APRO Co., Ltd.

SLC

Industrial Semi-Metal USB 3.1

Generation 3EL

HERMIT-E Series

Document No. : 100-xMUFD-HET3EL

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ISO 9001 : 2015 CERTIFIED

Product Features

- **Flash IC**
  - TOSHIBA NAND Flash IC.
  - Single-Level Cell (SLC) management
- **Compatibility**
  - Compliant to the USB 3.1 standard
  - Implements USB 3.1 Gen1 (SuperSpeed 5Gbps).
  - Supports Full Speed, High Speed and Super Speed transmission
  - USB mass storage device class (MSC)
  - USB Attached SCSI (UASP) support
- **Additional Capabilities**
  - hyMapR Flash Translation Layer offering class-leading random write performance, minimal write amplification, and highest endurance for random usage profiles (e.g. JEDEC Enterprise)
  - S.M.A.R.T.*[1] (Self-Monitoring, Analysis and Reporting Technology) feature set support.
  - AES-128 and AES-256 support with CBC and XTS modes, high performance on-the-fly encryption /decryption
  - Configurable Early-Acknowledge to avoid any data loss during power fail.
  - Blue LED status indicator at the bottom cap :
    Ready mode: LED constant light
  - **Working mode:** LED flashing
- **Mechanical**
  - Semi-metal casing
  - USB 3.1 standard A interface
  - Dimension: 62.1 mm x 17.6 mm x 8.4 mm.
  - Weight: 15.0 g / 0.53 oz.
- **Power Operating Voltage 5V(+/-) 10%**
  - Read Mode: 195.2 mA (max.)
  - Write Mode: 177.2 mA (max.)
  - Idle Mode: 39.5 mA (max.)
- **Performance (Maximum value) *[2, *3]**
  - Sequential Read: 189.8 MB/sec. (max.)
  - Sequential Write: 114.9 MB/sec. (max.)
  - 4KB Random Read (QD32): 14.5 MB/sec.
  - 4KB Random Write (QD32): 10.4 MB/sec.
  - Random Read latency time: 0.26 ms.
  - Random Write latency time: 0.29 ms.
- **Capacity**
  - 128MB, 256MB, 512MB,1GB, 2GB, 4GB, 8GB, 16GB, 32GB and 64GB
- **Reliability**
  - **TBW:** Up to 452.8TBW at 64GB Capacity. (Client workload by JESD-219A)
  - **MTBF:** > 3,000,000 hours.
  - **ECC Scheme:** up to 96 bits error correction in 1K Byte data
  - **Temperature:** (Operating)
    Standard Grade: 0ºC ~ +70ºC
    Wide Temp. Grade: -40ºC ~ +85ºC
  - **Vibration:** 70Hz ~ 2K Hz, 15G / 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. Performance values vary by capacity

Order Information

I. Part Number List

◆ **APRO Semi-Metal USB 3.1 Flash Disk – HERMIT-E Series**

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Wide Temp Grade (-40°C ~ +85°C)
	128MB	SMUFD128M-HECTC-3EL	WMUFD128M-HEITI-3EL
	256MB	SMUFD256M-HECTC-3EL	WMUFD256M-HEITI-3EL
	512MB	SMUFD512M-HECTC-3EL	WMUFD512M-HEITI-3EL
	1GB	SMUFD001G-HECTC-3EL	WMUFD001G-HEITI-3EL
	2GB	SMUFD002G-HECTC-3EL	WMUFD002G-HEITI-3EL
	4GB	SMUFD004G-HECTC-3EL	WMUFD004G-HEITI-3EL
	8GB	SMUFD008G-HECTC-3EL	WMUFD008G-HEITI-3EL
	16GB	SMUFD016G-HECTC-3EL	WMUFD016G-HEITI-3EL
	32GB	SMUFD032G-HECTC-3EL	WMUFD032G-HEITI-3EL
	64GB	SMUFD064G-HECTC-3EL	WMUFD064G-HEITI-3EL

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**

128M:	128MB	**004G:**	4GB
256M:	256MB	**008G:**	8GB
512M:	512MB	**016G:**	16GB
001G:	1GB	**032G:**	32GB
002G:	2GB	**064G:**	64GB

