APRO Co., Ltd.

SLC

Industrial Micro USB Module

HERMIT-C Series

(USB 2.0)

Document No. : 100-xBMUM-HCTSL

Version No. : 02V0

Date : June, 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 device class (MSC)
  - USB Attached SCSI (UASP) support

- **Additional Capabilities**
  - S.M.A.R.T.*[1] (Self-Monitoring, Analysis and Reporting Technology) feature set support.
  - Automatic power-down mode during wait periods for host data or Flash Memory operation completion, automatic sleep mode during host inactivity periods
  - 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.
  - Support Static and Global Leveling

- **Mechanical**
  - USB 2.0 female 10-pin @ 2 rows connector.
    Vertical Type: 2.54 mm pin pitch female connector
    Horizontal Type: Both 2.0 mm & 2.54 mm pin-pitch female connector
  - Dimension:
    Vertical Type: 42.0 mm x 26.7 mm
    Horizontal Type: 37.0 mm x 26.7 mm
  - Weight: 10.0 g / 0.35 oz.

- **Power Operating Voltage 5V(+/-) 10%**
  - Read Mode: 83.7 mA (max.)
  - Write Mode: 79.2 mA (max.)
  - Idle Mode: 33.3 mA (max.)

- **Performance (Maximum value)** [2, 3]
  - Sequential Read: 27.5 MB/sec. (max.)
  - Sequential Write: 18.8 MB/sec. (max.)
  - 4KB Random Read (QD32): 7.2 MB/sec. (max.)
  - 4KB Random Write (QD32): 5.2 MB/sec. (max.)
  - 4KB Avg. Read response time: 0.56 ms.
  - 4KB Avg. Write response time: 0.70 ms.

- **Capacity**
  - 128MB, 256MB, 512MB, 1GB, 2GB, 4GB, 8GB, 16GB and 32GB

- **Reliability**
  - **TBW:** Up to 225.6TBW at 32GB Capacity. (Client workload by JESD-219A)
  - **MTBF:** > 3,000,000 hours.
  - **ECC:** up to 96 bits error correction in 1K Byte data
  - **Temperature:** (Operating)
    Standard Grade: 0ºC ~ +70ºC
    Industrial. Grade: -40ºC ~ +85ºC
  - **Vibration:** 70Hz ~ 2K Hz, 15G / 3 axis.
  - **Shock:** 0.5ms, 1500 G, 3 axis.

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

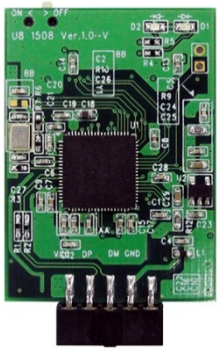
Remarks:

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

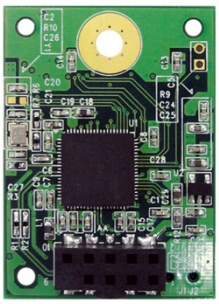
Order Information

I. Part Number List

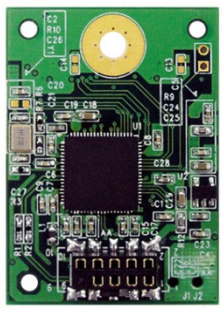
◆ **APRO Micro USB Flash Module Vertical Standard – HERMIT-C Series**

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Industrial Grade (-40°C ~ +85°C)
	128MB	SBMUM128M-HCCTC-VS	WBMUM128M-HCITI-VS
	256MB	SBMUM256M-HCCTC-VS	WBMUM256M-HCITI-VS
	512MB	SBMUM512M-HCCTC-VS	WBMUM512M-HCITI-VS
	1GB	SBMUM001G-HCCTC-VS	WBMUM001G-HCITI-VS
	2GB	SBMUM002G-HCCTC-VS	WBMUM002G-HCITI-VS
	4GB	SBMUM004G-HCCTC-VS	WBMUM004G-HCITI-VS
	8GB	SBMUM008G-HCCTC-VS	WBMUM008G-HCITI-VS
	16GB	SBMUM016G-HCCTC-VS	WBMUM016G-HCITI-VS
	32GB	SBMUM032G-HCCTC-VS	WBMUM032G-HCITI-VS

