{\lambda}_{Gi}\ \mathbf{TT}_{Qi}\mathbf{TT}_{Si}\mathbf{TT}_{Ti}$

Where $\boldsymbol{\lambda}_{Gi}$: Generic steady-state failure rate for device i

$\mathbf{TT}_{Qi}$: Quality factor for device i

$\mathbf{TT}_{Si}$: 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 Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series		Standard Grade	Industrial Grade
		SR2IFxxxG-MQCTC-U	WR2IFxxxG-MQITI-U
Temperature	Operating: Non-operating:	0ºC ~ +70ºC -20ºC ~ +80ºC	-40ºC ~ +85ºC -50ºC ~ +95ºC
Humidity	Operating & Non-operating:	10% ~ 95% non-condensing	
Vibration	Operating & Non-operating:	70 Hz to 2K Hz, 15G, 3 axes	
Shock	Operating & Non-operating:	0.5ms, 1500 G, 3 axes	

2.2. System Power Requirements

Table 2: Power Requirement

APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series		
DC Input Voltage (VCC)		+5V ± 5%
Maximum average value	Reading Mode :	190.0 mA (max.)
	Writing Mode :	230.0 mA (max.)
	Idle Mode :	5.7 mA (max.)

2.3. System Performance

Table 3: System Performances

Data Transfer Mode supporting		PIO 0~4, MWDMA 0~2, UDMA 0~6 supported				
Average Access Time		0.4 ms (estimated)				
Maximum Performance	Capacity	8GB	16GB	32GB	64GB	128GB
	Sequential Read (MB/s)	104.5	103.1	105.4	106.1	103.5
	Sequential Write(MB/s)	91.1	89.2	98.4	98.3	97.6

Note:

- *All values quoted are typically at 25℃ and nominal supply voltage.*
- *The performance is obtained from CrystalDiskMark Test*

2.4. System Reliability

Table 4: System Reliability

Wear-leveling Algorithms	Global wear-leveling algorithms
Bad Blocks Management	Supported
ECC Technology	72 bits per 1024 bytes
Erase counts	NAND SLC Flash Cell Level：60K P/E Cycles
TBW (Tera Bytes Written)	
Capacity	**TBW(TB)**
8GB	38.3
16GB	77.6
32GB	156.3
64GB	313.5
128GB	628.0

Note:

- *Client workload by JESD-219A*
- *Lifespan is calculated by device written per day.*

2.5. Physical Specifications

Refer to Table 5 and see Figure 3 for Rugged Metal 2.5” PATA SLC SSD HERCULES-Q Series physical specifications and dimensions.

Table 5: Physical Specifications

Length:	100.0 mm
Width:	70.10 mm
Thickness:	8.80 mm
Weight:	75.0 g / 2.64 oz.

