

Samsung eMMC Product family

eMMC 4.41 Specification compatibility

datasheet

SAMSUNG ELECTRONICS RESERVES THE RIGHT TO CHANGE PRODUCTS, INFORMATION AND SPECIFICATIONS WITHOUT NOTICE.

Products and specifications discussed herein are for reference purposes only. All information discussed herein is provided on an "AS IS" basis, without warranties of any kind.

This document and all information discussed herein remain the sole and exclusive property of Samsung Electronics. No license of any patent, copyright, mask work, trademark or any other intellectual property right is granted by one party to the other party under this document, by implication, estoppel or otherwise.

Samsung products are not intended for use in life support, critical care, medical, safety equipment, or similar applications where product failure could result in loss of life or personal or physical harm, or any military or defense application, or any governmental procurement to which special terms or provisions may apply.

For updates or additional information about Samsung products, contact your nearest Samsung office.

All brand names, trademarks and registered trademarks belong to their respective owners.

©2011 Samsung Electronics Co., Ltd. All rights reserved.

Revision History

<u>Revision No.</u>	<u>History</u>	<u>Draft Date</u>	<u>Remark</u>	<u>Editor</u>
0.0	1. Initial issue	Sep. 28, 2011	Target	S.M.Lee
1.0	1. Initialization time is deleted in Table 22 2. Performance is updated with measured value in Chapter 5.2.3 3. SEC_TRIM_MULT is changed to 0x11 in Chapter 6.4 4. Write Timeout is updated in Chapter 7.1	Nov. 16, 2011	Final	S.M.Lee
1.1	1. Max. Enhanced Partition Size of 16GB is changed in Table 25 2. MAX_ENH_SIZE_MULT of 16GB is changed to 0xBA in Chapter 6.4	Dec. 12, 2011	Final	S.M.Lee

Revision History Appendix(1.0)

Before(ver.0.0)							After(ver.1.0)								
[Table 32] Performance							[Table 32] Performance								
Density	Sequential Read (MB/s)			Sequential Write (MB/s)			Density	Sequential Read (MB/s)			Sequential Write (MB/s)				
16 GB							16 GB								
32 GB	80			35			32 GB	80			35				
64 GB							64 GB								
* Test Condition : Bus width x8, 52MHz DDR, 4MB data transfer, w/o file system overhead							* Test Condition : Bus width x8, 52MHz DDR, 4MB File Transfer, measured on Samsung's Internal Board, w/o file system overhead								
[Table 37] Extended CSD Register							[Table 37] Extended CSD Register								
Name	Field	Size (Bytes)	Cell Type	CSD-slice	CSD Value			Name	Field	Size (Bytes)	Cell Type	CSD-slice	CSD Value		
					16GB	32GB	64GB						16GB	32GB	64GB
Secure TRIM Multiplier	SEC_TRIM_MULT	1	R	[229]		0x1B		Secure TRIM Multiplier	SEC_TRIM_MULT	1	R	[229]		0x11	
7.1 Time Parameter							7.1 Time Parameter								
[Table 38] Time Parameter							[Table 38] Time Parameter								
Timing Parameter	Max. Value		Unit		Timing Parameter	Max. Value		Unit							
Initialization Time (tINIT)	1		s		Initialization Time (tINIT)	1		s							
Read Timeout	100		ms		Read Timeout	100		ms							
Write Timeout	300 (TBD)		ms		Write Timeout	350		ms							
Erase Timeout	15		ms		Erase Timeout	15		ms							
Force Erase Timeout	3		min		Force Erase Timeout	3		min							
Secure Erase Timeout	8		s		Secure Erase Timeout	8		s							
Secure Trim step1 Timeout	5		s		Secure Trim step1 Timeout	5		s							
Secure Trim step2 Timeout	3		s		Secure Trim step2 Timeout	3		s							
Trim Timeout ¹⁾	600		ms		Trim Timeout ¹⁾	600		ms							
Partition Switching Timeout (after Init)	100		us		Partition Switching Timeout (after Init)	100		us							
NOTE: 1) If 8KB Size and Address are aligned, Max. Timeout value is 300ms							NOTE: 1) If 8KB Size and Address are aligned, Max. Timeout value is 300ms								

Revision History Appendix(1.1)

Before(ver.1.0)				After(ver.1.1)			
[Table 38] Time Parameter				[Table 38] Time Parameter			
Timing Parameter	Max. Value	Unit		Timing Parameter	Max. Value	Unit	
Initialization Time (tINIT)	1	s		Initialization Time (tINIT)	Normal ¹⁾	1	s
Read Timeout	100	ms		Initialization Time (tINIT)	After partition setting ²⁾	3	s
Write Timeout	350	ms		Read Timeout		100	ms
Erase Timeout	15	ms		Write Timeout		350	ms
Force Erase Timeout	3	min		Erase Timeout		15	ms
Secure Erase Timeout	8	s		Force Erase Timeout		3	min
Secure Trim step1 Timeout	5	s		Secure Erase Timeout		8	s
Secure Trim step2 Timeout	3	s		Secure Trim step1 Timeout		5	s
Trim Timeout ¹⁾	600	ms		Secure Trim step2 Timeout		3	s
Partition Switching Timeout (after Init)	100	us		Trim Timeout ³⁾		600	ms
NOTE: 1) If 8KB Size and Address are aligned, Max. Timeout value is 300ms				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) If 8KB Size and Address are aligned, Max. Timeout value is 300ms			
[Table 25] Maximum Enhanced Partition Size				[Table 25] Maximum Enhanced Partition Size			
Device	Max. Enhanced Partition Size			Device	Max. Enhanced Partition Size		
16 GB	7,759,462,400 Bytes			16 GB	7,801,405,440 Bytes		

Table Of Contents

1.0 PRODUCT LIST	4
2.0 KEY FEATURES	4
3.0 PACKAGE CONFIGURATIONS	5
3.1 169 Ball Pin Configuration	5
3.1.1 12mm x 16mm x 1.0mm Package Dimension	6
3.1.2 12mm x 16mm x 1.2mm Package Dimension	7
3.2 Product Architecture	8
4.0 e.MMC 4.41 features	9
4.1 Data Write	9
4.2 Reliable Write	10
4.3 Secure Trim	10
4.4 High Priority Interrupt	10
4.5 Background Operation	12
5.0 Technical Notes	13
5.1 S/W Algorithm	13
5.1.1 Partition Management	13
5.1.1.1 Boot Area Partition and RPMB Area Partition	13
5.1.1.2 Enhanced Partition (Area)	13
5.1.2 Write protect management	14
5.1.2.1 User Area Write Protection	14
5.1.2.2 Boot Partition Write Protection	14
5.1.3 Boot operation	15
5.1.4 Wear Leveling	16
5.1.5 User Density	16
5.1.6 Auto Power Saving Mode	17
5.1.7 End of Life Management	17
5.2 Smart Report	17
5.2.1 Smart Report Sequence	17
5.2.2 Smart Report Output Data (For Customer)	18
5.2.3 Performance	18
6.0 REGISTER VALUE	19
6.1 OCR Register	19
6.2 CID Register	19
6.2.1 Product name table (In CID Register)	19
6.3 CSD Register	20
6.4 Extended CSD Register	21
7.0 AC PARAMETER	24
7.1 Time Parameter	24
7.2 Bus Timing Parameter	24
7.3 Bus timing for DAT signals during 2x data rate operation	26
7.3.1 Dual data rate interface timings	26
7.4 Bus signal levels	27
7.4.1 Open-drain mode bus signal level	27
7.4.2 Push-pull mode bus signal level.high-voltage MultiMediaCard	27
7.4.3 Push-pull mode bus signal level.dual-voltage MultiMediaCard	27
7.4.4 Push-pull mode bus signal level.e·MMC	28
8.0 DC PARAMETER	29
8.1 Active Power Consumption during operation	29
8.2 Standby Power Consumption in auto power saving mode and standby state	29
8.3 Sleep Power Consumption in Sleep State	29
8.4 Supply Voltage	29
8.5 Bus Operating Conditions	29
8.6 Bus Signal Line Load	30
9.0 e·MMC Connection Guide	31
9.1 x8 support Host connection Guide	31
9.2 x4 support Host connection Guide	31

INTRODUCTION

The SAMSUNG e-MMC is an embedded MMC solution designed in a BGA package form. e-MMC operation is identical to a MMC card and therefore is a simple read and write to memory using MMC protocol v4.41 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) whereas 1.8V or 3V dual supply voltage (VDD) is supported for the MMC controller. Maximum MMC interface frequency of 52MHz and maximum bus widths of 8 bit are supported.

