

# Samsung eMMC Product family

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## eMMC 5.0 Specification compatibility

# datasheet

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## INTRODUCTION

SAMSUNG e•MMC is an embedded MMC solution designed in a BGA package form. e•MMC operation is identical to a MMC device and therefore is a simple read and write to memory using MMC protocol v5.0 which is a industry standard.

e•MMC consists of NAND flash and a MMC controller. 3V supply voltage is required for the NAND area (VDDF or VCC) whereas 1.8V or 3V dual supply voltage (VDD or VCCQ) is supported for the MMC controller. SAMSUNG e•MMC supports 200MHz DDR – up to 400MBps with bus widths of 8 bit in order to improve sequential bandwidth, especially sequential read performance.

There are several advantages of using e•MMC. It is easy to use as the MMC interface allows easy integration with any microprocessor with MMC host. Any revision or amendment of NAND is invisible to the host as the embedded MMC controller insulates NAND technology from the host. This leads to faster product development as well as faster times to market.

The embedded flash management software or FTL(Flash Transition Layer) of e•MMC manages Wear Leveling, Bad Block Management and ECC. The FTL supports all features of the Samsung NAND flash and achieves optimal performance.

## 1.0 PRODUCT LIST

[Table 1] Product List

| Capacities | e•MMC Part ID   | NAND Flash Type | User Density (%) | Power System   | Package size          | Pin Configuration |
|------------|-----------------|-----------------|------------------|--|-----------------------|-------------------|
| 4 GB       | KLM4G1YEMD-B031 | 32Gb x 1        | 91.0%            | - Interface power :<br>VDD (1.70V ~ 1.95V or<br>2.7V ~ 3.6V)<br>- Memory power :<br>VDDF (2.7V ~ 3.6V) | 11.5mm x 13mm x 0.8mm | 153FBGA           |
| 8 GB       | KLM8G1WEMB-B031 | 64Gb x 1        |                  |  |                       |                   |
| 16 GB      | KLMAG2WEMB-B031 | 64Gb x 2        |                  |  |                       |                   |

## 2.0 KEY FEATURES

- embedded MultiMediaCard Ver. 5.0 compatible. Detail description is referenced by JEDEC Standard
- SAMSUNG e•MMC supports features of eMMC5.0 which are defined in JEDEC Standard
  - Supported Features : Packed command, Cache, Discard, Sanitize, Power Off Notification, Data Tag, Partition types, Context ID, Real Time Clock, Dynamic Device Capacity, HS200
  - Non-supported Features : Large Sector Size (4KB)
- Additional features of eMMC5.0 : HS400 mode (200MHz DDR - up to 400Mbps), Field Firmware Update, Device Health Report, Sleep Notification, Secure Removal Type
- Full backward compatibility with previous MultiMediaCard system specification (1bit data bus, multi-e•MMC systems)
- Data bus width : 1bit (Default), 4bit and 8bit
- MMC I/F Clock Frequency : 0 ~ 200MHz  
MMC I/F Boot Frequency : 0 ~ 52MHz
- Temperature : Operation (-25°C ~ 85°C), Storage without operation (-40°C ~ 85°C)
- Power : Interface power → VDD(VCCQ) (1.70V ~ 1.95V or 2.7V ~ 3.6V) , Memory power → VDDF(VCC) (2.7V ~ 3.6V)

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## 3.0 PACKAGE CONFIGURATIONS

### 3.1 153 Ball Pin Configuration

[Table 2] 153 Ball Information

| Pin NO | Name        |
|--------|-------------|
| A3     | DAT0        |
| A4     | DAT1        |
| A5     | DAT2        |
| B2     | DAT3        |
| B3     | DAT4        |
| B4     | DAT5        |
| B5     | DAT6        |
| B6     | DAT7        |
| K5     | RSTN        |
| C6     | VDD         |
| M4     | VDD         |
| N4     | VDD         |
| P3     | VDD         |
| P5     | VDD         |
| E6     | VDDF        |
| F5     | VDDF        |
| J10    | VDDF        |
| K9     | VDDF        |
| C2     | VDDI        |
| M5     | CMD         |
| H5     | Data Strobe |
| M6     | CLK         |
| J5     | VSS         |
| A6     | VSS         |
| C4     | VSS         |
| E7     | VSS         |
| G5     | VSS         |
| H10    | VSS         |
| K8     | VSS         |
| N2     | VSS         |
| N5     | VSS         |
| P4     | VSS         |
| P6     | VSS         |

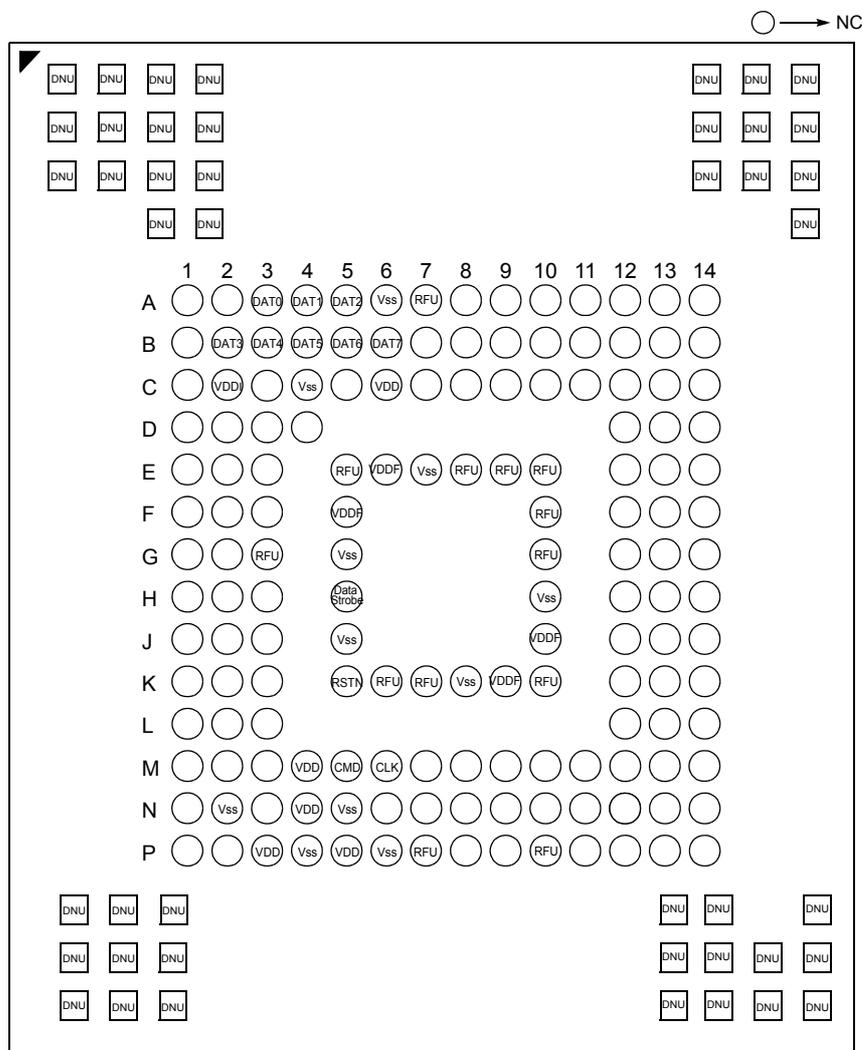


Figure 1. 153-FBGA

- CLK : Clock input
- Data Strobe : Newly assigned pin for HS400 mode. Data Strobe is generated from e.MMC to host.  
In HS400 mode, read data and CRC response are synchronized with Data Strobe.
- CMD : A bidirectional signal used for device initialization and command transfers.  
Command operates in two modes, open-drain for initialization and push-pull for fast command transfer.
- DAT0-7 : Bidirectional data channels. It operates in push-pull mode.
- RST\_n : H/W reset signal pin
- VDDF(VCC) : Supply voltage for flash memory
- VDD(VCCQ) : Supply voltage for memory controller
- VDDi : Internal power node to stabilize regulator output to controller core logics
- VSS : Ground connections
- RFU : Reserved for future use , do not use for any usage

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## 3.2 Product Architecture

- e-MMC consists of NAND Flash and Controller.  $V_{DD}$  ( $V_{CCQ}$ ) is for Controller power and  $V_{DDF}$  ( $V_{CC}$ ) is for flash power

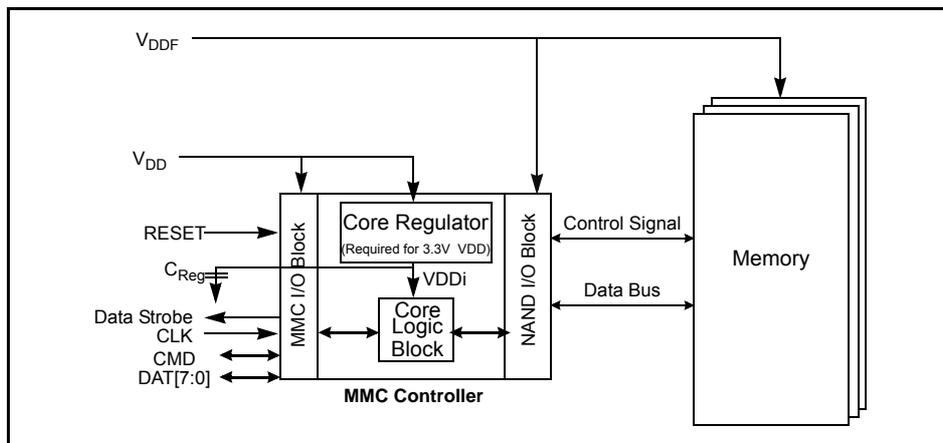


Figure 3. e-MMC Block Diagram

## 4.0 e.MMC 5.0 feature

### 4.1 HS400 mode

e.MMC5.0 product supports high speed DDR interface timing mode up to 400MB/s at 200MHz with 1.8V I/O supply.

