APRO Co., Ltd.

SLC

Industrial Rugged-Metal USB 2.0

Generation 4SB

HERCULES-PD Series

Document No. : 100-xRUFD-MPD4SB

Version No. : 01V0

Date : August, 2019

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.

- **Mechanical**
  - USB 2.0 Type-A Connector
  - IP-54 & IP-68 Waterproof (Non-operation)
  - Dimension: 54.82 mm x 15.95 mm x 15.95 mm
  - Weight: 22.0 g / 0.77 oz.

- **Power Operating Voltage 5V(+/-) 10%**
  - Read Mode: 97.5 mA (max.)
  - Write Mode: 110.0 mA (max.)
  - Idle Mode: 66.4 mA (max.)

- **Performance (Maximum value) *[1,]**
  - Sequential Read: 31.5 MB/sec. (max.)
  - Sequential Write: 24.5 MB/sec. (max.)

- **Capacity**
  - 128MB, 256MB, 512MB, 1GB, 2GB, 4GB and 8GB.

- **Reliability**
  - **TBW:** Up to 56.1 TBW at 8GB 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: 0ºC ~ +70ºC
    Industrial. Grade: -40ºC ~ +85ºC
  - **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 SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB HERCULES-PD Series**

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Industrial Grade (-40°C ~ +85°C)
	128MB	SRUFD128M-MPDTC-4SB	WRUFD128M-MPDTI-4SB
	256MB	SRUFD256M-MPDTC-4SB	WRUFD256M-MPDTI-4SB
	512MB	SRUFD512M-MPDTC-4SB	WRUFD512M-MPDTI-4SB
	1GB	SRUFD001G-MPDTC-4SB	WRUFD001G-MPDTI-4SB
	2GB	SRUFD002G-MPDTC-4SB	WRUFD002G-MPDTI-4SB
	4GB	SRUFD004G-MPDTC-4SB	WRUFD004G-MPDTI-4SB
	8GB	SRUFD008G-MPDTC-4SB	WRUFD008G-MPDTI-4SB

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**

R : Rugged Metal

X3 X4 X5 : **Product category**

UFD : USB Flash Disk

X6 X7 X8 X9 : **Capacity**

128M:	128MB	**002G:**	2GB
256M:	256MB	**004G:**	4GB
512M:	512MB	**008G:**	8GB
001G:	1GB		

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 : Commercial grade

I : Industrial grade

X17 X18 X19 : **Housing Generation**

4SB : Generation 4 housing , Screw Thread Black

X20 : **Reserved for specific requirement**

C : Conformal-coating (optional)

Revision History

Revision	Description	Date
1.0	Initial release	2019/08/15

Contents

1. Introduction

APRO SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB 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 Rugged-Metal USB Flash Disk Generation 4SB 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 capacities by Toshiba SLC Flash IC.

In order to sustain various harsh and tough operating environments, APRO design special rugged metal casing, and passed the IP-54 & IP-68 Waterproof environmental testing.

APRO SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB HERCULES-PD Series also offers unique customization for OEM customers by laser carvings.

Figure 1 shows a block diagram of APRO SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB HERCULES-PD Series

