

# SLC

## Industrial Semi-Metal USB 2.0

Generation 5/5L

**HERCULES-PD Series**

Document No. : 100-xMUFD-MPDT5L

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ISO 9001 : 2015 CERTIFIED



### Product Features

#### ■ Flash IC

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

#### ■ Compatibility

- Complete USB specification ver.2.0 and backward compatible ver.1.1
- High Speed and Full Speed transfer support.
- USB Mass Storage Class Specification Rev. 1.0

#### ■ Additional Capabilities

- Support Static Wear Leveling algorithm.
- Supports Windows Series O.S., Mac OS 10.x, and Linux kernel 2.4 operating systems.
- Supports Windows 8, Windows 7 and Windows Vista ReadyBoost function.
- Blue LED status indicator at the bottom cap :

**Ready mode:** LED constant light

**Working mode:** LED flashing

#### ■ Mechanical

- USB 2.0 Type-A Connector
- Dimension:  
**G5:** 47.20 mm x 17.20 mm x 7.80 mm  
**G5L:** 50.70 mm x 17.20 mm x 7.80 mm
- Weight:  
**G5:** 10 g / 0.35 oz.  
**G5L:** 12 g / 0.42 oz.

#### ■ Power Operating Voltage 5V(+/-) 10%

- Read Mode: 99.1 mA (max.)
- Write Mode: 111.0 mA (max.)
- Idle Mode: 58.7 mA (max.)

#### ■ Performance (Maximum value) \*1.

- Sequential Read: 31.5 MB/sec. (max.)
- Sequential Write: 24.5 MB/sec. (max.)

#### ■ Capacity

- **G5:** 128MB, 256MB, 512MB, 1GB, 2GB, 4GB and 8GB.
- **G5L:** 16GB.

#### ■ Reliability

- **TBW:** Up to 112.6 TBW at 16GB Capacity.  
(Client workload by JESD-219A)
- **MTBF:** > 3,000,000 hours.
- **ECC:** up to 72 bits error correction in 1K Byte data
- **Temperature:** (Operating)  
Standard Grade: 0°C ~ +70°C  
Industrial. Grade: -40°C ~ +85°C
- **Vibration:** 70Hz ~ 2K Hz, 15G / 3 axes.
- **Shock:** 0.5ms, 1500 G, 3 axis.

#### ■ Certifications and Declarations

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

#### Remarks:

1. Sequential performance is based on CrystalDiskMark 5.1.2 with file size 500MB.

### Order Information

#### I. Part Number List

##### ◆ APRO Semi Metal USB Flash Disk Generation-5 HERCULES-PD Series

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Industrial Grade (-40°C ~ +85°C)
	128MB	SMUFD128M-MPDTTC-5	WMUFD128M-MPDTI-5
	256MB	SMUFD256M-MPDTTC-5	WMUFD256M-MPDTI-5
	512MB	SMUFD512M-MPDTTC-5	WMUFD512M-MPDTI-5
	1GB	SMUFD001G-MPDTTC-5	WMUFD001G-MPDTI-5
	2GB	SMUFD002G-MPDTTC-5	WMUFD002G-MPDTI-5
	4GB	SMUFD004G-MPDTTC-5	WMUFD004G-MPDTI-5
	8GB	SMUFD008G-MPDTTC-5	WMUFD008G-MPDTI-5

##### ◆ APRO Semi Metal USB Flash Disk Generation 5L – HERCULES-PD Series

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Industrial Grade (-40°C ~ +85°C)
	16GB	SMUFD016G-MPDTTC-5L	WMUFD016G-MPDTI-5L

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

**X2** : The material of case

**M** : Semi Metal

**X3 X4 X5** : Product category

**UFD** : USB Flash Disk

**X6 X7 X8 X9** : Capacity

<b>128M:</b>	128MB	<b>004G:</b>	4GB
<b>256M:</b>	256MB	<b>008G:</b>	8GB
<b>512M:</b>	512MB	<b>016G:</b>	16GB
<b>001G:</b>	1GB		
<b>002G:</b>	2GB		