HS400 mode supports the following features :

- DDR Data sampling method
- CLK frequency up to 200MHz DDR – up to 400Mbps
- Only 8-bits bus width available
- Signaling levels of 1.8V
- Six selectable Drive Strength (refer to the table below)

[Table 3] I/O driver strength types

| Driver Type | HS200 & HS400 Support | Nominal Impedance | Approximated driving capability compared to Type-0 | Remark  |
|-------------|-----------------------|-------------------|--|---|
| 0           | Default               | 50Ω               | x1   | Default Driver Type. Supports up to 200MHz operation.                                     |
| 1           | Optional              | 33Ω               | x1.5   | Supports up to 200MHz Operation.  |
| 2           | Optional              | 66Ω               | x0.75  | The weakest driver that supports up to 200MHz operation.                                  |
| 3           | Optional              | 100Ω              | x0.5   | For low noise and low EMI systems. Maximal operating frequency is decided by Host design. |
| 4           | Optional              | 40Ω               | x1.2   | Supports up to 200MHz DDR operation   |

**NOTE:**

- 1) Support of Driver Type-0 is default for HS200 & HS400 Device, while supporting Driver types 1~5 are optional for HS200 & HS400 Device.
- 2) It is being discussed in JEDEC and is not confirmed yet. It can be modified according to JEDEC standard in the future.

[Table 4] Device type values (EXT\_CSD register : DEVICE\_TYPE [196])

| Bit | Device Type   | Supportability |
|-----|---|----------------|
| 7   | HS400 Dual Data Rate eMMC @ 200 MHz - 1.2V I/O          | Not support    |
| 6   | HS400 Dual Data Rate eMMC @ 200 MHz - 1.8V I/O          | Support        |
| 5   | HS200 Single Data Rate eMMC @ 200 MHz - 1.2V I/O        | Not support    |
| 4   | HS200 Single Data Rate eMMC @ 200 MHz - 1.8V I/O        | Support        |
| 3   | High-Speed Dual Data Rate eMMC @ 52MHz - 1.2V I/O       | Not support    |
| 2   | High-Speed Dual Data Rate eMMC @ 52MHz - 1.8V or 3V I/O | Support        |
| 1   | High-Speed eMMC @ 52MHz - at rated device voltage(s)    | Support        |
| 0   | High-Speed eMMC @ 26MHz - at rated device voltage(s)    | Support        |

**NOTE:**

- 1) It is being discussed in JEDEC and is not confirmed yet. It can be modified according to JEDEC standard in the future.

[Table 5] Extended CSD revisions (EXT\_CSD register : EXT\_CSD\_REV [192])

| Value | Timing Interface                   | EXT_CSD Register Value |
|-------|------------------------------------|------------------------|
| 255-8 | Reserved                           | -                      |
| 7     | Revision 1.7 (for MMC V5.0)        | 0x07 <sup>1)</sup>     |
| 6     | Revision 1.6 (for MMC V4.5, V4.51) | -                      |
| 5     | Revision 1.5 (for MMC V4.41)       | -                      |
| 4     | Revision 1.4 (Obsolete)            | -                      |
| 3     | Revision 1.3 (for MMC V4.3)        | -                      |
| 2     | Revision 1.2 (for MMC V4.2)        | -                      |
| 1     | Revision 1.1 (for MMC V4.1)        | -                      |
| 0     | Revision 1.0 (for MMC V4.0)        | -                      |

**NOTE:**

- 1) Current eMMC standard defined by JEDEC supports up to 0x06 for EXT\_CSD\_REV value, 0x07 is additionally assigned to support e.MMC5.0 product. It is being discussed in JEDEC and is not confirmed yet. It can be modified according to JEDEC standard in the future.

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[Table 6] High speed timing values (EXT\_CSD register : HS\_TIMING [185])

| Value | Timing Interface                                   | Supportability |
|-------|--|----------------|
| 0x0   | Selecting backwards compatibility interface timing | Support        |
| 0x1   | High Speed   | Support        |
| 0x2   | HS200  | Support        |
| 0x3   | HS400  | Support        |

**NOTE:**

1) It is being discussed in JEDEC and is not confirmed yet. It can be modified according to JEDEC standard in the future.

## 5.0 Technical Notes

### 5.1 S/W Algorithm

#### 5.1.1 Partition Management

The device initially consists of two Boot Partitions and RPMB Partition and User Data Area.

The User Data Area can be divided into four General Purpose Area Partitions and User Data Area partition. Each of the General Purpose Area partitions and a section of User Data Area partition can be configured as enhanced partition.

##### 5.1.1.1 Boot Area Partition and RPMB Area Partition

Boot Partition size & RPMB Partition Size are set by the following command sequence :

[Table 7] Setting sequence of Boot Area Partition size and RPMB Area Partition size

| Function                   | Command               | Description   |
|----------------------------|-----------------------|---|
| Partition Size Change Mode | CMD62(0xEFAC62EC)     | Enter the Partition Size Change Mode                                    |
| Partition Size Set Mode    | CMD62(0x00CBAAE7)     | Partition Size setting mode   |
| Set Boot Partition Size    | CMD62(BOOT_SIZE_MULT) | Boot Partition Size value   |
| Set RPMB Partition Size    | CMD62(RPMB_SIZE_MULT) | RPMB Partition Size value<br>F/W Re-Partition is executed in this step. |
| Power Cycle                |                       |   |

Boot partition size is calculated as (128KB \* BOOT\_SIZE\_MULT)

The size of Boot Area Partition 1 and 2 can not be set independently. It is set as same value.

RPMB partition size is calculated as (128KB \* RPMB\_SIZE\_MULT).

In RPMB partition, CMD 0, 6, 8, 12, 13, 15, 18, 23, 25 are admitted.

Access Size of RPMB partition is defined as the below:

[Table 8] REL\_WR\_SEC\_C value for write operation on RPMB partition

| REL_WR_SEC_C     | Description  |
|------------------|--|
| REL_WR_SEC_C = 1 | Access sizes 256B and 512B supported to RPMB partition                                   |
| REL_WR_SEC_C > 1 | Access sizes up to REL_WR_SEC_C * 512B supported to RPMB partition with 256B granularity |

Any undefined set of parameters or sequence of commands results in failure access.

If the failure is in data programming case, the data is not programmed. And if the failure occurs in data read case, the read data is '0x00'.

##### 5.1.1.2 Enhanced Partition (Area)

SAMSUNG eMMC adopts Enhanced User Data Area as SLC Mode. Therefore when master adopts some portion as enhanced user data area in User Data Area, that area occupies triple size of original set up size. ( ex> if master set 1MB for enhanced mode, total 3MB user data area is needed to generate 1MB enhanced area)

Max Enhanced User Data Area size is defined as (MAX\_ENH\_SIZE\_MULT x HC\_WP\_GRP\_SIZE x HC\_ERASE\_GRP\_SIZE x 512kBytes)

5.1.2 Boot operation

Device supports not only boot mode but also alternative boot mode. Device supports high speed timing and dual data rate during boot.

