一概述

1. SD 总线模式下

CLK:时钟信号

CMD:双向命令和响应信号

DAT0-3:双向数据信号

VDD,VSS:电源和地信号

SD 模式下允许有一个主机，多个从机(即多个卡)，主机可以给从机分别地址. 主机发命令有些命令是发送给指定的从机,有些命令可以以广播形式发送.

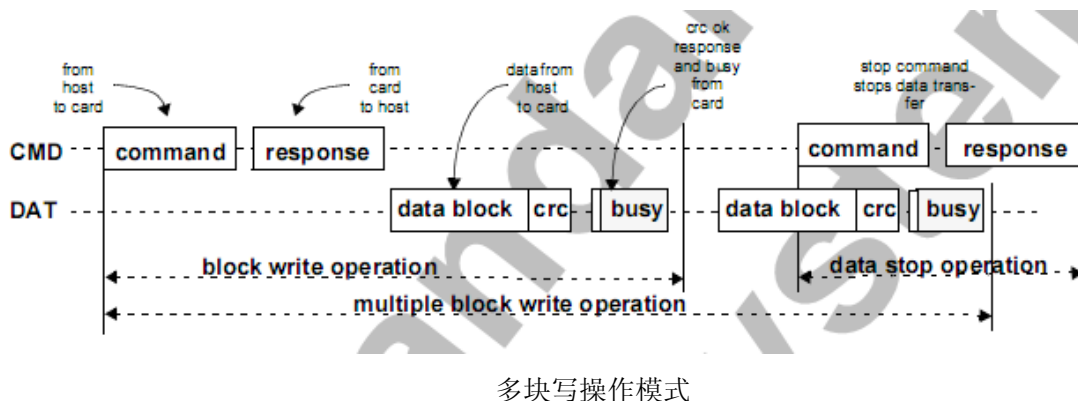　　SD 模式下可以选择总线宽度，即选用几根 DAT 信号线，可以在主机初始化后设置.

2. SD 总线协议
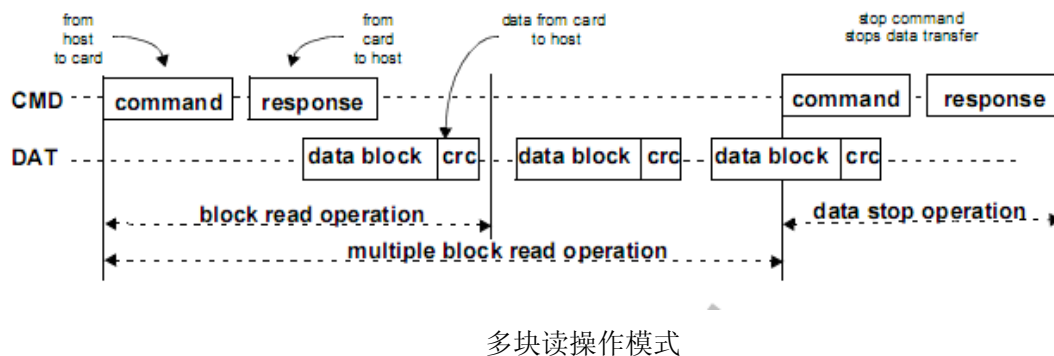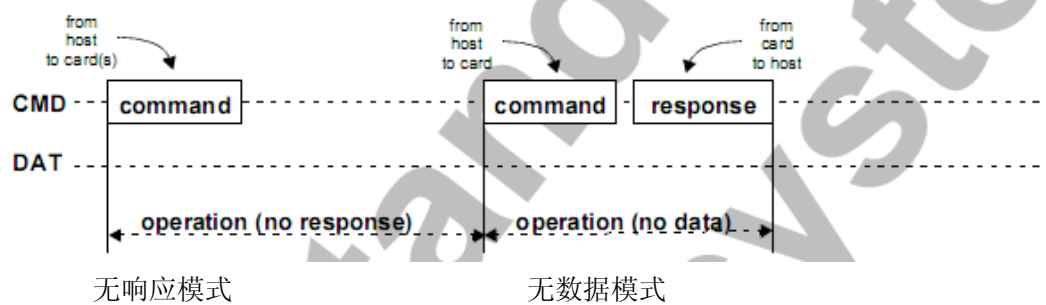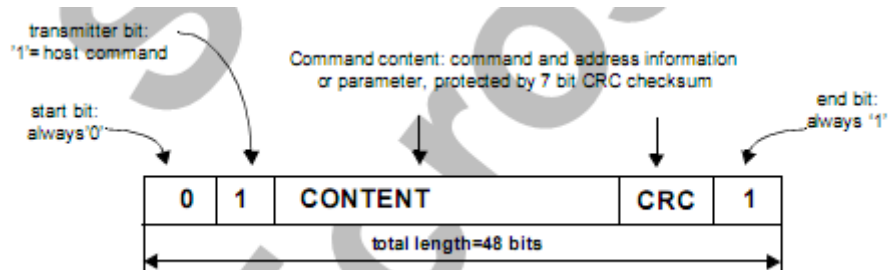
SD 模式下的命令和数据流都有一个开始位和结束位.
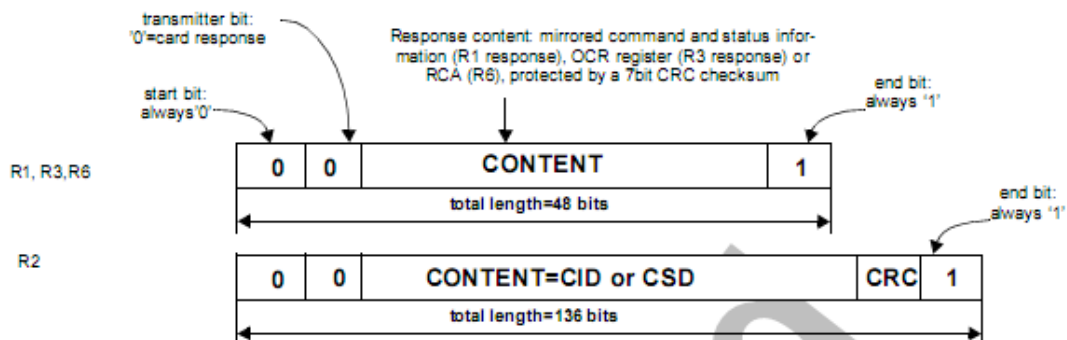
>命令：是在 CMD 上传输的用于启动一个操作的比特流. 由主机发往从机,可以是点对点也可以是广播的.

