

MultiMediaCard

MMC Host Algorithm Guideline

Date : October. 2004

Samsung Electronics Co., LTD
Semiconductor Flash Memory Product Planning & Applications

CONTENTS

1. Introduction

- 1.1 Introduction
- 1.2 Advantage of MMC

2. MMC card General Function

- 2.1 Comparison of MMC mode and SPI mode
- 2.2 MMC mode Bus protocol
- 2.3 SPI mode Bus protocol
- 2.4 General Function Description

3. MMC card Command

- 3.1 Command Format
- 3.2 MMC mode Command

4. MMC card Application & Algorithm Guideline

- 4.1 MMC card Application
- 4.2 Efficient MMC Standard Algorithm
 - 4.2.1 Operation Sequence
 - 4.2.2 Initialization
 - 4.2.3 MBR, PBR and FAT access
 - 4.2.4 Read, Write & Erase

5. Conclusion

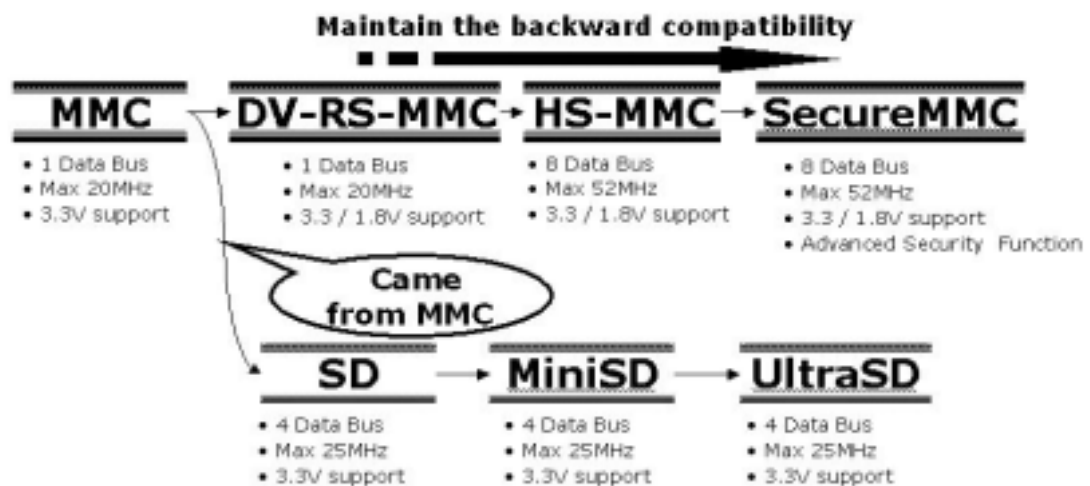
1. Introduction

1.1 Introduction

Today mobile devices' form factors are becoming smaller, and due to this fact MMC card is replacing the larger Compact Flash card rapidly. MMC card is flexible for the hosts, because of its compatibility with the SD card hosts. Recently MMCplus and MMC mobile has been developed to provide high performance with x8 bus and 52MHz clock speed.

Although most host devices are implemented according to the MMC standard specification, the implementations are largely depend on the developer's interpretation of the MMC specification. Due to this fact some implementation shows incompatibility with certain MMC cards. With the result from extensive compatibility test with various DSC, DVC, PDA, and USB reader, this report proposes MMC standard compatible MMC host device implementation methodology.

☐ SD cards originally came from MMC



➤ **Almost all DSC vendors support both MMC and SD easily**

1.2 Advantage of MMC

- MMCA Open Standard
- No License Fee, No Royalty, lowest cost
- Widest choice of top card suppliers with their own controller & flash design & fabrication
- Over 100 members representing the leading manufacturers of host systems, cards, controllers, connectors, etc
- Best specs (size, speed, voltage, security, compliance, etc.)
- Already adopted by 4 out of the top 5 mobile phone suppliers

2. MMC card General Function

2.1 Comparison of MMC mode and SPI mode

MMC Card supports both MMC mode and SPI mode. MMC host device supports one of these two modes. Although the default mode for the MMC card is MMC mode SPI mode is supported for the flexible application support. But under the SPI mode not all the features and registers of MMC mode is supported, and thus cannot fully utilize MMC cards performance. This guideline explains the implementation method for the MMC mode to fully exploit the high performance of the MMC card.