◆ **APRO Micro USB Flash Module Horizontal Standard – HERMIT-C Series**

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Industrial Grade (-40°C ~ +85°C)
	128MB	SBMUM128M-HCCTC-HS	WBMUM128M-HCITI-HS
	256MB	SBMUM256M-HCCTC-HS	WBMUM256M-HCITI-HS
	512MB	SBMUM512M-HCCTC-HS	WBMUM512M-HCITI-HS
	1GB	SBMUM001G-HCCTC-HS	WBMUM001G-HCITI-HS
	2GB	SBMUM002G-HCCTC-HS	WBMUM002G-HCITI-HS
	4GB	SBMUM004G-HCCTC-HS	WBMUM004G-HCITI-HS
	8GB	SBMUM008G-HCCTC-HS	WBMUM008G-HCITI-HS
	16GB	SBMUM016G-HCCTC-HS	WBMUM016G-HCITI-HS
	32GB	SBMUM032G-HCCTC-HS	WBMUM032G-HCITI-HS

◆ **APRO Micro USB Flash Module Horizontal Low Profile – HERMIT-C Series**

Product Picture	Grade	Standard grade (0°C ~ 70°C)	Industrial Grade (-40°C ~ +85°C)
	128MB	SBMUM128M-HCCTC-HL	WBMUM128M-HCITI-HL
	256MB	SBMUM256M-HCCTC-HL	WBMUM256M-HCITI-HL
	512MB	SBMUM512M-HCCTC-HL	WBMUM512M-HCITI-HL
	1GB	SBMUM001G-HCCTC-HL	WBMUM001G-HCITI-HL
	2GB	SBMUM002G-HCCTC-HL	WBMUM002G-HCITI-HL
	4GB	SBMUM004G-HCCTC-HL	WBMUM004G-HCITI-HL
	8GB	SBMUM008G-HCCTC-HL	WBMUM008G-HCITI-HL
	16GB	SBMUM016G-HCCTC-HL	WBMUM016G-HCITI-HL
	32GB	SBMUM032G-HCCTC-HL	WBMUM032G-HCITI-HL

II. Part Number Decoder:

X1 X2 X3 X4 X5 X6 X7 X8 X9—X11 X12 X13 X14 X15—X17 X18 X19

X1 : **Grade**

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

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

X2 : **The material of case**

B : Bare

X3 X4 X5 : **Product category**

MUM : Micro USB 2.0 Flash Module

X6 X7 X8 X9 : **Capacity**

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

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 SLC-NAND Flash IC

X15 : **Flash IC grade / Type**

C : Commercial grade

I : Industrial grade

X17 X18 : **Form Factor – MUM only**

VS : Vertical type Standard form factor

HS : Horizontal type Standard form factor

HL : Horizontal type Low Profile form factor

X19: **Reserved for specific requirement**

C : Conformal-coating (optional)

Revision History

Revision	Description	Date
1.0	Initial release	2016/04/25
1.1	Add. 128GB Capacity	2017/10/25
2.1	Updated performance	2019/04/01
2.2	Updated document form	2019/06/14

Contents

1. Introduction

APRO SLC Micro USB Module (MUM) HERMIT-C 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 MUM HERMIT-C 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 MUM for boosting up the average performance. They are available in 128MB, 256MB, 512MB, 1GB, 2GB, 4GB, 8GB, 16GB and 32GB 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 27.5 MB/sec, and sequential write is up to 18.8 MB/sec; 4k data random read is up to 7.2 MB/sec, and 4k data random write is up to 5.2 MB/sec.