>响应：是在 CMD 上传输的用于之前命令回答的比特流. 由从机发往主机.

>数据：是在 DAT 上传输的比特流，双向传输.

无响应模式　　　　　　　　　无数据模式

多块读操作模式

多块写操作模式

命令格式

响应格式
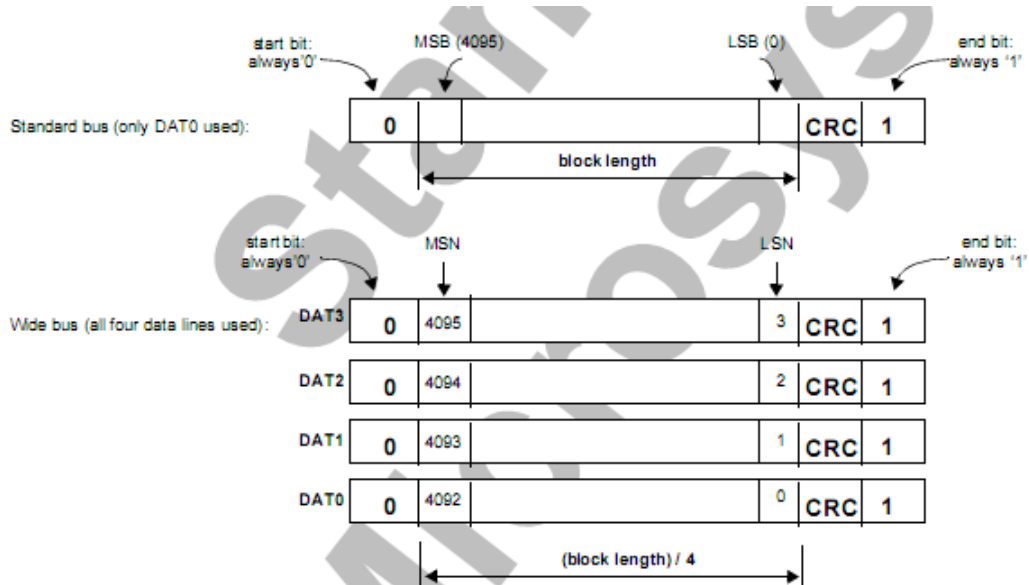
数据格式

SD 卡上电后会自动初始化, 通过给卡发送 CMD0 也可以复位卡.

二. SD 卡命令描述.

1. 广播命令:

给所有卡都发送,某些命令需要响应.

2. 点对点命令

给指定地址的卡发送,需要响应.

SD 卡系统有两种工作模式:

1. 卡识别模式.

主机上电复位后即处于此模式,它会在总线上等待卡. 卡复位后也处于此模式, 直到 SEND_RCA(CMD3)命令到来.

2. 数据传输模式.

卡收到 SEND_RCA(CMD3)命令后即进入此模式. 主机识别到卡后也进入此模式.

Card state	Operation mode
Inactive State	inactive
Idle State	card identification mode
Ready State	
Identification State	
Stand-by State	data transfer mode
Transfer State	
Sending-data State	
Receive-data State	
Programming State	
Disconnect State	

卡状态和工作模式对照表

1. 卡识别模式.

此模式下主机复位总线所有的卡,验证工作电压,询问卡的地址. 这个模式下所有数据的传输都是只通过 CMD 线来完成.

1) 卡的复位.

当卡上电或收到 GO_IDLE_STATE (CMD0)命令后,卡即进入 Idle State 状态. 此时卡将其 RCA 设为 0,相关寄存器设为传输稳定的最优模式.

2) 工作电压验证

每个卡的最高和最低工作电压存储在 OCR. 只有当电压比配时,CID 和 CSD 的数据才能正常传输给主机.

SD_SEND_OP_COND (ACMD41)命令用来判断卡的工作电压是否符合,如果不符合的话,卡应该放弃总线操作,进入 Inactive State 状态. 在发送 SD_SEND_OP_COND (ACMD41)命令前记得要首先发送 APP_CMD (CMD55).