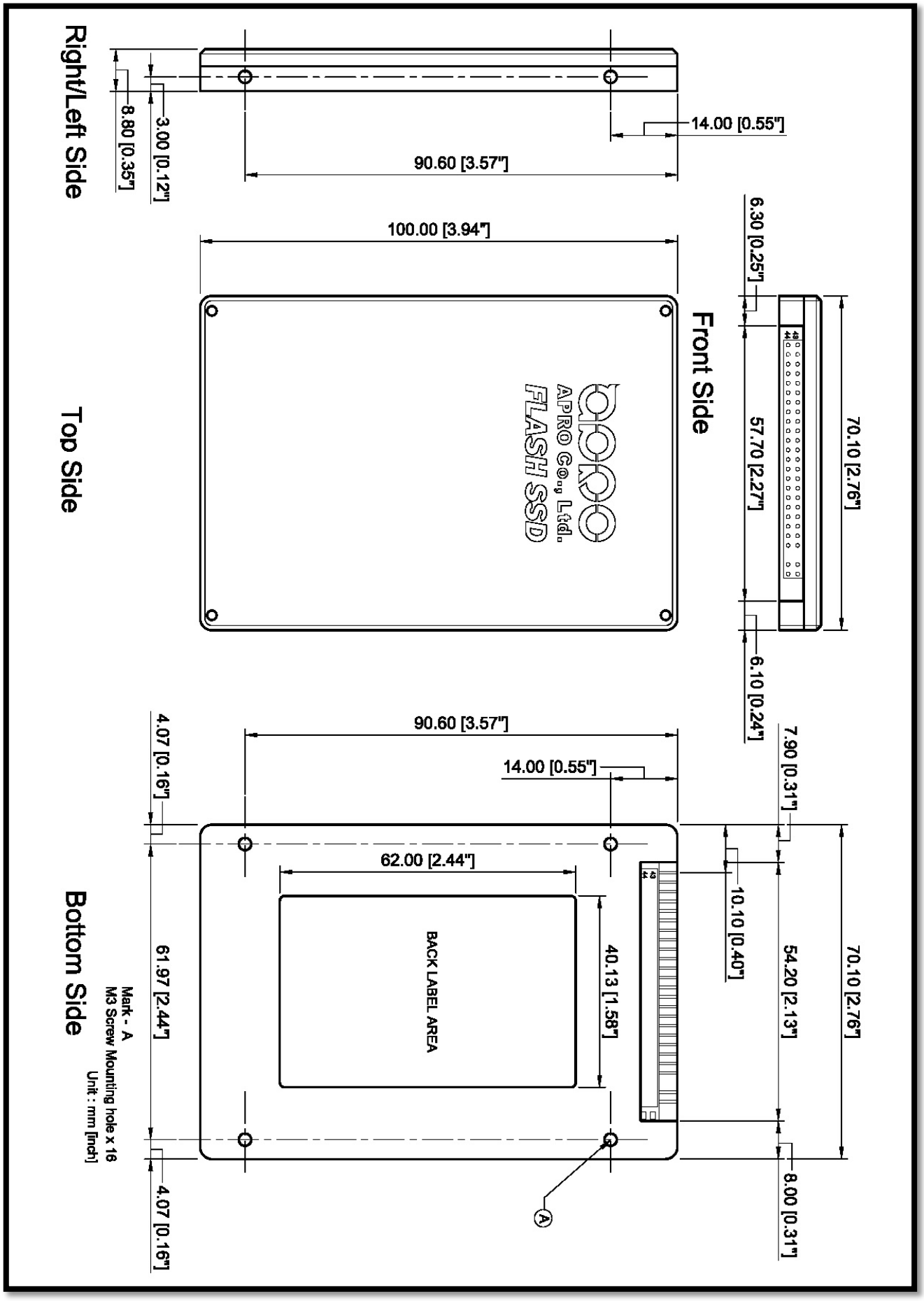

Figure 2: APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series Dimension

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

2.7. *Device Parameter*

The table 6 shows the specific capacity for the various models and the default number of heads, sectors/track and cylinders.

Table 6: Device Parameter

Unformatted Capacity	Cylinder	Head	Sector	LBA Total Sectors
8GB	15,343	16	63	15,465,744
16GB	16,383	15	63	30,932,992
32GB	16,383	16	63	61,865,984
64GB	16,383	15	63	123,731,968
128GB	16,383	15	63	247,463,936

3. Interface Description

3.1. PATA SSD interface

Pin 1 ~ pin 44 are for IDE interface. Pin A ~ pin D is for Master/Slave selection via physical jumpers.