- MMC mode : This mode is a main of the MultiMediaCard protocol. CMD and DAT lines are bi-directional channel.
- SPI mode : This mode is a subset of the MultiMediaCard protocol, designed to communicate with a SPI channel, commonly found in Motorola's (and lately a few other vendors') microcontrollers. The interface is selected during the first reset command after power up (CMD0) and cannot be changed once the part is power on. From the application point of view, the advantage of the SPI mode is the capability of using an off-the-shelf host, hence reducing the design-in effort to minimum. The disadvantage is the loss of performance of the SPI mode versus MultiMediaCard mode(lower data transfer rate, hardware CS, etc.).

Comparison of system specification	MMC Interface Mode				SPI Interface Mode		
	Interface	Ten-wire bus(CLK,CMD, DAT0-8)			Three-wire serial data bus(CLK,DI,DO)+CS		
	Frequency	0-20MHz, 0-26MHz, 0-52MHz			0-20MHz		
	Card selection	Card is selected by MMC bus protocol. Host sends the relative card address to select the card which has the same one.			Card is selected by the CS signal		
Pin Arrangement	Access mode	Single block access, Multiple block access, Stream access			Single block access, Multi block access		
	Pin No.	Name	Type	Description	Name	Type	Description
	1	DAT3	I/O/PP	Data	CS	Input	Chip Select
	2	CMD	I/O/PP/OD	Command/Response	DI	I/PP	Data In
	3	VSS1	-	GND	VSS	-	GND
	4	VDD	-	VCC	VDD	-	VCC
	5	CLK	Input	Clock	SCLK	Input	Clock
	6	VSS2	-	GND	VSS2	-	GND
	7	DAT0	I/O/PP	Data	DO	O/PP	Data Out
	8	DAT1	I/O/PP	Data	Not Used		
	9	DAT2	I/O/PP	Data	Not Used		
	10-13	DAT4-DAT7	I/O/PP	Data	Not Used		

Table 1. MultiMediaCard Interface Pin Configuration

2.2 MMC mode Bus protocol

CMD line is used for the command and response transfer and DAT line is used for the data transfer between MMC host device and the MMC card. Command is sent from

the host device to the card and response sent from the card to the host. Data is sent from the card to the host for the read operation and vice versa for the write operation.

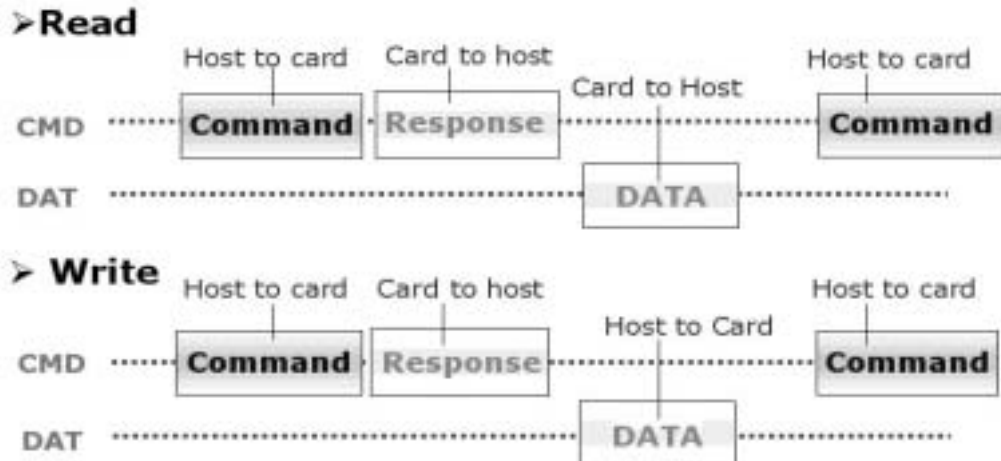


Figure 1. MMC Bus Protocol

2.3 SPI mode Bus protocol

CMD and DAT line for the MMC mode is replaced by dataIn and dataOut line for the SPI mode. While CMD and DAT line were bidirectional buses, dataIn and dataOut lines are unidirectional buses. So the command and data from the host device are sent over dataIn line and response and data from the card are sent over the dataOut line.

