JEDEC STANDARD

Embedded MultiMediaCard(*e*•MMC) *e*•MMC/Card Product Standard, High Capacity, including Reliable Write, Boot, Sleep Modes, Dual Data Rate, Multiple Partitions Supports, Security Enhancement, Background Operation and High Priority Interrupt (MMCA, 4.41)

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Foreword

This standard has been prepared by JEDEC and the MultiMediaCard Association, hereafter referred to as MMCA.

JEDEC has taken the basic MMCA specification and adopted it for embedded applications, calling it "*e*•MMC." In addition to the packaging differences, *e*•MMC devices use a reduced-voltage interface.

The purpose of this standard is the definition of the MMC/*e*•MMC Electrical Interface, its environment and handling. It provides guidelines for systems designers. The standard also defines a tool box (a set of macro functions and algorithms) that contributes to reducing design-in costs.

The SPI mode is obsolete in this version.

Introduction

The MMC/*e*•MMC is an universal low cost data storage and communication media. It is designed to cover a wide area of applications as smart phones, cameras, organizers, PDAs, digital recorders, MP3 players, pagers, electronic toys, etc. Targeted features are high mobility and high performance at a low cost price. These features include low power consumption and high data throughput at the memory card interface.

MMC/*e*•MMC communication is based on an advanced 10-signal bus. The communication protocol is defined as a part of this standard and referred to as the MultiMediaCard mode.

To provide for the forecasted migration of CMOS power (V_{DD}) requirements and for compatibility and integrity of MultiMediaCard systems, two types of MultiMediaCards are defined in this standard, which differ only in the valid range of system V_{DD}. These two card types are referred to as High Voltage MultiMediaCard and Dual Voltage MultiMediaCard.

Embedded MultiMediaCard (*e*•MMC) *e*•MMC/Card Product Standard, High Capacity, including Reliable Write, Boot, Sleep Modes, Dual Data Rate, Multiple Partitions supports, Security enhancement, Background Operation and High Priority Interrupt (MMCA 4.41)

(From BoD ballot, JCB-10-08, formulated under the cognizance of the JC-64 committee on Flash Memory Modules)

1 Scope

This document provides a comprehensive definition of the MMC/*e*•MMC Electrical Interface, its environment, and handling. It also provides design guidelines and defines a tool box of macro functions and algorithms intended to reduce design-in costs.

2 Normative reference

The following normative documents contain provisions that, through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

3 Terms and definitions

For the purposes of this publication, the following abbreviations for common terms apply:

Block: A number of bytes, basic data transfer unit

Broadcast: A command sent to all cards on the MultiMediaCard bus

NOTE Broadcast occurs only in MultiMediaCard systems supporting versions prior to 4.0. In version 4.0 and later only one card can be present on the bus

CID: Card IDentification number register

CLK: Clock signal

CMD: Command line or MultiMediaCard bus command (if extended CMDXX)

CRC: Cyclic Redundancy Check

3 Terms and definitions (cont'd)

CSD: Card Specific Data register

Copies: Copies of erase group(s) or copies of write groups shall be defined as copies of data that are generated by the deviec controller during internal device controller operations. These can include (but are not limited to) copies generated during error handling, wear-leveling or garbage collection. Copies does not refer to write block data, at a specific address. This overwritten data may still remain in the memory array but is no longer accessible by the host. If this data must be secure trimmed, it is the host application's responsibility to mark this data for secure trim prior to the overwrite event.

DAT: Data line

DSR: Driver Stage Register

***e*•MMC:** embedded MultiMediaCard

ERASE: Block erase operation which does not require actual physical NAND erase operation

Flash: A type of multiple time programmable non volatile memory

Group: A number of write blocks, composite erase and write protect unit

LOW, HIGH: Binary interface states with defined assignment to a voltage level

NSAC: Defines the worst case for the clock rate dependent factor of the data access time

MSB, LSB: Most Significant Bit or Least Significant Bit

OCR: Operation Conditions Register

open-drain: A logical interface operation mode. An external resistor or current source is used to pull the interface level to HIGH, the internal transistor pushes it to LOW

payload: Net data

push-pull: A logical interface operation mode, a complementary pair of transistors is used to push the interface level to HIGH or LOW

RCA: Relative Card Address register

Reset: CMD0 with arguement of 0x00000000 or 0xF0F0F0F0, H/W reset (or CMD15)

ROM: Read Only Memory

RPMB: Replay Protected Memory Block

3 Terms and definitions (cont'd)

Secure Purge: The process of overwriting all the addressable locations within an identified range with a single character and then performing an erase on those same locations. One or multiple write blocks or write protect groups depending on context.

NOTE The definition of secure purge is technology dependent (the definition above assumes NAND flash). Please refer to the http://www.killdisk.com/dod.htm or the following documents for more details. DoD 5220.22M(http://www.dtic.mil/whs/directives/corres/html/522022m.htm) and NIST SP 800-88 (http://csrc.nist.gov/publications/nistpubs/800-88/NISTSP800-88_rev1.pdf)

stuff bit: Filling 0 bits to ensure fixed length frames for commands and responses

SPI: Serial Peripheral Interface

TAAC: Defines the time dependent factor of the data access time

three-state driver: A driver stage which has three output driver states: HIGH, LOW and high impedance (which means that the interface does not have any influence on the interface level)

token: Code word representing a command

$\mathbf{V_{DD}}$: + Supply voltage (Card)

$\mathbf{V_{SS}}$: + Supply voltage ground for Core (BGA)

$\mathbf{V_{SS1}}$: + Supply voltage ground (card)

$\mathbf{V_{SS2}}$: + Supply voltage ground (card)

$\mathbf{V_{CC}}$: + Supply voltage for Core (BGA)

$\mathbf{V_{CC}Q}$: + Supply voltage for I/O (BGA)

$\mathbf{V_{SS}Q}$: + Supply voltage ground for I/O (BGA)

Write Protectin, Permanent: Write and erase prevention scheme, which once enabled, cannot be reversed.

Write Protection, Power-on: Write and erase prevention scheme, which once enabled, cannot be reversed until a power failure event that causes the device to reboot occurs or the device is reset using the reset pin.

Write protection, Temporary: Write and erase prevention scheme that can be enabled and disabled.

4 General description

The MultiMediaCard is an universal low cost data storage and communication media. It is designed to cover a wide area of applications as smart phones, cameras, organizers, PDAs, digital recorders, MP3 players, pagers, electronic toys, etc. Targeted features are high mobility and high performance at a low cost price. These features include low power consumption and high data throughput at the memory card interface.

The MultiMediaCard communication is based on an advanced 13-pin bus. The communication protocol is defined as a part of this standard and referred to as the MultiMediaCard mode.

To provide for the forecasted migration of CMOS power (V_{DD}) requirements and for compatibility and integrity of MultiMediaCard systems, two types of MultiMediaCards are defined in this standard, which differ only in the valid range of system V_{DD}. These two card types are referred to as High Voltage MultiMediaCard and Dual Voltage MultiMediaCard.

The purpose of the system specification is the definition of the MultiMediaCard, its environment and handling. It gives guidelines for a system designer. The system specification also defines a tool box (a set of macro functions and algorithms) which contributes to reducing the design-in costs.

The document is split up into several portions. The MultimediaCard Features are described in Section 5.

Section 6 gives a general overview of the system components: card, bus, and host.

The common MultiMediaCard characteristics are described in Section 7. As this description defines an overall set of card properties, you should work with the vendor-specific, product documentation in parallel.

Section 8 describes the card registers.

The SPI mode is removed from this standard.

All error protection techniques employed in this standard are described in Section 10.

Section 11 describes the physical and mechanical properties of the cards and the minimal requirements of the card slots and cartridges.

Section 12 defines the MultiMediaCard bus as a universal communication interface and the electrical parameters of the interface.

The standard compliance criteria for the cards and hosts are described in Section 13.

Annex A contains additional information that is informative in nature and not considered a constituent part of this standard. These Application Notes contain useful hints for the circuit and system designers, helping simplify the design process.

Annex B lists the errata for the current version of this standard.

Annex C lists the major changes between the previous and the current version of this standard.

As used in this document, “shall” or “will” denotes a mandatory provision of the standard. “Should” denotes a provision that is recommended but not mandatory. “May” denotes a feature whose presence does not preclude compliance, that may or may not be present at the option of the implementor.

5 System features

The MultiMediaCard System has a wide variety of system features, whose comprehensive elements serves several purposes, which include:

- Covering a broad category of applications from smart phones and PDAs to digital recorders and toys
- Facilitating the work of designers who seek to develop applications with their own advanced and enhanced features
- Maintaining compatibility and compliance with current electronic, communication, data and error handling standards.

The following list identifies the main features of the MultiMediaCard System, which:

- Is targeted for portable and stationary applications
- Has these System Voltage (V_{DD}) Ranges:

Table 1 — MultiMediaCard Voltage Modes

	High Voltage MultiMediaCard	Dual Voltage MultiMediaCard
Communication	**2.7 - 3.6**	**1.70 - 1.95, 2.7 - 3.6[1]**
Memory Access	**2.7 - 3.6**	**1.70 - 1.95, 2.7 - 3.6**

NOTE 1 V_{DD} range: 1.95V - 2.7V is not supported.

- Includes MMCplus and MMCmobile definitions
- Is designed for read-only, read/write and I/O cards
- Supports card clock frequencies of 0-20MHz, 0-26MHz or 0-52MHz
- Has a maximum data rate up to 832Mbits/sec.
- Has a defined minimum performance
- Maintains card support for three different data bus width modes: 1-bit (default), 4-bit, and 8-bit
- Includes definition for higher than 2GB of density of memories
- Includes password protection of data
- Supports basic file formats for high data interchangeability
- Includes application specific commands
- Enables correction of memory field errors
- Has built-in write protection features for the boot and user areas, which may be permanent, power-on, or temporary
- Includes a simple erase mechanism
- Maintains full backward compatibility with previous MultiMediaCard systems (1 bit data

bus, multi-card systems)

- Ensures that new hosts retain full compatibility with previous versions of MultiMediaCards (backward compatibility).
- Supports two form factors: Normal size (24mm x 32mm x 1.4mm) and reduced size (24mm x 18mm x 1.4mm)
- Supports multiple command sets
- Includes attributes of the available operation modes:

Table 2 — MMC System Operational Mode

MultiMediaCard Mode
Ten-wire bus (clock, 1 bit command, 8 bit data bus)
Card selection is done through an assigned unique card address to maintain backwards compatibility to prior versions of the standard
One card per MultiMediaCard bus
Easy identification and assignment of session address
Error-protected data transfer
Sequential and Single/Multiple block Read/Write commands

- Provides a possibility for the host to make sudden power failure safe-update operations for the data content.
- Enhanced power saving method by introducing a sleep functionality.
- Introduces Boot Operation Mode to provide a simple boot sequence method.
- Provides a new CID Register setting to recognize either *e*•MMC or a card.
- Obsoletes the SPI Mode.
- Defines I/O voltage ($V_{CC}Q$) and core voltage (V_{CC}) separately for *e*•MMC.
- Includes *e*•MMC BGA Form Factors:
  11.5mm x 13mm x 1.3mm
  12mm x 16mm x 1.4mm
  12mm x 18mm x 1.4mm
- Defines Erase-unit size and Erase timeout for high-capacity memory.
- Provides access size register indicating one (or multiple) programmable boundary unit(s) of device.
- Obsoletes the Absolute Minimum Performance.
- Introduces *e*•MMC OCR setting and response.
- Defines WP group size for high-capacity devices.
- Introduces Alternative Boot Operation Mode.
- Introduces Secure Erase & Trim to enhance data security.

- Supports Multiple User Data Partition with Enhanced User Data Area options
- Signed access to a Replay Protected Memory Block.
- Introduces dual data rate transfer.
- Introduces high speed boot.
- Enhanced Write Protection with Permanent and Partial protection options.
- Introduces hardware reset signal.
- Introduces optional manual background operations processing.
- Introduces optional high priority interrupt mechanism.

6 MultiMediaCard system concept

The main design goal of the MultiMediaCard system is to provide a very low cost mass storage product, implemented as a 'card' with a simple controlling unit, and a compact, easy-to-implement interface. These requirements lead to a reduction of the functionality of each card to an absolute minimum.

Nevertheless, since the complete MultiMediaCard system has to have the functionality to execute tasks (at least for the high end applications), such as error correction and standard bus connectivity, the system concept is described next. It is based on modularity and the capability of reusing hardware over a large variety of cards.

Figure 1 shows four typical architectures of possible MultiMediaCard systems.

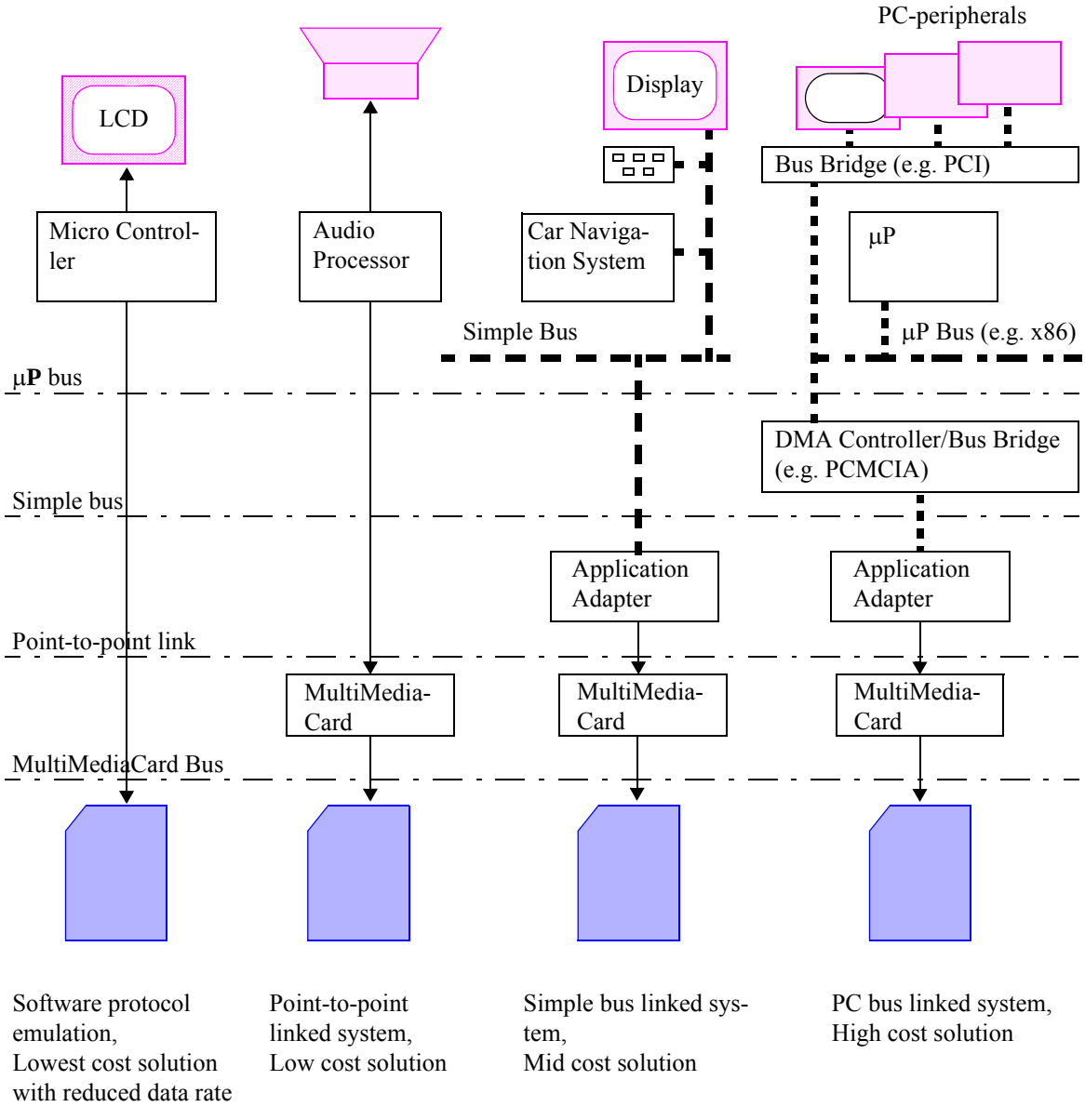


Figure 1 — Topology of MultiMediaCard systems

Four typical types of MultiMediaCard systems can be derived from the diagram shown in Figure 2. The typical systems include:

- Software emulation: reduced data rate, typically 100-300 kbit per second, restricted by the host
- Point to point linkage: full data rate (with additional hardware)
- Simple bus: full data rate, part of a set of addressable units
- PC bus: full data rate, addressable, extended functionality, such as DMA capabilities

In the first variant, the MultiMediaCard bus protocol is emulated in software using up to ten port pins of a microcontroller. This solution requires no additional hardware and is the cheapest system in the list. The other applications extend the features and requirements, step by step, towards a sophisticated PC solution. The various systems, although different in their feature set, have a basic common functionality, as can be seen in Figure 2. This diagram shows a system partitioned into hierarchical layers of abstract ('virtual') components. It describes a logical classification of functions which cover a wide variety of implementations. (See also Figure 1 on page 11.) It does not imply any specific design nor specify rules for implementing parts in hardware or software.

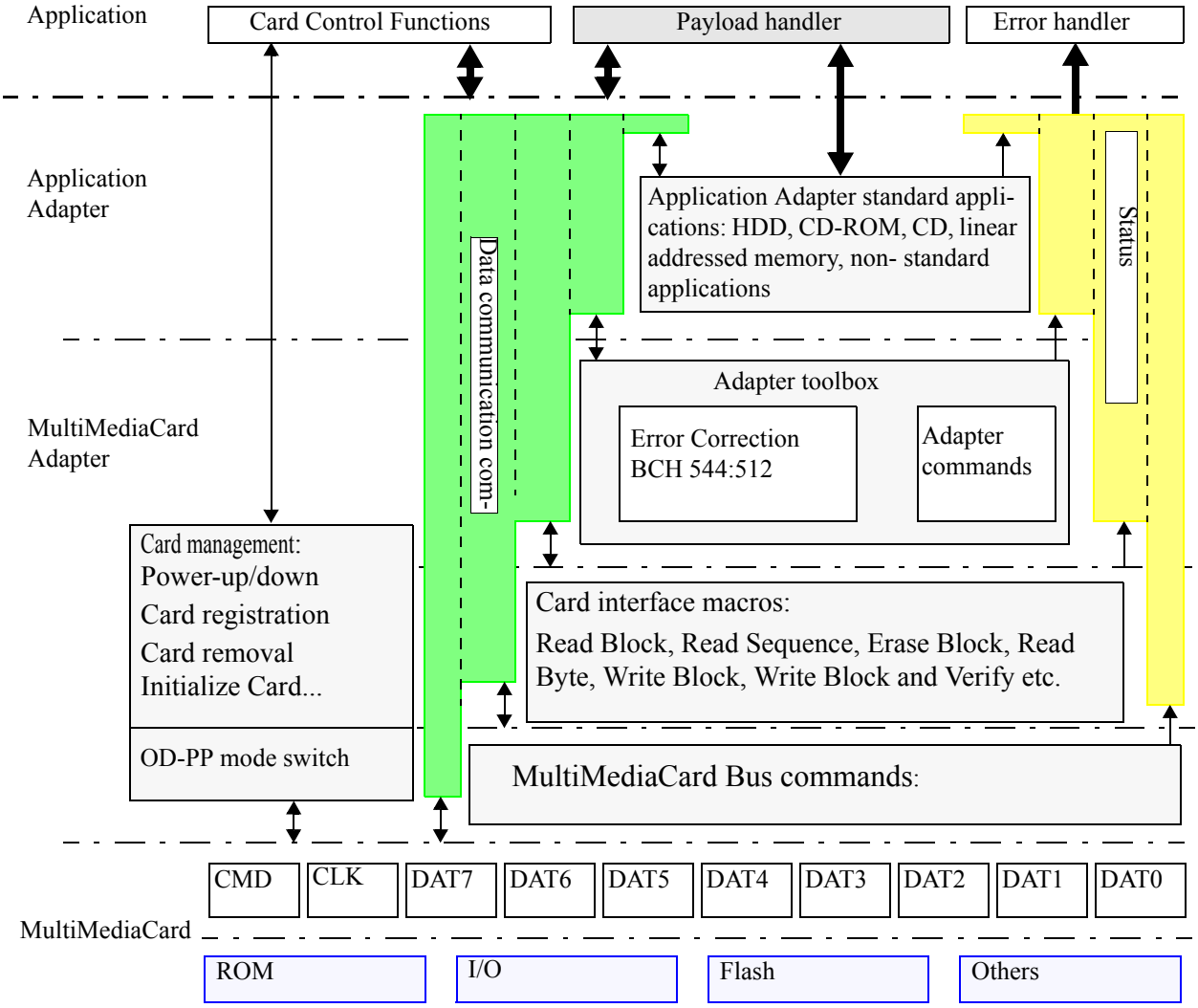


Figure 2 — MultiMediaCard system overview

Figure 3 is a specific design example based on the abstract layer model described in Figure 2 on page 12.

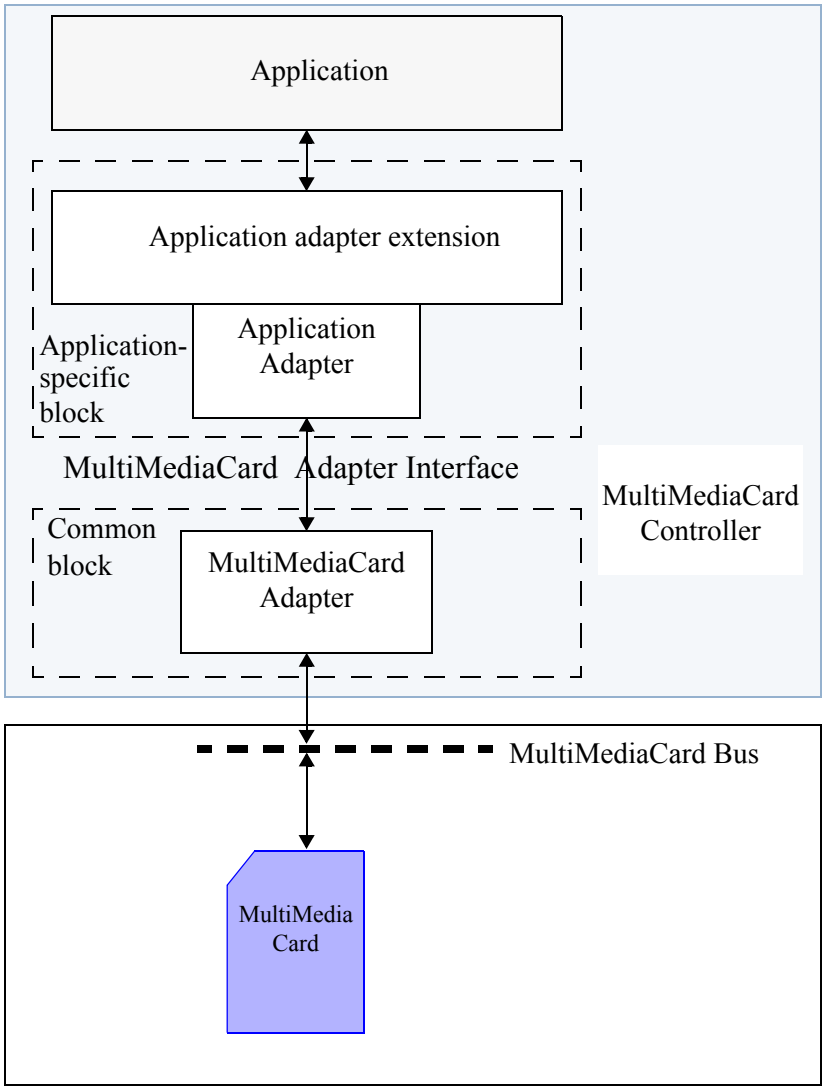


Figure 3 — MultiMediaCard system example

This MultiMediaCard system contains at least two components:

- The MultiMediaCard
- The MultiMediaCard controller

The MultiMediaCard controller is divided into two major blocks. In some implementations like the example shown in Figure 3, the controller may implement the whole application, while in others it may be divided into several physical components which, apart from the application itself, can be identified as:

1: Application adapter — the application specific block, for example, a microprocessor or an adapter to a standard bus like USB or ATA

- Performs application oriented tasks, e.g., display controlling or input decoding for hand-held applications

- Typically connected as a bus slave for a standard bus

2: MultiMediaCard adapter — the common block

- Contains all card specific functions, such as initialization and error correction
- Serves as a bus master for the MultiMediaCard bus
- Implements the standard interface to the card.

6.1 Higher than a density of 2GB

The maximum density possible to be implemented according to the versions up to v4.1 of this document was limited in practise to 2GB. This was due to the following reasons:

- Existed 32bit byte-address argument in the command frame (max 4GB could be addressed)
- Existed formula according to which to calculate the density of a card (max 4GB could be indicated)
- Capability of the FAT16 File System to address up to 2GB of address space per one partition

The lowest common nominator, 2GB in this case, will set the limit. The implementation of a higher than 2GB of density of memory will not be backwards compatible with the lower densities. First of all the address argument for higher than 2GB of density of memory is changed to be sector address (512B sectors) instead of byte address. Secondly the density of the card is read from the EXT_CSD register instead of CSD register. And finally the system implementation needs to include a File System capable of handling sector type of addresses.

6.2 MMC*plus* and MMC*mobile*

The standard further defines two card types, MMCplus and MMCmobile, to describe R/W or ROM cards with specifically defined mandatory features and attributes. Only cards meeting MMCplus or MMCmobile requirements are eligible to carry the MMCplus or MMCmobile name and logo.

- MMCplus is defined as normal size R/W or ROM cards that supports 2.7-3.6V operation, x1/x4/x8 bus widths.
- MMCmobile is defined as reduced size R/W or ROM card that supports 1.70-1.95V and 2.7-3.6V operations, x1/x4/x8 bus widths, minimum of 2.4MB/s read/write performance.

Both implementations are backwards compatible with MMCA System Specification versions 3.xx in max 20MHz clock frequency mode.

6.3 Card concept

The MultiMediaCard transfers data via a configurable number of data bus signals. The communication signals are:

- **CLK**: Each cycle of this signal directs a one bit transfer on the command and either a one bit (1x) or a two bits transfer (2x) on all the data lines. The frequency may vary between zero and the maximum clock frequency.
- **CMD**: This signal is a bidirectional command channel used for card initialization and transfer of commands. The CMD signal has two operation modes: open-drain for initialization mode, and push-pull for fast command transfer. Commands are sent from the MultiMediaCard bus master to the card and responses are sent from the card to the host.

- **DAT0-DAT7**: These are bidirectional data channels. The DAT signals operate in push-pull mode. Only the card or the host is driving these signals at a time. By default, after power up or reset, only DAT0 is used for data transfer. A wider data bus can be configured for data transfer, using either DAT0-DAT3 or DAT0-DAT7, by the MultiMediaCard controller. The MultiMediaCard includes internal pull-ups for data lines DAT1-DAT7. Immediately after entering the 4-bit mode, the card disconnects the internal pull ups of lines DAT1, DAT2, and DAT3. Correspondingly, immediately after entering to the 8-bit mode the card disconnects the internal pull-ups of lines DAT1–DAT7.
- MultiMediaCards can be grouped into several card classes which differ in the functions they provide (given by the subset of MultiMediaCard system commands):
- Read Only Memory (ROM) cards. These cards are manufactured with a fixed data content. They are typically used as a distribution media for software, audio, video etc.
- Read/Write (RW) cards (Flash, One Time Programmable - OTP, Multiple Time Programmable - MTP). These cards are typically sold as blank (empty) media and are used for mass data storage, end user recording of video, audio or digital images.
- I/O cards. These cards are intended for communication (e.g. modems) and typically will have an additional interface link.

The card is connected directly to the signals of the MultiMediaCard bus. The following table defines the card contacts:

Table 3 — MultiMediaCard interface pin configuration

Name	Type[1]	Description
CLK	I	Clock
DAT0[2]	I/O/PP	Data
DAT1	I/O/PP	Data
DAT2	I/O/PP	Data
DAT3	I/O/PP	Data
DAT4	I/O/PP	Data
DAT5	I/O/PP	Data
DAT6	I/O/PP	Data
DAT7	I/O/PP	Data
CMD	I/O/PP/OD	Command/Response
RST_n	I	Hardware reset
V_{CC}	S	Supply voltage for Core (BGA)
$V_{CC}Q$	S	Supply voltage for I/O (BGA)
V_{DD}	S	Supply voltage (card)
V_{SS}	S	Supply voltage ground for Core (BGA)
V_{SS1}	S	Supply voltage ground (card)
V_{SS2}	S	Supply voltage ground (card)
$V_{SS}Q$	S	Supply voltage ground for I/O (BGA)
NOTE 1 I: input; O: output; PP: push-pull; OD: open-drain; NC: Not connected (or logical high); S: power supply. NOTE 2 The DAT0–DAT7 lines for read-only cards are output only.		

The card initialization uses only the CMD channel and is, therefore, compatible for all cards.

Each card has a set of information registers (see also Section 8 on page 113):

Table 4 — MultiMediaCard registers

Name	Width (bytes)	Description	Implementation
CID	16	Card IDentification number, a card individual number for identification.	Mandatory
RCA	2	Relative Card Address, is the card system address, dynamically assigned by the host during initialization.	Mandatory
DSR	2	Driver Stage Register, to configure the card's output drivers.	Optional
CSD	16	Card Specific Data, information about the card operation conditions.	Mandatory
OCR	4	Operation Conditions Register. Used by a special broadcast command to identify the voltage type of the card.	Mandatory
EXT_CSD	512	Extended Card Specific Data. Contains information about the card capabilities and selected modes. Introduced in standard v4.0	Mandatory

The host may reset the card by switching the power supply off and back on. The card shall have its own power-on detection circuitry which puts the card into a defined state after the power-on. For MMC card, no explicit reset signal is necessary. However, for *e*•MMC, there is a reset signal which host can use to reset *e*•MMC device.. The MMC card and *e*•MMC can also be reset by a special command.

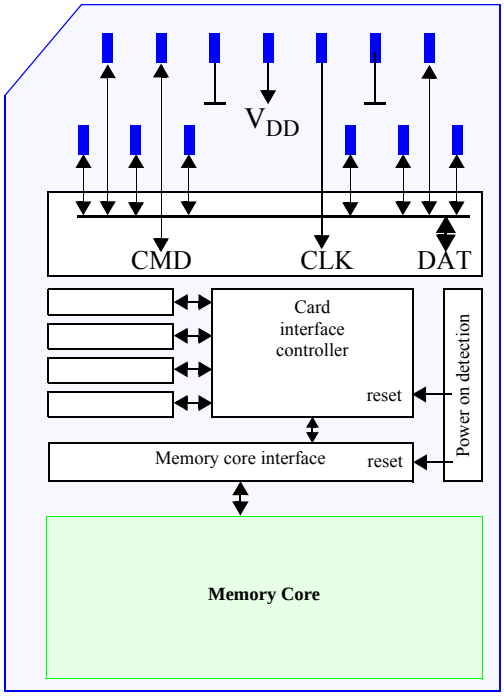


Figure 4 — MultiMediaCard architecture

6.3.1 Form factors

See chapter 11 "MultiMediaCard mechanical standard" for form factor details.

6.4 Bus concept

The MultiMediaCard bus is designed to connect either solid-state mass-storage memory or I/O-devices in a card format to multimedia applications. The bus implementation allows the coverage of application fields from low-cost systems to systems with a fast data transfer rate. It is a single master bus with a single slave. The MultiMediaCard bus master is the bus controller and the slave is either a single mass storage card (with possibly different technologies such as ROM, OTP, Flash etc.) or an I/O-card with its own controlling unit (on card) to perform the data transfer.

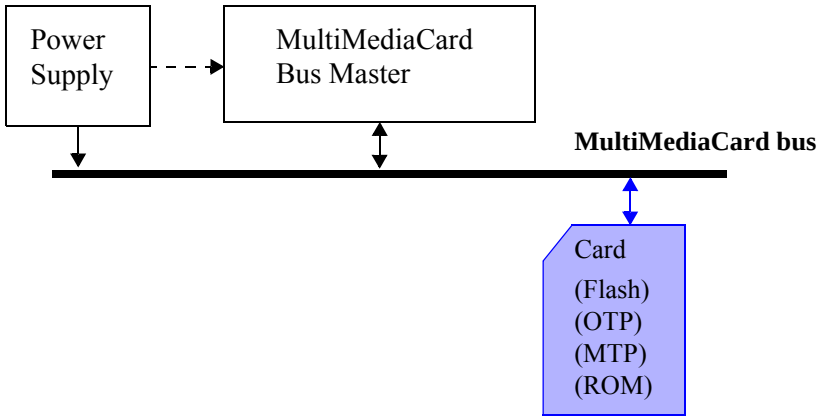


Figure 5 — MultiMediaCard bus system

The MultiMediaCard bus also includes power connections to supply the cards.

The bus communication uses a special protocol (MultiMediaCard bus protocol). The payload data transfer between the host and the card can be bidirectional.

6.4.1 Bus lines

The bus lines can be divided into three groups:

- Power supply: V_{SS1} and V_{SS2},V_{DD} - used to supply the cards.
  V_{SS}, $V_{SS}Q$, V_{CC}, and $V_{CC}Q$ - used to supply *e*•MMC.
- Data transfer: CMD, DAT0-DAT7 - used for bidirectional communication.
- Clock: CLK - used to synchronize data transfer across the bus.

The bus line definitions and the corresponding pad numbers are described in Section 6.3.

6.4.2 Bus protocol

After a power-on reset, the host must initialize the card by a special message-based MultiMediaCard bus protocol. Each message is represented by one of the following tokens:

- command: a command is a token which starts an operation. A command is sent from the host to a card. A command is transferred serially on the CMD line.
- response: a response is a token which is sent from the card to the host as an answer to a previously received command. A response is transferred serially on the CMD line.
- data: data can be transferred from the card to the host or vice versa. Data is transferred via the data lines. The number of data lines used for the data transfer can be 1(DAT0), 4(DAT0-DAT3) or 8(DAT0-DAT7).
  For each data lines, data can be transferred at the rate of one bit (single data rate) or two bits (dual data rate) per clock cycle.

Card addressing is implemented using a session address, assigned during the initialization phase, by the bus controller to the connected card. A card is identified by its CID number. This method requires the card to have an unique CID number. To ensure uniqueness of CIDs the CID register contains 24 bits (MID and OID fields—see Section 8.2 starting on page 113) which are defined by the MMCA/JEDEC. Every card manufacturer is required to apply for an unique MID (and optionally OID) number.

Command, response, and data block structures are described in Section 7 starting on page 27.

MultiMediaCard bus data transfers are composed of these tokens. One data transfer is a *bus operation*. There are different types of operations. Addressed operations always contain a command and a response token. In addition, some operations have a data token, the others transfer their information directly within the command or response structure. In this case no data token is present in an operation. The bits on the DAT0-DAT7 and CMD lines are transferred synchronous to the host clock.

Two types of data transfer commands are defined:

- Sequential commands[1]: These commands initiate a continuous data stream, they are terminated only when a stop command follows on the CMD line. This mode reduces the command overhead to an absolute minimum.
- Block-oriented commands: These commands send a data block succeeded by CRC bits. Both read and write operations allow either single or multiple block transmission. A multiple block transmission is terminated when a stop command follows on the CMD line similarly to the sequential read.

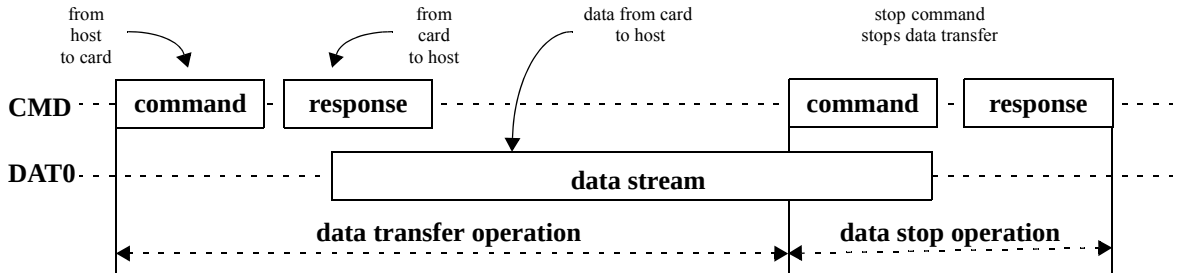


Figure 6 — Sequential read operation

1. Sequential commands are supported only in 1-bit bus mode, to maintain compatibility with previous versions of this standard

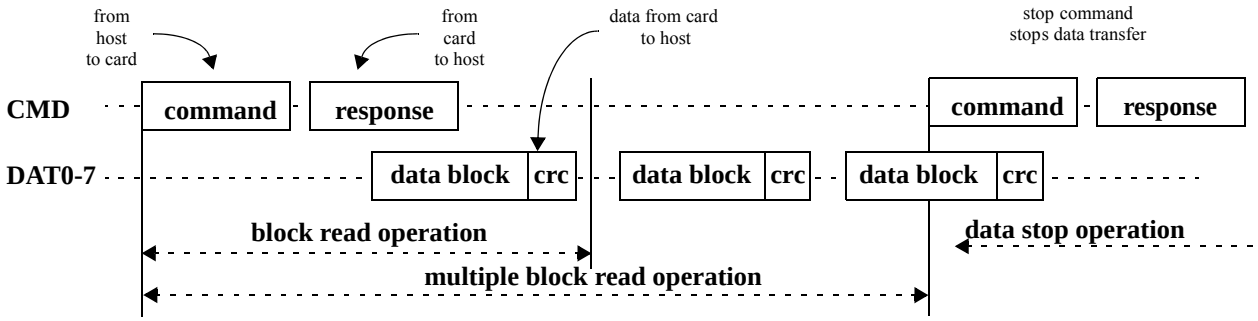


Figure 7 — Multiple-block read operation

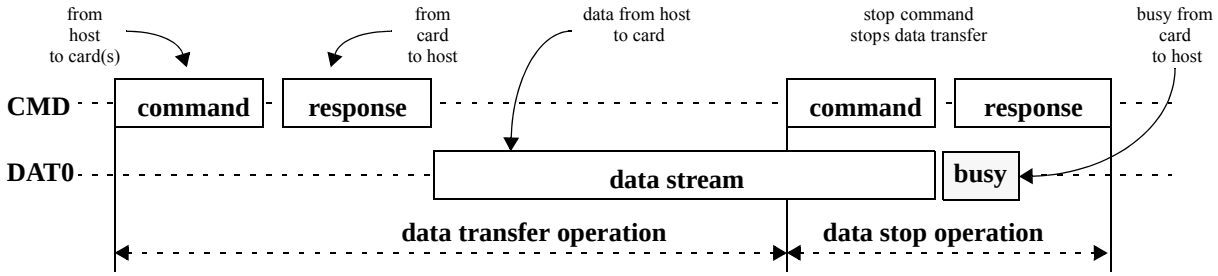


Figure 8 — Sequential write operation

The block write operation uses a simple busy signalling of the write operation duration on the data (DAT0) line. (See Figure 9.)

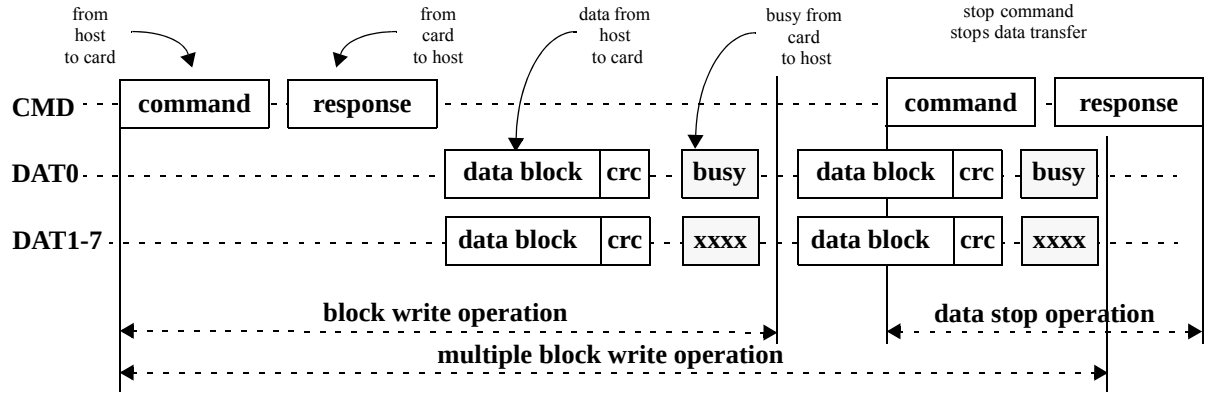


Figure 9 — (Multiple) Block write operation

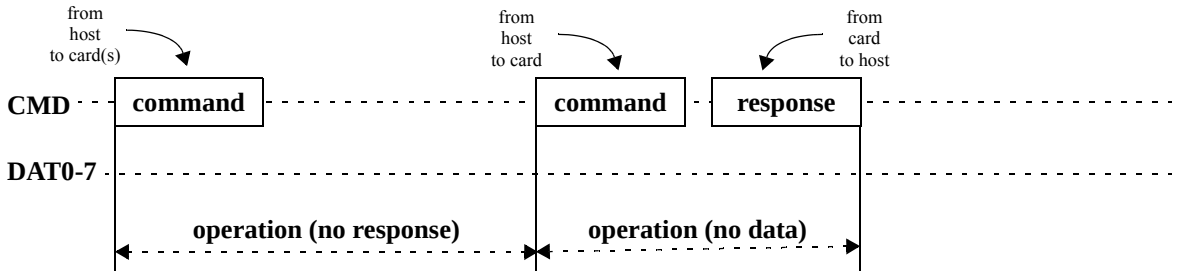


Figure 10 — No response" and "no data" operations

Command tokens have the following coding scheme:

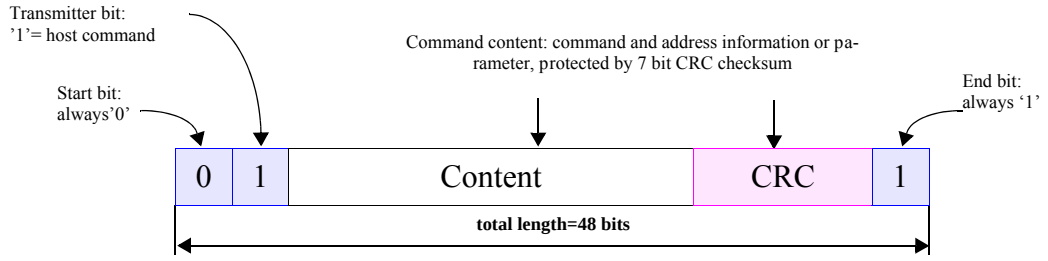


Figure 11 — Command token format

Each command token is preceded by a start bit ('0') and succeeded by an end bit ('1'). The total length is 48 bits. Each token is protected by CRC bits so that transmission errors can be detected and the operation may be repeated.

Response tokens have five coding schemes depending on their content. The token length is either 48 or 136 bits. The detailed command and response definitions are provided in Section 7.10 on page 85 and Section 7.12 on page 94.

Due to the fact that there is no predefined end in sequential data transfer, no CRC protection is included in this case. The CRC protection algorithm for block data is a 16 bit CCITT polynomial. All used CRC types are described in Section 10.2 starting on page 157.

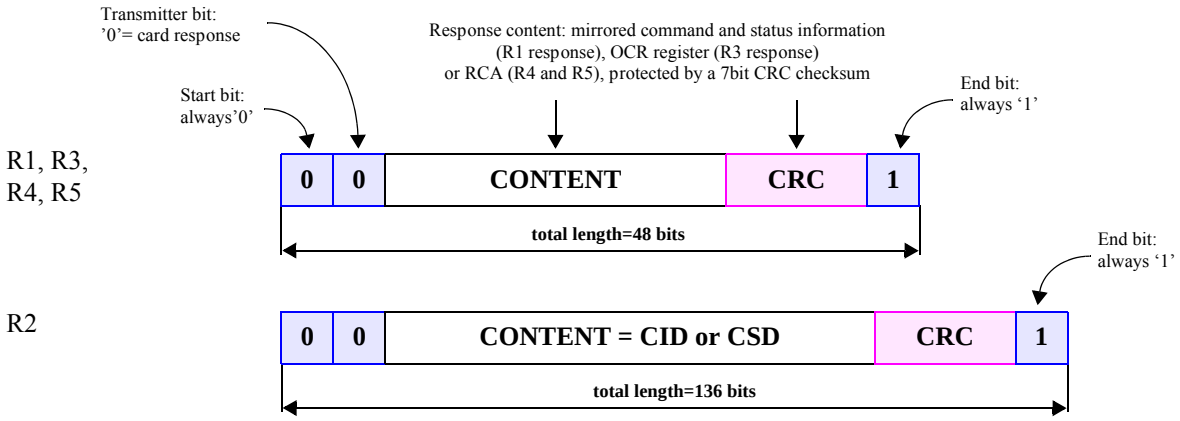


Figure 12 — Response token format

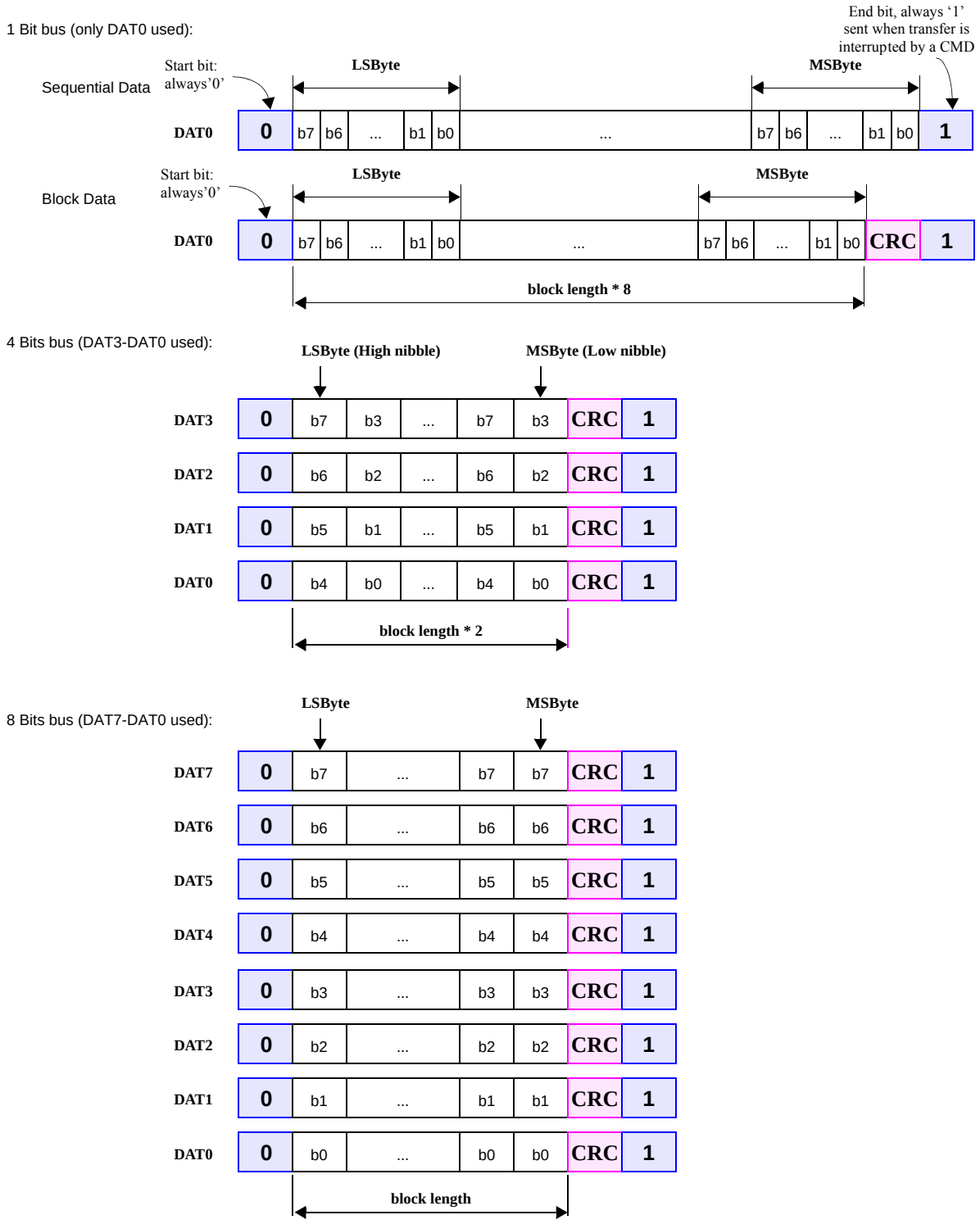
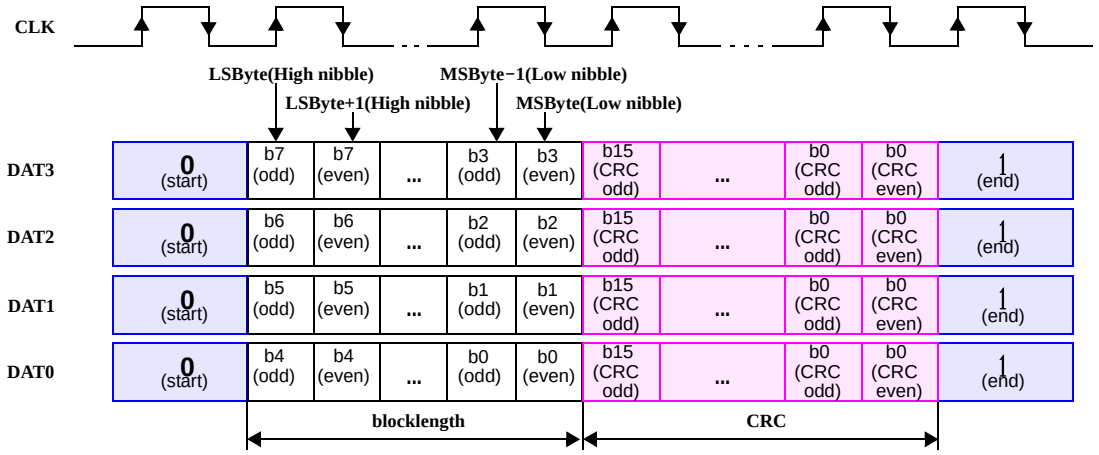
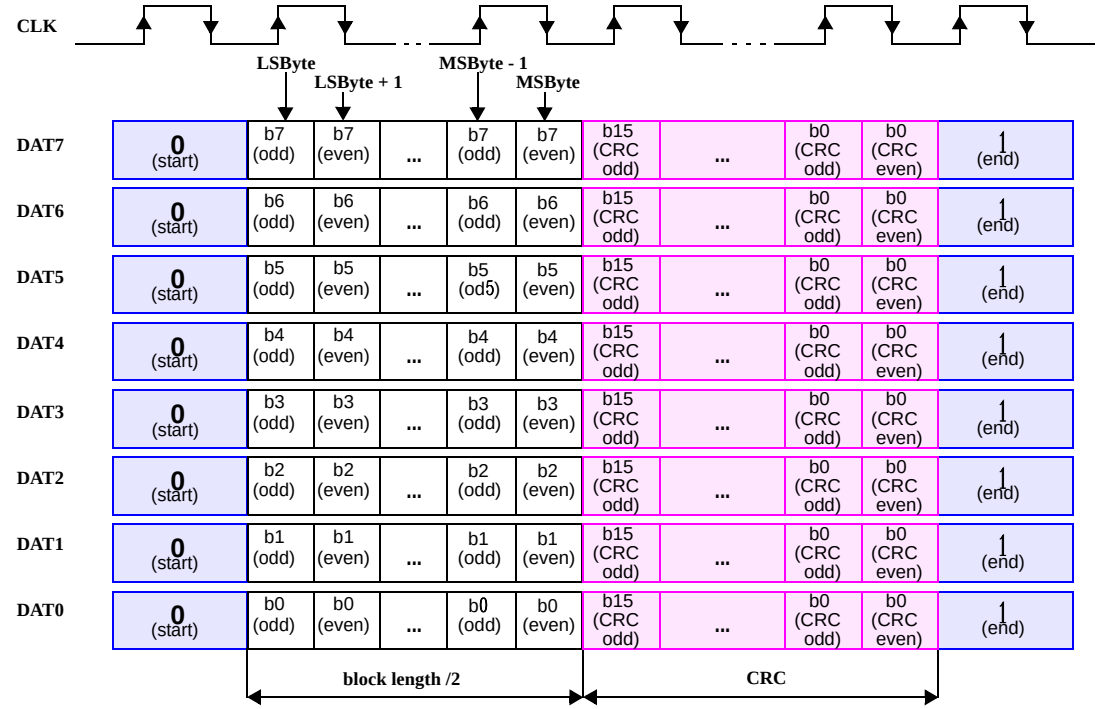


Figure 13 — Data packet format for SDR

4 Bits bus DDR (DAT3-DAT0 used):



8 Bits busDDR (DAT7-DAT0 used):



Notice that bytes data are not interleaved but CRC are interleaved.
Start and stop bits are full cycle.

Figure 14 — Data packet format for DDR

6.5 Controller Concept

The MultiMediaCard is defined as a low cost mass storage product. The shared functions have to be implemented in the MultiMediaCard system. The unit which contains these functions is called the MultiMediaCard controller. The following points are basic requirements for the controller:

- Protocol translation from standard MultiMediaCard bus to application bus
- Data buffering to enable minimal data access latency
- Macros for common complex command sequences

The MultiMediaCard controller is the link between the application and the MultiMediaCard bus with its card. It translates the protocol of the standard MultiMediaCard bus to the application bus. It is divided into two major parts:

- The application adapter: the application oriented part
- The MultiMediaCard adapter: the MultiMediaCard oriented part

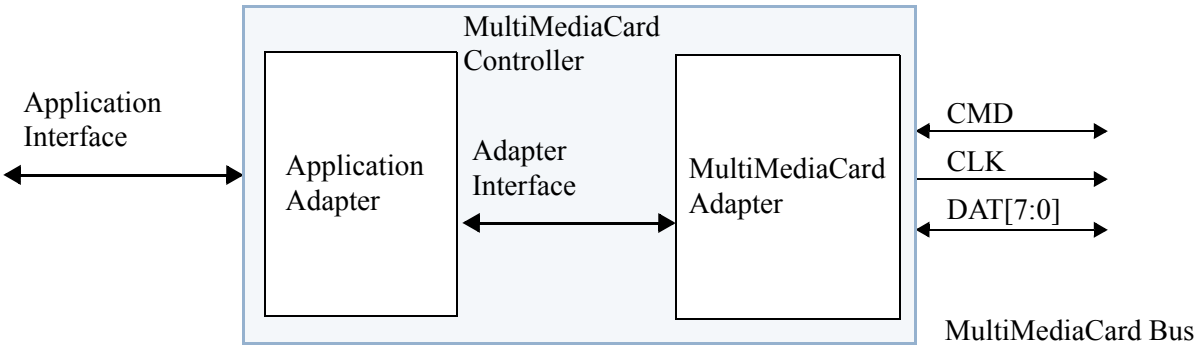


Figure 15 — MultiMediaCard controller scheme

The application adapter consists at least of a bus slave and a bridge into the MultiMediaCard system. It can be extended to become a master on the application bus and support functions like DMA or serve application specific needs. Higher integration will combine the MultiMediaCard controller with the application.

Independently of the type and requirements of the application the MultiMediaCard bus requires a host. This host may be the MultiMediaCard adapter. On the MultiMediaCard bus side it is the only bus master and controls all activity on that bus. On the other side, it is a slave to the application adapter or to the application, respectively. No application specific functions shall be supported here, except for those that are common to most MultiMediaCard systems. It supports all MultiMediaCard bus commands and provides additionally a set of macro commands. The adapter includes error correction capability for non error-free cards. The error correction codes used are defined in Section 10.1 on page 157.

Because the application specific needs and the chosen application interface are out of the scope of this standard, the MultiMediaCard controller defines an internal adapter interface. The two parts communicate across this interface. The adapter interface is directly accessible in low cost (point to point link) systems where the MultiMediaCard controller is reduced to an MultiMediaCard adapter.

6.5.1 Application adapter requirements

The application adapter enhances the MultiMediaCard system in the way that it becomes plug&play in every standard bus environment. Each environment will need its unique application adapter. For some bus systems standard, off the shelf, application adapters exist and can interface with the MultiMediaCard adapter. To reduce the bill of material it is recommended to integrate an existing application adapter with the MultiMediaCard adapter module, to form a MultiMediaCard controller.

The application adapter extension is a functional enhancement of the application adapter from a bus slave to a bus master on the standard application bus. For instance, an extended application adapter can be triggered to perform bidirectional DMA transfers.

6.5.2 MultiMediaCard adapter architecture

The architecture and the functional units described below are not implementation requirements, but general recommendations on the implementation of a MultiMediaCard adapter. The adapter is divided into two major parts:

- The controller: macro unit and power management
- The data path: Adapter interface, ECC unit, read cache, write buffer, CRC unit and MultiMediaCard bus interface

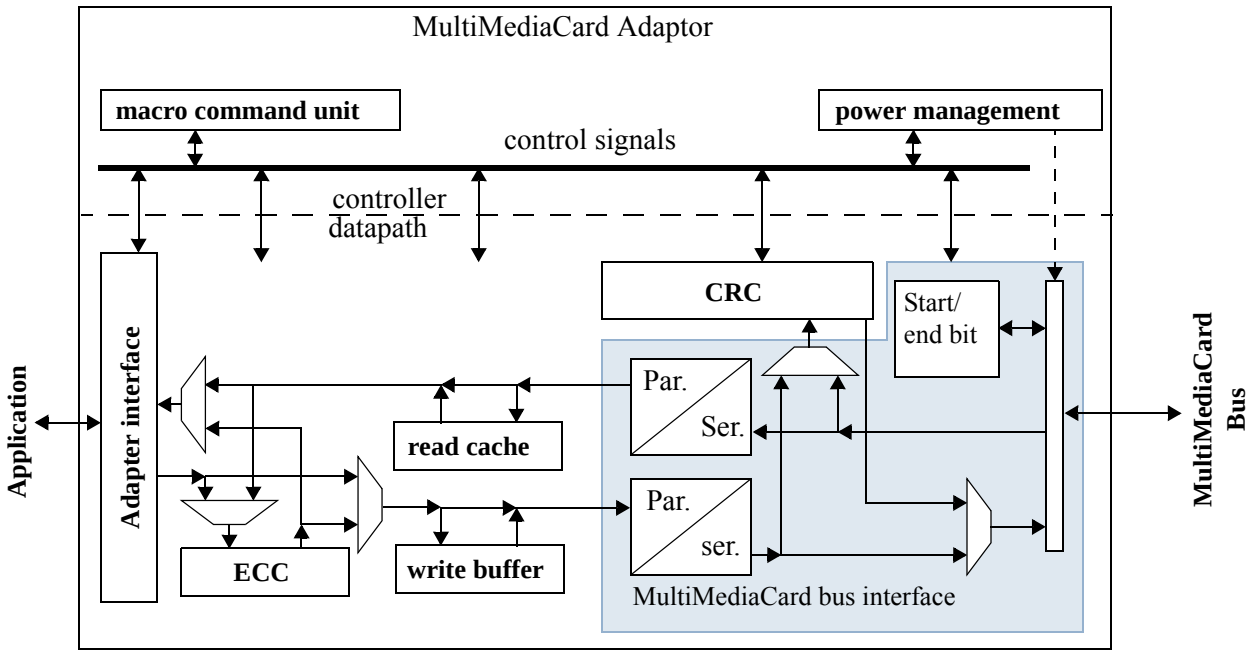


Figure 16 — MultiMediaCard adaptor architecture

The data path units should be implemented in hardware to guarantee the full capabilities of the MultiMediaCard system. The controller part of the adapter can be implemented in hardware or software depending on the application architecture.

The width of the data path should be a byte; the units which are handling data should work on bytes or blocks of bytes. This requirement is derived from the MultiMediaCard bus protocol, which is organized in data blocks. Blocks are multiples of bytes. Thus, the smallest unit of a data access or control unit is a byte.

Commands for the MultiMediaCard bus follow a strict protocol. Each command is encapsulated in a syntactical frame. Each frame contains some special control information like start/end bits and CRC protection. Some commands include stuffing bits to enable simple interpreters to use a fixed frame length. This transport management information should be generated in the MultiMediaCard adapter. These functions are combined in the MultiMediaCard bus interface of the adapter.

The response delays of the MultiMediaCard system may vary; they depend on the type of cards. So the adapter interface must handle asynchronous mode via handshake signals(STB,ACK) or the host has to poll the state (busy/not busy) if no handshake signals are required (synchronous mode). This interface may be a general unit supporting most application protocols or can be tailored to one application.

It is recommended to equip the MultiMediaCard adapter with data buffers for write and read operation. It will, in most cases, improve the system level performance on the application side.The MultiMediaCard bus transports its data with a data rate up to 832 Mbits/sec. This may be slower than a typical applications CPU bus. Enabling the CPU to off load the data to the buffers will free up CPU time for system level tasks, while the MultiMediaCard adapter handles the data transfer to the card.