X11 : **Controller**

H : HERMIT 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 : Standard grade

I : Industrial grade

X17 X18 X19: **Flash IC**

3EL: Generation 3EL Housing

X20 : **Reserved for specific requirement**

C : Conformal-coating (optional)

Revision History

Revision	Description	Date
1.0	Initial release.	2017/05/25
1.1	Add. 64GB Capacity	2017/10/23
2.0	Updated performance	2019/06/14
2.1	Add LED indicator decryptions.	2019/08/29

Contents

1. Introduction

APRO SLC Semi-Metal USB Flash Disk Generation 3EL HERMIT-E Series, is specified as USB 3.1 Gen1 (SuperSpeed 5Gbps) Device, Mass Storage Class; USB-IF (USB Implementers Forum), WHQL (Window Hardware Quality Labs). In addition to being as a removable storage device, MUFD HERMIT-E Series can also be configured as a bootable disk for system recovery. Also, its random access performance exceed the minimum requirement of Windows / Linux / VxWorks / QNX Embedded operating system, in which randomly access blocks of information are saved into MUFD - Generation 3EL for boosting up the average performance. They are available in 128MB, 256MB, 512MB, 1GB, 2GB, 4GB, 8GB, 16GB, 32GB and 64GB capacities by Toshiba SLC Flash IC.

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 189.8 MB/sec, and sequential write is up to 114.9 MB/sec; 4k data random read is up to 14.5 MB/sec, and 4k data random write is up to 10.4 MB/sec.

APRO SLC Semi-Metal USB - Generation 3EL HERMIT-E Series also offers unique customization for OEM customers by laser carvings.