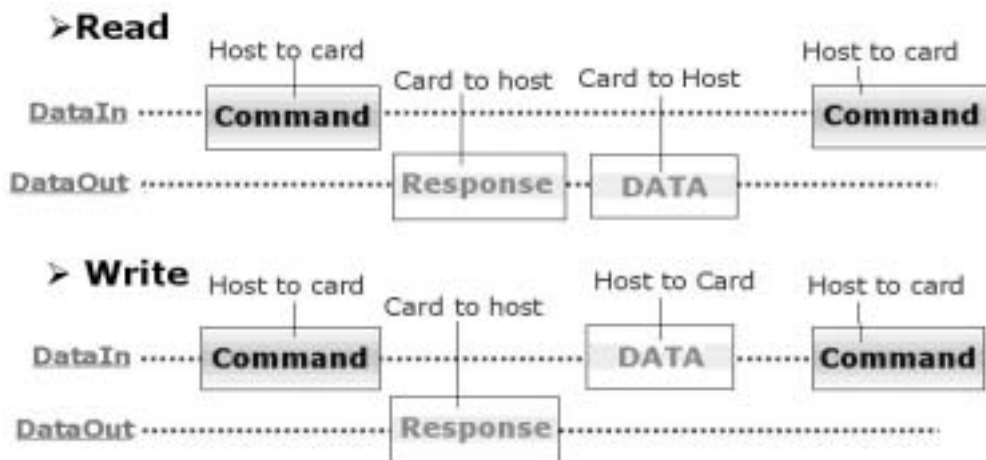


Figure2. SPI Bus Protocol

2.4 General Function Description

MMC system has various operation modes such as Inactive mode, Card identification mode, Data Transfer mode, Interrupt mode. Most of the time it's operational the system is under the Card identification mode and Data transfer mode.

- **Card identification mode :** The host will be in card identification mode after reset and while it is looking for new cards on the bus.. After power-on by the host, cards is in MultiMediaCard mode and in Idle State. Command GO_IDLE_STATE(CMD0) is the software reset command and puts the card into Idle State. After the bus is activated, the host will request the cards to send its valid operation conditions (CMD1). The response to CMD1 is the 'wired and' operation on the condition restrictions of all cards in the system. Incompatible cards are sent into Inactive State. The host then issues the

broadcast command ALL_SEND_CID(CMD2), asking all cards for its unique card identification(CID) number. Since CID numbers are unique for each card, there should be only one card which successfully sends its full CID-number to the host. This card then goes into Identification State. Thereafter, the host issues CMD3(SET_RELATIVE_ADDR) to assign to this card in the future data transfer mode.