The access time for random access read operations from a card may be improved by caching a block of data in the read cache. After reading a complete block into the MultiMediaCard adapter cache, repeated accesses to that block can be done very fast. Especially read-modify-write operations can be executed in a very efficient way on a block buffer with the help of the SRAM swapper.

7 MultiMediaCard functional description

In the following sections, the different card operation modes are described first. Thereafter, the restrictions for controlling the clock signal are defined. All MultiMediaCard commands together with the corresponding responses, state transitions, error conditions and timings are presented in the succeeding sections.

7.1 General

All communication between host and card is controlled by the host (master). The host sends commands of two types: broadcast and addressed (point-to-point) commands.

- Broadcast commands

  Broadcast commands are intended for all cards in a MultiMediaCard system[2]. Some of these commands require a response.

- Addressed (point-to-point) commands

  The addressed commands are sent to the addressed card and cause a response from this card.

A general overview of the command flow is shown in Figure 26 on page 43 for the card identification mode and in Figure 28 on page 47 for the data transfer mode. The commands are listed in the command tables (Table 22 on page 87 to Table 30 on page 91). The dependencies between current state, received command and following state are listed in Table 31 on page 92. Five operation modes are defined for the MultiMediaCard system (hosts and cards):

- Boot modeThe card will be in boot mode after power cycle, reception of CMD0 with arguement of 0xF0F0F0F0 or (*e*•MMC only) assertion of hardware reset signal.
- Card identification mode

  The card will will be in card identification mode after boot operation mode is finished or if host and /or card does not support boot operation mode. The card will be in this mode, until the SET_RCA command (CMD3) is received.

- Interrupt mode

  Host and card enter and exit interrupt mode simultaneously. In interrupt mode there is no data transfer. The only message allowed is an interrupt service request from the card or the host.

- Data transfer mode

  The card will enter data transfer mode once an RCA is assigned to it. The host will enter data transfer ode after identifying the card on the bus.

- Inactive mode

  The card will enter inactive mode mode either card operating voltage range or access mode is not valid. The card can also enter inactive mode with Go_INACTIVE_STATE command (CMD15). The card will reset to *Pre-idle* state with power cycle.

The following table shows the dependencies between bus modes, operation modes and card states. Each state in the MultiMediaCard state diagram (see Figure 26 and Figure 28) is associated with one bus mode and one operation mode:

2. Broadcast commands are kept for backwards compatibility to previous MultiMediaCard systems, where more than one card was allowed on the bus.

Table 5 — Bus modes overview

Card state	Operation mode	Bus mode
Inactive State	Inactive mode	Open-drain
Pre-Idle State	Boot mode	
Pre-Boot State		
Idle State	Card identification mode	
Ready State		
Identification State		
Stand-by State	Data transfer mode	Push-pull
Sleep State		
Transfer State		
Bus-Test State		
Sending-data State		
Receive-data State		
Programming State		
Disconnect State		
Boot State	Boot mode	
Wait-IRQ State	Interrupt mode	Open-drain

7.2 Partition Management

7.2.1 General

The default area of the memory device consists of a User Data Area to store data, two possible boot area partitions for booting (Section 7.3.2 on page 35) and the Replay Protected Memory Block Area Partition(Section 7.6.16 on page 69) to manage data in an authenticated and replay protected manner.
The memory configuration initially consists (before any partitioning operation) of the User Data Area and RPMB Area Partitionsm and Boot Area Partitions (whose dimensions and technology features are defined by the memory manufacturer).

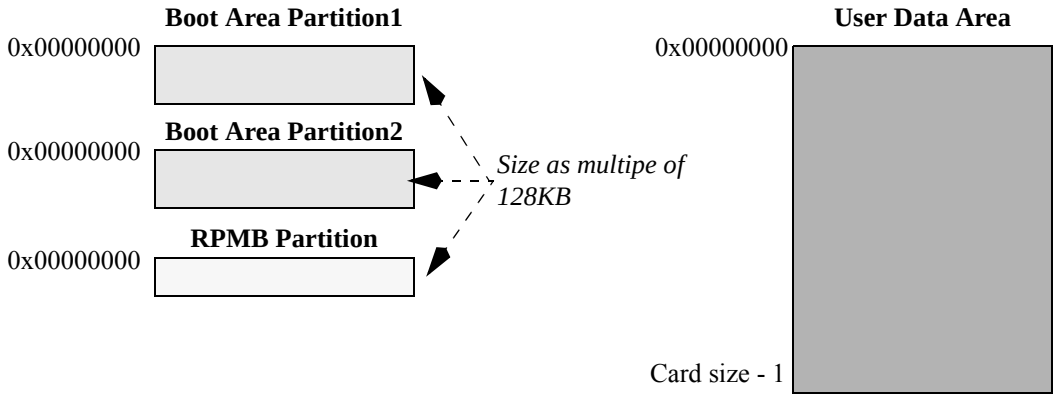


Figure 17 — *e*•MMC memory organization at time zero

The embedded device offers also the possibility of configuring by the host additional split local memory partitions with independent addressable space starting from logical address 0x00000000 for different usage models.
Therefore memory block Area scan be classified as follows:

- Two Boot Area Partitions, whose size is multiple of 128 KB and from which booting from *e*•MMC can be performed.
- One RPMB Partition accessed through a trusted mechanism, whose size is defined as multiple of 128 KB.
- Four General Purpose Area Partitions to store sensitive data or for other host usage models and whose size is multiple of a Write Protect Group.

Each of the General Purpose Area Partitions can be implemented with enhanced technological features (such as better reliability*) that distinguish them from the default storage media. If the enhanced storage media feature is supported by the device, boot and RPMB Area Partitions shall be implemented as enhanced storage media by default.

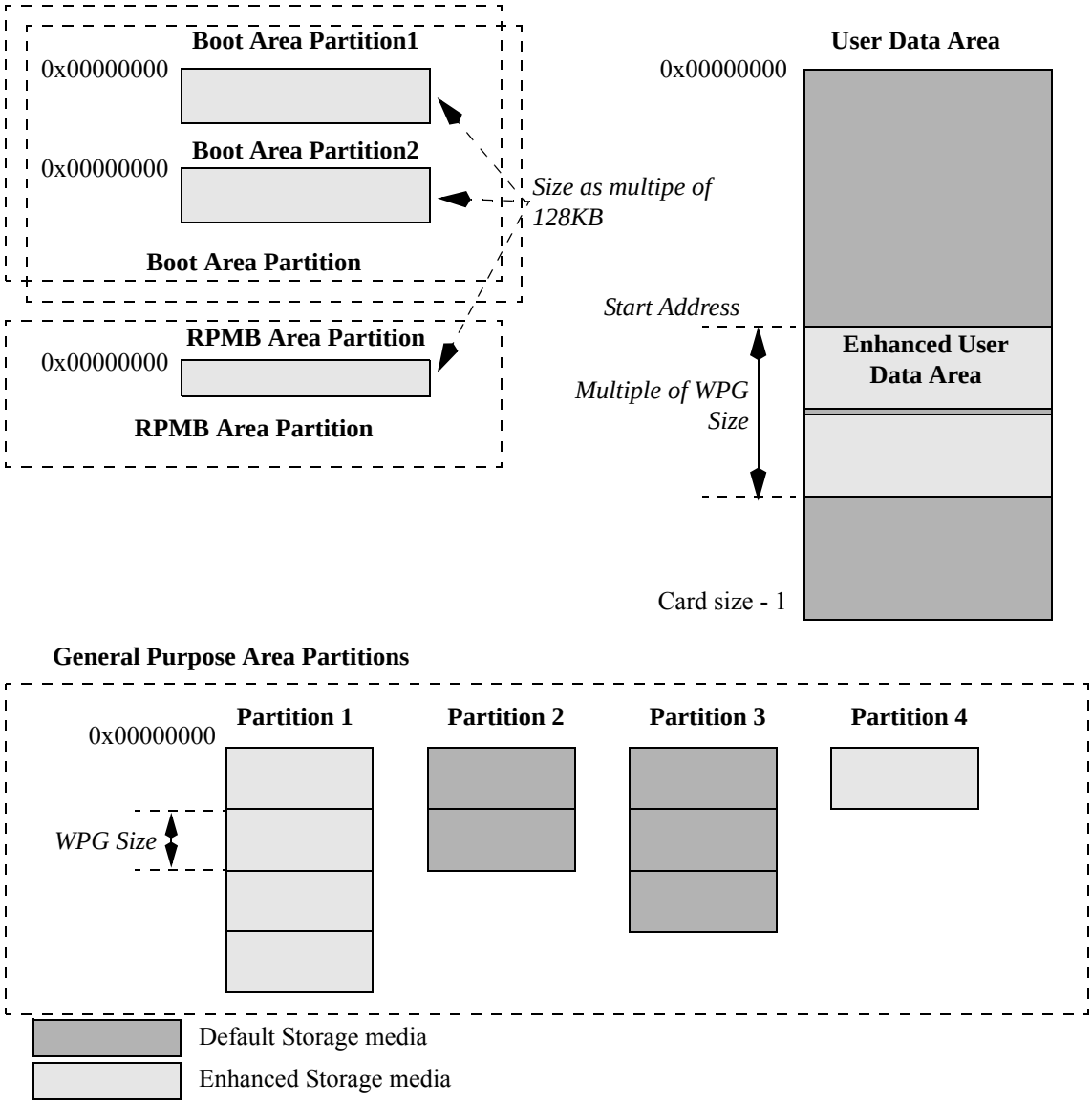
Boot and RPMB Area Partitions' sizes and attributes are defined by the memory manufacturer (read-only), while General Purpose Area Partitions' sizes and attributes can be programmed by the host only once in the device life-cycle (one-time programmable).

Moreover, the host is free to configure one segment in the User Data Area to be implemented as enhanced storage media, and to specify its starting location and size in terms of Write Protect Groups. The attributes of this Enhanced User Data Area can be programmed only once during the device life-cycle (one-time programmable).

* This is cited as an example of an enhanced storage media characteristics, and should not be considered as a necessary definition of enhanced storage media techology. The definition of enhanced storage media should be decided upon by each system manufacturer, and is outside the scope of this standard.

A possible final configuration can be the following one:

Figure 18 — Example of partitions and user data area configuration



General Purpose Partitions and Enhanced User Data Area configuration by the host can have effects on data previously stored (they will be destroyed) and the device initialization time.

In particular, the initialization time after first power cycle subsequent to the configuration can exceed the maximum initialization time defined by the specs since the internal controller could execute operations to set up the configurations stated by the host.

More generally also the following initialization phases can be affected by the new configuration.

Max power up timings shall be specified in the device technical literature.

7.2.2 Command restrictions

Some restrictions for the commands that can be issued to each partition is defined:

- Boot Paritions
  – Command class 6 (Write Protect) and class 7 (Lock card) not admitted.
- RPMB Partition
  – Only commands of classes Class0, Class2 and Class4 are admitted. Still usage of any other command than CMD0, CMD6, CMD8, CMD12, CMD13, CMD15 or commands defined in Section 7.6.16 shall be considered as illegal one.
- General Purpose Partitions
  – Command classes 0, 2, 4, 5, 6 are admitted.
  – Write protection can be set individually for each write protect group in each partition. So the host can set write protection types differently in each write protect group.

In the Enhanced User Data Area, all the commands belonging to the classes admitted in the User Data Area can be issued.

7.2.3 Configure partitions

Bit 0 (PARTITIONING_EN) in PARTITIONING_SUPPORT field of the Properties segment in the Extended CSD register indicates if the memory device supports partitioning features. Bit 1 (ENH_ATTRIBUTE_ EN) in the same field indicates if the memory device supports enhanced features attribute in the General Purpose Partitions and in the Enhanced User Data Area.

The attributes of General Purpose Partitions and Enhanced User Data Area can be programmed by the host setting the corresponding values in the Extended CSD registers only once in the device life-cycle.

In particular, the host may issue a SWITCH command to set the R/W field of partition features containing the following parameters

- General Purpose Partitions - size and attribute of max 4 partitions. The fields in the Modes segment of the EXT_CSD register to be set are:
  – GP_SIZE_MULT_GP0 - GP_SIZE_MULT_GP3 for the size
  – PARTITIONS_ATTRIBUTE for the Enhanced attribute
- Enhanced User Data Area - start address and attribute of the region. The fields in the Modes segment of the EXT_CSD register to be set are:
  – ENH_START_ADDR for the start address
  – ENH_SIZE_MULT for the size
  – PARTITIONS_ATTRIBUTE for the Enhanced attribute

The Enhanced User Data Area start address(ENH_START_ADDR in the Extended CSD) shall be write protect group aligned. It is a group address in byte units, for densities up to 2GB, and in sector units for densities greater than 2GB. The device will ignore the LSBs below the write group size and will align the Enhanced User Data Area start address to the Write Protect Group the address(in bytes or sectors) belongs to. The address space of the enhanced user data area is continuous to the address for the rest of the user data area (there is no address gap between the enhanced user data area and the rest of the user data area).

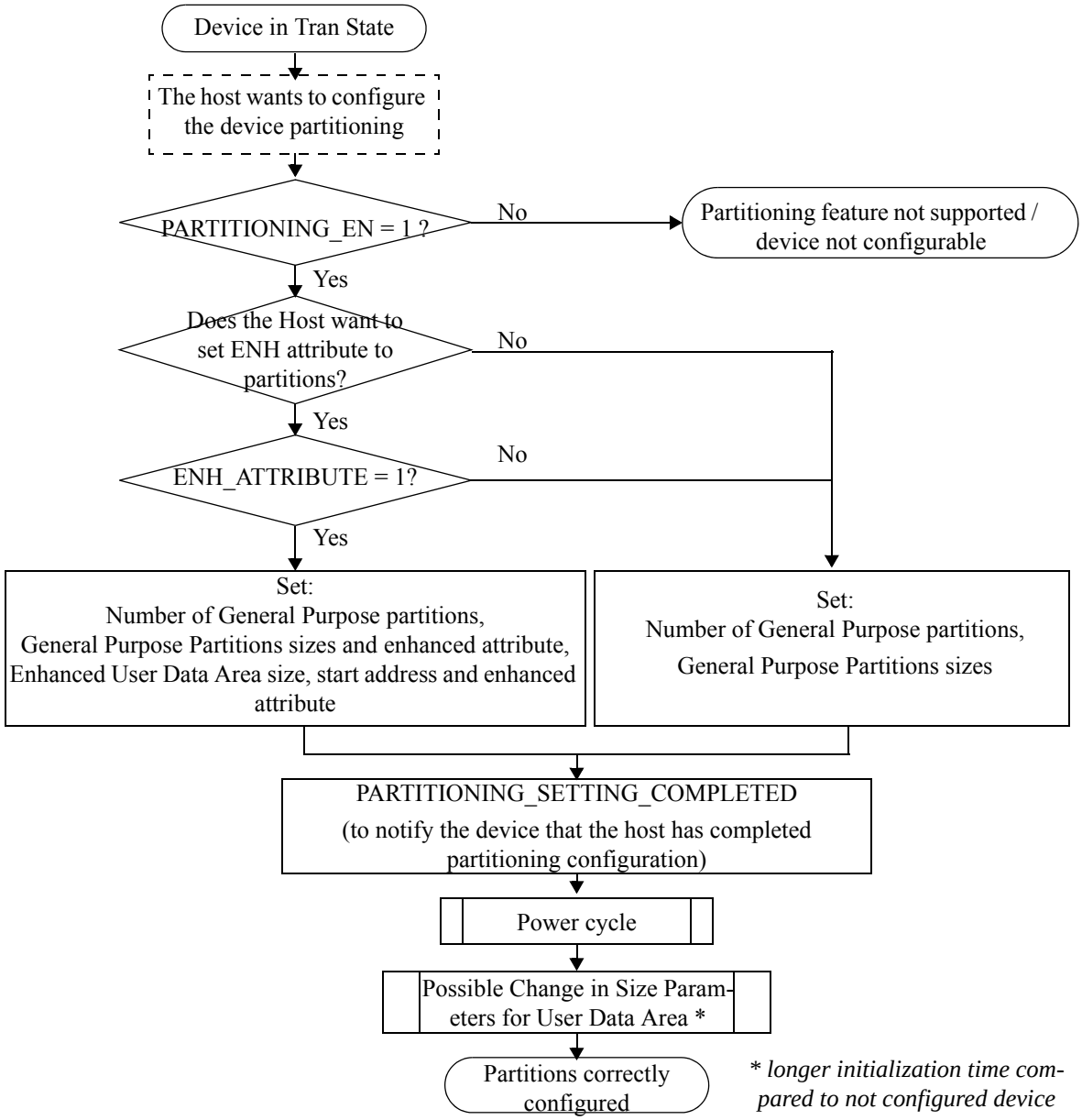
The granularity of General Purpose Partitions and of the Enhanced User Data Area is in units of High Capacity Write Protect Group Sizes (Section 8.4 on page 125). When the partition parameters are configured, ERASE_GROUP_ DEF bit in the Extended CSD shall be set to indicate that High Capacity Erase Group Sizes and High Capacity Write Protect Group Sizes are to be used. If the partition parameters are sent to a device by CMD6 before setting ERASE_GROUP_DEF bit, the slave shows

SWITCH_ERROR.

Once the device is partitioned and the configuration is stable, all the Command Class 5 and 6 commands will be referred to the high capacity erase groups and write protect groups.

In addition to partitioning parameters fields mentioned before, the host shall set Bit 0 in PARTITIONING_SETTING_COMPLETED in Modes segment: in this way the host notifies the device that the setting procedure has been successfully completed. This bit setting is to protect partitioning sequence against unexpected power loss event: if a sudden power loss occurs after that partioning process has been only partially executed, at the next power up the device can detect and invalidate - being this bit not set - the previous incomplete partitioning process giving the host the possibility to repeat and correctly complete it.

Figure 19 — Flow Chart for General Purpose Partitions & Enhanced User Data Area parameter setting



A CMD13 shall be issued by the host to make sure that all the parameters are correctly set. If any of the partitioning parameters is not correct a SWITCH_ERROR will be raised by the device.Since device will not know the total size of configured partitions and user area until PARTITIONING_SETTING_COMPLETED bit is set, device may show SWITCH_ERROR when host set PARTITIONING_SETTING_COMPLETED bit, if the total size of the configured partitions and user data area does not fit in the available space of the device. In this case, all the setting will be cleared after the next power cycle. So host need to set proper values in each of partition configuration register bytes again.

The device will actually configure itself, according to the partition parameters in the Extended CSD, only after a power cycle. Any valid commands issued after PARTITIONING_SETTING_COMPLETED bit is set but before a power cycle takes place will be normally executed. Any previous incomplete partitioning configuration sequence before this bit is set will be cancelled upon a power cycle.

After the power cycle following the partition configuration, C-SIZE value for up to 2GB devices and SEC_COUNT value for more than 2GB devices will be changed to indicate the size of user data area after the configuration. The size compared to 2GB shall be the size of user data area before configuring partitions (e.g. for more than 2GB devices before configuring partitions, SEC_COUNT shall keep indicating the size of user data area after configuring partitions, even if the size is decreased to lower than or equal to 2GB).The size of the user data area includes the size of Enhanced User Data area in the user area. So host may need to read these values after the power cycle to calculate the size of the user data area. Access mode shall keep after configuring partitions.

If the host tries to change General Purpose partitions and Enhanced User Data Area features by using CMD6 after a power up following the configuration procedure, the device will assert the SWITCH_ERROR bit in the status register of CMD 6 response without performing any internal action.

Partitions configuration parameters are stored in one time programmable fields of the Extended CSD register. The host can read them by a CMD8 even though the PARTITIONING_SETTING_COMPLETED has not yet been set but the execution of partitioning will take place only after the following power up. It is recommended to avoid changes on these parameters after reading them since they are one time programmable fields.

The host shall follow the flow chart in Figure 19 for configuring the parameters of General Purpose Area Partitions and Enhanced User Data Area; otherwise undefined behavior may result.

7.2.4 Access partitions

After every power up, when host uses a device in which partition(s) are configured, it must set the ERASE_GROUP_DEF bit to high before issuing read, write, erase and write protect commands, because this bit is reset after power up. Otherwise, these may not work correctly and it may leave the stored data in an unknown state.

Each time the host wants to access a partition the following flow shall be executed:

1. Set PARTITION_ACCESS bits in the PARTITION_CONFIG field of the Extended CSD register in order to address one of the partitions
2. Issue commands referred to the selected partition
3. Restore default access to the User Data Area or re-direction the access to another partition

All the reset events (CMD0 or hardware reset) will restore the access by default to the User Data Area.

If an unwanted power loss occurs, the access will be by default restored to the User Data Area.

When the host tries to access a partition which has not been created before, the devices sets the SWITCH_ERROR bit in the status register and will not change the PARTITION_ACCESS bits.

7.3 Boot operation mode

In boot operation mode, the master (MultiMediaCard host) can read boot data from the slave (MMC device) by keeping CMD line low or sending CMD0 with argument + 0xFFFFFFFA, before issuing CMD1. The data can be read from either boot area or user area depending on register setting.

7.3.1 Card reset to Pre-idle state

The card may enter into *Pre-idle* state through any of the following four mechanisms:

- After power-on by the host, the card (even if it has been in *Inactive* state) is in MultiMediaCard mode and in *Pre-idle* State.
- GO_PRE_IDLE_STATE command (CMD0 with argument of 0xF0F0F0F0) is the software reset command and puts the card into *Pre-idle* State.
- Hardware reset may be used by host resetting a card, moving the card to *Pre-idle* state and disabling power-on period write protect on blocks which had been set as power-on write protect before the reset was asserted. When card receives GO_PRE_IDLE_STATE command (CMD0 with argument of 0xF0F0F0F0) or assertion of hardware reset signal during sleep state, the card also moves to *Pre-idle* state.

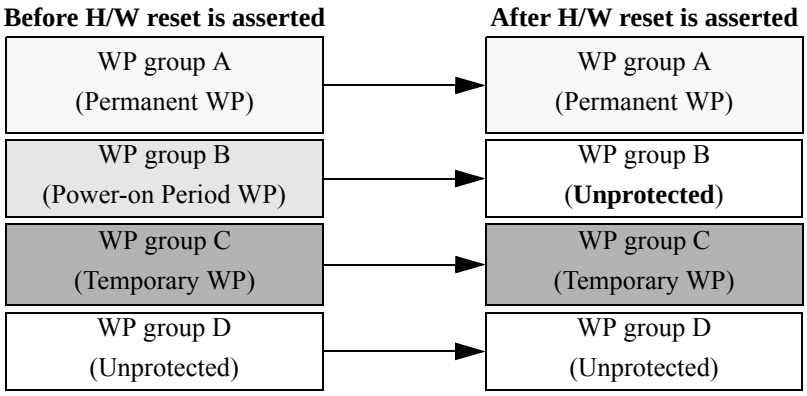


Figure 20 — WP condition transition due to H/W reset asssertion

After power-on, GO_PREIDLE_STATE command or hardware RESET assertion, the card's output bus drivers are in high-impedance state and the card is initialized with a default relative card address (0x0001) and with a default driver stage register setting, as shown in Section 8.6 on page 154.

When card powers up, RST_n signal also rises with power source ramp up. So the card may detect rising edge of the RST_n signal at the power up period (either (1), (2), (3) or (4) as shown in below).The card must handle this situation and work properly after the power up.

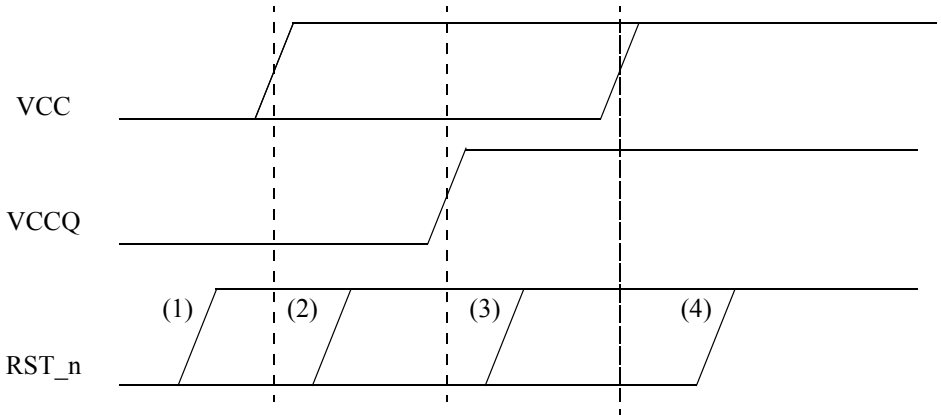


Figure 21 — RST_n signal at the power up period

If the RST_n signal falls before $V_{CC}Q$ fully powers up, the $V_{CC}Q$ rising edge is considered as the falling edge of RST_n signal. In this case, the pulse width of RST_n signal should be measured between the rising edge of RST_n signal and the time $V_{CC}Q$ powers up.

During the card internal initialization sequence right after power on, card may not be able to detect RST_n signal, because the card may not complete loading RST_n_ENABLE bits of the extended CSD register into the controller yet. However the card already started internal initialization sequence due to power-up, which essentially includes the reset sequence asserted by RST_n signal. The card may not have to do the reset sequence again but it should complete the internal initialization sequence within 1 second. In this case, the initialization delay should be the longest of 1msec, 74 clock cycles after RST_n asserted or the supply ramp up time.

7.3.2 Boot partition

There are two partition regions. The minimum size of each boot partition is 128KB. Boot partition size is calculated as follows:

Maximum boot partition size = 128K byte x BOOT_SIZE_MULT

BOOT_SIZE_MULT: the value in Extended CSD register byte [226]

The boot partitions are separated from the user area as shown in Figure 22 on page 36.

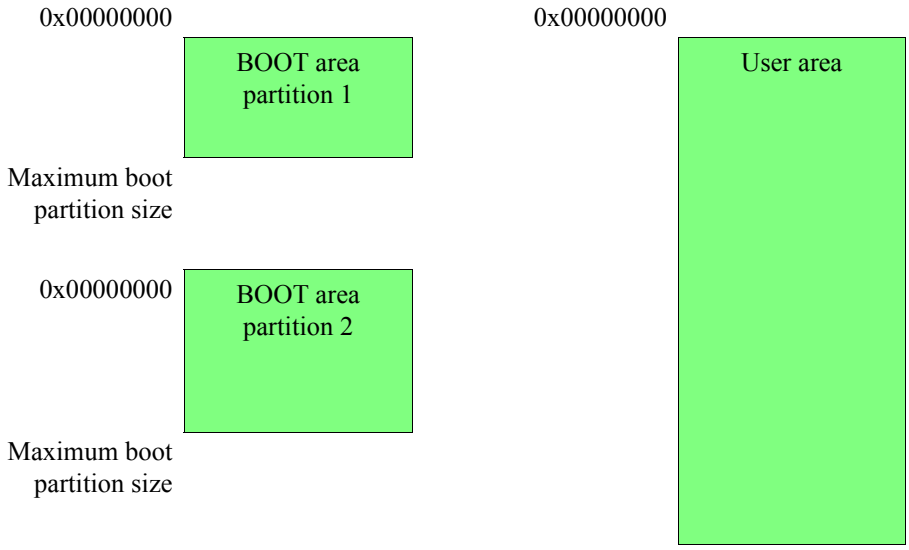


Figure 22 — Memory partition

Slave has boot configuration in Extended CSD register byte [179]. The master can choose the configuration by setting the register using CMD6 (switch). Slave also can be configured to boot from the user area by setting the BOOT_PARTITION_ ENABLE bits in the EXT_CSD register, byte [179] to 111b.

7.3.3 Boot operation

If the CMD line is held LOW for 74 clock cycles and more after power-up or reset operation (either through CMD0 with the argument of 0xF0F0F0F0 or assertion of hardware reset for *e*•MMC, if it is enabled in Extended CSD register byte [162], bits [1:0]) before the first command is issued, the slave recognizes that boot mode is being initiated and starts preparing boot data internally. The partition from which the master will read the boot data can be selected in advance using EXT_CSD byte [179], bits [5:3]. The data size that the master can read during boot operation can be calculated as 128KB × BOOT_SIZE_MULT (EXT_CSD byte [226]). Within 1 second after the CMD line goes LOW, the slave starts to send the first boot data to the master on the DAT line(s). The master must keep the CMD line LOW to read all of the boot data. The master must use push-pull mode until boot operation is terminated.

The master can choose to use single data rate mode with backward-compatible interface timing, single data rate with high-speed interface timing or dual data rate timing (if it supported) shown in Section 12.7 on page 176 by setting a proper value in EXT_CSD register byte [177] bits [4:3]. EXT_CSD register byte [228], bit 2 tells the master if the high-speed timing during boot is supported by the device.

The master can also choose to use the dual data rate mode with interface shown in Table 115 on page 180 during boot by setting “10” in EXT_CSD register byte [177], bits [4:3]. EXT_CSD register byte [228], bit 1 tells the master if the dual data rate mode during boot is supported by the device.

The master can choose to receive boot acknowledge from the slave by setting “1” in EXT_CSD register, byte [179], bit 6, so that the master can recognize that the slave is operating in boot mode.

If boot acknowledge is enabled, the slave has to send acknowledge pattern “010” to the master within 50ms after the CMD line goes LOW. If boot acknowledge is disabled, the slave will not send out acknowledge pattern “0-1-0.”

The master can terminate boot mode with the CMD line HIGH. If the master pulls the CMD line HIGH in the middle of data transfer, the slave has to terminate the data transfer or acknowledge pattern within N_{ST} clock cycles (one data cycle and end bit cycle). If the master terminates boot mode between consecutive blocks, the slave must release the data line(s) within N_{ST} clock cycles.

Boot operation will be terminated when all contents of the enabled boot data are sent to the master. After boot operation is executed, the slave shall be ready for CMD1 operation and the master needs to start a normal MMC initialization sequence by sending CMD1.

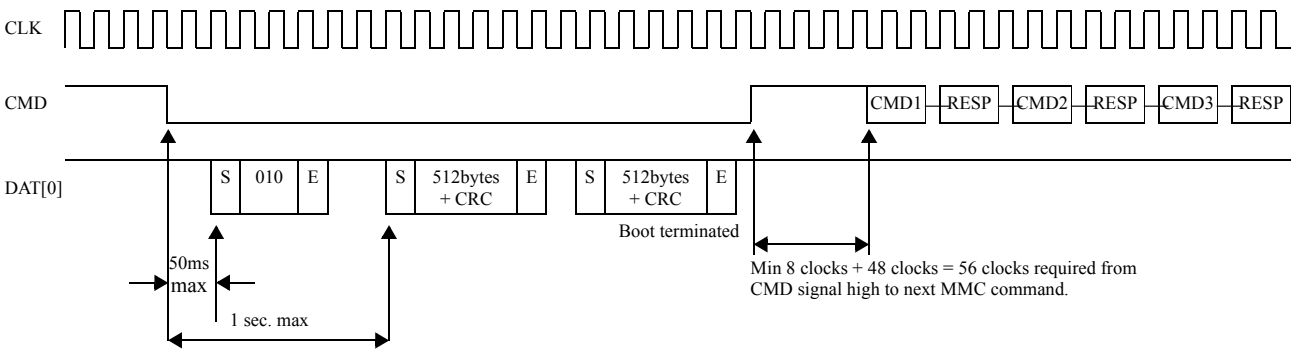


Figure 23 — MultiMediaCard state diagram (boot mode)

Detailed timings are shown in Section 7.15.5 on page 108. Min 8 clocks + 48 clocks = 56 clocks required from CMD signal high to next MMC command.

If the CMD line is held LOW for less than 74 clock cycles after power-up before CMD1 is issued, or the master sends any normal MMC command other than CMD0 with argument 0xFFFFFFFA before initiating boot mode, the slave shall not respond and shall be locked out of boot mode until the next power cycle or hardware reset, and shall enter *Idle* State.

When BOOT_PARTITION_ENABLE bits are set and master send CMD1 (SEND_OP_COND), slave must enter Card Identification Mode and respond to the command.

If the slave does not support boot operation mode, which is compliant with v4.2 or before, or BOOT_PARTITION_ENABLE bit is cleared, slave automatically enter *Idle* State after power-on.

7.3.4 Alternative boot operation

This boot function is mandatory for device from v4.4 standard. Device who follows v4.4 standard must show “1” bit 0 in the Extended CSD byte [228].

After power-up or reset operation (either assertion of CMD0 with the argument of 0xF0F0F0F0 or H/W reset if it is enabled), if the host issues CMD0 with the argument of 0xFFFFFFFA after 74 clock cycles, before CMD1 is issued or the CMD line goes low, the slave recognizes that boot mode is being initiated and starts preparing boot data internally. The partition from which the master will read the boot data can be selected in advance using EXT_CSD byte [179], bits [5:3]. The data size that the master can read during boot operation can be calculated as 128KB × BOOT_SIZE_MULT (EXT_CSD byte [226]). Within 1 second after CMD0 with the argument of 0xFFFFFFFA is issued, the slave starts to send the first boot data to the master on the DAT line(s). The master must use push-pull mode until boot operation is terminated. The master can choose to use single data rate mode with backward-compatible interface timing, single data rate with high-speed interface timing or dual data rate timing (if it is supported) shown in Section 12.7 by setting a proper value in EXT_CSD register byte [177] bit[4:3]. EXT_CSD register byte [228], bit 2 tells the master if the high-speed timing during boot is supported by the device.

The master can choose to receive boot acknowledge from the slave by setting “1” in EXT_CSD register, byte [179], bit 6, so that the master can recognize that the slave is operating in boot mode.

If boot acknowledge is enabled, the slave has to send the acknowledge pattern “010” to the master within 50ms after the CMD0 with the argument of 0xFFFFFFFA is received. If boot acknowledge is disabled, the slave will not send out acknowledge pattern “010.”

The master can terminate boot mode by issuing CMD0 (Reset). If the master issues CMD0 (Reset) in the middle of a data transfer, the slave has to terminate the data transfer or acknowledge pattern within N_{ST} clock cycles (one data cycle and end bit cycle). If the master terminates boot mode between consecutive blocks, the slave must release the data line(s) within N_{ST} clock cycles.

Boot operation will be terminated when all contents of the enabled boot data are sent to the master. After boot operation is executed, the slave shall be ready for CMD1 operation and the master needs to start a normal MMC initialization sequence by sending CMD1.

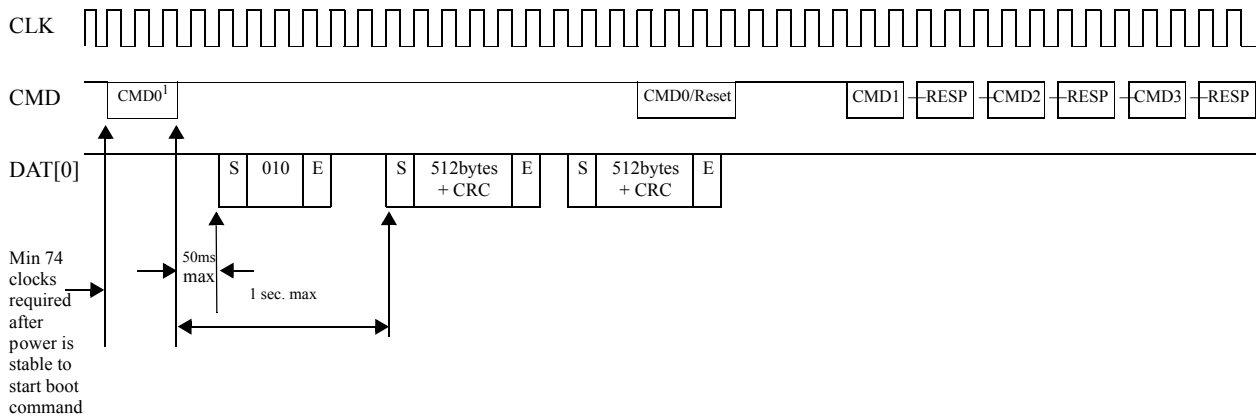


Figure 24 — MultiMediaCard state diagram (alternative boot mode)

Detailed timings are shown in Section 7.15.6 on page 110.

If the CMD line is held LOW for less than 74 clock cycles after power-up before CMD1 is issued, or the master sends any normal MMC command other than CMD1 and CMD0 with argument 0xFFFFFFFA before initiating boot mode, the slave does not respond and will be locked out of boot mode until the next power cycle and enter *Idle* State.

When BOOT_PARTITION_ENABLE bits are set and master send CMD1 (SEND_OP_COND), slave must enter Card Identification Mode and respond to the command.

If the slave does not support boot operation mode, which is compliant with v4.2 or before, or BOOT_PARTITION _ENABLE bit is cleared, slave automaticllay enter Idle State after power-on.

.

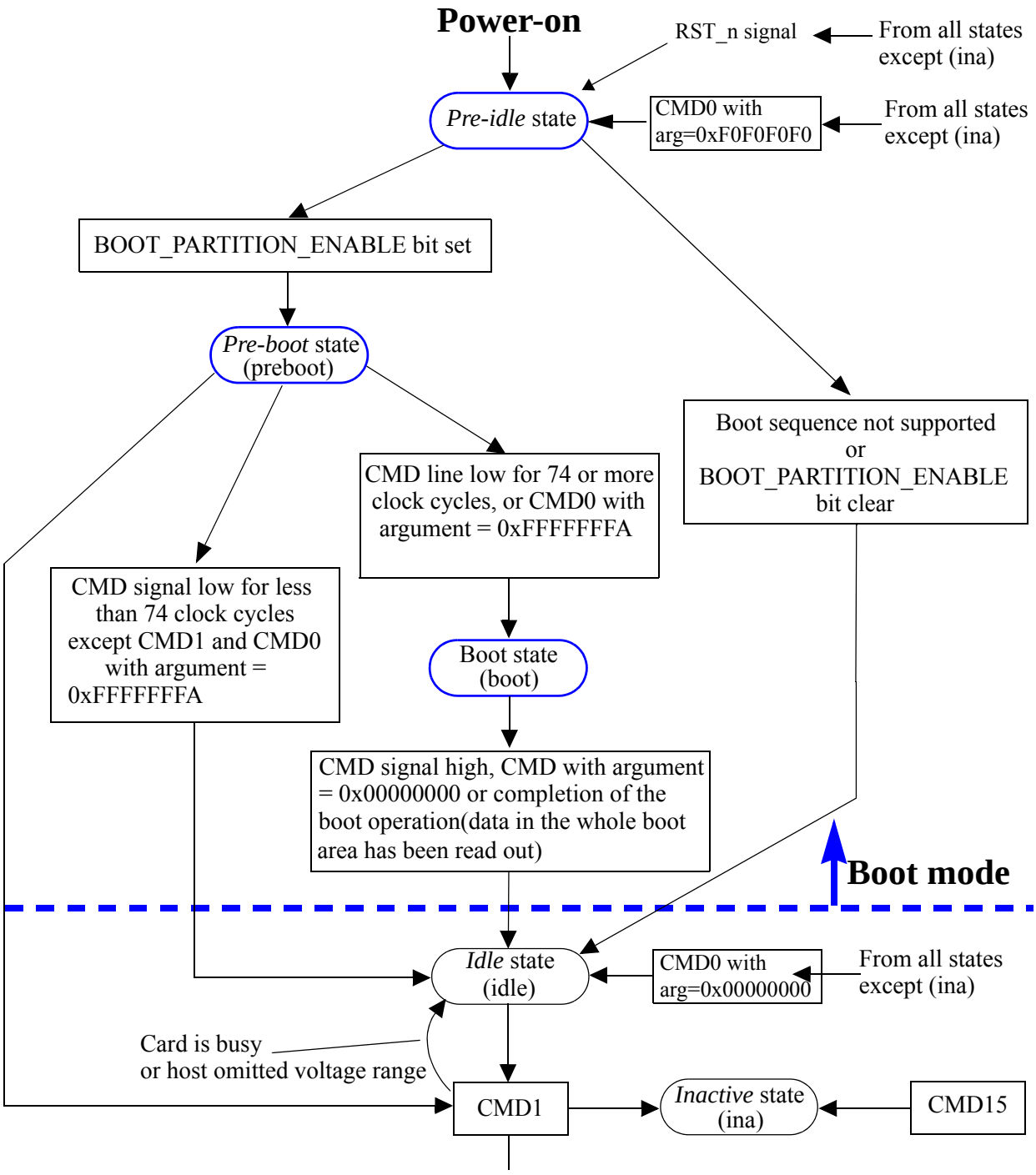


Figure 25 — MultiMediaCard state diagram (boot mode)

7.3.5 Access to boot partition

After putting a slave into transfer state, master sends CMD6 (SWITCH) to set the PARTITION_ACCESS bits in the EXT_CSD register, byte [179]. After that, master can use normal MMC commands to access a boot partition.

Master can program boot data on DAT line(s) using CMD24 (WRITE_BLOCK) or CMD25 (WRITE_MULTIPLE_BLOCK) with slave supported addressing mode i.e. byte addressing or sector addressing. If the master uses CMD25 (WRITE_MULTIPLE_BLOCK) and the writes past the selected partition boundary, the slave will report an “ADDRESS_OUT_OF_RANGE” error. Data that is within the partition boundary will be written to the selected boot partition.

Master can read boot data on DAT line(s) using CMD17 (READ_SINGLE_BLOCK) or CMD18 (READ_MULTIPLE_BLOCK) with slave supported addressing mode i.e. byte addressing or sector addressing. If the master page uses CMD18 (READ_MULTIPLE_BLOCK) and then reads past the selected partition boundary, the slave will report an “ADDRESS_OUT_OF_RANGE” error.

After finishing data access to the boot partition, the PARTITION_ACCESS bits should be cleared. Then, non-volatile BOOT_PARTITION_ENABLE bits in the EXT_CSD register should be set to indicate which partition is enabled for booting. This will permit the slave to read data from the boot partition during boot operation.

Master also can access user area by using normal command by clearing PARTITION_ACCESS bits in the EXT_CSD register, byte [179] to 000b.

If user area is locked and enabled for boot, data will not be sent out to master during boot operation mode. However, if the user area is locked and one of the two partitions is enabled, data will be sent out to the master during boot operation mode.

7.3.6 Boot bus width and data access configuration

During boot operation, bus width can be configured by non-volatile configuration bits in the Extend CSD register byte[177] bit[0:1]. Bit2 in register byte[177] determines if the slave returns to x1 bus width and single data rate mode with backward compatible timing after a boot operation or if it remains in the configured boot-bus width during normal operation. Bits[4:3] in register byte[177] determines if the data lines are configured for single data rate using backward compatible or high speed timings or dual data rate mode during boot operation. If boot operation is not executed, the slave will initialize in normal x1 bus width, single data rate operation and backward compatible timing regardless of the register setting.

7.3.7 Boot Partition Write Protection

In order to allow the host to protect the boot area against erase or write, the MultiMediaCard shall support two levels of write protection for the boot area.

- The boot area can be permanently write protected by setting B_PERM_WP_EN (EXT_CSD[173] bit 2).
- The boot area can power-on write protected by setting B_PWR_WP_EN (EXT_CSD[173] bit 0).

When using power-on write protection for the boot area the host must be aware of the following:

- After a power failure event that causes the device to reboot occurs or a hardware reset occurs the power-on write protection must be reapplied, if required, since the boot area returns to the unprotected state.
- Permanent write protection can still be applied to the boot area after power-on protection has been enabled. Therefore if permanent write protection is not required, B_PERM_WP_DIS (EXT_CSD[173] bit 4) should be set to prevent permanent protection from being set maliciously or unintentionally.

The host has the ability to disable both permanent and power on write protection in the boot area by setting B_PERM_WP_DIS (EXT_CSD[173] bit 4) and B_PWR_WP_DIS (EXT_CSD[173] bit 6). If boot area protection is not required it is recommended that these bits be set in order to ensure that the boot area is not protected unintentionally or maliciously.

7.4 Card identification mode

While in card identification mode the host resets the card, validates operation voltage range and access mode, identifies the card and assigns a Relative Card Address (RCA) to the card on the bus. All data communication in the Card Identification Mode uses the command line (CMD) only.

7.4.1 Card reset

After receiving Command GO_IDLE_STATE (CMD0 with argument of 0x00000000), the cards go to *Idle* State.

Also below are the cases in which device move into *Idle* State.

- After completing boot operation
- After receiving CMD1 at *pre-idle* state
- After power up if the device is not boot enabled

In this state, the cards' output bus drivers are in high-impedance state and the card is initialized with a default relative card address (0x0001) and with a default driver stage register setting, as shown in Section 8.6 on page 154 The host clocks the bus at the identification clock rate $f_{OD,}$ as described in Section 12.7 on page 176.

CMD0 with argument of 0x00000000 is valid in all states, with the exception of *Inactive* State. While in *Inactive* state the card does not accept CMD0 with argument of 0x00000000.

For backward compatibility reason, if device receive CMD0 with argument of other than 0xFFFFFFFA or 0xF0F0F0F0 in any state except *Inactive* state, device shall treat it as card reset command and move to *Idle* state. CMD0 with argument of 0xFFFFFFFA is a boot initiation command in *Pre-boot* state, but if host issue this command in any state except *Inactive* state and *Pre-boot* state, the device shall treat it as a rest command and mode to *Idle* state.

7.4.2 Operating voltage range validation

Each type of MultiMediaCard (either High voltage or Dual Voltage) shall be able to establish communication with the host, as well as perform the actual card function (e.g. accessing memory), using any operating voltage within the voltage range specified in this standard, for the given card type. (See Section 12.5 on page 171.)

The SEND_OP_COND (CMD1) command is designed to provide MultiMediaCard hosts with a mechanism to identify and reject cards which do not match the V_{DD} range desired by the host. This is accomplished by the host sending the required V_{DD} voltage window as the operand of this command. (See Section 8.1 on page 113.) If the card can not perform data transfer in the specified range it must discard itself from further bus operations and go into *Inactive* State. Otherwise, the card shall respond sending back its V_{DD} range, and the *e*•MMC device shall respond with a fixed pattern of either 0x00FF 8080 or 0x40FF 8080, depending on the density. (This will also be true if the operand generated by the host is 0x0000 0000, which does not represent any valid range.) For this, the levels in the OCR register shall be defined accordingly as described in Section 8.1 on page 113.

For *e*•MMC devices, the voltage range in CMD1 is no longer valid. Regardless of the voltage range indicated by the host, the *e*•MMC devices shall respond with a fixed pattern of either 0x00FF 8080 (capacity less than or equal to 2GB) or 0x40FF 8080 (capacity greater than 2GB) if device is busy, and they shall not move into *Inactive* state.

For *e*•MMC devices, the host shall still send the correct Access mode in CMD1 argument.

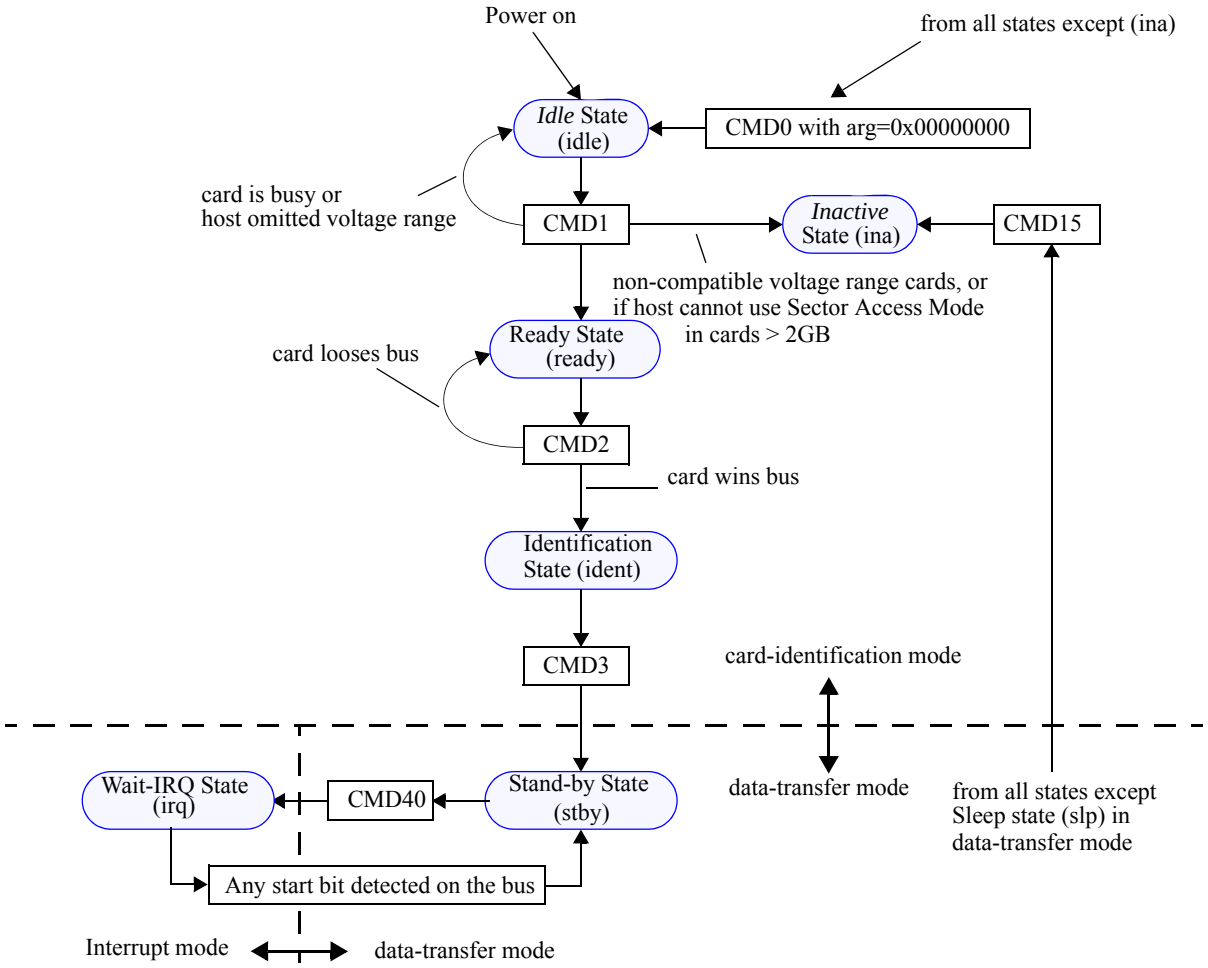


Figure 26 — MultiMediaCard state diagram (card identification mode)

If the host intends to operate the Dual Voltage MultiMediaCards in the 1.70V to 1.95V range, it is recommended that the host first validate the operating voltage in the 2.7V to 3.6V range, then power the card down fully, and finally power the card back up to the 1.70V to 1.95V range for operation. Using the 2.7V to 3.6V range initially, which is common to High and Dual voltage MultiMediaCards, will allow reliable screening of host & card voltage incompatibilities. High voltage cards may not function properly if VDD < 2.0V is used to establish communication. Dual voltage cards may fail if 1.95 to 2.7V is used.

7.4.3 Access mode validation (higher than 2GB of densities)

The SEND_OP_COND (CMD1) command and the OCR register are also including two bits for the indication of the supported access mode of the memory. The specifically set bits in the CMD1 command argument are indicating to a memory that the host is capable of handling sector type of addressing. The correspondingly set bits in the OCR register are indicating that the card is requiring usage of sector type of addressing. These specific bits of the OCR register are valid only in the last response from the card for CMD1 (card entering Ready state). This kind of two way handshaking is needed so that

- If there is no indication by a host to a memory that the host is capable of handling sector type of addressing the higher than 2GB of density of memory will change its state to *Inactive* (similarly to a situation in which there is no common voltage range to work with)
  (exception, if a host send 0x0000 0000 for voltage range validation, device shall not change its state to *Inactive* during voltage range validation stage)
  This will also be true if the operand generated by the host is 0x0000 0000, which does not represent any valid range.
- From the indication of the sector type of addressing requirement in the OCR register the host is able to separate the card from the byte access mode cards and prepare itself

It needs to be taken into account that in a multi card system a byte access mode card (<=2GB) is blocking the OCR response in such way that a sector access mode card (>2GB) is not necessarily recognized as a sector access mode card during the initialization. Thus this needs to be reconfirmed by reading the SEC_COUNT information from the EXT_CSD register.

7.4.4 From busy to ready

The busy bit in the CMD1 response can be used by a card to tell the host that it is still working on its power-up/reset procedure (e.g. downloading the register information from memory field) and is not ready yet for communication. In this case the host must repeat CMD1 until the busy bit is cleared.

During the initialization procedure, the host is not allowed to change the operating voltage range or access mode setting. Such changes shall be ignored by the card. If there is a real change in the operating conditions, the host must reset the card (using CMD0 with argument of 0x00000000) and restart the initialization procedure. However, for accessing cards already in *Inactive* State, a hard reset must be done by switching the power supply off and back on.

The command GO_INACTIVE_STATE (CMD15) can be used to send an addressed card into the *Inactive* State. This command is used when the host explicitly wants to deactivate a card (e.g. host is changing V_{DD} into a range which is known to be not supported by this card).

The command CMD1 shall be implemented by all cards defined by this standard.

7.4.5 Card identification process

The following explanation refers to a card working in a multi-card environment, as defined in versions of this standard previous to v4.0, and it is maintained for backwards compatibility to those systems.

The host starts the card identification process in open-drain mode with the identification clock rate f_{OD}. (See Section 12.7 on page 176.) The open drain driver stages on the CMD line allow parallel card operation during card identification.

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. All unidentified cards (i.e., those which are in *Ready* State) simultaneously start sending their CID numbers serially, while bit-wise monitoring their outgoing bitstream. Those cards, whose outgoing CID bits do not match the corresponding bits on the command line in any one of the bit periods, stop sending their CID immediately and must wait for the next identification cycle (remaining in the *Ready* State). 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 a relative card address (RCA), which is shorter than CID and which will be used to address the card in the future data transfer mode (typically with a higher clock rate than f_{OD}). Once the RCA is received the card state changes to the *Stand-by* State, and the card does not react to further identification cycles. Furthermore, the card switches its output drivers from open-drain to push-pull.

The host repeats the identification process, i.e., the cycles with CMD2 and CMD3, as long as it receives a response (CID) to its identification command (CMD2). If no more cards responds to this command, all cards have been identified. The time-out condition to recognize completion of the identification process is the absence of a start bit for more than N_{ID} clock cycles after sending CMD2. (See timing values in Section 7.15 on page 101.)

7.5 Interrupt mode

The interrupt mode on the MultiMediaCard system enables the master (MultiMediaCard host) to grant the transmission allowance to the slaves (card) simultaneously. This mode reduces the polling load for the host and hence, the power consumption of the system, while maintaining adequate responsiveness of the host to a card request for service. Supporting MultiMediaCard interrupt mode is an option, both for the host and the card.

The system behavior during the interrupt mode is described in the state diagram in Figure 27.

- The host must ensure that the card is in *Stand-by* State before issuing the GO_IRQ_STATE (CMD40) command. While waiting for an interrupt response from the card, the host must keep the clock signal active. Clock rate may be changed according to the required response time.
- The host sets the card into interrupt mode using GO_IRQ_STATE (CMD40) command.
- A card in Wait-IRQ-State is waiting for an internal interrupt trigger event. Once the event occurs, the card starts to send its response to the host. This response is sent in the open-drain mode.
- While waiting for the internal interrupt event, the card is also waiting for a start bit on the command line. Upon detection of a start bit, the card will abort interrupt mode and switch to the *stand-by* state.
- Regardless of winning or losing bus control during CMD40 response, the cards switches to *stand-by* state (as opposed to CMD2).
- After the interrupt response was received by the host, the host returns to the standard data communication procedure.

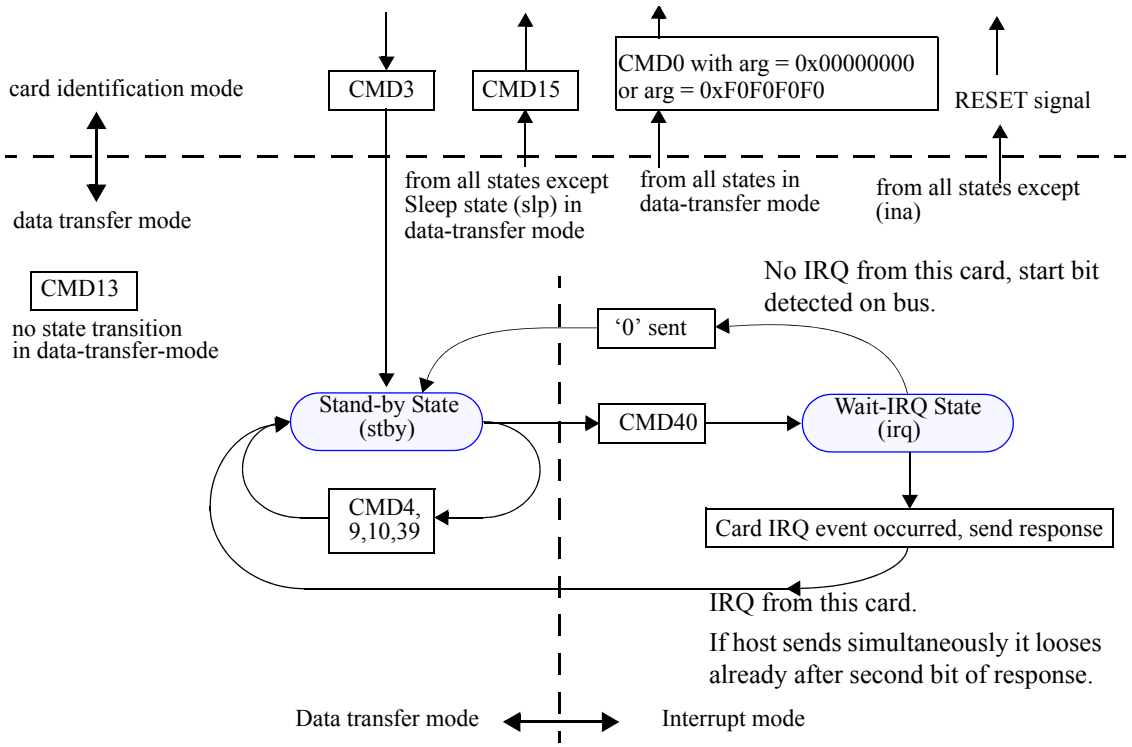


Figure 27 — MultiMediaCard state transition diagram, interrupt mode

- If the host wants to terminate the interrupt mode before an interrupt response is received, it can generate the CMD40 response by himself (with card bit = 0) using the reserved RCA address 0x0000; This will bring the card from Wait-IRQ-State back into the Stand-by-State. Now the host can resume the standard communication procedure.

7.6 Data transfer mode

When the card is in *Stand-by* State, communication over the CMD and DAT lines will be performed in push-pull mode. Until the contents of the CSD register is known by the host, the f_{PP} clock rate must remain at $f_{OD.}$ (See Section 12.7 on page 176.) 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.

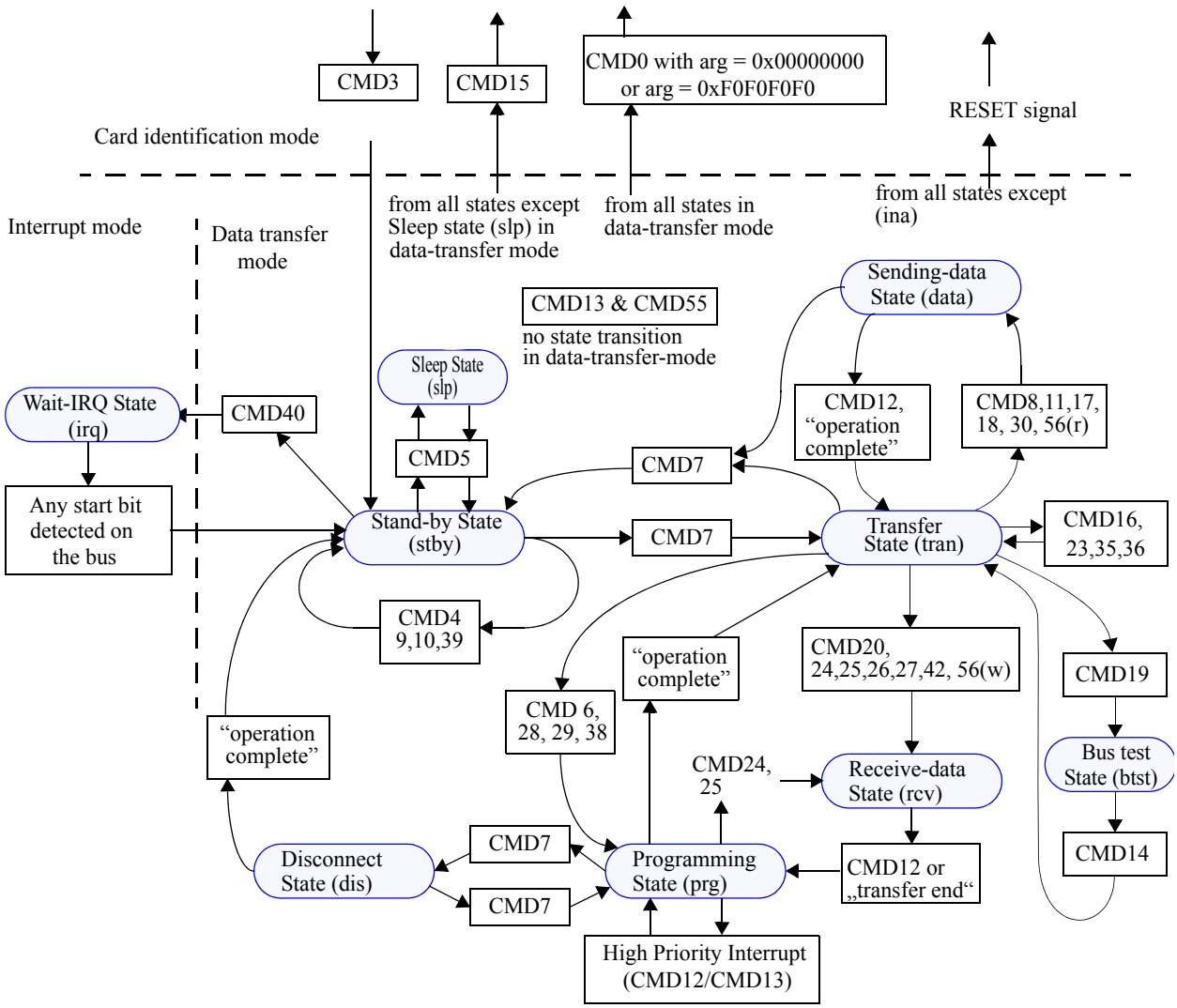


Figure 28 — MultiMediaCard state diagram (data transfer mode)

Note: The busy (Dat0=low) is always active during the prg-state. Due to legacy reasons, a card may still treat CMD24/25 during prg-state (while busy is active) as a legal or illegal command. A host should not send CMD24/25 while the card is in the prg state and busy is active.