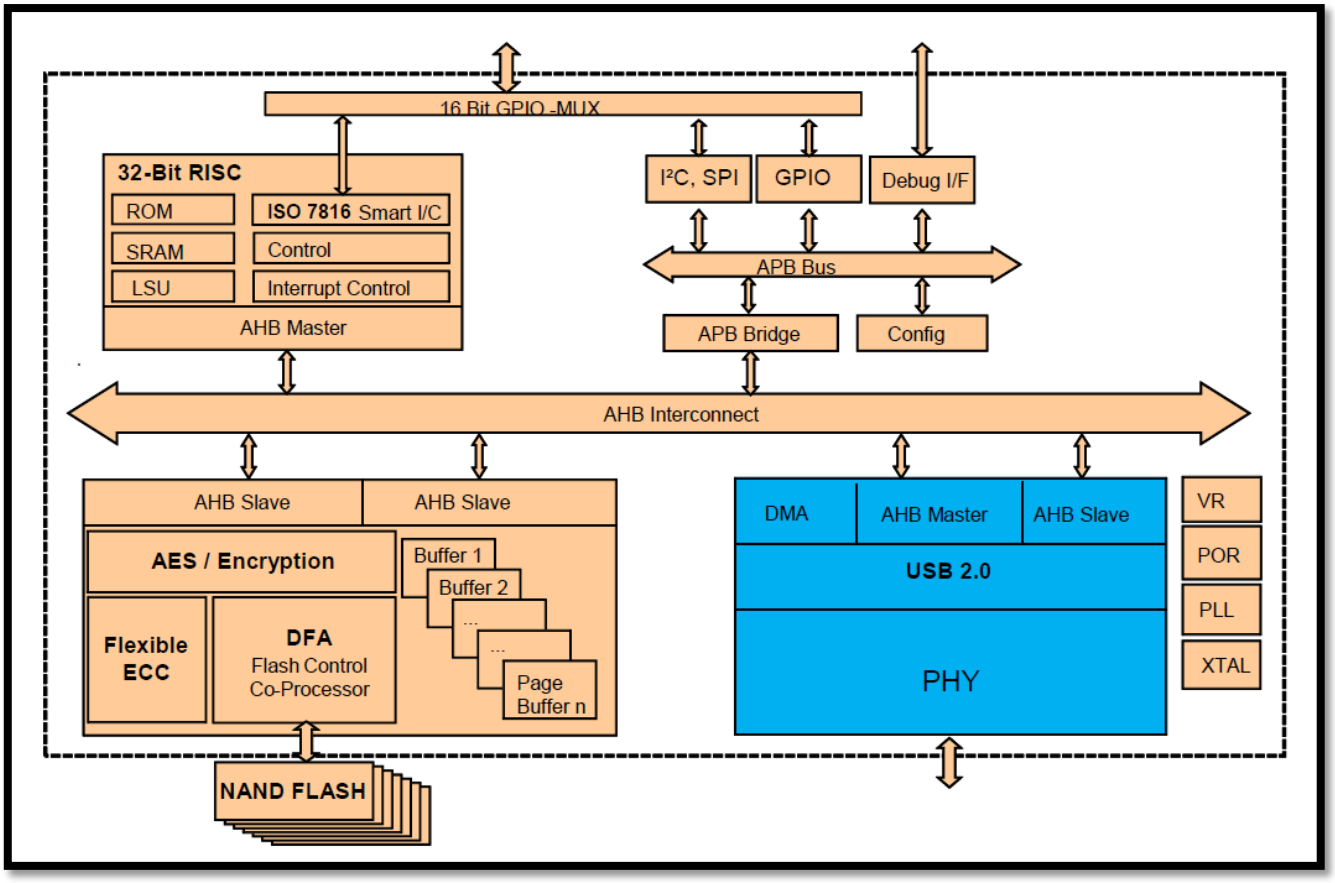


Figure 1: APRO SLC Micro USB Module (MUM) HERMIT-C Series block diagram

1.1. *Scope*

This document describes the key features and specifications of APRO SLC MUM HERMIT-C Series.

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

WL is used to allocate data in such a way that the Flash blocks of the system are used equally in terms of consuming their individual write-erase-cycle endurance budget. There is static, dynamic and global WL. Dynamic WL writes on the blocks that do not contain data and are the least worn-out. The static WL chooses the least worn-out block, too, but if this block already contains data, it relocates the data to a free block. This leads to a very even wear-out, but it requires a more complex controller compared to using dynamic WL. WL activities are triggered when achieving a predefined erase count, and it is executed in the background where it is interrupted in case of higher priority host commands. Global WL refers to the procedure of involving all blocks (user blocks, management blocks and free blocks) of a device regardless of whether the respective block is on the same channel or not. Generally, to write on a free block, the WL algorithm selects a block with the lowest erase count from a pool of all the unused blocks of the whole device.