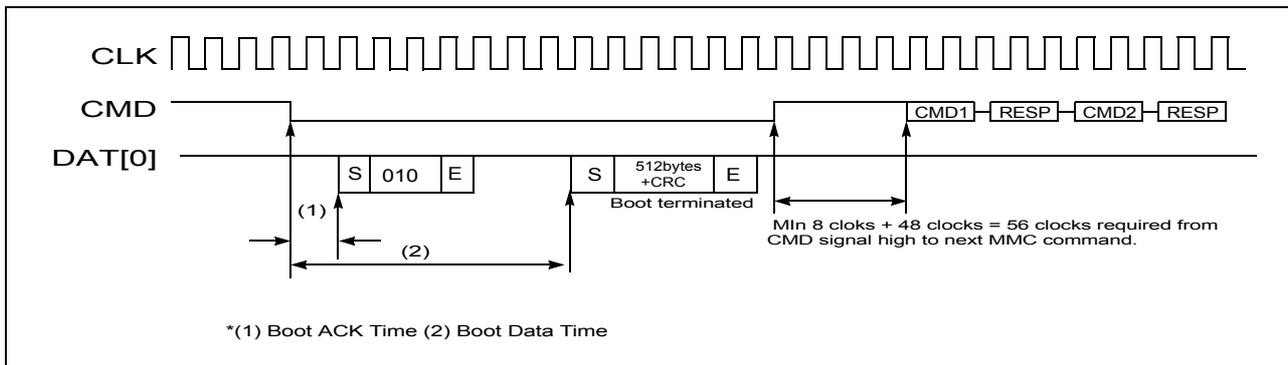


Figure 4. embedded MultiMediaCard state diagram (boot mode)

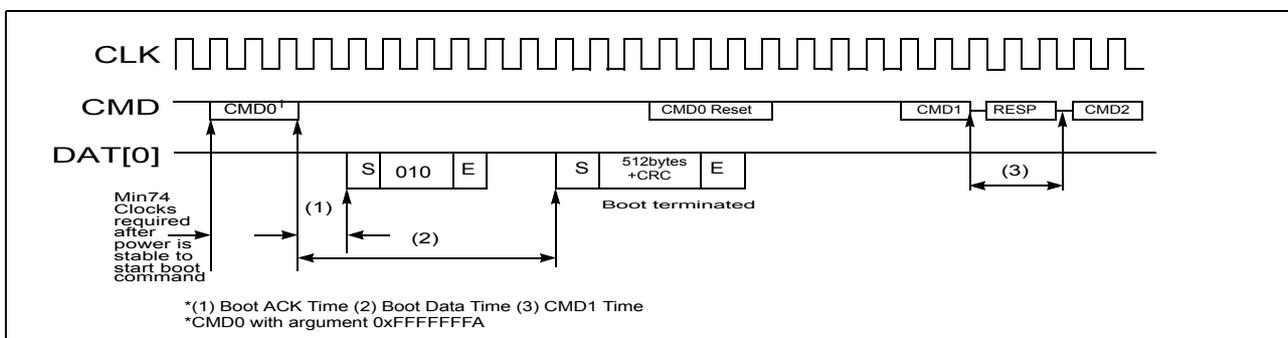


Figure 5. embedded MultiMediaCard state diagram (alternative boot mode)

[Table 9] Boot ack, boot data and initialization Time

| Timing Factor                         | Value    |
|---------------------------------------|----------|
| (1) Boot ACK Time                     | < 50 ms  |
| (2) Boot Data Time                    | < 100 ms |
| (3) Initialization Time <sup>1)</sup> | < 3 secs |

NOTE:

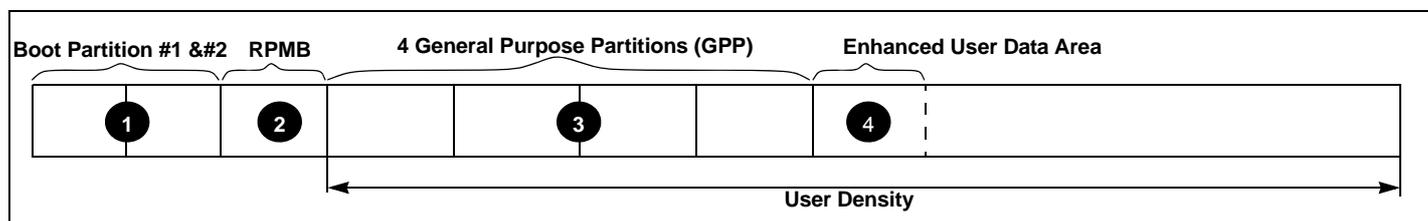
- 1) This initialization time includes partition setting, Please refer to INI\_TIMEOUT\_AP in 6.4 Extended CSD Register. Normal initialization time (without partition setting) is completed within 1sec

### 5.1.3 User Density

Total User Density depends on device type.

For example, 32MB in the SLC Mode requires 96MB in TLC.

This results in decreasing of user density



[Table 10] Capacity according to partition

|        |          | Boot partition 1 | Boot partition 2 | RPMB    |
|--------|----------|------------------|------------------|---------|
| 4,8 GB | Default. | 4,096KB          | 4,096KB          | 512KB   |
|        | Max.     | 4,096KB          | 4,096KB          | 4,096KB |
| 16 GB  | Default. | 4,096KB          | 4,096KB          | 4,096KB |
|        | Max.     | 4,096KB          | 4,096KB          | 4,096KB |

[Table 11] Maximum Enhanced Partition Size

| Device | Max. Enhanced Partition Size |
|--------|------------------------------|
| 4 GB   | 1,300,234,240 Bytes          |
| 8 GB   | 2,600,468,480 Bytes          |
| 16 GB  | 5,100,273,664 Bytes          |

[Table 12] User Density Size

| Device | User Density Size    |
|--------|----------------------|
| 4 GB   | 3,909,091,328 Bytes  |
| 8 GB   | 7,818,182,656 Bytes  |
| 16 GB  | 15,634,268,160 Bytes |

### 5.1.4 Auto Power Saving Mode

If host does not issue any command during a certain duration (1ms), after previously issued command is completed, the device enters "Power Saving mode" to reduce power consumption.

At this time, commands arriving at the device while it is in power saving mode will be serviced in normal fashion

[Table 13] Auto Power Saving Mode enter and exit

| Mode                   | Enter Condition   | Escape Condition           |
|------------------------|---|----------------------------|
| Auto Power Saving Mode | When previous operation which came from Host is completed and no command is issued during a certain time. | If Host issues any command |

[Table 14] Auto Power Saving Mode and Sleep Mode

|                | Auto Power Saving Mode | Sleep Mode |
|----------------|------------------------|------------|
| NAND Power     | ON                     | OFF        |
| GotoSleep Time | < 1ms                  | < 1ms      |

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## 5.1.5 Performance

[Table 15] Performance

| Density | Sequential Read (MB/s) | Sequential Write (MB/s) |
|---------|------------------------|-------------------------|
| 4 GB    | 90                     | 6                       |
| 8 GB    | 100                    |                         |
| 16 GB   | 170                    | 11                      |

\* Test Condition : Bus width x8, 200MHz SDR, 512KB data transfer, w/o file system overhead, measured on Samsung's internal board

## 6.0 REGISTER VALUE

### 6.1 OCR Register

The 32-bit operation conditions register stores the VDD voltage profile of the e-MMC. In addition, this register includes a status information bit. This status bit is set if the e-MMC power up procedure has been finished. The OCR register shall be implemented by all e-MMCs.

[Table 16] OCR Register

| OCR bit | VDD voltage window <sup>2</sup> | Register Value   |
|---------|---------------------------------|--|
| [6:0]   | Reserved                        | 00 00000b  |
| [7]     | 1.70 - 1.95                     | 1b   |
| [14:8]  | 2.0-2.6                         | 000 0000b  |
| [23:15] | 2.7-3.6                         | 1 1111 1111b   |
| [28:24] | Reserved                        | 0 0000b  |
| [30:29] | Access Mode                     | 00b (byte mode) 10b (sector mode) -[*Higher than 2GB only] |
| [31]    |                                 | e-MMC power up status bit (busy) <sup>1</sup>              |

**NOTE :**

- 1) This bit is set to LOW if the e-MMC has not finished the power up routine
- 2) The voltage for internal flash memory(VDDF) should be 2.7-3.6v regardless of OCR Register value.