The broadcast command SET_DSR (CMD4) configures the driver stages of the card. It programs its DSR register corresponding to the application bus layout (length) and the data transfer frequency. The clock rate is also switched from f_{OD} to f_{PP} at that point.

While the card is in *Stand-by* State, CMD7 is used to select the card and put it into the *Transfer* State by including card's relative address in the argument. If the card was previously selected and was in *Transfer* State its connection with the host is released and it will move back to the *Stand-by* State when deselected by CMD7 with any address in the argument that is not equal to card's own relative address. When CMD7 is issued with the reserved relative card address "0x0000", the card is put back to *Stand-by* State. Reception of CMD7 with card's own relative address while the card is in *Transfer* State is ignored by the card and may be treated as an Illegal Command. After the card is assigned an RCA it will not respond to identification commands — CMD1, CMD2, or CMD3. (See Section 7.4.5 on page 45).

While the card is in *Disconnect* State, CMD7 is used to select the card and put it into the *Programming* State by including card's relative address in the argument. If the card was previously selected and was in *Programming* State its connection with the host is released and it will move back to the *Disconnect* State when deselected by CMD7 with any address in the argument that is not equal to card's own relative address. Reception of CMD7 with card's own relative address while the card is in *Programming* State is ignored by the card and may be treated as an Illegal Command.

All data communication in the Data Transfer Mode is point-to point between the host and the selected card (using addressed commands). All addressed commands get acknowledged by a response on the CMD line.

The relationship between the various data transfer modes is summarized below (see Figure 28):

- All data read commands can be aborted any time by the stop command (CMD12). The data transfer will terminate and the card will return to the *Transfer* State. The read commands are: stream read (CMD11), block read (CMD17), multiple block read (CMD18) and send write protect (CMD30).
- All data write commands can be aborted any time by the stop command (CMD12). The write commands must be stopped prior to deselecting the card by CMD7. The write commands are: stream write (CMD20), block write (CMD24 and CMD25), write CID (CMD26), and write CSD (CMD27).
- If a stream write operation is stopped prior to reaching the block boundary and partial blocks are allowed (as defined in the CSD), the part of the last block will be packed as a partial block and programmed. If partial blocks are not allowed the data will be discarded.
- As soon as the data transfer is completed, the card will exit the data write state and move either to the *Programming* State (transfer is successful) or *Transfer* State (transfer failed).
- If a block write operation is stopped and the block length and CRC of the last block are valid, the data will be programmed.
- If data transfer in stream write mode is stopped, not byte aligned, the bits of the incomplete byte are ignored and not programmed.
- The card may provide buffering for stream and block write. This means that the next block can be sent to the card while the previous is being programmed.
- There is no buffering option for write CSD, write CID, write protection and erase. This means that while the card is busy servicing any one of these commands, no other data transfer commands will be accepted. DAT0 line will be kept low as long as the card is busy and in the *Programming* State.
- Parameter set commands are not allowed while card is programming.
  Parameter set commands are: set block length (CMD16), and erase group selection (CMD35-36).
- Read commands are not allowed while card is programming.
- Moving another card from *Stand-by* to *Transfer* State (using CMD7) will not terminate a programming operation. The card will switch to the *Disconnect* State and will release the DAT0 line.
- A card can be reselected while in the *Disconnect* State, using CMD7. In this case the card will move to the *Programming* State and reactivate the busy indication.
- Resetting a card (using CMD0, CMD15, or hardware reset for *e*•MMC) or power failure will terminate any pending or active programming operation. This may leave some or all of the data addressed by the operation in an unknown state unless Reliable Write was enabled. It is the host's responsibility to prevent this.

- Prior to executing the bus testing procedure (CMD19, CMD14), it is recommended to set up the clock frequency used for data transfer. This way the bus test gives a true result, which might not be the case if the bus testing procedure is performed with lower clock frequency than the data transfer frequency.
- The following commands: bus testing (CMD19, CMD14), lock-unlock (CMD42), set block-length (CMD16) and stream transfer (CMD11,CMD20) are not allowed once the card is configured to operate in dual data rate mode and shall not be executed but regarded as illegal commands.

In the following format definitions, all upper case flags and parameters are defined in the CSD (Section 8.3 on page 115), and the other status flags in the Card Status (Section 7.13 on page 96).

7.6.1 Command sets and extended settings

The card operates in a given command set, by default, after a power cycle, reset by CMD0 with argument of 0x00000000 or after boot operation; it is the MultiMediaCard standard command set, using a single data line, DAT0. The host can change the active command set by issuing the SWITCH command (CMD6) with the ‘Command Set’ access mode selected.

The supported command sets, as well as the currently selected command set, are defined in the EXT_CSD register. The EXT_CSD register is divided in two segments, a Properties segment and a Modes segment. The Properties segment contains information about the card capabilities. The Modes segment reflects the current selected modes of the card.

The host reads the EXT_CSD register by issuing the SEND_EXT_CSD command. The card sends the EXT_CSD register as a block of data, 512 bytes long. Any reserved, or write only field, reads as ‘0’.

The host can write the Modes segment of the EXT_CSD register by issuing a SWITCH command and setting one of the access modes. All three modes access and modify one of the EXT_CSD bytes, the byte pointed by the Index field.

NOTE The Index field can contain any value from 0–255, but only values 0–191 are valid values. If the Index value is in the 192-255 range the card does not perform any modification and the SWITCH_ERROR status bit is set.

Table 6 — EXT_CSD access mode

Access Bits	Access Name	Operation
00	Command Set	The command set is changed according to the Cmd Set field of the argument
01	Set Bits	The bits in the pointed byte are set, according to the ‘1’ bits in the Value field.
10	Clear Bits	The bits in the pointed byte are cleared, according to the ‘1’ bits in the Value field.
11	Write Byte	The Value field is written into the pointed byte.

The SWITCH command can be used either to write the EXT_CSD register or to change the command set. If the SWITCH command is used to change the command set, the Index and Value field are ignored, and the EXT_CSD is not written. If the SWITCH command is used to write the EXT_CSD register, the Cmd Set field is ignored, and the command set remains unchanged.

The SWITCH command response is of type R1b, therefore, the host should read the card status, using SEND_STATUS command, after the busy signal is de-asserted, to check the result of the SWITCH operation.

7.6.2 High-speed mode selection

After the host verifies that the card complies with version 4.0, or higher, of this standard, it has to enable the high speed mode timing in the card, before changing the clock frequency to a frequency higher than 20MHz.

After power-on, or software reset, the interface timing of the card is set as specified in Table 114 on page 177. For the host to change to a higher clock frequency, it has to enable the high speed interface timing. The host uses the SWITCH command to write 0x01 to the HS_TIMING byte, in the Modes segment of the EXT_CSD register.

The valid values for this register are defined in "HS_TIMING [185]" on page 141. If the host tries to write an invalid value, the HS_TIMING byte is not changed, the high speed interface timing is not enabled, and the SWITCH_ERROR bit is set.

7.6.3 Power class selection

After the host verifies that the card complies with version 4.0, or higher, of this standard, it may change the power class of the card.

After power-on, or software reset, the card power class is class 0, which is the default, minimum current consumption class for the card type, either High Voltage or Dual voltage card. The PWR_CL_ff_vvv bytes, in the EXT_CSD register, reflect the power consumption levels of the card, for a 4 bits bus, an 8 bit bus, at the supported clock frequencies (26MHZ or 52MHz).

The host reads this information, using the SEND_EXT_CSD command, and determines if it will allow the card to use a higher power class. If a power class change is needed, the host uses the SWITCH command to write the POWER_CLASS byte, in the Modes segment of the EXT_CSD register.

The valid values for this register are defined in "PWR_CL_ff_vvv [203:200], PWR_CL_DDR_ff_vvv [239:238]" on page 138. If the host tries to write an invalid value, the POWER_CLASS byte is not changed and the SWITCH_ERROR bit is set.

7.6.4 Bus testing procedure

By issuing commands CMD19 and CMD14 in single data rate mode the host can detect the functional pins on the bus. In the dual data rate mode, CMD19 and CMD14 are considered illegal commands. In a first step, the host sends CMD19 to the card, followed by a specific data pattern on each selected data lines. The data pattern to be sent per data line is defined in the table below. As a second step, the host sends CMD14 to request the card to send back the reversed data pattern. With the data pattern sent by the host and with the reversed pattern sent back by the card, the functional pins on the bus can be detected.

Table 7 — Bus testing pattern

Start Bit	Data Pattern	End bit
0	1 0 x x x x … x x	1

The card ignores all but the two first bits of the data pattern. Therefore, the card buffer size is not limiting the maximum length of the data pattern. The minimum length of the data pattern is two bytes, of which the first two bits of each data line are sent back, by the card, reversed. The data pattern sent by the host may optionally include a CRC16 checksum, which is ignored by the card.

The card detects the start bit on DAT0 and synchronizes accordingly the reading of all its data inputs.

The host ignores all but the two first bits of the reverse data pattern. The length of the reverse data pattern is eight bytes and is always sent using all the card's DAT lines (See Table 8 through Table 9 on page 51.) The reverse data pattern sent by the card may optionally include a CRC16 checksum, which is ignored by the host.

The card has internal pull ups in DAT1–DAT7 lines. In cases where the card is connected to only a 1-bit or a 4-bit HS-MMC system, the input value of the upper bits (e.g. DAT1–DAT7 or DAT4–DAT7) are detected as logical "1" by the card.

Table 8 — 1-bit bus testing pattern

Data line	Data pattern sent by the host	Reversed pattern sent by the card	Notes
DAT0	0, 10xxxxxxxxx, [CRC16], 1	0, 01000000, [CRC16], 1	Start bit defines beginning of pattern
DAT1		0, 00000000, [CRC16], 1	No data pattern sent
DAT2		0, 00000000, [CRC16], 1	No data pattern sent
DAT3		0, 00000000, [CRC16], 1	No data pattern sent
DAT4		0, 00000000, [CRC16], 1	No data pattern sent
DAT5		0, 00000000, [CRC16], 1	No data pattern sent
DAT6		0, 00000000, [CRC16], 1	No data pattern sent
DAT7		0, 00000000, [CRC16], 1	No data pattern sent

Table 9 — 4-bit bus testing pattern

Data line	Data pattern sent by the host	Reversed pattern sent by the card	Notes
DAT0	0, 10xxxxxxxxx, [CRC16], 1	0, 01000000, [CRC16], 1	Start bit defines beginning of pattern
DAT1	0, 01xxxxxxxxx, [CRC16], 1	0, 10000000, [CRC16], 1	
DAT2	0, 10xxxxxxxxx, [CRC16], 1	0, 01000000, [CRC16], 1	
DAT3	0, 01xxxxxxxxx, [CRC16], 1	0, 10000000, [CRC16], 1	
DAT4		0, 00000000, [CRC16], 1	No data pattern sent
DAT5		0, 00000000, [CRC16], 1	No data pattern sent
DAT6		0, 00000000, [CRC16], 1	No data pattern sent
DAT7		0, 00000000, [CRC16], 1	No data pattern sent

Table 10 — 8-bit bus testing pattern

Data line	Data pattern sent by the host	Reversed pattern sent by the card	Notes
DAT0	0, 10xxxxxxxxx, [CRC16], 1	0, 01000000, [CRC16], 1	Start bit defines beginning of pattern
DAT1	0, 01xxxxxxxxx, [CRC16], 1	0, 10000000, [CRC16], 1	
DAT2	0, 10xxxxxxxxx, [CRC16], 1	0, 01000000, [CRC16], 1	
DAT3	0, 01xxxxxxxxx, [CRC16], 1	0, 10000000, [CRC16], 1	
DAT4	0, 10xxxxxxxxx, [CRC16], 1	0, 01000000, [CRC16], 1	
DAT5	0, 01xxxxxxxxx, [CRC16], 1	0, 10000000, [CRC16], 1	
DAT6	0, 10xxxxxxxxx, [CRC16], 1	0, 01000000, [CRC16], 1	
DAT7	0, 01xxxxxxxxx, [CRC16], 1	0, 10000000, [CRC16], 1	

7.6.5 Bus width selection

After the host has verified the functional pins on the bus it should change the bus width configuration accordingly, using the SWITCH command.

The bus width configuration is changed by writing to the BUS_WIDTH byte in the Modes Segment of the EXT_CSD register (using the SWITCH command to do so). After power-on, or software reset, the contents of the BUS_WIDTH byte is 0x00.

The valid values for this register are defined in "BUS_WIDTH [183]" on page 141. If the host tries to write an invalid value, the BUS_WIDTH byte is not changed and the SWITCH_ERROR bit is set. This register is write only.

7.6.6 Data read

The DAT0-DAT7 bus line levels are high when no data is transmitted. A transmitted data block consists of a start bit (LOW), on each DAT line, followed by a continuous data stream. The data stream contains the payload data (and error correction bits if an off-card ECC is used). The data stream ends with an end bit (HIGH), on each DAT line. (See both Figure 36 on page 104, Figure 37 on page 104, and Figure 41 on page 106). The data transmission is synchronous to the clock signal.

The payload for block oriented data transfer is protected by one CRC check sum in single data rate mode or by two CRC check sums in dual data rate mode, on each DAT line (See Section 10.2 on page 157).

- Stream Read

There is a stream oriented data transfer controlled by READ_DAT_UNTIL_STOP (CMD11). This command instructs the card to send its payload, starting at a specified address, until the host sends a STOP_TRANSMISSION command (CMD12). The stop command has an execution delay due to the serial command transmission. The data transfer stops after the end bit of the stop command.

If the host provides an out of range address as an argument to CMD11, the card will reject the command, remain in *Tran* state and respond with the ADDRESS_OUT_OF_RANGE bit set.

Note that the stream read command works only on a 1 bit bus configuration (on DAT0) in single data ratemode. If CMD11 is issued in other bus configurations or in dual data rate mode, it is regarded as an illegal command.

If the end of the memory range is reached while sending data, and no stop command has been sent yet by the host, the contents of the further transferred payload is undefined. As the host sends CMD12 the card will respond with the ADDRESS_OUT_OF_RANGE bit set and return to *Tran* state.

In order for the card to sustain data transfer in stream mode, the time it takes to transmit the data (defined by the bus clock rate) must be lower then the time it takes to read it out of the main memory field (defined by the card in the CSD register). Therefore, the maximum clock frequency for stream read operation is given by the following formula:

$$\text{Max Read Frequency} = \min\left(\text{TRAN\_SPEED}, \frac{8 \times 2^{\text{READ\_BL\_LEN}} - 100 \cdot \text{NSAC}}{\text{TAAC} \times \text{R2W\_FACTOR}}\right)$$

All the parameters are defined in Section 8, starting on page 113,. If the host attempts to use a higher frequency, the card will not be able to sustain data transfer, and the content of the further transferred bits is undefined. As the host sends CMD12 the card will respond with the UNDERRUN bit set and return to *Tran* state.

Since the timing constrains in the CSD register are typical (not maximum) values (refer to Section 7.8.2 on page 82) using the above calculated frequency may still yield and occasional UNDERRUN error. In order to ensure that the card will not get into an UNDERRUN situation, the maximum read latency (defined as 10x the typical - refer to Section 7.8.2) should be used:

$$\text{No Underrun Read Frequency} = \min\left(\text{TRAN\_SPEED}, \frac{8 \times 2^{\text{READ\_BL\_LEN}} - 1000 \cdot \text{NSAC}}{10 \cdot \text{TAAC} \times \text{R2W\_FACTOR}}\right)$$

In general, the probability of an UNDERRUN error will decrease as the frequency decreases. The host application can control the trade-off between transfer speed (higher frequency) and error handling (lower frequency) by selecting the appropriate stream read frequency.

- Block read

In single data rate mode, block read is similar to stream read, except the basic unit of data transfer is a block whose maximum size is defined in the CSD (READ_BL_LEN). If READ_BL_PARTIAL is set, smaller blocks whose starting and ending address are entirely contained within one physical block (as defined by READ_BL_LEN) may also be transmitted. Unlike stream read, a CRC is appended to the end of each block ensuring data transfer integrity. CMD17 (READ_SINGLE_BLOCK) initiates a block read and after completing the transfer, the card returns to the *Transfer State*.

In dual data rate mode, the data size of a block read is always 512 bytes, partial block data read is not supported, and at the end of each block is appended two CRC . one for even bytes and one for odd bytes.

CMD18 (READ_MULTIPLE_BLOCK) starts a transfer of several consecutive blocks. Two types of multiple block read transactions are defined (the host can use either one at any time):

- Open-ended Multiple block read

  The number of blocks for the read multiple block operation is not defined. The card will continuously transfer data blocks until a stop transmission command is received.

- Multiple block read with pre-defined block count

  The card will transfer the requested number of data blocks, terminate the transaction and return to *transfer* state. Stop command is not required at the end of this type of multiple block read, unless terminated with an error. In order to start a multiple block read with pre-defined block count the host must use the SET_BLOCK_COUNT command (CMD23) immediately preceding the READ_MULTIPLE_BLOCK (CMD18) command. Otherwise the card will start an open-ended multiple block read which can be stopped using the STOP_TRANSMISION command.

The host can abort reading at any time, within a multiple block operation, regardless of the its type. Transaction abort is done by sending the stop transmission command.

If either one of the following conditions occur, the card will reject the command, remain in *Tran* state and respond with the respective error bit set.

- The host provides an out of range address as an argument to either CMD17 or CMD18. ADDRESS_OUT_OF_RANGE is set.
- The currently defined block length is illegal for a read operation. BLOCK_LEN_ERROR is set.
- The address/block-length combination positions the first data block misaligned to the card physical blocks. ADDRESS_MISALIGN is set.

If the card detects an error (e.g. out of range, address misalignment, internal error, etc.) during a multiple block read operation (both types) it will stop data transmission and remain in the *Data State.* The host must then abort the operation by sending the stop transmission command. The read error is reported in the response to the stop transmission command.

If the host sends a stop transmission command after the card transmits the last block of a multiple block operation with a pre-defined number of blocks, it is regarded as an illegal command, since the card is no longer in *data* state.

If the host uses partial blocks whose accumulated length is not block aligned, and block misalignment is not allowed, the card shall detect a block misalignment error condition during the transmission of the first misaligned block and the content of the further transferred bits is undefined. As the host sends CMD12 the card will respond with the ADDRESS_MISALIGN bit set and return to *Tran* state.

If the host sets the argument of the SET_BLOCK_COUNT command (CMD23) to all 0s, then the command is accepted; however, a subsequent read will follow the open-ended multiple block read protocol (STOP_TRANSMISSION command - CMD12 - is required).

If a host had sent a CMD16 for password setting to a higher than 2GB of density of card, then this host MUST re-send CMD16 before read data transfer; otherwise, the card will response a BLK_LEN_ERROR and stay in TRANS state without data transfer since the data block (except in password application) transfer is sector unit (512B). Same error applies to up to 2GB of density of cards in case partial read access are not supported.

7.6.7 Data write

The data transfer format of write operation is similar to the data read. For block oriented write data transfer, one CRC check bits in single data rate mode or by two CRC check bits in dual data rate mode are added to each data block. The card performs a CRC parity check (see Section 10.2 on page 157) for each received data block prior to the write operation. By this mechanism, writing of erroneously transferred data can be prevented.

In general, an interruption to a write process should not cause corruption in existing data at any other address. However, the risk of power being removed during a write operation is different in different applications. Also, for some technologies used to implement *e*•MMC, there is a tradeoff between protecting existing data (e.g., data written by the previous completed write operations), during a power failure, and write performance. When the write data reliability parameters (WR_DATA_REL_USR, WR_DATA_REL_1, WR_DATA_REL_2, WR_DATA_REL_3 and WR_DATA_REL_4) in EXT_CSD (WR_REL_SET) are set to 1 it will indicate to the host that the write mechanism in the associated partition has been implemented to protect existing data in that partition. This means that once a device indicates to the host that a write has successfully completed, the data that was written, along with all previous data written, cannot be corrupted by other operations that are host initiated, controller initiated or accidental. A value of 0 for these bits will indicate that there is some risk to previously written data in those partitions if power is removed. This reliability setting only impacts the reliability of the main user area and the general purpose partitions. The data in the boot partitions and the RPMB partition must have the same reliability that is implied by setting the WR_DATA_REL bit to 1. The reliability of these partitions is not impacted by the value of the WR_DATA_REL bit.

The bit HS_CTRL_REL in the EXT_CSD register WR_REL_PARAM indicates whether the bits in the WR_REL_SET register are read only or write once. If the bits are write once, the host has the option of changing the reliability of the writes in one or more partitions on the device. The entire register is considered to be write once so the host has one opportunity to write all of the bits in the register. (Separate writes to change individual bits are not permitted) This write must happen as part of the partitioning process and must occur before the PARTITIONING_SETTING_COMPLETED bit is set. The changes made to the WR_REL_SET register will not have an impact until the partitioning process is complete (i.e. after the power cycle has occurred and the partitioning has completed successfully). Data reliability settings for partitions that do not exist in the device have no impact on the device.

7.6.7 Data write (cont'd)

All write operations must be completed in the order in which they arrive. The order restriction is applicable to each write command that a device receives and does not apply to the data within a specific write command.

- Stream write

Stream write (CMD20) starts the data transfer from the host to the card beginning from the starting address until the host issues a stop command. If partial blocks are allowed (if CSD parameter WRITE_BL_PARTIAL is set) the data stream can start and stop at any address within the card address space, otherwise it shall start and stop only at block boundaries. Since the amount of data to be transferred is not determined in advance, CRC can not be used.

If the host provides an out of range address as an argument to CMD20, the card will reject the command, remain in *Tran* state and respond with the ADDRESS_OUT_OF_RANGE bit set.

Note that the stream write command works only on a 1 bit bus configuration (on DAT0) in single data ratemode. If CMD20 is issued in other bus configurations or in dual data rate mode, it is regarded as an illegal command.

If the end of the memory range is reached while writing data, and no stop command has been sent yet by the host, the further transferred data is discarded. As the host sends CMD12, the card will respond with the ADDRESS_OUT_OF_RANGE bit set and return to Tran state.

If the end of the memory range is reached while sending data and no stop command has been sent by the host, all further transferred data is discarded.

In order for the card to sustain data transfer in stream mode, the time it takes to receive the data (defined by the bus clock rate) must be lower than the time it takes to program it into the main memory field (defined by the card in the CSD register). Therefore, the maximum clock frequency for the stream-write operation is given by the following formula:

$$\text{Max Write Frequency} = \min\left(\text{TRAN\_SPEED}, \frac{8 \times 2^{\text{WRITE\_BL\_LEN}} - 100 \cdot \text{NSAC}}{\text{TAAC} \times \text{R2W\_FACTOR}}\right)$$

All the parameters are defined in Section 8, starting on page 113,. If the host attempts to use a higher frequency, the card may not be able to process the data and will stop programming, and while ignoring all further data transfer, wait (in the *Receive-data-State*) for a stop command. As the host sends CMD12, the card will respond with the OVERRUN bit set and return to *Tran* state

The write operation shall also be aborted if the host tries to write over a write protected area. In this case, however, the card shall set the WP_VIOLATION bit.

Since the timing constrains in the CSD register are typical (not maximum) values (see Section 7.8.2 on page 82), using the above calculated frequency may still yield and occasional OVERRUN error. In order to ensure that the card will not experience an OVERRUN situation, the maximum write latency (defined as 10x the typical -refer to Section 7.8.2) should be used:

$$\text{Error-Free Write Frequency} = \min\left(\text{TRAN\_SPEED}, \frac{8 \times 2^{\text{WRITE\_BL\_LEN}} - 1000 \cdot \text{NSAC}}{10 \cdot \text{TAAC} \times \text{R2W\_FACTOR}}\right)$$

7.6.7 Data write (cont'd)

In general, the probability of an OVERRUN error will decrease as the frequency decreases. The host application can control the trade-off between transfer speed (higher frequency) and error handling (lower frequency) by selecting the appropriate stream write frequency.

- Block write

In single data rate mode, during block write (CMD24 - 27) one or more blocks of data are transferred from the host to the card with a CRC appended to the end of each block by the host. A card supporting block write shall always be able to accept a block of data defined by WRITE_BL_LEN. If the CRC fails, the card shall indicate the failure on the DAT0 line (see below); the transferred data will be discarded and not written, and all further transmitted blocks (in multiple block write mode) will be ignored.

In dual data rate mode, the data size of a block write is always 512 bytes, partial block data write is not supported, and at the end of each block is appended two CRC . one for even bytes and one for odd bytes.

CMD25 (WRITE_MULTIPLE_BLOCK) starts a transfer of several consecutive blocks. Three types of multiple-block write transactions are defined (the host can use any of these three types at any time):

- Open-ended Multiple-block write

  The number of blocks for the write multiple block operation is not defined. The card will continuously accept and program data blocks until a stop transmission command is received.

- Multiple-block write with pre-defined block count

  The card will accept the requested number of data blocks, terminate the transaction and return to *transfer* state. Stop command is not required at the end of this type of multiple block write, unless terminated with an error. In order to start a multiple block write with pre-defined block count the host must use the SET_BLOCK_COUNT command (CMD23) immediately preceding the WRITE_MULTIPLE_BLOCK (CMD25) command. Otherwise the card will start an open-ended multiple-block write which can be stopped using the STOP_TRANSMISION command.

- Reliable Write: Multiple block write with pre-defined block count and Reliable Write parameters. This transaction is similar to the basic pre-defined multiple-block write (defined in previous bullet) with the following exceptions. The old data pointed to by a logical address must remain unchanged until the new data written to same logical address has been successfully programmed. This is to ensure that the target address updated by the reliable write transaction never contains undefined data. Data must remain valid even if a sudden power loss occurs during the programming.
- There are two versions of reliable write: legacy implementation and the enhance implementation. The type of reliable write supported by the device is indicated by the EN_REL_WR bit in the WR_REL_PARAM extended CSD register.
- For the case of EN_REL_WR = 0 :
  - A maximum of two different sizes of reliable write transactions are supported: 512B and the Reliable Write Sector Count parameter in EXT_CSD (REL_WR_SEC_C) multiplied by 512B.
  - The function is activated by setting the Reliable Write Request parameter (bit 31) to "1" in the SET_BLOCK_COUNT command (CMD23) argument. The Reliable Write Sector Count parameter in EXT_CSD indicates the supported write sector count.
  - The reliable write function is only possible under the following conditions:
    - The length of the write operation equals the supported reliable write size or 512B,
    - AND the start address of the reliable write operation is aligned to the length of the operation (i.e reliable write start address is always multiple of it's own length)
    - And the reliable write request is active.

7.6.7 Data write (cont'd)

– Otherwise the transaction is handled as basic pre-defined multiple block case. When the length of the write operation is set to "0," the operation is executed as a basic, open-ended, multiple-block-write case, even when the reliable write request is active.

- For the case of EN_REL_WR = 1:
  – The block size defined by SET_BLOCKLEN(CMD16) is ignored and all blocks are 512 B in length. There is no limit on the size of the reliable write.
  – The function is activated by setting the Reliable Write Request parameter (bit 31) to "1" in the SET_BLOCK_COUNT command (CMD23) argument.
  – Reliable write transactions must be sector aligned, if a reliable write is not sector aligned the error bit 19 will be set and the transaction will not complete.
  – If a power loss occurs during a reliable write, each sector being modified by the write is atomic. After a power failure sectors may either contain old data or new data. All of the sectors being modified by the write operation that was interrupted may be in one of the following states: all sectors contain new data, all sectors contain old data or some sectors contain new data and some sectors contain old data.
  – In the case where a reliable write operation is interrupted by a high priority interrupt operation, the sectors that the register marks as completed will contain new data and the remaining sectors will contain old data.
  – The REL_WR_SEC_C [222] register should be set to 1 and has no impact on the reliable write operation.

The host can abort writing at any time, within a multiple block operation, regardless of the its type. Transaction abort is done by sending the stop transmission command. If a multiple block write with predefined block count is aborted, the data in the remaining blocks is not defined.

If either one of the following conditions occur, the card will reject the command, remain in *Tran* state and respond with the respective error bit set.

- The host provides an out of range address as an argument to either CMD24 or CMD25. ADDRESS_OUT_OF_RANGE is set.
- The currently defined block length is illegal for a write operation. BLOCK_LEN_ERROR is set.
- The address/block-length combination positions the first data block misaligned to the card physical blocks. ADDRESS_MISALIGN is set.

If the card detects an error (e.g. write protect violation, out of range, address misalignment, internal error, etc.) during a multiple block write operation (both types) it will ignore any further incoming data blocks and remain in the *Receive State.* The host must then abort the operation by sending the stop transmission command. The write error is reported in the response to the stop transmission command.

If the host sends a stop transmission command after the card received the last data block of a multiple block write with a pre-defined number of blocks, it is regarded as an illegal command, since the card is no longer in *rcv* state.

If the host uses partial blocks whose accumulated length is not block aligned, and block misalignment is not allowed (CSD parameter WRITE_BLK_MISALIGN is not set), the card shall detect the block misalignment error during the reception of the first misaligned block, abort the write operation, and ignore all further incoming data. As the host sends CMD12, the card will respond with the ADDRESS_MISALIGN bit set and return to *Tran* state.

If the host sets the argument of the SET_BLOCK_COUNT command (CMD23) to all 0s, then the command is accepted; however, a subsequent write will follow the open-ended multiple block write protocol (STOP_TRANSMISSION command - CMD12 - is required).

7.6.7 Data write (cont'd)

Programming of the CID and CSD registers does not require a previous block length setting. The transferred data is also CRC protected. If a part of the CSD or CID register is stored in ROM, then this unchangeable part must match the corresponding part of the receive buffer. If this match fails, then the card will report an error and not change any register contents.

Some cards may require long and unpredictable times to write a block of data. After receiving a block of data and completing the CRC check, the card will begin writing and hold the DAT0 line low. The host may poll the status of the card with a SEND_STATUS command (CMD13) at any time, and the card will respond with its status (except in Sleep state). The status bit READY_FOR_DATA indicates whether the card can accept new data or not. The host may deselect the card by issuing CMD7 which will displace the card into the *Disconnect* State and release the DAT0 line without interrupting the write operation. When reselecting the card, it will reactivate busy indication by pulling DAT0 to low. See Section 7.15 on page 101 for details of busy indication

If a host had sent a CMD16 for password setting to a higher than 2GB of density of card, then this host MUST re-send CMD16 before write data transfer; otherwise, the card will response a BLK_LEN_ERROR and stay in TRANS state without data transfer since the data block (except in password application) transfer is sector unit (512B). Same error applies to up to 2GB of density of cards in case partial write access are not supported.

7.6.8 Erase

MultiMediaCards, in addition to the implicit erase executed by the card as part of the write operation, provides a host explicit erase function. The erasable unit of the MultiMediaCard is the "Erase Group"; Erase group is measured in write blocks which are the basic writable units of the card. The size of the Erase Group is a card specific parameter and defined in the CSD when ERASE_GROUP_DEF is disabled, and in the EXT_CSD when ERASE_GROUP_DEF is enabled. The content of an explicitly erased memory range shall be '0' or '1' depending on different memory technology. This value is defined in the EXT_CSD.

The host can erase a contiguous range of Erase Groups. Starting the erase process is a three steps sequence. First the host defines the start address of the range using the ERASE_GROUP_START (CMD35) command, next it defines the last address of the range using the ERASE_GROUP_END (CMD36) command and finally it starts the erase process by issuing the ERASE (CMD38) command with argument bits set to zero. See Table 11 on page 59 for the arguments supported by CMD38. The address field in the erase commands is an Erase Group address, in byte units for densities up to 2GB, and in sector units for densities greater than 2GB. The card will ignore all LSB's below the Erase Group size, effectively rounding the address down to the Erase Group boundary.

If an erase command (either CMD35, CMD36, CMD38) is received out of the defined erase sequence, the card shall set the ERASE_SEQ_ERROR bit in the status register and reset the whole sequence.

If the host provides an out of range address as an argument to CMD35 or CMD36, the card will reject the command, respond with the ADDRESS_OUT_OF_RANGE bit set and reset the whole erase sequence.

If an 'non erase' command (neither of CMD35, CMD36, CMD38 or CMD13) is received, the card shall respond with the ERASE_RESET bit set, reset the erase sequence and execute the last command. Commands not addressed to the selected card do not abort the erase sequence.

If the erase range includes write protected blocks, they shall be left intact and only the non protected blocks shall be erased. The WP_ERASE_SKIP status bit in the status register shall be set.

As described above for block write, the card will indicate that an erase is in progress by holding DAT0 low. The actual erase time may be quite long, and the host may issue CMD7 to deselect the card.

7.6.8 Erase (cont'd)

Table 11 — Erase command (CMD38) Valid arguments

Arguments	Command Description	SEC_GB_CL_EN (EXT_CSD[231] bit 4)	SEC_ER_EN (EXT_CSD[231] bit 0)
0x00000000	**Erase** Erase the erase groups identified by CMD35&36. Controller can perform actual erase at a convenient time. (legacy implementation)	n/a	n/a
0x80000000	**Secure Erase** Perform a secure purge on the erase groups identified by CMD35&36 and any copies of those erase groups.	n/a	Required
0x80008000	**Secure Trim Step 2** Perform a secure purge operation on the write blocks and copies of those write blocks that were previously identified using CMD 35,36 and 38 + argument 0x80000001.	Required	Required
0x00000001	**Trim** Erase (aka Trim) the write blocks identified by CMD35&36. The controller can perform the actual erase at a convenient time.	Required	n/a
0x80000001	**Secure Trim Step 1** Mark the write blocks, indicated by CMD35&36, for secure erase.	Required	Required

Table 12 — Erase Command Comparision

Operation	Minimum Unit Size	Basic Operation(s) required by the Controller	Impact all Copies of Data	All Copies Must be Removed	Operation Timing is Determined by the Controller
Secure Erase	Erase Group	Erase	*v*	*v*	
Erase	Erase Group	Erase			*v*
Secure Trim	Write Block	Write & Erase(1)	*v*	*v*	
Trim	Write Block	Write & Erase(1)			*v*

(1) Since the minimum size for an erase operation is an erase group and a write group is smaller than an erase group. The trim operation implies that write blocks in an erase group that are not marked for erase must be copied to another location before the erase is applied.

7.6.8 Erase (cont'd)

When executing the [Erase/Secure Erase] command the host should note that an erase group contains multiple write blocks, which could each contain different pieces of information. When the [Erase/Secure Erase] is executed it will apply to all write blocks within an erase group. Before the host executes the [Erase/Secure Erase] command it should make sure that the information in the individual write blocks no longer needed. So to avoid the deletion of valid data by accident, the Erase command is best used to erase the entire device or a partition. If the host only wishes to purge a single write block a [Secure Trim/Trim] command might be more appropriate.

7.6.9 Secure Erase

In addition to the standard Erase command there is also an optional Secure Erase command. The Secure Erase command differs from the basic Erase command (outlined in Section 7.6.8 on page 58) in that it requires the card to execute the erase operation on the memory array when the command is issued and requires the card and host to wait until the operation is complete before moving to the next card operation. Also, the secure erase command requires the card to do a secure purge operation on the erase groups, and any copies of items in those erase groups, identified for erase.

This command allows applications that have high security requirements to request that the device perform secure operations, while accepting a possible erase time performance impact.

The Secure Erase command is executed in the same way the erase command outlined in Section 7.6.8 on page 58, except that the Erase (CMD38) command is executed with argument bit 31 set to 1 and the other argument bits set to zero. See Table 11 on page 59 for details on the argument combinations supported with the Erase (CMD 38) command and Table 13 on page 60 for the definition of the argument bits associated with the ERASE (CMD38) command.

The host should excute the Secure Erase command with caution to avoid unintentional data loss.

Resetting a card (using CMD0, CMD15, or hardware reset for *e*•MMC) or power failure will terminate any pending or active Secure Erase command. This may leave the data involved in the operation in an unknown state.

Table 13 — Erase Command Argument Definition

Bit	Arguments	Arguments
31	Secure Request	'1' - Secure form of the command must be performed. '0' - Default in Secure Erase command is performed
15	Force Garbage Collect	'1' - CMD35 & 36 are ignored. Erase is performed on previously identified write blocks. '0' - Command uses the erase groups identified by CMD35&36
0	Identify Write Blocks for Erase	'1' - Mark write block identified by CMD35&36 for erase (bit 31 set) or execute Trim operation (bit 31 cleared). '0' - Execute an erase.

7.6.10 Secure Trim

The Secure Trim command is very similar to the Secure Erase command. The Secure Trim command performs a secure purge operation on write blocks instead of erase groups.

To minimize the impact on the card's performance and reliability the Secure Trim operation is completed by executing two distinct steps.

In Secure Trim Step 1 the host defines the range of write blocks that it would like to mark for the secure purge. This step does not perform the actual purge operation. The blocks are marked by defining the start address of the range using the ERASE_GROUP_START (CMD35) command, followed by defining the last address of the range using the ERASE_GROUP_END (CMD36) command. In the case of Secure Trim, both ERASE_GROUP_START and ERASE_GROUP_END arguments are identifying write block addresses. Once the range of blocks has been identified the ERASE (CMD 38) with argument bit 31and 0 set to 1 and the remainder of the argument bits set to 0 (See Table 11 on page 59 for the allowable arguments) is applied. This completes Secure Trim Step 1.

Secure Trim Step 1 can be repeated several times, with other commands being allowed in between, until all the write blocks that need to be purged have been identified. It is recommended that the Secure Trim Step 1 is done on as many blocks as possible to improve its efficiency of the secure trim operation.

Secure Trim Step 2 issues the ERASE_GROUP_START (CMD35) and ERASE_GROUP_END (CMD36) with addresses that are in range. Note the arguments used with these commands will be ignored. Then the ERASE (CMD 38) with bit 31 and 15 set to 1 and the remainder of the argument bits to 0 is sent. This step actually performs the secure purge on all the write blocks, as well as any copies of those blocks, that were marked during Secure Trim Step 1 and completes the secure trim operation. Other commands can be issued to the device in between Secure Trim Step 1 and Secure Trim Step 2.

The host may issue Secure Trim Step 2 without issuing Secure Trim Step 1. This may be required after a power failure event in order to complete unfinished secure trim operations. If Secure Trim Step 2 is done and there are no write blocks marked for erase then Secure Trim Step 2 again will have no impact on the device.

Once a write block is marked for erase using Secure Trim Step 1, it is recommended that the host consider this block as erased. However, if the host does write to a block after it has been marked for erase, then the last copy of the block, which occurred as a result of the modification, will not be marked for erase. All previous copies of the block will remain marked for erase.

If the host application wishes to use the secure TRIM command as the method to remove data from the device, then the host should make sure that it completes secure trim step 1 for a write block before using a write command to overwrite the block. This will ensure that the overwritten data is removed securely from the device the next time that secure Trim step 2 is issued.

If either CMD35, CMD36 or CMD38 is received out of the defined erase sequence, the card shall set the ERASE_SEQ_ERROR bit in the status register and reset the whole sequence for an individual step.

If the host provides an out of range address as an argument to CMD35 or CMD36, the card will reject the command, respond with the ADDRESS_OUT_OF_RANGE bit set and reset the whole erase sequence.

If a 'non erase' command (neither of CMD35, CMD36, CMD38 or CMD13) is received, while the card is performing the operations in Secure Trim Step 1 or Secure Trim Step 2, the card shall respond with the ERASE_RESET bit set, and reset the individual step without completing the operation and execute the last command. Commands not addressed to the selected card do not abort the sequence. Other commands may occur in between the multiple iterations of Secure Trim Step 1 and/or before Secure Trim Step 2 is sent. However, the sequence during each of the steps cannot be interrupted.

7.6.10 Secure Trim (cont'd)

If a power failure or reset occurs in between Secure Trim Step 1 and Secure Trim Step 2. The blocks that were identified for the secure purge operation will remain marked. The next time the card sees Secure Trim Step 2 it will purge the blocks that were marked prior to the power failure or reset and along with any blocks that have been identified since that point.

The host should excute the Secure Trim command with caution to avoid unintentional data loss.

Resetting a card (using CMD0, CMD15, or hardware reset for *e*•MMC) or power failure during either step 1 or step2 will terminate any pending or active secure trim command. This may leave the data involved in the operation in an unknown state.

If the erase range includes write protected blocks, they shall be left intact and only the non protected blocks shall be erased. The WP_ERASE_SKIP status bit in the status register shall be set.

If the card needs a write block that is marked for Secure Erase and Secure Trim Step 2 has not been issued. The card can issue a secure purge operation on that write block as a background task.

As described above for block write, the card will indicate that either Secure Trim Step 1 or Secure Trim Step 2 are in progress by holding DAT0 low. The actual time for the operation may be quite long, and the host may issue CMD7 to deselect the card.

If the write block size is changed in between Secure Trim Step 1 and Secure Trim Step 2 then the write block size used during step 1 of the operation will apply.

7.6.11 TRIM

The Trim operation is similar to the default erase operation described in Section 7.6.8 on page 58. The Trim function applies the erase operation to write blocks instead of erase groups. The Trim function allows the host to identify data that is no longer required so that the card can erase the data if necessary during background erase events. The contents of a write block where the trim function has been applied shall be '0' or '1' depending on different memory technology. This value is defined in the EXT_CSD.

Completing the TRIM process is a three steps sequence. First the host defines the start address of the range using the ERASE_GROUP_START (CMD35) command, next it defines the last address of the range using the ERASE_GROUP_END (CMD36) command and finally it starts the erase process by issuing the ERASE (CMD38) command with argument bit 0 set to one and the remainder of the arguments set to zero. In the case of a TRIM operation both CMD35 and CMD36 identify the addresses of write blocks rather than erase groups.

If an element of the Trim command (either CMD35, CMD36, CMD38) is received out of the defined erase sequence, the card shall set the ERASE_SEQ_ERROR bit in the status register and reset the whole sequence.

If the host provides an out of range address as an argument to CMD35 or CMD36, the card will reject the command, respond with the ADDRESS_OUT_OF_RANGE bit set and reset the whole erase sequence.

If a "non erase" command (neither of CMD35, CMD36, CMD38 or CMD13) is received, the card shall respond with the ERASE_RESET bit set, reset the erase sequence and execute the last command. Commands not addressed to the selected card do not abort the erase sequence.

If the trim range includes write protected blocks, they shall be left intact and only the non protected blocks shall be erased. The WP_ERASE_SKIP status bit in the status register shall be set.

As described above for block write, the card will indicate that a Trim command is in progress by holding DAT0 low. The actual erase time may be quite long, and the host may issue CMD7 to deselect the card.

The host should excute the Trim command with caution to avoid unintentional data loss.

Resetting a card (using CMD0, CMD15, or hardware reset for *e*•MMC) or power failure will terminate any pending or active Trim command. This may leave the data involved in the operation in an unknown state

7.6.12 Write protect management

In order to allow the host to protect data against erase or write, the MultiMediaCard shall support two levels of write protect commands:

- The entire card (including the Boot Area Partitions, General Purpose Area Partition, RPMB, and User/Enhanced User Data Area Partition) may be write-protected by setting the permanent or temporary write protect bits in the CSD. When permanent protection is applied to the entire card it overrides all other protection mechanisms that are currently enabled on the entire card or in a specific segment. CSD Register bits and Extended CSD Register bits are not impacted by this protection. When temporary write protection is enabled for the entire card it only applies to those segments that are not already protected by another mechanism. See Table 14 on page 64 for details.
- Specific segments of the cards may be permanent, power-on or temporarily write protected. ERASE_GROUP_DEF in EXT_CSD decides the segment size. When set to 0, the segment size is defined in units of WP_GRP_SIZE erase groups as specified in the CSD. When set to 1, the segment size is defined in units of HC_WP_GRP_SIZE erase groups as specified in the EXT_CSD. If host does not set ERASE_GROUP_DEF bit for a device of which high capacity write protect was already set in some of the area in the previous power cycle, then the device may show unknown behavior when host issue write or erase commands to the device, because the write protect group size previously set mismatches the current write protect group size. Similarly if host set ERASE_GROUP_DEF bit for a device of which default write protect was already set in some of the area in the previous power cycle, then the device may show unknown behavior when host issue write or erase commands to the device. In application, it is mandatory for host to use same ERASE GROUP DEF value to the device all the time.
- The SET_WRITE_PROT command sets the write protection of the addressed write-protect group, group to the type of write protection dictated by the US_PERM_WP_EN (EXT_CSD[171] bit 2) and US_PWR_WP_EN (EXT_CSD[171] bit 0). See Table 14 on page 64 for the result of the SET_WRITE_PROT(CMD28) command when protection is already enabled in a segment and Table 15 on page 64 for impact of the different combinations of the protection enable bits. The CLR_WRITE_PROT command clears the temporary write protection of the addressed write-protect group. If the CLR_WRITE_PROT command is applied to a write protection group that has either permanent or power-on write protection then the command will fail.

The ability for the host to set permanent protection for the entire card and permanent and power-on protection for specific segments can be disabled by setting the CD_PERM_WP_DIS, US_PERM_WP_DIS and US_PWR_WP_DIS bit in the EXT_CSD USER_WP byte. It is recommended to disable all protection modes that are not needed to prevent unused write protection modes from being set maliciously or unintentionally.

The host has the ability to check the write protection status of a given segment or 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.

The SEND_WRITE_PROT and SEND_WRITE_PROT_TYPE commands are similar to a single block read command. The card shall send a data block containing 32 or 64 write protection bits, respectively, (representing 32 write protect groups starting at the specified address) followed by 16 CRC bits. The address field in the write protect commands is a group address in byte units, for densities up to 2GB, and in sector units for densities greater than 2GB.

7.6.12 Write protect management (cont'd)

The card will ignore all LSBs below the group size for densities up to 2GB.

If the host provides an out of range address as an argument to CMD28, CMD29 or CMD30, the card will reject the command, respond with the ADDRESS_OUT_OF_RANGE bit set and remain in the *Tran* state.

Table 14 — Write Protection Hierarchy (when disable bits are clear)

Current Protection mode	CSD[12]	Action	Resulting Protection mode
Permanent	N/A	Power failure or hardware reset	Permanent
Permanent	N/A	SET_WRITE_PROT (US_PERM_WP_EN = 0)	Permanent
Power-On	1	Power failure or hardware reset	Temporary
Power-On	0	Power failure or hardware reset	None
Power-On	N/A	SET_WRITE_PROT (US_PERM_WP_EN = 1)	Permanent
Power-On	N/A	SET_WRITE_PROT (US_PERM_WP_EN = 0 and US_PWR_WP_EN = 0)	Power-On
Temporary	1	Power failure or hardware reset	Temporary
Temporary	1	SET_WRITE_PROT (US_PERM_WP_EN = 1)	Permanent
Temporary	1	SET_WRITE_PROT (US_PERM_WP_EN = 0 and US_PWR_WP_EN = 1)	Power-On

Table 15 — Write Protection Types (when disable bits are clear)

US_PERM_WP_EN	US_PWR_WP_EN	Type of protection set by SET_WRITE_PROT command
0	0	Temporary
0	1	Power-On
1	0	Permanent
1	1	Permanent

7.6.13 Card lock/unlock operation

The password protection feature enables the host to lock the card by providing a password, which later will be used for unlocking the card. The password and its size are kept in a 128 bit PWD and 8 bit PWD_LEN registers, respectively. These registers are non-volatile so that a power cycle will not erase them.

The password protection feature can be disabled permanently by setting the permanent password disable bit in the extended CSD (PERM_PSWD_DIS bit in the EXT_CSD byte [171]). If the host attempts to permanently disable CMD42 features on an *e*•MMC having a password set, the action will fail and the ERROR (bit 19) error bit will be set by the memory device in the card status register It is recommended to disable the password protection feature on the card, if it is not required, to prevent it being set unintentionally or maliciously.

An attempt to use password protection features (CMD42) on a card having password permanently disabled will fail and the LOCK_UNLOCK_FAILED (bit 24) error bit will be set in the status register.

7.6.13 Card lock/unlock operation (cont'd)

A locked card responds to (and executes) all commands in the "basic" command class (class 0) and "lock card" command class. Thus the host is allowed to reset, initialize, select, query for status, etc., but not to access data on the card. If the password was previously set (the value of PWD_LEN is not '0') the card will be locked automatically after power on.

On v4.3 and later version devices, the Lock command can be applied to user data area only. So the host can still access the boot partitions, RPMB and General partition area after Lock command is issued to the devices.

Similar to the existing CSD and CID register write commands the lock/unlock command is available in "transfer state" only. This means that it does not include an address argument and the card has to be selected before using it.

The card lock/unlock command (CMD42) has the structure and bus transaction type of a regular single block write command. The transferred data block includes all the required information of the command (password setting mode, PWD itself, card lock/unlock etc.). The following table describes the structure of the command data block.

The card lock/unlock command (CMD42) can only be performed when the card operates in single data rate mode. CMD42 is an illegal command in dual data rate mode.

Table 16 — Lock card data structure

Byte #	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved				ERASE	LOCK_UNLOCK	CLR_PWD	SET_PWD
1	PWD_LEN							
2	Password data							
...								
PWD_LEN + 1								

- **ERASE:** '1' Defines Forced Erase Operation (all other bits shall be '0') and only the cmd byte is sent.
- **LOCK/UNLOCK**: '1' = Locks the card. '0' = Unlock the card (note that it is valid to set this bit together with SET_PWD but it is not allowed to set it together with CLR_PWD).
- **CLR_PWD**: '1' = Clears PWD.
- **SET_PWD**: '1' = Set new password to PWD
- **PWD_LEN**: Defines the following password length (in bytes). Valid password length are 1 to 16 bytes.
- **PWD:** The password (new or currently used depending on the command).

The data block size shall be defined by the host before it sends the card lock/unlock command. This will allow different password sizes.

7.6.13 Card lock/unlock operation (cont'd)

The following paragraphs define the various lock/unlock command sequences:

- Setting the password
  - Select the card (CMD7), if not previously selected already
  - Define the block length (CMD16), given by the 8bit card lock/unlock mode, the 8 bits password size (in bytes), and the number of bytes of the new password. In case that a password *replacement* is done, then the block size shall consider that both passwords, the old and the new one, are sent with the command.
  - Send Card Lock/Unlock command (CMD42) with the appropriate data block size on the data line including 16 bit CRC. The data block shall indicate the mode (SET_PWD), the length (PWD_LEN) and the password itself. In case that a password *replacement* is done, then the length value (PWD_LEN) shall include both passwords, the old and the new one, and the PWD field shall include the old password (currently used) followed by the new password.
  - In case that a password replacement is attempted with PWD_LEN set to the length of the old password only, the LOCK_UNLOCK_FAILED error bit is set in the status register and the old password is not changed.
  - In case that the sent old password is not correct (not equal in size and content) then LOCK_UNLOCK_FAILED error bit will be set in the status register and the old password does not change. In case that PWD matches the sent old password then the given new password and its size will be saved in the PWD and PWD_LEN fields, respectively.

NOTE The password length register (PWD_LEN) indicates if a password is currently set. When it equals '0' there is no password set. If the value of PWD_LEN is not equal to zero the card will lock itself after power up. It is possible to lock the card immediately in the current power session by setting the LOCK/UNLOCK bit (while setting the password) or sending additional command for card lock.

- Reset the password:
  - Select the card (CMD7), if not previously selected already
  - Define the block length (CMD16), given by the 8 bit card lock/unlock mode, the 8 bit password size (in bytes), and the number of bytes of the currently used password.
  - Send the card lock/unlock command (CMD42) with the appropriate data block size on the data line including 16 bit CRC. The data block shall indicate the mode CLR_PWD, the length (PWD_LEN) and the password (PWD) itself (LOCK/UNLOCK bit is don't care). If the PWD and PWD_LEN content match the sent password and its size, then the content of the PWD register is cleared and PWD_LEN is set to 0. If the password is not correct then the LOCK_UNLOCK_FAILED error bit will be set in the status register.

- Locking the card:
  - Select the card (CMD7), if not previously selected already
  - Define the block length (CMD16), given by the 8 bit card lock/unlock mode, the 8 bit password size (in bytes), and the number of bytes of the currently used password.
  - Send the card lock/unlock command (CMD42) with the appropriate data block size on the data line including 16 bit CRC. The data block shall indicate the mode LOCK, the length (PWD_LEN) and the password (PWD) itself.

If the PWD content equals to the sent password then the card will be locked and the card-locked status bit will be set in the status register. If the password is not correct then LOCK_UNLOCK_FAILED error bit will be set in the status register.

NOTE It is possible to set the password and to lock the card in the same sequence. In such case the host shall perform all the required steps for setting the password (as described above) including the bit LOCK set while the new password command is sent.

7.6.13 Card lock/unlock operation (cont'd)

If the password was previously set (PWD_LEN is not '0'), then the card will be locked automatically after power on reset.

An attempt to lock a locked card or to lock a card that does not have a password will fail and the LOCK_UNLOCK_FAILED error bit will be set in the status register.

- Unlocking the card:
  - Select the card (CMD7), if not previously selected already.
  - Define the block length (CMD16), given by the 8 bit card lock/unlock mode, the 8 bit password size (in bytes), and the number of bytes of the currently used password.
  - Send the card lock/unlock command (CMD42) with the appropriate data block size on the data line including 16 bit CRC. The data block shall indicate the mode UNLOCK, the length (PWD_LEN) and the password (PWD) itself.

If the PWD content equals to the sent password then the card will be unlocked and the card-locked status bit will be cleared in the status register. If the password is not correct then the LOCK_UNLOCK_FAILED error bit will be set in the status register.

NOTE The unlocking is done only for the current power session. As long as the PWD is not cleared the card will be locked automatically on the next power up. The only way to unlock the card is by clearing the password.

An attempt to unlock an unlocked card will fail and LOCK_UNLOCK_FAILED error bit will be set in the status register.

- Forcing erase:

In case that the user forgot the password (the PWD content) it is possible to erase all the card data content along with the PWD content. This operation is called *Forced Erase*.

- Select the card (CMD7), if not previously selected already.
- Define the block length (CMD16) to 1 byte (8bit card lock/unlock command). Send the card lock/unlock command (CMD42) with the appropriate data block of one byte on the data line including 16 bit CRC. The data block shall indicate the mode ERASE (the ERASE bit shall be the only bit set).

If the ERASE bit is not the only bit in the data field then the LOCK_UNLOCK_FAILED error bit will be set in the status register and the erase request is rejected.

If the command was accepted then ALL THE CARD CONTENT WILL BE ERASED including the PWD and PWD_LEN register content and the locked card will get unlocked. In addition, if the card is temporary write protected it will be unprotected (write enabled), the temporary-write-protect bit in the CSD and all Write-Protect-Groups will be cleared.

An attempt to force erase on an unlocked card will fail and LOCK_UNLOCK_FAILED error bit will be set in the status register.

If a force erase command is issued on a permanently-write-protect media the command will fail (card stays locked) and the LOCK_UNLOCK_FAILED error bit will be set in the status register.

The Force Erase time-out is specified in Section 7.8.2 on page 82.

On v4.3 and later version devices, when host issues the Force erase, only the data stored in user data area (including enhanced attribute area) will be erased. The Force erase will not applied to Boot, RPMB and General partition area.

7.6.14 Application-specific commands

The MultiMediaCard system is designed to provide a standard interface for a variety applications types. In this environment, it is anticipated that there will be a need for specific customers/applications features. To enable a common way of implementing these features, two types of generic commands are defined in the standard:

- Application-specific command—APP_CMD (CMD55)

This command, when received by the card, will cause the card to interpret the following command as an application specific command, ACMD. The ACMD has the same structure as of regular MultiMediaCard standard commands and it may have the same CMD number. The card will recognize it as ACMD by the fact that it appears after APP_CMD.

The only effect of the APP_CMD is that if the command index of the, immediately, following command has an ACMD overloading, the non standard version will used. If, as an example, a card has a definition for ACMD13 but not for ACMD7 then, if received immediately after APP_CMD command, Command 13 will be interpreted as the non standard ACMD13 but, command 7 as the standard CMD7.

In order to use one of the manufacturer specific ACMD's the host will:

- Send APP_CMD. The response will have the APP_CMD bit (new status bit) set signaling to the host that ACMD is now expected.
- Send the required ACMD. The response will have the APP_CMD bit set, indicating that the accepted command was interpreted as ACMD. If a non-ACMD is sent then it will be respected by the card as normal MultiMediaCard command and the APP_CMD bit in the Card Status stays clear.

If a non valid command is sent (neither ACMD nor CMD) then it will be handled as a standard MultiMediaCard illegal command error.

From the MultiMediaCard protocol point of view the ACMD numbers will be defined by the manufacturers without any restrictions.

- General command—GEN_CMD (CMD56)

The bus transaction of the GEN_CMD is the same as the single block read or write commands (CMD24 or CMD17). The difference is that the argument denotes the direction of the data transfer (rather than the address) and the data block is not a memory payload data but has a vendor specific format and meaning.

The card shall be selected ('*tran_state'*) before sending CMD56. If the card operates in the single data rate mode, the data block size is the BLOCK_LEN that was defined with CMD16. If the card operates in the dual data rate mode, the data block size is 512 bytes. The response to CMD56 will be R1.

7.6.15 Sleep (CMD5)

A card may be switched between a Sleep state and a Standby state by SLEEP/AWAKE (CMD5). In the Sleep state the power consumption of the memory device is minimized. In this state the memory device reacts only to the commands RESET (CMD0 with argument of either 0x00000000 or 0xF0F0F0F0 or H/W reset) and SLEEP/AWAKE (CMD5). All the other commands are ignored by the memory device. The timeout for state transitions between Standby state and Sleep state is defined in the EXT_CSD register S_A_timeout. The maximum current consumptions during the Sleep state are defined in the EXT_CSD registers S_A_VCC and S_A_VCCQ.

Sleep command: The bit 15 as set to 1 in SLEEP/AWAKE (CMD5) argument.

Awake command: The bit 15 as set to 0 in SLEEP/AWAKE (CMD5) argument.

The Sleep command is used to initiate the state transition from Standby state to Sleep state. The memory device indicates the transition phase busy by pulling down the DAT0 line. No further commands should be sent during the busy. The Sleep state is reached when the memory device stops pulling down the DAT0 line.

The Awake command is used to initiate the transition from Sleep state to Standby state. The memory device indicates the transition phase busy by pulling down the DAT0 line. No further commands should be sent during the busy. The Standby state is reached when the memory device stops pulling down the DAT0 line.

During the Sleep state the Vcc power supply may be switched off. This is to enable even further system power consumption saving. The Vcc supply is allowed to be switched off only after the Sleep state has been reached (the memory device has stopped to pull down the DAT0 line). The Vcc supply have to be ramped back up at least to the min operating voltage level before the state transition from Sleep state to Standby state is allowed to be initiated (Awake command).

A locked card may be placed into Sleep state by first deselecting the card through CMD7, which is a Class 0 command that can be executed in the locked state, and then issuing the Sleep command. This would allow the card to save power consumption while it is locked. The locked card can subsequently exit sleep and be placed into Standby state through the Awake command.

The reverse sequence, locking the device after it has already entered sleep, is not allowed.

7.6.16 Replay Protected Memory Block

A signed access to a Replay Protected Memory Block is provided. This function provides means for the system to store data to the specific memory area in an authenticated and replay protected manner. This is provided by first programming authentication key information to the *e*•MMC memory (shared secret).

As the system can not be authenticated yet in this phase the authentication key programming have to take in a secure environment like in an OEM production. Further on the authentication key is utilized to sign the read and write accesses made to the replay protected memory area with a Message Authentication Code (MAC).