Key take-away: *WL is a key feature of almost every Flash controller. For page-based FTLs it is usually tightly coupled and interleaved with GC. As user data is ultimately moved without host intervention, possible Sudden Power Failure (SPF) may corrupt static data. Controllers need to ensure data integrity in such cases.*

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 Micro USB Module (MUM) HERMIT-C 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 Fail Robustness*

Flash memory is often used in removable storage applications or battery operated devices where a robust and reliable power source cannot be guaranteed. A user may remove the memory at any time and under these conditions security of data is of paramount importance. APRO SLC Micro USB Module (MUM) HERMIT-C Series has developed a patented concept in order to ensure data integrity when transferring or writing data. By

using certain buffer blocks, information is written in a way that minimizes the delta between an old and a new state. The data system is coherent at all times.

Upon a sudden power fail, the controller is reset and the flash is immediately write-protected. A log of the most recent Flash transactions is kept, where entries are made just before any programming to the Flash. Should the last entry of the log be corrupted, the controller recovers the last valid entry. This minimizes data loss due to power failures and data corruption at the physical layer is prevented completely. Should power loss happen at the very same time when data is written to the flash, this data might get lost. In no case, however, will the overall data system be corrupted.

APRO SLC Micro USB Module (MUM) HERMIT-C Series performs extensive power cycling tests to all controllers and firmware verifying no data corruption due to power failure.

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

  $\mathbf{TT}_{Ti}$: 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 Micro USB Module (MUM) HERMIT-C Series		Standard Grade	Industrial Grade
		SBMUMxxxG-HCCTC-xx	WBMUMxxxG- HCITI-xx
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 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 Micro USB Module (MUM) HERMIT-C Series		
DC Input Voltage (VCC)		5V±10%
Maximum average value	**Reading Mode :**	83.7 mA (max.)
	Writing Mode :	79.2 mA (max.)
	Idle Mode :	33.3 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**	**32GB**
	Sequential Read	10.0	15.2	19.1	23.7	23.8	23.8	27.5	27.4	27.4
	Sequential Write	4.9	8.6	13.5	12.9	13.1	13.9	18.8	15.9	16.4
	4KB Random Read	4.9	6.4	6.5	6.2	6.3	6.2	7.2	7.2	7.2
	4KB Random Write	2.1	3.2	3.8	4.2	4.2	4.3	4.9	5.2	5.1

Note: The performance was measured using CrystalDiskMark by file size 1000MB (QD32).

2.4. System Reliability

Table 4: System Reliability

Wear-leveling Algorithms		Static and Global Wear Leveling algorithms
Bad Block Management		Supportive
ECC Technology		96 bits per 1K bytes
Erase counts		NAND SLC Flash 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

Note:

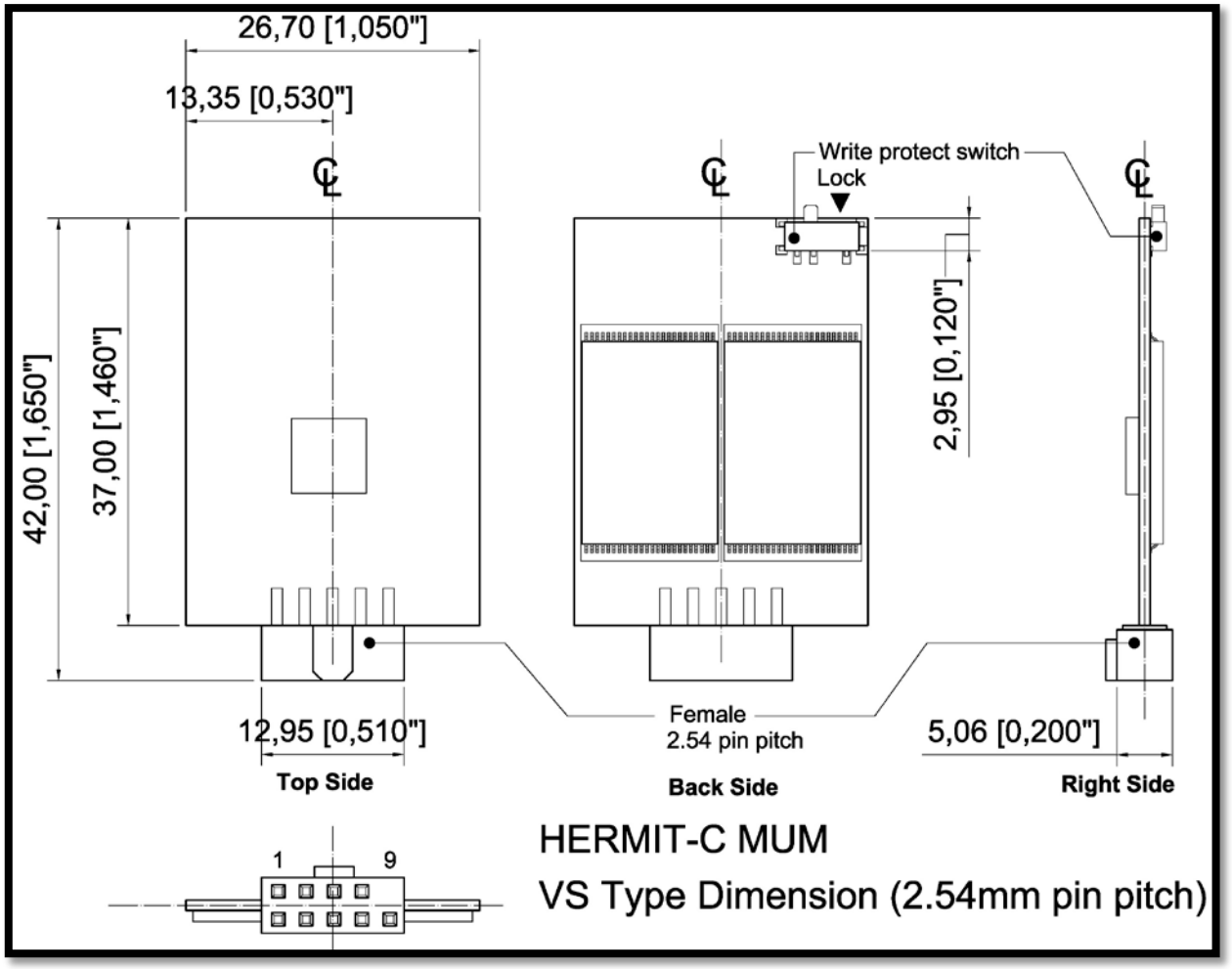
- *Client workload by JESD-219A.*
- *The endurance of disk could be varying based on user behavior, NAND endurance cycles, and write amplification factor. It is not guaranteed by flash vendor.*

2.5. *Physical Specifications*

Refer to Table 5 and see Figure 2 for APRO SLC Micro USB Module (MUM) HERMIT-C Series physical specifications and dimensions.

Table 5: Physical Specifications

Form factor:	HS & HL Type	VS Type
Length:	37.0 mm	42.0 mm
Width:	26.7 mm	26.7 mm
Weight:	10 g / 0.35 oz	