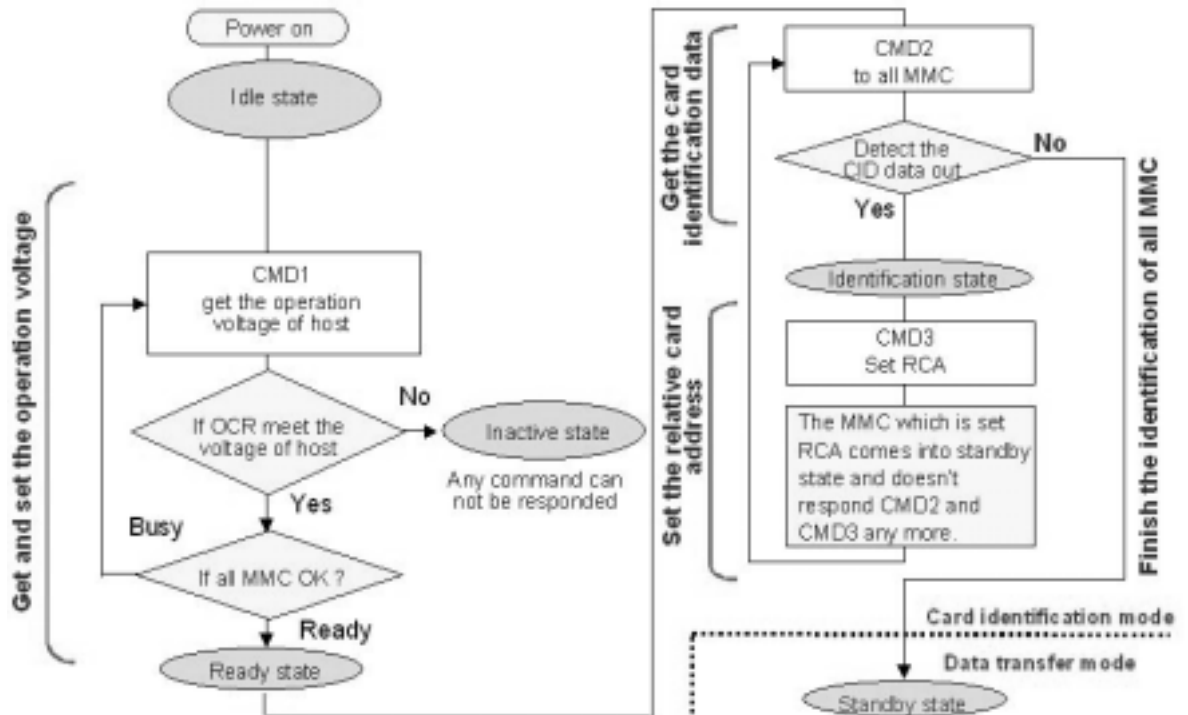


Figure 3. Card Identification Mode

- Data Transfer mode : Card will enter data transfer mode once an RCA is assigned to them. The host will enter data transfer mode after identifying all the cards on the bus. The host issues SEND_CSD(CMD9) to obtain the Card Specific Data(CSD register), e.g. block length, card storage capacity, maximum clock rate, etc.
The broadcast command SET_DSR(CMD4) configures the driver stages of the card. It programs its DSR register corresponding to the application bus layout and the data.
All data communication in the Data Transfer Mode is point-to-point between the host and the selected card. All addressed commands get acknowledged by response on the CMD line.

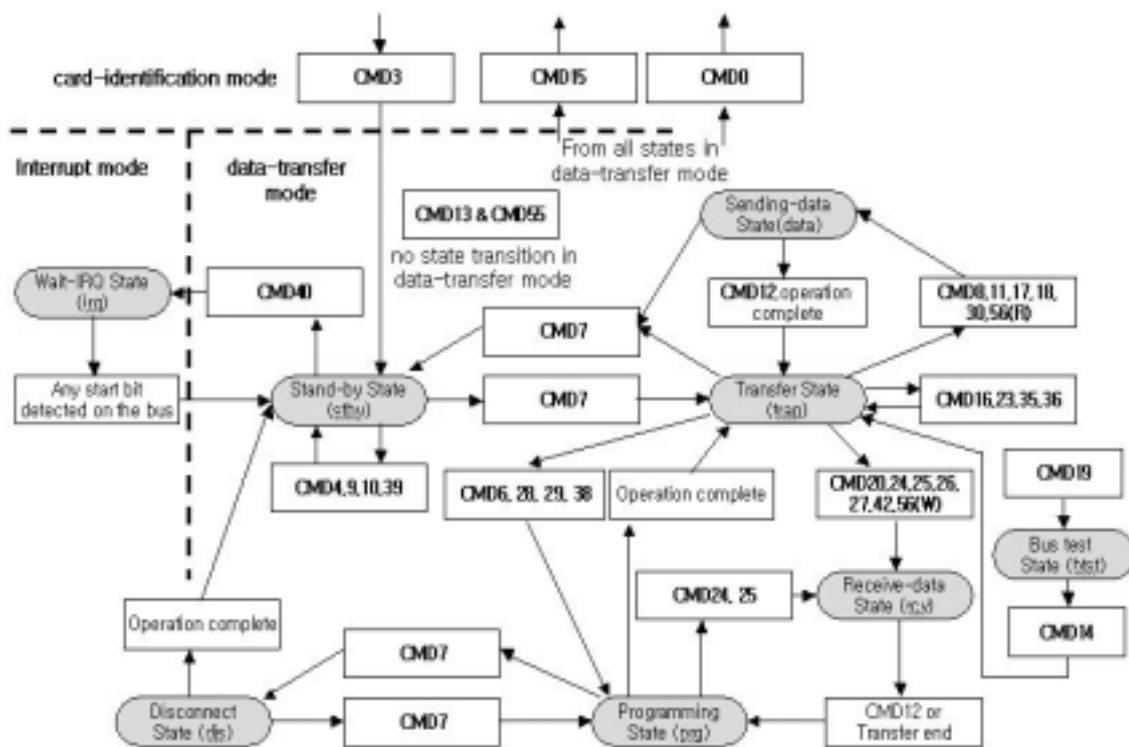


Figure 4. Data Transfer Mode

3. MMC card Command

3.1 Command Format

All commands have a fixed code length of 48 bits. A command always starts with a Start bit (always '0'), followed by the bit indicating the direction of transmission (host='1'). The next 6 bits indicate the index of the command, this value being interrupted as a binary coded number (between 0 and 63). Some commands need an argument (e.g. an address), which is coded by 32 bits. A value denoted by 'x' in the table above indicates the variable is dependent on the command. All commands are protected by a CRC. Every command codeword is terminated by the end bit (always '1'). All commands and their arguments are listed in chapter 3.2.

