APRO Co., Ltd.

# 3D NAND aSLC

(KIOXIA BiCS FLASH™ )

# SDHC/SDXC Card 6.10

## PHANES-T Series


**Document No. :** 100-xPSDX-PTCT5AS

**Version No. :** 01V1

**Date :** March, 2022

ISO 9001 : 2015 CERTIFIED

# *Product Features*

- **Flash IC**
  - KIOXIA **BiCS FLASH™ *3**
  - KIOXIA **BiCS5** 3D-NAND Flash w/aSLC Technology ***4**
- **Compatibility**
  - The Command List supports **Part 1 Physical Layer Specification Ver6.10 Final** Specifications.
  - Card Capacity of Non-secure Area, Secure Area Supports **Part 3 Security Specification Ver7.00 Final** Specifications.
  - Support **File System Specification Ver3.00**
- **Additional Capabilities**
  - S.M.A.R.T.***1** (Self-Monitoring, Analysis and Reporting Technology) feature set support.
  - Bus Speed supports UHS-1
  - Video Speed Class supports up to V30.
  - Speed Class supports: Class 10/A2/UHS-1, U3
  - Supports **SD mode** and **SPI mode**
  - Compliant with Part 1 Physical Layer Specification ver. 6.10, CPRM is Optional.
  - Supports Auto-Read Refresh
  - Support bad Block Management
  - Support both Static and Dynamic 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 2.7V to 3.6V**
  - Read Mode: 400 mA (max.)
  - Write Mode: 400 mA (max.)
  - Standby Mode: 1 mA (max.)
- **Performance (Maximum value) *2**

  **SDHC Card 3D NAND TLC performance**
  - Sequential Read: 101.0 MB/sec. (max.)
  - Sequential Write: 88.0 MB/sec. (max.)

  **SDXC Card 3D NAND TLC performance**
  - Sequential Read: 101.0 MB/sec. (max.)
  - Sequential Write: 89.0 MB/sec. (max.)
- **Capacity**
  - **SDHC Card**
    16GB, 32GB
  - **SDXC Card**
    64GB
- **Reliability**
  - **ECC:** Designed with ECC Algorithm. (Error Correcting Code)
  - **MTBF:** > 3,000,000 hours
  - **Temperature:**
    Operation temp. range: -25ºC ~ +85ºC
    Storage temp. range: -40ºC ~ +85ºC
  - **Vibration:** 80Hz~2000Hz/20G.
  - **Shock:** 0.5ms, 1500 G, 3 axes.
  - **Erase counts:** 30K
- **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 5.1.2 with file size 1000MB
3. **BiCS** means Bit Cost Scalable Technology.
   **BiCSFLASH** is a trademark of KIOXIA Corporation.

# Order Information

## I. Part Number List

◆ **APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series**

| Product Picture | Grade | Std. Temp. Grade (-25 ºC ~ +85ºC ) |
|---|---|---|
|  | 16GB | SPSDH016G-PTCT5AS |
| | 32GB | SPSDH032G-PTCT5AS |
| | 64GB | SPSDX064G-PTCT5AS |



## II. Part Number Decoder:

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

**X1** : **Grade**

**S:** Standard Grade – operating temp. -25º C ~ 85 º C

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

**P :** Plastic casing

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

**SDH :** Secure Digital High Capacity card

**SDX :** Secure Digital eXtended Capacity card

**X6 X7 X8 X9** : **Capacity**

**016G:** 16GB **064G:** 64GB

**032G:** 32GB

**X11** : **Controller**

**P :** PHANES Series

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

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

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

**C :** Commercial grade

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

**T :** KIOXIA NAND Flash IC

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

**5 :** KIOXIA BiCS5 3D-NAND Flash IC.

**X16 X17**: **Flash IC**

**AS :** KIOXIA 3D NAND Flash w/aSLC Technology.

# Revision History

| Revision | Description | Date |
|---|---|---|
| 1.0 | Initial release | 2021/12/01 |
| 1.1 | Add. TBW information | 2022/04/01 |

# Contents

# 1. Introduction

APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series is fully compliant to the specification released by SD Card Association. The Command List supports [Part 1 Physical Layer Specification Ver6.10 Final] definitions. Card Capacity of Non-secure Area, Secure Area Supports [Part 3 Security Specification Ver7.00 Final] Specifications.