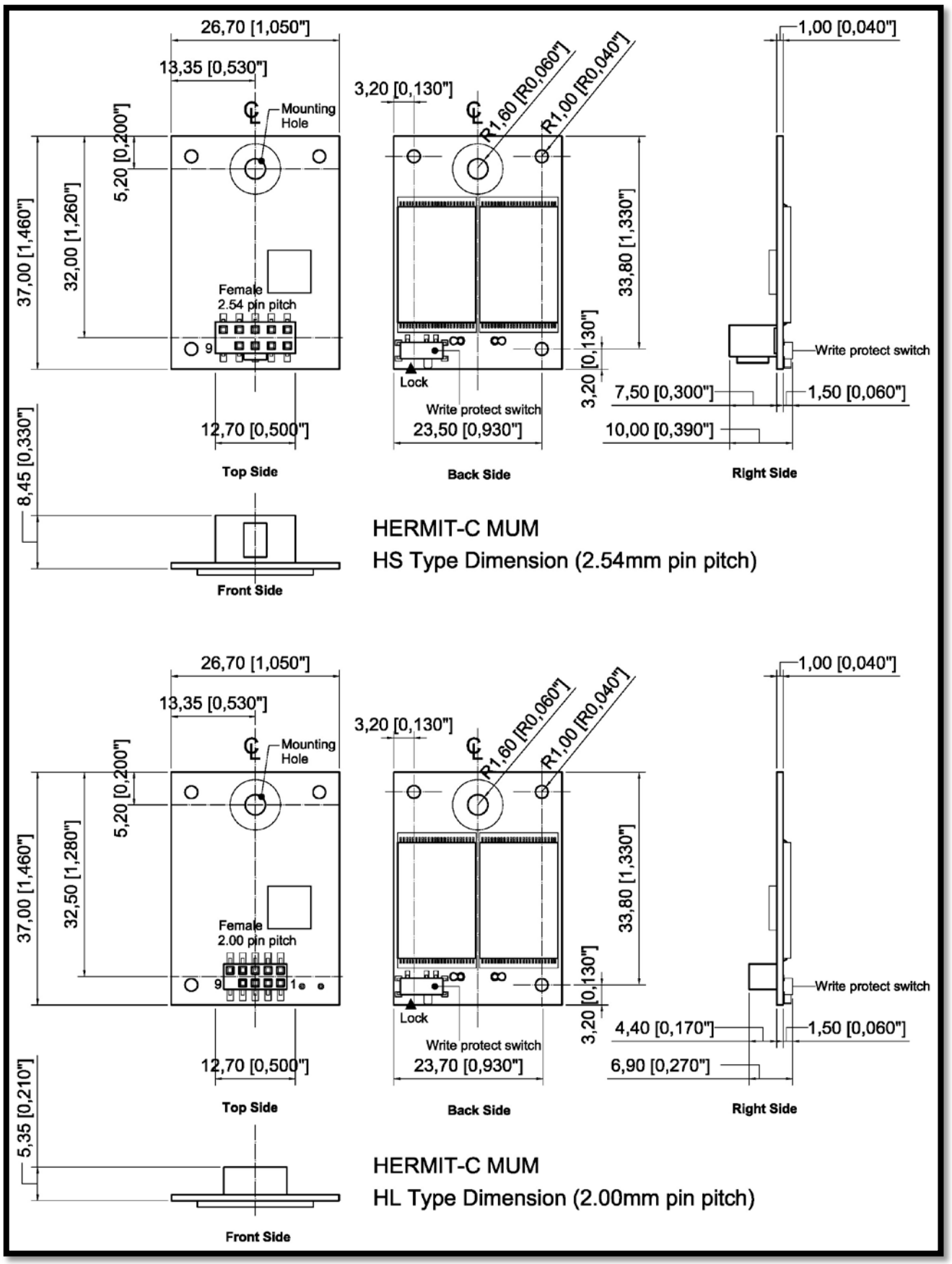


Figure 2: APRO SLC Micro USB Module (MUM) HERMIT-C Series Dimension

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. *USB2.0 male connector from host motherboard.*

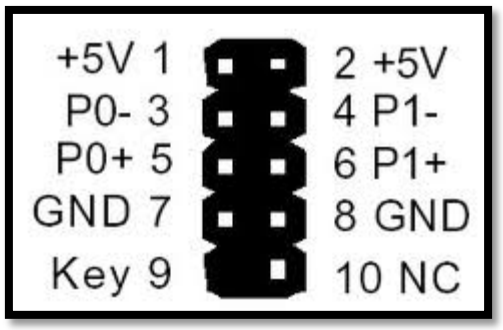


Figure 3: USB 10 pins Host male connector

Pin-1.3.5.7 and Pin-2.4.6.8 are the same pinout

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

Horizontal Type			
Pin Number	**Signal**	**Pin Number**	**Signal**
Pin 1	NC	**Pin 2**	+5VDC
Pin 3	NC	**Pin 4**	USB -
Pin 5	NC	**Pin 6**	USB +
Pin 7	NC	**Pin 8**	GND
Pin 9	Key	**Pin 10**	NC

Appendix A: Limited Warranty

APRO warrants your SLC Micro USB Module (MUM) HERMIT-C 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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