Bit position	47	46	[45:40]	[39:8]	[7:1]	0
Width(bits)	1	1	6	32	7	1
Value	0	1	x	x	x	1
Description	start bit	transmission bit	command index	argument	CRC7	end bit

3.2 MMC mode Command

Only the MMC mode command is explained since SPI mode is not recommended.

CMD Index	Abbreviation	Command Description
CMD0	GO_IDLE_STATE	Resets the card to idle state
CMD1	SEND_OP_COND	Asks the card, in idle state, to send its Operating Conditions Register contents in the response on the CMD line.
CMD2	ALL_SEND_CID	Asks the card to send its CID number on the CMD line.
CMD3	SET_RELATIVE_ADDR	Assigns relative address to the card

CMD Index	Abbreviation	Command Description
CMD4	SET_DSR	Programs the DSR of the card
CMD5	reserved	
CMD6	SWITCH	Switches the mode of operation of the selected card or modifies the EXT_CSD registers.
CMD7	SELECT/DESELECT_CARD	Command toggles a card between the stand-by and transfer states or between the programming and disconnect states. In both cases the card is selected by its own relative address and gets deselected by any other address; address 0 deselects the card.
CMD8	SEND_EXT_CSD	The card sends its EXT_CSD register as block of data.
CMD9	SEND_CSD	Addressed card sends its card-specific data(CSD) on the CMD line.
CMD10	SEND_CID	Addressed card sends its card identification data(CID) on the CMD line.
CMD11	READ_DAT_UNTIL_STOP	Reads data stream from the card, starting at the given address, until a STOP_TRANSMISSION follows.
CMD12	STOP_TRANSMISSION	Forces the card to stop transmission
CMD13	SEND_STATUS	Addressed card sends its status register
CMD14	BUSTEST_R	A host reads the reserved bus testing data pattern from a card.
CMD15	GO_INACTIVE_STATE	Sets the card to inactive state
CMD19	BUSTEST_W	A host sends the bus test data pattern to a card.

Table 2. Basic Commands and Read Stream Commands (Class 0 & Class 1)

CMD Index	Abbreviation	Command Description
CMD16	SET_BLOCKLEN	Sets the block length (in bytes) for all following block commands (read and write). Default block length is specified in the CSD.
CMD17	READ_SINGLE_BLOCK	Reads a block of the size selected by the SET_BLOCKLEN command.
CMD18	READ_MULTIPLE_BLOCK	Continuously transfers data block from card to host until interrupted by a stop command, or the requested number of data blocks it transmitted

Table 3. Block Oriented Read Commands (Class 2)

CMD Index	Abbreviation	Command Description
CMD20	WRITE_DAT_UNTIL_STOP	Writes a data stream from the host, starting at the given address, until a STOP_TRANSMISSION follows.
CMD21... CMD22	reserved.	

Table 4. Stream Write Commands (Class 3)

CMD Index	Abbreviation	Command Description
CMD23	SET_BLOCK_COUNT	Defines the number of blocks

		which are going to be transferred in the immediately succeeding multiple block read or write command. If argument is all 0s, the subsequent read/write operation will be open-ended.
CMD24	WRITE_BLOCK	Writes a block of the size selected by the SET_BLOCKLEN command.
CMD25	WRITE_MULTIPLE_BLOCK	Continuously writes blocks of data until a STOP_TRANSMISSION follows or the requested number of block received.
CMD26	PROGRAM_CID	Programming of the card identification register. This command shall be issued only once. The card contains hardware to prevent this operation after the first programming. Normally this command is reserved for the manufacturer.
CMD27	PROGRAM_CSD	Programming of the programmable bits of the CSD.