Usage of random number generation and count register are providing additional protection against replay of messages where messages could be recorded and played back later by an attacker

7.6.16.1 The Data Frame for Replay Protected Memory Block Access

The data frame to access the replay protected memory area is including following fields of data. :

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		

Byte order of the RPMB data frame is MSB first, e.g. Write Counter MSB [11] is storing the upmost byte of the counter value.

- **Name: Request/Response Type**
  •Length: 2B

•Direction: Request (to the memory), Response (from the memory)

•Description: defines the type of request and response to/from the memory. The table is listing the defined requests and responses. The response type is corresponding to the previous Replay Protected Memory Block read/write request.

Table 17 — RPMB Request/Response Message Types

Request Message Types	
0x0001	Authentication key programming request
0x0002	Reading of the Write Counter value -request
0x0003	Authenticated data write request
0x0004	Authenticated data read request
0x0005*	Result read request
Response Message Types	
0x0100	Authentication key programming response
0x0200	Reading of the Write Counter value -response
0x0300	Authenticated data write response
0x0400	Authenticated data read response

*Note that there is no corresponding response type for the Result read request because the reading of the result with this request is always relative to previous programming access.

- **Name: Authentication Key / Message Authentication Code (MAC)**

  •Length: 32Bytes (256bits)

  •Direction: Request (key or MAC) / Response (MAC)

  •Description: the authentication key or the message authentication code (MAC) depending on the request/response type. The MAC will be delivered in the last (or the only) block of data.

- **Name: Operation Result**

  •Length: 2B

  •Direction: Response

  •Description: includes information about the status of the write counter (valid, expired) and successfulness of the access made to the Replay Protected Memory Block. The table is listing the defined results and possible reasons for failures.

Table 18 — RPMB Operation Results data structure

Bit[7]	**Bit[6:0]**
Write Counter Status	Operation Result

Table 19 — RPMB Operation Results

Operation Results	
0x00 (0x80)*	Operation OK

Table 19 — RPMB Operation Results

0x01 (0x81)	General failure
0x02 (0x82)	Authentication failure (MAC comparison not matching, MAC calculation failure)
0x03 (0x83)	Counter failure (counters not matching in comparison, counter incrementing failure)
0x04 (0x84)	Address failure (address out of range, wrong address alignment)
0x05 (0x85)	Write failure (data/counter/result write failure)
0x06 (0x86)	Read failure (data/counter/result read failure)
0x07**	Authentication Key not yet programmed

* The values in parenthesis are valid in case the Write Counter has expired i.e. reached its max value

** This value is the only valid Result value until the Authentication Key has been programmed (after which it can never occur again)

- **Name: Write Counter**
  - •Length: 4Bytes
  - •Direction: Request and Response.
  - •Description: Counter value for the total amount of the successful authenticated data write requests made by the host.

- **Name: Data Address**
  - •Length: 2B
  - •Direction: Request and Response.
  - •Description: Address of the data to be programmed to or read from the Replay Protected Memory Block. Address is the serial number of the accessed half sector (256B). Address argument in CMD 18 and CMD 25 will be ignored.
- **Name: Nonce**
  - •Length: 16B
  - •Direction: Request and Response.
  - •Description: Random number generated by the host for the Requests and copied to the Response by the *e*•MMC Replay Protected Memory Block engine.

- **Name: Data**
  - •Length: 256B
  - •Direction: Request and Response.
  - •Description: Data to be written or read by signed access.

- **Name: Block Count**
  - •Length: 2B
  - •Direction: Request.
  - •Description: Number of blocks (half sectors, 256B) requested to be read/programmed. This value is equal to the count value in CMD23 argument.

7.6.16.2 Memory Map of the Replay Protected Memory Block

The Replay Protected Memory Block is including following registers and memory partition:

- **Name: Authentication Key**
  - •Size: 32B
  - •Type: Write once
  - •Description: One time programmable authentication key register. This register can not be overwritten, erased or read. The key is used by the *e*•MMC Replay Protected Memory Block engine to authenticate the accesses when MAC is calculated.

- **Name: Write Counter**
  - •Size: 4B
  - •Type: Read only
  - •Description: Counter value for the total amount of successful authenticated data write requests made by the host. Initial value after *e*•MMC production is 0x0000 0000. Value will be incremented by one automatically by the *e*•MMC Replay Protected Memory Block engine along with successful programming accesses. The value can not be reset. After the counter has reached its maximum value 0xFFFF FFFF it will not be incremented anymore (overflow prevention) and the bit [7] in Operation Result value will be permanently set.

- **Name: Data**
  - •Size: 128kB min (RPMB_SIZE_MULT x 128kB)
  - •Type: Read/Write
  - •Description: Data which can only be read and written via successfully authenticated read/write access. This data may be overwritten by the host but can never be erased.

7.6.16.3 Message Authentication Code Calculation

The message authentication code (MAC) is calculated using HMAC SHA-256 as defined in [HMAC-SHA]. The HMAC SHA-256 calculation takes as input a key and a message. The resulting MAC is 256 bits (32Byte), which are embedded in the data frame as part of the request or response.

The key used for the MAC calculation is always the 256 bit Authentication Key stored in the *e*•MMC. The message used as input to the MAC calacuation is the concatenation of the fields in the data frames excluding stuff bytes, the MAC itself, start bit, CRC16, and end bit. That is, the MAC is calculated over bytes [283:0] of the data frame in that order.

If several data frames are sent as part of one request or response then the input message to MAC is the concatenation of bytes [283:0] of each data frame in the order in which the data frames are sent. The MAC is added only to the last data frame.

Example: Assume that the write counter is 0x12345678. The host wants to write at address 0x0010 two sectors of where the first sector is 256 bytes of 0xAA and the second sector is 256 bytes of 0xBB. The host

must then send to following two requests frames:Where the MAC in the second request frame is an HMAC

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
Request frame 1											
	0x0000...	0x0000...	0xAA...	0x0000...	0x12345678	0x0010	0x0002	0x0000	0x0003		
Request frame 2											
	0x0000...	MAC	0xBB...	0x0000...	0x12345678	0x0010	0x0002	0x0000	0x0003		

SHA-256 calculated over the following message:

0xAA... (total 256 times) ... 0xAA
0x0000 0x0000 0x0000 0x0000 0x0000 0x0000 0x0000 0x0000

0x1234 0x5678 0x0010 0x0002 0x0000 0x0003
0xBB... (total 256 times) ... 0xBB

0x0000 0x0000 0x0000 0x0000 0x0000 0x0000 0x0000 0x0000

0x1234 0x5678 0x0010 0x0002 0x0000 0x0003

The key used for the HMAC SHA-256 calculation is the authentication key stored in the *e*•MMC.

Reference:

[HMAC-SHA] Eastlake, D. and T. Hansen, "US Secure Hash Algorithms (SHA and HMAC-SHA)", RFC 4634, July 2006.

7.6.16.4 Accesses to the Replay Protected Memory Block

After putting a slave into transfer state, master sends CMD6 (SWITCH) to set the PARTITION_ACCESS bits in the EXT_CSD register, byte [179]. After that, master can use the Multiple Block read and Multiple Block Write commands (CMD23, CMD18 and CMD25) to access the Replay Protected Memory Block partition. The defined accesses are listed in following sections.

Any undefined set of parameters or sequence of commands, or High Priority Interrupt during Authenticated Write will result failured access.

- In Data Programming case the data shall not be programmed
- In Data Read case the data read shall be “0x00” (in multiple block case in all frames)”

A General Failure (0x01) will be indicated in the Results register (in multiple block case in all frames). If there are more than one failures related to an access then the first type of error shall be indicated in the Results register.”The order of the error checking is defined under each access below.

After finishing data access to the Replay Protected Memory Block partition, the PARTITION_ACCESS bits should be cleared.

- **Programming of the Authentication Key:**

The Authentication Key is programmed with the Write Multiple Block command, CMD25. In prior to the command CMD25 the block count is set to 1 by CMD23, with argument bit [31] set as 1 to indicate Reliable Write type of programming. If block count has not been set to 1 and/or argument bit [31] has not been set to 1 then the subsequent Write Multiple Block command must fail and General Failure shall be indicated.

The key information itself is delivered in data packet. The packet is size of 512B and it is including the request type information and the Authentication Key. The request type value 0x0001 indicates programming of the Authentication Key.

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...		0x00	0x00	0x00	0x00	0x00	0x00	0x0001		1b

The busy signaling in the Dat0 line after the CRC status by the *e*•MMC is indicating programming busy of the key. The status can also be polled with CMD13. The status response received in R1 is indicating the generic status condition, excluding the status of successful programming of the key.

The successfulness of the programming of the key should be checked by reading the result register of the Replay Protected Memory Block. The result read sequence is initiated by Write Multiple Block command, CMD25. In prior to the command CMD25 the block count is set to 1 by CMD23. If block count has not been set to 1 then the subsequent Write Multiple Block command must fail and General Failure shall be indicated.

The request type information is delivered in data packet. The packet is size of 512B and is including the request type information. The request type value 0x0005 indicates Result register read request initiation.

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x0005		1b

The busy signaling in the Dat0 line after the CRC status by the *e*•MMC is indicating request busy. The result itself is read out with the Read Multiple Block command, CMD18. In prior to the read command the block count is set to 1 by CMD23. If block count has not been set to 1 then the Read Multiple Block command must fail and General Failure shall be indicated.

The result information itself is delivered in the read data packet. The packet size is 512B and is including the response type information and result of the key programming operation. The response type value

0x0100 corresponds to the key programming request.

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...	0x00	0x00	0x00	0x00	0x00	0x00		0x0100		1b

Access to Reply Protected Memory Block is not allowed/possible before Authentication Key is programmed. The state of the device can be checked by trying to write/read data to/from the Replay Protected Memory Block and then reading the result register. If the Authentication Key is not yet programmed then message 0x07 (Authentication Key not yet programmed) is returned in result field.

If programming of Authentication Key fails then returned result is 0x05 (Write failure).

If some other error occurs during Authentication Key programming then returned result is 0x01 (Generalfailure).

- **Reading of the Counter Value**

The counter read sequence is initiated by Write Multiple Block command, CMD25. In prior to the command CMD25 the block count is set to 1 by CMD23. If block count has not been set to 1 then the subsequent Write Multiple Block command must fail and General Failure shall be indicated.

The request type information is delivered in data packet. The packet is size of 512B and it is including the request type information and the nonce. The request type value 0x0002 indicates counter value read request initiation.

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...	0x00	0x00		0x00	0x00	0x00	0x00	0x0002		1b

The busy signaling in the Dat0 line after the CRC status by the *e*•MMC is indicating request busy.

The counter value itself is read out with the Read Multiple Block command, CMD18. In prior to the command CMD18 the block count is set to 1 by CMD23. If block count has not been set to 1 then the Read Multiple Block command must fail and General Failure shall be indicated.

The counter value itself is delivered in the read data packet. The packet size is 512B and it is including the response type information, a copy of the nonce received in the request, the write counter value, the MAC

and the Result.

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...		0x00			0x00	0x00		0x0200		1b

If reading of the counter value fails then returned result is 0x06 (Read failure).

If some other error occurs then Result is 0x01 (General failure).

If counter has expired also bit 7 is set to 1 in returned results (Result values 0x80,0x86 and 0x81, respectively).

- **Authenticated Data Write**

Data to the Replay Protected Memory Block is programmed with the Write Multiple Block command, CMD25. In prior to the command CMD25 the block count is set by CMD23, with argument bit [31] set as 1 to indicate Reliable Write type of programming access. The block count is the number of the half sectors (256B) to be programmed. Note that the size of the access can not exceed the size of the reliable Write access (REL_WR_SEC_C x 512B).

- 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_Cx512B supported to RPMB partition with 256B granularity”

If block count has not been set and/or argument bit[31] has not been set to 1and/or the size exceeds the max size of Reliable Write access then the subsequent Write Multiple Block command must fail and General Failure shall be indicated.

Data itself is delivered in data packet. The packet is size of 512B and it is including the request type information, the block count, the counter value, the start address of the data, the data itself and the MAC. In multiple block write case the MAC is included only to the last packet n, the n-1 packets will include value 0x00. In every packet the address is the start address of the full access (not address of the individual half a sector) and the block count is the total count of the half sectors (not the sequence number of the half a sector).The request type value 0x0003 indicates programming of the data.

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...			0x00				0x00	0x0003		1b

The busy signaling in the Dat0 line after the CRC status by the *e*•MMC is indicating buffer busy between the sent blocks (in multiple block write case) and programming busy of the key after the last block (or in single block case). The status can also be polled with CMD13. The status response received in R1 is indicating the generic access status condition (e.g. state transitions), excluding the status of successfulness of programming of the data.

When the *e*•MMC receives this message it first checks whether the write counter has expired. If the write counter is expired then *e*•MMC sets the result to 0x85 (write failure, write counter expired). No data is written to the *e*•MMC

Next the address is checked. If there is an error in the address (out of range) then the result is set to 0x04 (address failure). No data are written to the *e*•MMC.

If the write counter was not expired then the *e*•MMC calculates the MAC of request type, block count, write counter, address and data, and compares this with the MAC in the request. If the two MAC's are different then *e*•MMC sets the result to 0x02 (authentication failure). No data are written to the *e*•MMC.

If the MAC in the request and the calculated MAC are equal then the *e*•MMC compares the write counter in the request with the write counter stored in the *e*•MMC. If the two counters are different then *e*•MMC sets the result to 0x03 (counter failure). No data are written to the *e*•MMC.

If the MAC and write counter comparisons are successfull then the write request is considered to be authenticated. The data from the request are written to the address indicated in the request and the write counter is incremented by 1.

If write fails then returned result is 0x05 (write failure).

If some other error occurs during the write procedure then returned result is 0x01 (General failure).

The successfulness of the programming of the data should be checked by the host by reading the result register of the Replay Protected Memory Block. The result read sequence is initiated by Write Multiple Block command, CMD 25. In prior to the command CMD25 the block count is set to 1 by CMD23. If block count has not been set to 1 then the subsequent Write Multiple Block command must fail and General Failure shall be indicated.

The request type information is delivered in data packet. The packet is size of 512B and is including the request type information. The request type value 0x0005 indicates result register read request initiation.

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x0005		1b

The busy signaling in the Dat0 line after the CRC status by the *e*•MMC is indicating request busy.

The result itself is read out with the Read Multiple Block command, CMD18. In prior to the read command the block count is set to 1 by CMD23. If block count has not been set to 1 then the Read Multiple Block command must fail and General Failure shall be indicated.

The result information itself is delivered in the read data packet. The packet size is 512B and is including the response type information, the incremented counter value, the data address, the MAC and result of the

data programming operation.

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...		0x00	0x00			0x00		0x0300		1b

- **Authenticated Data Read**

Data read sequence is initiated by Write Multiple Block command, CMD25. In prior to the command CMD25 the block count is set to 1 by CMD23. If block count has not been set to 1 then the subsequent Write Multiple Block command must fail and General Failure shall be indicated.

The request type information is delivered in the data packet. The packet is size of 512B and it is including the request type information, the nonce and the data address. The request type value 0x0004 indicates data read request initiation.

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...	0x00	0x00		0x00		0x00	0x00	0x0004		1b

The busy signaling in the Dat0 line after the CRC status by the *e*•MMC is indicating request busy.

When the *e*•MMC receives this request it first checks the address. If there is an error in the address then result is set to 0x04 (address failure). The data read is not valid.

After successful data fetch the MAC is calculated from response type, nonce, address, data and result .

If the MAC calculation fails then returned result is 0x02 (Authentication failure).

The data itself is read out with the Read Multiple Block command, CMD18. In prior to the read command the block count is set by CMD23. The block count is the number of the half sectors (256B) to be read. If block count has not been set then the Read Multiple Block command must fail and General Failure shall be indicated.

The data information itself is delivered in the read data packet. The packet size is 512B and it is including the response type information, the block count, a copy of the nonce received in the request, the data address, the data itself, the MAC and the result. In multiple block read case the MAC is included only to the last packet n, the n-1 packets will include value 0x00. In every packet the address is the start address of the full access (not address of the individual half a sector) and the block count is the total count of the half sectors (not the sequence number of the half a sector).

Start	Stuff Bytes	Key/ (MAC)	Data	Nonce	Write Counter	Address	Block Count	Result	Req/ Resp	CRC16	End
1bit	196Byte	32Byte (256b)	256Byte	16Byte	4Byte	2Byte	2Byte	2Byte	2Byte	2Byte	1bit
	[511:316]	[315:284]	[283:28]	[27:12]	[11:8]	[7:6]	[5:4]	[3:2]	[1:0]		
0b	0x0000...				0x00				0x0400		1b

If data fetch from addressed location inside *e*•MMC fails then returned result is 0x06 (Read failure).

If some other error occurs during the read procedure then returned result is 0x01 (General failure).

7.6.17 Dual Data Rate mode selection

After the host verifies that the card complies with version 4.4, or higher, of this standard, and supports dual data rate mode, it may enable the dual data rate data transfer mode in the card.

After power-on, hardware reset, or software reset, the operating mode of the card is single data rate, except when the card begins by performing boot operation, in which case the selection between single or dual data rate mode is determined by EXT_CSD register byte [177] (BOOT_BUS_WIDTH) settings specified in Table 92 on page 143. For the host to change to dual data rate mode, HS_TIMING must be set to 0x1 (Section 7.6.2 on page 50) and the card shall supports this mode as defined in EXT_CSD register [196] (CARD_TYPE) specified in Table 84 on page 139.

The host uses the SWITCH command to write 0x05 (4-bit data width) or 0x06 (8-bit data width) to the BUS_WIDTH byte, in the Modes segment of the EXT_CSD register byte [183]. The valid values for this register are defined in "BUS_WIDTH" on page 141. If the host tries to write an invalid value, the BUS_WIDTH byte is not changed, the dual data rate mode is not enabled, and the SWITCH_ERROR bit is set.

Conversely, a card in the dual data mode may be switched back to single data rate mode by writing new values in the BUS_WIDTH byte.

7.6.18 Dual Data Rate mode operation

After the card has been enabled for dual data rate operating mode, the block length parameter of CMD17, CMD18, CMD24, CMD25 and CMD56 automatically default to 512 bytes and cannot be changed by CMD16 (SET_BLOCKLEN) command which becomes illegal in this mode.

Therefore, all single or multiple block data transfer read or write will operates on a fixed block size of 512 bytes while the card remains in dual data rate mode.

CMD 30 and CMD 31 are used in dual data rate mode with their native data size.

Additionally to CMD16, CMD42 (LOCK_UNLOCK), CMD14 (BUSTEST_R), CMD19 (BUSTEST_W), CMD11 (READ_DAT_UNTIL_STOP) and CMD 20 (WRITE_DAT_UNTIL_STOP) are considered illegal in the dual data rate mode. If any of these commands are required, the card shall be switched to operate in single data rate mode before using these.

7.6.19 Background Operations

Devices have various maintenance operations need to perform internally. In order to reduce latencies during time critical operations like read and write, it is better to execute maintenance operations in other times - when the host is not being serviced. Operations are then separated into two types:

- Foreground operations – operations that the host needs serviced such as read or write commands;
- Background operations – operations that the device executes while not servicing the host;

In order for the device to know when the host does not need it and it can execute background operations, host shall write any value to BKOPS_START (EXT_CSD byte [164]) to manually start background operations. Device will stay busy till no more background processing is needed.

Since foreground operations are of higher priority than background operations, host may interrupt on-going background operations using the High Priority Interrupt mechanism (see Section 7.6.20).

In order for the device to know if host is going to periodically start background operations, host shall set bit 0 of BKOPS_EN (EXT_CSD byte [163]) to indicate that it is going to write to BKOPS_START periodically. The device may then delay some of its maintenance operations to when host writes to BKOPS_START.

The device reports its background operation status in bits [1:0] of BKOPS_STATUS (EXT_CSD byte [246]), which can be in one of four possible levels:

0x0: No operations required

0x1: Operations outstanding – non critical

0x2: Operations outstanding – performance being impacted

0x3: Operations outstanding – critical

Host shall check the status periodically and start background operations as needed, so that the device has enough time for its maintenance operations, to help reduce the latencies during foreground operations.

If the status is at level 3 ("critical"), some operations may extend beyond their original timeouts due to maintenance operations which cannot be delayed anymore. The host should give the device enough time for background operations to avoid getting to this level in the first place.

To allow hosts to quickly detect the higher levels, the URGENT_BKOPS bit in the Card Status is set whenever the levels is either 2 or 3. This allows hosts to detect urgent levels on every R1 type response. Hosts shall still read the full status from the BKOPS_STATUS byte periodically and start background operations as needed.

The background operations feature is optional. If it is supported, bit 0 of BKOPS_SUPPORT (EXT_CSD byte [502]) shall be set.

7.6.20 High Priority Interrupt (HPI)

In some scenarios, different types of data on the device may have different priorities for the host. For example, writing operation may be time consuming and therefore there might be a need to suppress the writing to allow demand paging requests in order to launch a process when requested by the user.

The high priority interrupt (HPI) mechanism enables servicing high priority requests, by allowing the device to interrupt a lower priority operation before it is actually completed, within OUT_OF_INTERRUPT_BUSY_TIME timeout. Host may need to repeat the interrupted operation or part of it to complete the original request.

The HPI command may have one of two implementations in the device:

- CMD12 – based on STOP_TRANSMISSION command when the HPI bit in its argument is set.
- CMD13 – based on SEND_STATUS command when the HPI bit in its argument is set.

Host shall check the read-only HPI_IMPLEMENTATION bit in HPI_FEATURES (EXT_CSD byte [503]) and use the appropriate command index accordingly.

If CMD12 is used with HPI bit set, it differs from the non-HPI command in the allowed state transitions. See card state transition table (Table 31 on page 92) for the specific transitions for both cases.

HPI shall only be executed during prg-state. Then, it indicates the device that a higher priority command is pending and therefore it should interrupt the current operation and return to tran-state as soon as possible, with a different timeout value.

If HPI is received in states other than prg-state, the device behavior is defined by the card state transition table (Table 31 on page 92). If the state transition is allowed, response is sent but the HPI bit is ignored. If the state transition is not allowed, the command is regarded as an illegal command.

HPI command is accepted as a legal command in prg-state. However, only some commands may be interrupted by HPI. If HPI is received during commands which are not interruptible, a response is sent but the HPI command has no effect and the original command is completed normally, possibly exceeding the OUT_OF_INTERRUPT_TIME timeout. Table 20 shows which commands are interruptible and which are not.

Following a WRITE_MULTIPLE_BLOCK command (CMD25), the device updates the

Table 20 — Interruptible commands

CMD Index	Name	Is interruptible?	Restrictions
CMD24	WRITE_BLOCK	Yes	
CMD25	WRITE_MULTIPLE_BLOCK	Yes	
CMD38	ERASE	Yes	
CMD6	SWITCH	Yes	Only interruptible when writing to the BKOPS_START field in EXT_CSD
All others		No	

CORRECTLY_PRG_SECTORS_NUM field (EXT_CSD bytes [245:242]) with the number of 512B sectors successfully written to the device. Host may use this information when repeating an interrupted write command – it does not need to re-write again all data sectors, it may skip the correctly programmed sectors and continue writing only the rest of the data that wasn't yet programmed.

If HPI is received during a reliable-write command and EN_REL_WR=0, the reliable-write command is either completed (all new data is written) or canceled (no new data is written). Note that if HPI is supported, REL_WR_SEC_C is always 1.

If HPI is received during a reliable-write command and EN_REL_WR=1, the first CORRECTLY_PRG_SECTORS_NUM sectors shall contain the new data and all the rest of the sectors shall contain the old data.

The HPI mechanism shall be enabled before it may be used, by setting the HPI_EN bit in the HPI_MGMT field (EXT_CSD byte [161]).

The HPI feature is optional. If it is supported, HPI_SUPPORT bit in HPI_FEATURES field (EXT_CSD byte [503]) shall be set.

7.7 Clock control

The MultiMediaCard bus clock signal can be used by the host to put the card into energy saving mode, or to control the data flow (to avoid under-run or over-run conditions) on the bus. The host is allowed to lower the clock frequency or shut it down.

There are a few restrictions the host must follow:

- The bus frequency can be changed at any time (under the restrictions of maximum data transfer frequency, defined by the card, and the identification frequency defined by the standard document).

- It is an obvious requirement that the clock must be running for the card to output data or response tokens. After the last MultiMediaCard bus transaction, the host is required, to provide 8 (eight) clock cycles for the card to complete the operation before shutting down the clock. Following is a list of the various bus transactions:
- A command with no response. 8 clocks after the host command end bit.
- A command with response. 8 clocks after the card response end bit.
- A read data transaction. 8 clocks after the end bit of the last data block.
- A write data transaction. 8 clocks after the CRC status token.
- The host is allowed to shut down the clock of a “busy” card. The card will complete the programming operation regardless of the host clock. However, the host must provide a clock edge for the card to turn off its busy signal. Without a clock edge the card (unless previously disconnected by a deselect command -CMD7) will force the DAT0 line down, forever.

7.8 Error conditions

7.8.1 CRC and illegal command

All commands are protected by CRC (cyclic redundancy check) bits. If the addressed card’s CRC check fails, the card does not respond, and the command is not executed; the card does not change its state, and COM_CRC_ERROR bit is set in the status register.

Similarly, if an illegal command has been received, the card shall not change its state, shall not respond and shall set the ILLEGAL_COMMAND error bit in the status register. Only the non-erroneous state branches are shown in the state diagrams. (See Figure 26 to Figure 28). Table 31 on page 92 contains a complete state transition description.

There are different kinds of illegal commands:

- Commands which belong to classes not supported by the card (e.g. write commands in read only cards).
- Commands not allowed in the current state (e.g. CMD2 in Transfer State).
- Commands which are not defined (e.g. CMD44).

7.8.2 Time-out conditions

The times after which a time-out condition for read/write/erase operations occurs are (card independent) 10 times longer than the typical access/program times for these operations given below. A card shall complete the command within this time period, or give up and return an error message. If the host does not get a response within the defined time-out it should assume the card is not going to respond anymore and try to recover (e.g. reset the card, power cycle, reject, etc.). The typical access and program times are defined as follows:

- Read

The read access time is defined as the sum of the two times given by the CSD parameters TAAC and NSAC (see Section 7.15 on page 101). These card parameters define the typical delay between the end bit of the read command and the start bit of the data block. This number is card dependent and should be used by the host to calculate throughput and the maximal frequency for stream read.

- Write

The R2W_FACTOR field in the CSD is used to calculate the typical block program time obtained by multiplying the read access time by this factor. It applies to all write/erase commands (e.g. SET(CLEAR)_WRITE_PROTECT, PROGRAM_CSD(CID) and the block write commands). It should be used by the host to calculate throughput and the maximal frequency for stream write.

- Erase / Secure Erase

The duration of an erase command will be (order of magnitude) the number of Erase blocks to be erased multiplied by the block write delay. If ERASE_GROUP_DEF (EXT_CSD byte [175]) is enabled, ERASE_TIMEOUT_MULT should be used to calculate the duration.
Secure Erase timeout is calculated based on the Erase Timeout and additional SEC_ERASE_MULT factor (EXT_CSD byte [230]).

- TRIM / Secure TRIM

The TRIM function timeout is calculated based on the TRIM_MULT factor (EXT_CSD byte [232]).

Secure TRIM timeout is calculated based on the Erase Timeout and additional SEC_TRIM_MULT factor (EXT_CSD byte [229]).

- Force erase

The duration of the Force Erase command using CMD42 is specified to be a fixed time-out of 3 minutes.

- High-Priority Interrupt (HPI)

OUT_OF_INTERRUPT_TIME (EXD_CSD byte[198]) defines the maximum time between the end bit of CMD12/13, arg[0]=1 to the DAT0 release by the device.

- Partition Switch

PARTITION_SWITCH_TIME (EXD_CSD byte[199]) defines the maximum time between the end bit of the SWITCH command (CMD6) to the DAT0 release by the device, when switching partitions by changing PARTITION_ACCESS bits in PARTITION_CONFIG field (EXT_CSD byte [179]).

7.8.3 Read ahead in stream and multiple block read operation

In stream, or multiple block, read operations, in order to avoid data under-run condition or improve read performance, the card may fetch data from the memory array, ahead of the host. In this case, when the host is reading the last addresses of the memory, the card attempts to fetch data beyond the last physical memory address and generates an ADDRESS_OUT_OF_RANGE error.

Therefore, even if the host times the stop transmission command to stop the card immediately after the last byte of data was read, The card may already have generated the error, and it will show in the response to the stop transmission command. The host should ignore this error.

7.9 Minimum performance

A MMCplus and MMCmobile card has to fullfill the requirements set for the read and write access performance.

7.9.1 Speed class definition

The speed class definition is for indication of the minimum performance of a card. The classes are defined based on respectively the 150kB/s base value for single data rate operation (normal mode) and 300kB/s base value for dual data rate operation. The minimum performance of the card can then be marked by defined multiples of the base value e.g. 2.4MB/s (SDR) or 4.8MB/s (DDR). Only following speed classes are defined (note that MMCplus and MMCmobile cards are always including 8bit data bus and the categories below states the configuration with which the card is operated):

Low bus category classes (26MHz clock with 4bit data bus operation)

- 2.4 MB/s (sdr) or 4.8MB/s (ddr) Class A
- 3.0 MB/s (sdr) or 6.0MB/s (ddr) Class B
- 4.5 MB/s (sdr) or 9.0MB/s (ddr) Class C
- 6.0 MB/s (sdr) or 12.0MB/s (ddr) Class D
- 9.0 MB/s (sdr) or 18.0MB/s (ddr) Class E

Mid bus category classes (26MHz clock with 8bit data bus or 52MHz clock with 4bit data bus operation):

- 12.0 MB/s (sdr) or 24.0MB/s (ddr) Class F
- 15.0 MB/s (sdr) or 30.0MB/s (ddr) Class G
- 18.0 MB/s (sdr) or 36.0MB/s (ddr) Class H
- 21.0MB/s (sdr) or 42.0MB/s (ddr) Class J

High bus category classes (52MHz clock with 8bit data bus operation):

- 24.0MB/s (sdr) or 48.0MB/s (ddr) Class K
- 30.0MB/s (sdr) or 60.0MB/s (ddr) Class M
- 36.0MB/s (sdr) or 72.0MB/s (ddr) Class O
- 42.0MB/s (sdr) or 84.0MB/s (ddr) Class R
- 48.0MB/s (sdr) or 96.0MB/s (ddr) Class T

The performance values for both write and read accesses are stored into the EXT_CSD register for electrical reading (see Section 8.4 on page 125). Only the defined values and classes are allowed to be used.

7.9.2 Measurement of the performance

The procedure for the measurement of the performance of the card is defined in detail in the Compliance Documentation. Initial state of the memory in prior to the test is: filled with random data. The test is performed by writing/reading a 64kB chunk of data to/from random logical addresses (aligned to physical block boundaries) of the card. A predefined multiple block write/read is used with block count of 128 (64kB as 512B blocks are used). The performance is calculated as average out of several 64kB accesses.

Same test is performed with all applicable clock frequency and bus width options as follows:

- 52MHz, 8bit bus in the dual data mode (if 52MHz clock frequency and dual data mode is supported by the card)
- 52MHz, 8bit bus (if 52MHz clock frequency is supported by the card)
- 52MHz, 4bit bus (if 52MHz clock frequency is supported by the card)
- 26MHz, 8bit bus
- 26MHz, 4bit bus

In case the minimum performance of the card exceeds the physical limit of one of the above mentioned options the card has to also fulfill accordingly the performance criteria as defined in MIN_PERF_a_b_ff.

7.10 Commands

7.10.1 Command types

There are four kinds of commands defined to control the MultiMediaCard:

- broadcast commands (bc), no response
- broadcast commands with response (bcr)
- addressed (point-to-point) commands (ac), no data transfer on DAT lines
- addressed (point-to-point) data transfer commands (adtc), data transfer on DAT lines

All commands and responses are sent over the CMD line of the MultiMediaCard bus. The command transmission always starts with the left bit of the bitstring corresponding to the command codeword.

7.10.2 Command format

All commands have a fixed code length of 48 bits, needing a transmission time of 0.92 microSec @ 52 MHz.

Description	Start Bit	Transmission Bit	Command Index	Argument	CRC7	End Bit
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”

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 interpreted 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 this variable is dependent on the command. All commands are protected by a CRC (see Section 10.2 on page 157 for the definition of CRC7). Every command codeword is terminated by the end bit (always ‘1’). All commands and their arguments are listed in Table 21 on page 86 through Table 30 on page 91.

7.10.3 Command classes

The command set of the MultiMediaCard system is divided into several classes. (See Table 21 on page 86.) Each class supports a subset of card functions.

Class 0 is mandatory and shall be supported by all cards. The other classes are either mandatory only for specific card types or optional (refer to Section 13, starting on page 181, for detailed description of supported command classes as a function of card type). By using different classes, several configurations can be chosen (e.g. a block writable card or a stream readable card). The supported Card Command Classes (CCC) are coded as a parameter in the card specific data (CSD) register of each card, providing the host with information on how to access the card.

Table 21 — Supported card command classes (0–56)

Card Command Class (CCC)	Class Description	Supported commands																						
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**23**	**24**	**25**
class 0	basic	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+				+				
class 1	stream read												+												
class 2	block read																	+	+	+			+		
class 3	stream write																					+			
class 4	block write																	+					+	+	+
class 5	erase																								
class 6	write protection																								
class 7	lock card																	+							
class 8	application-specific																								
class 9	I/O mode																								
class 10–11	reserved																								

Card Command Class (CCC)	Class Description	Supported commands													
		26	**27**	**28**	**29**	**30**	**31**	**35**	**36**	**38**	**39**	**40**	**42**	**55**	**56**
class 0	basic														
class 1	stream read														
class 2	block read														
class 3	stream write														
class 4	block write	+	+												
class 5	erase							+	+	+					
class 6	write protection			+	+	+	+								
class 7	lock card												+		
class 8	application-specific													+	+
class 9	I/O mode										+	+			
class 10–11	reserved														

7.10.4 Detailed command description

The following tables define in detail all MultiMediaCard bus commands. The responses R1-R5 are defined in Section 7.12 on page 94. The registers CID, CSD, EXT_CSD and DSR are described in Section 8.

Table 22 — Basic commands and read-stream command (class 0 and class 1)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD0	bc	[31:0] 00000000	—	GO_IDLE_STATE	Resets the card to *idle* state
	bc	[31:0] F0F0F0F0	—	GO_PRE_IDLE_STATE	Resets the card to *pre-idle* state
	—	[31:0] FFFFFFFA	—	BOOT_INITIATION	Inititiate alternative boot operation
CMD1	bcr	[31:0] OCR without busy	R3	SEND_OP_COND	Asks the card, in *idle* state, to send its Operating Conditions Register contents in the response on the CMD line.
CMD2	bcr	[31:0] stuff bits	R2	ALL_SEND_CID	Asks the card to send its CID number on the CMD line
CMD3	ac	[31:16] RCA [15:0] stuff bits	R1	SET_RELATIVE_ADDR	Assigns relative address to the card
CMD4	bc	[31:16] DSR [15:0] stuff bits	-	SET_DSR	Programs the DSR of the card
CMD5	ac	[31:16] RCA [15] Sleep/Awake [14:0] stuff bits	R1b	SLEEP_AWAKE	Toggles the card between Sleep state and Standby state. (See Section 7.6.15 on page 68).
CMD6	ac	[31:26] Set to 0 [25:24] Access [23:16] Index [15:8] Value [7:3] Set to 0 [2:0] Cmd Set	R1b	SWITCH	Switches the mode of operation of the selected card or modifies the EXT_CSD registers. (See Section 7.6.1 on page 49.)
CMD7	ac	[31:16] RCA [15:0] stuff bits	R1/R1b[1]	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	adtc	[31:0] stuff bits	R1	SEND_EXT_CSD	The card sends its EXT_CSD register as a block of data.
CMD9	ac	[31:16] RCA [15:0] stuff bits	R2	SEND_CSD	Addressed card sends its card-specific data (CSD) on the CMD line.
CMD10	ac	[31:16] RCA [15:0] stuff bits	R2	SEND_CID	Addressed card sends its card identification (CID) on CMD the line.
CMD11	adtc	[31:0] data address[2]	R1	READ_DAT_UNTIL_STOP	Reads data stream from the card, starting at the given address, until a STOP_TRANSMISSION follows.
CMD12	ac	[31:16] RCA[3] [15:1] stuff bits [0] HPI	R1/R1b[4]	STOP_TRANSMISSION	Forces the card to stop transmission. If HPI flag is set the device shall interrupt its internal operations in a well defined timing.

Table 22 — Basic commands and read-stream command (class 0 and class 1) (continued)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD13	ac	[31:16] RCA [15:1] stuff bits [0] HPI	R1	SEND_STATUS	Addressed card sends its status register. If HPI flag is set the device shall interrupt its internal operations in a well defined timing.
CMD14	adtc	[31:0] stuff bits	R1	BUSTEST_R	A host reads the reversed bus testing data pattern from a card.
CMD15	ac	[31:16] RCA [15:0] stuff bits	–	GO_INACTIVE_STATE	Sets the card to *inactive* state
CMD19	adtc	[31:0] stuff bits	R1	BUSTEST_W	A host sends the bus test data pattern to a card.

NOTE 1. R1 while selecting from Stand-By State to Transfer State; R1b while selecting from Disconnected State to Programming State.
NOTE 2. Data address for media =<2GB is a 32bit byte address and data address for media > 2GB is a 32bit sector (512B) address.
NOTE 3. RCA in CMD12 is used only if HPI bit is set. The argument does not imply any RCA check on the device side.
NOTE 4. R1 for read cases and R1b for write cases.

Table 23 — Block-oriented read commands (class 2)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD16	ac	[31:0] block length	R1	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	adtc	[31:0] data address[1]	R1	READ_SINGLE_BLOCK	Reads a block of the size selected by the SET_BLOCKLEN command.[2]
CMD18	adtc	[31:0] data address[1]	R1	READ_MULTIPLE_BLOCK	Continuously transfers data blocks from card to host until interrupted by a stop command, or the requested number of data blocks is transmitted

NOTE 1. Data address for media =<2GB is a 32bit byte address and data address for media > 2GB is a 32bit sector (512B) address.
NOTE 2. The transferred data must not cross a physical block boundary, unless READ_BLK_MISALIGN is set in the CSD register.

Table 24 — Stream write commands (class 3)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD20	adtc	[31:0] data address[1]	R1	WRITE_DAT_UNTIL_STOP	Writes a data stream from the host, starting at the given address, until a STOP_TRANSMISSION follows.
CMD21 CMD22	reserved				

NOTE 1. Data address for media =<2GB is a 32bit byte address and data address for media > 2GB is a 32bit sector (512B) address.

Table 25 — Block-oriented write commands (class 4)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD23	ac	[31] Reliable Write Request [30:16] set to 0 [15:0] number of blocks	R1	SET_BLOCK_COUNT	Defines the number of blocks (read/write) and the reliable writer parameter (write) for a block read or write command. (See Section 7.6.6 and Section 7.6.7)
CMD24	adtc	[31:0] data address[1]	R1	WRITE_BLOCK	Writes a block of the size selected by the SET_BLOCKLEN command.[2]
CMD25	adtc	[31:0] data address[1]	R1	WRITE_MULTIPLE_BLOCK	Continuously writes blocks of data until a STOP_TRANSMISSION follows or the requested number of block received.
CMD26	adtc	[31:0] stuff bits	R1	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	adtc	[31:0] stuff bits	R1	PROGRAM_CSD	Programming of the programmable bits of the CSD.

NOTE 1. Data address for media =<2GB is a 32bit byte address and data address for media > 2GB is a 32bit sector (512B) address.
NOTE 2. The transferred data must not cross a physical block boundary unless WRITE_BLK_MISALIGN is set in the CSD.

Table 26 — Block-oriented write protection commands (class 6)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD28	ac	[31:0] data address[1]	R1b	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 or HC_WP_GRP_SIZE).
CMD29	ac	[31:0] data address[1]	R1b	CLR_WRITE_PROT	If the card provides write protection features, this command clears the write protection bit of the addressed group.
CMD30	adtc	[31:0] write protect data address	R1	SEND_WRITE_PROT	If the card provides write protection features, this command asks the card to send the status of the write protection bits.[2]
CMD31	adtc	[31:0] write protect data address	R1	SEND_WRITE_PROT_TYPE	This command sends the type of write protection that is set for the different write protection groups.[3]

Table 26 — Block-oriented write protection commands (class 6) (continued)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
NOTE 1. Data address for media =<2GB is a 32bit byte address and data address for media > 2GB is a 32bit sector (512B) address. NOTE 2. 32 write protection bits (representing 32 write protect groups starting at the specified address) followed by 16 CRC bits are transferred in a payload format via the data lines. The last (least significant) bit of the protection bits corresponds to the first addressed group. If the addresses of the last groups are outside the valid range, then the corresponding write protection bits shall be set to zero. NOTE 3. 64 write protection bits (representing 32 write protect groups starting at the specified address) followed by 16 CRC bits are transferred in a payload format via the data lines. Each set of two protection bits shows the type of protection set for each of the write protection groups. The definition of the different bit settings are shown below. The last (least significant) two bits of the protection bits correspond to the first addressed group. If the addresses of the last groups are outside the valid range, then the corresponding write protection bits shall be set to zero. “00” Write protection group not protected “01” Write protection group is protected by temporary write protection “10” Write protection group is protected by power-on write protection “11” Write protection group is protected by permanent write protection					

Table 27 — Erase commands (class 5)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD32 … CMD34	Reserved. These command indexes cannot be used in order to maintain backwards compatibility with older versions of the MultiMediaCards				
CMD35	ac	[31:0] data address[1,2]	R1	ERASE_GROUP_START	Sets the address of the first erase group within a range to be selected for erase
CMD36	ac	[31:0] data address[1,2]	R1	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 MultiMediaCards				
CMD38	ac	[31] Secure request[4] [30:16] set to 0 [15]Force Garbage Collect request[5] [14:1] set to 0 [0]Identify Write block for Erase[5]	R1b	ERASE	Erases all previously selected write blocks according to argument bits[3].
NOTE 1. Data address for media =<2GB is a 32bit byte address and data address for media > 2GB is a 32bit sector (512B) address. NOTE 2. The card will ignore all LSB’s below the Erase Group size, effectively rounding the address down to the Erase Group boundary. NOTE 3. Table 11 on page 59 and Table 13 on page 60 give a description of the argument bits and a list of supported argument combinations. NOTE 4. Argument bit 31 is an optional feature that is only supported if SEC_ER_EN (EXT_CSD 231, bit 0) is set. NOTE 5. Argument bit 15 and 0 are optional feature that are only supported if SEC_GB_CL_EN (EXT_CSD 231 bit 4) is set.					

All future reserved commands, and their responses (if there are any), shall have a codeword length of 48 bits.

Table 28 — I/O mode commands (class 9)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD39	ac	[31:16] RCA [15:15] register write flag [14:8] register address [7:0] register data	R4	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 if the write flag is cleared to 0. This command accesses application dependent registers which are not defined in the MultiMediaCard standard.
CMD40	bcr	[31:0] stuff bits	R5	GO_IRQ_STATE	Sets the system into interrupt mode
CMD41	reserved				

Table 29 — Lock card commands (class 7)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD42	adtc	[31:0] stuff bits.	R1	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 30 — Application-specific commands (class 8)

CMD INDEX	Type	Argument	Resp	Abbreviation	Command Description
CMD55	ac	[31:16] RCA [15:0] stuff bits	R1	APP_CMD	Indicates to the card that the next command is an application specific command rather than a standard command
CMD56	adtc	[31:1] stuff bits. [0]: RD/WR[1]	R1	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				
CMD60 … CMD63	reserved for manufacturer				

NOTE 1. RD/WR: “1” the host gets a block of data from the card. “0” the host sends block of data to the card.

7.11 Card state transition table

Table 31 defines the card state transitions in dependency of the received command.

Table 31 — Card state transitions

	Current State												
	idle	**ready**	**ident**	**stby**	**tran**	**data**	**btst**	**rcv**	**prg**	**dis**	**ina**	slp	**irq**
Command	**Changes to**												
Class Independent													
CRC error	-	-	-	-	-	-	-	-	-	-	-	-	stby
command not supported	-	-	-	-	-	-	-	-	-	-	-	-	stby
Class 0													
CMD0 (arg=0x00000000)	idle	idle	idle	idle	idle	idle	idle	idle	idle	idle	-	idle	stby
CMD0 (arg=0xF0F0F0F0)	Pre-idle	Pre-idle	Pre-idle	Pre-idle	Pre-idle	Pre-idle	Pre-idle	Pre-idle	Pre-idle	Pre-idle	-	Pre-idle	stby
CMD1, card V_{DD} range compatible	ready	-	-	-	-	-	-	-	-	-	-	-	stby
CMD1, card is busy	idle	-	-	-	-	-	-	-	-	-	-	-	stby
CMD1, card V_{DD} range not compatible	ina	-	-	-	-	-	-	-	-	-	-	-	stby
CMD2, card wins bus	-	ident	-	-	-	-	-	-	-	-	-	-	stby
Class 0 (continued)													
CMD2, card loses bus	-	ready	-	-	-	-	-	-	-	-	-	-	stby
CMD3	-	-	stby	-	-	-	-	-	-	-	-	-	stby
CMD4	-	-	-	stby	-	-	-	-	-	-	-	-	stby
CMD5	-	-	-	slp								stby	stby
CMD6	-	-	-	-	prg	-	-	-	-	-	-	-	stby
CMD7, card is addressed	-	-	-	tran	-	-	-	-	-	prg	-	-	stby
CMD7, card is not addressed	-	-	-	-	stby	stby	-	-	dis	-	-	-	stby
CMD8	-	-	-	-	data	-	-	-	-	-	-	-	stby
CMD9	-	-	-	stby	-	-	-	-	-	-	-	-	stby
CMD10	-	-	-	stby	-	-	-	-	-	-	-	-	stby
CMD12, arg[0] = 0	-	-	-	-	-	tran	-	prg	-	-	-	-	stby
CMD12, arg[0] = 1	-	-	-	-	-	-	-	-	prg	-	-	-	stby
CMD13, arg[0] = 0 or 1	-	-	-	stby	tran	data	btst	rcv	prg	dis	-	-	stby
CMD14	-	-	-	-	-	-	tran	-	-	-	-	-	stby
CMD15	-	-	-	ina	ina	ina	ina	ina	ina	ina	-	-	stby
CMD19	-	-	-	-	btst	-	-	-	-	-	-	-	stby
Class 1													
CMD11	-	-	-	-	data	-	-	-	-	-	-	-	stby

Table 31 — Card state transitions (continued)

	Current State												
	idle	**ready**	**ident**	**stby**	**tran**	**data**	**btst**	**rcv**	**prg**	**dis**	**ina**	slp	**irq**
Command	**Changes to**												
Class 2													
CMD16	-	-	-	-	tran	-	-	-	-	-	-	-	stby
CMD17	-	-	-	-	data	-	-	-	-	-	-	-	stby
CMD18	-	-	-	-	data	-	-	-	-	-	-	-	stby
CMD23	-	-	-	-	tran	-	-	-	-	-	-	-	stby
Class 3													
CMD20	-	-	-	-	rcv	-	-	-	-	-	-	-	stby
Class 4													
CMD16	see class 2												
CMD23	see class 2												
CMD24	-	-	-	-	rcv	-	-	-	rcv[1]	-	-	-	stby
CMD25	-	-	-	-	rcv	-	-	-	rcv[2]	-	-	-	stby
CMD26	-	-	-	-	rcv	-	-	-	-	-	-	-	stby
CMD27	-	-	-	-	rcv	-	-	-	-	-	-	-	stby
Class 6													
CMD28	-	-	-	-	prg	-	-	-	-	-	-	-	stby
CMD29	-	-	-	-	prg	-	-	-	-	-	-	-	stby
Class 6 (continued)													
CMD30	-	-	-	-	data	-	-	-	-	-	-	-	stby
CMD31	-	-	-	-	data	-	-	-	-	-	-	-	stby
Class 5													
CMD35	-	-	-	-	tran	-	-	-	-	-	-	-	stby
CMD36	-	-	-	-	tran	-	-	-	-	-	-	-	stby
CMD38	-	-	-	-	prg	-	-	-	-	-	-	-	stby
Class 7													
CMD16	see class 2												
CMD42	-	-	-	-	rcv	-	-	-	-	-	-	-	stby
Class 8													
CMD55	-	-	-	stby	tran	data	btst	rcv	prg	dis	-	-	irq
CMD56; RD/WR = 0	-	-	-	-	rcv	-	-	-	-	-	-	-	stby
CMD56; RD/WR = 1	-	-	-	-	data	-	-	-	-	-	-	-	stby
Class 9													
CMD39	-	-	-	stby	-	-	-	-	-	-	-	-	stby
CMD40	-	-	-	irq	-	-	-	-	-	-	-	-	stby
Class 10–11													

Table 31 — Card state transitions (continued)

	Current State												
	idle	**ready**	**ident**	**stby**	**tran**	**data**	**btst**	**rcv**	**prg**	**dis**	**ina**	slp	**irq**
Command	**Changes to**												
CMD41; CMD43…CMD54, CMD57…CMD59	Reserved												
CMD60…CMD63	Reserved for Manufacturer												

NOTE 1. Due to legacy considerations, a card may treat CMD24/25 during a prg state—while busy is active—as a legal or an illegal command. A card that treats CMD24/25 during a prg-state—while busy is active—as an illegal command will not change its state to the rcv state. A host should not send CMD24/25 while the card is in prg state and busy is active.

NOTE 2. Due to legacy considerations, a card may treat CMD24/25 during a prg state—while busy is active—as a legal or an illegal command. A card that treats CMD24/25 during a prg state—while busy is active—as an illegal command will not change its state to the rcv state. A host should not send CMD24/25 while the card is in prg state and busy is active.

NOTE 3. As there is no way to obtain state information in boot mode, boot-mode states are not shown in this table.

7.12 Responses

All responses are sent via the command line CMD. The response transmission always starts with the left bit of the bitstring corresponding to the response codeword. The code length depends on the response type.

A response always starts with a start bit (always ‘0’), followed by the bit indicating the direction of transmission (card = ‘0’). A value denoted by ‘x’ in the tables below indicates a variable entry. All responses except for the type R3 (see below) are protected by a CRC (see Section 10.2 on page 157 for the definition of CRC7). Every command codeword is terminated by the end bit (always ‘1’).

There are five types of responses. Their formats are defined as follows:

- **R1** (normal response command): code length 48 bit. The bits 45:40 indicate the index of the command to be responded to, this value being interpreted as a binary coded number (between 0 and 63). The status of the card is coded in 32 bits. The card status is described in Section 7.13 on page 96.

Table 32 — R1 response

Bit position	47	46	[45:40]	[39:8]	7	0
Width (bits)	1	1	6	32	x	1
Value	“0”	“0”	x	x	CRC7	“1”
Description	**Start bit**	**Transmission bit**	**Command index**	**Card status**	**CRC7**	**End bit**

- **R1b** is identical to R1 with an optional busy signal transmitted on the data line DAT0. The card may become busy after receiving these commands based on its state prior to the command reception. Refer to Section 7.15 on page 101 for detailed description and timing diagrams.
- **R2** (CID, CSD register): code length 136 bits. The contents of the CID register are sent as a response to the commands CMD2 and CMD10. The contents of the CSD register are sent as a response to CMD9. Only the bits [127...1] of the CID and CSD are transferred, the reserved bit [0] of these registers is

replaced by the end bit of the response.

Table 33 — R2 response

Bit position	135	134	[133:128]	[127:1]	0
Width (bits)	1	1	6	127	1
Value	“0”	“0”	111111	x	“1”
Description	**Start bit**	**Transmission bit**	**Check bits**	**CID or CSD register incl. internal CRC7**	**End bit**

- **R3** (OCR register): code length 48 bits. The contents of the OCR register is sent as a response to CMD1. The level coding is as follows: restricted voltage windows=LOW, card busy=LOW.

Table 34 — R3 response

Bit position	47	46	[45:40]	[39:8]	[7:1]	0
Width (bits)	1	1	6	32	7	1
Value	“0”	“0”	“111111”	x	“1111111”	“1”
Description	**Start bit**	**Transmission bit**	**Check bits**	**OCR register**	**Check bits**	**End bit**

- **R4** (Fast I/O): code length 48 bits. The argument field contains the RCA of the addressed card, the register address to be read out or written to, and its contents.
  The status bit in the argument is set if the operation was successful.

Table 35 — R4 response

Bit position	47	46	[45:40]	[39:8] Argument field				[7:1]	0
Width (bits)	1	1	6	16	1	7	8	7	1
Value	“0”	“0”	“100111”	x	x	x	x	x	“1”
Description	**Start bit**	**Transmission bit**	**CMD39**	**RCA [31:16]**	**Status [15]**	**Register address [14:8]**	**Read register contents [7:0]**	**CRC7**	**End bit**

- **R5** (Interrupt request): code length 48 bits. If the response is generated by the host, the RCA field in the argument shall be 0x0.

Table 36 — R5 response

Bit position	47	46	[45:40]	[39:8] Argument field		[7:1]	0
Width (bits)	1	1	6	16	16	7	1
Value	“0”	“0”	“101000”	x	x	x	“1”
Description	**Start bit**	**Transmission bit**	**CMD40**	**RCA [31:16] of winning card or of the host**	**[15:0] Not defined. May be used for IRQ data**	**CRC7**	**End bit**

7.13 Card status

The response format R1 contains a 32-bit field named *card status*. This field is intended to transmit the card's status information.

Two different attributes are associated with each one of the card status bits:

- Bit type.

  Two types of card status bits are defined:

  (a) **Error bit**. Signals an error condition detected by the card. These bits are cleared as soon as the response (reporting the error) is sent out. Clear Cond. B

  (b) **Status bit**. These bits serve as information fields only, and do not alter the execution of the command being responded to. These bits are persistent, they are set and cleared in accordance with the card status. Clear Cond. A

  The "Type" field of Table 37 on page 96 defines the type of each bit in the card status register. The symbol "E" is used to denote an Error bit while the symbol "S" is used to denote a Status bit.

- Detection mode of Error bits.

  Exceptions are detected by the card either during the command interpretation and validation phase (Response Mode) or during command execution phase (Execution Mode). Response mode exceptions are reported in the response to the command that raised the exception. Execution mode exceptions are reported in the response to a STOP_TRANSMISSION command used to terminate the operation or in the response to a GET_STATUS command issued while the operation is being carried out or after the operation is completed.

  The "Det Mode" field of Table 37 defines the detection mode of each bit in the card status register. The symbol "R" is used to denote a Response Mode detection while the symbol "X" is used to denote an Execution Mode detection.

  When an error bit is detected in "R" mode the card will report the error in the response to the command that raised the exception. The command will not be executed and the associated state transition will not take place. When an error is detected in "X" mode the execution is terminated. The error will be reported in the response to the next command.

  The ADDRESS_OUT_OF_RANGE and ADDRESS_MISALIGN exceptions may be detected both in Response and Execution modes. The conditions for each one of the modes are explicitly defined in the table.

Table 37 — Card status

Bits	Identifier	Type	Det Mode	Value	Description	Clear Cond
31	ADDRESS_ OUT_OF_RANGE	E	R	"0" = no error "1" = error	The command's address argument was out of the allowed range for this card.	B
			X		A multiple block or stream read/write operation is (although started in a valid address) attempting to read or write beyond the card capacity	

Table 37 — Card status (continued)

Bits	Identifier	Type	Det Mode	Value	Description	Clear Cond
30	ADDRESS_ MISALIGN	E	R	“0” = no error “1” = error	The command’ s address argument (in accordance with the currently set block length) positions the first data block misaligned to the card physical blocks.	B
			X		A multiple block read/write operation (although started with a valid address/block-length combination) is attempting to read or write a data block which does not align with the physical blocks of the card.	
29	BLOCK_LEN_ ERROR	E	R	“0” = no error “1” = error	Either the argument of a SET_BLOCKLEN command exceeds the maximum value allowed for the card, or the previously defined block length is illegal for the current command (e.g. the host issues a write command, the current block length is smaller than the card’s maximum and write partial blocks is not allowed)	B
28	ERASE_SEQ_ ERROR	E	R	“0” = no error “1” = error	An error in the sequence of erase commands occurred.	B
27	ERASE_PARAM	E	X	“0” = no error “1” = error	An invalid selection of erase groups for erase occurred.	B
26	WP_VIOLATION	E	X	“0” = no error “1” = error	Attempt to program a write protected block	B
25	CARD_IS_LOCKED	S	R	“0” = card unlocked “1” = card locked	When set, signals that the card is locked by the host	A
24	LOCK_UNLOCK_ FAILED	E	X	“0” = no error “1” = error	Set when a sequence or password error has been detected in lock/unlock card command	B
23	COM_CRC_ERROR	E	R	“0” = no error “1” = error	The CRC check of the previous command failed.	B
22	ILLEGAL_ COMMAND	E	R	“0” = no error “1” = error	Command not legal for the card state	B
21	CARD_ECC_ FAILED	E	X	“0” = success “1” = failure	Card internal ECC was applied but failed to correct the data.	B
20	CC_ERROR	E	R	“0” = no error “1” = error	(Undefined by the standard) A card error occurred, which is not related to the host command.	B
19	ERROR	E	X	“0” = no error “1” = error	(Undefined by the standard) A generic card error related to the (and detected during) execution of the last host command (e.g. read or write failures).	B
18	UNDERRUN	E	X	“0” = no error “1” = error	The card could not sustain data transfer in stream read mode	B
17	OVERRUN	E	X	“0” = no error “1” = error	The card could not sustain data programming in stream write mode	B

Table 37 — Card status (continued)

Bits	Identifier	Type	Det Mode	Value	Description	Clear Cond
16	CID/CSD_ OVERWRITE	E	X	“0” = no error “1” = error	Can be either one of the following errors: - The CID register has been already written and can not be overwritten - The read only section of the CSD does not match the card content. - An attempt to reverse the copy (set as original) or permanent WP (unprotected) bits was made.	B
15	WP_ERASE_SKIP	E	X	“0” = not protected “1” = protected	Only partial address space was erased due to existing write protected blocks.	B
14	Reserved, must be set to 0					
13	ERASE_RESET	E	R	“0” = cleared “1” = set	An erase sequence was cleared before executing because an out of erase sequence command was received (commands other than CMD35, CMD36, CMD38 or CMD13	B
12:9	CURRENT_STATE	S	R	0 = Idle 1 = Ready 2 = Ident 3 = Stby 4 = Tran 5 = Data 6 = Rcv 7 = Prg 8 = Dis 9 = Btst 10 = Slp 11–15 = reserved	The state of the card when receiving the command. If the command execution causes a state change, it will be visible to the host in the response on the next command. The four bits are interpreted as a binary number between 0 and 15. As there is no way to obtain state information in boot mode, boot-mode states are not shown in this table.	A
8	READY_FOR_ DATA	S	R	“0” = not ready “1” = ready	Corresponds to buffer empty signalling on the bus	A
7	SWITCH_ERROR	E	X	“0” = no error “1” = switch error	If set, the card did not switch to the expected mode as requested by the SWITCH command	B
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.	A
5	APP_CMD	S	R	“0” = Disabled “1” = Enabled	The card will expect ACMD, or indication that the command has been interpreted as ACMD	A
4	Reserved					
3:2	Reserved for Application Specific commands					
1:0	Reserved for Manufacturer Test Mode					

The following table defines, for each command responded by a R1 response, the affected bits in the status field. A “R” or a “X” mean the error/status bit may be affected by the respective command (using the R or X detection mechanism respectively). The Status bits are valid in any R1 response and are marked with

“S” symbol in the table.

Table 38 — Card status field/command—cross reference

CMD #	Response 1 Format - Status bit #																						
	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	13	12:9	8	7	6	5
0							S		R			R	X						S	S		S	
1									R	R			X										
2									R	R			X										
3							S		R	R		R	X						S	S		S	
4							S		R	R		R	X						S	S		S	
5							S		R	R		R	X					R	S	S		S	
6							S		R	R		R	X					R	S	S	X	S	
7							S		R	R		R	X					R	S	S		S	
8							S		R	R		R	X					R	S	S		S	
9							S		R	R		R	X					R	S	S		S	
10							S		R	R		R	X					R	S	S		S	
11	R						S		R	R	X	R	X	X				R	S	S		S	
12							S		R	R		R	X						S	S		S	
13							S		R	R		R	X						S	S		S	
14							S		R	R		R	X					R	S	S		S	
15							S		R			R	X					R	S	S		S	
16			R				S		R	R		R	X					R	S	S		S	
17	R	R	R				S		R	R	X	R	X					R	S	S		S	
18	R	R	R				S		R	R	X	R	X					R	S	S		S	
19							S		R	R		R	X					R	S	S		S	
20	R					X	S		R	R		R	X		X			R	S	S		S	
23							S		R	R		R	X					R	S	S		S	
24	R	R	R			X	S		R	R		R	X					R	S	S		S	
25	R	R	R			X	S		R	R		R	X					R	S	S		S	
26							S		R	R		R	X			X		R	S	S		S	
27							S		R	R		R	X			X		R	S	S		S	
28	R						S		R	R		R	X					R	S	S		S	
29	R						S		R	R		R	X					R	S	S		S	
30	R						S		R	R		R	X					R	S	S		S	
35	R			R	X		S		R	R		R	X						S	S		S	
36	R			R	X		S		R	R		R	X						S	S		S	
38				R			S		R	R		R	X				X		S	S		S	
39							S		R	R		R	X					R	S	S		S	
40							S		R	R		R	X					R	S	S		S	
42							S	X	R	R		R	X					R	S	S		S	
55							S		R			R	X					R	S	S		S	S
56							S		R	R		R	X					R	S	S		S	S

Table 38 — Card status field/command—cross reference (continued)

CMD #	Response 1 Format - Status bit #																						
	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	13	12:9	8	7	6	5
Bit is valid for classes	1, 2, 3, 4, 5, 6	2, 4	2, 4, 7	5	5	3, 4	All ways	7	All ways	All ways	1, 2	All ways	All ways	1	3	All ways	5	All ways	All ways	All ways	All ways	All ways	All ways

Not all Card status bits are meaningful all the time. Depending on the classes supported by the card, the relevant bits can be identified. If all the classes that affect a status bit, or an error bit, are not supported by the card, the bit is not relevant and can be ignored by the host.