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 mangement 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
16GB	KLMA2GE4A-A001	64Gb MLC x 2	91.0%	- Interface power : VDD (1.70V ~ 1.95V or 2.7V ~ 3.6V) - Memory power : VDDF (2.7V ~ 3.6V)	12mm x 16mm x 1.0mm	169FBGA
32GB	KLMBG4GE4A-A001	64Gb MLC x 4				
64GB	KLMSG8GE4A-A001	64Gb MLC x 8			12mm x 16mm x 1.2mm	

2.0 KEY FEATURES

- MultiMediaCard System Specification Ver. 4.41 compatible. Detail description is referenced by JEDEC Standard
- SAMSUNG e-MMC supports below special features which are being discussed in JEDEC
 - High Priority Interrupt scheme is supported
 - Back ground operation is supported.
- Full backward compatibility with previous MultiMediaCard system (1bit data bus, multi-e-MMC systems)
- Data bus width : 1bit (Default) , 4bit and 8bit
- MMC I/F Clock Frequency : 0 ~ 52MHz
MMC I/F Boot Frequency : 0 ~ 52MHz
- Temperature : Operation(-25°C ~ 85°C), Storage without operation (-40°C ~ 85°C)
- Power : Interface power → VDD (1.70V ~ 1.95V or 2.7V ~ 3.6V) , Memory power → VDDF(2.7V ~ 3.6V)

3.0 PACKAGE CONFIGURATIONS

3.1 169 Ball Pin Configuration

[Table 2] 169 Ball Information

Pin NO	Name	Pin NO	Name
K6	VDD	AA5	VDD
T10	VDDF	W4	VDD
K2	VDDI	Y4	VDD
R10	Vss	AA3	VDD
W5	CMD	U9	VDDF
W6	CLK	M6	VDDF
H3	DAT0	N5	VDDF
H4	DAT1	U8	Vss
H5	DAT2	M7	Vss
J2	DAT3	AA6	Vss
J3	DAT4	P5	Vss
J4	DAT5	Y5	Vss
J5	DAT6	K4	Vss
J6	DAT7	Y2	Vss
H6	RFU	AA4	Vss
H7	RFU	U5	RSTN
K5	RFU		
M5	RFU		
M8	RFU		
M9	RFU		
M10	RFU		
N10	RFU		
P3	RFU		
P10	RFU		
R5	RFU		
T5	RFU		
U6	RFU		
U7	RFU		
U10	RFU		
AA7	RFU		
AA10	RFU		

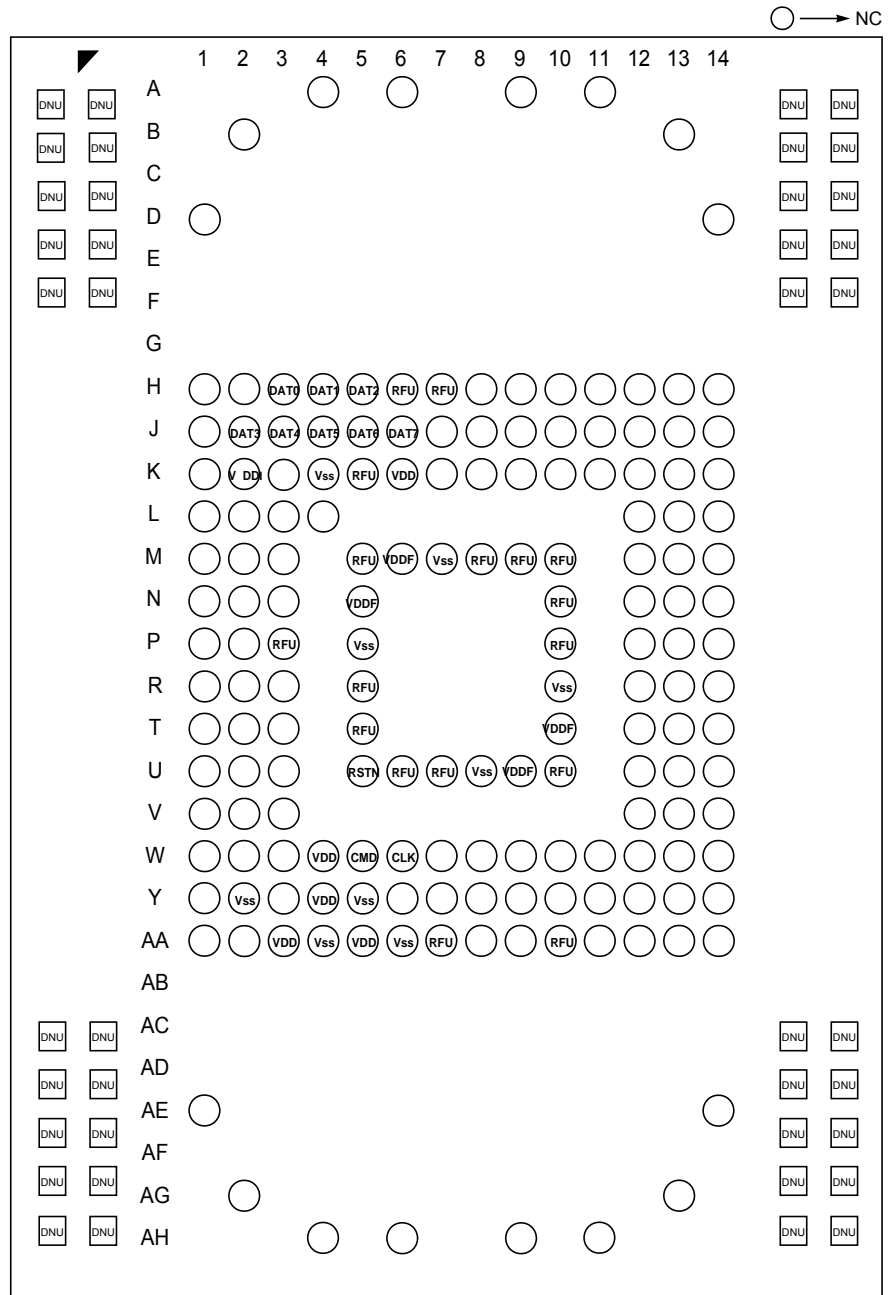


Figure 1. 169-FBGA

3.1.1 12mm x 16mm x 1.0mm Package Dimension

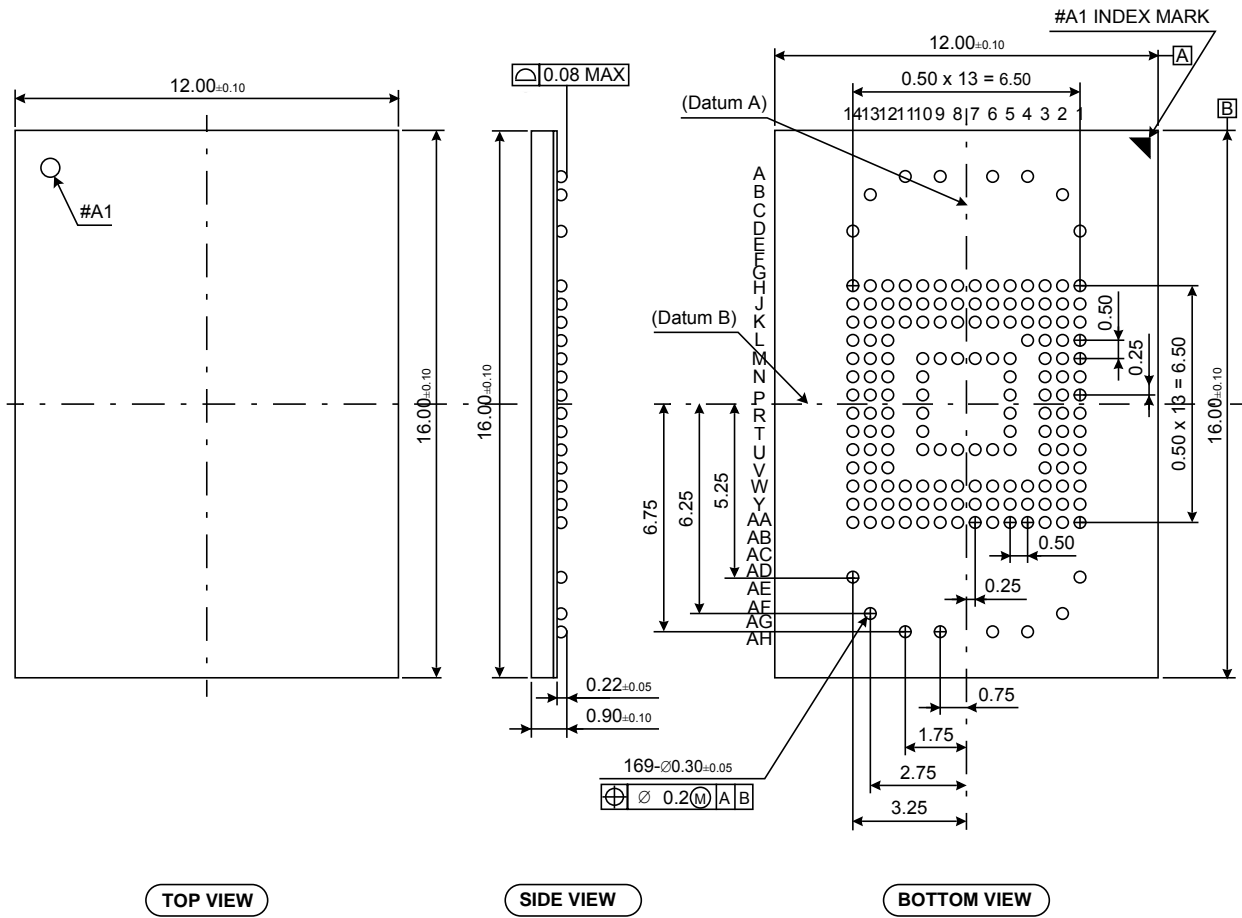


Figure 2. 12mm x 16mm x 1.0mm Package Dimension

3.2 Product Architecture

- e-MMC consists of NAND Flash and Controller. VDD is for Controller power and VDDF is for flash power