Power on

SPI Operation Mode ← CMD0 + CS Asserted ('0') → Idle State (idle) ← CMD0 ← from all states except (ina)

card is busy or host omitted voltage range

ACMD41 → Inactive State (ina) ← CMD15

No Response (Non valid command) Must be a MultiMediaCard

cards with non compatible voltage range

Ready State (ready)

Start MultiMediaCard initialization process starting at CMD1

CMD2

Identification State (ident)

card-identification mode

Card responds with new RCA   CMD3

data-transfer mode

Stand-by State (stby)   CMD3

from all states in data-transfer-mode

Card responds with new RCA

卡的状态变换图.

ACMD41 命令响应中的 BUSY 位也用于卡表示其还没准备好，主机此时应重发 ACMD41 命令，直到卡准备好.

主机在这个阶段的 ACMD41 中不允许改变工作电压，如果确实想改变的话，应该先发送 CMD0，然后再发送改变后的 ACMD41.

GO_INACTIVE_STATE（CMD15）命令用于使指定地址的卡进入 Inactive State 模式.

3）卡识别过程.

ALL_SEND_CID（CMD2）命令用于获取卡的 CID 信息，如果卡处于 Ready State，它就会在 CMD 线上传送它的 CID 信息，然后进入 Identification State 模式. 紧接着发送 CMD3（SEND_RELATIVE_ADDR）命令，用于设置卡新的地址. 卡收到新的地址后进入 Stand-by State 模式.

2. 数据传输模式.

数据传输模式下卡的状态转变图

进入数据传输模式后，主机先不停的发送 SEND_CSD（CMD9)命令获取卡的 CSD 信息.
SET_DSR（CMD4)用于设置卡的 DSR 寄存器，包括数据总线宽度，总线上卡的数目，总线频率，当设置成功后，卡的工作频率也随之改变. 此步操作是可选的.

CMD7 命令用于使指定地址的卡进入传输模式，任何指定时刻只能有一个卡处于传输模式.

传输模式下所有的数据传输都是点对点的，并且所有有地址的命令都需要有响应.

. 所有读命令都可以由 CMD12 命令停止, 之后卡进入 Transfer State. 读命令包括单块读(CMD17)，多块读(CMD18)，发送写保护(CMD30)，发送 scr(ACMD51)和读模式一般命令(CMD56).

. 所有写命令都可以由 CMD12 命令停止. 写命令包括单块读(CMD24)，多块读(CMD25)，写 CID(CMD26)，写 CSD(CMD27),锁和解锁命令(CMD42)和写模式一般命令(CMD56).

. 当写命令传输完成后，卡进入 Programming State(传输成功)或 Transfer State(传输失败)

. 如果一个卡写操作被停止,但其前面数据的 CRC 和块长度正确，数据还是会被写入.

. 卡要提供写缓冲，如果写缓冲已满并且卡处于 Programming State, DAT0 保持低 BUSY.

. 写 CID,CSD，写保护，擦除命令没有缓冲，当这些命令没完时，不应发送其他的数据传输命令.

. 参数设置命令在卡被编程时是不允许发送的，这些命令包括设置块长度(CMD16)，擦除块起始(CMD32)和擦除块结束(CMD33).

. 当卡正编程时读命令是禁止的.

. 用 CMD7 使另一个卡进入 Transfer State 不会终止当前卡的编程和擦除，当前卡会进入

Disconnect State 并且释放 DAT 线.

. Disconnect State 模式的卡可通过 CMD7 重新被选中,此时卡进入 Programming State 并且使能 busy 信号.

. CMD0 或 CMD15 会终止卡的编程操作, 造成数据混乱, 此操作应禁止.

1) 总线宽度选择命令

ACMD6 命令用于选择总线宽度, 此命令只有在 Transfer State 有效. 应在 CMD7 命令后使用.

2) 块读命令

块是数据传输的最小单位, 在 CSD (READ_BL_LEN)中定义, SD 卡为固定的 512B.

每个块传输的后面都跟着一个 CRC 校验. CMD17(READ_SINGLE_BLOCK)用于传输单个块, 传输完之后,卡进入 Transfer State. CMD18 (READ_MULTIPLE_BLOCK)用于多个块的传输, 直到收到一个 CMD12 命令.

3) 块写命令

与块读命令类似, 每个块传输的后面都跟着一个 CRC 校验.卡写数据时会进行 CRC 校验. 多块写比重复的单块写更能提高效率.

如果CSD中的WRITE_BLK_MISALIGN没设置, 并且发送的数据不是块对齐的, 卡会设置状态寄存器中的ADDRESS_ERROR位,并且进入Receive-data-State状态等待停止命令.此时写操作也会停止, 并且卡会设置其的 WP_VIOLATION 位.

如果写缓冲满的话, 卡会停止接受 WRITE_BLOCK 命令. 此时主机应发送 SEND_STATUS (CMD13)命令, 卡返回数据的 READY_FOR_DATA 位标志卡是否准备好接受新的数据.

在多块写操作中通过事先发送 ACMD23 命令可提高写速度. ACMD23 用于定义接下来要写数据的块的数目. 每次多块写操作后, 这个值又被设为默认的 1.

ACMD22 会使卡返回写成功的块数目.

4) 擦除命令

擦除命令的顺序是: ERASE_WR_BLK_START(CMD32), ERASE_WR_BLK_END(CMD33)and ERASE (CMD38).