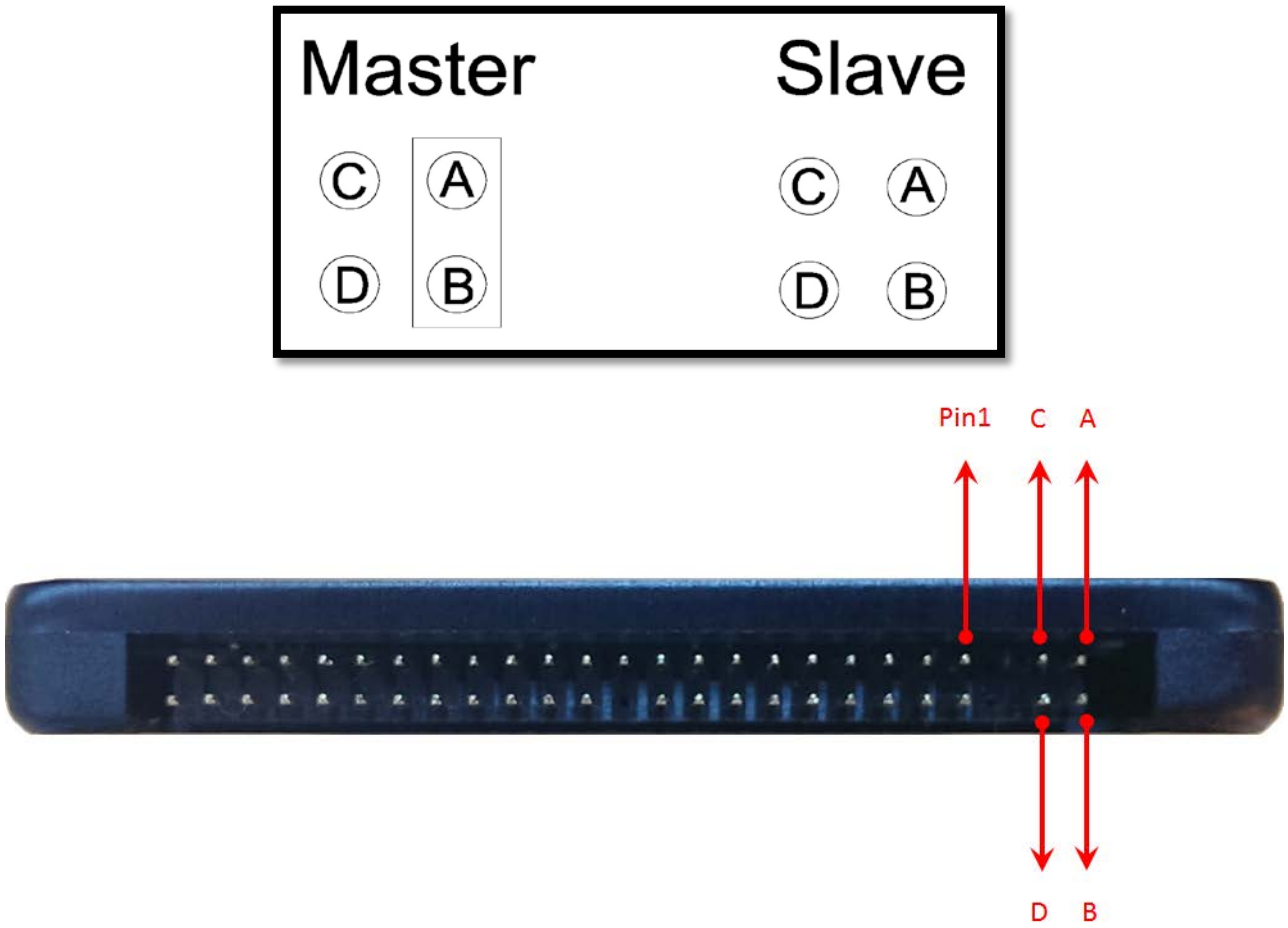

Figure 3 : The connectors of 2.5" PATA SSD

3.2. *Pin Assignments*

Signals whose source is the host is designated as inputs while signals that APRO Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q Series sources are outputs.

The pin assignments are listed in below table 7.

Table 7 - Pin Assignments

Pin	Name	Descriptions	Pin	Name	Descriptions
01	-RESET	Drive Reset	**02**	GND	Ground
03	DD7	Drive data bus bit 7	**04**	DD8	Drive data bus bit 8
05	DD6	Drive data bus bit 6	**06**	DD9	Drive data bus bit 9
07	DD5	Drive data bus bit 5	**08**	DD10	Drive data bus bit 10
09	DD4	Drive data bus bit 4	**10**	DD11	Drive data bus bit 11
11	DD3	Drive data bus bit 3	**12**	DD12	Drive data bus bit 12
13	DD2	Drive data bus bit 2	**14**	DD13	Drive data bus bit 13
15	DD1	Drive data bus bit 1	**16**	DD14	Drive data bus bit 14
17	DD0	Drive data bus bit 0	**18**	DD15	Drive data bus bit 15
19	GND	Ground	**20**	KEY	No pin
21	DMARQ	DMA request	**22**	GND	Ground
23	-DIOW:STOP	Drive I/O Write	**24**	GND	Ground
25	DIOR-	Drive I/O Read	**26**	GND	Ground
27	IORDY	I/O channel ready	**28**	CSEL	Cable select
29	-DMACK	DMA acknowledge	**30**	GND	Ground
31	INTRQ	Drive interrupt	**32**	IOIS16	Drive 16 bit I/O
33	DA1	Drive address bus bit 1	**34**	-PDIAG:-CBLID	Passed diagnostics
35	DA0	Drive address bus bit 0	**36**	DA2	Drive address bus bit 2
37	-CS0	Chip select 0	**38**	CS1	Chip select 1
39	-DASP	Drive active slave present	**40**	GND	Ground
41	VCC	+5V supply	**42**	VCC	+5V supply
43	GND	Ground	**44**	NC	Reserved for future definition

Appendix A: Limited Warranty

APRO warrants your Industrial SLC 2.5" Rugged Metal PATA SSD HERCULES-Q 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 (Standard grade) 3 years / Within 60K Erasing Counts**
- **SLC (Industrial grade) 5 years / Within 60K Erasing Counts**

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