Table 5. Block Oriented Write Commands (Class 4)

CMD Index	Abbreviation	Command Description
CMD28	SET_WRITE_PROT	If the card has write protection features, this command sets the write protection bit of the addressed group. The properties of write protection are coded in the card specific data(WP_GRP_SIZE).
CMD29	CLR_WRITE_PROT	If the card provides write protection features, this command clears the write protection bit of the addressed group.
CMD30	SEND_WRITE_PROT	If the card provides write protection features, this command asks the card to send the status of the write protection bit.
CMD31	reserved	

Table 6. Block Oriented Write Protection Commands (Class 6)

CMD Index	Abbreviation	Command Description
CMD32... CMD34	reserved. These command indexes cannot be used in order to maintain backwards compatibility with older versions of the MMC.	
CMD35	ERASE_GROUP_START	Sets the address of the first erase group within a range to be selected for erase

CMD Index	Abbreviation	Command Description
CMD36	ERASE_GROUP_END	Sets the address of the last erase group within a continuous range to be selected for erase
CMD37	reserved. This command index cannot be used in order to maintain backwards compatibility with older versions of the MMC.	
CMD38	ERASE	Erases all previously selected write blocks

Table 7. Erase Commands (Class 5)

CMD Index	Abbreviation	Command Description
CMD39	FAST_IO	Used to write and read 8 bit (register) data fields. The command addresses a card and a register and provides the data for writing if the write flag is set. The R4 response contains data read from the addressed register. This command accesses application dependent registers which are not defined in the MMC standard.
CMD40	GO_IRQ_STATE	Sets the system into interrupt mode
CMD41	reserved	

Table 8. I/O Mode Commands (Class 9)

CMD Index	Abbreviation	Command Description
CMD42	LOCK_UNLOCK	Used to set/reset the password or lock/unlock the card. The size of the data block is set by the SET_BLOCK_LEN command.
CMD43... CMD54	reserved	

Table 9. Lock Card (Class 7)

CMD Index	Abbreviation	Command Description
CMD55	APP_CMD	Indicates to the card that the next command is an application specific command rather than a standard command
CMD56	GEN_CMD	Used either to transfer a data block to the card or to get a data block from the card for general purpose/application specific commands. The size of the data block shall be set by the SET_BLOCK_LEN command.
CMD57... CMD59	reserved	

CMD Index	Abbreviation	Command Description
CMD60... CMD63	reserved for manufacturer	

Table 10. Application Specific Commands (Class 8)

4. MMC card Application & General Algorithm

4.1 MMC card Application

Today the biggest application for the MMC card is DSC, which comprises 70% of the total MMC card market. But other applications such as DVC, PDA, MP3, Mobile phone are growing rapidly. With the introduction of RS-MMC to the market and rapid multimedia feature convergence for the mobile phones, the adaptation of the MMC card by the mobile phone is expected to grow tremendously.

4.2 Efficient MMC Standard Algorithm

Although the MMC host devices implement the MMC standard specification, many times the host device results in unstable state by issuing abundant needless commands, or continuing without proper status checking.

4.2.1 Operation Sequence

In summary, the host device goes through initialization step after the Power-On. At this step the card is under the Identification mode. After this step the card is under data transfer mode. After the initialization the host device reads the FAT information from the card and performs read and write operation afterwards. Following are detailed explanations of the each step

4.2.2 Initialization

After the Power-on the host devices sends reset command (CMD0). To check the card's operation condition Host issues CMD1 and puts the card into ready state. After CMD1 host issues CMD2 to check the card's CID. Then the host issues CMD3 to put the card into Stand-by state.