如果(CMD38或(CMD32, 33)接收到出错信息, 卡会设置状态寄存器中的ERASE_SEQ_ERROR 位并且重新等待新的命令时序.

如果接收到时序错误命令, 卡会设置其 ERASE_RESET 位并且重新等待新的命令时序.

5) 写保护管理

三种机制:

-.写保护物理开关

-.卡内部写保护

通过设置 CSD 中的 WP_GRP_ENABLE 位和 WP_GRP_SIZE 位, SET_WRITE_PROT 和 CLR_WRITE_PROT 命令用来设置和清除保护机制.

-. 密码保护.

三. 时钟控制

如果主机要发送 1K 的数据, 但是主机缓冲区只有 512B, 那么主机可以在发送完前 512B 后, 可以先停止时钟, 然后把后 512B 填充入缓冲区, 再启动时钟, 这样卡并不会检测要两次发送之间的间隔, 认为其是一次完整的数据发送过程.

四 CRC 校验

  1.CRC7

  CRC7 用于所有的命令, 除 R3 以外的响应, 以及 CID 和 CSD 寄存器.

  2.CRC16

  CRC16 用于数据块的校验

五. 错误类型.

1. CRC 错误和命令非法错误

  命令的 CRC 校验出错, 卡设置其状态寄存器的 COM_CRC_ERROR 位.

  非法命令错误, 卡设置其状态寄存器的 ILLEGAL_COMMAND 位. 非法命令包括:不支持的命令,未定义的命令以及当前状态不支持的命令.

2. 读,写和擦除超时.

  卡应该在指定的时间内完成一个命令或返回移动的错误信息. 如果在指定的超时时间内主机收不到响应, 应认为卡停止工作, 应重新复位卡.

六 命令

1. 命令类型:

- bc 不需要响应的广播命令.

- bcr 需要响应的广播命令. 每个卡都会独立的接收命令和发送响应.

- ac 点对点命令, DAT 线上没数据

- adtc 点对点命令, DAT 线上有数据

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

所有命令均遵守上图中的格式, 总共 48 位. 首先是 1 个起始位 0, 接着是 1 个方向位(主机发送位 1), 6 个命令位(0-63), 32 位参数(有些命令需要), CRC7 位校验, 1 个停止位.

2.卡命令根据不同的类型分成了不同的 Class, 见下表,其中 Class0,2,4,5,8 是每个卡都必须支持的命令, 不同的卡所支持的命令保存在 CSD 中.

Supported commands	Card Command Class (CCC) / class description	0 basic	1 reserved	2 block read	3 reserved	4 block write	5 erase	6 write protection	7 lock card	8 application specific	9-11 reserved
CMD0	Mandatory	+									
CMD2	Mandatory	+									
CMD3	Mandatory	+									
CMD4	Mandatory	+									
CMD7	Mandatory	+									
CMD9	Mandatory	+									
CMD10	Mandatory	+									
CMD12	Mandatory	+									
CMD13	Mandatory	+									
CMD15	Mandatory	+									
CMD16	Mandatory			+		+					
CMD17	Mandatory			+							
CMD18	Mandatory			+							
CMD24	Mandatory					+					
CMD25	Mandatory					+					
CMD27	Mandatory					+					
CMD28	Optional							+			
CMD29	Optional							+			
CMD30	Optional							+			

Supported commands	Card Command Class (CCC) / class description	0 basic	1 reserved	2 block read	3 reserved	4 block write	5 erase	6 write protection	7 lock card	8 application specific	9-11 reserved
CMD32	Mandatory						+				
CMD33	Mandatory						+				
CMD38	Mandatory						+				
CMD42	Optional								+		
CMD55	Mandatory									+	
CMD56	Mandatory									+	
ACMD6	Mandatory									+	
ACMD13	Mandatory									+	
ACMD22	Mandatory									+	
ACMD23	Mandatory									+	
ACMD41	Mandatory									+	
ACMD42	Mandatory									+	
ACMD51	Mandatory									+	

3. 命令详细描述

1)基本命令 Class0

CMD INDEX	type	argument	resp	abbreviation	command description
CMD0	bc	[31:0] stuff bits	-	GO_IDLE_STATE	resets all cards to idle state
CMD1	reserved				
CMD2	bcr	[31:0] stuff bits	R2	ALL_SEND_CID	asks any card to send the CID numbers on the CMD line (any card that is connected to the host will respond)
CMD3	bcr	[31:0] stuff bits	R6	SEND_RELATIVE_ADDR	ask the card to publish a new relative address (RCA)
CMD4	bc	[31:16] DSR [15:0] stuff bits	-	SET_DSR	programs the DSR of all cards
CMD5	reserved				
CMD6	reserved				

CMD INDEX	type	argument	resp	abbreviation	command description
CMD7	ac	[31:16] RCA [15:0] stuff bits	R1b (only from the selected card)	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 all.
CMD8	reserved				
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	reserved				
CMD12	ac	[31:0] stuff bits	R1b	STOP_ TRANSMISSION	forces the card to stop transmission
CMD13	ac	[31:16] RCA [15:0] stuff bits	R1	SEND_STATUS	addressed card sends its status register.
CMD14	reserved				
CMD15	ac	[31:16] RCA [15:0] stuff bits	-	GO_INACTIVE_ STATE	sets the card to inactive state in order to protect the card stack against communication breakdowns.