The SD card comes with a 9-pin interface, designed to operate at a maximum frequency of 208MHz. It can alternate communication protocol between the SD mode and SPI mode. It performs data error detection and correction with very low power consumption.

The main used Flash memory is 3D-NAND Type Flash memory chips w/aSLC technology, and which capacities are 16GB, 32GB and 64GB.

APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series support the standard grade operating temp. -25º C ~ 85 º C and the storage temp. is -40~+85°C.

## 1.1. Scope

This document describes the key features and specifications of APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series.

## 1.2. Flash Management Technology – Static & Dynamic Wear Leveling

NAND flash devices can only undergo a limited number of program/erase cycles, and in most cases, the flash media are not used evenly. If some areas get updated more frequently than others, the lifetime of the device would be reduced significantly. Thus, Wear Leveling is applied to extend the lifespan of NAND Flash by evenly distributing write and erase cycles across the media.

APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series provides advanced Wear Leveling algorithm, which can efficiently spread out the flash usage through the whole flash media area. Moreover, by implementing both dynamic and static Wear Leveling algorithms, the life expectancy of the NAND flash is greatly improved.

## 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 3D NAND aSLC SDXC Card Version 6.10 PHANES-T 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. *Error Correction Code (ECC)*

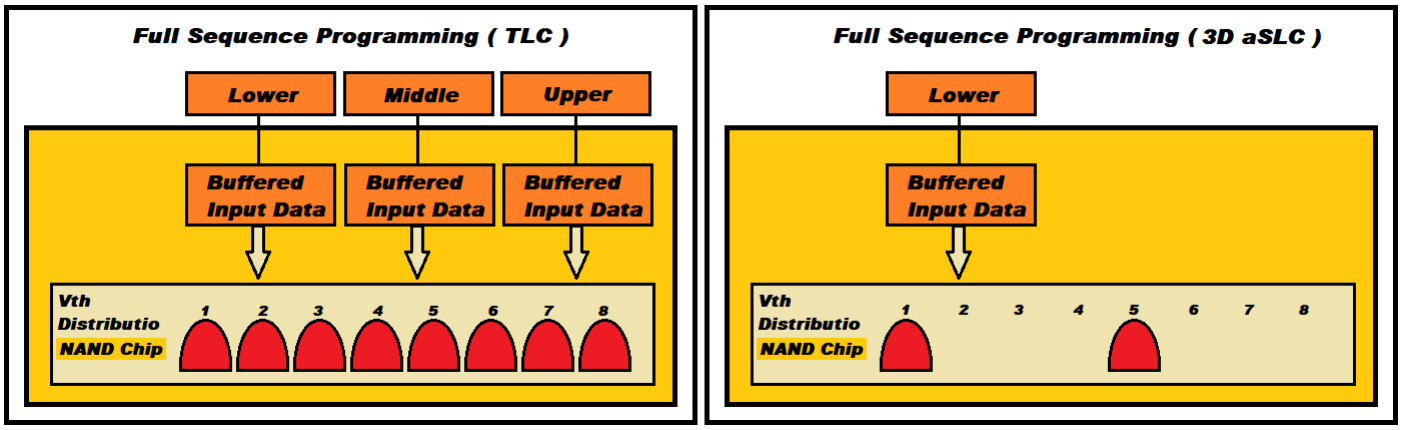
Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, SDXC Card applies ECC Algorithm, which can detect and correct errors during Read processes, ensuring data is read correctly, as well as protecting data from corruption.

## 1.5. *Auto-Read Refresh*

Auto-Read Refresh is especially applied on devices that read data mostly but rarely write data, such as GPS. When blocks are continuously read, then the device cannot activate wear leveling since it can only be applied while writing data. Thus, errors will accumulate and become uncorrectable. Accordingly, to avoid errors exceed the amount ECC can correct and blocks turn bad, APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series firmware will automatically refresh the bit errors when the error number in one block approaches the threshold, ex., 24 bits.