**X11** : Controller

**M** : HERCULES Series

**X12 X13** : Controller version

**A, B, C.....**

**X14** : Flash IC

**T** : Toshiba SLC-NAND Flash IC

**X15** : Flash IC grade / Type

**C** : Standard grade

**I** : Industrial grade

**X17 X18** : Housing Generation

**5** : Generation 5 housing

**5L** : Generation 5 housing Long type

**X20** : Reserved for specific requirement

**C** : Conformal-coating (optional)

## *Revision History*

Revision	Description	Date
1.0	Initial release	2019/08/15
1.1	Add LED indicator decryptions.	2019/08/29

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### 1. Introduction

APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD Series, is specified as 2.0 High Speed Device, Mass Storage Class; USB-IF (USB Implementers Forum), WHQL (Window Hardware Quality Labs). In addition to being as a removable storage device, APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD Series can also be configured as a bootable disk for system recovery. Also, its supports the Windows Series O.S., Mac OS 10.x, and Linux kernel 2.4 operating systems, and supports Windows 8, Windows 7 and Windows Vista ReadyBoost function. They are available in 128MB, 256MB, 512MB, 1GB, 2GB, 4GB and 8GB with G5 housing and the big capacity in 16GB with G5L (Longer) housing.

APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD Series also offers unique customization for OEM customers by laser carvings.

Figure 1 shows a block diagram of APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD Series

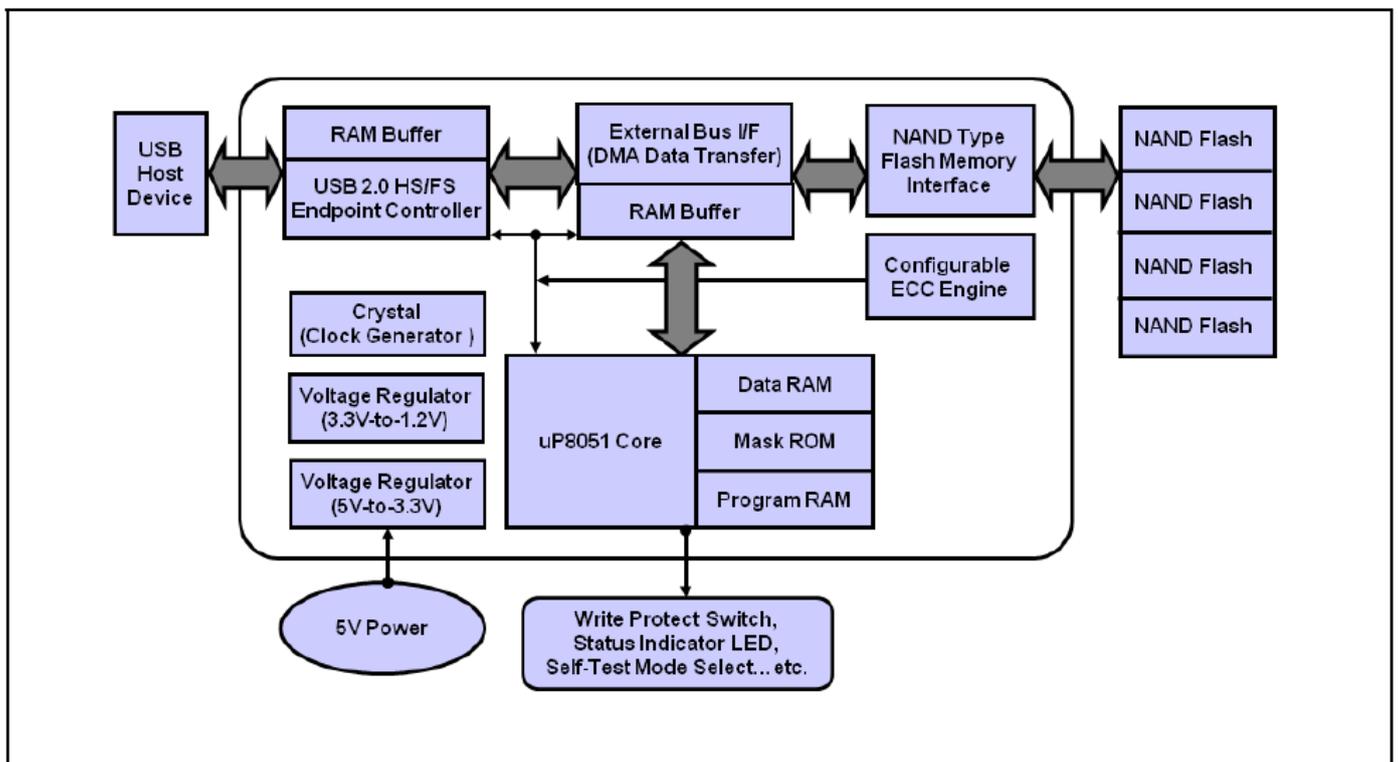


Figure 1: APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD Series block diagram

### 1.1. Scope

This document describes the key features and specifications of APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD Series.