2)读命令 Class2

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. Supported only if Partial block RD/WR operation are allowed in CSD.
CMD17	adtc	[31:0] data address	R1	READ_SINGLE_ BLOCK	reads a block of the size selected by the SET_BLOCKLEN command.[1]
CMD18	adtc	[31:0] data address	R1	READ_MULTIPLE_ BLOCK	continuously transfers data blocks from card to host until interrupted by a STOP_TRANSMISSION command.
CMD19 ... CMD23	reserved				

3)写命令 Class4

CMD INDEX	type	argument	resp	abbreviation	command description
CMD24	adtc	[31:0] data address	R1	WRITE_BLOCK	writes a block of the size selected by the SET_BLOCKLEN command.[1]
CMD25	adtc	[31:0] data address	R1	WRITE_MULTIPLE_BLOCK	continuously writes blocks of data until a STOP_TRANSMISSION follows.
CMD26	Reserved For Manufacturer				
CMD27	adtc	[31:0] stuff bits	R1	PROGRAM_CSD	programming of the programmable bits of the CSD.

3)擦除命令 Class5

CMD INDEX	type	argument	resp	abbreviation	command description
CMD32	ac	[31:0] data address	R1	ERASE_WR_BLK_START	sets the address of the first write-block to be erased.
CMD33	ac	[31:0] data address	R1	ERASE_WR_BLK_END	sets the address of the last write block of the continuous range to be erased.
CMD34 ... CMD37	reserved				

4)应用特定命令 Class8

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 -63	reserved for manufacturer				

下表中的所有命令使用前都应先跟一个 APP_CMD(CMD55)命令

ACMD INDEX	type	argument	resp	abbreviation	command description
ACMD6	ac	[31:2] stuff bits [1:0]bus width	R1	SET_BUS_WIDTH	Defines the data bus width ('00'=1bit or '10'=4 bits bus) to be used for data transfer. The allowed data bus widths are given in SCR register.
ACMD13	adtc	[31:0] stuff bits	R1	SD_STATUS	Send the SD Memory Card status. The status fields are given in Table 24.
ACMD17	reserved				
ACMD18	--	--	--	--	Reserved for SD security applications[1]
ACMD19 to ACMD21	reserved				
ACMD22	adtc	[31:0] stuff bits	R1	SEND_NUM_WR_ BLOCKS	Send the number of the written (without errors) write blocks. Responds with 32bit+CRC data block.
ACMD23	ac	[31:23] stuff bits [22:0]Number of blocks	R1	SET_WR_BLK_ ERASE_COUNT	Set the number of write blocks to be pre-erased before writing (to be used for faster Multiple Block WR command). "1"=default (one wr block)[(2)].
ACMD24	reserved				
ACMD25	--	--	--	--	Reserved for SD security applications[1]
ACMD26	--	--	--	--	Reserved for SD security applications[1]
ACMD38	--	--	--	--	Reserved for SD security applications[1]
ACMD39 to ACMD40	reserved				
ACMD41	bcr	[31:0]OCR without busy	R3	SD_APP_OP_COND	Asks the accessed card to send its operating condition register (OCR) content in the response on the CMD line.
ACMD42	ac	[31:1] stuff bits [0]set_cd	R1	SET_CLR_CARD_ DETECT	Connect[1]/Disconnect[0] the 50KOhm pull-up resistor on CD/DAT3 (pin 1) of the card. The pull-up may be used for card detection.
ACMD43 ACMD49	--	--	--	--	Reserved for SD security applications[1]
ACMD51	adtc	[31:0] staff bits	R1	SEND_SCR	Reads the SD Configuration Register (SCR).

七. 卡状态转换表

command	current state									
	idle	ready	ident	stby	tran	data	rcv	prg	dis	ina
	changes to									
class independent										
CRC error	-	-	-	-	-	-	-	-	-	-
command not supported	-	-	-	-	-	-	-	-	-	-
class 0										
CMD0	idle	idle	idle	idle	idle	idle	idle	idle	idle	-
CMD2	-	ident	-	-	-	-	-	-	-	-
CMD3	-	-	stby	stby	-	-	-	-	-	-
CMD4	-	-	-	stby	-	-	-	-	-	-
CMD7, card is addressed	-	-	-	tran	-	-	-	-	prg	-
CMD7, card is not addressed	-	-	-	stby	stby	stby	-	dis	-	-
CMD9	-	-	-	stby	-	-	-	-	-	-
CMD10	-	-	-	stby	-	-	-	-	-	-
CMD12	-	-	-	-	-	tran	prg	-	-	-
CMD13	-	-	-	stby	tran	data	rcv	prg	dis	-
CMD15	-	-	ina	ina	ina	ina	ina	ina	-	-
class 2										
CMD16	-	-	-	-	tran	-	-	-	-	-
CMD17	-	-	-	-	data	-	-	-	-	-
CMD18	-	-	-	-	data	-	-	-	-	-
class 4										
CMD16	see class 2									
CMD24	-	-	-	-	rcv	-	-	-	-	-
CMD25	-	-	-	-	rcv	-	-	-	-	-
CMD27	-	-	-	-	rcv	-	-	-	-	-
class 6										
CMD28	-	-	-	-	prg	-	-	-	-	-
CMD29	-	-	-	-	prg	-	-	-	-	-
CMD30	-	-	-	-	data	-	-	-	-	-
class 5										