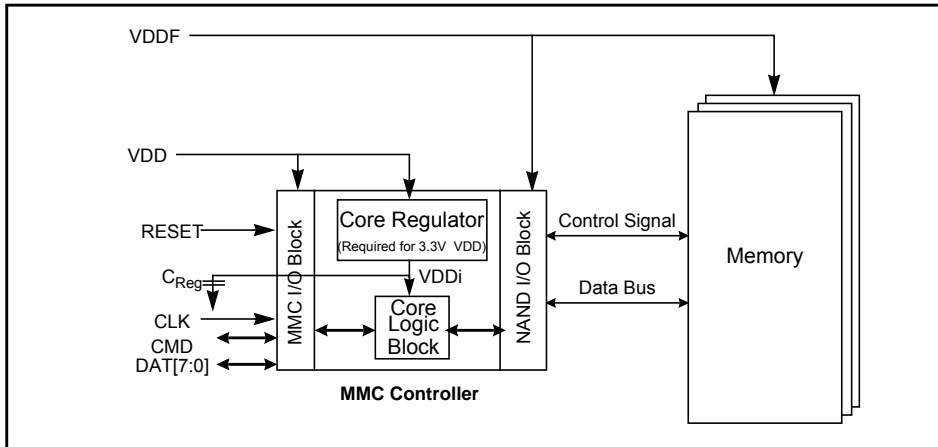


Figure 4. e-MMC Block Diagram

4.0 e.MMC 4.41 features

4.1 Data Write

Host can configure reliability mode to protect existing data per each partition.

This reliability mode has to be set before partitioning is completed.

This reliability setting only impacts the reliability of the main user area and the general purpose partitions.

[Table 3] EXT_CSD value for reliability setting in write operation

Name	Field	Size (Bytes)	Cell Type	EXT_CSD-slice	Value
Data Reliability Supports	WR_REL_PARAM	1	R	166	0x05
Data Reliability Configuration	WR_REL_SET	1	R/W	167	0x1F

Explanation of each field in the upper table is mentioned below

[Table 4] Definition of EXT_CSD value for reliability setting

Fields	Definitions
HS_CTRL_REL	0x0: All the WR_DATA_REL parameters in the WR_REL_SET registers are read only bits. 0x1: All the WR_DATA_REL parameters in the WR_REL_SET registers are R/W.
EN_REL_WR	0x0: The device supports the previous definition of reliable write. 0x1: The device supports the enhanced definition of reliable write

The below table shows each field for WE_REL_SET

[Table 5] Description of each field for WE_REL_SET

Name	Field	Bit	Size	Type
Write Data Reliability (user Area)	WR_DATA_REL_USR	0	1	R (if HS_CTRL_REL=0) R/W (if HS_CTRL_REL=1)
Write Data Reliability Partition 1	WR_DATA_REL_1	1	1	R (if HS_CTRL_REL=0) R/W (if HS_CTRL_REL=1)
Write Data Reliability Partition 2	WR_DATA_REL_2	2	1	R (if HS_CTRL_REL=0) R/W (if HS_CTRL_REL=1)
Write Data Reliability Partition 3	WR_DATA_REL_3	3	1	R (if HS_CTRL_REL=0) R/W (if HS_CTRL_REL=1)
Write Data Reliability Partition 4	WR_DATA_REL_4	4	1	R (if HS_CTRL_REL=0) R/W (if HS_CTRL_REL=1)
Reserved	-	7:5	-	-

4.2 Reliable Write

[Table 6] EXT_CSD value for reliable write

Name	Field	Size (Bytes)	Cell Type	CSD-slice	Value
Data Reliability Supports	WR_REL_PARAM	1	R	166	0x05

Reliable write with EN_REL_WR is 0x1 supports atomicity of sector unit.

The block size defined by SET_BLOCKLEN (CMD16) is ignored and reliable write is executed as only 512 byte length. There is no limit on the size of the reliable write.

[Table 7] EXT_CSD value for reliable write

Name	Field	Size (Bytes)	Cell Type	CSD-slice	Value
Reliable Write Sector Count	REL_WR_SEC_C	1	R	[222]	0x01

4.3 Secure Trim

Secure Trim operation consists of Secure Trim Step1 and Secure Trim Step2.

In Secure Trim Step 1 the host defines the range of write blocks that it would like to mark for the secure purge.

[Table 8] EXT_CSD value for secure trim

Field	Definitions	Value
SEC_TRIM_MULT	Secure Trim Step2 Timeout = 300ms x ERASE_TIMEOUT_MULT x SEC_TRIM_MULT	0x11

Area marked by Secure Trim Step1 is shown as EXT_CSD[181](ERASED_MEM_CONT) before Secure Trim Step2 is completed.

When Secure Trim Step2 is issued, if there is no data marked by Secure Trim Step1, Secure Trim Step2 does not work.

4.4 High Priority Interrupt

High Priority Interrupt is to stop ongoing operation and perform read operation with high priority

Command set for High Priority Interrupt operation is the below

[Table 9] Command List for High Priority Interrupt

CMD Index	Type	Argument	Resp	Abbreviation	Command Description
CMD12	ac	[31:16] – RCA* [15:1] – stuff bits [0] – High Priority Interrupt * *To be used only to send a High Priority Interrupt	R1b	STOP_TRANSMISSION	If High Priority Interrupt flag is set the device shall interrupt its internal operations in a well defined timing

Interruptible commands by read while write operation are the below.

[Table 10] List of Interruptible Command

Commands	Names	Notes
CMD24	WRITE SINGLE BLOCK	-
CMD25	WRITE MULTIPLE BLOCKS	-
CMD25	RELIABLE WRITE	Stopping a reliable write command with 'High Priority Interrupt' flag set turns that command into a reliable write command
CMD38	ERASE	-
	TRIM	-
	SECURE ERASE	-
	SECURE TRIM	-
CMD6	SWITCH	BACKGROUND OPERATION ONLY

[Table 11] EXT_CSD value for HPI

Name	Field	Size(Bytes)	Cell Type	CSD-Slice	Value
HPI features	HPI_FEATURES	1	R	[503]	0x03
Number of correctly programmed sectors	CORRECTLY_PRG_SECTORS_NUM	4	R	[245:242]	0x00
Partition switching timing	PARTITION_SWITCH_TIME	1	R	[199]	0x01
Out of interrupt busytiming	OUT_OF_INTERRUPT_TIME	1	R	[198]	0x02
HPI management	HPI_MGMT	1	R/W/E_P	[161]	0x00

[Table 12] Definition of EXT_CSD value for HPI

Fields	Definitions
HPI_FEATURES	<p>Bit 0 means HPI_SUPPORT Bit 0 = 0x0 : High Priority Interrupt mechanism not supported Bit 0 = 0x1 : High Priority Interrupt mechanism supported</p> <p>Bit 1 means HPI_IMPLEMENTATION 0x0 : HPI mechanism implementation based on CMD13 0x1 : HPI mechanism implementation based on CMD12</p>
CORRECTLY_PRG_SECTOR_NUM	<p>This field indicates how many 512B sectors were successfully programmed by the last WRITE_MULTIPLE_BLOCK command (CMD25). $CORRECTLY_PRG_SECTORS_NUM = EXT_CSD[242] * 2^0 + EXT_CSD[243] * 2^8 + EXT_CSD[244] * 2^{16} + EXT_CSD[245] * 2^{24}$</p>
PARTITION_SWITCH_TIME	<p>This field indicates the maximum timeout for the SWITCH command (CMD6) when switching partitions by changing PARTITION_ACCESS bits in PARTITION_CONFIG field (EXT_CSD byte [179]). Time is expressed in units of 10 milliseconds</p>
OUT_OF_INTERRUPT_TIME	<p>This field indicates the maximum timeout to close a command interrupted by HPI - time between the end bit of CMD12 / CMD 13 to the DAT0 release by the device.</p>
HPI_MGMT	<p>Bit 0 means HPI_EN 0x0 : HPI mechanism not activated by the host 0x1 : HPI mechanism activated by the host</p>