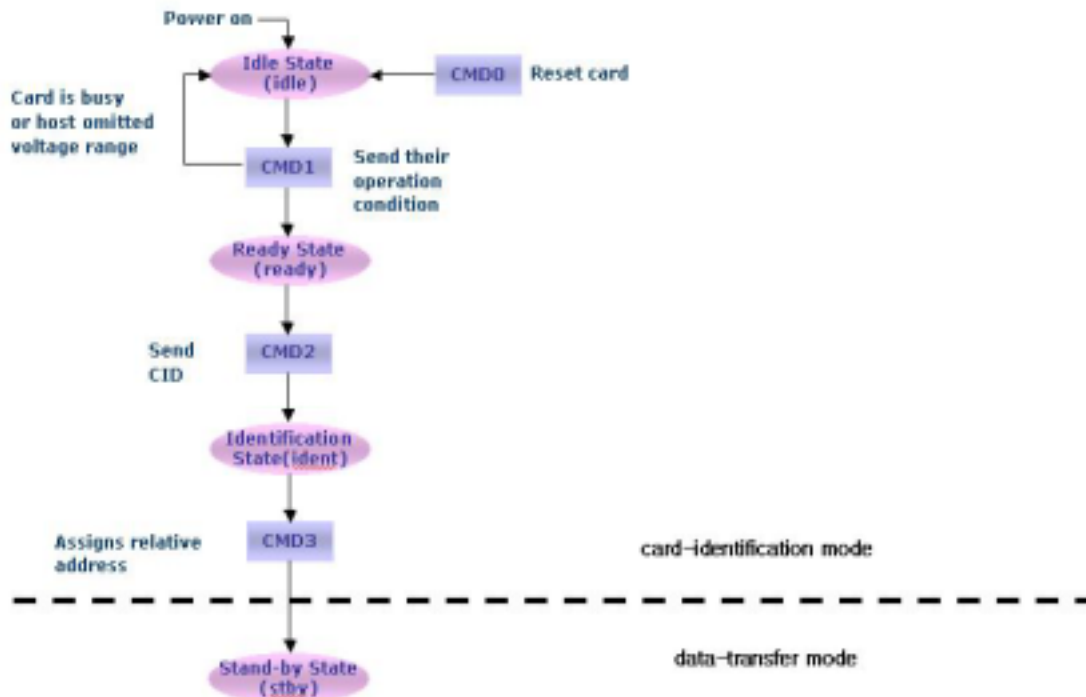


Figure 5. Initialization

4.2.3 MBR, PBR and FAT access

After the initialization the host accesses the card's MBR, PBR, and FAT region. When accessing FAT information, CMD18 should be used over CMD17 to achieve accurate and stable transfer of the information. Under the Data transfer mode CMD13 (SEND_STATUS) should be used prior to each command to check the card's current status.

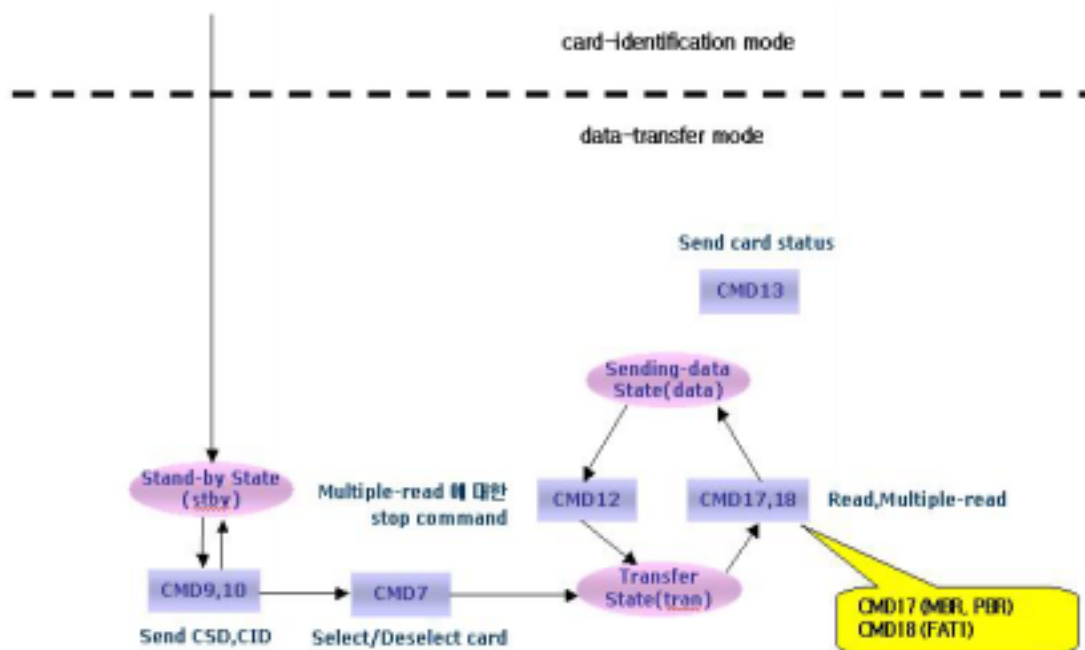


Figure 6. MBR,PBR & FAT access

4.2.4 Read, Write & Erase

■ Data read

For the read operation CMD17 (READ_SINGLE_BLOCK) and CMD18 (READ_MULTIPLE_BLOCK) are used. For the efficient read operation only the required data should be read.