	current state								
	idle	ready	ident	stby	tran	data	rcv	prg	dis	ina
CMD32	-	-	-	-	tran	-	-	-	-	-
CMD33	-	-	-	-	tran	-	-	-	-	-
CMD38	-	-	-	-	prg	-	-	-	-	-
class 7										
CMD42	-	-	-	-	rcv	-	-	-	-	-
class 8										
CMD55	idle	-	-	stby	tran	data	rcv	prg	dis	-
CMD56; RD/WR = 0	-	-	-	-	rcv	-	-	-	-	-
CMD56; RD/WR = 1	-	-	-	-	data	-	-	-	-	-
ACMD6	-	-	-	-	tran	-	-	-	-	-
ACMD13	-	-	-	-	tran	-	-	-	-	-
ACMD22	-	-	-	-	tran	-	-	-	-	-
ACMD23	-	-	-	-	tran	-	-	-	-	-
ACMD18,25,26,38,43,44,45,46,47,48,49	Refer to "SD Memory Card Security Specification" for explanation about the SD Security Features									
ACMD41, card V_{DD} range compatible	ready	-	-	-	-	-	-	-	-	-
ACMD41, card is busy	idle	-	-	-	-	-	-	-	-	-
ACMD41, card V_{DD} range not compatible	ina	-	-	-	-	-	-	-	-	-
ACMD42	-	-	-	-	tran	-	-	-	-	-
ACMD51	-	-	-	-	data	-	-	-	-	-
class 9- 11										
CMD41; CMD43...CMD54, CMD57-CMD59	reserved									
CMD60...CMD63	reserved for manufacturer									

八. 应答.

所有的应答都是通过 CMD 发送, 不同的应答长度可能不同. 总共有四种类型的应答.

1. R1: 长度位 48 位. 注意每个块传输完成后有一个 BUSY 位.

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

2. R1b: 与 R1 类似, 只是将 BUSY 位加入响应中.

3.R2(CID CSD 寄存器)：长度为 136 位，CID 为 CMD2 和 CMD10 的应答，CSD 为 CMD9 的应答.

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	reserved	CID or CSD register incl. internal CRC7	end bit

4.R3(OCR 寄存器):长度位 48 位. 作为 ACMD41 的应答.

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	reserved	OCR register	reserved	end bit

5.R6(RCA 地址应答):长度为 48 位

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'	x	x	x	x	'1'
Description	start bit	transmission bit	command index ('000011')	New published RCA [31:16] of the card	[15:0] card status bits: 23,22,19,12:0 (see Table 22)	CRC7	end bit

九． 卡的状态

SD 卡支持两种状态:

–卡状态:与 MMC 卡兼容.

–SD 卡状态:扩充到了 512 位.

1.卡状态:

R1 应答包含一个 32 位的卡状态. 见下表.

其中 Type 中的含义为:

E:错误位.　S:状态位.　R:根据命令在响应中设置.

X:根据在命令执行期间设置，必须再次读此位才能获得命令执行后的情况.

Clear Condition:

A: 与卡的当前状态有关

B: 总是与命令有关,无效的命令会清除此位.

C: 通过读此位来清除

Bits	Identifier	Type	Value	Description	Clear Cond ition
31	OUT_OF_RANGE	E R	'0'= no error '1'= error	The command's argument was out of the allowed range for this card.	C
30	ADDRESS_ERROR	E R X	'0'= no error '1'= error	A misaligned address which did not match the block length was used in the command.	C
29	BLOCK_LEN_ERROR	E R	'0'= no error '1'= error	The transferred block length is not allowed for this card, or the number of transferred bytes does not match the block length.	C
28	ERASE_SEQ_ERROR	E R	'0'= no error '1'= error	An error in the sequence of erase commands occurred.	C
27	ERASE_PARAM	E X	'0'= no error '1'= error	An invalid selection of write-blocks for erase occurred.	C
26	WP_VIOLATION	E R X	'0'= not protected '1'= protected	Attempt to program a write protected block.	C
25	CARD_IS_LOCKED	S X	'0' = card unlocked '1' = card locked	When set, signals that the card is locked by the host	A
24	LOCK_UNLOCK_FAIL ED	E R X	'0' = no error '1' = error	Set when a sequence or password error has been detected in lock/ unlock card command or if there was an attempt to access a locked card	C
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.	C
20	CC_ERROR	E R X	'0'= no error '1'= error	Internal card controller error	C
19	ERROR	E R X	'0'= no error '1'= error	A general or an unknown error occurred during the operation.	C

18	UNDERRUN	E X	'0'= no error '1'= error	The card could not sustain data transfer in stream read mode	C
17	OVERRUN	E X	'0'= no error '1'= error	The card could not sustain data programming in stream write mode	C
16	CID/ CSD_OVERWRITE	E R 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.	C
15	WP_ERASE_SKIP	S X	'0'= not protected '1'= protected	Only partial address space was erased due to existing write protected blocks.	C
14	CARD_ECC_DISABLED	S X	'0'= enabled '1'= disabled	The command has been executed without using the internal ECC.	A
13	ERASE_RESET	S R	'0'= cleared '1'= set	An erase sequence was cleared before executing because an out of erase sequence command was received	C
12:9	CURRENT_STATE	S X	0 = idle 1 = ready 2 = ident 3 = stby 4 = tran 5 = data 6 = rcv 7 = prg 8 = dis 9-15 = 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 to the next command. The four bits are interpreted as a binary coded number between 0 and 15.	B
8	READY_FOR_DATA	S X	'0'= not ready '1'= ready	corresponds to buffer empty signalling on the bus	A
7:6					