### 6.2 CID Register

[Table 17] CID Register

| Name                  | Field | Width | CID-slice | CID Value              |
|-----------------------|-------|-------|-----------|------------------------|
| Manufacturer ID       | MID   | 8     | [127:120] | 0x15                   |
| Reserved              |       | 6     | [119:114] | ---                    |
| Card/BGA              | CBX   | 2     | [113:112] | 01                     |
| OEM/Application ID    | OID   | 8     | [111:104] | ... <sup>1</sup>       |
| Product name          | PNM   | 48    | [103:56]  | See Product name table |
| Product revision      | PRV   | 8     | [55:48]   | ... <sup>2</sup>       |
| Product serial number | PSN   | 32    | [47:16]   | ... <sup>3</sup>       |
| Manufacturing date    | MDT   | 8     | [15:8]    | ... <sup>4</sup>       |
| CRC7 checksum         | CRC   | 7     | [7:1]     | ... <sup>5</sup>       |
| not used, always '1'  | -     | 1     | [0:0]     | ---                    |

**NOTE :**

- 1),4),5) description are same as e.MMC JEDEC standard
- 2) PRV is composed of the revision count of controller and the revision count of F/W patch
- 3) A 32 bits unsigned binary integer. (Random Number)

#### 6.2.1 Product name table (In CID Register)

[Table 18] Product name table

| Part Number     | Density | Product Name in CID Register (PNM) |
|-----------------|---------|------------------------------------|
| KLM4G1YEMD-B031 | 4 GB    | 0 x 34594D443352                   |
| KLM8G1WEMB-B031 | 8 GB    | 0 x 38574D423352                   |
| KLMAG2WEMB-B031 | 16 GB   | 0 x 41574D423352                   |

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## 6.3 CSD Register

The Card-Specific Data register provides information on how to access the e-MMC contents. The CSD defines the data format, error correction type, maximum data access time, data transfer speed, whether the DSR register can be used etc. The programmable part of the register (entries marked by W or E, see below) can be changed by CMD27. The type of the entries in the table below is coded as follows:

R : Read only

W: One time programmable and not readable.

R/W: One time programmable and readable.

W/E : Multiple writable with value kept after power failure, H/W reset assertion and any CMD0 reset and not readable.

R/W/E: Multiple writable with value kept after power failure, H/W reset assertion and any CMD0 reset and readable.

R/W/C\_P: Writable after value cleared by power failure and HW/ rest assertion (the value not cleared by CMD0 reset) and readable.

R/W/E\_P: Multiple writable with value reset after power failure, H/W reset assertion and any CMD0 reset and readable.

W/E/\_P: Multiple writable with value reset after power failure, H/W reset assertion and any CMD0 reset and not readable.

[Table 19] CSD Register

| Name   | Field              | Width | Cell Type | CSD-slice | CSD Value |      |       |
|--|--------------------|-------|-----------|-----------|-----------|------|-------|
|  |                    |       |           |           | 4 GB      | 8 GB | 16 GB |
| CSD structure                                    | CSD_STRUCTURE      | 2     | R         | [127:126] | 0x03      |      |       |
| System specification version                     | SPEC_VERS          | 4     | R         | [125:122] | 0x04      |      |       |
| Reserved   | -                  | 2     | R         | [121:120] | -         |      |       |
| Data read access-time 1                          | TAAC               | 8     | R         | [119:112] | 0x27      |      |       |
| Data read access-time 2 in CLK cycles (NSAC*100) | NSAC               | 8     | R         | [111:104] | 0x01      |      |       |
| Max. bus clock frequency                         | TRAN_SPEED         | 8     | R         | [103:96]  | 0x32      |      |       |
| Device command classes                           | CCC                | 12    | R         | [95:84]   | 0xF5      |      |       |
| Max. read data block length                      | READ_BL_LEN        | 4     | R         | [83:80]   | 0x09      |      |       |
| Partial blocks for read allowed                  | READ_BL_PARTIAL    | 1     | R         | [79:79]   | 0x00      |      |       |
| Write block misalignment                         | WRITE_BLK_MISALIGN | 1     | R         | [78:78]   | 0x00      |      |       |
| Read block misalignment                          | READ_BLK_MISALIGN  | 1     | R         | [77:77]   | 0x00      |      |       |
| DSR implemented                                  | DSR_IMP            | 1     | R         | [76:76]   | 0x00      |      |       |
| Reserved   | -                  | 2     | R         | [75:74]   | -         |      |       |
| Device size                                      | C_SIZE             | 12    | R         | [73:62]   | 0xFFFF    |      |       |
| Max. read current @ VDD min                      | VDD_R_CURR_MIN     | 3     | R         | [61:59]   | 0x06      |      |       |
| Max. read current @ VDD max                      | VDD_R_CURR_MAX     | 3     | R         | [58:56]   | 0x06      |      |       |
| Max. write current @ VDD min                     | VDD_W_CURR_MIN     | 3     | R         | [55:53]   | 0x06      |      |       |
| Max. write current @ VDD max                     | VDD_W_CURR_MAX     | 3     | R         | [52:50]   | 0x06      |      |       |
| Device size multiplier                           | C_SIZE_MULT        | 3     | R         | [49:47]   | 0x07      |      |       |
| Erase group size                                 | ERASE_GRP_SIZE     | 5     | R         | [46:42]   | 0x1F      |      |       |
| Erase group size multiplier                      | ERASE_GRP_MULT     | 5     | R         | [41:37]   | 0x1F      |      |       |
| Write protect group size                         | WP_GRP_SIZE        | 5     | R         | [36:32]   | 0x0F      |      |       |
| Write protect group enable                       | WP_GRP_ENABLE      | 1     | R         | [31:31]   | 0x01      |      |       |
| Manufacturer default ECC                         | DEFAULT_ECC        | 2     | R         | [30:29]   | 0x00      |      |       |
| Write speed factor                               | R2W_FACTOR         | 3     | R         | [28:26]   | 0x03      |      |       |
| Max. write data block length                     | WRITE_BL_LEN       | 4     | R         | [25:22]   | 0x09      |      |       |
| Partial blocks for write allowed                 | WRITE_BL_PARTIAL   | 1     | R         | [21:21]   | 0x00      |      |       |
| Reserved   | -                  | 4     | R         | [20:17]   | -         |      |       |
| Content protection application                   | CONTENT_PROT_APP   | 1     | R         | [16:16]   | 0x00      |      |       |
| File format group                                | FILE_FORMAT_GRP    | 1     | R/W       | [15:15]   | 0x00      |      |       |
| Copy flag (OTP)                                  | COPY               | 1     | R/W       | [14:14]   | 0x01      |      |       |
| Permanent write protection                       | PERM_WRITE_PROTECT | 1     | R/W       | [13:13]   | 0x00      |      |       |
| Temporary write protection                       | TMP_WRITE_PROTECT  | 1     | R/W/E     | [12:12]   | 0x00      |      |       |
| File format                                      | FILE_FORMAT        | 2     | R/W       | [11:10]   | 0x00      |      |       |
| ECC code   | ECC                | 2     | R/W/E     | [9:8]     | 0x00      |      |       |
| CRC  | CRC                | 7     | R/W/E     | [7:1]     | -         |      |       |
| Not used, always '1'                             | -                  | 1     | —         | [0:0]     | -         |      |       |

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## 6.4 Extended CSD Register

The Extended CSD register defines the e·MMC properties and selected modes. It is 512 bytes long.

The most significant 320 bytes are the Properties segment, which defines the e·MMC capabilities and cannot be modified by the host. The lower 192 bytes are the Modes segment, which defines the configuration the e·MMC is working in. These modes can be changed by the host by means of the SWITCH command.

R : Read only

W: One time programmable and not readable.

R/W: One time programmable and readable.

W/E : Multiple writable with value kept after power failure, H/W reset assertion and any CMD0 reset and not readable.

R/W/E: Multiple writable with value reset after power failure, H/W reset assertion and any CMD0 reset and readable.

R/W/C\_P: Writable after value cleared by power failure and HW/ rest assertion (the value not cleared by CMD0 reset) and readable.

R/W/E\_P: Multiple writable with value reset after power failure, H/W reset assertion and any CMD0 reset and readable.

W/E/\_P: Multiple writable with value reset after power failure, H/W reset assertion and any CMD0 reset and not readable