### 1.2. Flash Management Technology – Static Leveling

In order to gain the best management for flash memory, APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD 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 SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD 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. Mean Time Between Failure (MTBF)

#### 1.4.1. 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.

### 1.4.2. 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:  $Af = e\{ (1/k \times Ea ( 1/273+Tmax - 1/273+Ttest))\}$

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

#### ➤ **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. Relx supports Telcordia Issues 1 and 2 and also Bellcore Issues 4, 5, and 6. Telcordia Issue 2, released in September 2006, are supported by Relx and Telcordia Issue 1, released in May 2001, is replaced with Relx. Refer to Telcordia Issue 2 Fields for information about the fields in Relx 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.

### 1.4.3. 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 ( $\lambda$ ) =  $10^9$  hours (FITs)

MTBF =  $1/\lambda$

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

Where  $\lambda_{Gi}$  : 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°C

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 Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD Series		Standard Grade SMUFDxxxG-MPDTG-5(5L)	Industrial Grade WMUFDxxxG-MPDTI-5(5L)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:	85 °C / 910% RH Non-Operating	
Vibration	Frequency/Displacement:	20Hz ~ 70 Hz, 1.52mm / 3 axes.	
	Frequency/Acceleration:	70Hz ~ 2K Hz, 15G / 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 SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD Series		
DC Input Voltage (VCC)		5V±10%
Maximum average value	Reading Mode :	97.5 mA (max.)
	Writing Mode :	110.0 mA (max.)
	Idle Mode :	58.7 mA (max.)

#### 2.3. System Performance

**Table 3: System Performances**

Data Transfer Mode supporting		USB 2.0							
Maximum Performance (MB/s)	Capacity	128MB	256MB	512MB	1GB	2GB	4GB	8GB	16GB
	Sequential Read	29.5	29.5	29.5	29.5	29.5	31.5	31.5	31.2
	Sequential Write	21.0	21.0	21.0	20.5	24.0	24.0	24.5	24.5

Note: The performance was measured using CrystalDiskMark by file size 100MB (QD32).

### 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>		72 bits per 1K bytes
<b>Erase counts</b>		NAND SLC Flash Cell Level : 60K P/E Cycles
<b>Endurance</b>		<b>TBW (Tera Bytes Written)</b>
<b>Capacity</b>	<b>128MB</b>	1.0
	<b>256MB</b>	2.2
	<b>512MB</b>	3.9
	<b>1GB</b>	8.0
	<b>2GB</b>	15.5
	<b>4GB</b>	27.8
	<b>8GB</b>	56.1
	<b>16GB</b>	112.6

Note:

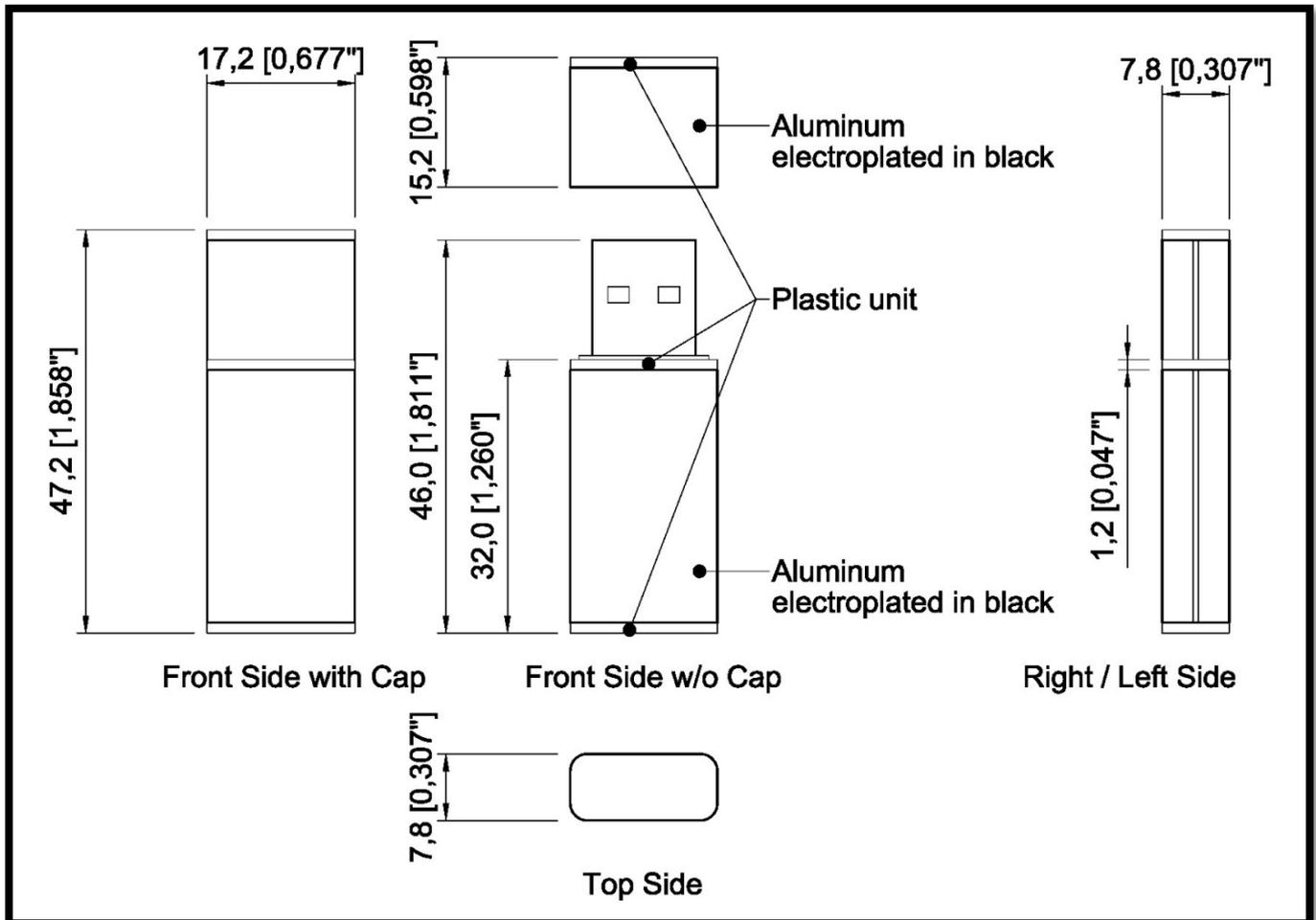
- Client workload by JESD-219A.
- The endurance of disk could be varying based on user behavior, NAND endurance cycles, and write amplification factor. It is not guaranteed by flash vendor.