7.14 Memory array partitioning

The basic unit of data transfer to/from the MultiMediaCard is one byte. All data transfer operations which require a block size always define block lengths as integer multiples of bytes. Some special functions need other partition granularity.

For block oriented commands, the following definition is used:

- **Block**: is the unit which is related to the block oriented read and write commands. Its size is the number of bytes which will be transferred when one block command is sent by the host. The size of a block is either programmable or fixed. The information about allowed block sizes and the programmability is stored in the CSD.

For R/W cards, special erase and write protect commands are defined:

- The granularity of the erasable units is the **Erase Group:** The smallest number of consecutive write blocks which can be addressed for erase. The size of the Erase Group is card specific and stored in the CSD when ERASE_GROUP_DEF is disabled, and in the EXT_CSD when ERASE_GROUP_DEF is enabled.
- The granularity of the Write Protected units is the **WP-Group:** The minimal unit which may be individually write protected. Its size is defined in units of erase groups. The size of a WP-group is card specific and stored in the CSD when ERASE_GROUP_DEF is disabled, and in the EXT_CSD when ERASE_GROUP_DEF is enabled.

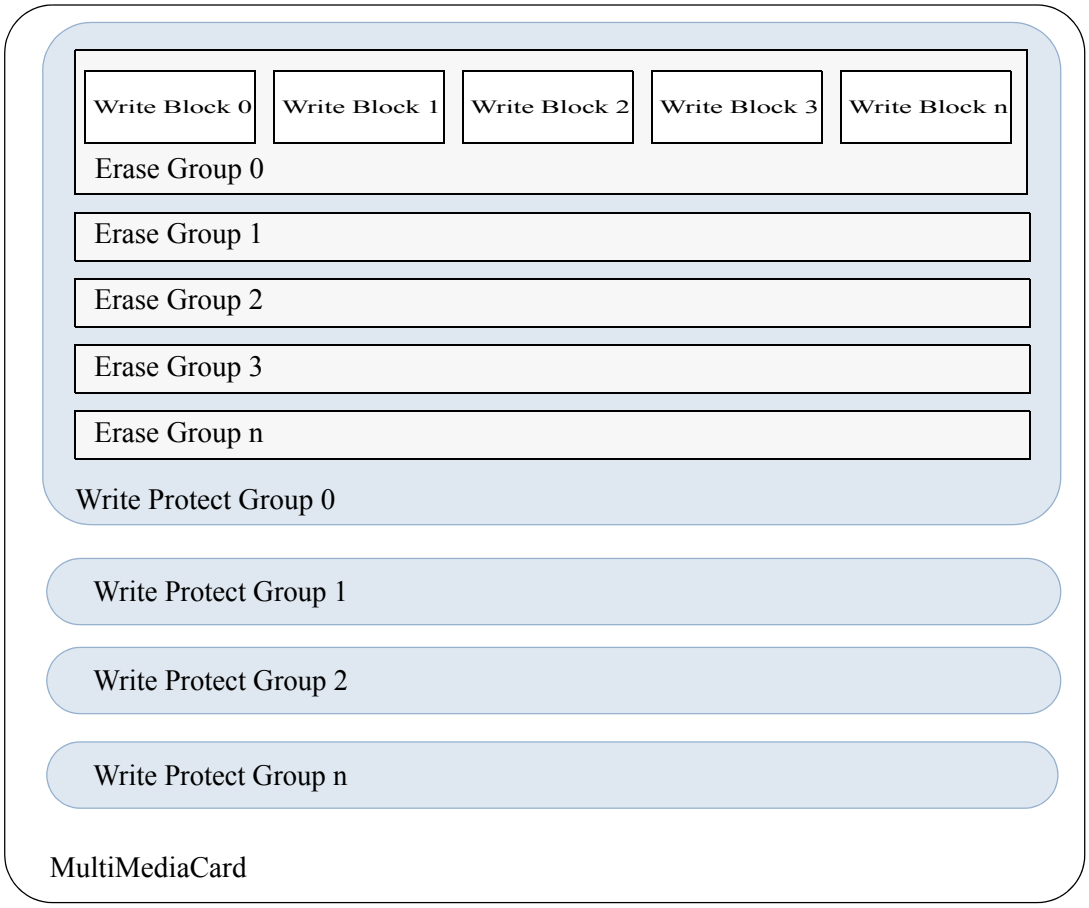


Figure 29 — Memory array partitioning

7.15 Timings

All timing diagrams use the following schematics and abbreviations:

S	Start bit (= “0”)
T	Transmitter bit (Host = “1,” Card = “0”)
P	One-cycle pull-up (= “1”)
E	End bit (= “1”)
L	One-cycle pull-down (= “0”)
Z	High impedance state (-> = “1”)
X	Driven value, “1” or “0”
D	Data bits
*	Repetition
CRC	Cyclic redundancy check bits (7 bits)
	Card active
	Host active

The difference between the P-bit and Z-bit is that a P-bit is actively driven to HIGH by the card respectively host output driver, while Z-bit is driven to (respectively kept) HIGH by the pull-up resistors R_{CMD} respectively R_{DAT}. Actively-driven P-bits are less sensitive to noise.

All timing values are defined in Table 39 on page 111.

7.15.1 Command and response

Both host command and card response are clocked out with the rising edge of the host clock in either the single data rate or dual data rate modes.

- Card identification and card operation conditions timing

The card identification (CMD2) and card operation conditions (CMD1) timing are processed in the open-drain mode. The card response to the host command starts after exactly N_{ID} clock cycles.

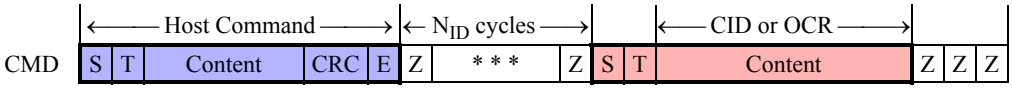


Figure 30 — Identification timing (card identification mode)

- Assign a card relative address

The SET_RCA (CMD 3) is also processed in the open-drain mode. The minimum delay between the host command and card response is N_{CR} clock cycles.

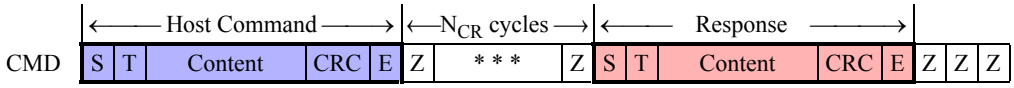


Figure 31 — SET_RCA timing (card identification mode)

- Data transfer mode.

After a card receives its RCA it will switch to data transfer mode. In this mode the CMD line is driven with push-pull drivers. The command is followed by a period of two Z bits (allowing time for direction switching on the bus) and than by P bits pushed up by the responding card. This timing diagram is relevant for all responded host commands except CMD1,2,3:

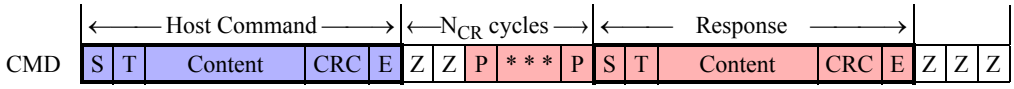


Figure 32 — Command response timing (data transfer mode)

- R1b responses

Some commands, like CMD6, may assert the BUSY signal and respond with R1. If the busy signal is asserted, it is done two clock cycles after the end bit of the command. The DAT0 line is driven low, DAT1–

DAT7 lines are driven by the card though their values are not relevant.

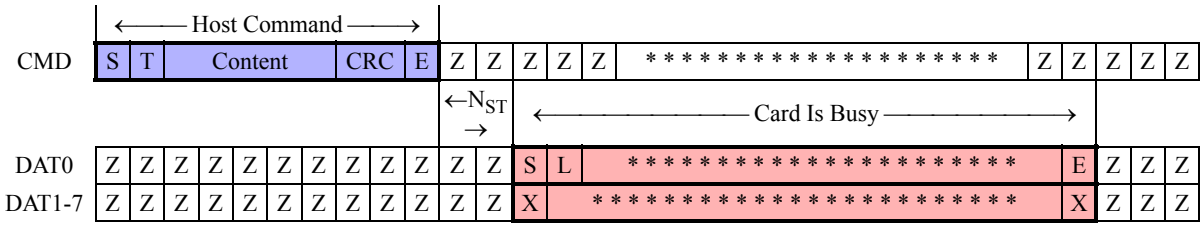


Figure 33 — R1b response timing

- Last card response—next host command timing

After receiving the last card response, the host can start the next command transmission after at least N_{RC} clock cycles. This timing is relevant for any host command.

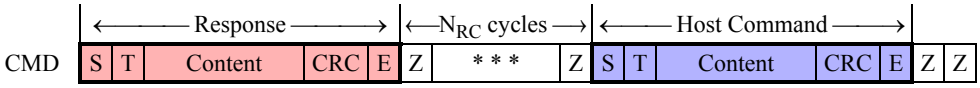


Figure 34 — Timing response end to next command start (data transfer mode)

- Last host command—next host command timing

After the last command has been sent, the host can continue sending the next command after at least N_{CC} clock periods.

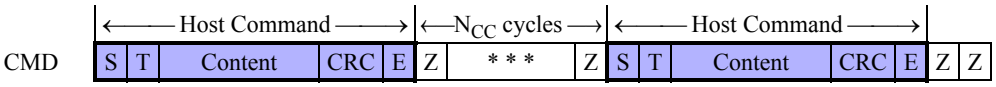


Figure 35 — Timing of command sequences (all modes)

If the ALL_SEND_CID command is not responded by the card after N_{ID} + 1 clock periods, the host can conclude there is no card present in the bus.

7.15.2 Data read

Data read can be made in single data rate mode or in dual rate mode.

In the single data rate mode, data are clocked out by the card and sampled by the host with the rising edge of the clock and there is a single CRC per data line.

In the dual data rate mode, data are clocked out with both the rising edge of the clock and the falling edge of the clock and there are two CRC appended per data line. In this mode, the block length is always 512 bytes, and bytes come interleaved in either 4-bit or 8-bit width configuration. Bytes with odd number (1,3,5, ... ,511) shall be sampled on the rising edge of the clock by the host and bytes with even number (2,4,6, ... ,512) shall be sampled on the falling edge of the clock by the host. The card will append two CRC16 per each valid data line, one corresponding to the bits of the 256 odd bytes to be sampled on the rising edge of the clock by the host and the second for the remaining bits of the 256 even bytes of the block to be sampled on the falling edge of the clock by the host.

Remark: only the data block and the two CRC use both edges of the clock. Start and end bits remains full

cycle and all timings stays identical to the single data rate read mode.

- Single block read

The host selects one card for data read operation by CMD7, and sets the valid block length for block oriented data transfer by CMD16(CMD16 only applies to single data rate mode). The basic bus timing for a read operation is given in Figure 36. The sequence starts with a single block read command (CMD17) which specifies the start address in the argument field. The response is sent on the CMD line as usual.

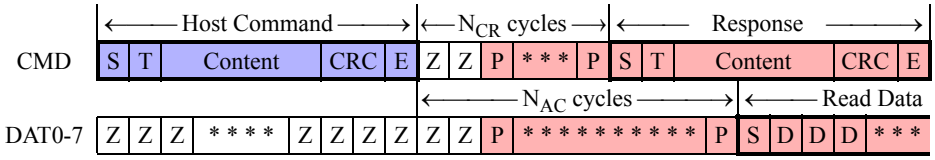


Figure 36 — Single-block read timing

Data transmission from the card starts after the access time delay N_{AC} beginning from the end bit of the read command. After the last data bit, the CRC check bits are suffixed to allow the host to check for transmission errors.

- Multiple block read

In multiple block read mode, the card sends a continuous flow of data blocks following the initial host read command. The data flow is terminated by a stop transmission command (CMD12). Figure 37 describes the timing of the data blocks and Figure 38 the response to a stop command. The data transmission stops two clock cycles after the end bit of the stop command.

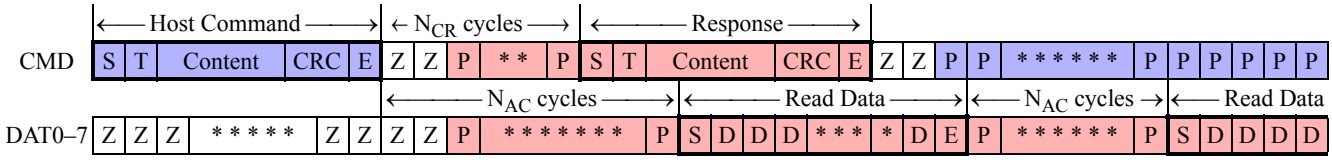


Figure 37 — Multiple-block read timing

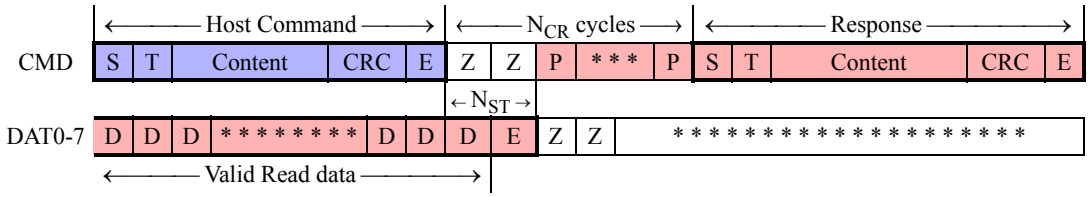


Figure 38 — Stop command timing (CMD12, data transfer mode)

- Stream read

The data transfer starts N_{AC} clock cycles after the end bit of the host command. The bus transaction is identical to that of a read block command (see Figure 38). As the data transfer is not block oriented, the data stream does not include the CRC checksum. Consequently the host can not check for data validity. The data stream is terminated by a stop command. The corresponding bus transaction is identical to the stop command for the multiple read block (see Figure 38).

Stream read is a valid transfer only for card operating in 1-bit single data rate mode.

7.15.3 Data write

Data write can be made in single data rate mode or in dual rate mode.

In the single data rate mode, data are clocked out by the host and sampled by the card with the rising edge of the clock and there is a single CRC per data line.

In the dual data rate mode, data are clocked out with both the rising edge of the clock and the falling edge of the clock and there are two CRC appended per data line. In this mode, the block length is always 512 bytes, and bytes come interleaved in either 4-bit or 8-bit width configuration. Bytes with odd number (1,3,5,...,511) shall be sampled on the rising edge of the clock by the card and bytes with even number (2,4,6,...,512) shall be sampled on the falling edge of the clock by the card. The host will append two CRC16 per valid data line, one corresponding to bits of the 256 odd bytes to be sampled on the rising edge of the clock by the card and the second for the remaining bits of the 256 even bytes of the block to be sampled on the falling edge of the clock by the card.

Remark: In a similar manner to the data read, only the data block and the two CRC use both edges of the clock. Start, end and the 3-bit CRC token status bits remains full cycle and all timings stays identical to the single data rate write mode.

- Single block write

The host selects the card for data write operation by CMD7.

The host sets the valid block length for block oriented data transfer (a stream write mode is also available) by CMD16 (CMD16 only applies to single data rate mode).

The basic bus timing for a write operation is given in Figure 39 on page 105. The sequence starts with a single block write command (CMD24) which determines (in the argument field) the start address. It is responded by the card on the CMD line as usual. The data transfer from the host starts N_{WR} clock cycles after the card response was received.

The data is suffixed with CRC check bits to allow the card to check it for transmission errors. The card sends back the CRC check result as a CRC status token on DAT0. In the case of transmission error, occurring on any of the active data lines, the card sends a negative CRC status (‘101’) on DAT0. In the case of successful transmission, over all active data lines, the card sends a positive CRC status (‘010’) on DAT0 and starts the data programming procedure.

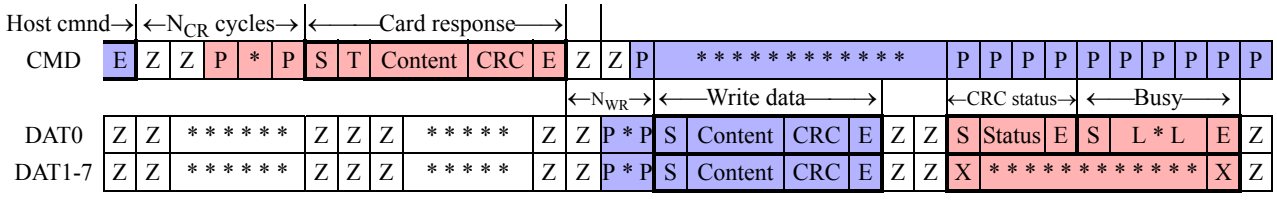


Figure 39 — Block write command timing

While the card is programming it indicates busy by pulling down the Dat0 line. This busy status is directly related to Programming state. As soon as the card completes the programming it stops pulling down the Dat0 line.

- Multiple block write

In multiple block write mode, the card expects continuous flow of data blocks following the initial host write command. The data flow is terminated by a stop transmission command (CMD12). Figure 40

describes the timing of the data blocks with and without card busy signal.

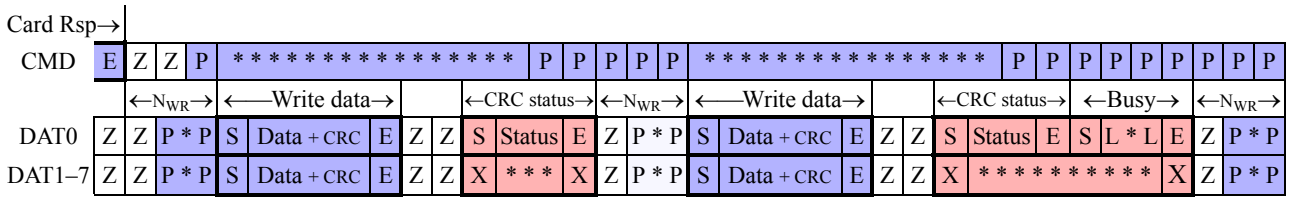


Figure 40 — Multiple-block write timing

The stop transmission command works similar as in the read mode. Figure 41 on page 106 to Figure 44 on page 107 describe the timing of the stop command in different card states.

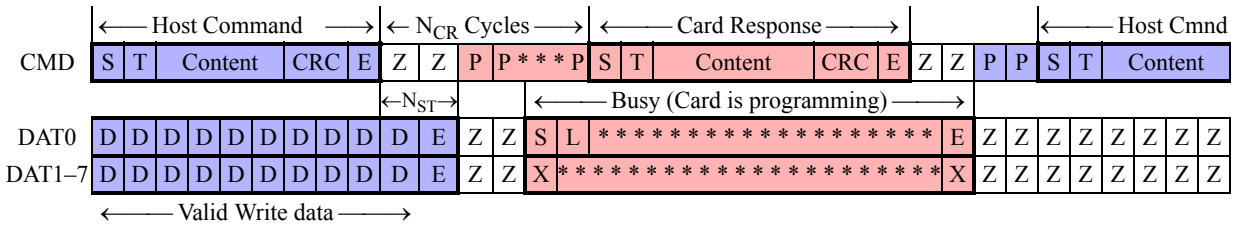
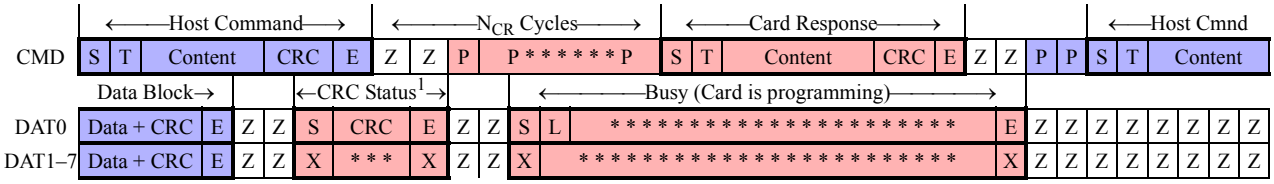


Figure 41 — Stop transmission during data transfer from the host

The card will treat a data block as successfully received and ready for programming only if the CRC data of the block was validated and the CRC status tokens sent back to the host. Figure 42 is an example of an interrupted (by a host stop command) attempt to transmit the CRC status block. The sequence is identical to all other stop transmission examples. The end bit of the host command is followed, on the data lines, with one more data bit, an end bit and two Z clocks for switching the bus direction. The received data block, in this case is considered incomplete and will not be programmed.



NOTE 1. The card CRC status response is interrupted by the host.

Figure 42 — Stop transmission during CRC status transfer from the card

All previous examples dealt with the scenario of the host stopping the data transmission during an active data transfer. The following two diagrams describe a scenario of receiving the stop transmission between data blocks. In the first example the card is busy programming the last block while in the second the card is idle. However, there are still unprogrammed data blocks in the input buffers. These blocks are being

programmed as soon as the stop transmission command is received and the card activates the busy signal.

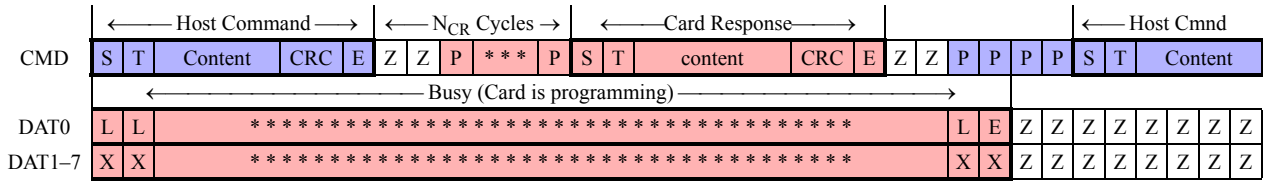


Figure 43 — Stop transmission after last data block; card is busy programming

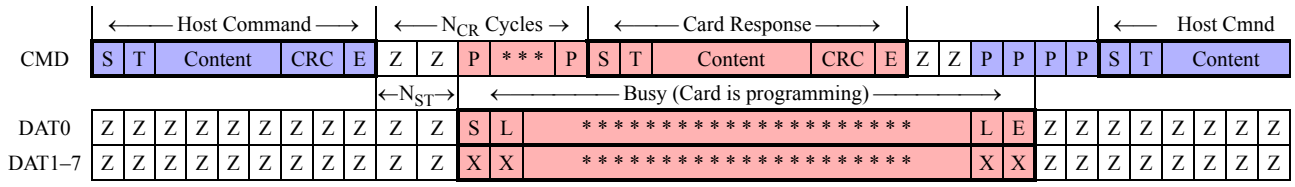


Figure 44 — Stop transmission after last data block; card becomes busy

In an open-ended multiple block write case the busy signal between the data blocks should be considered as buffer busy signal. As long as there is no free data buffer available the card should indicate this by pulling down the Dat0 line. The card stops pulling down DAT0 as soon as at least one receive buffer for the defined data transfer block length becomes free. After the card receives the stop command (CMD12), the following busy indication should be considered as programming busy and being directly related to the Programming state. As soon as the card completes the programming, it stops pulling down the Dat0 line.

In pre-defined multiple block write case the busy signal between the data blocks should be considered as buffer busy signal similar to the open-ended multiple block case. After the card receives the last data block the following busy indication should be considered as programming busy and being directly related to the Programming state. The meaning of busy signal (from buffer busy to programming busy) changes at the same time with the state change (from rcv to prg). The busy signal remains “low” all the time during the process and is not released by the card between the state change from rcv to prg. As soon as the card completes the programming, it stops pulling down the Dat0 line.

- Stream write

The data transfer starts N_{WR} clock cycles after the card response to the sequential write command was received. The bus transaction is identical to that of a write block command. (See Figure 39 on page 105.) As the data transfer is not block oriented, the data stream does not include the CRC checksum. Consequently the host can not receive any CRC status information from the card. The data stream is terminated by a stop command. The bus transaction is identical to the write block option when a data block is interrupted by the stop command. (See Figure 41 on page 106.)

Stream write is a valid transfer only for card operating in 1-bit single data rate mode.

- Erase, set, and clear write protect timing

The host must first select the erase groups to be erased using the erase start and end command (CMD35, CMD36). The erase command (CMD38), once issued, will erase all selected erase groups. Similarly, set and clear write protect commands start a programming operation as well. The card will signal “busy” (by pulling the DAT0 line low) for the duration of the erase or programming operation. The bus transaction timings are identical to the variation of the stop transmission described in Figure 44.

- Reselecting a busy card

When a busy card which is currently in the dis state is reselected it will reinstate its busy signaling on the data line DAT0. The timing diagram for this command / response / busy transaction is given in Figure 44.

7.15.4 Bus test procedure timing

After reaching the Tran-state in the single data rate mode a host can initiate the Bus Testing procedure. The Bus Testing procedure is invalid in dual data rate mode. If there is no response to the CMD19 sent by the host, the host should read the status from the card with CMD13. If there was no response to CMD19, the host may assume that this function is not supported by the card.

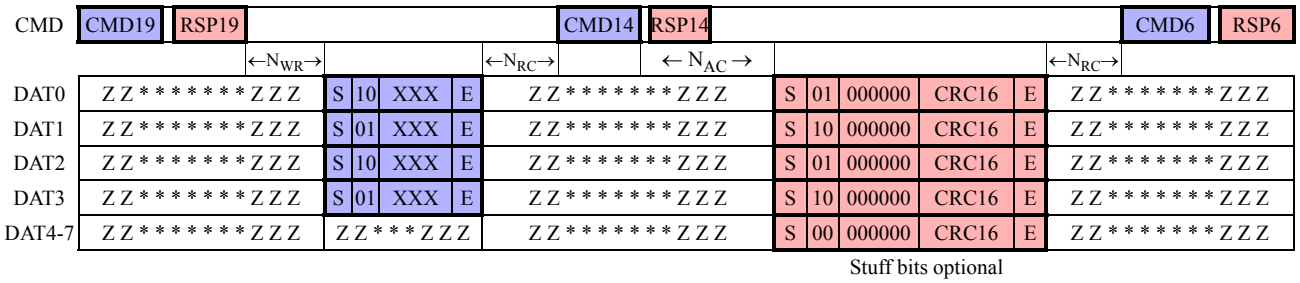
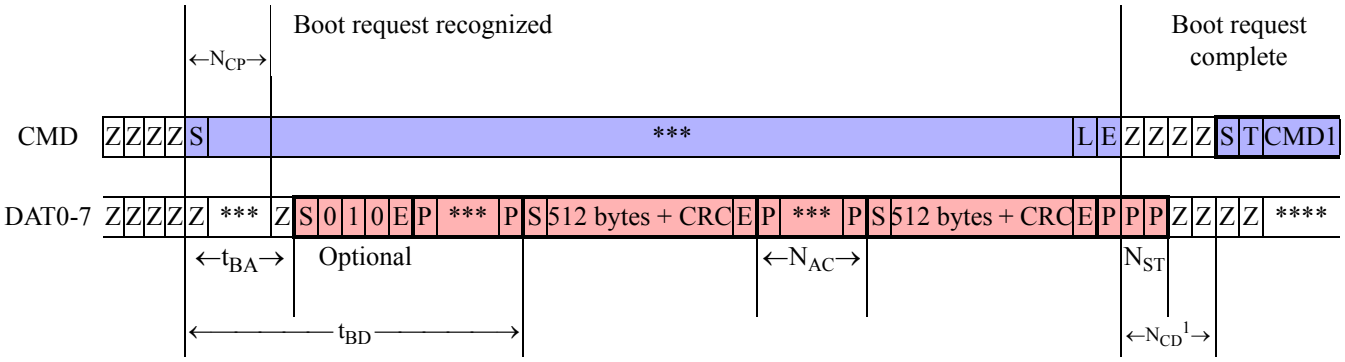


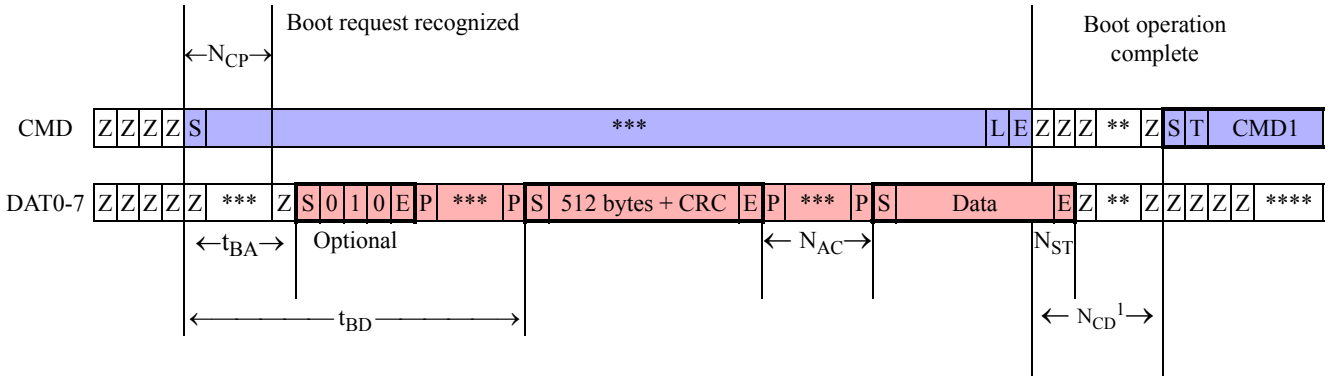
Figure 45 — Bus test procedure timing

7.15.5 Boot operation



NOTE 1. Also refer to Figure 48 on page 109.

Figure 46 — Boot operation, termination between consecutive data blocks



NOTE 1. Also refer to Figure 48 on page 109.

Figure 47 — Boot operation, termination during transfer

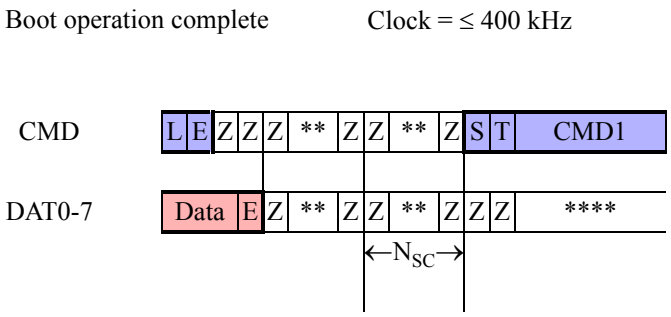
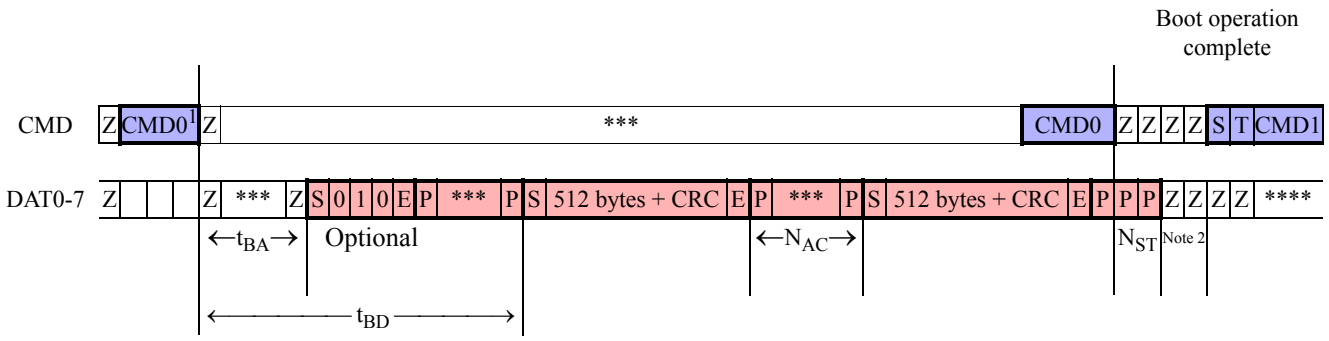


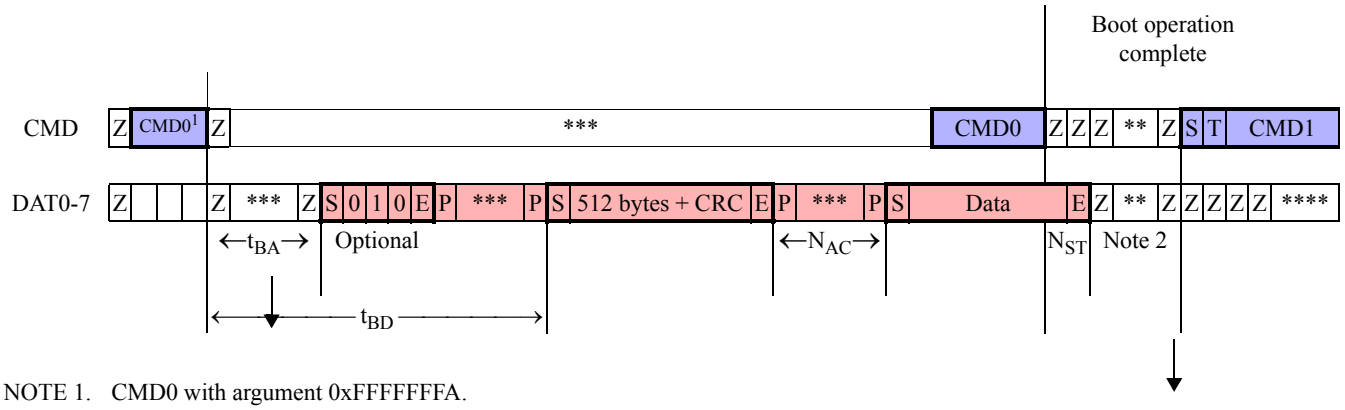
Figure 48 — Bus mode change timing (push-pull to open-drain)

7.15.6 Alternative boot operation



NOTE 1. CMD0 with argument 0xFFFFFFFA.
NOTE 2. Refer to Figure 48.

Figure 49 — Alternative boot operation, termination between consecutive data blocks



NOTE 1. CMD0 with argument 0xFFFFFFFA.
NOTE 2. Refer to Figure 48 on page 109.

Figure 50 — Alternative boot operation, termination during transfer

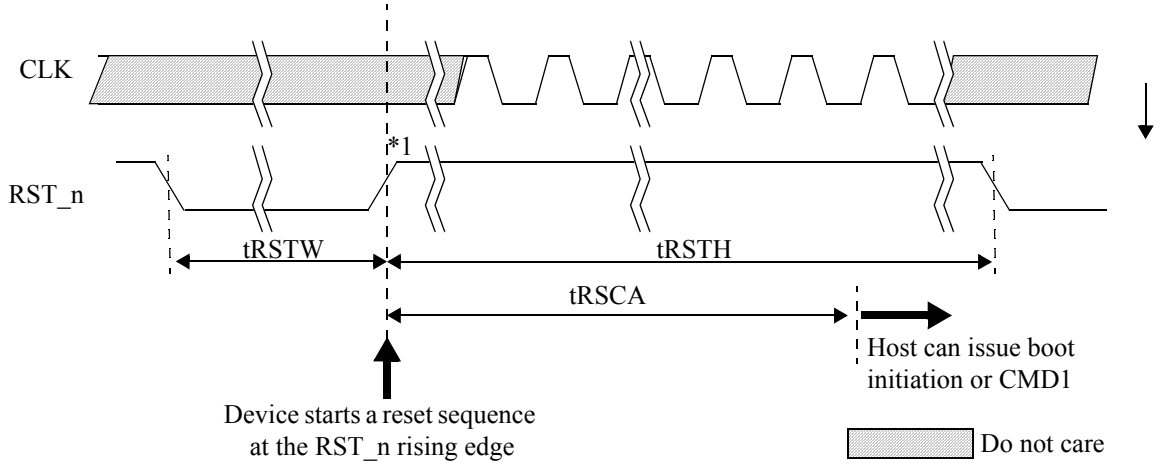
7.15.7 Timing values

Table 39 — Timing parameters

Symbol	Min	Max	Unit
N_{AC}	2	10 * (TAAC * F_{OP} + 100 * NSAC)[1]	Clock cycles
N_{CC}	8	-	Clock cycles
N_{CD}	56	-	Clock cycles
N_{CP}	74	-	Clock cycles
N_{CR}	2	64	Clock cycles
N_{ID}	5	5	Clock cycles
N_{RC}	8	-	Clock cycles
N_{SC}	8	-	Clock cycles
N_{ST}	2	2	Clock cycles
N_{WR}	2	-	Clock cycles
^{t}BA	-	50	ms
^{t}BD	-	1	s

NOTE 1. FOP is the MMC clock frequency the host is using for the read operation.
Following is a calculation example:
CSD value for TAAC is 0x26; this is equal to 1.5mSec;
CSD value for NSAC is 0;
The host frequency FOP is 10MHz
$N_{AC} = 10 \times (1.5 \times 10^{-3} \times 10 \times 10^{6} + 0) = 150{,}000$ clock cycles

7.15.8 H/W Reset operation



Note1: Device will detect the rising edge of RST_n signal to trigger internal reset sequence

Figure 51 — H/W reset waveform

Table 40 — H/W reset timing parameters

Symbol	Comment	Min	Max	Unit
tRSTW	RST_n pulse width	1		[us]
tRSCA	RST_n to Command time	200[1]		[us]
tRSTH	RST_n high period (interval time)	1		[us]

Notes:1.74 cycles of clok signal required before issuing CMD1 or CMD0 with argument 0xFFFFFFFA

7.15.9 Noise filtering timing for H/W Reset

Device must filter out 5ns or less pulse width for noise immunity

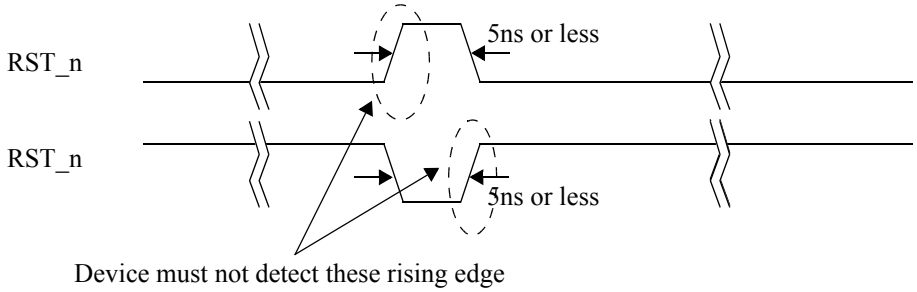


Figure 52 — Noise filtering timing for H/W reset

Card must not detect 5ns or less of positive or negative RST_n pulse. Card must detect more than or equal to 1us of positive or negative RST_n pulse width.

8 Card registers

Within the card interface six registers are defined: OCR, CID, CSD, EXT_CSD, RCA and DSR. These can be accessed only by corresponding commands (see Section 7.10 on page 85). The OCR, CID and CSD registers carry the card/content specific information, while the RCA and DSR registers are configuration registers storing actual configuration parameters. The EXT_CSD register carries both, card specific information and actual configuration parameters.

8.1 OCR register

The 32-bit operation conditions register (OCR) stores the V_{DD} voltage profile of the card and the access mode indication. In addition, this register includes a status information bit. This status bit is set if the card power up procedure has been finished. The OCR register shall be implemented by all cards.

Table 41 — OCR register definitions

OCR bit	VDD voltage window	High Voltage MultimediaCard	Dual voltage MultiMediaCard and *e*•MMC
[6:0]	Reserved	000 0000b	00 00000b
[7]	1.70–1.95V	0b	1b
[14:8]	2.0–2.6V	000 0000b	000 0000b
[23:15]	2.7–3.6V	1 1111 1111b	1 1111 1111b
[28:24]	Reserved	000 0000b	000 0000b
[30:29]	Access mode	00b (byte mode) 10b (sector mode)	00b (byte mode) 10b (sector mode)
[31]	(card power up status bit (busy)[1]		

1) This bit is set to LOW if the card has not finished the power up routine

The supported voltage range is coded as shown in Table 41, for high-voltage MultiMediaCards, dual-voltage MultiMediaCards, and *e*•MMC. As long as the card is busy, the corresponding bit (31) is set to LOW, the ‘wired-and’ operation, described in Section 7.4.2 on page 42 yields LOW, if at least one card is still busy.

8.2 CID register

The Card IDentification (CID) register is 128 bits wide. It contains the card identification information used during the card identification phase (MultiMediaCard protocol). Every individual flash or I/O card shall have an unique identification number. Every type of MultiMediaCard ROM cards (defined by content) shall have an unique identification number. Table 42 on page 114 lists these identifiers.

The structure of the CID register is defined in the following sections.

Table 42 — CID fields

Name	Field	Width	CID-slice
Manufacturer ID	MID	8	[127:120]
Reserved		6	[119:114]
Card/BGA	CBX	2	[113:112]
OEM/Application ID	OID	8	[111:104]
Product name	PNM	48	[103:56]
Product revision	PRV	8	[55:48]
Product serial number	PSN	32	[47:16]
Manufacturing date	MDT	8	[15:8]
CRC7 checksum	CRC	7	[7:1]
not used, always “1”	-	1	[0:0]

- MID [127:120]

An 8 bit binary number that identifies the card manufacturer. The MID number is controlled, defined and allocated to a MultiMediaCard manufacturer by the MMCA/JEDEC. This procedure is established to ensure uniqueness of the CID register.

- CBX [113:112]

CBX indicates the device type.

Table 43 — Device types

[113:112]	Type
00	Card (removable)
01	BGA (Discrete embedded)
10	POP
11	Reserved

- OID [111:104]

A **8**-bit binary number that identifies the card OEM and/or the card contents (when used as a distribution media either on ROM or FLASH cards). The OID number is controlled, defined and allocated to a Multi-MediaCard manufacturer by the MMCA/JEDEC. This procedure is established to ensure uniqueness of the CID register.

- PNM [103:56]

The product name is a string, 6 ASCII characters long.

- PRV [55:48]

The product revision is composed of two Binary Coded Decimal (BCD) digits, four bits each, representing an “n.m” revision number. The “n” is the most significant nibble and “m” is the least significant nibble.

As an example, the PRV binary value field for product revision “6.2” will be: 0110 0010.

- PSN [47:16]

A 32-bit unsigned binary integer.

- MDT [15:8]

The manufacturing date is composed of two hexadecimal digits, four bits each, representing a two digits date code m/y;

The “m” field, most significant nibble, is the month code. 1 = January.

The “y” field, least significant nibble, is the year code. 0 = 1997.

As an example, the binary value of the MDT field for production date “April 2000” will be: 0100 0011

- CRC [7:1]

CRC7 checksum (7 bits). This is the checksum of the CID contents computed according to Section 10.2.

8.3 CSD register

The Card-Specific Data (CSD) register provides information on how to access the card 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 CSD Registry entries in the Table 44 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 44 — CSD fields

Name	Field	Width	Cell Type	CSD-slice
CSD structure	CSD_STRUCTURE	2	R	[127:126]
System specification version	SPEC_VERS	4	R	[125:122]
Reserved	-	2	R	[121:120]
Data read access-time 1	TAAC	8	R	[119:112]
Data read access-time 2 in CLK cycles (NSAC*100)	NSAC	8	R	[111:104]
Max. bus clock frequency	TRAN_SPEED	8	R	[103:96]
Card command classes	CCC	12	R	[95:84]
Max. read data block length	READ_BL_LEN	4	R	[83:80]

Table 44 — CSD fields (continued)

Name	Field	Width	Cell Type	CSD-slice
Partial blocks for read allowed	READ_BL_PARTIAL	1	R	[79:79]
Write block misalignment	WRITE_BLK_MISALIGN	1	R	[78:78]
Read block misalignment	READ_BLK_MISALIGN	1	R	[77:77]
DSR implemented	DSR_IMP	1	R	[76:76]
Reserved	-	2	R	[75:74]
Device size	C_SIZE	12	R	[73:62]
Max. read current @ V_{DD} min	VDD_R_CURR_MIN	3	R	[61:59]
Max. read current @ V_{DD} max	VDD_R_CURR_MAX	3	R	[58:56]
Max. write current @ V_{DD} min	VDD_W_CURR_MIN	3	R	[55:53]
Max. write current @ V_{DD} max	VDD_W_CURR_MAX	3	R	[52:50]
Device size multiplier	C_SIZE_MULT	3	R	[49:47]
Erase group size	ERASE_GRP_SIZE	5	R	[46:42]
Erase group size multiplier	ERASE_GRP_MULT	5	R	[41:37]
Write protect group size	WP_GRP_SIZE	5	R	[36:32]
Write protect group enable	WP_GRP_ENABLE	1	R	[31:31]
Manufacturer default ECC	DEFAULT_ECC	2	R	[30:29]
Write speed factor	R2W_FACTOR	3	R	[28:26]
Max. write data block length	WRITE_BL_LEN	4	R	[25:22]
Partial blocks for write allowed	WRITE_BL_PARTIAL	1	R	[21:21]
Reserved	-	4	R	[20:17]
Content protection application	CONTENT_PROT_APP	1	R	[16:16]
File format group	FILE_FORMAT_GRP	1	R/W	[15:15]
Copy flag (OTP)	COPY	1	R/W	[14:14]
Permanent write protection	PERM_WRITE_PROTECT	1	R/W	[13:13]
Temporary write protection	TMP_WRITE_PROTECT	1	R/W/E	[12:12]
File format	FILE_FORMAT	2	R/W	[11:10]
ECC code	ECC	2	R/W/E	[9:8]
CRC	CRC	7	R/W/E	[7:1]
Not used, always'1'	-	1	—	[0:0]

The following sections describe the CSD fields and the relevant data types. If not explicitly defined otherwise, all bit strings are interpreted as binary coded numbers starting with the left bit first.

- CSD_STRUCTURE [127:126]

Describes the version of the CSD structure.

Table 45 — CSD register structure

CSD_STRUCTURE	CSD Structure Version	Valid for System Specification Version
0	CSD version No. 1.0	Allocated by MMCA
1	CSD version No. 1.1	Allocated by MMCA
2	CSD version No. 1.2	Version 4.1–4.2–4.3
3	Version is coded in the CSD_STRUCTURE byte in the EXT_CSD register	

- SPEC_VERS [125:122]

Defines the MultiMediaCard System Specification version supported by the card.

Table 46 — System specification version

SPEC_VERS	System Specification Version Number
0	Allocated by MMCA
1	Allocated by MMCA
2	Allocated by MMCA
3	Allocated by MMCA
4	Version 4.1–4.2–4.3
5–15	Reserved

- TAAC [119:112]

Defines the asynchronous part of the data access time.

Table 47 — TAAC access-time definition

TAAC bit position	Code
2:0	Time unit 0 = 1ns, 1 = 10ns, 2 = 100ns, 3 = 1µs, 4 = 10µs, 5 = 100µs, 6 = 1ms, 7 = 10ms
6:3	Multiplier factor 0 = reserved, 1 = 1.0, 2 = 1.2, 3 = 1.3, 4 = 1.5, 5 = 2.0, 6 = 2.5, 7 = 3.0, 8 = 3.5, 9 = 4.0, A = 4.5, B = 5.0, C = 5.5, D = 6.0, E = 7.0, F = 8.0
7	Reserved

- NSAC [111:104]

Defines the typical case for the clock dependent factor of the data access time. The unit for NSAC is 100 clock cycles. Therefore, the maximal value for the clock dependent part of the data access time is 25.5k clock cycles.

The total access time N_{AC} as expressed in Table 39 on page 111 is calculated based on TAAC and NSAC. It has to be computed by the host for the actual clock rate. The read access time should be interpreted as a typical delay for the first data bit of a data block or stream.

- TRAN_SPEED [103:96]

The following table defines the clock frequency when not in high speed mode. For cards supporting version 4.0, 4.1, and 4.2 of the standard, the value shall be 20MHz (0x2A). For cards supporting version 4.3, the value shall be 26 MHz (0x32).

Table 48 — Maximum bus clock frequency definition

TRAN_SPEED bit	Code
2:0	Frequency unit 0 = 100KHz, 1 = 1MHz, 2 = 10MHz, 3 = 100MHz, 4…7 = reserved
6:3	Multiplier factor 0 = reserved, 1 = 1.0, 2 = 1.2, 3 = 1.3, 4 = 1.5, 5 = 2.0, 6 = 2.6, 7 = 3.0, 8 = 3.5, 9 = 4.0, A = 4.5, B = 5.2, C = 5.5, D = 6.0, E = 7.0, F = 8.0
7	reserved

- CCC [95:84]

The MultiMediaCard command set is divided into subsets (command classes). The card command class register CCC defines which command classes are supported by this card. A value of ‘1’ in a CCC bit means that the corresponding command class is supported. For command class definition refer to Table 21 on page 86.

Table 49 — Supported card command classes

CCC bit	Supported Card Command Class
0	class 0
1	class 1
…	
11	class 11

- READ_BL_LEN [83:80]

The data block length is computed as $2^{READ\_BL\_LEN}$. The block length might therefore be in the range 1B, 2B,4B...16kB. (See Section 7.13 on page 96 for details.)

Note that the support for 512B read access is mandatory for all cards. And that the cards has to be in 512B block length mode by default after power-on, or software reset. The purpose of this register is to indicate the supported maximum read data block length.:

Table 50 — Data block length

READ_BL_LEN	Block length	Remark
0	2^0 = 1 Byte	
1	2^1 = 2 Bytes	
…		
11	2^{11} = 2048 Bytes	
12	2^{12} = 4096 Bytes	
13	2^{13} = 8192 Bytes	
14	2^{14} = 16 kBytes	
15	2^{15} = Extension	New register TBD to EXT_CSD

- READ_BL_PARTIAL [79]

Defines whether partial block sizes can be used in block read commands.

Up to 2GB of density (byte access mode):

READ_BL_PARTIAL=0 means that only the 512B and the READ_BL_LEN block size can be used for block oriented data transfers.

READ_BL_PARTIAL=1 means that smaller blocks can be used as well. The minimum block size will be equal to minimum addressable unit (one byte).

Higher than 2GB of density (sector access mode):

READ_BL_PARTIAL=0 means that only the 512B and the READ_BL_LEN block sizes can be used for block oriented data transfers.

READ_BL_PARTIAL=1 means that smaller blocks than indicated in READ_BL_LEN can be used as well. The minimum block size will be equal to minimum addressable unit, one sector (512B).

- WRITE_BLK_MISALIGN [78]

Defines if the data block to be written by one command can be spread over more than one physical block of the memory device. The size of the memory block is defined in WRITE_BL_LEN.

WRITE_BLK_MISALIGN=0 signals that crossing physical block boundaries is invalid.

WRITE_BLK_MISALIGN=1 signals that crossing physical block boundaries is allowed.

- READ_BLK_MISALIGN [77]

Defines if the data block to be read by one command can be spread over more than one physical block of the memory device. The size of the memory block is defined in READ_BL_LEN.

READ_BLK_MISALIGN=0 signals that crossing physical block boundaries is invalid.

READ_BLK_MISALIGN=1 signals that crossing physical block boundaries is allowed.

- DSR_IMP [76]

Defines if the configurable driver stage is integrated on the card. If set, a driver stage register (DSR) must be implemented also. (See Section 8.6 on page 154.).

Table 51 — DSR implementation code table

DSR_IMP	DSR type
0	DSR is not implemented
1	DSR implemented

- C_SIZE [73:62]

This parameter is used to compute the card capacity for cards up to 2GB of density. Please see "SEC_COUNT [215:212]" on page 136 for densities greater than 2GB. Note that for card densities greater than 2GB, the maximum possible value should be set to this register (0xFFF).

This parameter is used to compute the card capacity. The memory capacity of the card is computed from the entries C_SIZE, C_SIZE_MULT and READ_BL_LEN as follows:

memory capacity = BLOCKNR * BLOCK_LEN

where

BLOCKNR = (C_SIZE+1) * MULT

MULT = $2^{C\_SIZE\_MULT+2}$ (C_SIZE_MULT < 8)

BLOCK_LEN = $2^{READ\_BL\_LEN}$, (READ_BL_LEN < 12)

Therefore, the maximal capacity which can be coded is 4096*512*2048 = 4 GBytes. Example: A 4 MByte card with BLOCK_LEN = 512 can be coded by C_SIZE_MULT = 0 and C_SIZE = 2047.

When the partition configuration is executed by host, device will re-calculate the C_SIZE value which can indicate the size of user data area after the partition.

- VDD_R_CURR_MIN [61:59], VDD_W_CURR_MIN [55:53]

The maximum values for read and write currents at the minimal power supply V_{DD} are coded as follows:

Table 52 — V_{DD} (min) current consumption

VDD_R_CURR_MIN VDD_W_CURR_MIN	Code for current consumption @ V_{DD}
2:0	0 = 0.5mA; 1 = 1mA; 2 = 5mA; 3 = 10mA; 4 = 25mA; 5 = 35mA; 6 = 60mA; 7 = 100mA

The values in these fields are valid when the card is not in high speed mode. When the card is in high speed mode, the current consumption is chosen by the host, from the power classes defined in the PWR_ff_vvv registers, in the EXT_CSD register.

- VDD_R_CURR_MAX [58:56], VDD_W_CURR_MAX [52:50]

The maximum values for read and write currents at the maximal power supply V_{DD} are coded as follows:

Table 53 — V_{DD} (max) current consumption

VDD_R_CURR_MAX VDD_W_CURR_MAX	Code for current consumption @ V_{DD}
2:0	0 = 1mA; 1 = 5mA; 2 = 10mA; 3 = 25mA; 4 = 35mA; 5 = 45mA; 6 = 80mA; 7 = 200mA

The values in these fields are valid when the card is not in high speed mode. When the card is in high speed mode, the current consumption is chosen by the host, from the power classes defined in the PWR_ff_vvv registers, in the EXT_CSD register.

- C_SIZE_MULT [49:47]

Note that for higher than 2GB of density of card the maximum possible value should be set to this register (0x7).This parameter is used for coding a factor MULT for computing the total device size (see 'C_SIZE'). The factor MULT is defined as $2^{C\_SIZE\_MULT+2}$.

Table 54 — Multiplier factor for device size

C_SIZE_MULT	MULT	Remarks
0	$2^2 = 4$	
1	$2^3 = 8$	
2	$2^4 = 16$	
3	$2^5 = 32$	
4	$2^6 = 64$	
5	$2^7 = 128$	
6	$2^8 = 256$	
7	$2^9 = 512$	

- ERASE_GRP_SIZE [46:42]

The contents of this register is a 5 bit binary coded value, used to calculate the size of the erasable unit of the card. The size of the erase unit (also referred to as erase group) is determined by the ERASE_GRP_SIZE and the ERASE_GRP_MULT entries of the CSD, using the following equation:

size of erasable unit = (ERASE_GRP_SIZE + 1) * (ERASE_GRP_MULT + 1)

This size is given as minimum number of write blocks that can be erased in a single erase command.

- ERASE_GRP_MULT [41:37]

A 5 bit binary coded value used for calculating the size of the erasable unit of the card. See ERASE_GRP_SIZE section for detailed description.

- WP_GRP_SIZE [36:32]

The size of a write protected group. The contents of this register is a 5 bit binary coded value, defining the number of erase groups which can be write protected. The actual size is computed by increasing this number by one. A value of zero means 1 erase group, 31 means 32 erase groups.

- WP_GRP_ENABLE [31]

A value of ‘0’ means no group write protection possible.

- DEFAULT_ECC [30:29]

Set by the card manufacturer. It defines the ECC code which is recommended for use. The field definition is the same as for the ECC field described later.

- R2W_FACTOR [28:26]

Defines the typical block program time as a multiple of the read access time. The following table defines the field format.

Table 55 — R2W_FACTOR

R2W_FACTOR	Multiples of read access time
0	1
1	2 (write half as fast as read)
2	4
3	8
4	16
5	32
6	64
7	128

- WRITE_BL_LEN [25:22]

Block length for write operations. See READ_BL_LEN for field coding.

Note that the support for 512B write access is mandatory for all cards. And that the cards has to be in 512B block length mode by default after power-on, or software reset. The purpose of this register is to indicate the supported maximum write data block length.

Defines whether partial block sizes can be used in block write commands.

Up to 2GB of density (byte access mode):

WRITE_BL_PARTIAL=’0’ means that only the 512B and the WRITE_BL_LEN block size can be used for block oriented data write.

WRITE_BL_PARTIAL=’1’ means that smaller blocks can be used as well. The minimum block size is one byte.

Higher than 2GB of density (sector access mode):

WRITE_BL_PARTIAL=’0’ means that only the 512B and the WRITE_BL_LEN block size can be used for block oriented data write.

WRITE_BL_PARTIAL=’1’ means that smaller blocks can be used as well. The minimum block size will be equal to minimum addressable unit, one sector (512B).

- CONTENT_PROT_APP [16]

This field in the CSD indicates whether the content protection application is supported. MultiMediaCards which implement the content protection application will have this bit set to ‘1’;

- FILE_FORMAT_GRP [15]

Indicates the selected group of file formats. This field is read-only for ROM. The usage of this field is shown in Table 56. (See FILE_FORMAT.)

- COPY [14]

Defines if the contents is original (= ‘0’) or has been copied (=’1’). The COPY bit for OTP and MTP devices, sold to end consumers, is set to ‘1’ which identifies the card contents as a copy. The COPY bit is an one time programmable bit.

- PERM_WRITE_PROTECT [13]

Permanently protects the whole card (boot, RPMB and all user area partitions) content against overwriting or erasing (all data write and erase commands for this card are permanently disabled). The default value is ‘0’, i.e. not permanently write protected.

Setting permanent write protection for the entire card will take precedence over any other write protection mechanism currently enabled on the card. The ability to permanently protect the card by setting PERM_WRITE_PROTECT(CSD[13]) can be disabled by setting CD_PERM_WP_DIS (EXT_CSD[171] bit 6). If CD_PERM_WP_DIS is set and the master attempts to set PERM_WRITE_PROTECT(CSD[13]) the operation will fail and the ERROR (bit 19) error bit will be set in the status register.

- TMP_WRITE_PROTECT [12]

Temporarily protects the whole card content from being overwritten or erased (all write and erase commands for this card are temporarily disabled). This bit can be set and reset. The default value is ‘0’, i.e. not write protected.

Temporary write protection only applies to the write protection groups on the card where another write protection mechanism (Password, Permanent or Power-On) has not already been enabled.

- FILE_FORMAT [11:10]

Indicates the file format on the card. This field is read-only for ROM. The following formats are defined:

Table 56 — File formats

FILE_FORMAT_GRP	FILE_FORMAT	Type
0	0	Hard disk-like file system with partition table
0	1	DOS FAT (floppy-like) with boot sector only (no partition table)
0	2	Universal File Format
0	3	Others / Unknown
1	0, 1, 2, 3	Reserved

- ECC [9:8]

Defines the ECC code that was used for storing data on the card. This field is used by the host (or application) to decode the user data. The following table defines the field format.

Table 57 — ECC type

ECC	ECC type	Maximum number of correctable bits per block
0	None (default)	none
1	BCH (542, 512)	3
2–3	reserved	—

- CRC [7:1]

The CRC field carries the check sum for the CSD contents. It is computed according to Section 10.2 on page 157. The checksum has to be recalculated by the host for any CSD modification. The default corresponds to the initial CSD contents.

The following table lists the correspondence between the CSD entries and the command classes. A '+' entry indicates that the CSD field affects the commands of the related command class.