4.5 Background Operation

When the host is not being serviced, e-MMC can do internal operation by using “Background Operation” command. In this operation which takes long time to complete can be handled later when host ensure enough idle time (In Back ground operation)

Background Operation Sequence is the following

[Table 13] Background Operation Sequence

Function	Command	Description
Background Operation Check	CMD8 Or Card Status Register	If BKOPS_STATUS is not 0 or 6 th bit of card status register is set, there are something to be performed by background operation
Background Operation Start	CMD6	Background operation starts by BKOPS_START is set to any value. When background operation is completed BKOPS_STATUS is set to 0 and BKOPS_START is set to 0.
Background Operation Stop	HPI	If the background operation is stopped BKOPS_START is set to 0

[Table 14] EXT_CSD value for Background Operation

Name	Field	Size(Bytes)	Cell Type	CSD-Slice	Value
Background operations Support	BKOPS_SUPPORT	1	R	[502]	0x01
Background operations status	BKOPS_STATUS	1	R	[246]	0x00
Manually start background operations	BKOPS_START	1	W/E_P	[164]	0x00
Enable background operations hand shake	BKOP_EN	1	R/W	[163]	0x00

[Table 15] Definition of EXT_CSD value for Bakground Operation

Fields	Definitions
BKOPS_SUPPORT	'0' means Background operation is not supported '1' means Background operation is supported
BKOPS_STATUS	'0' means No background work pending '1' means pending background work existing. '2' means pending background work existing & performance being impacted. '3' means pending background work existing & critical
BKOPS_START	Background operation start while BKOPS_START is set to any value. '0' means Background operation is enabled.
BKOPS_EN	'0' means host does not support background operation '1' means host use background operation manually

[Table 16] Card Status Register for Background Operation

Bits	Identifier	Type	Det Mode	Value	Description	Clear Cond
6	URGENT_BKOPS	S	R	"0" = Not Urgent "1" = Urgent	If set, device needs to perform background operations urgently. Host can check EXT_CSD field BKOPS_STATUS for the detailed level (in case of BKOPS_STATUS is 2 or 3)	A

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

Default size of each Boot Area Partition is 512KB and can be changed by Vendor Command as multiple of 512KB.
Default size of RPMB Area Partition is 128 KB and can be changed by Vendor Command as multiple of 128KB.

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

[Table 17] 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_MULTI)	Boot Partition Size value
Set RPMB Partition Size	CMD62(RPMB_SIZE_MULTI)	RPMB Partition Size value F/W Re-Partition is executed in this step.
Power Cycle		

Boot partition size is calculated as (128KB * BOOT_SIZE_MULTI)
BOOT_SIZE_MULTI should be set as multiple of 8.

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_MULTI).
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 18] 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 e-MMC 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 double size of original set up size. (ex> if master set 1MB for enhanced mode, total 2MB 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_GPR_SIZE x 512kBytes)

5.1.2 Write protect management

In order to allow the host to protect data against erase or write, the device shall support write protect commands.

5.1.2.1 User Area Write Protection

TMP_WRITE_PROTECT (CSD[12]) and PERM_WRITE_PROTECT(CSD[13]) registers allow the host to apply write protection to whole device including Boot Partition, RPMB Partition and User Area.

[Table 19] whole device write protect priority

Class	Setting
Permanent write protect	SET : One time programmable
	CLR : Not available
Temporary write protect	SET : Multiple programmable
	CLR : Multiple programmable

USER_WP (EXT_CSD[171]) register allows the host to apply write protection to all the partitions in the user area.

[Table 20] User area write protect priority

Class	Setting
Permanent write protect	SET : One time programmable
	CLR : Not available
Power-on write protect	SET : One time programmable on power-on
	CLR : After power reset
Temporary write protect	SET : Multiple programmable
	CLR : Multiple programmable

The host has the ability to check the write protection status of segments by using the SEND_WRITE_PROT_TYPE command (CMD31). When full card protection is enabled all the segments will be shown as having permanent protection.

5.1.2.2 Boot Partition Write Protection

BOOT_WP (EXT_CSD [173]) register allows the host to apply write protection to Boot Area Partitions.

[Table 21] Boot area write protect priority

Class	Setting
Permanent write protect	SET : One time programmable
	CLR : Not available
Power-on write protect	SET : One time programmable on power-on
	CLR : After power reset

An attempt to set both the disable and enable bit for a given protection mode (permanent or power-on) in a single switch command will have no impact and switch error occurs.

Setting both B_PERM_WP_EN and B_PWR_WP_EN will result in the boot area being permanently protected.

5.1.3 Boot operation

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

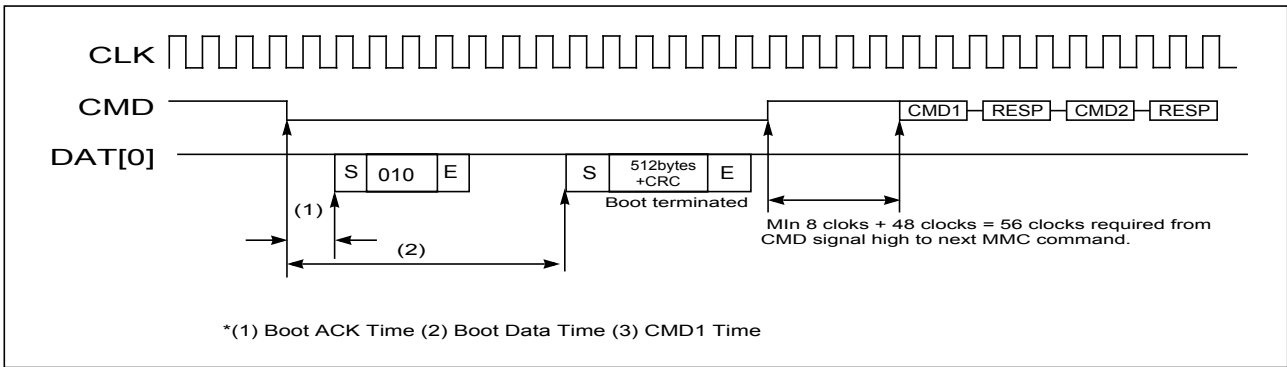


Figure 5. MultiMediaCard state diagram (boot mode)

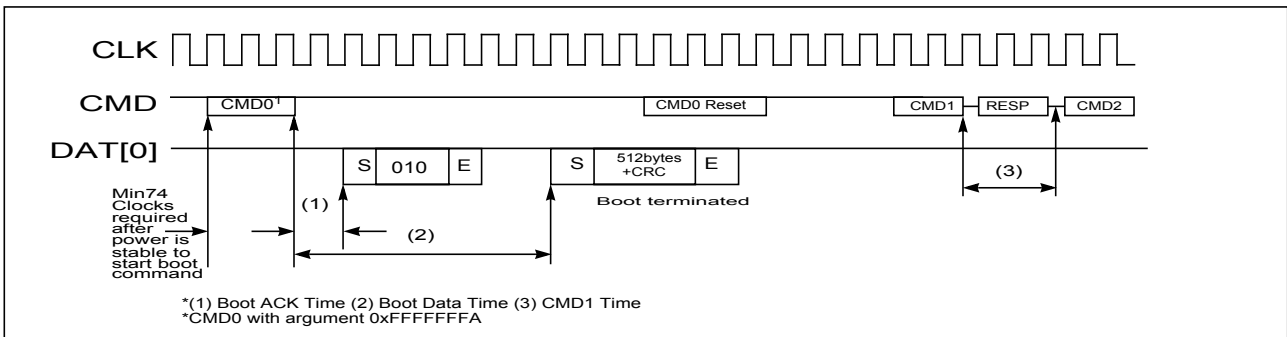


Figure 6. MultiMediaCard state diagram (alternative boot mode)

[Table 22] Boot ack, boot data and initialization Time

Timing Factor	Value
(1) Boot ACK Time	< 50 ms
(2) Boot Data Time	< 60 ms
(3) Initialization Time ¹⁾	< 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

Minimum function for reading boot data is initialized during boot time and after that full function is initialized during initialization time.

5.1.4 Wear Leveling

The partitions in device have the following NAND type in case of MLC type NAND.

[Table 23] NAND type in each partitions

Partitions		NAND Operation Mode
Boot Area Partition 1		SLC Mode
Boot Area Partition 2		SLC Mode
RPMB Area Partition		SLC Mode
General Purpose Partition		MLC Mode or SLC Mode
User Data Area	Enhanced Area	SLC Mode
	Default Area	MLC Mode

Wear leveling means that blocks should be used evenly in order to expand life span of device. Wear leveling is executed in each partition locally because of each partition with different attribute.

