APRO Co., Ltd.

# SLC

## Industrial SD/SDHC Card 3.0

### THEMIS-A Series


**Document No. :** 100-xPSDC-EATS

**Version No. :** 02V0

**Date :** June, 2019

ISO 9001 : 2015 CERTIFIED

# Product Features

- **Flash IC**
  - TOSHIBA NAND Flash IC.
  - Single-Level Cell (SLC) management
- **Compatibility**
  - Fully compatible to SDA Specifications V1.01/V1.1/V2.0 / V3.0
- **Additional Capabilities**
  - Supports SD command Class 2,4,5, 6,7,8,10
  - Supports SD mode and SPI mode
  - Supports CPRM
  - Support bad Block Management
  - Support both Global Wear Leveling
- **Mechanical**
  - 9 exposed contact pins on one side.
  - Dimension: 32.0mm x 24.0mm x 2.1mm.
  - Weight: 2.5 g / 0.09 oz.
- **Power Operating Voltage 3.3V(+/-) 5%**
  - Read Mode: 49.8 mA (max.)
  - Write Mode: 52.2 mA (max.)
  - Idle Mode: 0.2 mA (max.)
- **Performance (Maximum value) *2**
  - **SD card performance**

    Sequential Read: 22.1 MB/sec. (max.)

    Sequential Write: 16.8 MB/sec. (max.)
  - **SDHC card performance**

    Sequential Read: 22.3 MB/sec. (max.)

    Sequential Write: 18.7 MB/sec. (max.)
- **Capacity**
  - SD card: 128MB, 256MB, 512MB, 1GB, 2GB
  - SDHC card: 4GB, 8GB, 16GB and 32GB.
- **Reliability**
  - **ECC:** Up to 16bits per 1024bytes in an ECC block.
  - **MTBF:** > 3,000,000 hours
  - **Temperature:** (Operating)

    Standard Grade: 0ºC ~ +70ºC

    Industrial Grade: -40ºC ~ +85ºC
  - **Vibration:** 70Hz~2K Hz / 20G.
  - **Shock:** 0.5ms, 1500G, 3 axes
  - **Erase counts:** 60K
- **Certifications and Declarations**
  - **Certifications**: CE & FCC
  - **Declarations**: RoHS & REACH

**Remarks:**

1. Support official S.M.A.R.T. Utility.
2. Sequential performance is based on CrystalDiskMark

# Order Information

## I. Part Number List

◆ **APRO SLC Industrial Secure Digital Memory Card THEMIS-A Series**

| Product Picture | Grade | Industrial Grade ( -40°C ~ +85°C ) |
|---|---|---|
|  | 128MB | WPSDC128M-EAITI |
| | 256MB | WPSDC256M-EAITI |
| | 512MB | WPSDC512M-EAITI |
| | 1GB | WPSDC001G-EAITI |
| | 2GB | WPSDC002G-EAITI |
| | 4GB | WPSDH004G-EAITI |
| | 8GB | WPSDH008G-EAITI |
| | 16GB | WPSDH016G-EAITI |
| | 32GB | WPSDH032G-EAITI |

## II. Part Number Decoder:

**X1 X2 X3 X4 X5 X6 X7 X8 X9—X11 X12 X13 X14 X15**

**X1** : **Grade**

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

**X2** : **The material of case**

**P :** Plastic casing

**X3 X4 X5** : **Product category**

**SD :** Secure Digital (SD) memory card

**SDH** : Secure Digital High Capacity (SDHC) memory card

**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**

**E :** THEMIS Series

**X12** : **Controller version**

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

**X13** : **Controller Grade**

**I :** Industrial grade

**X14** : **Flash IC**

**T :** Toshiba NAND Flash IC

**X15** : **Flash IC grade / Type**

**I :** Industrial grade

# Revision History

| Revision | Description | Date |
|---|---|---|
| 1.0 | Initial release | 2015/10/14 |
| 1.1 | Typo correction | 2019/3/29 |
| 2.0 | Updated Document form | 2019/06/17 |

# Contents

# 1. Introduction

APRO SLC Industrial Secure Digital Memory Card THEMIS-A Series is specifically designed to meet the security, performance and environmental requirements of some significant applications such like networking, telecommunications and data-communications, mobile & embedded computing, medical instruments and industrial computing applications.

The main used Flash memory is SLC-NAND Type Flash memory chips are 128MB, 256MB, 512MB, 1GB, 2GB, 4GB, 8GB, 16GB and 32GB. APRO SLC Industrial Secure Digital Memory Card THEMIS-A Series include a copyright protection that complies with the security of the SDMI standard, and the physical form-factor, pin assignment.