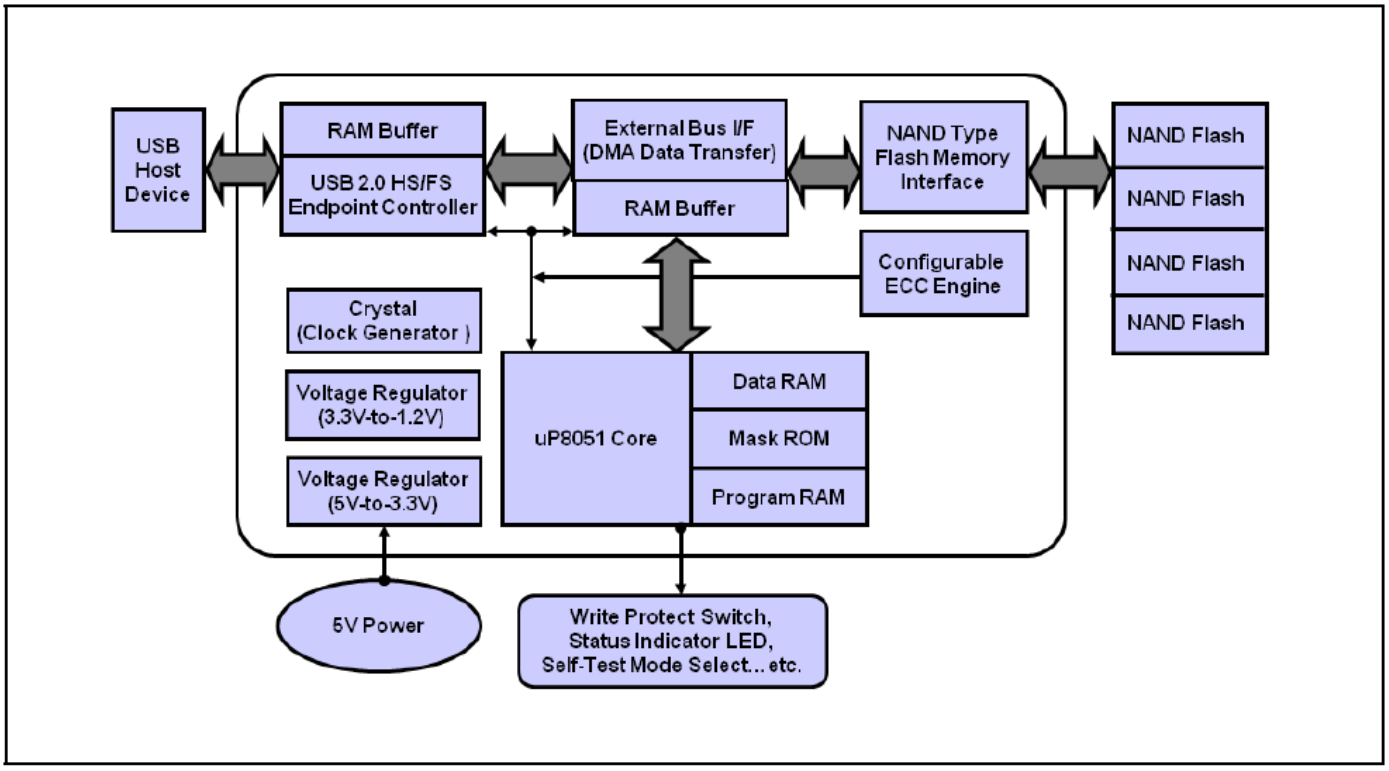

Figure 1: APRO SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB HERCULES-PD Series block diagram

1.1. *Scope*

This document describes the key features and specifications of APRO SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB HERCULES-PD Series.

1.2. *Flash Management Technology – Static Leveling*

In order to gain the best management for flash memory, APRO SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB 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 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 SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB 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: $\mathbf{Af = e\{ (1/k \times Ea (1/273+Tmax - 1/273+Ttest)\}}$

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.

1.4.3. 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 ($\boldsymbol{\lambda}$) = 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

  $\mathbf{TT}_{Ti}$: 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 Industrial Rugged-Metal USB Flash Disk Generation 4SB HERCULES-PD Series		Standard Grade	Industrial Grade
		SRUFDxxxG-MPDTC-4SB	WRUFDxxxG-MPDTC-4SBC
Temperature	Operating: Non-operating:	0ºC ~ +70ºC -20ºC ~ +80ºC	-40ºC ~ +85ºC -50ºC ~ +95ºC
Humidity	Operating & Non-operating:	85 ºC / 95% 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:	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 Industrial Rugged-Metal USB Flash Disk Generation 4SB 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 :	66.4 mA (max.)

2.3. System Performance

Table 3: System Performances

Data Transfer Mode supporting		USB 2.0						
Average Access Time		0.6 ms (estimated)						
Maximum Performance	Capacity	128MB	256MB	512MB	1GB	2GB	4GB	8GB
	Sequential Read (MB/s)	29.5	29.5	29.5	29.5	29.5	31.5	31.5
	Sequential Write(MB/s)	21.0	21.0	21.0	20.5	24.0	24.0	24.5

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

2.4. System Reliability

Table 4: System Reliability

Wear-leveling Algorithms		Static Wear Leveling algorithms
Bad Block Management		Supportive
ECC Technology		72 bits per 1K bytes
Erase counts		NAND SLC Flash Cell Level：60K P/E Cycles
Endurance		**TBW (Tera Bytes Written)**
Capacity	***128MB***	1.0
	256MB	2.2
	512MB	3.9
	1GB	8.0
	2GB	15.5
	4GB	27.8
	8GB	56.1

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 Rugged-Metal USB Flash Disk Generation 4SB HERCULES-PD Series physical specifications and dimensions.

Table 5: Physical Specifications

Generation	G4SB
Length:	54.82 mm
Width:	15.95 mm
Thickness:	15.95 mm
Weight:	22.0g / 0.77 oz.