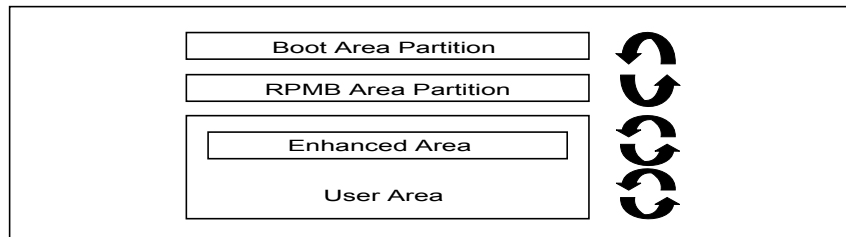


Figure 7. Wear leveling

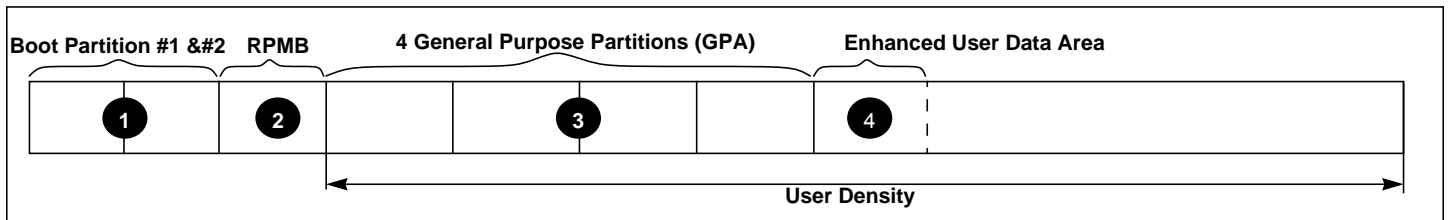
And then device reserves free block and executes wear-level at each partition respectively.

5.1.5 User Density

Total User Density depends on device type.

For example, 32MB in the SLC Mode requires 64MB in MLC.

This results in decreasing of user density



[Table 24] Capacity according to partition

		Boot partition 1	Boot partition 2	RPMB
MLC	Min.	2,048KB	2,048KB	128KB
	Max.	16,384KB	16,384KB	4,096KB

[Table 25] Maximum Enhanced Partition Size

Device	Max. Enhanced Partition Size
16 GB	7,801,405,440 Bytes
32 GB	15,602,810,880 Bytes
64 GB	31,247,564,800 Bytes

[Table 26] User Density Size

Device	User Density Size
16 GB	15,634,268,160 Bytes
32 GB	31,268,536,320 Bytes
64 GB	62,537,072,640 Bytes

5.1.6 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 27] 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 28] Auto Power Saving Mode and Sleep Mode

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

5.1.7 End of Life Management

The end of device life time is defined when there is no more available reserved block for bad block management in the device. When the device reaches to end of its life time, device shall change its state to permanent write protection state. In this case, write operation is not allowed any more but read operation are still allowed.

But, reliability of the operation can not be guaranteed after end of life

5.2 Smart Report

Samsung provides Report feature for the Host to notice the device state by Meta data. Samsung calls this Smart Report. So Customer can acquire prime factor for understanding at the beginning analysis of error. Below table is the information about Smart Report.

[Table 29] Smart Report

Mode	Contents
Customer Report	<ol style="list-style-type: none"> 1. Detect Error Mode 2. Detect Super Block Size 3. Detect Super Page Size 4. Detect Optimal Write Size 5. Detect Number Of Banks 6. The number of Initial Bad Block, Per Bank 7. The number of Run Time Bad Block, Per Bank 8. Number of remain block in Reserved Block 9. Max, Min, Avg Erase Count 10. Number of read reclaim 11. Detect Optimal Trim Size 12. Hash code 13. Max, Min, Avg Erase Count (SLC) 14. Max, Min, Avg Erase Count (MLC)

5.2.1 Smart Report Sequence

[Table 30] Smart Report Sequence

Functions	Command	Description
Entering Smart Report Mode	CMD62h(0xEFAC62EC) →CMD62h(0xCCEE)	After entering Smart Report Mode, the report-related Values are able to be checked on Read Command.
Confirming Smart Report	CMD17h(0x0)	It is possible to confirm Smart Report after reading Sector 1 at Address 0.
Removing Smart Report Mode	CMD62h(0xEFAC62EC) →CMD62h(0xDECCEE)	Smart Report Mode is removed by this command.

5.2.2 Smart Report Output Data (For Customer)

[Table 31] Smart Report Output Data (For Customer)

Data Slice	Field	Width	Remark
[3:0]	Error Mode	4 bytes	Normal : 0xD2D2D2D2, OpenFatalError : 0x37373737, RuntimeFatalError : 0x5C5C5C5C, MetaBrokenError : 0xE1E1E1E1 * In case of open error, other fields are not valid.
[7:4]	Super Block Size	4 bytes	Total Size(in byte) of simultaneously erasable physical blocks (e.g., Number of Channel * N-way Interleaving * physical block size)
[11:8]	Super Page Size	4 bytes	Total Size(in byte) of simultaneously programmable physical pages (e.g., Number of Channel * physical page size)
[15:12]	Optimal Write Size	4 bytes	Write size(in byte) at which the device performs best (e.g., Super Page Size * N-way Interleaving)
[19:16]	Number Of Banks	4 bytes	Number of banks connecting to each NAND flash. Bad blocks are managed by each banks.
[23:20]	Bank0 Init Bad Block	4 bytes	Number of Init defective physical blocks of plane which has the least remaining blocks in Bank0
[27:24]	Bank0 Runtime Bad Block	4 bytes	Number of Runtime defective physical blocks of plane which has the least remaining blocks in Bank0
[31:28]	Bank0 remain reserved Block	4 bytes	Number of remain reserved blocks of plane which has the least remaining blocks in Bank0
[35:32]	Bank1 Init Bad Block	4 bytes	Number of Init defective physical blocks of plane which has the least remaining blocks in Bank1
[39:36]	Bank1 Runtime Bad Block	4 bytes	Number of Runtime defective physical blocks of plane which has the least remaining blocks in Bank1
[43:40]	Bank1 remain reserved Block	4 bytes	Number of remain reserved blocks of plane which has the least remaining blocks in Bank1
[47:44]	Bank2 Init Bad Block	4 bytes	Number of Init defective physical blocks of plane which has the least remaining blocks in Bank2
[51:48]	Bank2 Runtime Bad Block	4 bytes	Number of Runtime defective physical blocks of plane which has the least remaining blocks in Bank2
[55:52]	Bank2 remain reserved Block	4 bytes	Number of remain reserved blocks of plane which has the least remaining blocks in Bank2
[59:56]	Bank3 Init Bad Block	4 bytes	Number of Init defective physical blocks of plane which has the least remaining blocks in Bank3
[63:60]	Bank3 Runtime Bad Block	4 bytes	Number of Runtime defective physical blocks of plane which has the least remaining blocks in Bank3
[67:64]	Bank3 Reserved Block	4 bytes	Number of remain reserved blocks of plane which has the least remaining blocks in Bank3
[71:68]	Max. Erase Count	4 bytes	Maximum erase count from among all physical blocks
[75:72]	Min. Erase Count	4 bytes	Minimum erase count from among all physical blocks
[79:76]	Avg. Erase Count	4 bytes	Average erase count of all physical blocks
[83:80]	Read Reclaim cnt	4 bytes	Number of Read Reclaim Count
[87:84]	Optimal Trim Size	4 bytes	Optimal Trim size
[119:88]	Hash Code	32 Byte	Hash Code
[123:120]	Max. Erase Count (SLC)	4 bytes	Maximum erase count from among all SLC physical blocks
[127:124]	Min. Erase Count (SLC)	4 bytes	Minimum erase count from among all SLC physical blocks
[131:128]	Avg. Erase Count (SLC)	4 bytes	Average erase count of all SLC physical blocks
[135:132]	Max. Erase Count (MLC)	4 bytes	Maximum erase count from among all MLC physical blocks
[139:136]	Min. Erase Count (MLC)	4 bytes	Minimum erase count from among all MLC physical blocks
[143:140]	Avg. Erase Count (MLC)	4 bytes	Average erase count of all MLC physical blocks
[511:144]	Reserved		

5.2.3 Performance

[Table 32] Performance

Density	Sequential Read (MB/s)	Sequential Write (MB/s)
16 GB	80	35
32 GB		
64 GB		

* Test Condition : Bus width x8, 52MHz DDR, 4MB File Transfer, measured on Samsung's Internal Board, w/o file system overhead

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 33] OCR Register

OCR bit	VDD voltage window ²	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) ¹	

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 34] 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]	... ¹
Product name	PNM	48	[103:56]	See Product name table
Product revision	PRV	8	[55:48]	... ²
Product serial number	PSN	32	[47:16]	... ³
Manufacturing date	MDT	8	[15:8]	... ⁴
CRC7 checksum	CRC	7	[7:1]	... ⁵
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 35] Product name