Table 58 — CSD field command classes

CSD Field	Command Classes									
	0	1	2	3	4	5	6	7	8	9
CSD_STRUCTURE	+	+	+	+	+	+	+	+	+	+
SPEC_VERS	+	+	+	+	+	+	+	+	+	+
TAAC		+	+	+	+	+	+	+	+	
NSAC		+	+	+	+	+	+	+	+	
TRAN_SPEED		+	+	+	+					
CCC	+	+	+	+	+	+	+	+	+	+
READ_BL_LEN			+							
READ_BL_PARTIAL			+							
WRITE_BLK_MISALIGN					+					
READ_BLK_MISALIGN			+							
DSR_IMP	+	+	+	+	+	+	+	+	+	+
C_SIZE_MANT		+	+	+	+	+	+	+	+	
C_SIZE_EXP		+	+	+	+	+	+	+	+	
VDD_R_CURR_MIN		+	+							
VDD_R_CURR_MAX		+	+							
VDD_W_CURR_MIN				+	+	+	+	+	+	
VDD_W_CURR_MAX				+	+	+	+	+	+	
ERASE_GRP_SIZE						+	+	+	+	
WP_GRP_SIZE							+	+	+	
WP_GRP_ENABLE							+	+	+	
DEFAULT_ECC		+	+	+	+	+	+	+	+	
R2W_FACTOR				+	+	+	+	+	+	
WRITE_BL_LEN				+	+	+	+	+	+	

Table 58 — CSD field command classes (continued)

CSD Field	Command Classes									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
WRITE_BL_PARTIAL				+	+	+	+	+	+	
FILE_FORMAT_GRP										
COPY	+	+	+	+	+	+	+	+	+	+
PERM_WRITE_PROTECT	+	+	+	+	+	+	+	+	+	+
TMP_WRITE_PROTECT	+	+	+	+	+	+	+	+	+	+
FILE_FORMAT										
ECC		+	+	+	+	+	+	+	+	
CRC	+	+	+	+	+	+	+	+	+	+

8.4 Extended CSD register

The Extended CSD register defines the card properties and selected modes. It is 512 bytes long. The most significant 320 bytes are the Properties segment, which defines the card capabilities and cannot be modified by the host. The lower 192 bytes are the Modes segment, which defines the configuration the card 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 59 — Extended CSD

Name	Field	Size (Bytes)	Cell Type	CSD-slice
Properties Segment				
Reserved[1]		7	TBD	[511:505]
Supported Command Sets	S_CMD_SET	1	R	[504]
HPI features	HPI_FEATURES	1	R	[503]
Background operations support	BKOPS_SUPPORT	1	R	[502]
Reserved[1]		255	TBD	[501:247]
Background operations status	BKOPS_STATUS	1	R	[246]
Number of correctly programmed sectors	CORRECTLY_PRG_SECTORS_NUM	4	R	[245:242]
1st initialization time after partitioning	INI_TIMEOUT_AP	1	R	[241]
Reserved[1]		1	TBD	[240]
Power class for 52MHz, DDR at 3.6V	PWR_CL_DDR_52_360	1	R	[239]
Power class for 52MHz, DDR at 1.95V	PWR_CL_DDR_52_195	1	R	[238]
Reserved[1]		2	TBD	[237:236]
Minimum Write Performance for 8bit at 52MHz in DDR mode	MIN_PERF_DDR_W_8_52	1	R	[235]
Minimum Read Performance for 8bit at 52MHz in DDR mode	MIN_PERF_DDR_R_8_52	1	R	[234]
Reserved[1]		1	TBD	[233]
TRIM Multiplier	TRIM_MULT	1	R	[232]
Secure Feature support	SEC_FEATURE_SUPPORT	1	R	[231]
Secure Erase Multiplier	SEC_ERASE_MULT	1	R	[230]
Secure TRIM Multiplier	SEC_TRIM_MULT	1	R	[229]
Boot information	BOOT_INFO	1	R	[228]
Reserved[1]		1	TBD	[227]
Boot partition size	BOOT_SIZE_MULTI	1	R	[226]
Access size	ACC_SIZE	1	R	[225]
High-capacity erase unit size	HC_ERASE_GRP_SIZE	1	R	[224]
High-capacity erase timeout	ERASE_TIMEOUT_MULT	1	R	[223]
Reliable write sector count	REL_WR_SEC_C	1	R	[222]
High-capacity write protect group size	HC_WP_GRP_SIZE	1	R	[221]
Sleep current (VCC)	S_C_VCC	1	R	[220]
Sleep current (VCCQ)	S_C_VCCQ	1	R	[219]
Reserved[1]		1	TBD	[218]
Sleep/awake timeout	S_A_TIMEOUT	1	R	[217]
Reserved[1]		1	TBD	[216]
Sector Count	SEC_COUNT	4	R	[215:212]
Reserved[1]		1	TBD	[211]

Table 59 — Extended CSD (continued)

Name	Field	Size (Bytes)	Cell Type	CSD-slice
Minimum Write Performance for 8bit at 52MHz	MIN_PERF_W_8_52	1	R	[210]
Minimum Read Performance for 8bit at 52MHz	MIN_PERF_R_8_52	1	R	[209]
Minimum Write Performance for 8bit at 26MHz, for 4bit at 52MHz	MIN_PERF_W_8_26_4_52	1	R	[208]
Minimum Read Performance for 8bit at 26MHz, for 4bit at 52MHz	MIN_PERF_R_8_26_4_52	1	R	[207]
Minimum Write Performance for 4bit at 26MHz	MIN_PERF_W_4_26	1	R	[206]
Minimum Read Performance for 4bit at 26MHz	MIN_PERF_R_4_26	1	R	[205]
Reserved[1]		1	TBD	[204]
Power class for 26MHz at 3.6V	PWR_CL_26_360	1	R	[203]
Power class for 52MHz at 3.6V	PWR_CL_52_360	1	R	[202]
Power class for 26MHz at 1.95V	PWR_CL_26_195	1	R	[201]
Power class for 52MHz at 1.95V	PWR_CL_52_195	1	R	[200]
Partition switching timing	PARTITION_SWITCH_TIME	1	R	[199]
Out-of-interrupt busy timing	OUT_OF_INTERRUPT_TIME	1	R	[198]
Reserved[1]		1	TBD	[197]
Card type	CARD_TYPE	1	R	[196]
Reserved[1]		1	TBD	[195]
CSD structure version	CSD_STRUCTURE	1	R	[194]
Reserved[1]		1	TBD	[193]
Extended CSD revision	EXT_CSD_REV	1	R	[192]
Modes Segment				
Command set	CMD_SET	1	R/W/E_P	[191]
Reserved[1]		1	TBD	[190]
Command set revision	CMD_SET_REV	1	R	[189]
Reserved[1]		1	TBD	[188]
Power class	POWER_CLASS	1	R/W/E_P	[187]
Reserved[1]		1	TBD	[186]
High-speed interface timing	HS_TIMING	1	R/W/E_P	[185]
Reserved[1]		1	TBD	[184]
Bus width mode	BUS_WIDTH	1	W/E_P	[183]
Reserved[1]		1	TBD	[182]
Erased memory content	ERASED_MEM_CONT	1	R	[181]
Reserved[1]		1	TBD	[180]

Table 59 — Extended CSD (continued)

Name	Field	Size (Bytes)	Cell Type	CSD-slice
Partition configuration	PARTITION_CONFIG	1	R/W/E & R/W/E_P	[179]
Boot config protection	BOOT_CONFIG_PROT	1	R/W & R/W/C_P	[178]
Boot bus width1	BOOT_BUS_WIDTH	1	R/W/E	[177]
Reserved[1]		1	TBD	[176]
High-density erase group definition	ERASE_GROUP_DEF	1	R/W/E_P	[175]
Reserved[1]		1	TBD	[174]
Boot area write protection register	BOOT_WP	1	R/W & R/W/C_P	[173]
Reserved[1]		1	TBD	[172]
User area write protection register	USER_WP	1	R/W, R/W/C_P & R/W/E_P	[171]
Reserved[1]		1	TBD	[170]
FW configuration	FW_CONFIG	1	R/W	[169]
RPMB Size	RPMB_SIZE_MULT	1	R	[168]
Write reliability setting register	WR_REL_SET	1	R/W	[167]
Write reliability parameter register	WR_REL_PARAM	1	R	[166]
Reserved[1]		1	TBD	[165]
Manually start background operations	BKOPS_START	1	W/E_P	[164]
Enable background operations handshake	BKOPS_EN	1	R/W	[163]
H/W reset function	RST_n_FUNCTION	1	R/W	[162]
HPI management	HPI_MGMT	1	R/W/E_P	[161]
Partitioning Support	PARTITIONING_SUPPORT	1	R	[160]
Max Enhanced Area Size	MAX_ENH_SIZE_MULT	3	R	[159:157]
Partitions attribute	PARTITIONS_ATTRIBUTE	1	R/W	[156]
Paritioning Setting	PARTITION_SETTING_ COMPLETED	1	R/W	[155]
General Purpose Partition Size	GP_SIZE_MULT	12	R/W	[154:143]
Enhanced User Data Area Size	ENH_SIZE_MULT	3	R/W	[142:140]
Enhanced User Data Start Address	ENH_START_ADDR	4	R/W	[139:136]
Reserved[1]		1	TBD	[135]
Bad Block Management mode	SEC_BAD_BLK_MGMNT	1	R/W	[134]
Reserved[1]		134	TBD	[133:0]

NOTE 1. Reserved bits should read as “0.”

- S_CMD_SET [504]

This field defines the command sets supported by the card.

Table 60 — Card-supported command sets

Bit	Command Set
7–5	Reserved
4	Allocated by MMCA
3	Allocated by MMCA
2	Allocated by MMCA
1	Allocated by MMCA
0	Standard MMC

- HPI_FEATURES [503]

This field indicates if the HPI feature is supported and which implementation is used by the device.

Table 61 — HPI features

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved						HPI_IMPLEMENTATION	HPI_SUPPORT

Bit[7:2]: Reserved

Bit[1]: HPI_IMPLEMENTATION

0x0 : HPI mechanism implementation based on CMD13

0x1 : HPI mechanism implementation based on CMD12

Bit[0]: HPI_SUPPORT

0x0 : HPI mechanism not supported (default)

0x1 : HPI mechanism supported

- BKOPS_SUPPORT [502]

This field indicates if the background operations feature is supported by the device.

Table 62 — Background operations support

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved							SUPPORTED

Bit[7:1]: Reserved

Bit[0]: SUPPORTED

0x0 : Background operations are not supported. The fields BKOPS_STATUS, BKOPS_EN, BKOPS_START and Card Status bit URGENT_BKOPS are not supported.

0x1 : Background operations are supported. The fields BKOPS_STATUS, BKOPS_EN, BKOPS_START and Card Status bit URGENT_BKOPS are supported.

- BKOPS_STATUS [246]

This field indicates the level of background operations urgency.

Table 63 — Background operations status

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved						OUTSTANDING	

Bit[7:2]: Reserved

Bit[1:0]: OUTSTANDING

0x0 : No operations required

0x1 : Operations outstanding (non critical)

0x2 : Operations outstanding (performance being impacted)

0x3 : Operations outstanding (critical)

- CORRECTLY_PRG_SECTORS_NUM [245:242]

This field indicates how many 512B sectors were successfully programmed by the last WRITE_MULTIPLE_BLOCK command (CMD25).

Table 64 — Correctly programmed sectors number

CORRECTLY_PRG_SECTORS_NUM	
EXT_CSD[245]	CORRECTLY_PRG_SECTORS_NUM_3
EXT_CSD[244]	CORRECTLY_PRG_SECTORS_NUM_2
EXT_CSD[243]	CORRECTLY_PRG_SECTORS_NUM_1
EXT_CSD[242]	CORRECTLY_PRG_SECTORS_NUM_0

Number of correctly programmed sectors =

[CORRECTLY_PRG_SECTORS_NUM_3 * 2^{24} + CORRECTLY_PRG_SECTORS_NUM_2 * 2^{16}+ CORRECTLY_PRG_SECTORS_NUM_1 * 2^{8}+ CORRECTLY_PRG_SECTORS_NUM_0 * 2^{0}]

- INI_TIMEOUT_PA [241]

This register indicates the maximum initialization timeout during the first power up after successful partitioning of an *e*•MMC device. Note that all of the initialization timeouts during consequtive power ups will have timeout max 1s (like in case of non partitioned *e*•MMC device).

Table 65 — Initilaiztion Time out value

Value	Timeout Value
0x00	Not defined
0x01	100ms × 1 = 100 ms
...	...
0xFF	100ms × 255 = 25500 ms

- TRIM_MULT [232]

This register is used to calculate the TRIM function timeout. The following formula defines the timeout value for the TRIM operation of inside a logical erase group.

TRIM Timeout = 300ms x TRIM_MULT

If the host executes TRIM operation including write sectors belonging to multiple erase groups, the total timeout value should be the multiple of the number of the erase groups involved.

Table 66 — TRIM Time out value

Value	Timeout Value
0x00	Not defined
0x01	300ms × 1 = 300 ms
...	...
0xFF	300ms × 255 = 76500 ms

- SEC_FEATURE_SUPPORT [231]

This byte allows the host to determine which secure data management features are supported on the card. The bits in this register determine whether the ERASE (CMD38) command arguments are supported and whether the host can manage the way defected portions of the memory array are retired by using SEC_BAD_BLK_MGMNT (EXT_CSD[134])

Table 67 — SEC Feature Support

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved			SEC_GB_CL_EN	Reserved	SEC_BD_BLK_EN	Reserved	SEC_ER_EN

Bit7:5:Reserved

Bit4:SEC_GB_CL_EN (R)

0x0: Card does not support the secure and insecure trim operations.

0x1: Card supports the secure and insecure trim operations. This bit being set means that argument bits 15 and 0 are supported with CMD38.

Bit3:Reserved

Bit 2:SEC_BD_BLK_EN (R)

0x0: Card does not support the automatic secure purge operation on retired defective portions of the array.

0x1: Card supports the automatic secure purge operation on retired defective portions of the array. This bit being set enables the host to set SEC_BAD_BLK_MGMNT (EXT_CSD[134]).

Bit 1:Reserved

Bit 0:SECURE_ER_EN (R)

0x0: Secure purge operations are not supported on the card.

0x1: Scure purge operations are supported. This bit being set allows the host to set bit 31 of the argument for the ERASE (CMD38) Command.

- SEC_ERASE_MULT [230]

This register is used to calculate Secure_Erase function timeout. The following formula defines the time-out value for the Secure_Erase operation of one logical erase group.

Secure Erase Timeout = 300ms x ERASE_TIMEOUT_MULT x SEC_ERASE_MULT

If the host executes Secure Erase operation including erase groups the total timeout value should be the multiple of the number of the erase groups involved.

Table 68 — Secure Erase Time out value

Value	Timeout Value
0x00	Not defined
0x01	300ms × ERASE_TIMEOUT_MULT x 1
...	...
0xFF	300ms × ERASE_TIMEOUT_MULT x 255

- SEC_TRIM_MULT [229]

This register is used to calculate Secure_TRIM function timeout. The following formula defines the time-out value for the Secure_TRIM operation of one logical erase group.

Secure TRIM Timeout = 300ms x ERASE_TIMEOUT_MULT x SEC_TRIM_MULT

If the host executes Secure Trim operation including write sectors belonging to multiple erase groups, the total timeout value should be the multiple of the number of the erase groups involved..

Table 69 — Secure Trim Time out value

Value	Timeout Value
0x00	Not defined
0x01	300ms × ERASE_TIMEOUT_MULT x 1
...	...
0xFF	300ms × ERASE_TIMEOUT_MULT x 255

BOOT_INFO [228]

Table 70 — Boot information

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved					HS_BOOT_MODE	DDR_BOOT_MODE	ALT_BOOT_MODE

Bit[7:3]: Reserved

Bit[2]: HS_BOOT_MODE

0: Device does not support high speed timing during boot.

1: Device supports high speed timing during boot.

Bit[1]: DDR_BOOT_MODE

0: Device does not support dual data rate during boot.

1: Device supports dual data rate during boot.

Bit[0]: ALT_BOOT_MODE

0: Device does not support alternative boot method (obsolete)

1: Device supports alternative boot method.

Device must show “1” since this is mandatory in v4.4 standard

The only currently valid values for this register are 0x0, 0x1, 0x05, and 0x07. A device supporting dual data rate mode during boot shall also have bit 2 set.

- BOOT_SIZE_MULT [226]

The boot partition size is calculated from the register by using the following equation:

Boot Partition size = 128Kbytes × BOOT_SIZE_MULT

Table 71 — Boot partition size

Value	Boot Size Mult
0x00	No boot partition available / Boot mode not supported
0x01	1 × 128Kbytes = 128Kbytes
0x02	2 × 128Kbytes = 256Kbytes
:	:
0xFE	254 × 128Kbytes = 32512Kbytes
0xFF	255 × 128Kbytes = 32640Kbytes

- ACC_SIZE [225]

Table 72 — Access size

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved				SUPER_PAGE_SIZE			

Bit[7:4]: Reserved

Bit[3:0]: SUPER_PAGE_SIZE

This register defines one or multiple of programmable boundary unit which is programmed at the same time. This value can be used by the master for the following cases:

As a guide for format clusters

To prevent format-page misalignment

As a guide for minimum data-transfer size

Super-page size = $512 \times 2^{(SUPER\_PAGE\_SIZE - 1)}$: $0 < X < 9$

Table 73 — Superpage size

Value	Superpage Size
0x0	Not defined
0x1	512 × 1 = 512 bytes
0x2	512 × 2 = 1K bytes
:	:
0x8	512 × 128 = 64K bytes
0x9–0xF	Reserved

- HC_ERASE_GRP_SIZE [224]

This register defines the erase-unit size for high-capacity memory. If the master enables bit "0" in the extended CSD register byte [175], the slave uses these value for the erase operation.

Erase Unit Size = 512Kbyte × HC_ERASE_GRP_SIZE

Table 74 — Erase-unit size

Value	Value definition
0x00	No support for high-capacity erase-unit size
0x01	512Kbyte × 1 = 524,288 bytes
0x02	512Kbyte × 2 = 1,048,576 bytes
:	:
0xFF	512Kbyte × 255 = 133,693,440 bytes

If the ENABLE bit in ERASE_GROUP_DEF is cleared to LOW or HC_WP_GRP_SIZE is set to 0x00, the write protect group size definition would be the original case.

- ERASE_TIMEOUT_MULT [223]

This register is used to calculate erase timeout for high-capacity erase operations and defines the timeout value for the erase operation of one erase group.

Erase Timeout = 300ms × ERASE_TIMEOUT_MULT

If the host executes erase operations for multiple erase groups, the total timeout value should be the multiple of the number of erase groups issued.

If the master enables bit 0 in the extended CSD register byte [175], the slave uses ERASE_TIMEOUT_MULT values for the timeout value.

If ERASE_TIMEOUT_MULT is set to 0x00, the slave must support the previous timeout definition.

Table 75 — Erase timeout values

Value	Timeout Values
0x00	No support for high-capacity erase timeout
0x01	300ms × 1 = 300ms
0x02	300ms × 2 = 600ms
:	:
0xFF	300ms × 255 = 76,500ms

- REL_WR_SEC_C [222]

The reliable write feature requires mandatory sector count 1 (512B) support. In the case where the

EN_REL_WR parameter in the WR_REL_PARAM extended CSD register is set to 1, this register has no meaning. If HPI_SUPPORT =1 and EN_REL_WR=0 then the REL_WR_SEC_C register value must be 1. Otherwise, when EN_REL_WR is set to 0 and HPI_SUPPORT=0 thenthis register may indicate an additional supported sector count.

In applications where only the single-sector write is supported, the value in the register should be “1.” Otherwise, the value should be the multiple of the number of sectors supported.

Table 76 — Reliable write sector count

Name	Field	Size	Cell Type
Reliable Write Sector Count	REL_WR_SEC_C	1	R

- HC_WP_GRP_SIZE [221]

This register defines the write protect group size for high-capacity memory. If the ENABLE bit in ERASE_GROUP_DEF is set to HIGH, the write protect group size would be defined as follows:

Write protect group size = 512KB * HC_ERASE_GRP_SIZE * HC_WP_GRP_SIZE.

Table 77 — Write protect group size

Value	Value definition
0x00	No support for high-capacity write protect group size
0x01	1 high-capacity erase unit size
0x02	2 high-capacity erase unit size
0x03	3 high-capacity erase unit size
:	:
0xFF	255 high-capacity erase unit size

If the ENABLE bit in ERASE_GROUP_DEF is cleared to LOW or HC_WP_GRP_SIZE is set to 0x00, the write protect group size definition would be the original case.

- S_C_VCC, S_C_VCCQ [220], [219]

The S_C_VCC and S_C_VCCQ registers define the max VCC current consumption during the Sleep state (slp). The formula to calculate the max current value is:

Sleep current = 1µA * 2^X : register value = X >0

Sleep current = no value (legacy) : register value = 0

Max register value defined is 0x0D which equals 8.192mA. Values between 0x0E and 0xFF are reserved.

Table 78 — S_C_VCC, S_C_VCCQ timeout values

Value	Value definition
0x00	Not defined
0x01	$1\mu A \times 2^1 = 2\mu A$
0x02	$1\mu A \times 2^2 = 4\mu A$
:	:
0x0D	$1\mu A \times 2^{13} = 8.192mA$
0x0E–0xFF	Reserved

- S_A_TIMEOUT [217]

This register defines the max timeout value for state transitions from Standby state (stby) to Sleep state (slp) and from Sleep state (slp) to Standby state (stby). The formula to calculate the max timeout value is:

Sleep/Awake Timeout = 100ns * 2^S_A_timeout

Max register value defined is 0x17 which equals 838.86ms timeout. Values between 0x18 and 0xFF are reserved.

Table 79 — Sleep/awake timeout values

Value	Timeout Values
0x00	Not defined
0x01	$100ns \times 2^1 = 200ns$
0x02	$100ns \times 2^2 = 400ns$
:	:
0x17	$100ns \times 2^{23} = 838.86ms$
0x18–0xFF	Reserved

- SEC_COUNT [215:212]

The device density is calculated from the register by multiplying the value of the register (sector count) by 512B/sector as shown in following equation.

Device density = SEC_COUNT x 512B

The maximum density possible to be indicated is thus 4 294 967 295x 512B.

The addressable sector range for the device will be from Sector 0 to Sector (SEC_COUNT-1).

The least significant byte (LSB) of the sector count value is the byte [212].

When the partition configuration is executed by host, device will re-calculate the SEC_COUNT value which can indicate the size of user data area after the partition.

- MIN_PERF_a_b_ff [210/:205], MIN_PERF_DDR_a_b_ff [235:234]

These fields defines the overall minimum performance value for the read and write access with different bus width and max clock frequency modes. The value in the register is coded as follows. Other than defined values are illegal.

Table 80 — R/W access performance values

Value	Performance
Single Data Rate mode	
0x00	For cards not reaching the 2.4MB/s value
0x08	Class A: 2.4MB/s and is the next allowed value (16x150kB/s)
0x0A	Class B: 3.0MB/s and is the next allowed value (20x150kB/s)
0x0F	Class C: 4.5MB/s and is the next allowed value (30x150kB/s)
0x14	Class D: 6.0MB/s and is the next allowed value (40x150kB/s)
0x1E	Class E: 9.0MB/s and is the next allowed value (60x150kB/s) This is also the highest class which any MMCplus or MMC mobile card is needed to support in low bus category operation mode (26MHz with 4bit data bus). A MMCplus or MMCmobile card supporting any higher class than this have to support this class also (in low category bus operation mode).
0x28	Class F: Equals 12.0MB/s and is the next allowed value (80x150kB/s)
0x32	Class G: Equals 15.0MB/s and is the next allowed value (100x150kB/s)
0x3C	Class H: Equals 18.0MB/s and is the next allowed value (120x150kB/s)
0x46	Class J: Equals 21.0MB/s and is the next allowed value (140x150kB/s) This is also the highest class which any MMCplus or MMC mobile card is needed to support in mid bus category operation mode (26MHz with 8bit data bus or 52MHz with 4bit data bus). A MMCplus or MMCmobile card supporting any higher class than this have to support this Class (in mid category bus operation mode) and Class E also (in low category bus operation mode)
0x50	Class K: Equals 24.0MB/s and is the next allowed value (160x150kB/s)
0x64	Class M: Equals 30.0MB/s and is the next allowed value (200x150kB/s)
0x78	Class O: Equals 36.0MB/s and is the next allowed value (240x150kB/s)
0x8C	Class R: Equals 42.0MB/s and is the next allowed value (280x150kB/s)
0xA0	Class T: Equals 48.0MB/s and is the last defined value (320x150kB/s)
Dual Data Rate mode	
0x00	For cards not reaching the 4.8MB/s value
0x08	Class A: Equals 4.8MB/s and is the next allowed value (16x300kB/s)
0x0A	Class B: Equals 6.0MB/s and is the next allowed value (20x300kB/s)
0x0F	Class C: Equals 9.0MB/s and is the next allowed value (30x300kB/s)
0x14	Class D: Equals 12.0MB/s and is the next allowed value (40x300kB/s)
0x1E	Class E: Equals 18.0MB/s and is the last defined value (60x300kB/s)
0x28	Class F: Equals 24.0MB/s and is the next allowed value (80x300kB/s)
0x32	Class G: Equals 30.0MB/s and is the next allowed value (100x300kB/s)
0x3C	Class H: Equals 36.0MB/s and is the next allowed value (120x300kB/s)
0x46	Class J: Equals 42.0MB/s and is the last defined value (140x300kB/s)
0x50	Class K: Equals 48.0MB/s and is the next allowed value (160x300kB/s)
0x64	Class M: Equals 60.0MB/s and is the next allowed value (200x300kB/s)
0x78	Class O: Equals 72.0MB/s and is the next allowed value (24 0x300kB/s)
0x8C	Class R: Equals 84.0MB/s and is the next allowed value (280x300kB/s)
0xA0	Class T: Equals 96.0MB/s and is the last defined value (320x300kB/s)

- PWR_CL_ff_vvv [203:200], PWR_CL_DDR_ff_vvv [239:238]

These fields define the supported power classes by the card. By default, the card has to operate at maximum frequency using 1 bit bus configuration, within the default max current consumption, as stated in the table below. If 4 bit/8 bits bus configurations, require increased current consumption, it has to be stated in these registers.

By reading these registers the host can determine the power consumption of the card in different bus modes. Bits [7:4] code the current consumption for the 8 bit bus configuration. Bits [3:0] code the current consumption for the 4 bit bus configuration.

The PWR_52_vvv registers are not defined for 26MHz MultiMediaCards.

Table 81 — Power classes

Voltage	Value	Max RMS Current	Max Peak Current	Remarks
3.6V	0	100 mA	200 mA	Default current consumption for high voltage cards
	1	120 mA	220 mA	
	2	150 mA	250 mA	
	3	180 mA	280 mA	
	4	200 mA	300 mA	
	5	220 mA	320 mA	
	6	250 mA	350 mA	
	7	300 mA	400 mA	
	8	350 mA	450 mA	
	9	400 mA	500 mA	
	10	450 mA	550 mA	
	11-15			Reserved for future use
1.95V	0	65 mA	130 mA	Default current consumption for Dual voltage cards
	1	70 mA	140 mA	
	2	80 mA	160 mA	
	3	90 mA	180 mA	
	4	100 mA	200 mA	
	5	120 mA	220 mA	
	6	140 mA	240 mA	
	7	160 mA	260 mA	
	8	180 mA	280 mA	
	9	200 mA	300 mA	
	10	250 mA	350 mA	
	11-15			Reserved for future use

The measurement for max RMS current is done as average RMS current consumption over a period of 100ms.

Max peak current is defined as absolute max value not to be exceeded at all.

The conditions under which the power classes are defined are:

- Maximum bus frequency
- Maximum operating voltage

- Worst case functional operation
- Worst case environmental parameters (temperature,...)

These registers define the maximum power consumption for any protocol operation in data transfer mode, Ready state and Identification state.

- PARTITION_SWITCH_TIME [199]

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.

Table 82 — Partition switch timeout definition

Value	Timeout value definition
0x00	Not defined
0x01	10ms x 1 = 10ms
0x02	10ms x 2 = 20ms
:	:
0xFF	10ms x 255 = 2550ms

- OUT_OF_INTERRUPT_TIME [198]

This field indicates the maximum timeout to close a command interrupted by HPI – time between the end bit of CMD12/13 to the DAT0 release by the device.

Time is expressed in units of 10-milliseconds.

Table 83 — Out-of-interrupt timeout definition

Value	Timeout value definition
0x00	Not defined
0x01	10ms x 1 = 10ms
0x02	10ms x 2 = 20ms
:	:
0xFF	10ms x 255 = 2550ms

- CARD_TYPE [196]

This field defines the type of the card.

Table 84 — Card types

Bit	Card Type
7:4	Reserved
3	High-Speed Dual Data Rate MultimediaCard @ 52MHz - 1.2V I/O
2	High-Speed Dual Data Rate MultimediaCard @ 52MHz - 1.8V or 3V I/O
1	High-Speed MultiMediaCard @ 52MHz - at rated device voltage(s)
0	High-Speed MultiMediaCard @ 26MHz - at rated device voltage(s)

The only currently valid values for this field are 0x01, 0x03, 0x07, 0x0B and 0x0F.
Ex) A dual voltage 1.2V/1.8V device which supports 52MHz DDR mode at 1.8V and not at 1.2V will be coded 0x7.
Dual Data Rate mode support is optional

- CSD_STRUCTURE [194]

This field is a continuation of the CSD_STRUCTURE field in the CSD register

Table 85 — CSD register structure

CSD_STRUCTURE	CSD structure version	Valid for System Specification Version
0	CSD version No. 1.0	Allocated by MMCA
1	CSD version No. 1.1	Allocated by MMCA
2	CSD version No. 1.2	Version 4.1–4.2–4.3-4.4
3–255	Reserved for future use	

- EXT_CSD_REV [192]

Defines the fixed parameters related to the EXT_CSD, according to its revision

Table 86 — Extended CSD revisions

EXT_CSD_REV	Extended CSD Revision
255–6	Reserved
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)

- CMD_SET [191]

Contains the binary code of the command set that is currently active in the card. The command set can be changed using the Command Set-access type of the SWITCH command (CMD6). Note that while changing the command set with the SWITCH command, bit index values according to the S_CMD_SET register should be used. For backward compatibility, the CMD_SET is set to 0x00 (standard MMC) following power-up. After switching back to the standard MMC command set with the SWITCH command, the value of the CMD_SET is 0x01.

- CMD_SET_REV [189]

Contains a binary number reflecting the revision of the currently active command set. For Standard MMC. command set it is:

Table 87 — Standard MMC command set revisions

Code	MMC Revision
255–1	Reserved
0	v4.0

This field, though in the Modes segment of the EXT_CSD, is read only.

- POWER_CLASS [187]

This field contains the 4-bit value of the selected power class for the card. The power classes are defined in Table 88. The host should be responsible of properly writing this field with the maximum power class it allows the card to use. The card uses this information to, internally, manage the power budget and deliver an optimized performance.

This field is 0 after power-on or software reset.

Table 88 — Power class codes

Bits	Description
[7:4]	Reserved
[3:0]	Card power class code (See Table 81 on page 138)

- HS_TIMING [185]

This field is 0 after power-on, H/W reset or software reset, thus selecting the backwards compatibility interface timing for the card. If the host writes 1 to this field, the card changes its timing to high speed interface timing (see Section 12.7.1 on page 177)

- BUS_WIDTH [183]

It is set to ‘0’ (1 bit data bus) after power up and can be changed by a SWITCH command.

Table 89 — Bus mode values

Value	Bus Mode
255–7	Reserved
6	8 bit data bus (dual data rate)
5	4 bit data bus (dual data rate)
4–3	Reserved
2	8 bit data bus
1	4 bit data bus
0	1 bit data bus

HS_TIMING must be set to “0x1” before setting BUS_WIDTH for dual data rate operation (values 5 or 6)

- ERASED_MEM_CONT [181]

This field defines the content of an explicitly erased memory range.

Table 90 — Erased memory content values

Value	Erased Memory Content
255–2	Reserved
1	Erased memory range shall be ‘1’
0	Erased memory range shall be ‘0’

- PARTITION_CONFIG (before BOOT_CONFIG) [179]

This register defines the configuration for partitions.

Table 91 — Boot configuration bytes

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	BOOT_ACK	BOOT_PARTITION_ENABLE			PARTITION_ACCESS		
	R/W/E	R/W/E			R/W/E_P		

Bit 7: Reserved

Bit 6: BOOT_ACK (R/W/E)

0x0 : No boot acknowledge sent (default)

0x1 : Boot acknowledge sent during boot operation

Bit[5:3] : BOOT_PARTITION_ENABLE (R/W/E)

User selects boot data that will be sent to master

0x0 : Device not boot enabled (default)

0x1 : Boot partition 1 enabled for boot

0x2 : Boot partition 2 enabled for boot

0x3–0x6 : Reserved

0x7 : User area enabled for boot

Bit[2:0] : PARTITION_ACCESS (before BOOT_PARTITION_ACCESS, R/W/E_P)

User selects partitions to access

0x0 : No access to boot partition (default)

0x1 : R/W boot partition 1

0x2 : R/W boot partition 2

0x3 : R/W Replay Protected Memory Block (RPMB)

0x4 : Access to General Purpose partition 1

0x5 : Access to General Purpose partition 2

0x6 : Access to General Purpose partition 3

0x7 : Access to General Purpose partition 4

- BOOT_CONFIG_PROT [178]

This register defines boot configuration protection.

Table 92 — Boot config protection

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved			PERM_BOOT_ CONFIG_PROT	Reserved			PWR_BOOT_ CONFIG_PROT
			R/W				R/W/C_P

Bit [7:5] : Reserved

Bit [4]: PERM_BOOT_CONFIG_PROT (R/W)

0x0 : PERM_BOOT_CONFIG_PROT is not enabled (default)

0x1 : Permanently disable the change of boot configuration register bits relating boot mode operation (BOOT_PARTITION_ENABLE, BOOT_ACK, RESET_BOOT_BUSWIDTH BOOT_MODE and BOOT_BUS_WIDTH).

Bit[3:1] : Reserved

Bit[0] : PWR_BOOT_CONFIG_PROT (R/W/C_P)

0x0 : PWR_BOOT_CONFIG_PROT_ is not enabled (default)

0x1 : Disable the change of boot configuration register bits relating to boot mode operation (BOOT_PARTITION_ENABLE, BOOT_ACK, RESET_BOOT_BUSWIDTH BOOT_MODE and BOOT_BUS_WIDTH) from at this point until next power cycle or next H/W reset operation (but not CMD0 Reset operation).

If PERM_BOOT_CONFIG_PROT is enabled,whether PWR_BOOT_CONFIG_PROT is enable or not, BOOT mode is permanently locked and cannot reversed.

- BOOT_BUS_WIDTH [177]

This register defines the bus width for boot operation.

Table 93 — Boot bus configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved			BOOT_MODE		RESET_BOOT_BUS_WIDTH	BOOT_BUS_WIDTH	

Bit[7:5] : Reserved

Bit [4:3] : BOOT_MODE (non-volatile)

0x0 : Use single data rate + backward compatible timings in boot operation (default)

0x1 : Use single data rate + high speed timings in boot operation mode

0x2 : Use dual data rate in boot operation

0x3 : Reserved

Bit [2]: RESET_BOOT_BUS_WIDTH (non-volatile)

0x0 : Reset bus width to x1, single data rate and backward compatible timings after boot operation (default)

0x1 : Retain BOOT_BUS_WIDTH and BOOT_MODE values after boot operation. This is relevant to Push-pull mode operation only.

Bit[1:0] : BOOT_BUS_WIDTH (non-volatile)

0x0 : x1 (sdr) or x4 (ddr) bus width in boot operation mode (default)

0x1 : x4 (sdr/ddr) bus width in boot operation mode

0x2 : x8 (sdr/ddr) bus width in boot operation mode

0x3 : Reserved

- ERASE_GROUP_DEF [175]

This register allows master to select high capacity erase unit size, timeout value, and write protect group size. Bit defaults to “0” on power on.

Table 94 — ERASE_GROUP_DEF

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved							ENABLE

Bit[7:1]: Reserved

Bit0: ENABLE

0x0 : Use old erase group size and write protect group size definition (default)

0x1 : Use high-capacity erase unit size, high capacity erase timeout, and high-capacity write protect group size definition.

- BOOT_WP [173]

This byte allows the host to apply permanent or power-on write protection to the boot area. Also, the register allows the master to disable either power-on or permanent write protection or both. The default state of the bits is zero.

Table 95 — BOOT area write protection

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	B_PWR_WP_DIS	Reserved	B_PERM_WP_DIS	Reserved	B_PERM_WP_EN	Reserved	B_PWR_WP_EN
	R/W/C_P		R/W		R/W		R/W/C_P

Bit[7]: Reserved

Bit[6]: B_PWR_WP_DIS (R/W/C_P)

0x0:Master is permitted to set B_PWR_WP_EN(bit 0)

0x1: Disable the use of B_PWR_WP_EN(bit 0). This bit must be zero if PWR_WP_EN is set.

Bit[5]: Reserved

Bit[4]: B_PERM_WP_DIS (R/W)

0x0: Master is permitted to set B_PERM_WP_EN(bit 2)

0x1: Permanently disable the use of B_PERM_WP_EN(bit 2). This bit must be zero if B_PERM_WP_EN is set. This bit has no impact on the setting of CSD[13].

Bit[3]: Reserved

Bit[2]: B_PERM_WP_EN (R/W)

0x0: Boot region is not permanently write protected.

0x1: Boot region is permanently write protected. This bit must be zero if B_PERM_WP_DIS is set. This bit only indicates if permanent protection has been set specifically for the boot region. This bit may be zero if the whole card is permanently protected using CSD[13].

Bit[1]: Reserved

Bit[0]: B_PWR_WP_EN (R/W/C_P)

0x0 : Boot region is not power-on write protected.

0x1 : Enable Power-On Period write protection to the boot area. This bit must be zero if B_PWR_WP_DIS (bit 6) is set

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.

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

- USER_WP [171]

This byte allows the host to apply permanent or power-on write protection to all the partitions in the user area. Also, the register allows the host to disable the different protection modes that apply to the user area.

Table 96 — User area write protection

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
PERM_PSWD_DIS	CD_PERM_WP_DIS	Reserved	US_PERM_WP_DIS	US_PWR_WP_DIS	US_PERM_WP_EN	Reserved	US_PWR_WP_EN
R/W	R/W		R/W	R/W/C_P	R/W/E_P		R/W/E_P

Bit[7]: PERM_PSWD_DIS (R/W)

0x0: Password protection features are enabled.

0x1: Password protection features (ERASE (Forcing erase), LOCK, UNLOCK, CLR_PWD, SET_PWD) are disabled permanently.

Bit[6]: CD_PERM_WP_DIS (R/W)

0x0: Host is permitted to set PERM_WP_PROTECT (CSD[13])

0x1: Disable the use of PERM_WP_PROTECT (CSD[13]).

Bit[5]: Reserved

Bit[4]: US_PERM_WP_DIS (R/W)

0x0: Permanent write protection can be applied to write protection groups.

0x1: Permanently disable the use of permanent write protection for write protection groups within all the partitions in the user area from the point this bit is set forward. Setting this bit does not impact areas that are already protected.

Bit[3]: US_PWR_WP_DIS (R/W/C_P)

0x0: Power-on write protection can be applied to write protection groups.

0x1: Disable the use of power-on period write protection for write protection groups within all the partitions in the user area from the point this bit is set until power is removed or a hardware reset occurs. Setting this bit does not impact areas that are already protected.

Bit[2]: US_PERM_WP_EN (R/W/E_P)

0x0: Permanent write protection is not applied when CMD28 is issued.

0x1: Apply permanent write protection to the protection group indicated by CMD28. This bit cannot be set if US_PERM_WP_DIS is set.

Bit[1]: Reserved

Bit[0]: US_PWR_WP_EN (R/W/E_P)

0x0: Power-on write protection is not applied when CMD28 is issued.

0x1: Apply Power-On Period protection to the protection group indicated by CMD28. This bit cannot be set if US_PWR_WP_DIS is set. This bit has not impact if US_PERM_WP_EN is set.

This field is set to zero after power on or hardware reset.

Issuing CMD28 when both US_PERM_WP_EN and US_PWR_WP_EN, will result in the write protection group being permanently protected.

- FW_CONFIG [169]

The Update_Disable bit disables the possibility to update the FW of the *e*•MMC.

Table 97 — FW Update Disable

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved							Update_Disable

Bit[7:1]: Reserved

Bit[0]: Update_Disabl

0x0: FW updates enabled.

0x1: FW update disabled permanently

- RPMB_SIZE_MULT [168]

The RPMB partition size is calculated from the register by using the following equation:

RPMB partition size = 128kB x RPMB_SIZE_MULT

Table 98 — RPMB Partition Size

Value	Value definition
0x00	No RPMB partition available.
0x01	1 x 128Kbyte = 128Kbytes
0x02	2 x 128Kbyte = 256Kbytes
:	:
0xFF	255 x 128Kbyte = 32640Kbytes

- WR_REL_SET [167]

The write reliability settings register indicates the reliability setting for each of the user and general area partitions in the device. The contents of this register are read only if the HS_CTRL_REL is 0 in the WR_REL_PARAM extended CSD register. The default value of these bits is not specified and is determined by the device.

Table 99 — Write reliability setting

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

Bit[7:5]: Reserved

Bit[4]: WR_DATA_REL_4

0x0: In general purpose partition 4, the write operation has been optimized for performance and existing data in the partition could be at risk if a power failure occurs.

0x1: In general purpose partition 4, the device protects previously written data if power failure occurs during a write operation.

Bit[3]: WR_DATA_REL_3

0x0: In general purpose partition 3, the write operation has been optimized for performance and existing data in the partition could be at risk if a power failure occurs.

0x1: In general purpose partition 3, the device protects previously written data if power failure occurs during a write operation.

Bit[2]: WR_DATA_REL_2

0x0: In general purpose partition 2, the write operation has been optimized for performance and existing data in the partition could be at risk if a power failure occurs.

0x1: In general purpose partition 2, the device protects previously written data if power failure occurs during a write operation.

Bit[1]: WR_DATA_REL_1

0x0: In general purpose partition 1, the write operation has been optimized for performance and existing data in the partition could be at risk if a power failure occurs.

0x1: In general purpose partition 1, the device protects previously written data if power failure occurs during a write operation.

Bit[0]: WR_DATA_REL_USR

0x0: In the main user area, write operations have been optimized for performance and existing data could be at risk if a power failure occurs.

0x1: In the main user area, the device protects previously written data if power failure occurs during a write operation.

- WR_REL_PARAM [166]

This write reliability parameter register indicates whether the device supports the MMC v4.41 data reliability definitions.

Table 100 — Write reliability parameter register

Name	Field	Bit	Type
Host controlled data reliability	HS_CTRL_REL	0	R
Reserved		1	
Enhanced Reliabilit Write	EN_REL_WR	2	R
Reserved		7:3	

Bit[7:3]: Reserved

Bit[2]: EN_REL_WR (R)

0x0: The device supports the previous definition of reliable write.

0x1: The device supports the enhanced definition of reliable write

Bit[1]: Reserved

Bit[0]: HS_CTRL_REL (R)

0x0: All the WR_DATA_REL parameters in the WR_REL_SET register are read only bits.

0x1: All the WR_DATA_REL parameters in the WR_REL_SET registers are R/W.

- BKOPS_START [164]

Writing any value to this field shall manually start background operations. Device shall stay busy till no more background operations are needed.

- BKOPS_EN [163]

This field allows the host to indicate to the device if it is expected to periodically manually start background operations by writing to the BKOPS_START field.

Table 101 — Background operations enable

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved							ENABLE

Bit[7:1]: Reserved

Bit[0]: ENABLE

0x0 : Host does not support background operations handling and is not expected to write to BKOPS_START field.

0x1 : Host is indicating that it shall periodically write to BKOPS_START field to manually start background operations.

- RST_n_FUNCTION [162]

For backward compatibility reason, RST_n signal is temporary disabled in device by default. Host may need to set the signal as either permanently enable or permanently disable before it uses the card.

Table 102 — H/W reset function

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved						RST_n_ENABLE	

Bit[7:2]: Reserved

Bit[1:0]: RST_n_ENABLE (Reable and Writable once)

0x0: RST_n signal is temporarily disabled (default)

0x1: RST_n signal is permanently enabled

0x2: RST_n signal is permanently disabled

0x3: Reserved

By default, RST_n_ENABLE is set to 0x0, which is RST_n is temporarily disabled. Host can change the value to either 0x1 (permanently enabled) or 0x2 (permanently disabled). Once host sets the value to either one, the value can not be changed again.

Once host sets RST_n_ENABLE bits to 0x2 (permanently disabled), the card will not accept the input of RST_n signal permanently.

During the disable period, the card has to take care that any state of RST_n (high, low and floating) will not cause any issue (i.e. mal function and high leakage current in the input buffer) in the device.

When RST_n_ENABLE is set to 0x1 (permanently enabled), the card accepts the input of RST_n permanently. Host can not change the bits back to the disabled values. Also, when host set RST_n_ENABLE to 0x1, the card must not start resetting internal circuits by triggering the register bit change. Internal reset sequence must be triggered by RST_n rising edge but not by the register change.

Since card does not have any internal pull up or pull down resistor on RST_n terminal, host has to pull up or down RST_n to prevent the input circuits from flowing unnecessary leakage current when RST_n is enabled.

- HPI_MGMT [161]

This field allows the host to activate the HPI mechanism.

Table 103 — HPI management

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved							HPI_EN

Bit[7:1]: Reserved

Bit[0]: HPI_EN

0x0 : HPI mechanism not activated by the host (default)

0x1 : HPI mechanism activated by the host

- PARTITIONING_SUPPORT [160]

This register defines supported partition features.

Table 104 — Partitioning Support

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved						ENH_ATTRIBUTE_EN	PARTITIONING_EN

Bit[7:2]: Reserved

Bit[1]: ENH_ATTRIBUTE_EN

0x0: Device can not have enhanced technological features in partitions and user data area

0x1: Device can have enhanced technological features in partitions and user data area

Bit[0]: PARTITIONING_EN

0x0: Device does not support partitioning features

0x1: Device supports partitioning features

Partitioning feature is optional for device

- MAX_ENH_SIZE_MULT [159:157]

This register defines max. amount of memory area which can have the enhanced attribute. The Write Protect Group size refers to the high capacity definition.

Table 105 — Max. Enhanced Area Size

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
MAX_ENH_SIZE_MULT_2							
MAX_ENH_SIZE_MULT_1							
MAX_ENH_SIZE_MULT_0							

Max Enhanced Area = MAX_ENH_SIZE_MULT x HC_WP_GRP_SIZE x HC_ERASE_GPR_SIZE x 512kBytes

$$\sum_{i=1} \text{Enhanced general partition Size(i)} + \text{Enhanced user data area} \leq \text{Max Enhanced Area}$$

- **PARTITIONS_ATTRIBUTE** [156]

This register bits sets enhanced attribute in general purpose partitions.

Table 106 — Partitions Attribute

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved			ENH_4	ENH_3	ENH_2	ENH_1	ENH_USR

Bit[7:5]: Reserved

Bit[4]: ENH_4

0x0: Default

0x1: Set Enhanced attribute in General Purpose partition 4

Bit[3]: ENH_3

0x0: Default

0x1: Set Enhanced attribute in General Purpose partition 3

Bit[2]: ENH_2

0x0: Default

0x1: Set Enhanced attribute in General Purpose partition 2

Bit[1]: ENH_1

0x0: Default

0x1: Set Enhanced attribute in General Purpose partition 1

Bit[0]: ENH_USR

0x0: Default

0x1: Set Enhanced attribute in User Data Area

- PARTITION_SETTING_COMPLETED [156]

Default value states that any partitions configuration procedure has been issued by the host. The bit is set to notify the device that the definition of parameters has been completed and the device can start its internal configuration activity. If a sudden power loss occurs and this bit has not been set yet, the configuration of partitions shall be invalidated and must be repeated.

Table 107 — Partition Setting

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved							PARTITION_SETTING_COMPLETED

- GP_SIZE_MULT_GP0 - GP_SIZE_MULT_GP3 [154:143]

This register defines general purpose partition size.

General Purpose Partitions size shall be expressed in terms of high capacity write protect groups.

Table 108 — General Purpose Partition Size

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
GP_SIZE_MULT_X_2							
GP_SIZE_MULT_X_1							
GP_SIZE_MULT_X_0							

GP_SIZE_MULT_X_Y

Where X refers to the General Purpose Partition (from 1 to 4) and Y refers to the factors in the formula (from 0 to 2), so;

$$\text{General\_Purpose\_Partition\_X Size} = (\text{GP\_SIZE\_MULT\_X\_2} \times 2^{16} + \text{GP\_SIZE\_MULT\_X\_1} \times 2^{8} + \text{GP\_SIZE\_MULT\_X\_0} \times 2^{0}) \times \text{HC\_WP\_GPR\_SIZE} \times \text{HC\_ERASE\_GPR\_SIZE} \times 512\text{kBytes}$$

GPP1:

-GP_SIZE_MULT_1_0 = EXT_CSD[143]

-GP_SIZE_MULT_1_1 = EXT_CSD[144]

-GP_SIZE_MULT_1_2 = EXT_CSD[145]

GPP2:

-GP_SIZE_MULT_2_0 = EXT_CSD[146]

-GP_SIZE_MULT_2_1 = EXT_CSD[147]

-GP_SIZE_MULT_2_2 = EXT_CSD[148]

GPP3:

-GP_SIZE_MULT_3_0 = EXT_CSD[149]

-GP_SIZE_MULT_3_1 = EXT_CSD[150]

-GP_SIZE_MULT_3_2 = EXT_CSD[151]

GPP4:

-GP_SIZE_MULT_4_0 = EXT_CSD[152]

-GP_SIZE_MULT_4_1 = EXT_CSD[153]

-GP_SIZE_MULT_4_2 = EXT_CSD[154]

- ENH_SIZE_MULT [142:140]

This regiser defines enhanced user data area size.

Enhanced User Data Area size is defined in terms of High Capacity Write Protect Groups.

Table 109 — Enhanced User Data Area Size

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ENH_SIZE_MULT_2							
ENH_SIZE_MULT_1							
ENH_SIZE_MULT_0							

Enhanced User Data Area x Size = (ENH_SIZE_MULT_2 x 2^{16} + ENH_SIZE_MULT_1 x 2^{8} + ENH_SIZE_MULT_0 x 2^{0}) x HC_WP_GRP_SIZE x HC_ERASE_GPR_SIZE x 512kBytes

- ENH_START_ADDR [139:136]

This register defines starting address of the enhanced user data area.

Start address of the Enhanced User Data Area segment in the User Data Area (expressed in bytes or in sectors in case of high capacity devices).

Table 110 — Enhanced User Data Start Address

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ENH_START_ADDR_3							
ENH_START_ADDR_2							
ENH_START_ADDR_1							
ENH_START_ADDR_0							

- SEC_BAD_BLK_MGMNT [134]

In some memory array technologies that are used for MulitMediaCards portions of the memory array can become defective with use. In these technologies the card will recover the information from the defective portion of the memory array before it retires the block. This register bit, when set, requires the card to perform a secure purge on the contents of the defective region before it is retired. This feature requires only those bits that are not defective in the region to be purged.

Table 111 — Secure Bad Block management

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved							SEC_BAD_BLK

Bit7:1:Reserved

Bit0:SEC_BAD_BLK (R/W)

0x0: (Default) Feature disabled

0x1: All data must be secure purged from defective memory array regions before they are retired from use. SEC_BD_BLK_EN (EXT_CSD[231] bit 2) must be set in order to use this bit.

8.5 RCA register

The writable 16-bit relative card address (RCA) register carries the card address assigned by the host during the card identification. This address is used for the addressed host-card communication after the card identification procedure. The default value of the RCA register is 0x0001. The value 0x0000 is reserved to set all cards into the *Stand-by State* with CMD7.

8.6 DSR register

The 16-bit driver stage register (DSR) is described in detail in Section 12.4 on page 169. It can be optionally used to improve the bus performance for extended operating conditions (depending on parameters like bus length, transfer rate or number of cards). The CSD register carries the information about the DSR register usage. The default value of the DSR register is 0x404.

9 SPI mode

SPI mode was removed since V4.3.

10 Error protection

The CRC is intended for protecting MultiMediaCard commands, responses and data transfer against transmission errors on the MultiMediaCard bus. One CRC is generated for every command and checked for every response on the CMD line. For data blocks one CRC per transferred block is generated.

10.1 Error correction codes (ECC)

In order to detect data defects on the cards the host may include error correction codes in the payload data. For error free devices this feature is not required. With the error correction implemented off card, an optimal hardware sharing can be achieved. On the other hand the variety of codes in a system must be restricted or one will need a programmable ECC controller, which is beyond the intention of a MultiMediaCard adapter.

If a MultiMediaCard requires an external error correction (external means outside of the card), then an ECC algorithm has to be implemented in the MultiMediaCard host. The DEFAULT_ECC field in the CSD register defines the recommended ECC algorithm for the card.

The shortened BCH (542,512) code was chosen for matching the requirement of having high efficiency at lowest costs. The following table gives a brief overview of this code:

Table 101 — Error correction codes

Parameter	Value
Code type	Shortened BCH (542,512) code
Payload block length	512 bit
Redundancy	5.5%
Number of correctable errors in a block	3
Codec complexity (error correction in HW)	Encoding + decoding: 5k gates
Decoding latency (HW @ 20MHz)	< 30 microSec
Codec gatecount (error detection in HW, error correction in SW-only if block erroneous)	Encoding + error detection: ~ 1k gates Error correction: ~ 20 SW instructions/each bit of the erroneous block
Codec complexity (SW only)	Encoding: ~ 6 instructions/bit Error detection: ~ 8 instructions/bit Error correction: ~ 20 instructions/each bit of erroneous block

As the ECC blocks are not necessarily byte-aligned, bit stuffing is used to align the ECC blocks to byte boundaries. For the BCH(542,512) code, there are two stuff bits added at the end of the 542-bits block, leading to a redundancy of 5.9%.

10.2 Cyclic redundancy codes (CRC)

The CRC is intended for protecting MultiMediaCard commands, responses and data transfer against transmission errors on the MultiMediaCard bus. One CRC is generated for every command and checked for every response on the CMD line. For data blocks one CRC per transferred block, per data line, is generated. The CRC is generated and checked as described in the following.

- CRC7

The CRC7 check is used for all commands, for all responses except type R3, and for the CSD and CID registers. The CRC7 is a 7-bit value and is computed as follows:

Generator polynomial $G(x) = x^7 + x^3 + 1$

$M(x) = (\text{first bit}) \times x^n + (\text{second bit}) \times x^{n-1} + \ldots + (\text{last bit}) \times x^0$

$CRC[6\ldots0] = \text{Remainder}[(M(x) \cdot x^7)/G(x)]$

All CRC registers are initialized to zero. The first bit is the most left bit of the corresponding bit string (of the command, response, CID or CSD). The degree *n* of the polynomial is the number of CRC protected bits decreased by one. The number of bits to be protected is 40 for commands and responses (n = 39), and 120 for the CSD and CID (n = 119).

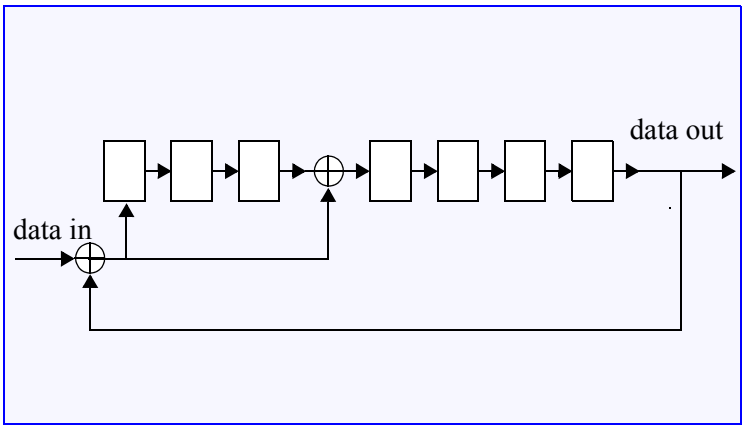


Figure 53 — CRC7 generator/checker

- CRC16

The CRC16 is used for payload protection in block transfer mode. The CRC check sum is a 16-bit value and is computed as follows:

Generator polynomial $G(x) = x^{16} + x^{12} + x^5 + 1$

$M(x) = (\text{first bit}) \times x^n + (\text{second bit}) \times x^{n-1} + \ldots + (\text{last bit}) \times x^0$

$CRC[15\ldots0] = \text{Remainder}[(M(x) \cdot x^{16})/G(x)]$

All CRC registers are initialized to zero. The first bit is the first data bit of the corresponding block. The degree *n* of the polynomial denotes the number of bits of the data block decreased by one (e.g. n = 4095 for a block length of 512 bytes). The generator polynomial $G(x)$ is a standard CCITT polynomial. The code has a minimal distance d=4 and is used for a payload length of up to 2048 Bytes (n <= 16383).

The same CRC16 calculation is used for all bus configurations. In 4 bit and 8 bit bus configurations, the CRC16 is calculated for each line separately. Sending the CRC is synchronized so the CRC code is transferred at the same time in all lines.

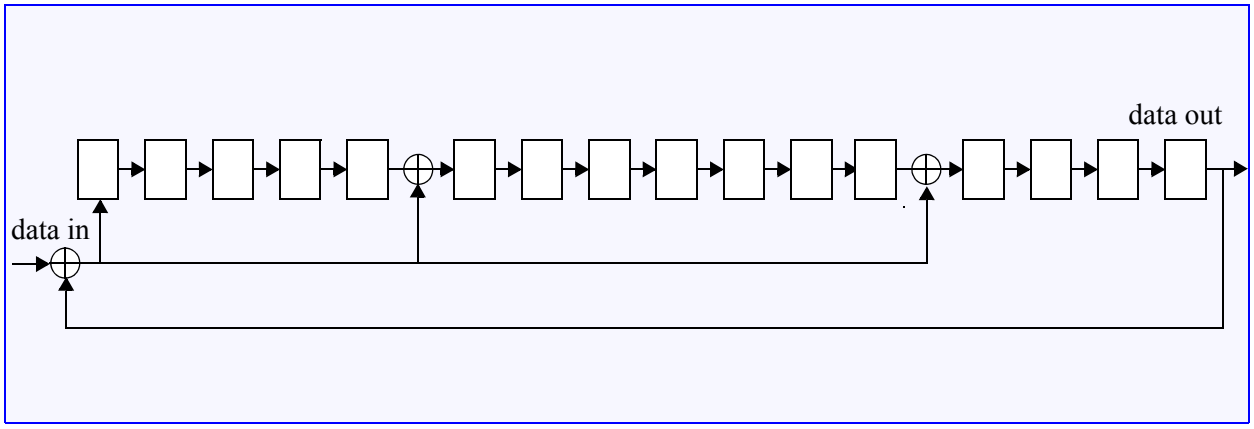


Figure 54 — CRC16 generator/checker

11 MultiMediaCard mechanical standard

See “MultiMediaCard (MMC) Card Mechanical Standard JESD84-C01,” and “MultiMediaCard (MMC) Card Bend, Torque, and Drop Test standard JESD84-C02” for card applications; see “Embedded MultiMediaCard (*e*•MMC) Mechanical Standard JESD84-C44” for *e*•MMC applications.

12 The MultiMediaCard bus

The MultiMediaCard bus has ten communication lines and three supply lines:

- CMD: Command is a bidirectional signal. The host and card drivers are operating in two modes, open drain and push/pull.
- DAT0-7: Data lines are bidirectional signals. Host and card drivers are operating in push-pull mode
- CLK: Clock is a host to card signal. CLK operates in push-pull mode
- V_{DD}: V_{DD} is the power supply line for all cards.
- V_{SS1}, V_{SS2} are two ground lines.

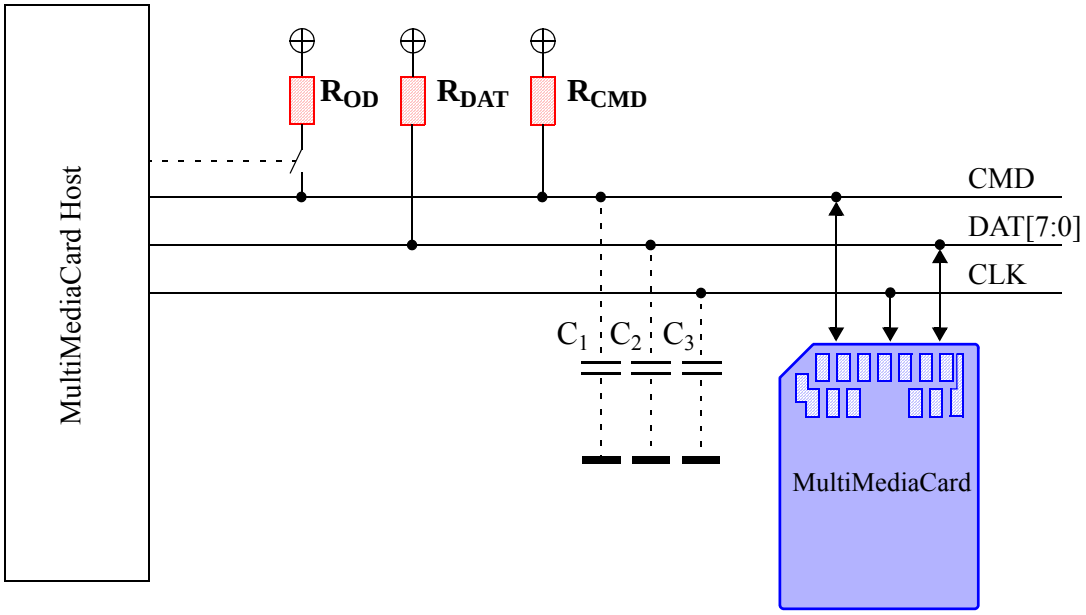


Figure 55 — Bus circuitry diagram

The R_{OD} is switched on and off by the host synchronously to the open-drain and push-pull mode transitions. The host does not have to have open drain drivers, but must recognize this mode to switch on the R_{OD}. R_{DAT} and R_{CMD} are pull-up resistors protecting the CMD and the DAT lines against bus floating when no card is inserted or when all card drivers are in a high-impedance mode.