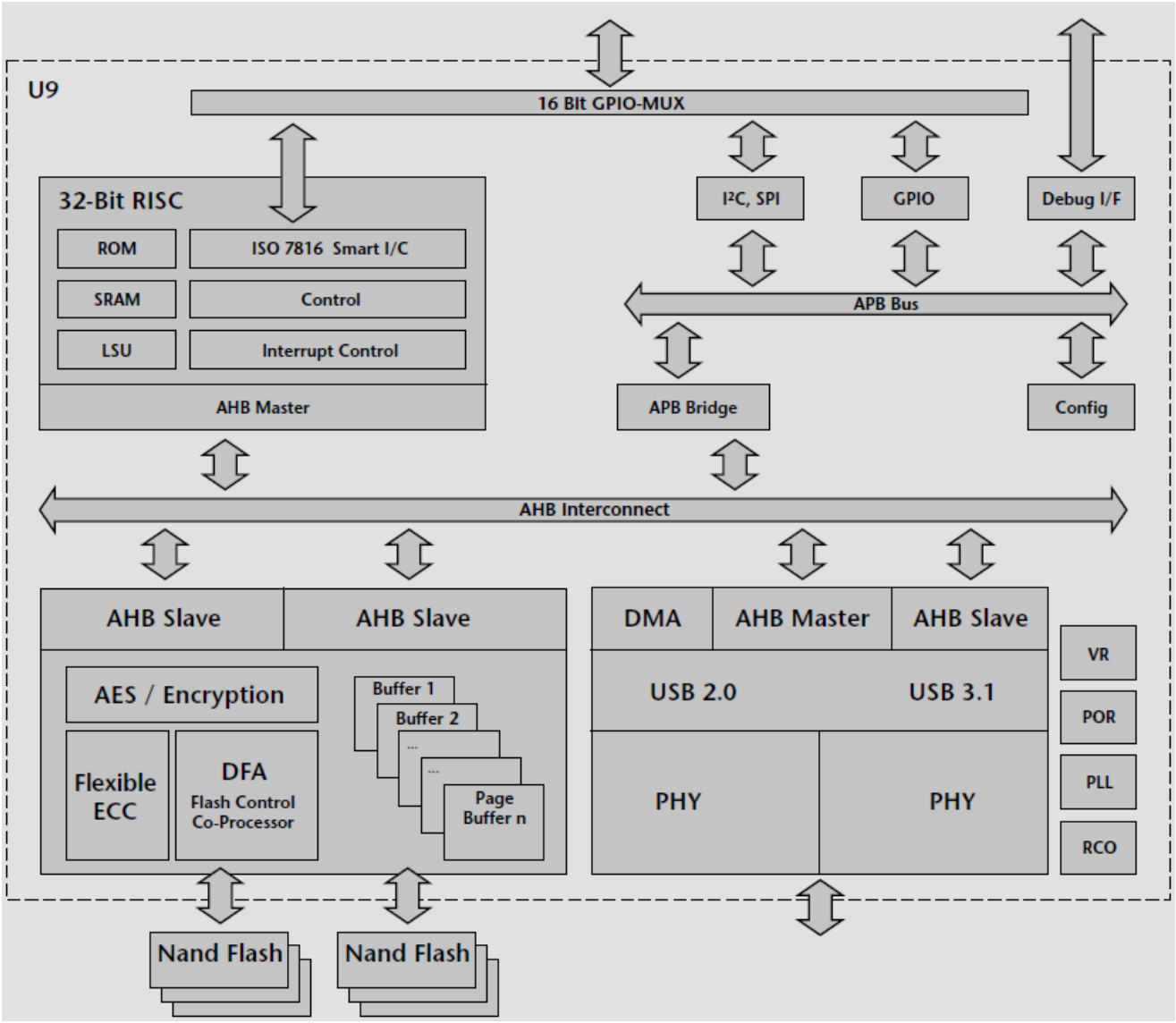

Figure 1: APRO SLC Semi-metal USB 3.1 Flash Disk HERMIT-E Series controller block diagram

1.1. *Scope*

This document describes features, specifications and installation guide of APRO Semi-Metal USB 3.1 Flash Disk HERMIT-E Series. In the appendix, there provides order information, warranty policy, RMA/DOA procedure for the most convenient reference.

1.2. *Flash Management Technology - Dynamic, Static, and Global Leveling*

Wear Levelling (WL) is used to systematically utilize all Flash blocks of the system equally in terms of consuming their individual write-erase-cycle endurance budget. hyMap® supports dynamic, static, and global Wear levelling. Dynamic WL requires no copy-overhead but alone would be limited to blocks not containing data. Static WL includes also those blocks containing data. Static data is relocated if needed. This WL activity is triggered at predefined threshold levels. Also these routines are executed in the background and interrupted in case of higher priority host commands.

Global WL refers to the procedure of involving all blocks (user blocks, management blocks, free blocks) of a device and is not limited to flash chips for instance. Generally, the WL algorithm selects a block with the lowest erase count from a pool of unused blocks to be written to (dynamic WL). At some point formerly used blocks enter the pool of unused blocks again as a result of the garbage collection. When a block enters the pool of unused blocks, its erase counter value is compared with the lowest erase counter value of all used blocks (global WL). If the difference exceeds a configurable threshold, the data of a used block with lowest erase count is moved into the block that just became unused and the used block with lowest erase count enters the pool of unused blocks instead (static WL).

The threshold is configurable and defines the granularity and the spread between the block(s) with the “lowest erase counts” and the “highest erase counts”. Within hyMap® this is called Adaptive Wear Levelling.

1.3. *Power Fail Robustness*

Generally, all HERMIT-E Series UFD proved voltage sensing capability and as soon as a power down is recognized, the controller is reset and the flash is write-protected. A log of all recent flash transactions is kept. Should the latest data be corrupt, the controller will recover the latest valid entry before that last failed write.

1.4. *No external DRAM no capacitor*

All mapping information is reliably stored on the flash. No external DRAM is used to store vital mapping information in volatile memory and no external capacitor is needed to make sure that DRAM content is stored in the Flash in case of a power fail situation. Hence, there is no additional reliability risk and endurance impact related to implementing these additional components.

1.5. *Reliable Write*

hyMap® is targeted to making SLC Flash as reliable as possible. Since two logical SLC Flash pages are physically correlated, it is possible to destroy data of an older page by writing another new one within the same block (paired pages).hyMap® applies Reliable Write to cope with this occurrence and in order to make SLC power-fail safe.

Note: Detail information of hyMap® technology, please contact with your distributer.