## 1.1. Scope

This document describes the key features and specifications of APRO SLC Industrial Secure Digital Memory Card THEMIS-A Series.

## 1.2. Flash Management Technology – Global Wear Leveling

In order to gain the best management for flash memory, APRO SLC Industrial Secure Digital Memory Card THEMIS-A Series supports 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.

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 SLC Industrial Secure Digital Memory Card THEMIS-A 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 Secure Digital Memory Card THEMIS-A Series | | Environmental Specification |
|---|---|---|
| Temperature | Operating:<br>Non-operating: | -40ºC ~ +85ºC<br>-50ºC ~ +95ºC |
| Humidity | Operating & Non-operating: | 10% ~ 95% non-condensing |
| Vibration | Operating & Non-operating: | 70Hz~2K Hz/20G. |
| Shock | Operating & Non-operating: | 0.5ms, 1500 G, 3 axes |

## 2.2. System Power Requirements

***Table 2: Power Requirement***

| APRO SLC Industrial Secure Digital Memory Card THEMIS-A Series | | DC Input Voltage (VCC): 3.3V(+/-) 5% |
|---|---|---|
| Maximum average value | Reading Mode : | 49.8 mA (max.) |
| | Writing Mode : | 52.2 mA (max.) |
| | Idle Mode : | 0.2 mA (max.) |

## 2.3. System Performance

***Table 3: System Performances***

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Data Transfer Mode supporting** | | SDA Specification Ver 3.0 | | | | | | | |
| **Average Access Time** | | 1 ms (estimated) | | | | | | | |
| **Maximum Performance** | **Capacity** | **128MB** | **256MB** | **512MB** | **1GB** | **2GB** | **4GB** | **8GB** | **16GB** | **32GB** |
| | **Sequential Read (MB/s)** | 21.3 | 21.6 | 22.0 | 22.0 | 22.1 | 22.2 | 22.3 | 22.2 | 22.2 |
| | **Sequential Write (MB/s)** | 5.3 | 11.9 | 13.4 | 11.9 | 16.8 | 18.3 | 18.7 | 17.8 | 18.7 |

*Note:*

- *All values quoted are typically at 25℃ and nominal supply voltage.*
- *Base on CrystalDiskMark 3.01 with file size 1000MB Test*

## 2.4. System Reliability

***Table 4: System Reliability***

| | |
|---|---|
| **Wear-leveling Algorithms** | Global wear-leveling algorithms |
| **Bad Blocks Management** | Supportive |
| **ECC Technology** | Up to 16bits per 1024bytes in an ECC block |
| **Endurance** | NAND SLC Flash : 60K Erase counts |
| **Durability** | 10,000 inserting cycles |
| **Bending** | >10N |
| **Torque** | 0.1N +/- 2.5 deg. |
| **Drop Test** | 1.5M free fall |
| **Salt Spray** | Concentration: 3% NaCl/35℃ |
| **Waterproof** | 1000mm submerge for 30 minutes, IPx7 compliance |
| **Electrostatic Discharge (ESD)** | Contact: +/- 4KV each item 25 times<br>Air: +/- 8KV 10 times |
| **X-Ray Exposure Test** | 0.1 Gy of medium energy radiation (70 keV to 140keV, cumulative does per year) to both sides of the card. |

*Note:*

- *The endurance of SSD could be estimated based on user behavior, NAND endurance cycles, and write amplification factor. It is not guaranteed by flash vendor.*