Part Number	Density	Product Name in CID Register (PNM)
KLMAG2GE4A-A001	16 GB	0x4D4147324741
KLMBG4GE4A-A001	32 GB	0x4D4247344741
KLMCG8GE4A-A001	64 GB	0x4D4347384741

6.3 CSD Register

The Card-Specific Data register provides information on how to access the eMMC 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/ reset 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 36] CSD Register

Name	Field	Width	Cell Type	CSD-slice	CSD Value		
					16GB	32GB	64GB
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		
Card 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]	-		
Card 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		
Card 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]	0x1F		
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]	0x02		
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]	-		

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 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 37] Extended CSD Register

Name	Field	Size (Bytes)	Cell Type	CSD-slice	CSD Value		
					16GB	32GB	64GB
Properties Segment							
Reserved ¹		7	-	[511:505]	-		
Supported Command Sets	S_CMD_SET	1	R	[504]	0x01		
HPI features	HPI_FEATURES	1	R	[503]	0x03		
Background operations support	BKOPS_SUPPORT	1	R	[502]	0x01		
Reserved ¹		255	-	[501:247]	-		
Background operations status	BKOPS_STATUS	1	R	[246]	0x00		
Number of correctly programmed sectors	CORRECTLY_PRG_SECTOR_S_NUM	4	R	[245:242]	0x00		
1st initialization time after partitioning	INI_TIMEOUT_AP	1	R	[241]	0x1E		
Reserved ¹		1	-	[240]	-		
Power class for 52MHz, DDR at 3.6V	PWR_CL_DDR_52_360	1	R	[239]	0x00		
Power class for 52MHz, DDR at 1.95V	PWR_CL_DDR_52_195	1	R	[238]	0x00		
Reserved ¹		2	-	[237:236]	-		
Minimum Write Performance for 8 bit at 52MHz in DDR mode	MIN_PERF_DDR_W_8_52	1	R	[235]	0x00		
Minimum Read Performance for 8 bit at 52MHz in DDR mode	MIN_PERF_DDR_R_8_52	1	R	[234]	0x00		
Reserved ¹		1	-	[233]	-		
TRIM Multiplier	TRIM_MULT	1	R	[232]	0x02		
Secure Feature support	SEC_FEATURE_SUPPORT	1	R	[231]	0x15		
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 ¹		1	-	[227]	-		
Boot partition size	BOOT_SIZE_MULT ⁽²⁾	1	R/W	[226]	0x10		
Access size	ACC_SIZE	1	R	[225]	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]	0x50		
Sleep current (VDDF)	S_C_VDDF	1	R	[220]	0x07		
Sleep current (VDD)	S_C_VDD	1	R	[219]	0x07		
Reserved ¹		1	-	[218]	-		
Sleep/awake timeout	S_A_TIMEOUT	1	R	[217]	0x11		

Reserved ¹		1	-	[216]	-		
Sector Count	SEC_COUNT	4	R	[215:212]	0x1D1F000	0x3A3E000	0x747C000
Reserved ¹		1	-	[211]	-		
Minimum Write Performance for 8bit @52MHz	MIN_PERF_W_8_52	1	R	[210]	0x00		
Minimum Read Performance for 8bit @52MHz	MIN_PERF_R_8_52	1	R	[209]	0x00		
Minimum Write Performance for 8bit @26MHz / 4bit @52MHz	MIN_PERF_W_8_26_4_52	1	R	[208]	0x00		
Minimum Read Performance for 8bit @26MHz / 4bit @52MHz	MIN_PERF_R_8_26_4_52	1	R	[207]	0x00		
Minimum Write Performance for 4bit @26MHz	MIN_PERF_W_4_26	1	R	[206]	0x00		
Minimum Read Performance for 4bit @26MHz	MIN_PERF_R_4_26	1	R	[205]	0x00		
Reserved ¹		1	-	[204]	-		
Power Class for 26MHz @ 3.6V	PWR_CL_26_360	1	R	[203]	0x00		
Power Class for 52MHz @ 3.6V	PWR_CL_52_360	1	R	[202]	0x00		
Power Class for 26MHz @ 1.95V	PWR_CL_26_195	1	R	[201]	0x00		
Power Class for 52MHz @ 1.95V	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]	0x02		
Reserved ¹		1	-	[197]	-		
Card Type	CARD_TYPE	1	R	[196]	0x07		
Reserved ¹		1	-	[195]	-		
CSD Structure Version	CSD_STRUCTURE	1	R	[194]	0x02		
Reserved ¹		1	-	[193]	-		
Extended CSD Revision	EXT_CSD_REV	1	R	[192]	0x05		
Modes Segment							
Command Set	CMD_SET	1	R/W	[191]	0x00		
Reserved ¹		1	-	[190]	-		
Command Set Revision	CMD_SET_REV	1	R	[189]	0x00		
Reserved ¹		1	-	[188]	-		
Power Class	POWER_CLASS	1	R/W	[187]	0x00		
Reserved ¹		1	-	[186]	-		
High Speed Interface Timing	HS_TIMING	1	R/W	[185]	0x00		
Reserved ¹		1	-	[184]	-		
Bus Width Mode	BUS_WIDTH	1	W/E_P	[183]	0x00		
Reserved ¹		1	-	[182]	-		
Erased Memory Content	ERASED_MEM_CONT	1	R	[181]	0x00		
Reserved ¹		1	-	[180]	-		
Partition configuration	PARTITION_CONFIG	1	R/W/E & R/W/E_P	[179]	0x00		
Boot config protection	BOOT_CONFIG_PRPT	1	R/W & R/W/C_P	[178]	0x00		
Boot bus width1	BOOT_BUS_WIDTH	1	R/W/E	[177]	0x00		
Reserved ¹		1	-	[176]	-		
High-density erase group definition	ERASE_GROUP_DEF	1	R/W/E_P	[175]	0x00		
Reserved ¹		1	-	[174]	-		
Boot area write protection register	BOOT_WP	1	R/W & R/W/C_P	[173]	0x00		
Reserved ¹		1	-	[172]	-		

User area write protection register	USER_WP	1	R/W, R/W/ C_P& R/W/E_P	[171]	0x00		
Reserved ¹		1	-	[170]	-		
FW configuration	FW_CONFIG	1	R/W	[169]	0x00		
RPMB Size	RPMB_SIZE_MULT	1	R	[168]	0x01		
Write reliability setting register	WR_REL_SET	1	R/W	[167]	0x1F		
Write reliability parameter register	WR_REL_PARAM	1	R	[166]	0x05		
Reserved ¹		1	-	[165]	-		
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		
Partitioning support	PARTITIONING_SUPPORT	1	R	[160]	0x03		
Max Enhanced Area Size	MAX_ENH_SIZE_MULT	3	R	[159:157]	0xBA	0x174	0x2E9
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 ¹		1	-	[135]	-		
Bad Block Management mode	SEC_BAD_BLK_MGMT	1	R/W	[134]	0x00		
Reserved ¹		134	-	[133:0]	-		

NOTE :

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

7.0 AC PARAMETER

7.1 Time Parameter

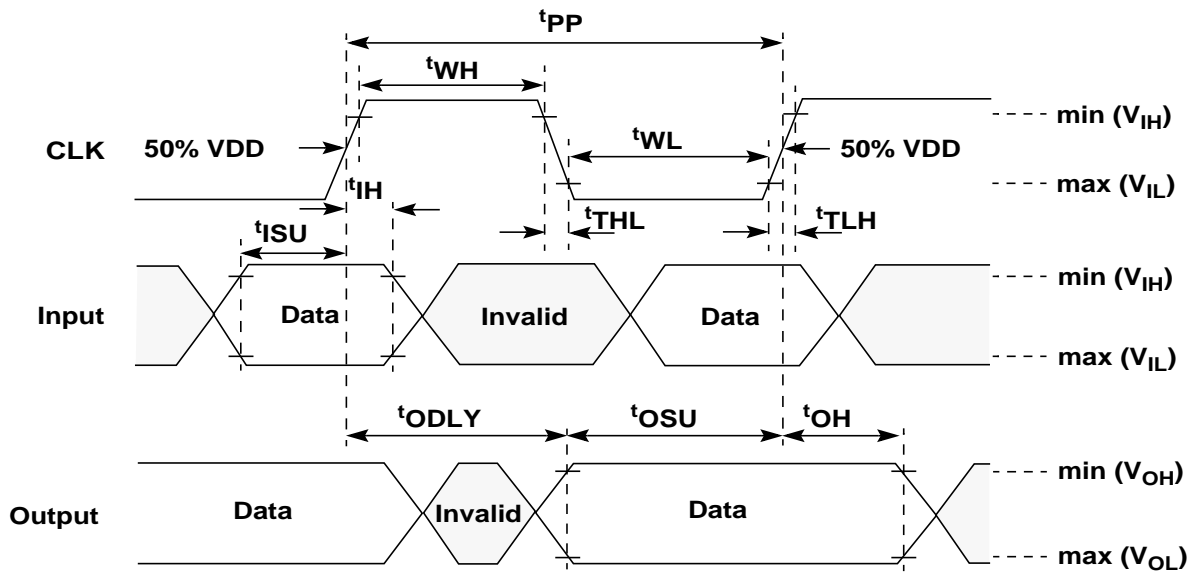
[Table 38] Time Parameter

Timing Parameter		Max. Value	Unit
Initialization Time (tINIT)	Normal ¹⁾	1s	
	After partition setting ²⁾	3s	
Read Timeout		100	ms
Write Timeout		350	ms
Erase Timeout		15	ms
Force Erase Timeout		3	min
Secure Erase Timeout		8s	
Secure Trim step1 Timeout		5s	
Secure Trim step2 Timeout		3s	
Trim Timeout ³⁾		600	ms
Partition Switching Timeout (after Init)		100	us

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) If 8KB Size and Address are aligned, Max. Timeout value is 300ms

7.2 Bus Timing Parameter



Data must always be sampled on the rising edge of the clock.