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 ($\boldsymbol{\lambda}$) = 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 Semi-Metal USB 3.1 Flash Disk HERMIT-E Series		Standard Grade SMUFDxxxG-HECTC3EL	Wide Temp Grade WMUFDxxxG-HEITI3EL
Temperature	Operating:	0ºC ~ +70ºC	-40ºC ~ +85ºC
	Non-operating:	-20ºC ~ +80ºC	-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 axis.	
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 Semi-Metal USB 3.1 Flash Disk HERMIT-E Series		
DC Input Voltage (VCC)		5V±10%
Maximum average value	Reading Mode :	195.2 mA (64GB)
	Writing Mode :	177.2 mA (64GB)
	Idle Mode :	39.5 mA (64GB)

2.3. System Performance

Table 3: System Performances

Data Transfer Mode supporting		USB 3.0 Super Speed 5Gbps (USB 3.1 Gen1)									
Maximum Performance	Capacity	128MB	256MB	512MB	1GB	2GB	4GB	8GB	16GB	32GB	64GB
	Sequential Read (MB/s)	18.9	26.7	30.5	30.5	30.5	39.2	39.2	140.3	189.8	138.5
	Sequential Write (MB/s)	5.0	8.4	14.0	14.0	14.1	21.0	21..1	97.3	114.9	96.0
	4KB Random Read (MB/s)	8.0	8.7	9.2	9.2	9.2	10.3	10.3	14.3	14.5	12.5
	4KB Random Write (MB/s)	3.0	4.6	6.2	6.2	6.2	7.7	7.8	10.5	10.4	10.3

Note: The performance was measured using CrystalDiskMark (QD32).

2.4. System Reliability

Table 4: System Reliability

Wear-leveling Algorithms		Dynamic, Static, and Global Leveling wear-leveling algorithms
Bad Block Management		Supportive
ECC Technology		96 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
	16GB	112.6
	32GB	225.6
	64GB	452.8

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 Semi-Metal USB 3.1 Flash Disk G3EL HERMIT-E Series physical specifications and dimensions.

Table 5: Physical Specifications

Length:	62.1 mm.
Width:	17.6 mm.
Thickness:	8.4 mm.
Weight:	15.0 g / 0.53 oz.