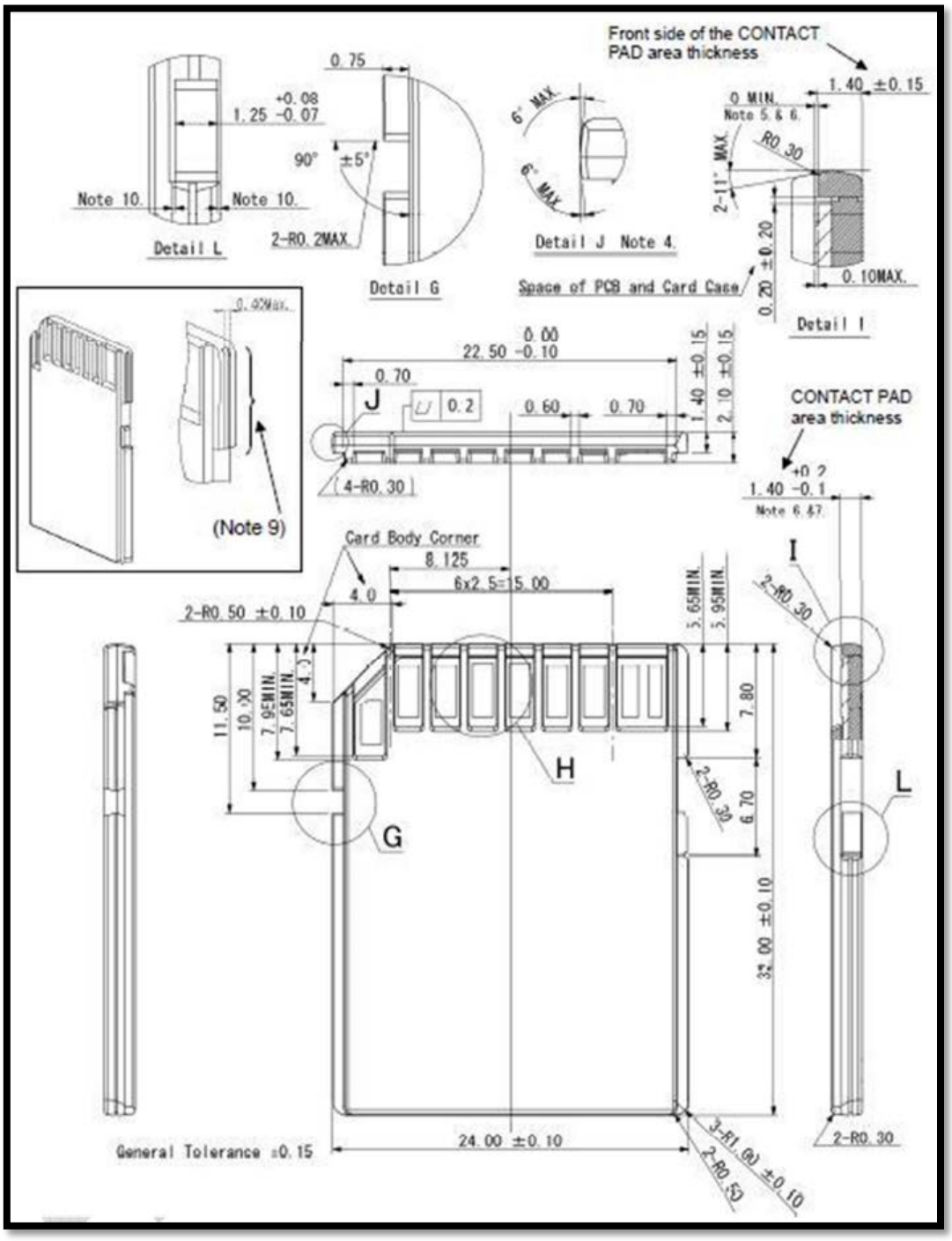
## 2.5. *Physical Specifications*

Refer to Table 5 and see Figure 1 for APRO SLC Secure Digital Memory Card THEMIS-A Series physical specifications and dimensions.

***Table 5: Physical Specifications of APRO SLC Secure Digital Memory Card THEMIS-A Series***

| | |
|---|---|
| **Length:** | 32.00 mm |
| **Width:** | 24.00 mm |
| **Thickness:** | 2.10 mm |
| **Weight:** | 2.5 g / 0.09 oz |

***Figure 1: APRO SLC Secure Digital Memory Card THEMIS-A Series Dimension***



# 3. Interface Description

## 3.1. Secure Digital Memory Card interface

APRO SLC Secure Digital Memory Card has 9 exposed contacts on one side.