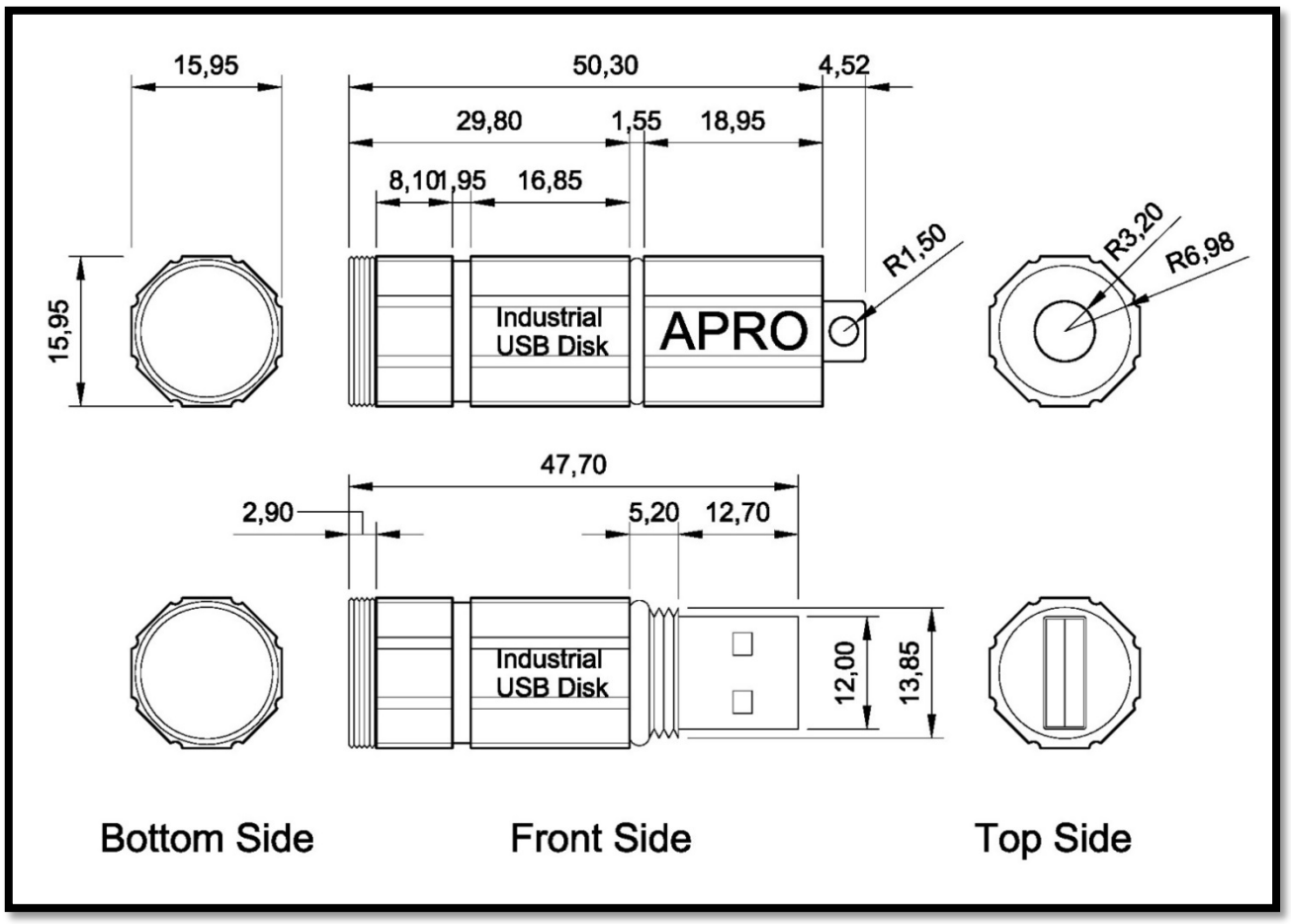

Figure 2: APRO SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB HERCULES-PD Series Dimension

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 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. USB 2.0 Flash Disk interface

APRO SLC Industrial Rugged-Metal USB Flash Disk Generation 4SB HERCULES-PD Series is equipped with standard USB Type A connector.

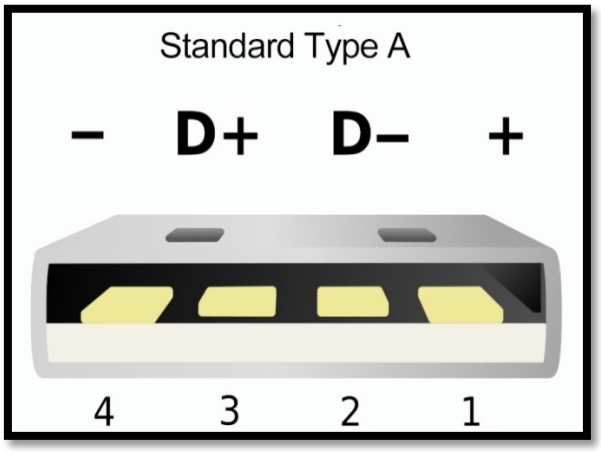

Figure 3: USB Type A Connector

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 Rugged-Metal USB Flash Disk Generation 4SB 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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