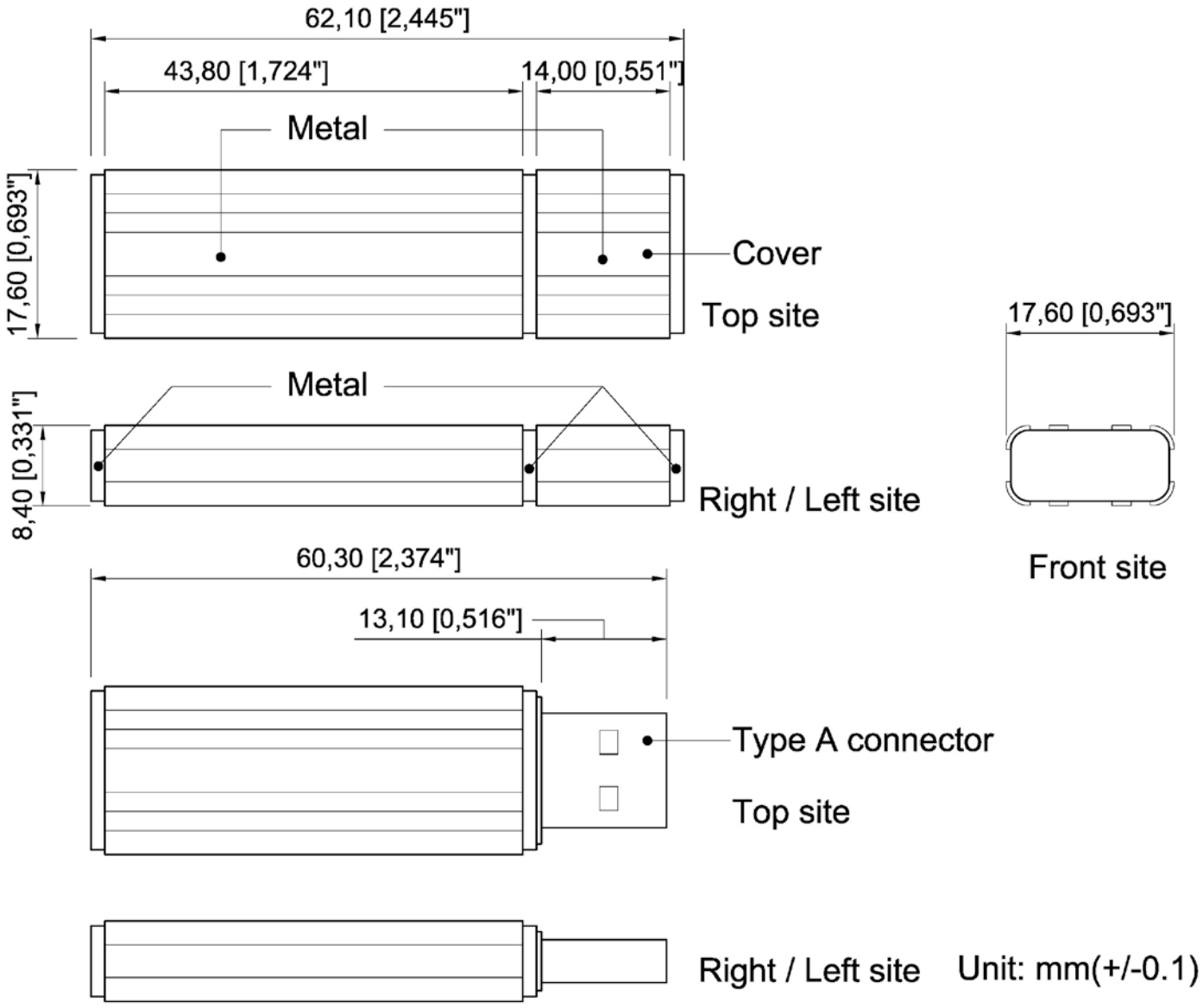

Figure 2: APRO Semi-Metal USB 3.1 Flash Disk HERMIT-E Series G3EL Dimension

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. *Semi-Metal USB 3.1 Flash Disk Type A male interface*

APRO Semi-Metal USB 3.1 Flash Disk is equipped with standard 9 pins USB 3.1 Type A male connector.

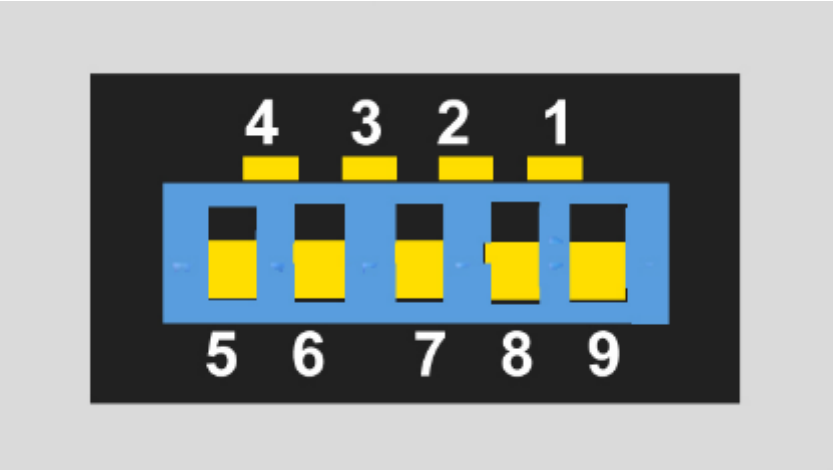

Figure 3: The Type A male connector of APRO Semi-Metal USB 3.1 Flash Disk

3.2. *Pin Assignments*

There are total of 9 pins in the signal segment. The pin assignments are listed in below table 6.

Table 6 - Pin Assignments

Name	Type	Description
1	**VBUS**	Power
2	**D-**	USB2.0 Differential Pair
3	**D+**	
4	**GND**	Ground for power return
5	**StdA_SSRX-**	Super-speed transmitter differential pair
6	**StdA_SSRX+**	
7	**GND_DRAIN**	Ground for signal return
8	**StdA_SSTX-**	Super-speed receiver differential pair
9	**StdA_SSTX+**	

Appendix A: Limited Warranty

APRO warrants your SLC Semi-Metal USB 3.1 Flash Disk G3EL HERMIT-E 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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