Data Read(CMD17+CMD13 or CMD18+CMD12+CMD13)

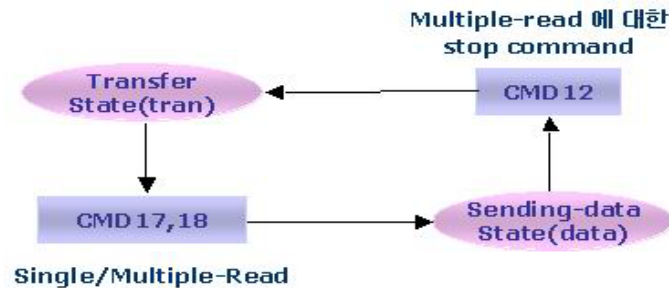


Figure 7. Read

■ Data write

For the write operation CMD24 (WRITE_SINGLE_BLOCK) and CMD25 (WRITE_MULTIPLE_BLOCK) are used. After the FAT is read, data write operation is performed followed by the FAT update.

FAT read(CMD18+CMD12) →

Data Write(CMD24+CMD13 or CMD25+CMD12+CMD13) →

FAT update(CMD24 or CMD25)

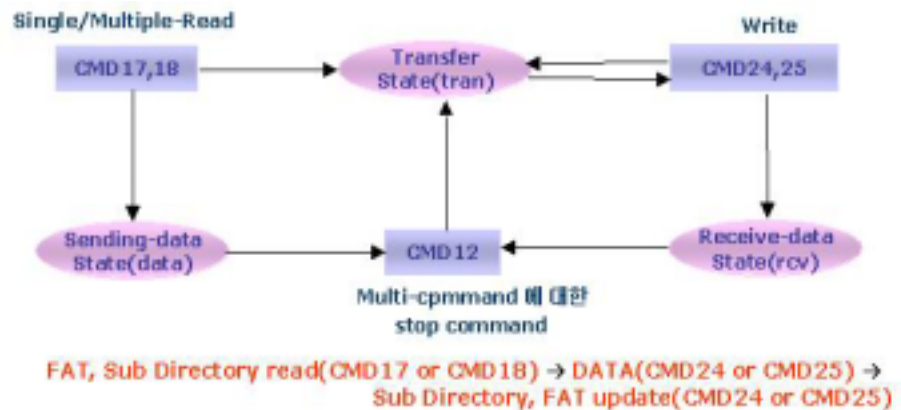


Figure 8. Write

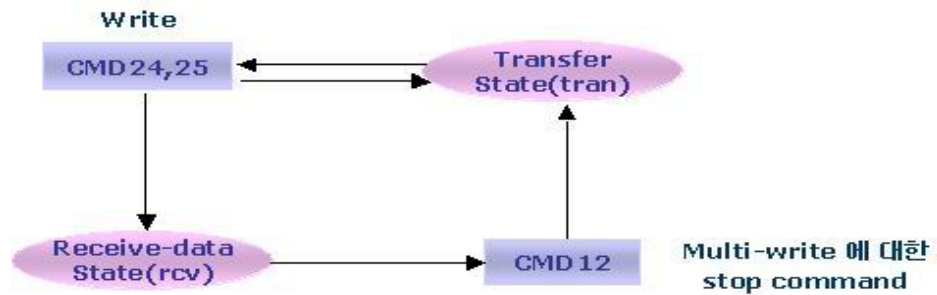
Multiple Block Read and Write command continues until the STOP command is issued. So when the CMD18 and CMD25 are used, it has to be finished with the CMD12.

■ Data erase

The information in the FAT has to be erased and the file in the sub-directory has to be erased.

FAT update(CMD24 or CMD25+CMD12) →

Sub Directory update(CMD24 or CMD25+CMD12)



After each Read, Write, and Erase operation is performed the host has to use CMD13 to check the card's status

5. Conclusion

The implementation guideline explained in this paper is based on the MMC standard specification. On top of the standard specification, the result from the benchmarking of the various application hosts has been used to guide the most stable and efficient host implementation methodology.