A constant current source can replace the R_{OD} by achieving a better performance (constant slopes for the signal rising and falling edges). If the host does not allow the switchable R_{OD} implementation, a fixed R_{CMD} can be used (the minimum value is defined in the Section 12.5 on page 171). Consequently the maximum operating frequency in the open drain mode has to be reduced if the used R_{CMD} value is higher than the minimal one given in Section 12.5 on page 171.

12.1 Hot insertion and removal

To guarantee the proper sequence of card pin connection during hot insertion, the use of either a special hot-insertion capable card connector or an auto-detect loop on the host side (or some similar mechanism) is mandatory (see Section 11 starting on page 161).

No card shall be damaged by inserting or removing a card into the MultiMediaCard bus even when the power (V_{DD}) is up. Data transfer operations are protected by CRC codes, therefore any bit changes induced

by card insertion and removal can be detected by the MultiMediaCard bus master.

The inserted card must be properly reset also when CLK carries a clock frequency f_{PP}. Each card shall have power protection to prevent card (and host) damage. Data transfer failures induced by removal/insertion are detected by the bus master. They must be corrected by the application, which may repeat the issued command.

12.2 Power protection

Cards shall be inserted/removed into/from the bus without damage. If one of the supply pins (V_{DD} or V_{SS}) is not connected properly, then the current is drawn through a data line to supply the card.

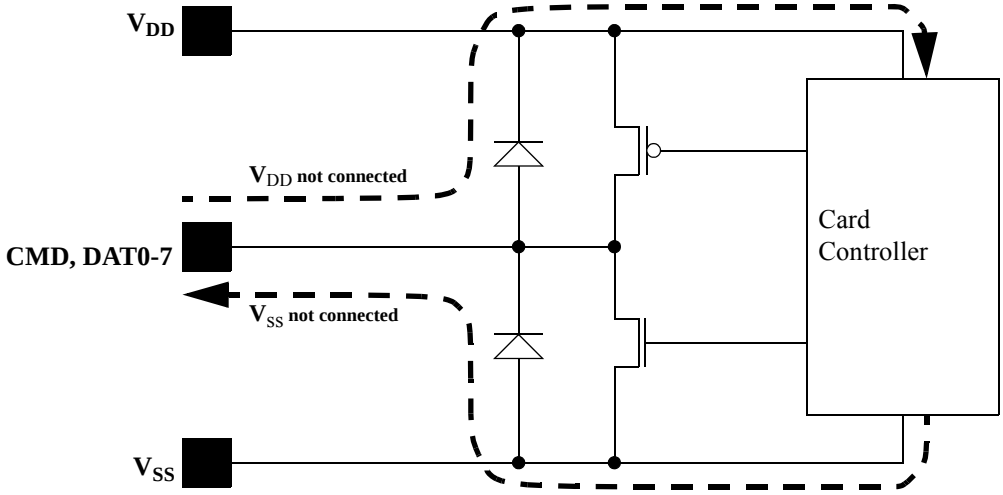


Figure 56 — Improper power supply

Every card's output also shall be able to withstand shortcuts to either supply.

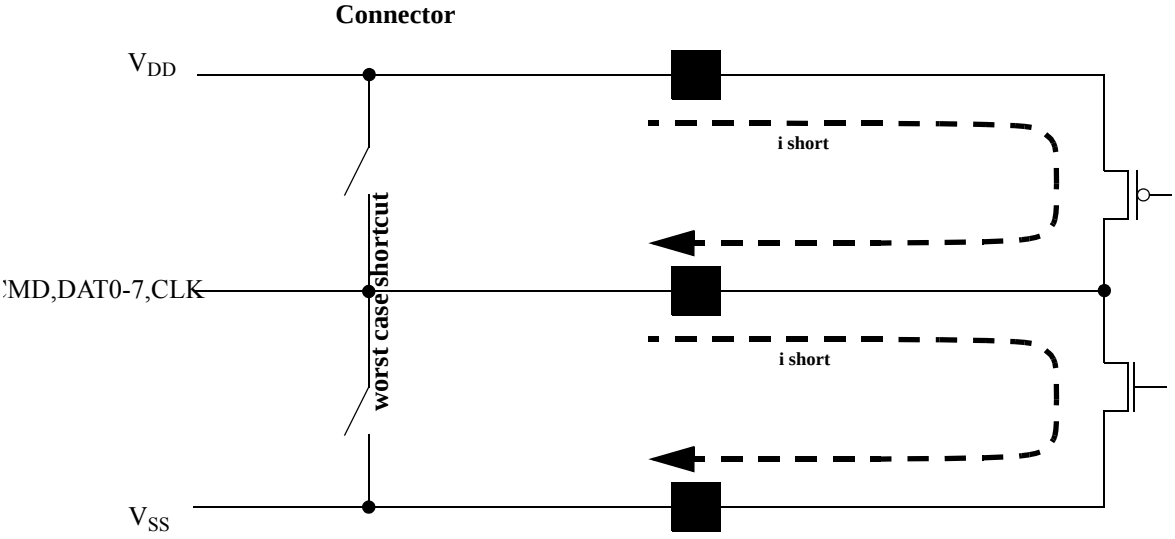


Figure 57 — Shortcut protection

If hot insertion feature is implemented in the host, than the host has to withstand a shortcut between V_{DD} and V_{SS} without damage.

12.3 Power-up

The power up of the MultiMediaCard bus is handled locally in the card and in the bus master.

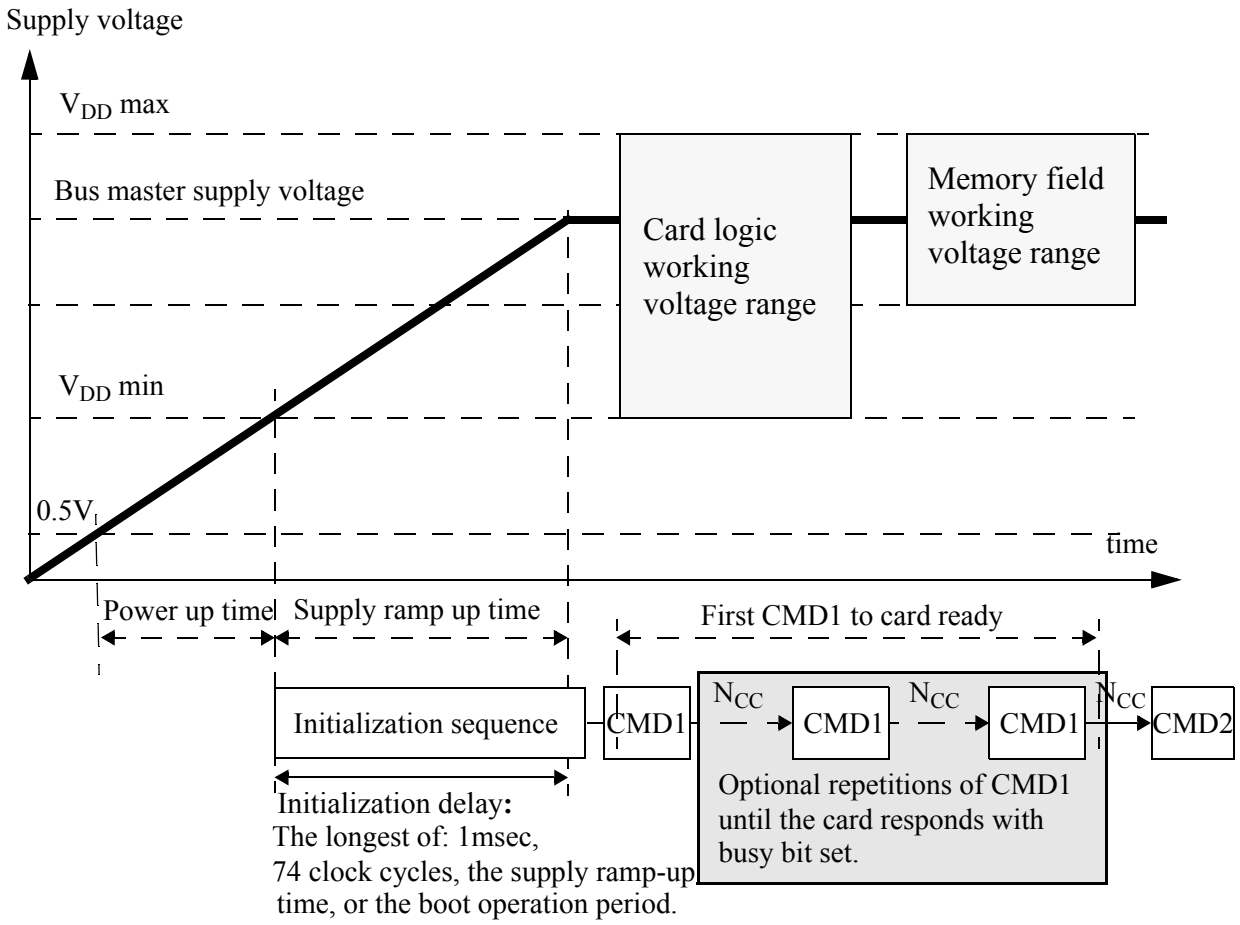


Figure 58 — Power-up diagram

- After power up (including hot insertion, i.e., inserting a card when the bus is operating), the card enters the *pre-idle* state. The power up time of the supply voltage should be less than the specified tPRU for the Bus master supply voltage.
- If the card does not support boot mode, or its BOOT_PARTITION_ENABLE bit is cleared, the card moves immediately to the *idle* state. While in the *idle* state, the card ignores all bus transactions until CMD1 is received. If the card supports only standard v4.2 or earlier versions, it enters the *idle* state immediately following power-up.
- If the card BOOT_PARTITION_ENABLE bit is set, the card moves to the *pre-boot* state. The card then waits for boot initiation sequence. Following the boot operation period, the card enters the *idle* state. During the *pre-boot* state, if the card receives any CMD line transaction other than CMD1 or the boot initiation sequence (keeping the CMD line low for at least 74 clock cycles, or issuing CMD0 with the argument of 0xFFFFFFFA), the card moves to the *idle* state. If the card receives the boot initiation sequence (keeping the CMD line low for at least 74 clock cycles, or issuing CMD0 with the argument of 0xFFFFFFFA), the card begins boot operation. If boot acknowledge is enabled, the card shall send acknowledge pattern “010” to the host within the specified time. After boot operation is terminated, the card enters the *idle* state and shall be ready for CMD1 operation. If the card receives CMD1 in the *pre-*

boot state, it begins responding to the command and moves to card identification mode.

- While in the *idle* state, the card ignores all bus transactions until CMD1 is received.
- The maximum initial load (after power up or hot insertion) that the MultiMediaCard can present on the VDD line shall be a maximum of 10 uF in parallel with a minimum of 330 ohms. At no time during operation shall the card capacitance on the VDD line exceed 10 uF
- CMD1 is a special synchronization command used to negotiate the operation voltage range and to poll the card until it is out of its power-up sequence. Besides the operation voltage profile of the card, the response to CMD1 contains a busy flag, indicating that the card is still working on its power-up procedure and is not ready for identification. This bit informs the host that the card is not ready. The host has to wait until this bit is cleared.
    - The card shall complete its initialization within 1 second from the first CMD1 with a valid OCR range if boot operation is not executed.
- Getting the card out of *idle* state is up to the responsibility of the bus master. Since the power up time and the supply ramp up time depend on application parameters as the bus length and the power supply unit, the host must ensure that the power is built up to the operating level (the same level which will be specified in CMD1) before CMD1 is transmitted.
- After power up the host starts the clock and sends the initializing sequence on the CMD line. The sequence length is the longest of: 1msec, 74 clocks, the supply-ramp-up-time, or the boot operation period. The additional 10 clocks (over the 64 clocks after what the card should be ready for communication) is provided to eliminate power-up synchronization problems.
- Every bus master has to implement CMD1. The CMD1 implementation is mandatory for all MultiMediaCards.

12.3.1 *e*•MMC power-up

An *e*•MMC bus power-up is handled locally in each device and in the bus master. Figure 59 shows the power-up sequence and is followed by specific instructions regarding the power-up sequence.

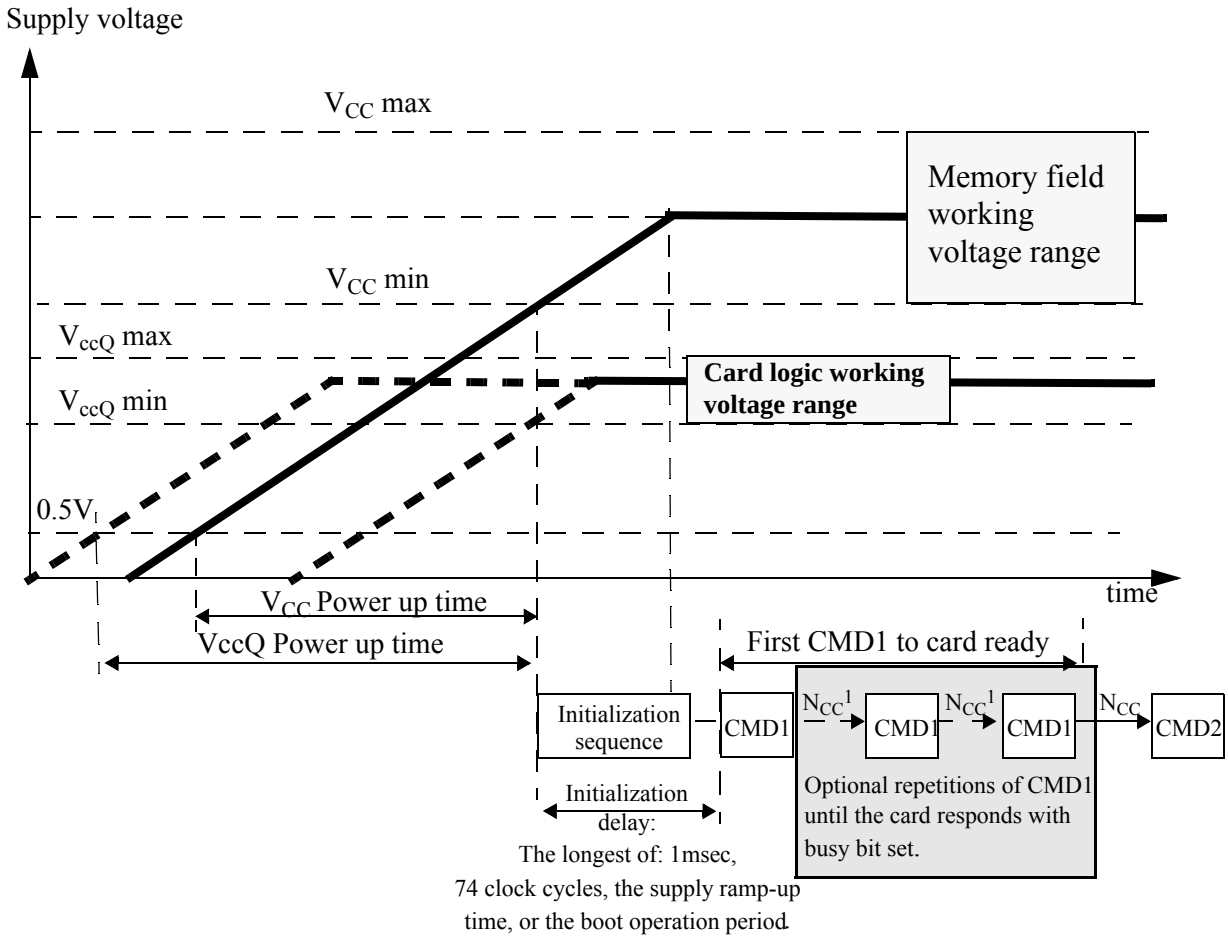


Figure 59 — *e*•MMC power-up diagram

12.3.2 *e*•MMC power-up guidelines

An *e*•MMC power-up must adhere to the following guidelines:

- When power-up is initiated, either V_{CC} or $V_{CC}Q$ can be ramped up first, or both can be ramped up simultaneously.
- After power up, the *e*•MMC enters the *pre-idle* state. The power up time of each supply voltage should be less than the specified tPRU (tPRUH, tPRUL or tPRUV) for the appropriate voltage range.
- If the *e*•MMC does not support boot mode or its BOOT_PARTITION_ENABLE bit is cleared, the *e*•MMC moves immediately to the *idle* state. While in the *idle* state, the *e*•MMC ignores all bus transactions until CMD1 is received. If the *e*•MMC supports only standard v4.2 or earlier versions, the device enters the *idle* state immediately following power-up.
- If the BOOT_PARTITION_ENABLE bit is set, the *e*•MMC moves to the *pre-boot* state, and the *e*•MMC waits for the boot-initiation sequence. Following the boot operation period, the *e*•MMC enters the *idle* state. During the *pre-boot* state, if the *e*•MMC receives any CMD-line transaction other than the boot initiation sequence (keeping CMD line low for at least 74 clock cycles, or issuing CMD0 with the argument of 0xFFFFFFFA) and CMD1, the *e*•MMC moves to the *Idle* state. If *e*•MMC receives the boot initiation sequence (keeping the CMD line low for at least 74 clock cycles, or issuing CMD0 with

the argument of 0xFFFFFFFA), the *e*•MMC begins boot operation. If boot acknowledge is enabled, the *e*•MMC shall send acknowledge pattern "010" to the host within the specified time. After boot operation is terminated, the *e*•MMC enters the *idle* state and shall be ready for CMD1 operation. If the *e*•MMC receives CMD1 in the *pre-boot* state, it begins responding to the command and moves to the card identification mode.

- While in the *idle* state, the *e*•MMC ignores all bus transactions until CMD1 is received.
- CMD1 is a special synchronization command used to negotiate the operation voltage range and to poll the device until it is out of its power-up sequence. In addition to the operation voltage profile of the device, the response to CMD1 contains a busy flag indicating that the device is still working on its power-up procedure and is not ready for identification. This bit informs the host that the device is not ready, and the host must wait until this bit is cleared. The device must complete its initialization within 1 second of the first CMD1 issued with a valid OCR range.
    - If the *e*•MMC device was successfully partitioned during the previous power up session (bit 0 of EXT_CSD byte [155] PARTITION_SETTING_COMPLETE successfully set) then the initialization delay is (instead of 1s) calculated from INI_TIMEOUT_PA (EXT_CSD byte [241]). This timeout applies only for the very first initializastion after successful partitioning. For all the consequtive initialization 1sec timeout will apply.
- The bus master moves the device out of the *idle* state. Because the power-up time and the supply ramp-up time depend on application parameters such as the bus length and the power supply unit, the host must ensure that power is built up to the operating level (the same level that will be specified in CMD1) before CMD1 is transmitted.
- After power-up, the host starts the clock and sends the initializing sequence on the CMD line. The sequence length is the longest of: 1ms, 74 clocks, the supply ramp-up time, or the boot operation period. An additional 10 clocks (beyond the 64 clocks of the power-up sequence) are provided to eliminate power-up synchronization problems.
- Every bus master must implement CMD1.

12.3.3 *e*•MMC power cycling

The master can execute any sequence of V_{CC} and $V_{CC}Q$ power-up/power-down. However, the master must not issue any commands until V_{CC} and $V_{CC}Q$ are stable within each operating voltage range. After the slave enters sleep mode, the master can power-down V_{CC} to reduce power consumption. It is necessary for the slave to be ramped up to V_{CC} before the host issues CMD5 (SLEEP_AWAKE) to wake the slave unit.

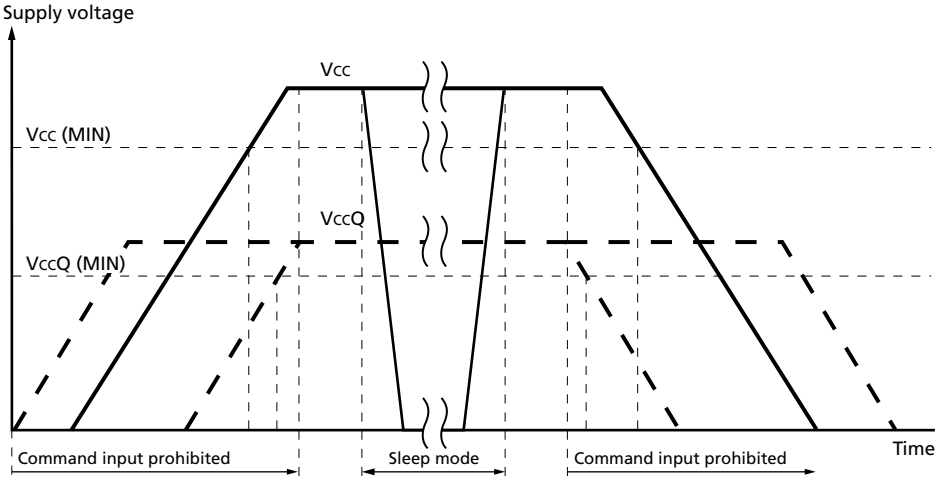


Figure 60 — The *e*•MMC power cycle

If VCC or VCCq are below 0.5 V for longer than 1 ms, the slave shall always return to the *pre-idle* state, and perform the appropriate boot behavior, as appropriate. The slave will behaves as in a standard power-up condition once the voltages have returned to their functional ranges.

An exception to the this behavior is if the device is in sleep state, in which the voltage on VCC is not monitored.

12.4 Programmable card output driver

The bus capacitance of each line of the MultiMediaCard bus is the sum of the bus master capacitance, the bus capacitance itself and the capacitance of each inserted card. The sum of host and bus capacitance are fixed for one application, but may vary between different applications.The card load may vary in one application with each of the inserted cards.

The CMD and DAT bus drivers consist of a predriver stage and a complementary driver transistor (Figure 61).

The DSR register is used to configure the predriver stage output rise and fall time, and the complementary driver transistor size. The proper combination of both allows optimum bus performance.Table 102 defines the DSR register contents:

Table 102 — DSR register content

	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
$t_{switch\text{-}on\ max}$	reserved							
$t_{switch\text{-}on\ min}$								

	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**
$i_{peak\ min}$	reserved							
$i_{peak\ max}$								

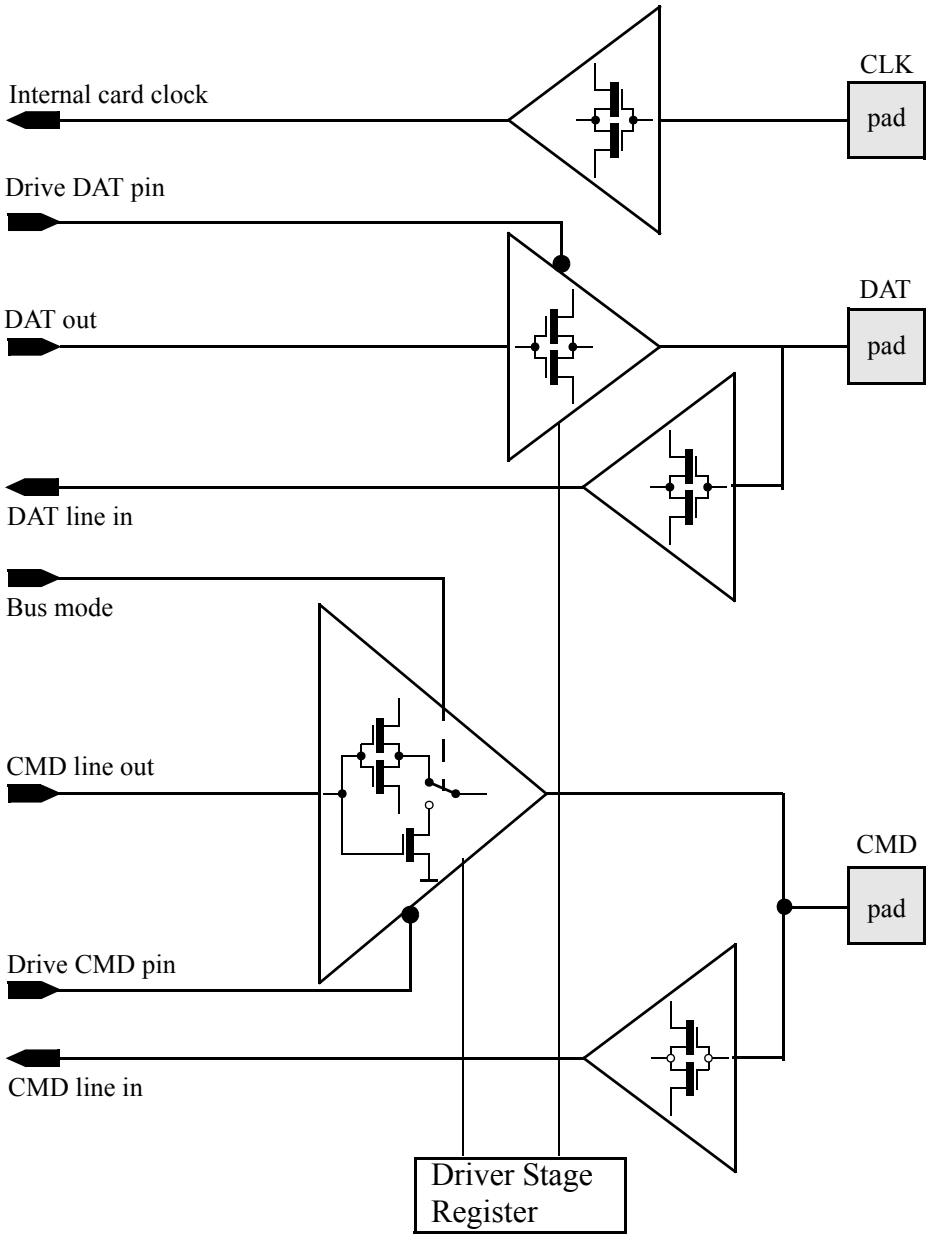


Figure 61 — MultiMediaCard bus driver

All data is valid for the specified operating range (voltage, temperature). The DSR register has two byte codes (e.g., bits 0-7 = 0x02, bits 8-15 = 0x01) that define specific min and max values for the switching speed and current drive of the register, respectively (actual values are TBD). Any combination of switching speed and driving force may be programmed. The selected speed settings must be in accordance with the system frequency. The following relationship must be kept:

$$t_{\text{switch-on-max}} \pm 0.4 * (\text{FOD})^{-1}$$

12.5 Bus operating conditions

Table 103 — General operating conditions

Parameter		Symbol	Min	Max.	Unit	Remark
Peak voltage on all lines	Card		-0.5	V_{DD} + 0.5	V	
	BGA		-0.5	$V_{CC}Q$ + 0.5	V	
All Inputs						
Input Leakage Current (before initialization sequence and/or the internal pull up resistors connected)			-100	100	µA	
Input Leakage Current (after initialization sequence and the internal pull up resistors disconnected)			-2	2	µA	
All Outputs						
Output Leakage Current (before initialization sequence)			-100	100	µA	
Output Leakage Current (after initialization sequence)			-2	2	µA	

NOTE 1. Initialization sequence is defined in Section 12.3 on page 165

12.5.1 Power supply: high-voltage MultiMediaCard

Table 104 — Power supply voltage: high-voltage MultiMediaCard

Parameter	Symbol	Min	Max.	Unit	Remarks
Supply voltage	V_{DD}	2.7	3.6	V	
Supply voltage differentials (V_{SS1}, V_{SS2})		-0.5	0.5	V	
Supply power-up	tPRU	-	35	ms	

12.5.2 Power supply: dual-voltage MultiMediaCard

Table 105 — Power supply voltage: dual-voltage MultiMediaCard

Parameter	Symbol	Min	Max.	Unit	Remarks
Supply voltage (low voltage range)	V_{DDL}	1.70	1.95	V	1.95V–2.7V range is not supported
Supply voltage (high voltage range)	V_{DDH}	2.7	3.6	V	
Supply voltage differentials (V_{SS1}, V_{SS2})		-0.5	0.5	V	
Supply power-up (low voltage range)	tPRUL	-	25	ms	
Supply power-up (high voltage range)	tPRUH	-	35	ms	

The current consumption of the card for the different card configurations is defined in the power class fields in the EXT_CSD register.

The current consumption of any card during the power-up procedure (except in boot operation), while the host has not sent yet a valid OCR range, must not exceed 10mA.

12.5.3 Power supply: *e*•MMC

In the *e*•MMC, VCC is used for the NAND flash device and its interface voltage; VCCQ is for the controller and the MMC interface voltage shown in Figure 62. The core regulator is optional and only required when VCCQ is in the 3V range. A Creg capacitor must be connected to the VDDi terminal to stabilize regulator output on the system.

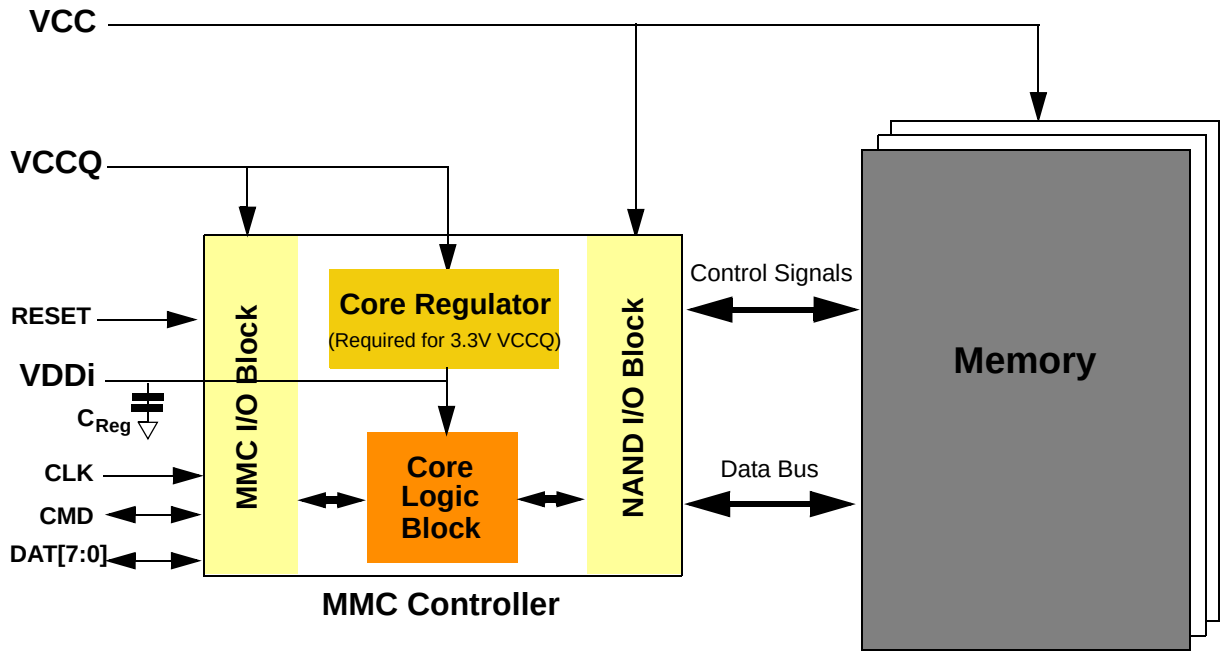


Figure 62 — *e*•MMC internal power diagram

12.5.4 Power supply: *e*•MMC

The *e*•MMC supports one or more combinations of V_{CC} and $V_{CC}Q$ as shown in Table 106. The $V_{CC}Q$ must be defined at equal to or less than V_{CC}. The available voltage configuration is shown in Table 107.

Table 106 — *e*•MMC power supply voltage

Parameter	Symbol	Min	Max	Unit	Remarks
Supply voltage (NAND)	V_{CC}	2.7	3.6	V	
		1.7	1.95	V	
Supply voltage (I/O)	$V_{CC}Q$	2.7	3.6	V	
		1.65	1.95	V	
		1.1	1.3	V	
Supply power-up for 3.3V	tPRUH		35	ms	
Supply power-up for 1.8V	tPRUL		25	ms	
Supply power-up for 1.2V	tPRUV		20	ms	

The *e*•MMC must support at least one of the valid voltage configurations, and can optionally support all valid voltage configurations (see Table 107).

Table 107 — *e*•MMC voltage combinations

		$V_{CC}Q$		
		1.1V-1.3V	**1.65V–1.95V**	**2.7V–3.6V**
V_{CC}	**2.7V–3.6V**	Valid	Valid	Valid
	1.7V–1.95V	Valid	Valid	NOT VALID

12.5.5 Bus signal line load

The total capacitance C_L of each line of the MultiMediaCard bus is the sum of the bus master capacitance C_{HOST}, the bus capacitance C_{BUS} itself, and the capacitance C_{CARD} of the card connected to this line,

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

and requiring the sum of the host and bus capacitances not to exceed 20 pF (see Table 108).

Table 108 — Capacitance

Parameter	Symbol	Min	Typ	Max	Unit	Remark
Pull-up resistance for CMD	R_{CMD}	4.7		100(1)	Kohm	to prevent bus floating
Pull-up resistance for DAT0–7	R_{DAT}	10		100(1)	Kohm	to prevent bus floating
Internal pull up resistance DAT1–DAT7	R_{int}	10		150	kohm	to prevent unconnected lines floating
Bus signal line capacitance	C_L			30	pF	Single card
Single card capacitance	C_{MICRO}			12	pF	For MMC*micro*
	C_{MOBILE}			18		For MMC*mobile* and MMC*plus*
	C_{BGA}		7	12		For BGA
Maximum signal line inductance				16	nH	$f_{PP} \leq 52$ MHz
VDDi capacitor value	C_{REG}(2)	0.1			µF	to stablize regulator output to controller core logics

(1) Recommanded maximum pull-up is 50Kohm for 1.2V and 1.8V interface supply voltages.A 3V part, may use the whole range up to 100Kohms.

(2) Recommended value for C_{REG} might be different between e•MMC device vendors. Please confirm the maximum value and the accuracy of the capacitance with e•MMC vendor because the electrical characteristics of the regulator inside e•MMC is affected by the fluctuation of the capacitance.

12.6 Bus signal levels

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

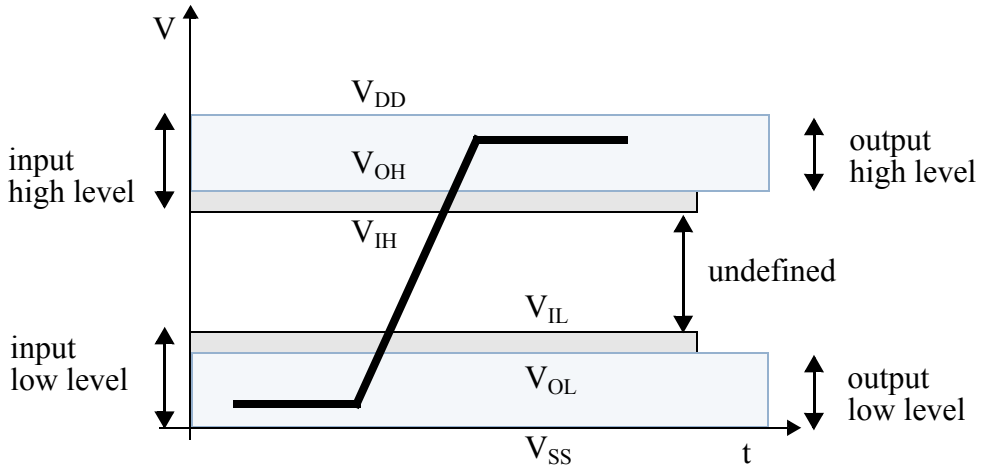


Figure 63 — Bus signal levels

12.6.1 Open-drain mode bus signal level

Table 109 — Open-drain bus signal level

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

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

12.6.2 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 110 — Push-pull signal level—high-voltage MultiMediaCard

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

12.6.3 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 Section 12.6.2 on page 174 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 111 — 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 * V_{DD}(1)	V_{DD} + 0.3	V	
Input LOW voltage	V_{IL}	V_{SS} - 0.3	0.35 * V_{DD}(2)	V	

(1) 0.7 * V_{DD} for MMC4.3 and older revisions.

(2) 0.3 * V_{DD} for MMC4.3 and older revisions.

12.6.4 Push-pull mode bus signal level—*e*•MMC

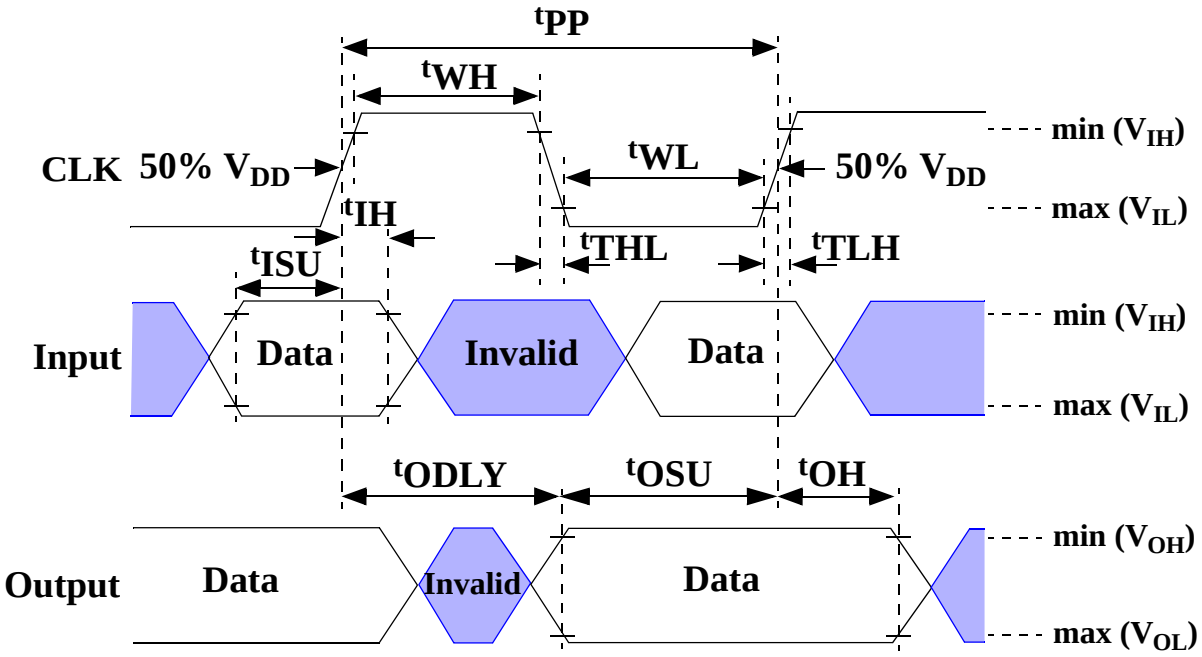
The definition of the I/O signal levels for the *e*•MMC devices changes as a function of VCCQ.

- 2.7V-3.6: Identical to the High Voltage MultiMediaCard (refer to Section 12.6.2 on page 174).
- 1.95- 2.7V: Undefined. The *e*•MMC 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 Section 12.6.3 on page 174).
- 1.3V - 1.65V: Undefined. The *e*•MMC 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 112 — Push-pull signal level—1.1V-1.3V VCCQ range *e*•MMC

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	

12.7 Bus timing



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

Figure 64 — Timing diagram: data input/output

12.7.1 Card interface timings

Table 113 — High-speed card interface timing

Parameter	Symbol	Min	Max.	Unit	Remark
Clock CLK[1]					
Clock frequency Data Transfer Mode (PP)[2]	f_{PP}	0	52[3]	MHz	$C_L \le 30$ pF Tolerance: +100KHz
Clock frequency Identification Mode (OD)	f_{OD}	0	400	kHz	Tolerance: +20KHz
Clock high time	t_{WH}	6.5		ns	$C_L \le 30$ pF
Clock low time	t_{WL}	6.5		ns	$C_L \le 30$ pF
Clock rise time[4]	t_{TLH}		3	ns	$C_L \le 30$ pF
Clock fall time	t_{THL}		3	ns	$C_L \le 30$ pF
Inputs CMD, DAT (referenced to CLK)					
Input set-up time	t_{ISU}	3		ns	$C_L \le 30$ pF
Input hold time	t_{IH}	3		ns	$C_L \le 30$ pF
Outputs CMD, DAT (referenced to CLK)					
Output delay time during data transfer	t_{ODLY}		13.7	ns	$C_L \le 30$ pF
Output hold time	t_{OH}	2.5		ns	$C_L \le 30$ pF
Signal rise time[5]	t_{RISE}		3	ns	$C_L \le 30$ pF
Signal fall time	t_{FALL}		3	ns	$C_L \le 30$ pF

NOTE 1. CLK timing is measured at 50% of VDD.
NOTE 2. A MultiMediaCard shall support the full frequency range from 0-26Mhz, or 0-52MHz
NOTE 3. Card can operate as high-speed card interface timing at 26 MHz clock frequency.
NOTE 4. CLK rise and fall times are measured by min (VIH) and max (VIL).
NOTE 5. Inputs CMD, DAT rise and fall times are measured by min (VIH) and max (VIL), and outputs CMD, DAT rise and fall times are measured by min (VOH) and max (VOL).

Table 114 — Backward-compatible card interface timing

Parameter	Symbol	Min	Max.	Unit	Remark[1]
Clock CLK[2]					
Clock frequency Data Transfer Mode (PP)[3]	f_{PP}	0	26	MHz	$C_L \le 30$ pF
Clock frequency Identification Mode (OD)	f_{OD}	0	400	kHz	
Clock high time	t_{WH}	10			$C_L \le 30$ pF
Clock low time	t_{WL}	10		ns	$C_L \le 30$ pF
Clock rise time[4]	t_{TLH}		10	ns	$C_L \le 30$ pF
Clock fall time	t_{THL}		10	ns	$C_L \le 30$ pF
Inputs CMD, DAT (referenced to CLK)					
Input set-up time	t_{ISU}	3		ns	$C_L \le 30$ pF
Input hold time	t_{IH}	3		ns	$C_L \le 30$ pF

Table 114 — Backward-compatible card interface timing (continued)

Parameter	Symbol	Min	Max.	Unit	Remark[1]
Outputs CMD, DAT (referenced to CLK)					
Output set-up time[5]	t_{OSU}	11.7		ns	$C_L \leq 30$ pF
Output hold time[5]	t_{OH}	8.3		ns	$C_L \leq 30$ pF

NOTE 1. The card must always start with the backward-compatible interface timing. The 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.

NOTE 2. CLK timing is measured at 50% of VDD.

NOTE 3. For compatibility with cards that support the v4.2 standard or earlier, host should not use > 20 MHz before switching to high-speed interface timing.

NOTE 4. CLK rise and fall times are measured by min (V_{IH}) and max (V_{IL}).

NOTE 5. tOSU and tOH are defined as values from clock rising edge. However, there may be cards or devices which utilize clock falling edge to output data in backward compatibility mode.
Therefore, it is recommended for hosts either to settWL value as long as possible within the range which will not go over tCK-tOH(min) in the systemor to use slow clock frequency, so that host could have data set up margin for those devices.
In this case, each device which utilizes clock falling edge might show the correlation either between tWL and tOSU or between tCK and tOSU for the device in its own datasheet as a note or its' application notes.

12.8 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 complies with the bus timing specified in section 12.7, therefore there is no timing change for the CMD signal

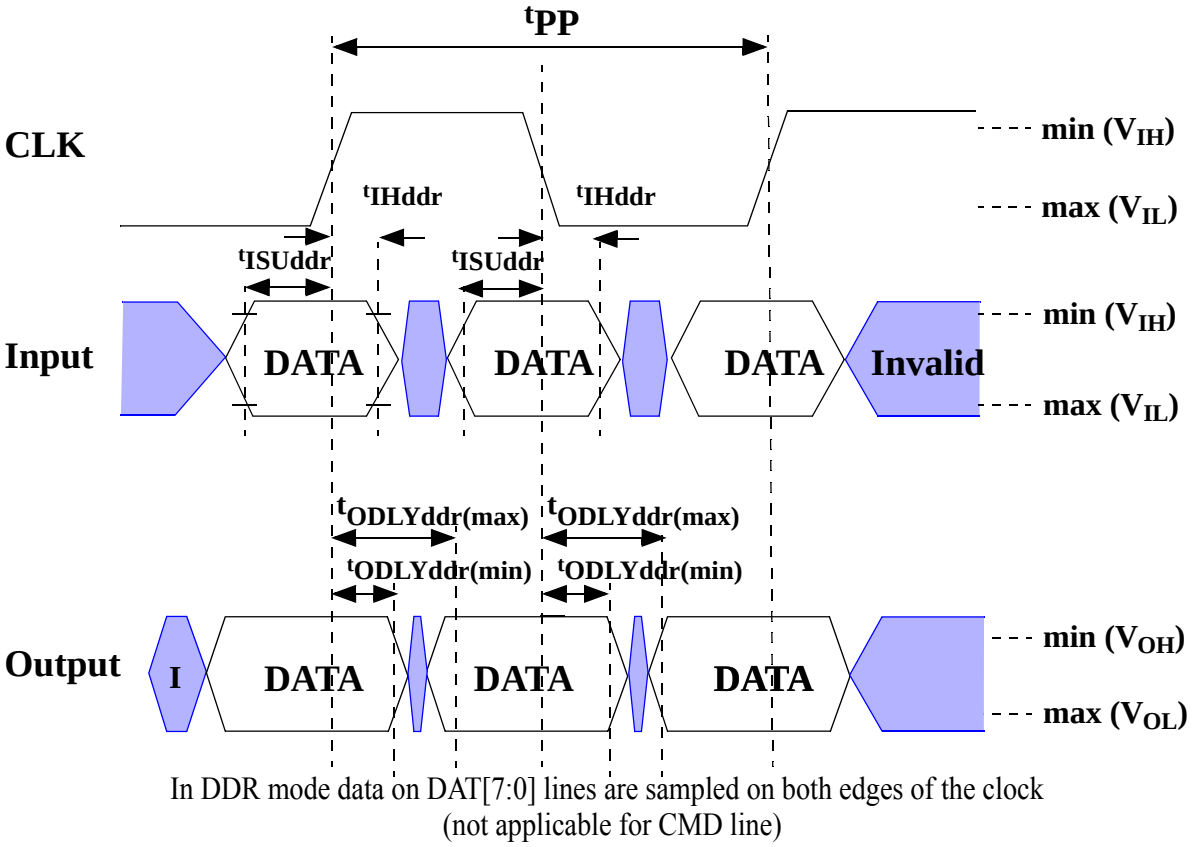


Figure 65 — Timing diagram: data input/output in dual data rate mode

12.8.1 Dual data rate interface timings

Table 115 — 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	tISUddr	2.5		ns	CL ≤ 20 pF
Input hold time	tIHddr	2.5		ns	CL ≤ 20 pF
Output DAT (referenced to CLK-DDR mode)					
Output delay time during data transfer	tODLYddr	1.5	7	ns	CL ≤ 20 pF
Signal rise time (all signals)[2]	tRISE		2	ns	CL ≤ 20 pF
Signal fall time (all signals)	tFALL		2	ns	CL ≤ 20 pF

NOTE 1. CLK timing is measured at 50% of VDD.
NOTE 2. 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})

13 *e*•MMC standard compliance

The MultiMediaCard standard provides all the necessary information required for media exchangeability and compatibility.

- Generic card access and communication protocol (Section 7 starting on page 27, Section 8 starting on page 113)
- The description of the SPI mode was removed from the v.4.3 standard.
- Data integrity and error handling (Section 10 starting on page 157)
- Mechanical interface parameters, such as: connector type and dimensions and the card form factor (Section 11 starting on page 161)
- Electrical interface parameters, such as: power supply, peak and average current consumption and data transfer frequency (Section 12 starting on page 163)
- Basic file formats for achieving high data interchangeability.

However, due to the wide spectrum of targeted MultiMediaCard applications—from a full blown PC based application down to the very-low-cost market segments—it is not always cost effective nor useful to implement every MultiMediaCard standard feature in a specific MultiMediaCard system. Therefore, many of the parameters are configurable and can be tailored per implementation.

A card is compliant with the standard as long as all of its configuration parameters are within the valid range. A MultiMediaCard host is compliant as long as it supports at least one MultiMediaCard class as defined below. Card classes have been introduced in Section 6.3 on page 14: Read Only Memory (ROM) cards, Read/Write (RW) cards and I/O cards. Every provider of MultiMediaCard system components is required to clearly specify (in its product manual) all the MultiMediaCard specific restrictions of the device.

MultiMediaCards (slaves) provide their configuration data in the Card Specific Data (CSD) register (refer to Section 8.3 on page 115). The MultiMediaCard protocol includes all the necessary commands for querying this information and verifying the system concept configuration. MultiMediaCard hosts (masters) are required (as part of the system boot-up process) to verify host-to-card compatibility with each of the cards connected to the bus. The I/O card class characteristics and compliance requirements will be refined in coming revisions.

The following table summarizes the requirements from a MultiMediaCard host for each card class (CCC = card command class, see Section 7.10 on page 85). The meaning of the entries is as follows:

- *Mandatory*: any MultiMediaCard host supporting the specified card class must implement this function.
- *Optional*: this function is an added option. The host is compliant to the specified card class without having implemented this function.
- *Not required*: this function has no use for the specified card class.

Table 116 — MultiMediaCard host requirements for card classes

Function	ROM card class	R/W card class	I/O card class
26–52 MHz transfer rate	Optional	Optional	Optional
20–26 MHz transfer rate	Mandatory	Mandatory	Mandatory
0–20 MHz transfer rate	Mandatory	Mandatory	Mandatory
2.7–3.6V power supply	Mandatory	Mandatory	Mandatory
1.70–1.95V power supply	Optional	Optional	Optional

Table 116 — MultiMediaCard host requirements for card classes (continued)

Function	ROM card class	R/W card class	I/O card class
CCC 0 basic	Mandatory	Mandatory	Mandatory
CCC 1 sequential read	Optional	Optional	Optional
CCC 2 block read	Mandatory	Mandatory	Optional
CCC 3 sequential write	Not required	Optional	Optional
CCC 4 block write	Not required	Mandatory	Optional
CCC 5 erase	Not required	Mandatory	Not required
CCC 6 write protection functions	Not required	Mandatory	Not required
CCC 7 lock card commands	Mandatory	Mandatory	Mandatory
CCC 8 application specific commands	Optional	Optional	Optional
CCC 9 interrupt and fast read/write	Not required	Optional	Mandatory
DSR	Optional	Optional	Optional
SPI Mode	Obsolete	Obsolete	Obsolete

Comments on the optional functions:

- The interrupt command is intended for reducing the overhead on the host side required during polling for some events.
- The setting of the DSR allows the host to configure the MultiMediaCard bus in a very flexible, application dependent manner
- The external ECC in the host allows the usage of extremely low-cost cards.
- The Card Status bits relevance, according to the supported classes, is defined in Table 38 on page 99.
- Secure erase, secure trim and bad block management are features that enable the device to be used in secure applications.
- The Trim command allows the host to assist with the optimization of the internal card garbage collection operations

Table 117 — New Features List for device type

Function	Removable	*e*•MMC
Boot	Not required	Mandatory
RPMB	Optional	Mandatory
Reset Pin	Not required	Mandatory
Write Protection (including Perm & Temp)	Mandatory (exepct H/W reset)	Mandatory

Table 117 — New Features List for device type

Function	Removable	*e*•MMC
1.2 V I/0	Not required	Optional
Dual Data Rate timing	Optional	Optional
Multi Partitioning	Optional	Optional
Secure Erase	Optional	Optional
Trim & Secure Trim	Optional	Optional
High Priority Interrupt	Optional	Optional
Background Operation	Optional	Optional
Enhance Reliable Write	Optional	Optional

Annex A Application Notes

A.1 Power supply decoupling

The V_{SS1}, V_{SS2} and V_{DD} lines supply the card with operating voltage. For this, decoupling capacitors for buffering current peak are used. These capacitors are placed on the bus side corresponding to Figure A.1.

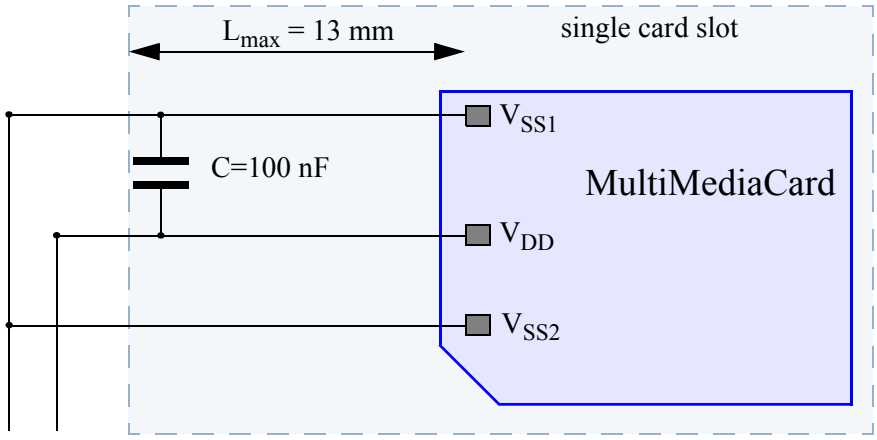


Figure A.1 — Power supply decoupling

The host controller includes a central buffer capacitor for V_{DD}. Its value is 1 µF/slot.

A.2 Payload block length and ECC types handling

There are two entries in the CSD register concerning the payload block length:

- block length type and
- external ECC.

The block length entry depends on the card memory field architecture. There are fixed values in 2-exponent steps defined for the block length size in the range 1 Byte - 2 kByte. Alternatively, the device allows application of any block length in the range between 1 Byte and the maximum block size.

The other CSD entry having an influence on the block length is the selected external ECC type. If there is an external ECC code option selected, this entry generally does not have to match with the block length entry in the CSD. If these entries do not match, however, there is an additional caching at the host side required. To avoid that, using cards allowing the usage of any block length within the allowed range for applications with an external ECC is strongly recommended.

A.3 Connector

The connector described in this chapter serves as an example and is subject to further changes.

A.3.1 General

The connector housing which accommodates the card is formed of plastic. Inside are 7 contact springs for contacting the pads of the inserted card. Testing procedures are performed according to DIN IEC 68.

A.3.2 Card insertion and removal

Insertion of the MultiMediaCard is only possible when the contact area of the card and the contact area of the connector are in the correct position to each other. This is ensured by the reclining corners of the card and the connector, respectively.

To guarantee a reliable initialization during hot insertion, some measures must be taken on the host side. One possible solution is shown in Figure A.2. It is based on the idea of a defined sequence for card contact connection during the card insertion process. The card contacts are contacted in two steps:

1. Ground V_{SS1} (pin 3) and supply voltage V_{DD} (pin 4)
2. Others (CLK, CMD, DAT, V_{SS2} and R_{SV})

Pins 3 and 4 should make first contact when inserting and release last when extracting.

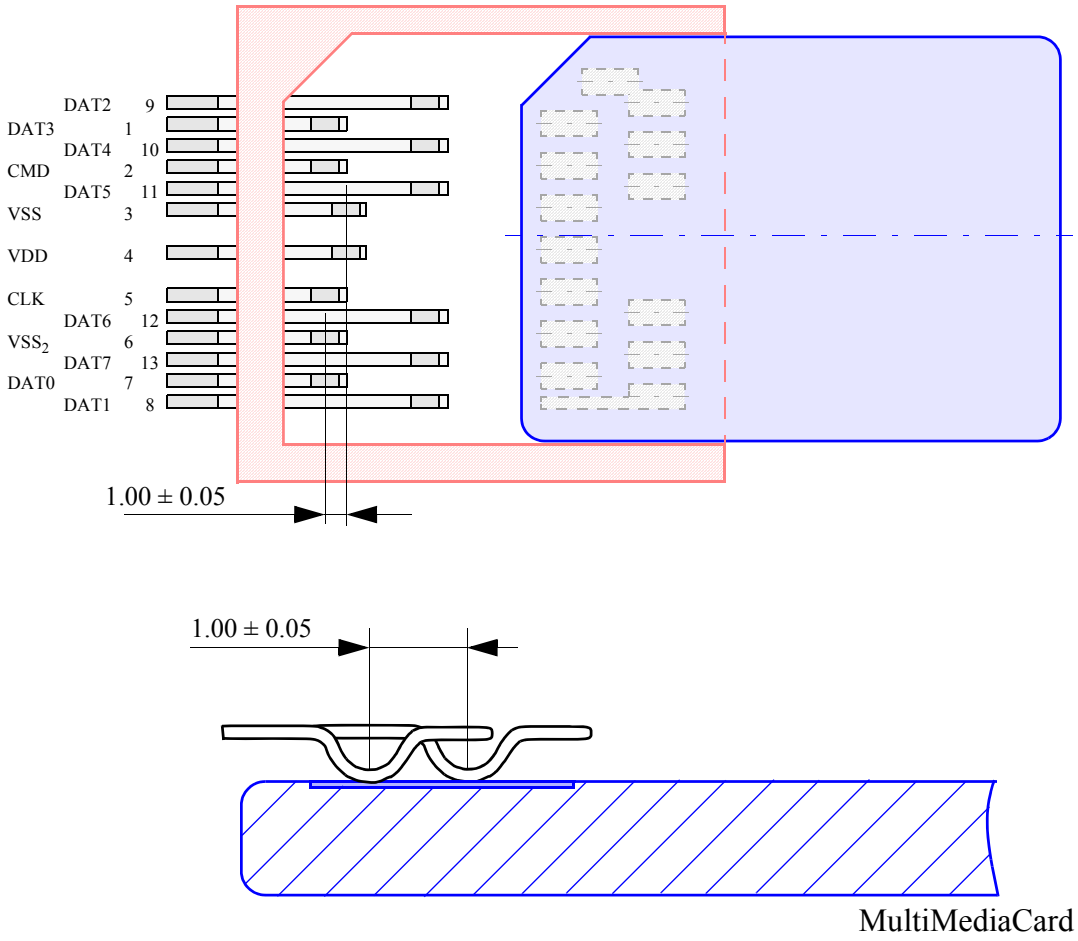


Figure A.2 — Modified MultiMediaCard connector for hot insertion

A.3.3 Characteristics

The features described in the following must be considered when designing a MultiMediaCard connector. The given values are typical examples.

Table A.1 — Mechanical characteristics

Characteristic	Value	
Max. number of mating operations	> 10000	
Contact force	0.2…0.6 N	
Total pulling force	Min 2 N	DIN IEC 512 part 7
Total insertion force	Max 40 N	DIN IEC 512 part 7
Vibration and High Frequency		
Mechanical frequency range	10…2000Hz	DIN IEC 512 part 2 and 4
Acceleration	2g	
Shock		
Acceleration	5g	

Table A.2 — Electrical characteristics

DIN IEC 512	Value
Contact resistance	100 mOhm
Current-carrying capacity at +25°C	0.5 A
Insulation resistance	> 1000 MOhm, > MOhm after test
Operating voltage	3.3V
Testing voltage	500V
Operating current	100 mA max

Table A.3 — Climatic characteristics

DIN IEC 512 part 6–9	Range
Operating temperature	-25°C…+90°C
Storage temperature	-40°C…+90°C
Humidity	95% max non-condensing

A.4 Description of method for storing passwords on the card

In order to improve compatibility and inter-operability of the card between different applications, it is required that different host applications use identical algorithms and data formats. Following is a recommended way of storing passwords in the 128-bit password block on the card. It is provided as application note only.

This method is applicable only if the password consists of text, possibly entered by the user. The application may opt to use another method if inter-operability between devices is not important, or if the application chooses to use, for example, a random bit pattern as the password.

- Get the password (from the user, from a local storage on the device, or something else). The password can be of any length, and in any character set.
- Normalize the password into UTF-8 encoded Unicode character set. This guarantees inter-operability

with all locales, character sets and country-specific versions. In UTF-8, the first 128 characters are mapped directly to US-ASCII, and therefore a device using only US-ASCII for the password can easily conform to this standard.

- Run the normalized password through SHA-1 secure hash algorithm. This uses the whole key space available for password storage, and makes it possible to use also longer passwords than 128 bits. As an additional bonus, it is not possible to reverse-engineer the password from the card, since it is not possible to derive the password from its hash.
- Use the first 128 bits of this hash as the card password. (SHA-1 produces a 160-bit hash. The last 32 bits are not used.)

Following is an example (note that the exact values need to be double-checked before using this as implementation reference):

The password is “foobar”. First, it is converted to UTF-8. As all of the characters are US-ASCII, the resulting bit string (in hex) is:

```
66 6F 6F 62 61 72
```

After running this string through SHA-1, it becomes:

```
88 43 d7 f9 24 16 21 1d e9 eb b9 63 ff 4c e2 81 25 93 28 78
```

Of which the first 128 bits are:

```
88 43 d7 f9 24 16 21 1d e9 eb b9 63 ff 4c
```

Which is then used as the password for the card.