Figure 8. Bus signal levels

[Table 39] Default (under 26MHz)

Parameter	Symbol	Min	Max	Unit	Remark ¹
Clock CLK(All values are referred to $\min(V_{IH})$ and $\max(V_{IL})$ ²)					
Clock frequency Data Transfer Mode ³	f _{PP}	0 ⁴	26	MHz	CL ≤ 30 pF Tolerance: +100KHz
Clock frequency Identification Mode	f _{OD}	0 ⁴	400	kHz	Tolerance: +20KHz
Clock low time	t _{WL}	10		ns	C _L ≤ 30 pF
Clock high time	t _{WH}	10			
Clock rise time ⁵	t _{TLH}		10	ns	C _L ≤ 30 pF
Clock fall time	t _{THL}		10	ns	C _L ≤ 30 pF
Inputs CMD, DAT (referenced to CLK)					
Input set-up time	t _{ISU}	3n		s	C _L ≤ 30 pF
Input hold time	t _{IH}	3n		s	C _L ≤ 30 pF
Outputs CMD, DAT (referenced to CLK)					
Output hold time	t _{OH}	8.3		ns	CL ≤ 30 pF
Output set-up time	t _{OSU}	11.7		ns	CL ≤ 30 pF

NOTE :

- 1)The card must always start with the backward-compatible interface timing mode can be switched to high-speed interface timing by the host sending the SWITCH command (CMD6) with the argument for high-speed interface select.
- 2) CLK timing is measured at 50% of VDD.
- 3) For compatibility with cards that support the v4.2 standard or earlier version, host should not use >20MHz before switching to high-speed interface timing.
- 4) Frequency is periodically sampled and is not 100% tested.
- 5) CLK rise and fall times are measured by $\min(V_{IH})$ and $\max(V_{IL})$.

[Table 40] High-Speed Mode

Parameter	Symbol	Min	Max	Unit	Remark
Clock CLK(All values are referred to $\min(V_{IH})$ and $\max(V_{IL})$ ¹)					
Clock frequency Data Transfer Mode ²	f _{PP}	0 ³	52 ⁴	MHz	C _L ≤ 30 pF
Clock frequency Identification Mode	f _{OD}	0 ³	400	kHz	CL ≤ 30 pF
Clock low time	t _{WL}	6.5		ns	C _L ≤ 30 pF
Clock High time	t _{WH}	6.5		ns	C _L ≤ 30 pF
Clock rise time ⁵	t _{TLH}		3	ns	C _L ≤ 30 pF
Clock fall time	t _{THL}		3	ns	C _L ≤ 30 pF
Inputs CMD, DAT (referenced to CLK)					
Input set-up time	t _{ISU}	3		ns	C _L ≤ 30 pF
Input hold time	t _{IH}	3		ns	C _L ≤ 30 pF
Outputs CMD, DAT (referenced to CLK)					
Output Delay time during Data Transfer Mode	t _{ODLY}		13.7	ns	CL ≤ 30 pF
Output hold time	t _{OH}	2.5			C _L ≤ 30 pF
Signal rise time	t _{RISE}		3	ns	C _L ≤ 30 pF
Signal fall time	t _{FALL}		3	ns	C _L ≤ 30 pF

NOTE :

- 1) CLK timing is measured at 50% of VDD.
- 2) A MultiMediaCard shall support the full frequency range from 0-26MHz, or 0-52MHz
- 3) Frequency is periodically sampled and is not 100% tested.
- 4) Card can operate as high-speed card interface timing at 26MHz clock frequency.
- 5) CLK rise and fall times are measured by $\min(V_{IH})$ and $\max(V_{IL})$.6) Inputs CMD, DAT rise and fall times are measured by $\min(V_{IH})$ and $\max(V_{IL})$, and outputs CMD, DAT rise and fall times are measured by $\min(V_{OH})$ and $\max(V_{OL})$.

7.3 Bus timing for DAT signals during 2x data rate operation

These timings applies to the DAT[7:0] signals only when the device is configured for dual data mode operation. In this dual data mode, the DAT signals operates synchronously of both the rising and the falling edges of CLK. The CMD signal still operates synchronously of the rising edge of CLK and therefore it complies with the bus timing specified in chapter 7.2. Therefore there is no timing change for the CMD signal

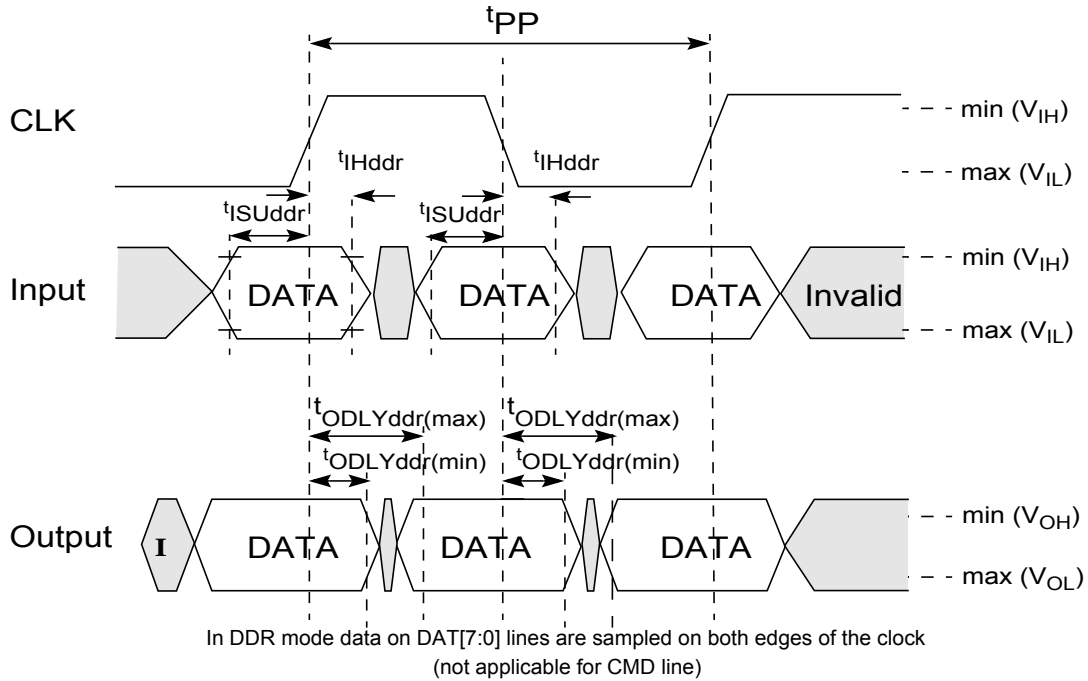


Figure 9. Timing diagram: data input/output in dual data rate mode

7.3.1 Dual data rate interface timings

[Table 41] High-speed dual rate interface timing

Parameter	Symbol	Min	Max.	Unit	Remark ¹
Input CLK ¹					
Clock duty cycle		45	55	%	Includes jitter, phase noise
Input DAT (referenced to CLK-DDR mode)					
Input set-up time	t _{ISUddr}	2.5		ns	CL ≤ 20 pF
Input hold time	t _{IHddr}	2.5		ns	CL ≤ 20 pF
Output DAT (referenced to CLK-DDR mode)					
Output delay time during data transfer	t _{ODLYddr}	1.5	7	ns	CL ≤ 20 pF
Signal rise time (all signals) ²	t _{RISE}		2	ns	CL ≤ 20 pF
Signal fall time (all signals)	t _{FALL}		2	ns	CL ≤ 20 pF