[Table 20] Extended CSD Register

| Name                                    | Field                            | Size (Bytes) | Cell Type | CSD-slice | CSD Value     |      |       |
|---|----------------------------------|--------------|-----------|-----------|---------------|------|-------|
|   |                                  |              |           |           | 4 GB          | 8 GB | 16 GB |
| Properties Segment                      |                                  |              |           |           |               |      |       |
| Reserved <sup>1</sup>                   |                                  | 6            | -         | [511:506] | -             |      |       |
| Extended Security Commands Error        | EXT_SECURITY_ERR                 | 1            | R         | [505]     | 0x00          |      |       |
| Supported Command Sets                  | S_CMD_SET                        | 1            | R         | [504]     | 0x01          |      |       |
| HPI features                            | HPI_FEATURES                     | 1            | R         | [503]     | 0x01          |      |       |
| Background operations support           | BKOPS_SUPPORT                    | 1            | R         | [502]     | 0x01          |      |       |
| Max packed read commands                | MAX_PACKED_READS                 | 1            | R         | [501]     | 0x3F          |      |       |
| Max packed write commands               | MAX_PACKED_WRITES                | 1            | R         | [500]     | 0x3F          |      |       |
| Data Tag Support                        | DATA_TAG_SUPPORT                 | 1            | R         | [499]     | 0x01          |      |       |
| Tag Unit Size                           | TAG_UNIT_SIZE                    | 1            | R         | [498]     | 0x04          |      |       |
| Tag Resources Size                      | TAG_RES_SIZE                     | 1            | R         | [497]     | 0x00          |      |       |
| Context management capabilities         | CONTEXT_CAPABILITIES             | 1            | R         | [496]     | 0x05          |      |       |
| Large Unit size                         | LARGE_UNIT_SIZE_M1               | 1            | R         | [495]     | 0x07          |      |       |
| Extended partitions attribute support   | EXT_SUPPORT                      | 1            | R         | [494]     | 0x03          |      |       |
| Supported modes                         | SUPPORTED_MODES                  | 1            | R         | [493]     | 0x03          |      |       |
| FFU features                            | FFU_FEATURES                     | 1            | R         | [492]     | 0x00          |      |       |
| Operation codes timeout                 | OPERATION_CODE_TIMEOUT           | 1            | R         | [491]     | 0x00          |      |       |
| FFU Argument                            | FFU_ARG                          | 4            | R         | [490:487] | 0x00          |      |       |
| Reserved <sup>1</sup>                   |                                  | 181          | -         | [486:306] | -             |      |       |
| Number of received sectors              | NUMBER_OF_RECEIVED_SECTORS       | 4            | R         | [305:302] | 0x00          |      |       |
| Vendor proprietary health report        | VENDOR_PROPRIETARY_HEALTH_REPORT | 32           | R         | [301:270] | 0x00          |      |       |
| Device life time estimation type B      | DEVICE_LIFE_TIME_EST_TYP_B       | 1            | R         | [269]     | 0x01          |      |       |
| Device life time estimation type A      | DEVICE_LIFE_TIME_EST_TYP_A       | 1            | R         | [268]     | 0x01          |      |       |
| Pre EOL information                     | PRE_EOL_INFO                     | 1            | R         | [267]     | 0x01          |      |       |
| Optimal read size                       | OPTIMAL_READ_SIZE                | 1            | R         | [266]     | 0x00          |      |       |
| Optimal write size                      | OPTIMAL_WRITE_SIZE               | 1            | R         | [265]     | 0x04          | 0x08 |       |
| Optimal trim unit size                  | OPTIMAL_TRIM_UNIT_SIZE           | 1            | R         | [264]     | 0x01          |      |       |
| Device version                          | DEVICE_VERSION                   | 2            | R         | [263:262] | 0x00          |      |       |
| Firmware version                        | FIRMWARE_VERSION                 | 8            | R         | [261:254] | FW Patch Ver. |      |       |
| Power class for 200MHz, DDR at VCC=3.6V | PWR_CL_DDR_200_360               | 1            | R         | [253]     | 0x00          |      |       |
| Cache size                              | CACHE_SIZE                       | 4            | R         | [252:249] | 0x00010000    |      |       |
| Generic CMD6 timeout                    | GENERIC_CMD6_TIME                | 1            | R         | [248]     | 0x0A          |      |       |

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|  |                                    |   |   |           |          |          |           |
|--|------------------------------------|---|---|-----------|----------|----------|-----------|
| Power off notification(long) timeout                           | POWER_OFF_LONG_TIME                | 1 | R | [247]     | 0x3C     |          |           |
| Background operations status                                   | BKOPS_STATUS                       | 1 | R | [246]     | 0x00     |          |           |
| Number of correctly programmed sectors                         | CORRECTLY_PRG_SECTORS_NUM          | 4 | R | [245:242] | 0x00     |          |           |
| 1st initialization time after partitioning                     | INI_TIMEOUT_AP                     | 1 | R | [241]     | 0x1E     |          |           |
| Reserved <sup>1</sup>  |                                    | 1 | - | [240]     | -        |          |           |
| Power class for 52MHz, DDR at Vcc = 3.6V                       | PWR_CL_DDR_52_360                  | 1 | R | [239]     | 0x00     |          |           |
| Power class for 52MHz, DDR at Vcc = 1.95V                      | PWR_CL_DDR_52_195                  | 1 | R | [238]     | 0x00     |          |           |
| Power class for 200MHz at Vccq = 1.95V, Vcc = 3.6V             | PWR_CL_200_195                     | 1 | R | [237]     | 0x00     |          |           |
| Power class for 200MHz, at Vccq = 1.3V, Vcc = 3.6V             | PWR_CL_200_130                     | 1 | R | [236]     | 0x00     |          |           |
| Minimum Write Performance for 8bit at 52MHz in DDR mode        | MIN_PERF_DDR_W_8_52                | 1 | R | [235]     | 0x00     |          |           |
| Minimum Read Performance for 8bit at 52MHz in DDR mode         | MIN_PERF_DDR_R_8_52                | 1 | R | [234]     | 0x00     |          |           |
| Reserved <sup>1</sup>  |                                    | 1 | - | [233]     | -        |          |           |
| TRIM Multiplier  | TRIM_MULT                          | 1 | R | [232]     | 0x02     |          |           |
| Secure Feature support   | SEC_FEATURE_SUPPORT                | 1 | R | [231]     | 0x55     |          |           |
| Secure Erase Multiplier  | SEC_ERASE_MULT                     | 1 | R | [230]     | 0x1B     |          |           |
| Secure TRIM Multiplier   | SEC_TRIM_MULT                      | 1 | R | [229]     | 0x11     |          |           |
| Boot information   | BOOT_INFO                          | 1 | R | [228]     | 0x07     |          |           |
| Reserved <sup>1</sup>  |                                    | 1 | - | [227]     | -        |          |           |
| Boot partition size  | BOOT_SIZE_MULT                     | 1 | R | [226]     | 0x20     |          |           |
| Access size  | ACC_SIZE                           | 1 | R | [225]     | 0x06     | 0x07     |           |
| High-capacity erase unit size                                  | HC_ERASE_GRP_SIZE                  | 1 | R | [224]     | 0x01     |          |           |
| High-capacity erase timeout                                    | ERASE_TIMEOUT_MULT                 | 1 | R | [223]     | 0x01     |          |           |
| Reliable write sector count                                    | REL_WR_SEC_C                       | 1 | R | [222]     | 0x01     |          |           |
| High-capacity write protect group size                         | HC_WP_GRP_SIZE                     | 1 | R | [221]     | 0x10     |          |           |
| Sleep current (VCC)  | S_C_VCC                            | 1 | R | [220]     | 0x07     |          |           |
| Sleep current (VCCQ)   | S_C_VCCQ                           | 1 | R | [219]     | 0x07     |          |           |
| Product state awareness timeout                                | PRODUCTION_STATE_AWARENESS_TIMEOUT | 1 | R | [218]     | 0x00     |          |           |
| Sleep/awake timeout  | S_A_TIMEOUT                        | 1 | R | [217]     | 0x11     |          |           |
| Sleep Notification Timeout                                     | SLEEP_NOTIFICATION_TIME            | 1 | R | [216]     | 0x07     |          |           |
| Sector Count   | SEC_COUNT                          | 4 | R | [215:212] | 0x748000 | 0xE90000 | 0x1D1F000 |
| Reserved <sup>1</sup>  |                                    | 1 | - | [211]     | -        |          |           |
| Minimum Write Performance for 8bit at 52MHz                    | MIN_PERF_W_8_52                    | 1 | R | [210]     | 0x00     |          |           |
| Minimum Read Performance for 8bit at 52MHz                     | MIN_PERF_R_8_52                    | 1 | R | [209]     | 0x00     |          |           |
| Minimum Write Performance for 8bit at 26MHz, for 4bit at 52MHz | MIN_PERF_W_8_26_4_52               | 1 | R | [208]     | 0x00     |          |           |
| Minimum Read Performance for 8bit at 26MHz, for 4bit at 52MHz  | MIN_PERF_R_8_26_4_52               | 1 | R | [207]     | 0x00     |          |           |
| Minimum Write Performance for 4bit at 26MHz                    | MIN_PERF_W_4_26                    | 1 | R | [206]     | 0x00     |          |           |
| Minimum Read Performance for 4bit at 26MHz                     | MIN_PERF_R_4_26                    | 1 | R | [205]     | 0x00     |          |           |
| Reserved <sup>1</sup>  |                                    | 1 | - | [204]     | -        |          |           |
| Power class for 26MHz at 3.6V 1 R                              | PWR_CL_26_360                      | 1 | R | [203]     | 0x00     |          |           |