UTF-8 is specified in *UTF-8, a transformation format of Unicode and ISO 10646*, RFC 2044, October 1996. ftp://ftp.nordu.net/rfc/rfc2044.txt

SHA-1 is specified in *Secure Hash Standard*, Federal Information Processing Standards Publication (FIPS PUB) 180-1, April 1995. http://www.itl.nist.gov/fipspubs/fip180-1.htm

A.5 MultiMediaCard macro commands

This section defines the way complex MultiMediaCard bus operations (e.g. erase, read, etc.) may be executed using predefined command sequences. Executing these sequences is the responsibility of the MultiMediaCard bus master. Nevertheless, it may be used for host compatibility test purposes.

Table A.4 — Macro commands

Mnemonic	Description
CIM_SINGLE_CARD_ACQ	Starts an identification cycle of a single card.
CIM_SETUP_CARD	Select a card by writing the RCA and reads its CSD.
CIM_STREAM_READ	Sets the start address and reads a continuous stream of data from the card.
CIM_READ_BLOCK	Sets the block length and the starting address and reads a data block from the card.
CIM_READ_MBLOCK	Sets the block length and the starting address and reads (continuously) data blocks from the card. Data transfer is terminated by a stop command.
CIM_WRITE_BLOCK	Sets the block length and the starting address and writes a data block from the card.
CIM_WRITE_MBLOCK	Sets the block length and the starting address and writes (continuously) data blocks to the card. Data transfer is terminated by a stop command.
CIM_ERASE_GROUP	Erases a range of erase groups on the card.
CIM_SECURE_ERASE	Secure Erases a range of erase groups on the card.

Table A.4 — Macro commands

Mnemonic	Description
CIM_SECURE_TRIM	Secure Erases a number of ranges of write blocks on the card.
CIM_TRIM	Erases a number of ranges of write blocks on the card.
CIM_US_PWR_WP	Applies power-on write protection to a write protection group on the card.
CIM_US_PERM_WP	Applies permanent write protection to a write protection group on the card.

The MultiMediaCard command sequences are described in the following paragraphs. Figure A.3 provides a legend for the symbols used in the sequence flow charts.

The status polling by CMD13 can explicitly be done any time after a response to the previous command has been received.

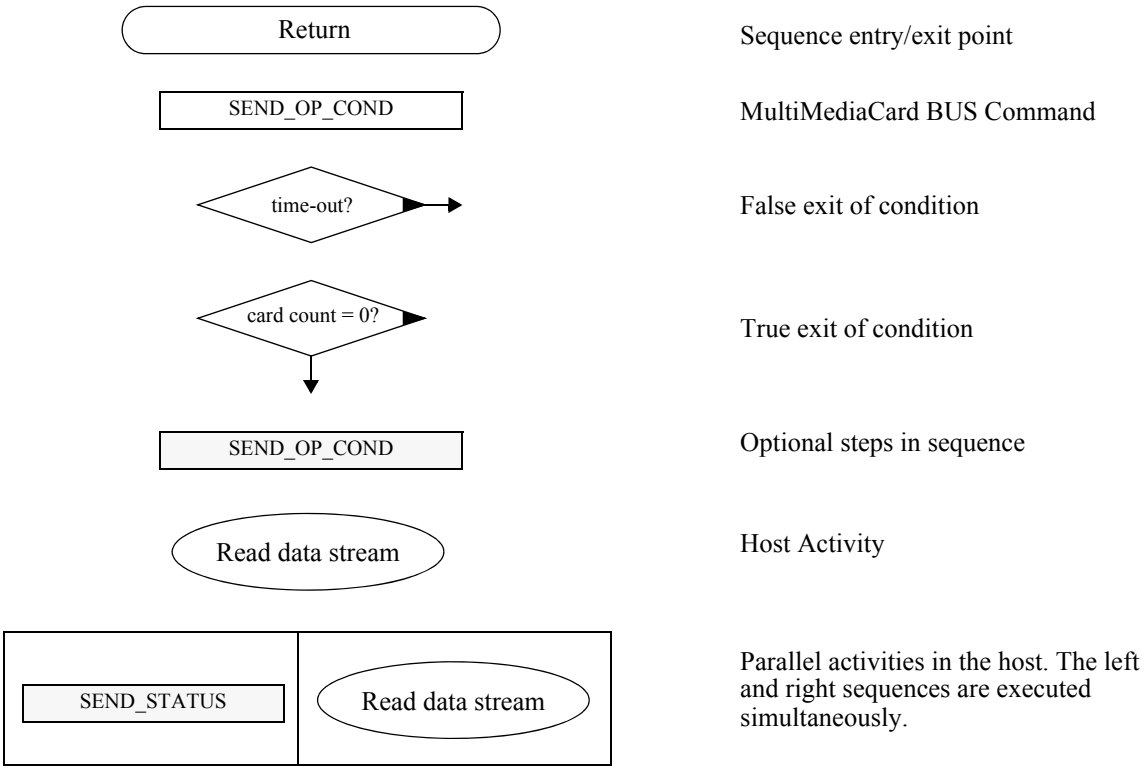


Figure A.3 — Legend for command-sequence flow charts

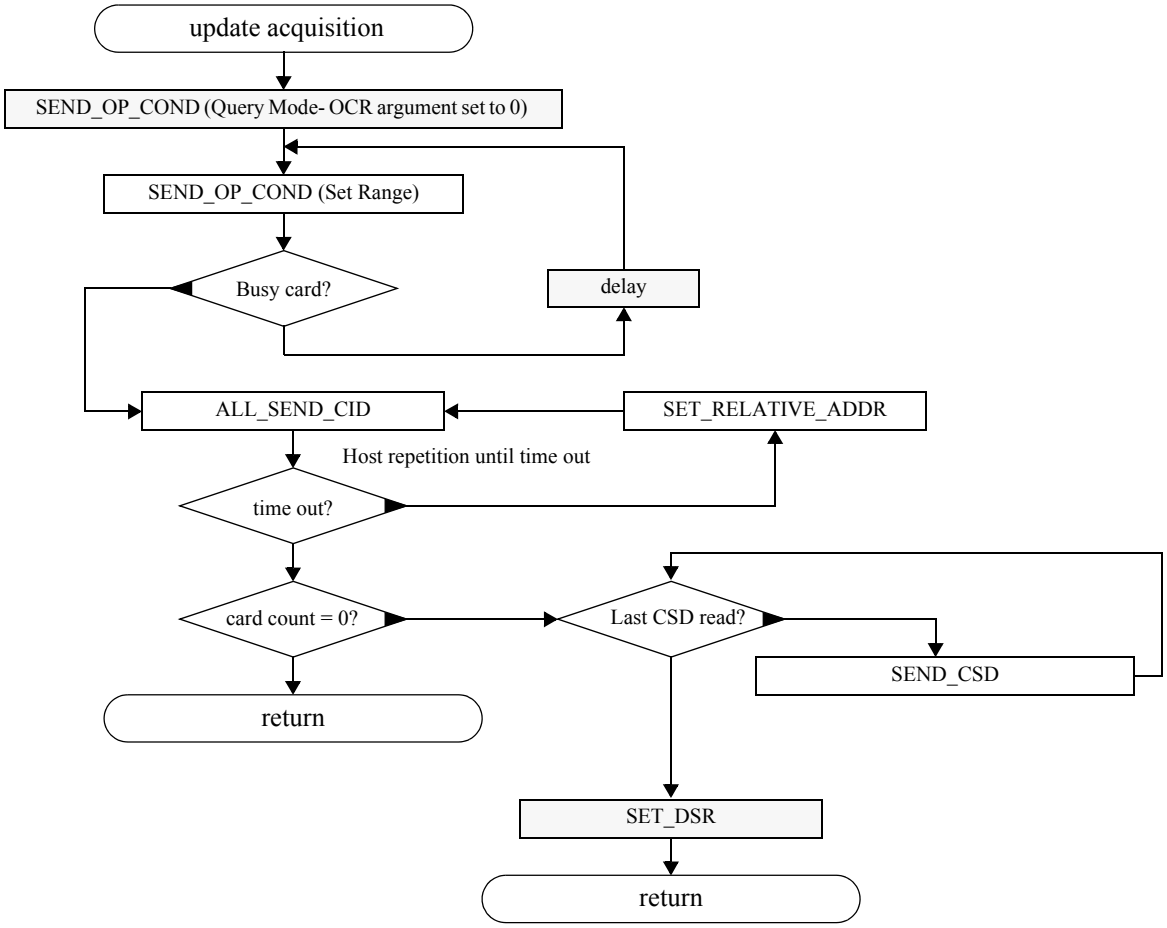


Figure A.4 — SEND_OP_COND command flow chart

- CIM_SINGLE_CARD_ACQ

The host knows that there is a single card in the system and, therefore, does not have to implement the identification loop. In this case only one ALL_SEND_CID is required.

Similarly, a single SEND_CSD is sufficient.

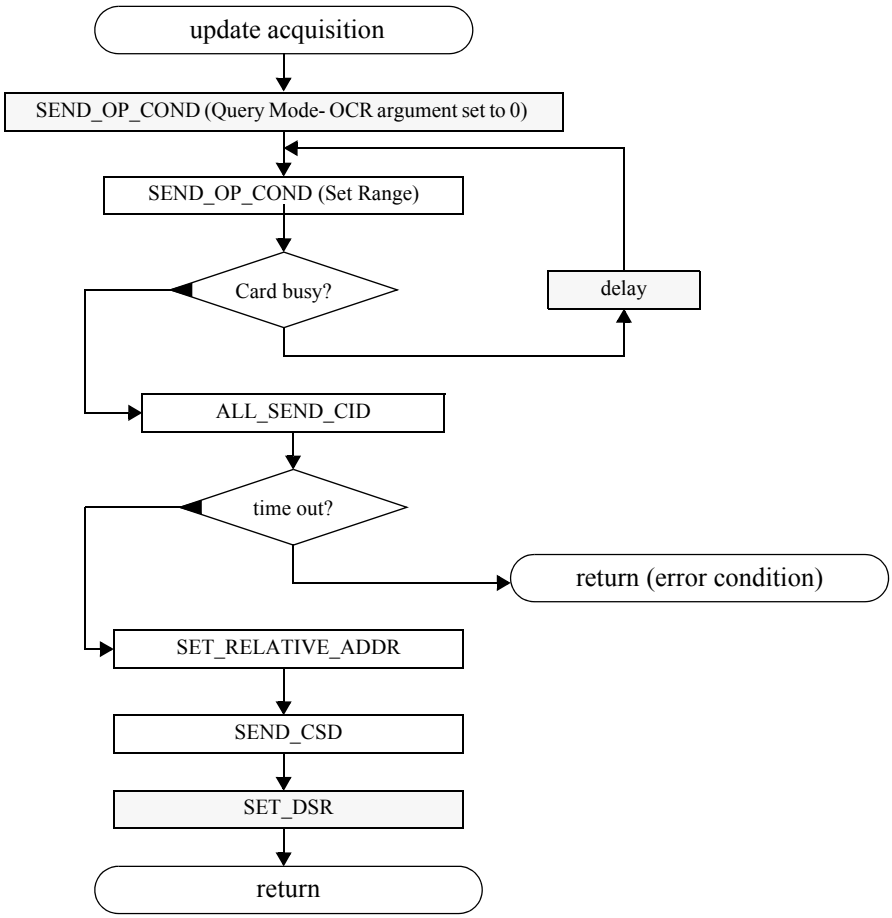


Figure A.5 — CIM_SINGLE_CARD_ACQ

- CIM_SETUP_CARD

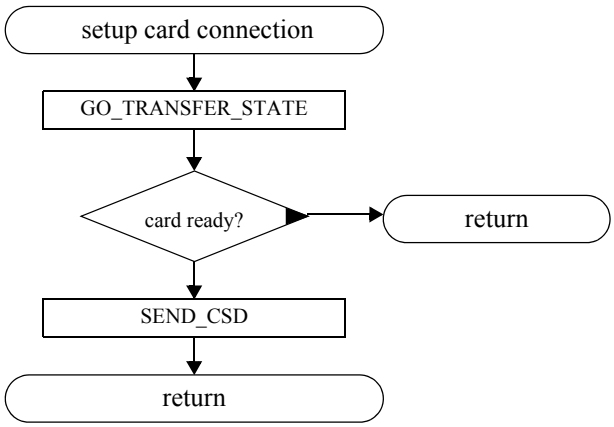


Figure A.6 — CIM_SETUP_CARD

The setup card connection procedure (CIM_SETUP_CARD) links the bus master with a single card. The argument required for this command is the RCA of the chosen card. A single card is selected with GO_TRANSFER_STATE (CMD7) command by its RCA. The response indicates whether the card is ready or not. If the card confirms the connection, the adapter will read the card specific data with SEND_CSD (CMD9). The information within the response is used to configure the data path and controller options.

- CIM_STREAM_READ

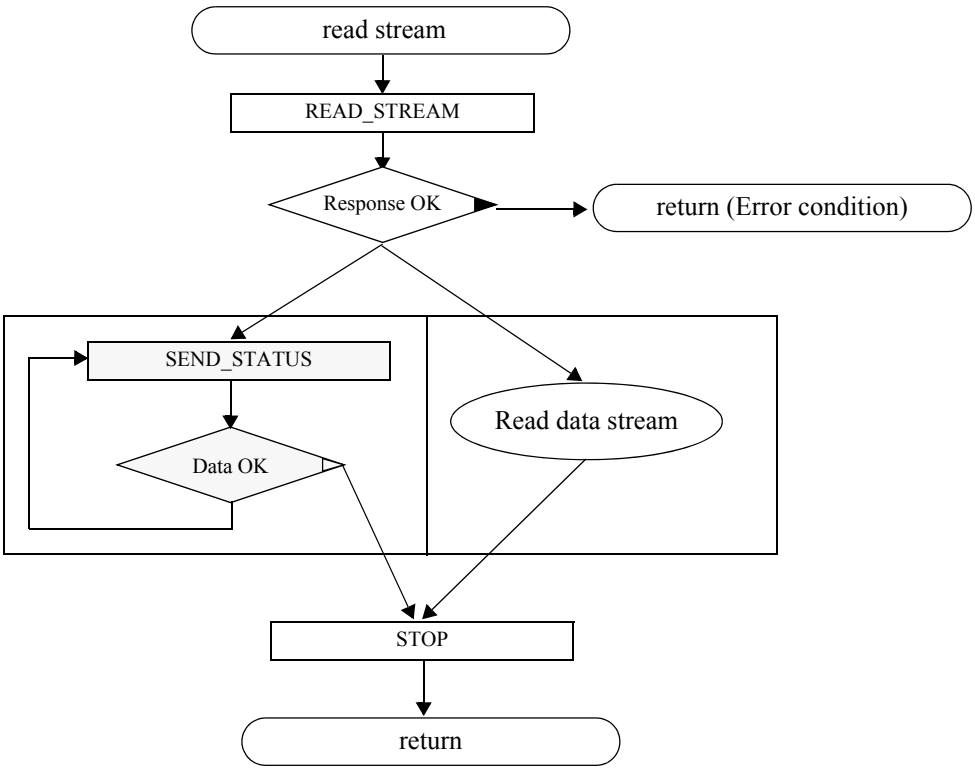


Figure A.7 — CIM_STREAM_READ

The sequence of stream read starts with the STREAM_READ (CMD11) command. If the card accepts the command it will send the data out on the DAT line and the host will read it. While reading the data line the host may send SEND_STATUS (CMD13) commands to the card to poll any new status information the card may have (e.g. UNDERRUN).

When the host has read all the data it needs or the card is reporting an error, the host will stop data transmission using the STOP (CMD12) command.

- CIM_READ_BLOCK

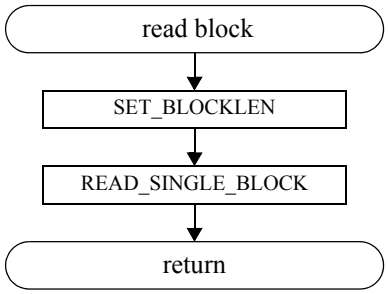


Figure A.8 — CIM_READ_BLOCK

The read block procedure (CIM_READ_BLOCK) reads a data block from a card. The arguments required for this command are the block length (4 bytes) and the starting address of the block (4 bytes). This operation also includes a data portion (in this case, the read block). The procedure starts by setting the required block length with the SET_BLOCKLEN (CMD16) command. If the card accepts this setting, the data block is transferred via command READ_SINGLE_BLOCK (CMD17), starting at the given address.

- CIM_READ_MBLOCK

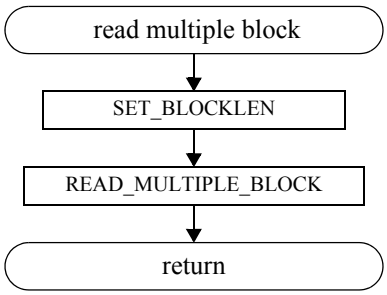


Figure A.9 — CIM_READ_MBLOCK

The read multiple block procedure (CIM_READ_BLOCK) sequentially reads blocks of data from a card. The arguments required for this command are the block length (4 bytes) and the starting address of the first block (4 bytes). This operation also includes a data portion (in this case, the read blocks). The procedure starts by setting the required block length with the SET_BLOCKLEN (CMD16) command. If the card accepts this setting, the data blocks are transferred via command READ_MULTIPLE_BLOCK (CMD18), starting at the given address.

- CIM_WRITE_BLOCK

This command sequence is similar to multiple block write except that there is no repeat loop for write data block.

- CIM_WRITE_MBLOCK

The sequence of write multiple block starts with an optional SET_BLOCK_LEN command. If there is no change in block length this command can be omitted. If the card accepts the two starting commands the host will begin sending data blocks on the data line.

After each data block the host will check the card response on the DAT line. If the CRC is OK, the card is not busy and the host will send the next block if there are more data blocks.

While sending data blocks, the host may query the card status register (using the SEND_STATUS conned) to poll any new status information the card may have (e.g. WP_VIOLATION, MISALIGMENT, etc.)

The sequence must be terminated with a STOP command.

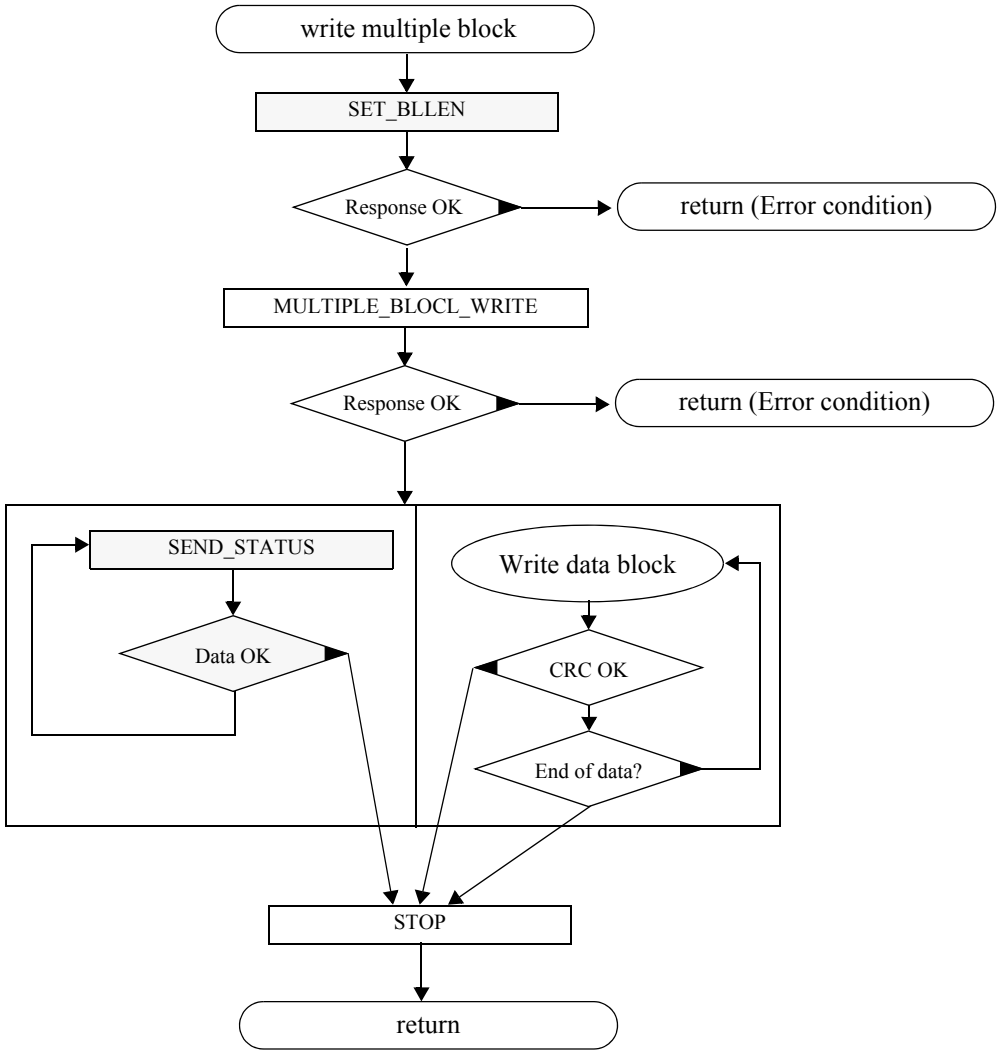


Figure A.10 — CIM_WRITE_MBLOCK

- CIM_ERASE_GROUP

The erase group procedure starts with ERASE_START (CMD35) and ERASE_END (CMD336 commands. Once the erase groups are selected the host will send an ERASE (CMD38) command. It is recommended that the host terminates the sequence with a SEND_STATUS (CMD13) to poll any additional status information the card may have (e.g. WP_ERASE_SKIP, etc.).

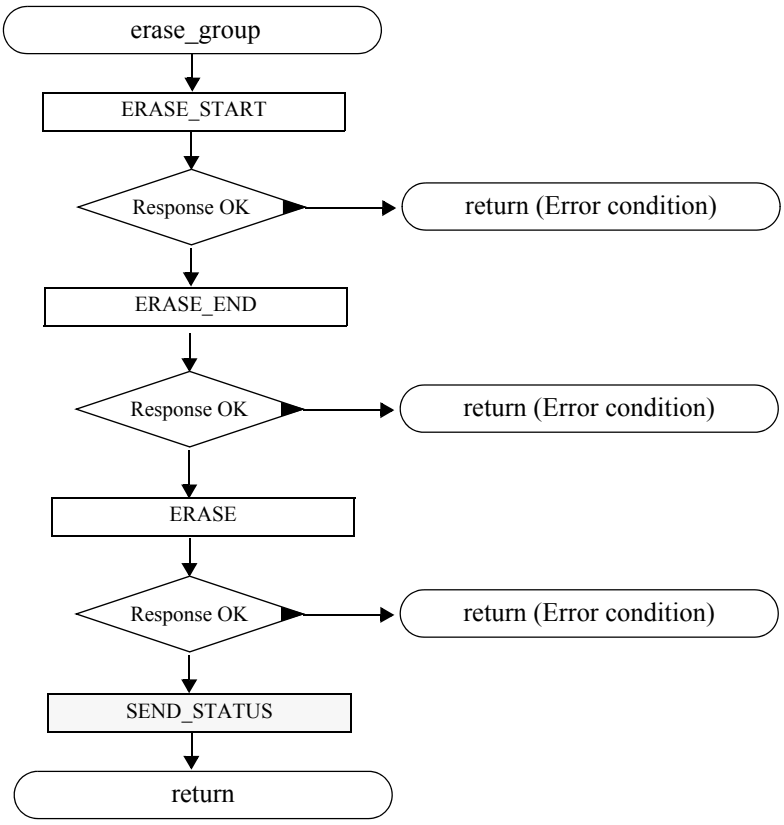


Figure A.11 — CIM_ERASE_GROUP

- CIM_SECURE_ERASE

The secure erase procedure starts with ERASE_START (CMD35) and ERASE_END (CMD36) commands. Once the erase groups are selected the host will send an ERASE (CMD38) command with argument bit 31 set to one and the remainder of the bits set to zero. It is recommended that the host terminates the sequence with a SEND_STATUS (CMD13) to poll any additional status information the card may have (e.g. WP_ERASE_SKIP, etc.).

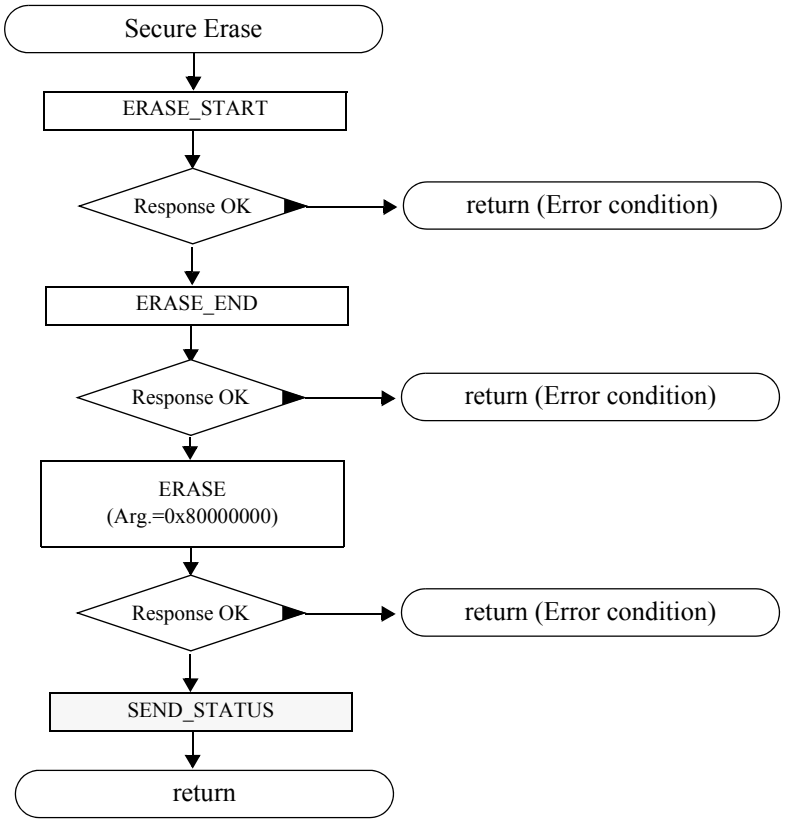


Figure A.12 — CIM_SECURE_ERASE

- CIM_SECURE_TRIM

The secure trim procedure starts with ERASE_START (CMD35) and ERASE_END (CMD36) commands, these commands are used to select write blocks. Once the write blocks are selected the host will send an ERASE (CMD38) command with argument bit 31 and 0 set to one and the remainder of the bits set to zero. It is recommended that the host terminates the sequence with a SEND_STATUS (CMD13) to poll any additional status information the card may have (e.g. WP_ERASE_SKIP, etc.). After this the host can choose to select additional blocks by performing the same steps or complete the secure trim operation by sending the ERASE_START (CMD35), ERASE_END (CMD36) and ERASE (CMD38) command with argument bits 31 and 15 set to one and the remainder of the bits set to zero. It is recommended that the host terminates the sequence with a SEND_STATUS (CMD13).

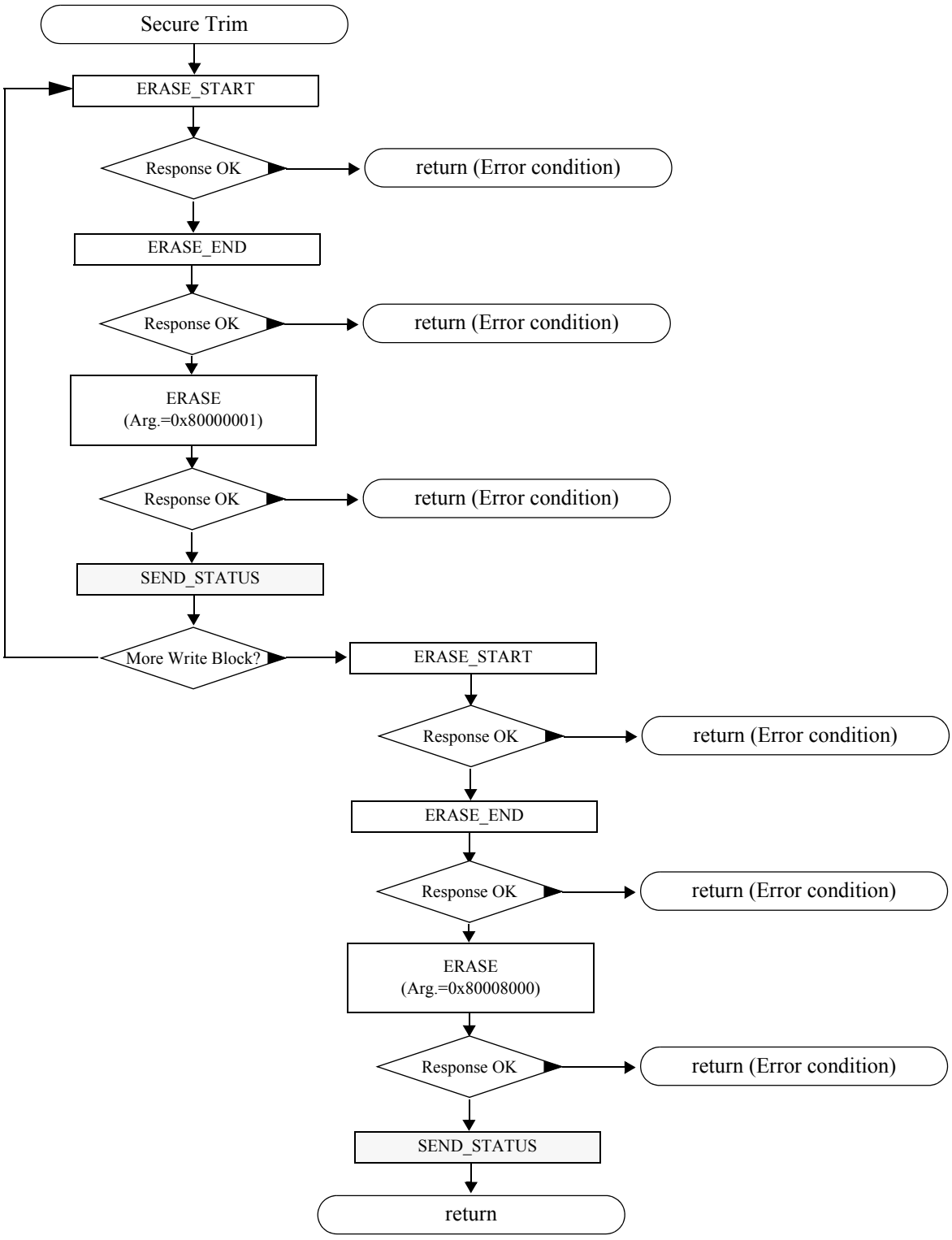


Figure A.13 — CIM_SECURE_TRIM

- CIM_TRIM

The trim procedure starts with ERASE_START (CMD35) and ERASE_END (CMD36) commands, these commands are used to select write block. Once the write blocks are selected the host will send an ERASE (CMD38) command with argument bit 0 set to one and the remainder of the bits set to zero. It is recommended that the host terminates the sequence with a SEND_STATUS (CMD13) to poll any additional status information the card may have (e.g. WP_ERASE_SKIP, etc.).

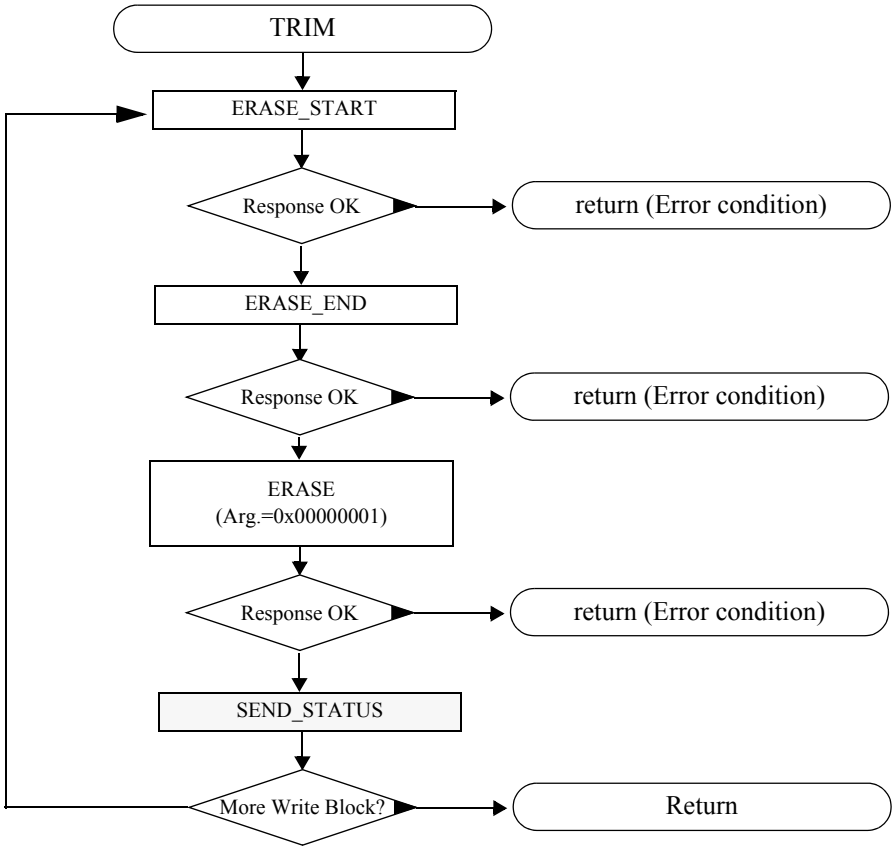


Figure A.14 — CIM_TRIM

- CIM_US_PWR_WP

The minimum required sequence to apply Power-On write protection to a write protection group is to set US_PWR_WP_EN (EXT_CSD[171] bit 0) and then use the SET_WR_PROT(CMD28) command.

It is recommended to disable permanent write protection, if it is not needed, before issuing the first power-on write protection sequence since if an area is permanently protected then power-on write protection cannot be applied.

The host can check if power-on protection has been disabled before following the minimum required sequence to apply power-on protection by reading US_DIS_PWR_WP (EXT_CSD[171] bit 3). Also, the host can verify the protection status of the write group after the required sequence has been executed by using the SEND_WR_PROTECT_TYPE (CMD31) command.

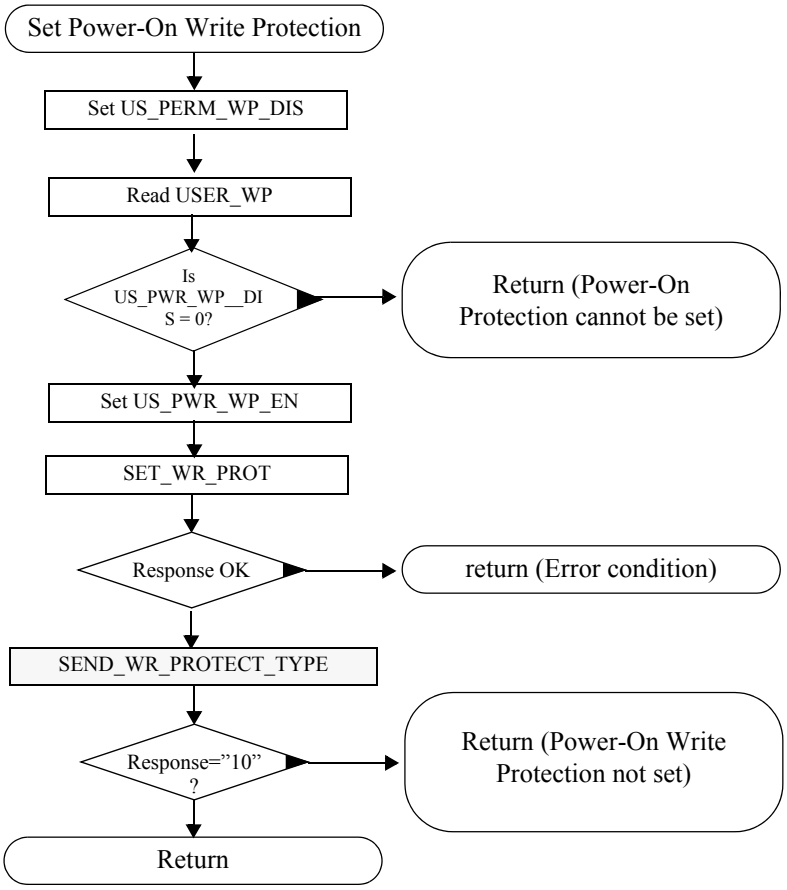


Figure A.15 — CIM_US_PWR_WP

- CIM_US_PERM_WP

The minimum required sequence to apply permanent write protection to a write protection group is to set US_PERM_WP_EN (EXT_CSD[171] bit 2) and then use the SET_WR_PROT(CMD28) command.

The host has the option to check that permanent protection is not disabled before setting permanent write protection by reading US_DIS_PERM_WP (EXT_CSD[171] bit 4). Also, the host can verify the protection status of the write group after the required sequence has been executed by using the SEND_WR_PROTECT_TYPE (CMD31) command.

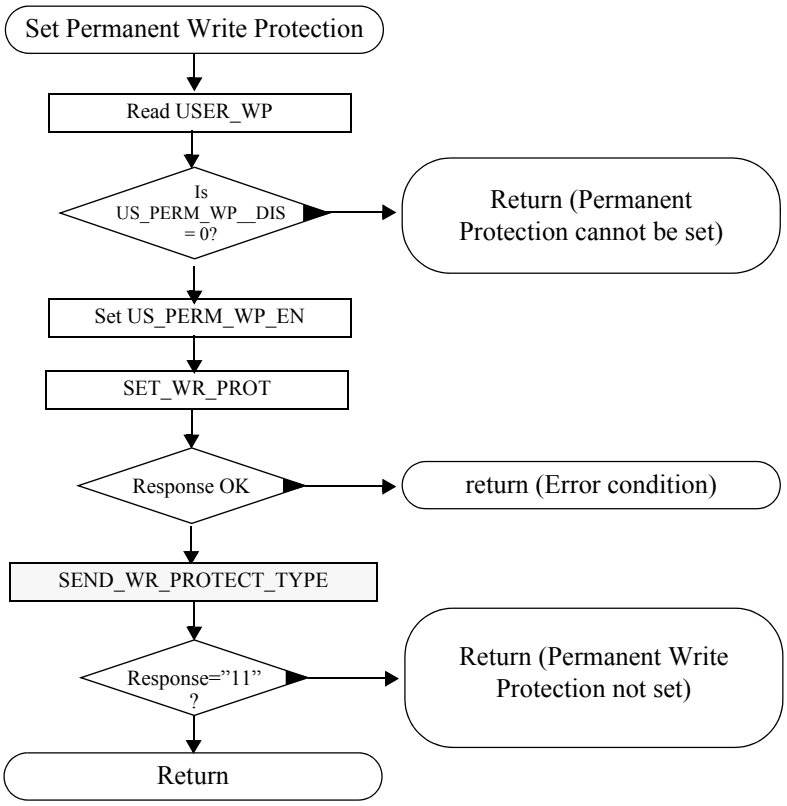


Figure A.16 — CIM_US_PERM_WP

A.6 Host interface timing

With the introduction of MultiMediaCard standard version 4.0, higher clock speeds are used in both hosts and cards. In order to maintain backward and forward compatibilities, the card, and the host, are required to implement two different sets of timings. One set of timings is the interface timing aimed at high speed systems, working at clock frequencies higher than 20MHz, up to 52MHz. The other set of timing is different for the card and for the host. The card has to maintain backwards compatibility, allowing it to be inserted into an older MultiMediaCard system. The host has to maintain forward compatibility, allowing old MultiMediaCard to be inserted into new high speed MultiMediaCard systems.

Follows the table for the forward compatibility interface timing. The high speed interface timing is already defined in Table 113 on 177.

Table A.5 — Forward-compatible host interface timing

Parameter	Symbol	Min	Max.	Unit	Remark
Clock CLK[1]					
Clock frequency Data Transfer Mode (PP)	f_{PP}	0	20	MHz	C_L <= 30 pF
Clock frequency Identification Mode (OD)	f_{OD}	0	400	kHz	
Clock low time	t_{WL}	10		ns	C_L <= 30 pF
Clock rise time[2]	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}	4.8		ns	C_L <= 30 pF
Input hold time	t_{IH}	4.4		ns	C_L <= 30 pF
Outputs CMD, DAT (referenced to CLK)					
Output set-up time	t_{OSU}	5		ns	C_L <= 30 pF
Output hold time	t_{OH}	5		ns	C_L <= 30 pF

NOTE 1. All timing values are measured relative to 50% of voltage level
NOTE 2. Rise and fall times are measured from 10%-90% of voltage level.

A.7 Handling of passwords

There is only one length indicator for the password instead of having separate length bytes reserved for both new and old passwords. Due to this there is a possibility for conflict during the password change operation after which the new password does not match to the one which the user set. There has also proven to be various interpretations related to the removal of the lock function in card implementations.

Thus the procedures in the following sections are recommended to be used to enable best possible compatibility over host-card systems.

A.7.1 Changing the password

This applies for the host systems. Instead of using the password replacement function implement the password change as follows:

- First, remove the old password

- Second, set the new password

A.7.2 Removal of the password

This applies to the host systems. Before resetting the password (CLR_PWD) unlock the card.

A.8 High-speed MultiMediaCard bus functions

A.8.1 Bus initialization

There is more than one way to use the new features, introduced in v4.0 of this document. This application note describes a way to switch a high speed MultiMediaCard from the initial lower frequency to the high frequency and different bus configuration.

High Speed MultiMediaCards are backwards compatible, therefore after power up, they behave identically to old cards, with no visible difference[1].

The steps a host can do to identify a High Speed MultiMediaCard, and to put it to high speed mode are described next, from power-up until the card is ready to work at high data rates.

a. Power-up

1- Apply power to the bus, communication voltage range (2.7-3.6V)
2- Set clock to 400KHz, or less
3- Wait for 1ms, then wait for 74 more clock cycles
4- Send CMD0 to reset the bus, keep CS line high during this step.
5- Send CMD1, with the intended voltage range in the argument (either 0x00FF8000 or 0x00000080)
6- Receive R3
7- If the OCR busy bit is ‘0’, repeat steps 5 and 6
8- From the R3 response argument the host can learn if the card is a High Voltage or Dual Voltage card. If the argument is 0x80FF8000 the card is only High Voltage, if the argument is 0x80FF8080 the card is Dual Voltage.
9- If R3 returned some other value, the card is not compliant (since it should have put itself into *inactive* state, due to voltage incompatibility, and not respond); in such a case the host must power down the bus and start its error recovery procedure (the definition of error recovery procedures is host dependent and out of the scope of this application note)

Low-voltage power-up

Do the following steps if low voltage operations are supported by the host; otherwise skip to step 16.

10- If the host is a low voltage host, and recognized a dual voltage card, power down the MMC bus
11- Apply power to the MMC bus, in the low voltage range (1.70 -1.95V)
12- Wait for 1ms, then for 74 more clock cycles
13- Send CMD1 with argument 0x00000080
14- Receive R3, it should read 0x00FF8080
15- If the OCR busy bit is ‘0’, repeat steps 13 and 14

b. CID retrieval and RCA assignment

16- Send CMD2

1. Some legacy cards correctly set the ILLEGAL_CMD bit, when the bus testing procedure is executed upon them, and some other legacy cards in the market do not show any error.

17-Receive R2, and get the card's CID
18-Send CMD3 with a chosen RCA, with value greater than 1

c. CSD retrieval and host adjustment

19-Send CMD9
20-Receive R2, and get the card's CSD from it.
21-If necessary, adjust the host parameters according to the information in the CSD
If the SPEC_VERS indicates a version 4.0 or higher, the card is a high speed card and supports SWITCH and SEND_EXT_CSD commands.
Otherwise the card is an old MMC card.
Regardless of the type of card, the maximum clock frequency that can be set at this point is defined in the TRAN_SPEED field.

A.8.2 Switching to high-speed mode

The following steps are supported by cards implementing version 4.0 or higher. Do these steps after the bus is initialized according to section Annex A.8.1 on page 203.

22-Send CMD7 with the card's RCA to place the card in *tran* state
23-Send CMD8, SEND_EXT_CSD. From the EXT_CSD the host can learn the power class of the card, and choose to work with a wider data bus (See steps 26-37)
24-Send CMD6, writing 0x1 to the HS_TIMING byte of the EXT_CSD. The argument 0x03B9_0100 will do it.
24.1-The card might enter BUSY right after R1, if so, wait until the BUSY signal is de-asserted
24.2-After the card comes out of BUSY it is configured for high speed timing
25-Change the clock frequency to the chosen frequency (any frequency between 0 and 26/52MHz).

A.8.3 Changing the data bus width

The following steps are optionally done if the card's power class allows the host to work on a wider bus, within the host power budget. Do these steps after the bus is initialized according to section Annex A.8.1 on page 203.

a. Bus testing procedure

26-Send CMD19
27-Send a block of data, over all the bus data lines, with the data pattern as follows (CRC16 is optional):
27.1-For 8 data lines the data block would be (MSB to LSB): 0x0000_0000_0000_AA55
27.2-For 4 data lines the data block would be (MSB to LSB): 0x0000_005A
27.3-For only 1 data line the data block would be: 0x80

	Start	Test Pattern								Optional	End
DAT7	0	0	1	0	0	0	0	0	0	CRC16	1
DAT6	0	1	0	0	0	0	0	0	0	CRC16	1
DAT5	0	0	1	0	0	0	0	0	0	CRC16	1
DAT4	0	1	0	0	0	0	0	0	0	CRC16	1
DAT3	0	0	1	0	0	0	0	0	0	CRC16	1
DAT2	0	1	0	0	0	0	0	0	0	CRC16	1
DAT1	0	0	1	0	0	0	0	0	0	CRC16	1
DAT0	0	1	0	0	0	0	0	0	0	CRC16	1
		LSB							MSB		
		0x55	0xAA	0x00	0x00	0x00	0x00	0x00	0x00		

Figure A.17 — Bus testing for eight data lines

	Start	Test Pattern								Optional	End
DAT3	0	0	1	0	0	0	0	0	0	CRC16	1
DAT2	0	1	0	0	0	0	0	0	0	CRC16	1
DAT1	0	0	1	0	0	0	0	0	0	CRC16	1
DAT0	0	1	0	0	0	0	0	0	0	CRC16	1
		LSB						MSB			
		0x5A		0x00		0x00		0x00			

Figure A.18 — Bus testing for four data lines

	Start	Test Pattern								Optional	End
DAT0	0	1	0	0	0	0	0	0	0	CRC16	1
		0x80									

Figure A.19 — Bus testing for one data line

28-Wait for at least N_{CR} clock cycles before proceeding
29-Send CMD14 and receive a block of data from all the available data lines[1]
  29.1-For 8 data lines receive 8 bytes
  29.2-For 4 data lines receive 4 bytes
  29.3-For 1 data line receive 1 byte
30-XNOR the masked data with the data sent in step 27

1. This represents the host expected values. The card always responds to CMD19 over all eight DAT lines.

Table A.6 — XNOR values

A	B	A XNOR B
0	0	1
0	1	0
1	0	0
1	1	1

31- Mask the result according to the following:
  31.1-For 8 data lines the mask is (MSB to LSB): 0x0000_0000_0000_FFFF
  31.2-For 4 data lines the mask is (MSB to LSB): 0x0000_00FF
  31.3-For 1 data line the mask is 0xC0
32- The result should be 0 for all. Any other result indicates a problem in the card connection to the system; in such a case the host must power down the bus and start its error recovery procedure (the definition of error recovery procedures is host dependent and out of the scope of this application note)

b. Power and bus-width selection

33- Choose the width of bus you want to work with
34- If the power class, for the chosen width, is different from the default power class, send CMD6, and write the POWER_CLASS byte of the EXT_CSD with the required power class.
35- The card might signal BUSY after CMD6; wait for the card to be out of BUSY
36- Send CMD6, writing the BUS_WIDTH byte of the EXT_CSD with the chosen bus width. An argument of 0x03B7_0100 will set a 4-bits bus, an argument 0x03B7_0200 will set an 8-bit bus.
37- The bus is ready to exchange data using the new width configuration.

A.9 Erase-unit size selection flow

The flow chart in Figure A.20 shows how the master selects the erase unit size if the master supports the JEDEC MMC Electrical Interface standard v4.3.

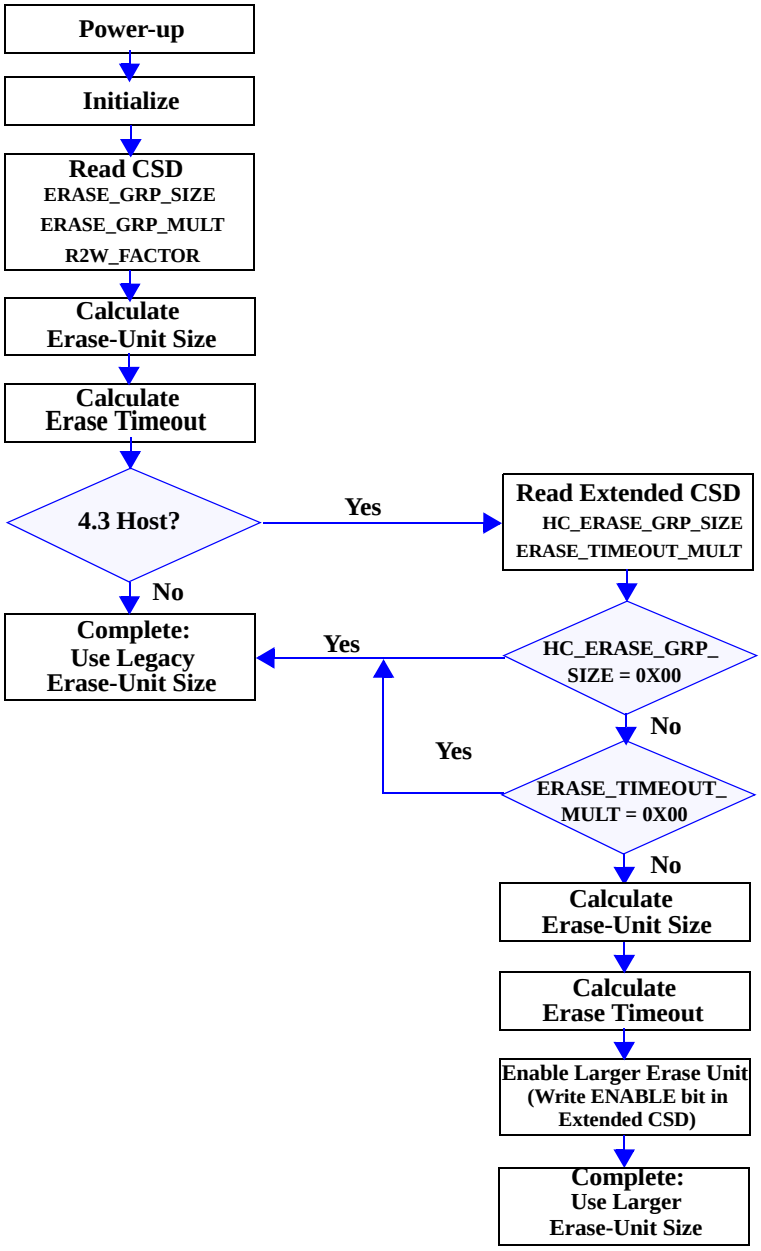


Figure A.20 — Erase-unit size selection flow

A.10 HPI background and one of possible solutions

A.10.1 Background - issues with HPI

There are concerns with the High Priority Interrupt (HPI).

One case is when the interruptible operation (e.g. write) is being repeatedly interrupted in order to allow execution of the High Priority Read operations. There is concern that the delaying the write operation for too long time can stall the host system. If it really would be a problem or not is hard to predict because of different system characteristics; different types of applications that will be launched by High Priority Read, different types of applications that might have their write operations interrupted, different timing of the systems, etc.

Another case is when a process with high priority has requested a write operation and a process with lower priority has requested a new code page, and in the case that the write operation is being interrupted by the HPI, we are facing a priority violation against the intention of the scheduling defined in the system.

A.10.2 One of possible solutions

There might be different solutions to resolve the observed issues with the HPI.

One of possible solutions to the observed issues is to resolve a conflict at the host by letting the write operation come through when a dedicated timer has been expired. With an adjustable timeout value depending on the context, flexibility is gained making it possible to adopt the method for different needs.

Using the following examples, a possible method is explained for the two most interesting use cases.

Assume that we want to protect the write commands not being delayed by more than 1s after the write command has been originally sent to the memory device. In such case we need to set the timeout value 1s for each write command. A timer will be started when the write command has been sent to the memory device. If HPI is requested while the write command is still ongoing, the driver in the host will check the timer value. If the timer value has expired compared to the timeout (1s), the HPI will not be able to interrupt the write command. On the other hand, if the timer value is lower than the timeout (1s), then the HPI will interrupt the write operation and the requested read operation will be provided. When the write operation has finally been concluded, the timer will be reset.

Assume another case, protecting high priority write operations in Linux. When a write operation has been requested, the check will be made of the priority of the process that has requested this operation. If it is a real time process or a kernel process, the timeout value will be set to zero and a timer will be started in the same way as in the example above. If HPI is requested while the write command is still ongoing, the driver in the host will check the timer value. The timer value will be checked towards the timeout (0s), indicating the expiration of the timer that means that the write command will never be interrupted. When the write operation has been concluded, the timer will be reset.

Annex B Errata

B.1 Note on Boot Bus Width

In case CMD0 is used while RESET_BOOT_BUS_WIDTH flag is set (bit 2 in EXT_CSD[177]) , some implementations may keep bus width and mode after boot mode while others may reset them. Therefore, host should not assume bus width and mode are retained after boot mode and set them explicitly. In all cases during boot mode the bus width and bus mode are always the values set in EXT_CSD[177].

Annex C Changes between system specification versions

C.1 Version 4.1, the first version of this standard

This Electrical Standard is derived from the MMCA System Specification version 4.1. There are no technical changes made. The editorial changes are listed below.

- The pin number references were removed (see Section 6.3 on page 14).
- The form factor references were removed (see Section 6.3 on page 14).
- The CSD_STRUCTURE and SPEC_VERS registers were modified to include only allocations applicable to this Electrical standard (see Section 8.3 on page 115 and Section 8.5 on page 154).
- The S_CMD_SET allocations were removed from this standard and are defined in detail in a separate Application Note (see Section 8.5 on page 154).
- The mechanical standard was removed (see Section 11 on page 161).
- The Appendix A was removed and introduced as a separate document (see Annex A on page 185).

C.2 Changes from version 4.1 to 4.2

A major new item is handling densities greater then 2GB.

Additional changes include:

- A definition for implementation of media higher than 2GB was introduced (see Section 6.1 on page 14, Section 7 starting on page 27, Section 8 starting on page 113, and Section 9 on page 155).
- The definition for the card pull-up resistors was clarified (see Section 6.3 on page 14, Section 7.6.4 on page 50, and Section 12.5 on page 171).
- Switching between the tran state and standby states by CMD7 was clarified (see Section 7.6 on page 47 and Table 22 on page 87).
- A new register for indication of the state of an erased block was introduced (see Section 7.6.8 on page 58 and Section 8.5 on page 154).
- Command CMD39 argument was clarified (see Table 28 on page 91).
- The definition of busy indication during write operations was partly changed and partly clarified (see Section 7.15.7 on page 111).
- The minimum voltage of the Low-Voltage range was changed from 1.65V to 1.70V (see Section 12.5 on page 171).

C.3 Changes from version 4.2 to 4.3

Major new items added to this standard are the *e*•MMC definition, boot operation, sleep mode, voltage configuration for *e*•MMC, and reliable write. The chapter dedicated to SPI mode was removed.

Additional changes include:

- Added *e*•MMC features (see Section 5 starting on page 7).
- Boot operation mode was introduced (see Section 7.2 on page 29, Section 7.15.5 on page 108, Section 8.5 on page 154, and Section 12.3 on page 165).

- Sector address definition for Erase and Write Protection was defined (see Section 7.6.8 on page 58 and Section 7.6.12 on page 63).
- CID register setting was changed to recognize either *e*•MMC or a card (see Section 8.2 on page 113).
- The chapter defining SPI mode and all SPI-mode references were removed.
- Sleep mode was introduced (see Section 7.6.15 on page 68 and Section 8.5 on page 154).
- Voltage configuration for *e*•MMC was defined (see Section 12.3.1 on page 166 through Section 12.3.3 on page 168, Section 12.5.3 on page 172, and Section 12.5.4 on page 172).
- Reliable Write was defined (see Section 7.6.7 on page 54, under "Block Write," and Table 59 on page 126).
- Input capacitance for *e*•MMC was defined (see Section 12.5 on page 171).
- New bus timings (setup & Hold) were redefined (see Section 12.7 on page 176).
- Switch command definition was clarified (see Section 7.6.1 on page 49).
- Peak voltage on all signal lines are redefined for card and defined for *e*•MMC (see Section 12.5 on page 171).
- Redefined Access size register (see Section 8.5 on page 154).
- Redefined input capacitance for MMC*micro*, MMC*mobile,* and MMC*plus* (see Section 12.5.5 on page 173).
- Redefined erase-unit size and erase timeout for high-capacity memory (see Section 8.5 on page 154).
- Removed "Absolute Minimum" section formerly section 4.8.2.
- Defined OCR setting and response for *e*•MMC (see Section 7.4.2 on page 42).
- Defined high-capacity WP group size (see Section 7.6.12 on page 63, Section 7.10.4 on page 87, Section 7.14 on page 100, and Section 8.5 on page 154).
- Alternative boot operation (device-optional) introduced (see Section 7.3 on page 34, and Section 7.15.7 on page 111).
- Added "/JEDEC" to "MMCA" as the source of definitions for MID and OID (see Section 6.4.2 on page 18, "MID [127:120]" on page 114, and "OID [111:104]" on page 114).

C.4 Changes from version 4.3 to 4.4

Major new items added to this standard are the Dual Data Rate mode, Multiple Partition Supports and Security Enhancement.

Additional changes include:

- Introduce of Partition Management features with enhanced storage option (see Section 7.2 on page 29).
- Add *Pre-idle* reset arguments at CMD0 (see Section 7.3.1 on page 34).
- Clarify CMD1 for Voltage Operation Range and Access mode validation (see Section 7.4.2 on page 42).
- Introduce of New Secure Features, Replay Protected Memory Block (see Section 7.6.16 on page 69).
- Introduce of dual data rate interface with maximum 104MB/s (see Section 7.6 on page 47 and Section 12.8 on page 179).
- Introduce of Secure Erase, Secure TRIM (see Section 7.6.9 on page 60 and Section 7.6.10 on page 61).
- Introduce of TRIM (see Section 7.6.11 on page 62)

- Introduce of New Time value for Secure Erase, Trim (see Section 7.8.2 on page 82).
- Enhancement of write protection with H/W reset and non-reversable register setting (see Section 7.6.12 on page 63).
- Introduce of Replay Protected Memory Block and access control (see Section 7.6.16 on page 69).
- Alternative boot operation was changed as mandatory for device instead of device-optional (see Section 7.3 on page 34 and Section 7.15.6 on page 110).
- Introduce of H/W reset signal (see Section 7.15.8 on page 112 and Section 7.15.9 on page 112).
- Introduce New Extended CSD registers (see Section 8.4 on page 125).
- Clarify maximum density calculation from SEC_COUNT(see page 136).
- Clarify of tOSU timing for compatibility (see Section 12.7.1 on page 177).

C.5 Changes from version 4.4 to 4.41

Major new items assed to this standard are the Background Operations and High Priority Interrupt.

Additional changes include:

- Added clarification for command operation in RPMB partition (see Section 7.2.2 on page 31 and Section 7.6.16.4 on page 73).
- Added clarification of address sequence for user area including enhanced area and error condition for partition configuration (see Section 7.2.3 on page 31).
- Added clarification for error behavior when partition is configured without setting ERASE_GROUP_DEF (see Section 7.2.3 on page 31) and clarification for the device behavior in case the device received a write/erase command when the condition of ERASE_GROUP_DEF bit has been changed from the previous power cycle (see Section 7.2.4 on page 33 and Section 7.6.12 on page 63).
- Add a clarification for C_SIZE and SEC_COUNT after configuring partitions (see Section 7.2.3 on page 31).
- Added Clarification for the configuration of boot and alternative boot operation (see Section 7.3.3 on page 36 and Section 7.3.4 on page 38).
- Introduce of Enhanced Reliable Write (see Section 7.6.7 on page 54).
- Added clarification for LOCK_UNLOCK feature of the *e*•MMC (see Section 7.6.13 on page 64).
- Introduce of Background Operations (see Section 7.6.19 on page 79).
- Introduce of High Priority Interrupt mechanism (see Section 7.6.20 on page 80), HPI background and one of possible solutions (see Section A.10 on page 208).
- Introduce New Extended CSD registers (see Section 8.4 on page 125).
- Corrected equation of General purpose partition size and Enhanced user data area size (see page 153 to page 151).
- Removed “File formats for the MultiMediaCard” section formerly section 14.
- Added “Errata” Annex B and moved “Changes between system specification versions” Annex B formerly to Annex C.

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