5	APP_CMD	S R	'0' = Disabled '1' = Enabled	The card will expect ACMD, or indication that the command has been interpreted as ACMD	C
4	reserved				
3	AKE_SEQ_ERROR (SD Memory Card app. spec.)	E R	'0' = no error '1' = error	Error in the sequence of authentication process	C

2	reserved for application specific commands
1, 0	reserved for manufacturer test mode

下表指明了哪些命令可能使哪些位产生变化

CMD#	Response Format 1 Status bit #																					
	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12:9	8	5
3[1]									x	x			x							x		
7					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
12	x	x				x	x		x	x	x	x	x	x	x			x		x		
13	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
16			x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
17	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
18	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
24	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
25	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
26					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
27					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
28	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
29	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
30	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
32	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
33	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
38				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
42					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
55					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
56					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
ACMD6	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
ACMD13					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
ACMD22					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
ACMD23					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
ACMD42					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
ACMD51					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x

2. SD 卡状态:

这些位通过 DAT 线传输，并伴有 CRC16 校验. 其是作为 ACMD13 的应答.

Bits	Identifier	Type	Value	Description	Clear Condition
511: 510	DAT_BUS_WIDTH	S R	'00'= 1 (default) '01'= reserved '10'= 4 bit width '11'= reserved	Shows the currently defined data bus width that was defined by SET_BUS_WIDTH command	A
509	SECURED_MODE	S R	'0'= Not in the mode '1'= In Secured Mode	Card is in Secured Mode of operation (refer to "SD Security Specification").	A
508: 496	reserved				
495: 480	SD_CARD_TYPE	SR	All '0'= SD Memory Cards (as defined in Physical Spec Ver.1	Each bit will define different SD Type [Various SD Types to be defined in the future]	A
479: 448	SIZE_OF_PROTECTED_AREA	SR	Size of protected area (in units of MULT*BLOCK_LEN refer to CSD register Table 5.3)	Shows the size of protected area. The actual area = (SIZE_OF_PROTECTED_AREA) * MULT * BLOCK_LEN.	A
447: 312	reserved				
311: 0	reserved for manufacturer				

十．卡存储器形式．

–块:块是基本读写命令的单位,它可以是固定的或可变的．关于块的大小以及其是否可变性存储在 CSD 中．

–扇区:扇区是擦除命令的单位，它是固定的值,保存在 CSD 中．
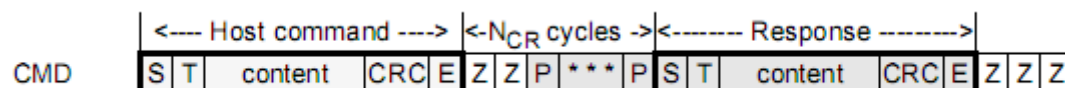

十一．时序图

时序图中字母含义：

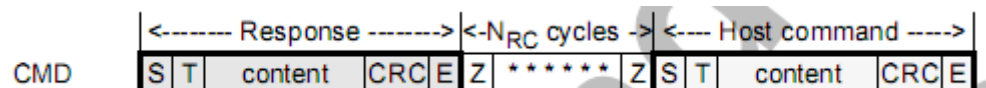| S | Start bit (= '0') |
T	Transmitter bit (Host = '1', Card = '0')
P	One-cycle pull-up (= '1')
E	End bit (=1)
Z	High impedance state (-> = '1')
D	Data bits
X	Don't Care data bits (from card)
*	Repetition
CRC	Cyclic redundancy check bits (7 bits)
	Card active
	Host active

1.命令和应答

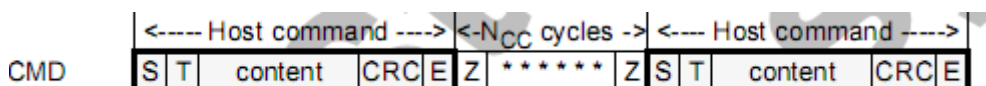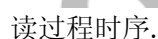1)卡识别和卡工作电压确认模式:CMD2,ACMD41
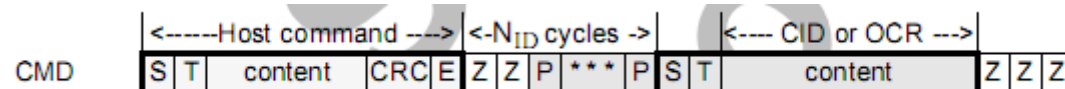
2)地址分配模式:CMD3

3)数据传输模式:

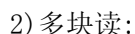4)命令结束->下一个命令:

5)两个命令直接

2. 数据读.