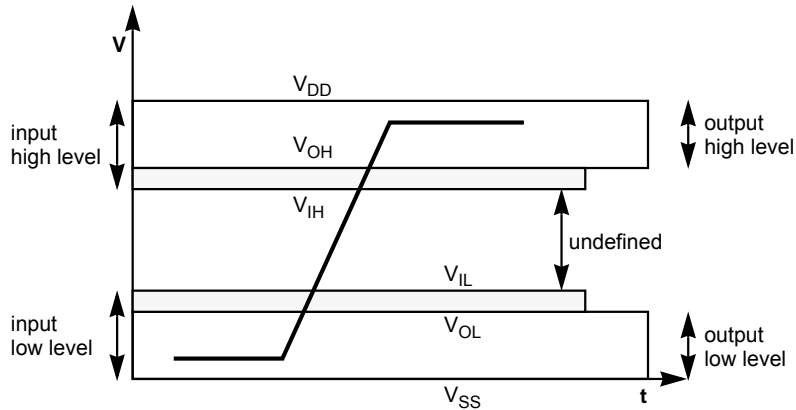
NOTE :

1) CLK timing is measured at 50% of VDD

2) Inputs CMD, DAT rise and fall times are measured by min (V_{IH}) and max(V_{IL}), and outputs CMD,DATrise and fall times measured by min(V_{OH}) and max(V_{OL})

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 42] Open-drain bus signal level

Parameter	Symbol	Min	Max.	Unit	Conditions
Output HIGH voltage	V_{OH}	$V_{DD} - 0.2$		V	$I_{OH} = -100 \mu A$
Output LOW voltage	V_{OL}		0.3	V	$I_{OL} = 2 \text{ mA}$

The input levels are identical with the push-pull mode bus signal levels.

7.4.2 Push-pull mode bus signal level.high-voltage MultiMediaCard

To meet the requirements of the JEDEC standard JESD8C.01, the card input and output voltages shall be within the following specified ranges for any V_{DD} of the allowed voltage range:

[Table 43] Push-pull signal level.high-voltage MultiMediaCard

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

7.4.3 Push-pull mode bus signal level.dual-voltage MultiMediaCard

The definition of the I/O signal levels for the Dual voltage MultiMediaCard changes as a function of V_{DD} .

- 2.7V - 3.6V: Identical to the High Voltage MultiMediaCard (refer to Chapter 7.4.2 on page27 above).
- 1.95V - 2.7V: Undefined. The card is not operating at this voltage range.
- 1.70V - 1.95V: Compatible with EIA/JEDEC Standard "EIA/JESD8-7 Normal Range" as defined in the following table.

[Table 44] Push-pull signal level—dual-voltage MultiMediaCard

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

NOTE:

- 1) $0.7 \cdot V_{DD}$ for MMC4.3 and older revisions.
- 2) $0.3 \cdot V_{DD}$ for MMC4.3 and older revisions.

7.4.4 Push-pull mode bus signal level.eMMC

The definition of the I/O signal levels for the eMMC devices changes as a function of VCCQ.

- 2.7V-3.6: Identical to the High Voltage MultiMediaCard (refer to Chapter 7.4.2 on page27).
- 1.95- 2.7V: Undefined. The eMMC device is not operating at this voltage range.
- 1.65V-1.95V: Identical to the 1.8V range for the Dual Voltage MultiMediaCard (refer to Chapter 7.4.3 on page27).
- 1.3V - 1.65V: Undefined. The eMMC device is not operating at this voltage range.
- 1.1V-1.3V: Compatible with EIA/JEDEC Standard "JESD8-12A.01 normal range: as defined in the following table.

[Table 45] Push-pull signal level.1.1V-1.3V VCCQ range eMMC

Parameter	Symbol	Min	Max.	Unit	Conditions
Output HIGH voltage	V_{OH}	$0.75V_{CCQ}$		V	$I_{OH} = -2mA$
Output LOW voltage	V_{OL}		$0.25V_{CCQ}$	V	$I_{OL} = 2mA$
Input HIGH voltage	V_{IH}	$0.65*V_{CCQ}$	$V_{CCQ} + 0.3$	V	
Input LOW voltage	V_{IL}	$V_{SS} - 0.3$	$0.35*V_{CCQ}$	V	

8.0 DC PARAMETER

8.1 Active Power Consumption during operation

[Table 46] Active Power Consumption during operation

Density	NAND Type	CTRL	NAND	Unit
16GB	64Gb MLC x 2	100	100	mA
32GB	64Gb MLC x 4			
64GB	64Gb MLC x 8			

* Power Measurement conditions: Bus configuration =x8 @52MHz

* 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 47] 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	
16GB	64Gb MLC x 2	100	250	30	100	uA
32GB	64Gb MLC x 4			60	200	
64GB	64Gb MLC x 8			120	400	

NOTE:

Power Measurement conditions: Bus configuration =x8 @52MHz , 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 48] Sleep Power Consumption in Sleep State

Density	NAND Type	CTRL		NAND	Unit
		25°C(Typ)	85°C		
16GB	64Gb MLC x 2	100	250	0 ¹⁾	uA
32GB	64Gb MLC x 4				
64GB	64Gb MLC x 8				

NOTE:

Power Measurement conditions: Bus configuration =x8 @52MHz ,

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 49] Supply Voltage

Item	Min	Max	Unit
VDD	1.70 (2.7)	1.95 (3.6)	V
VDDF	2.7	3.6	V
Vss	-0.5	0.5	V

8.5 Bus Operating Conditions

[Table 50] Bus Operating Conditions

Parameter	Min	Max	Unit
Peak voltage on all lines	-0.5	3.6	V
Input Leakage Current	-2	2	μA
Output Leakage Current	-2	2	μA

8.6 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_{movi} of the e-MMC connected to this line:

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

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

[Table 51] Bus Signal Line Load

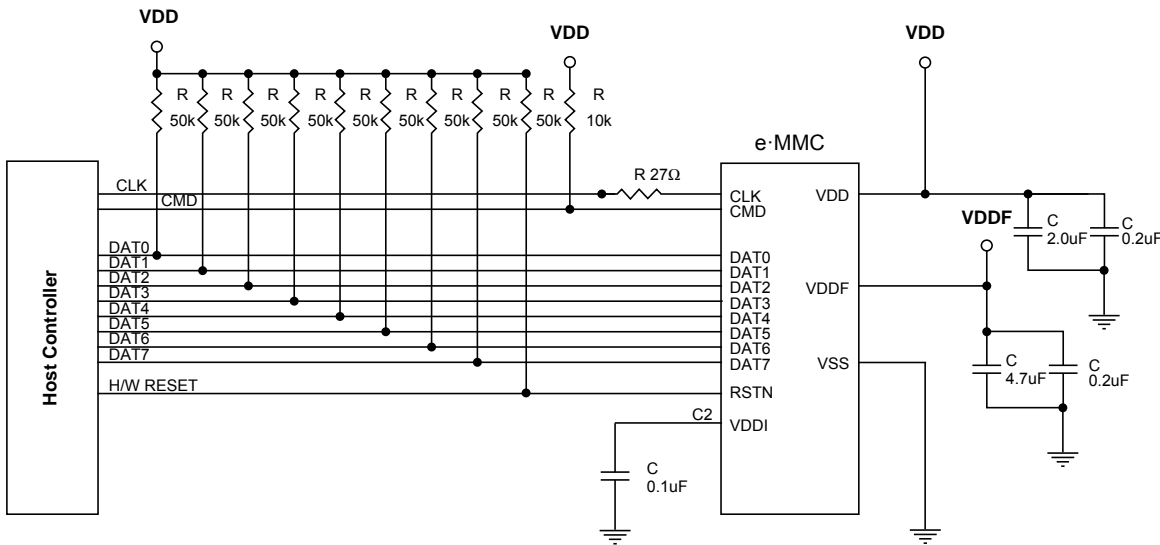
Parameter	Symbol	Min	Typ.	Max	Unit	Remark
Pull-up resistance for CMD	R_{CMD}	4.7		100	KOhm	to prevent bus floating
Pull-up resistance for DAT0-DAT7	R_{DAT}	10		100	KOhm	to prevent bus floating
Internal pull up resistance DAT1-DAT7	R_{int}	10		150	KOhm	to prevent unconnected lines floating
Single e-MMC capacitance	C_{movi}		71	2	pF	
Maximum signal line inductance				16	nH	$f_{pp} \leq 52$ MHz

A. e-MMC Connection Guide

This Connection guide is an example for customers to adopt e-MMC more easily

- This appendix is just guideline for e-MMC connection. This value and schematic can be changed depending on the system environment.
- Coupling capacitor should be connected with VDD and VSS as closely as possible.
- VDDI Capacitor is min 0.1uF
- Impedance on CLK match is needed.
- SAMSUNG recommends 27Ω for resistance on CLK line. However 0Ω ~47Ω is also available.
- If host does not have a plan to use H/W reset, it is not needed to put 50KΩ pull-up resistance on H/W rest line.
- SMASUNG Recommends to separate VDD and VDDF power.

A.1 x8 support Host connection Guide



A.2 x4 support Host connection Guide