## 1.6. *3D NAND Flash w/ aSLC Technology*

3D aSLC can be considered as an extended version of TLC. While TLC does Full Sequence Programming into 8 Vth distributions, 3D aSLC only does lower page programming into 2 Vth distributions. Accordingly, because only Lower pages are programmed, 3D aSLC provides better performance and endurance than TLC. Moreover, 3D aSLC performs similarly with SLC, yet 3D aSLC is more cost-effective



# 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 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series | | Standard temp. grade |
|---|---|---|
| **Temperature** | **Operating:** | -25ºC ~ +85ºC |
| | **Non-operating:** | -40ºC ~ +85ºC |
| **Humidity** | **Operating & Non-operating:** | 10% ~ 95% non-condensing |
| **Vibration** | **Operating & Non-operating:** | 80Hz~2000Hz/20G. |
| **Shock** | **Operating & Non-operating:** | 0.5ms, 1500 G, 3 axes |

## 2.2. System Power Requirements

***Table 2: Power Requirement***

| APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series | | Standard temp. grade |
|---|---|---|
| **DC Input Voltage (VCC)** | | **2.7V to 3.6V** |
| **Maximum average value** | **Reading Mode :** | < 400 mA |
| | **Writing Mode :** | < 400 mA |
| | **Standby Mode :** | < 1 mA |

## 2.3. System Performance

***Table 3: System Performances***

| Product Solution | 3D NAND aSLC | | |
|---|---|---|---|
| Speed level | A2, V30, Class10, U3, UHS-1 | | |
| Capacity level | SDHC | | SDXC |
| Capacity | 16GB | 32GB | 64GB |
| Sequential Read (MB/s) | 101.0 | 101.0 | 101.0 |
| Sequential Write (MB/s) | 86.0 | 88.0 | 89.0 |

*Note:*

- *The performance is obtained from TestMetrix Test (@500MB).*

## 2.4. *System Reliability*

***Table 4: System Reliability***

| | |
|---|---|
| **Wear-leveling Algorithms** | Static and Dynamic wear-leveling algorithms |
| **Bad Blocks Management** | Supportive |
| **ECC Technology** | Designed with ECC Algorithm |
| **MTBF** | > 3,000,000 hours |
| **Endurance** | 3D NAND aSLC : 30K 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. *Tera Bytes Written*

***Table 4: System Reliability***

| | |
|---|---|
| **Erase counts** | KIOXIA **BiCS5** 3D-NAND Flash w/aSLC Technology: 30K P/E Cycles |
| **Capacity** | **TBW(TB)** |
| **16GB** | 457 |
| **32GB** | 914 |
| **64GB** | 1,828 |