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|   |                       |   |                        |       |      |      |
|---|-----------------------|---|------------------------|-------|------|------|
| Power class for 52MHz at 3.6V 1 R         | PWR_CL_52_360         | 1 | R                      | [202] | 0x00 |      |
| Power class for 26MHz at 1.95V 1 R        | PWR_CL_26_195         | 1 | R                      | [201] | 0x00 |      |
| Power class for 52MHz at 1.95V 1 R        | PWR_CL_52_195         | 1 | R                      | [200] | 0x00 |      |
| Partition switching timing                | PARTITION_SWITCH_TIME | 1 | R                      | [199] | 0x01 |      |
| Out-of-interrupt busy timing              | OUT_OF_INTERRUPT_TIME | 1 | R                      | [198] | 0x05 |      |
| I/O Driver Strength CSD structure version | DRIVER_STRENGTH       | 1 | R                      | [197] | 0x1F |      |
| Device type                               | DEVICE_TYPE           | 1 | R                      | [196] | 0x57 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [195] | -    |      |
| CSD structure version                     | CSD_STRUCTURE         | 1 | R                      | [194] | 0x02 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [193] | -    |      |
| Extended CSD revision                     | EXT_CSD_REV           | 1 | R                      | [192] | 0x07 |      |
| Modes Segment                             |                       |   |                        |       |      |      |
| Command set                               | CMD_SET               | 1 | R/W/E_P                | [191] | 0x00 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [190] | -    |      |
| Command set revision                      | CMD_SET_REV           | 1 | R                      | [189] | 0x00 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [188] | -    |      |
| Power class                               | POWER_CLASS           | 1 | R/W/E_P                | [187] | 0x00 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [186] | -    |      |
| High-speed interface timing               | HS_TIMING             | 1 | R/W/E_P                | [185] | 0x00 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [184] | -    |      |
| Bus width mode                            | BUS_WIDTH             | 1 | W/E_P                  | [183] | 0x00 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [182] | -    |      |
| Erased memory content                     | ERASED_MEM_CONT       | 1 | R                      | [181] | 0x00 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [180] | -    |      |
| Partition configuration                   | PARTITION_CONFIG      | 1 | R/W/E & R/W/E_P        | [179] | 0x00 |      |
| Boot config protection                    | BOOT_CONFIG_PROT      | 1 | R/W & R/W/C_P          | [178] | 0x00 |      |
| Boot bus Conditions                       | BOOT_BUS_CONDITIONS   | 1 | R/W/E                  | [177] | 0x00 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [176] | -    |      |
| High-density erase group definition       | ERASE_GROUP_DEF       | 1 | R/W/E_P                | [175] | 0x00 |      |
| Boot write protection status registers    | BOOT_WP_STATUS        | 1 | R                      | [174] | 0x00 |      |
| Boot area write protection register       | BOOT_WP               | 1 | R/W & R/W/C_P          | [173] | 0x00 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [172] | -    |      |
| User area write protection register       | USER_WP               | 1 | R/W, R/W/C_P & R/W/E_P | [171] | 0x00 |      |
| Reserved <sup>1</sup>                     |                       | 1 | -                      | [170] | -    |      |
| FW configuration                          | FW_CONFIG             | 1 | R/W                    | [169] | 0x00 |      |
| RPMB Size                                 | RPMB_SIZE_MULT        | 1 | R                      | [168] | 0x04 | 0x20 |
| Write reliability setting register        | WR_REL_SET            | 1 | R/W                    | [167] | 0x1F |      |
| Write reliability parameter register      | WR_REL_PARAM          | 1 | R                      | [166] | 0x04 |      |
| Start Sanitize operation                  | SANITIZE_START        | 1 | W/E_P                  | [165] | 0x00 |      |
| Manually start background operations      | BKOPS_START           | 1 | W/E_P                  | [164] | 0x00 |      |
| Enable background operations handshake    | BKOPS_EN              | 1 | R/W                    | [163] | 0x00 |      |
| H/W reset function                        | RST_n_FUNCTION        | 1 | R/W                    | [162] | 0x00 |      |
| HPI management                            | HPI_MGMT              | 1 | R/W/E_P                | [161] | 0x00 |      |

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|  |                                    |    |           |           |      |       |       |
|--|------------------------------------|----|-----------|-----------|------|-------|-------|
| Partitioning Support                                     | PARTITIONING_SUPPORT               | 1  | R         | [160]     | 0x07 |       |       |
| Max Enhanced Area Size                                   | MAX_ENH_SIZE_MULT                  | 3  | R         | [159:157] | 0x9B | 0x136 | 0x26D |
| Partitions attribute                                     | PARTITIONS_ATTRIBUTE               | 1  | R/W       | [156]     | 0x00 |       |       |
| Partitioning Setting                                     | PARTITION_SETTING_COMPLETED        | 1  | R/W       | [155]     | 0x00 |       |       |
| General Purpose Partition Size                           | GP_SIZE_MULT                       | 12 | R/W       | [154:143] | 0x00 |       |       |
| Enhanced User Data Area Size                             | ENH_SIZE_MULT                      | 3  | R/W       | [142:140] | 0x00 |       |       |
| Enhanced User Data Start Address                         | ENH_START_ADDR                     | 4  | R/W       | [139:136] | 0x00 |       |       |
| Reserved <sup>1</sup>                                    |                                    | 1  | -         | [135]     | -    |       |       |
| Bad Block Management mode                                | SEC_BAD_BLK_MGMNT                  | 1  | R/W       | [134]     | 0x00 |       |       |
| Production state awareness                               | PRODUCTION_STATE_AWARENESS         | 1  | R/W/E     | [133]     | 0x00 |       |       |
| Package Case Temperature is controlled                   | TCASE_SUPPORT                      | 1  | W/E_P     | [132]     | 0x00 |       |       |
| Periodic Wake-up   | PERIODIC_WAKEUP                    | 1  | R/W/E     | [131]     | 0x00 |       |       |
| Program CID/CSD in DDR mode support                      | PROGRAM_CID_CSD_DDR_SUPPORT        | 1  | R         | [130]     | 0x01 |       |       |
| Reserved <sup>1</sup>                                    |                                    | 64 | -         | [129:66]  | -    |       |       |
| Optimized Features                                       | OPTIMIZED_FEATURES                 | 2  | R         | [65:64]   | 0x0F |       |       |
| Native sector size                                       | NATIVE_SECTOR_SIZE                 | 1  | R         | [63]      | 0x00 |       |       |
| Sector size emulation                                    | USE_NATIVE_SECTOR                  | 1  | R/W       | [62]      | 0x00 |       |       |
| Sector size  | DATA_SECTOR_SIZE                   | 1  | R         | [61]      | 0x00 |       |       |
| 1st initialization after disabling sector size emulation | INI_TIMEOUT_EMU                    | 1  | R         | [60]      | 0x00 |       |       |
| Class 6 commands control                                 | CLASS_6_CTRL                       | 1  | R/W/E_P   | [59]      | 0x00 |       |       |
| Number of addressed group to be Released                 | DYNCAP_NEEDED                      | 1  | R         | [58]      | 0x00 |       |       |
| Exception events control                                 | EXCEPTION_EVENTS_CTRL              | 2  | R/W/E_P   | [57:56]   | 0x00 |       |       |
| Exception events status                                  | EXCEPTION_EVENTS_STATUSES          | 2  | R         | [55:54]   | 0x00 |       |       |
| Extended Partitions Attribute                            | EXT_PARTITIONS_ATTRIBUTE           | 2  | R/W       | [53:52]   | 0x00 |       |       |
| Context configuration                                    | CONTEXT_CONF                       | 15 | R/W/E_P   | [51:37]   | 0x00 |       |       |
| Packed command status                                    | PACKED_COMMAND_STATUS              | 1  | R         | [36]      | 0x00 |       |       |
| Packed command failure index                             | PACKED_FAILURE_INDEX               | 1  | R         | [35]      | 0x00 |       |       |
| Power Off Notification                                   | POWER_OFF_NOTIFICATION             | 1  | R/W/E_P   | [34]      | 0x00 |       |       |
| Control to turn the Cache ON/OFF                         | CACHE_CTRL                         | 1  | R/W/E_P   | [33]      | 0x00 |       |       |
| Flushing of the cache                                    | FLUSH_CACHE                        | 1  | W/E_P     | [32]      | 0x00 |       |       |
| Reserved <sup>1</sup>                                    |                                    | 1  | -         | [31]      | -    |       |       |
| Mode config  | MODE_CONFIG                        | 1  | R/W/E_P   | [30]      | 0x00 |       |       |
| Mode operation codes                                     | MODE_OPERATION_CODES               | 1  | W/E_P     | [29]      | 0x00 |       |       |
| Reserved <sup>1</sup>                                    |                                    | 2  | -         | [28:27]   | -    |       |       |
| FFU status   | FFU_STATUS                         | 1  | R         | [26]      | 0x00 |       |       |
| Pre loading data size                                    | PRE_LOADING_DATA_SIZE              | 4  | R/W/E_P   | [25:22]   | 0x00 |       |       |
| Max pre loading data size                                | MAX_PRE_LOADING_DATA_SIZE          | 4  | R         | [21:18]   | 0x00 |       |       |
| Product state awareness enablement                       | PRODUCT_STATE_AWARENESS_ENABLEMENT | 1  | R/W/E & R | [17]      | 0x00 |       |       |
| Secure Removal Type                                      | SECURE_REMOVAL_TYPE                | 1  | R/W & R   | [16]      | 0x09 |       |       |
| Reserved <sup>1</sup>                                    |                                    | 16 | -         | [15:0]    | -    |       |       |

**NOTE :**

1) Reserved bits should be read as "0."