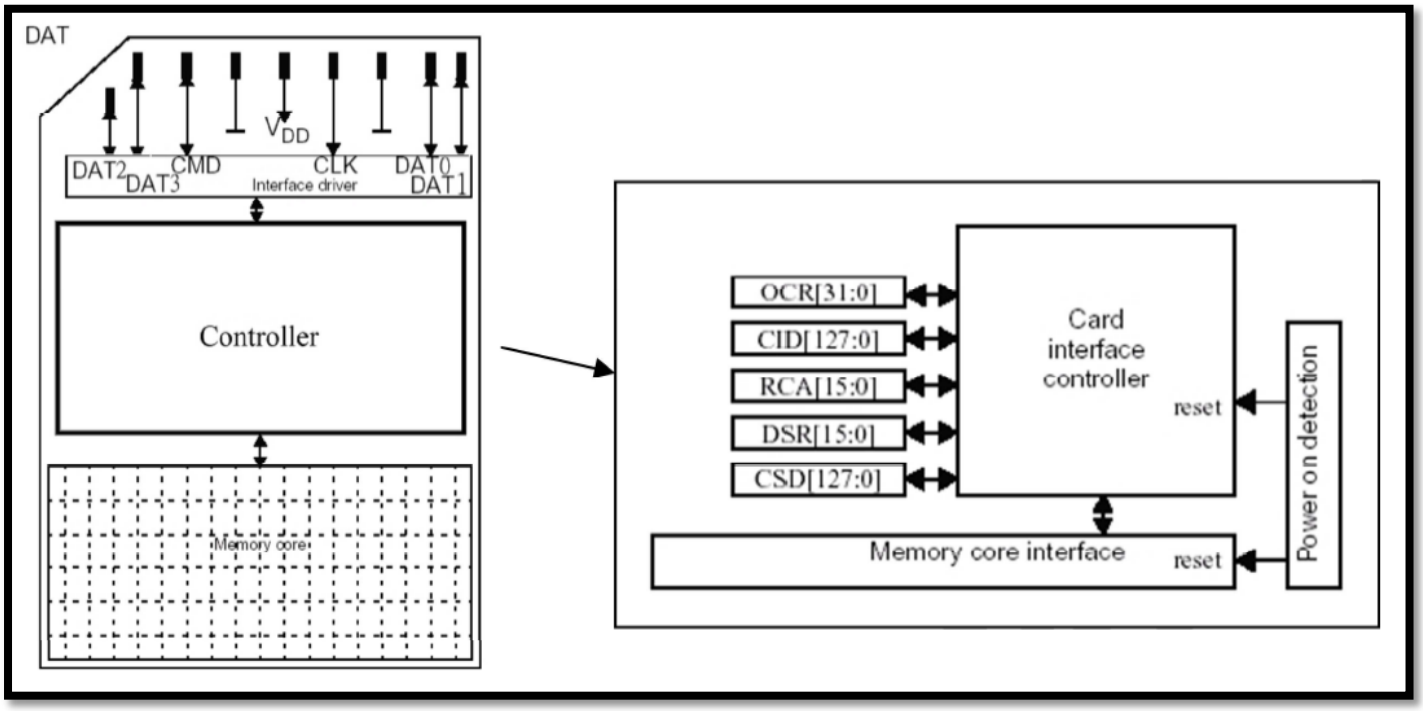



***Figure 2: 9 Pins Connector***

## 3.2. *Pin Assignments*

There are total of 9 pins in the Micro SD Connector. The pin assignments are listed in below table 6.

***Table 6 - Pin Assignments***

| Pin Number | SD Mode | | | SPI Mode | | |
|---|---|---|---|---|---|---|
| | Pin Name | Type [1] | Description | Pin Name | Type | Description |
| Pin 1 | CD / DAT3[2] | I/O/PP[3] | Card Detect / Data Line [bit3] | CS | I[3] | Chip Select |
| Pin 2 | CMD | PP | Command / Response | DI | I | Data in |
| Pin 3 | $V_{SS1}$ | S | Supply voltage ground | $V_{SS}$ | S | Supply voltage ground |
| Pin 4 | $V_{DD}$ | S | Supply voltage | $V_{DD}$ | S | Supply voltage |
| Pin 5 | CLK | I | Clock | SCLK | I | Clock |
| Pin 6 | $V_{SS2}$ | S | Supply voltage ground | $V_{SS2}$ | S | Supply voltage ground |
| Pin 7 | DAT0 | I/O/PP | Data Line [bit0] | DO | O/PP | Data Out |
| Pin 8 | DAT1 | I/O/PP | Data Line [bit1] | RSV | | |
| Pin 9 | DAT2 | I/O/PP | Data Line [bit2] | RSV | | |

- S: power supply, I:input; O:output using push-pull drivers; PP:I/O using push-pull drivers.
- The extended DAT lines (DAT1-DAT3) are input on power up. They start to operate as DAT lines after SET_BUS_WIDTH command. The Host shall keep its own DAT1-DAT3 lines in input mode, as well, while they are not used. It is defined so, in order to keep compatibility to Multi-Media Cards.
- At power up this line has a 50KOhm pull up enabled in the card. This resistor serves two functions Card detection and Mode Selection. For Mode Selection, the host can drive the line high or let it be pulled high to select SD mode. If the host wants to select SPI mode it should drive the line low. For Card detection, the host detects that the line is pulled high. This pull-up should be disconnected by the user during regular data transfer period, withSET_CLR_CARD_DETECT(ACMD42) command.

## Appendix A: Limited Warranty

APRO warrants your SLC Secure Digital Memory Card THEMIS-A 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 IND. Grade 5 years / Within 60K Erasing Counts**

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