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

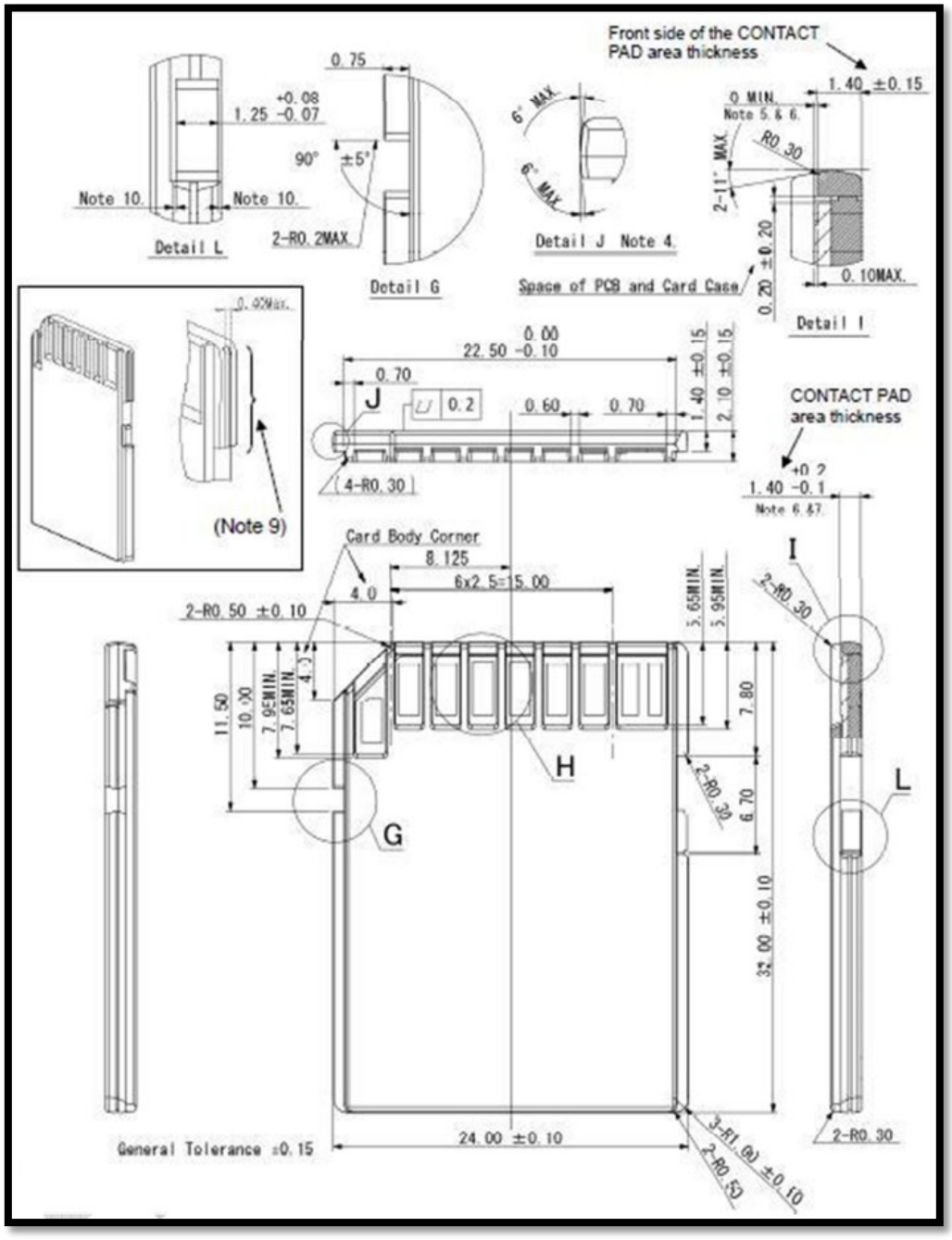
## 2.6. *Physical Specifications*

Refer to Table 5 and see Figure 1 for APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series physical specifications and dimensions.

***Table 5: Physical Specifications of APRO 3D NAND aSLC SDXC Card PHANES-T Series***

| | |
|---|---|
| **Length:** | 32.00 mm |
| **Width:** | 24.00 mm |
| **Thickness:** | 2.1 mm |
| **Weight:** | 2.5 g / 0.09 oz |

***Figure 2: APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series Dimension***



# 3. Interface Description

## 3.1. SDXC Card interface

APRO 3D NAND aSLC SDXC Card Version 6.10 PHANES-T Series has 9 exposed contacts on one side.

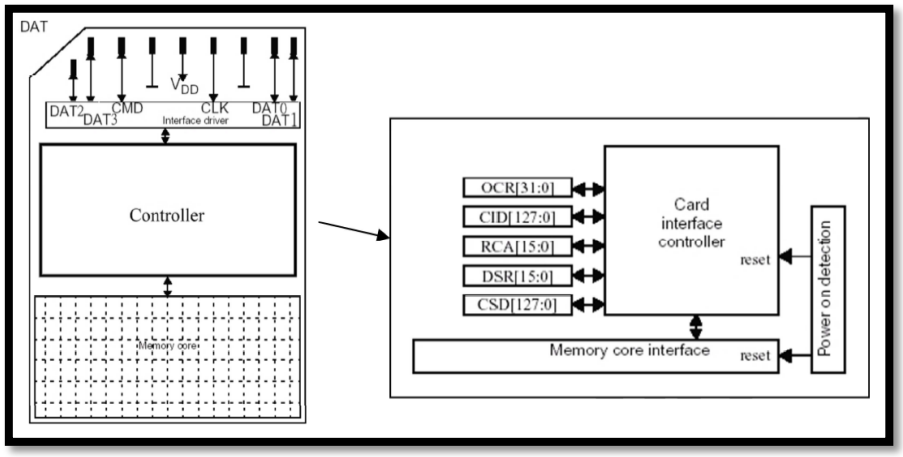



***Figure 3: 9 Pins Connector***

## 3.2. Pin Assignments

There are total of 9 pins in the SDXC 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 3D NAND TLC SDXC Card Version 6.10 PHANES-T 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:***

- **3D NAND aSLC ( Standard grade / Wide temp. grade )  2 years / Within 30K Erasing Counts**

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