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## 7.0 AC PARAMETER

### 7.1 Timing Parameter

[Table 21] Timing Parameter

| Timing Parameter                         |                                       | Max. Value | Unit |
|--|---------------------------------------|------------|------|
| Initialization Time (tINIT)              | Normal <sup>1)</sup>                  | 1          | s    |
|  | After partition setting <sup>2)</sup> | 3          | s    |
| Read Timeout                             |                                       | 100        | ms   |
| Write Timeout                            |                                       | 350        | ms   |
| Erase Timeout                            |                                       | 20         | ms   |
| Force Erase Timeout                      |                                       | 3          | min  |
| Secure Erase Timeout                     |                                       | 8          | s    |
| Secure Trim step1 Timeout                |                                       | 5          | s    |
| Secure Trim step2 Timeout                |                                       | 3          | s    |
| Trim Timeout                             |                                       | 600        | ms   |
| Partition Switching Timeout (after Init) |                                       | 1          | ms   |
| Power Off Notification (Short) Timeout   |                                       | 100        | ms   |
| Power Off Notification (Long) Timeout    |                                       | 600        | ms   |

**NOTE:**

1) Normal Initialization Time without partition setting

2) Initialization Time after partition setting, refer to INI\_TIMEOUT\_AP in 6.4 EXT\_CSD register

3) Be advised Timeout Values specified in Table above are for testing purposes under Samsung test pattern only and actual timeout situations may vary

4) EXCEPTION\_EVENT may occur and the actual timeout values may vary due to user environment

### 7.2 Previous Bus Timing Parameters for DDR52 and HS200 mode are defined by JEDEC standard

## 7.3 Bus Timing Specification in HS400 mode

### 7.3.1 HS400 Device Input Timing

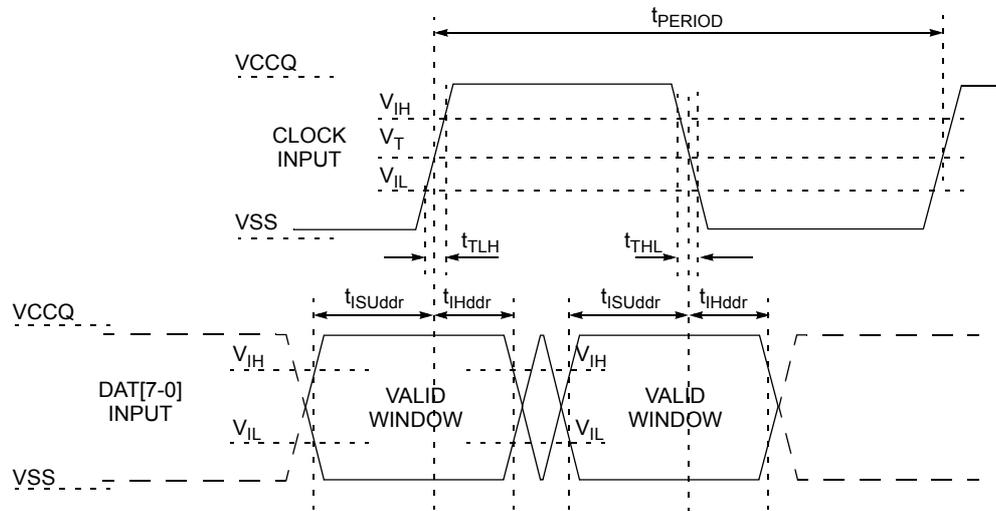


Figure 6. HS400 Device Input Timing

**NOTE:**

- 1)  $t_{ISU}$  and  $t_{IH}$  are measured at  $V_{IL}(\text{max.})$  and  $V_{IH}(\text{min.})$ .
- 2)  $V_{IH}$  denotes  $V_{IH}(\text{min.})$  and  $V_{IL}$  denotes  $V_{IL}(\text{max.})$

[Table 22] HS400 Device input timing

| Parameter                     | Symbol             | Min | Max.                          | Unit |
|-------------------------------|--------------------|-----|-------------------------------|------|
| Input CLK                     |                    |     |                               |      |
| Cycle time data transfer mode | $t_{PERIOD}$       | 5   | -                             | ns   |
| Clock rising / falling time   | $t_{TLH}, t_{THL}$ | -   | $0.1 \cdot t_{PERIOD} (=0.5)$ | ns   |
| Clock duty cycle              |                    | 46  | 54                            | %    |
| Input DAT (referenced to CLK) |                    |     |                               |      |
| Input set-up time             | $t_{ISUddr}$       | 0.4 |                               | ns   |
| Input hold time               | $t_{IHddr}$        | 0.4 |                               | ns   |

**NOTE :**

- 1) It is being discussed in JEDEC and is not confirmed yet. It can be modified according to JEDEC standard in the future.

## 7.3.2 HS400 Device Output Timing

Data Strobe is used to read data (data read and CRC status response read) in HS400 mode. The device output value of Data Strobe is "High-Z" when the device is not in outputting data (data read, CRC status response). Data Strobe is toggled only during data read period.

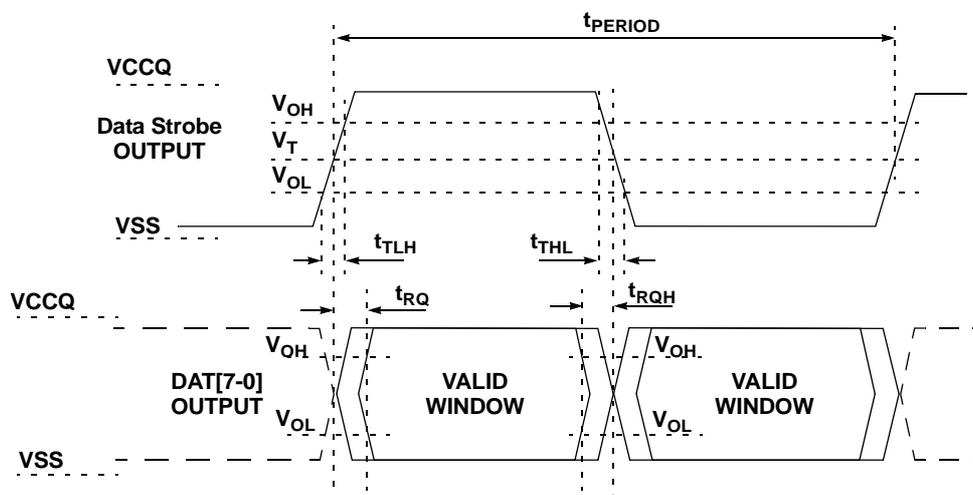


Figure 7. HS400 Device Output Timing

## NOTE:

$V_{OH}$  denotes  $V_{OH(min.)}$  and  $V_{OL}$  denotes  $V_{OL(max.)}$ .

[Table 23] HS400 Device Output timing

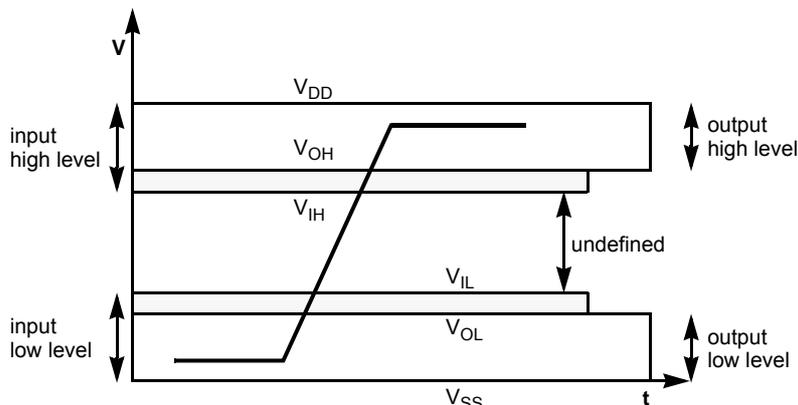
| Parameter                              | Symbol                | Min | Max.                           | Unit |
|--|-----------------------|-----|--------------------------------|------|
| Output Data Strobe                     |                       |     |                                |      |
| Cycle time data transfer mode          | $t_{PERIOD}$          | 5   | -                              | ns   |
| Clock rising/falling time              | $t_{TLH}$ , $t_{THL}$ | -   | $0.16 \cdot t_{PERIOD} (=0.8)$ | ns   |
| Clock duty cycle                       |                       | 42  | 58                             | %    |
| Output DAT (referenced to Data Strobe) |                       |     |                                |      |
| Output hold skew                       | $t_{RQ}$              |     | 0.4                            | ns   |
| Output hold time                       | $t_{RQH}$             |     | 0.4                            | ns   |

## NOTE :

1) It is being discussed in JEDEC and is not confirmed yet. It can be modified according to JEDEC standard in the future.