### 2.5. Physical Specifications

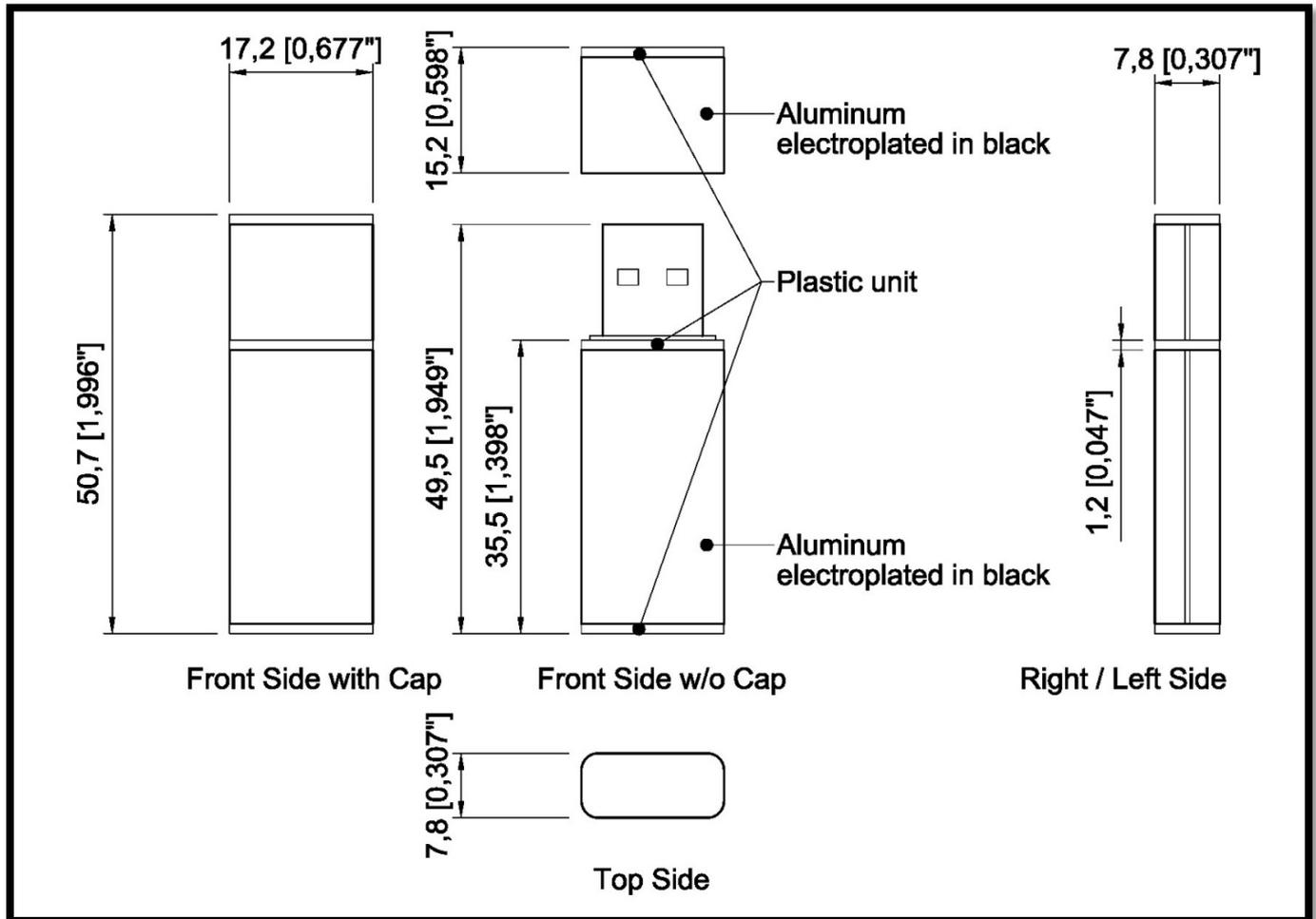
Refer to Table 5 and see Figure 2 for APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD Series physical specifications and dimensions.

Table 5: Physical Specifications

Generation	G5	G5L
Length:	47.20 mm	50.70 mm
Width:	17.20 mm	17.20 mm
Thickness:	7.80 mm	7.80 mm
Weight:	10 g / 0.35 oz.	12 g / 0.42 oz.



### Generation 5



## Generation 5L

Figure 2: APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD 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 uses MIL-I-46058C silicon conformal coating

### 3. Interface Description

#### 3.1. Semi-Metal USB Flash Disk interface

APRO Semi-Metal USB Flash Disk is equipped with standard USB Type A connector.

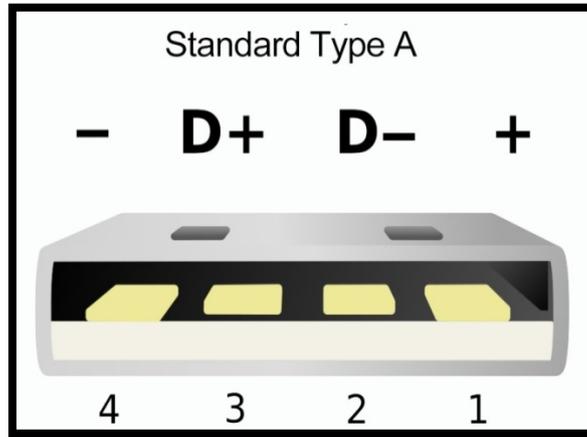


Figure 3: USB Type A Connector

#### 3.2. Pin Assignments

There are total of 4 pins in the USB Type-A Connector. The pin assignments are listed in below table 6.

Table 6 - Pin Assignments

Pin Number	Pin Name	Function
Pin 1	Vcc	Power
Pin 2	USB -	The pairs are used to transmit Address, Data and Command.
Pin 3	USB +	
Pin 4	Vss	Ground

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

APRO warrants your APRO SLC Industrial Semi-Metal USB Flash Disk Gen-5/5L HERCULES-PD 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**

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