## 7.4 Bus signal levels

As the bus can be supplied with a variable supply voltage, all signal levels are related to the supply voltage.



### 7.4.1 Open-drain mode bus signal level

[Table 24] Open-drain bus signal level

| Parameter           | Symbol   | Min            | Max. | Unit | Conditions              |
|---------------------|----------|----------------|------|------|-------------------------|
| Output HIGH voltage | $V_{OH}$ | $V_{DD} - 0.2$ | -    | V    | 1)                      |
| Output LOW voltage  | $V_{OL}$ | -              | 0.3  | V    | $I_{OL} = 2 \text{ mA}$ |

**NOTE:**

1) Because  $V_{oh}$  depends on external resistance value (including outside the package), this value does not apply as device specification. Host is responsible to choose the external pull-up and open drain resistance value to meet  $V_{oh}$  Min value.

### 7.4.2 Push-pull mode bus signal level eMMC

The device input and output voltages shall be within the following specified ranges for any  $V_{DD}$  of the allowed voltage range

[Table 25] Push-pull signal level—high-voltage eMMC

| Parameter           | Symbol   | Min                   | Max.                  | Unit | Conditions                                       |
|---------------------|----------|-----------------------|-----------------------|------|--|
| Output HIGH voltage | $V_{OH}$ | $0.75 \cdot V_{CCQ}$  | -                     | V    | $I_{OH} = -100 \text{ uA} @ V_{CCQ} \text{ min}$ |
| Output LOW voltage  | $V_{OL}$ | -                     | $0.125 \cdot V_{CCQ}$ | V    | $I_{OL} = 100 \text{ uA} @ V_{CCQ} \text{ min}$  |
| Input HIGH voltage  | $V_{IH}$ | $0.625 \cdot V_{CCQ}$ | $V_{CCQ} + 0.3$       | V    | -  |
| Input LOW voltage   | $V_{IL}$ | $V_{SS} - 0.3$        | $0.25 \cdot V_{CCQ}$  | V    | -  |

[Table 26] Push-pull signal level—1.70 - 1.95  $V_{CCQ}$  voltage Range

| Parameter           | Symbol   | Min                                | Max.                               | Unit | Conditions      |
|---------------------|----------|------------------------------------|------------------------------------|------|-----------------|
| Output HIGH voltage | $V_{OH}$ | $V_{CCQ} - 0.45V$                  | -                                  | V    | $I_{OH} = -2mA$ |
| Output LOW voltage  | $V_{OL}$ | -                                  | 0.45V                              | V    | $I_{OL} = 2mA$  |
| Input HIGH voltage  | $V_{IH}$ | $0.65 \cdot V_{CCQ}$ <sup>1)</sup> | $V_{CCQ} + 0.3$                    | V    | -               |
| Input LOW voltage   | $V_{IL}$ | $V_{SS} - 0.3$                     | $0.35 \cdot V_{CCQ}$ <sup>2)</sup> | V    | -               |

**NOTE:**

1)  $0.7 \cdot V_{CCQ}$  for MMC4.3 and older revisions.

2)  $0.3 \cdot V_{CCQ}$  for MMC4.3 and older revisions.

**IF THERE IS ANY OTHER OPERATION TO IMPLEMENT IN ADDITION TO SPECIFICATION IN THE DATASHEET OR JEDEC STANDARD, PLEASE CONTACT EACH BRANCH OFFICE OR HEADQUARTERS OF SAMSUNG ELECTRONICS.**

## 8.0 DC PARAMETER

### 8.1 Active Power Consumption during operation

[Table 27] Active Power Consumption during operation

| Density | NAND Type | CTRL | NAND | Unit |
|---------|-----------|------|------|------|
| 4 GB    | 32 Gb x 1 | 150  | 80   | mA   |
| 8 GB    | 64 Gb x 1 |      | 130  |      |
| 16 GB   | 64 Gb x 2 |      |      |      |

\* Power Measurement conditions: Bus configuration =x8 @200MHz DDR

\* The measurement for max RMS current is the average RMS current consumption over a period of 100ms.

### 8.2 Standby Power Consumption in auto power saving mode and standby state.

[Table 28] Standby Power Consumption in auto power saving mode and standby state

| Density | NAND Type | CTRL      |      | NAND      |      | Unit |
|---------|-----------|-----------|------|-----------|------|------|
|         |           | 25°C(Typ) | 85°C | 25°C(Typ) | 85°C |      |
| 4 GB    | 32 Gb x 1 | 120       | 400  | 40        | 85   | uA   |
| 8 GB    | 64 Gb x 1 |           |      | 50        | 135  |      |
| 16 GB   | 64 Gb x 2 |           |      |           |      |      |

**NOTE:**

Power Measurement conditions: Bus configuration =x8, No CLK

\*Typical value is measured at Vcc=3.3V, TA=25°C. Not 100% tested.

### 8.3 Sleep Power Consumption in Sleep State

[Table 29] Sleep Power Consumption in Sleep State

| Density | NAND Type | CTRL      |      | NAND            | Unit |
|---------|-----------|-----------|------|-----------------|------|
|         |           | 25°C(Typ) | 85°C |                 |      |
| 4 GB    | 32 Gb x 1 | 120       | 400  | 0 <sup>1)</sup> | uA   |
| 8 GB    | 64 Gb x 1 |           |      |                 |      |
| 16 GB   | 64 Gb x 2 |           |      |                 |      |

**NOTE:**

Power Measurement conditions: Bus configuration =x8, No CLK

1) In auto power saving mode, NAND power can not be turned off. However in sleep mode NAND power can be turned off. If NAND power is alive, NAND power is same with that of the Standby state.

### 8.4 Supply Voltage

[Table 30] Supply voltage

| Item                                | Min        | Max        | Unit |
|-------------------------------------|------------|------------|------|
| V <sub>DD</sub> (V <sub>CCQ</sub> ) | 1.70 (2.7) | 1.95 (3.6) | V    |
| V <sub>DDF</sub> (V <sub>CC</sub> ) | 2.7        | 3.6        | V    |
| V <sub>SS</sub>                     | -0.5       | 0.5        | V    |

IF THERE IS ANY OTHER OPERATION TO IMPLEMENT IN ADDITION TO SPECIFICATION IN THE DATASHEET OR JEDEC STANDARD, PLEASE CONTACT EACH BRANCH OFFICE OR HEADQUARTERS OF SAMSUNG ELECTRONICS.

## 8.5 Bus Signal Line Load

The total capacitance  $C_L$  of each line of the e-MMC bus is the sum of the bus master capacitance  $C_{HOST}$ , the bus capacitance  $C_{BUS}$  itself and the capacitance  $C_{DEVICE}$  of the e-MMC connected to this line:

$$C_L = C_{HOST} + C_{BUS} + C_{DEVICE}$$

The sum of the host and bus capacitances should be under 20pF.

[Table 31] Bus Signal Line Load

| Parameter                             | Symbol       | Min | Typ. | Max | Unit | Remark                                |
|---------------------------------------|--------------|-----|------|-----|------|---------------------------------------|
| Pull-up resistance for CMD            | $R_{CMD}$    | 4.7 |      | 100 | KOhm | to prevent bus floating               |
| Pull-up resistance for DAT0-DAT7      | $R_{DAT}$    | 10  |      | 100 | KOhm | to prevent bus floating               |
| Internal pull up resistance DAT1-DAT7 | $R_{int}$    | 10  |      | 150 | KOhm | to prevent unconnected lines floating |
| Single Device capacitance             | $C_{DEVICE}$ |     |      | 12  | pF   |                                       |
| Maximum signal line inductance        |              |     |      | 16  | nH   | $f_{PP} \leq 52$ MHz                  |

[Table 32] Capacitance and Resistance for HS400 mode

| Parameter                            | Symbol             | Min | Typ | Max | Unit | Remark        |
|--------------------------------------|--------------------|-----|-----|-----|------|---------------|
| Bus signal line capacitance          | CL                 |     |     | 13  | pF   | Single Device |
| Single Device capacitance            | $C_{DEVICE}$       |     |     | 6   | pF   |               |
| Pull-down resistance for Data Strobe | $R_{Data\ Strobe}$ | 10  |     | 100 | KOhm |               |