1) 单块读：CMD17

```
       <----- Host command ----->   <-N_CR cycles ->  <-------- Response -------->
CMD   S T    content    CRC E    Z Z P * * * P    S T    content    CRC E
                                 <------- N_AC cycles ------->  <- Read Data
DAT   Z Z Z  * * * *  Z Z Z  Z Z P  * * * * * * * * *  P S D D D * * *
```

2) 多块读：

```
      <-- Host command -->  <-N_CR cycles->  <---- Response ------>
CMD S T  content  CRC E  Z Z P * P S T  content  CRC E Z Z P P P P P P P P P P P P P
                         <--- N_AC cycles --->  <-- Read Data ->  <-- N_AC cycles --><- Read Data ->
DAT Z Z Z * * * * Z Z Z Z Z Z P * * * * * * * P S  content  CRC E P * * * * * * P S D D D D D
```

读过程时序.

```
       <----- Host command ----->   <-N_CR cycles ->  <-------- Response -------->
CMD   S T    content    CRC E    Z Z P * * * P    S T    content    CRC E
DAT   D D D  * * * * * * * *  D D D E Z Z  * * * * * * * * * * * * * * * * * *
```

停止命令时序

3. 数据写

1) 单块写：

```
     <-Host cmnd->   <- N_CR ->   <-Card response >
CMD   E Z Z P * P S T Content CRC E Z Z P  * * * * * * * * * * * * * * * * * *  P P P P P P P P
                                 <-N_WR->  <- Write data ->   CRC status  <- Busy ->
DAT0  Z Z * * * * * * Z Z Z * * * Z Z Z Z P * P S content CRC E Z Z S Status E S L * L E Z
DAT1-3 Z Z * * * * * * Z Z Z * * * Z Z Z Z P * P S content CRC E Z Z X X X X X X X X X X X Z
```

注意 Busy 信号.

2) 多块写：

```
     <-CardRsp->
CMD   E Z Z P  * * * * * * * * * * * * * * *  P P P P P  * * * * * * * * * * * * *  P P P P P P P P P
     <-N_WR-> <- Write data ->     CRC status <-N_WR-> <- Write data ->   CRC status <- Busy -> <-N_WR->
DAT   Z Z P * P S Data+CRC E Z Z S Status E Z P * P S Data+CRC E  Z Z S Status E S L * L E Z P * P
```

多块写命令时序

```
       <---- Host Command ---->   < N_cr Cycles >   <----- Card response---->   <Host Cmnd>
CMD   S T  content  CRC E Z Z P  P * * * * * * P  S T  content  CRC E          S T  Content
                                 <--------- Card is programming --------->
DAT   D D D D D D D D D D E Z Z S L  * * * * * * * * * * * * * * * * * *  E Z Z Z Z Z Z Z
```

停止命令时序

```
       <---- Host Command ---->   < N_cr Cycles >   <----- Card response---->   <Host Cmnd>
CMD   S T  content  CRC E Z Z P  P * * * * * * P  S T  content  CRC E          S T  Content
     --Data block->     CRC Status¹ <--------- Card is programming --------->
DAT   D D D D Z Z S Status E Z Z S L  * * * * * * * * * * * * * * * * * *  E Z Z Z Z Z Z Z Z
```

卡主动停止时的时序

4.时序值

	Min	Max	Unit
N_{CR}	2	64	clock cycles
N_{ID}	5	5	clock cycles
N_{AC}	2	TAAC + NSAC	clock cycles
N_{RC}	8	-	clock cycles
N_{CC}	8	-	clock cycles
N_{WR}	2	-	clock cycles

十二. 寄存器.

SD卡有六个寄存器OCR，CID，CSD，RCA，DSR and SCR. 其中前四个保存卡的特定信息，后两个用来对卡进行配置.

1.OCR 寄存器:保存有卡支持的工作电压，支持的话相应的位置1,否则为0.

OCR bit position	VDD voltage window
0-3	reserved
4	1.6-1.7
5	1.7-1.8
6	1.8-1.9
7	1.9-2.0
8	2.0-2.1
9	2.1-2.2
10	2.2-2.3
11	2.3-2.4
12	2.4-2.5
13	2.5-2.6
14	2.6-2.7
15	2.7-2.8
16	2.8-2.9
17	2.9-3.0
18	3.0-3.1
19	3.1-3.2
20	3.2-3.3
21	3.3-3.4
22	3.4-3.5
23	3.5-3.6
24-30	reserved
31	card power up status bit (busy)[1]

2.CID:保存有卡的身份信息.

Name	Field	Width	CID-slice
Manufacturer ID	MID	8	[127:120]
OEM/Application ID	OID	16	[119:104]
Product name	PNM	40	[103:64]
Product revision	PRV	8	[63:56]
Product serial number	PSN	32	[55:24]
reserved	--	4	[23:20]
Manufacturing date	MDT	12	[19:8]
CRC7 checksum	CRC	7	[7:1]
not used, always '1'	-	1	[0:0]

3. CSD 保存有如何访问卡的信息.

Name	Field	Width	Cell Type	CSD-slice
CSD structure	CSD_STRUCTURE	2	R	[127:126]
reserved	-	6	R	[125:120]
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. data transfer rate	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]
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 single block enable	ERASE_BLK_EN	1	R	[46:46]
erase sector size	SECTOR_SIZE	7	R	[45:39]
write protect group size	WP_GRP_SIZE	7	R	[38:32]
write protect group enable	WP_GRP_ENABLE	1	R	[31:31]
reserved for MultiMediaCard compatibility		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	-	5	R	[20:16]
File format group	FILE_FORMAT_GRP	1	R/W(1)	[15:15]
copy flag (OTP)	COPY	1	R/W(1)	[14:14]
permanent write protection	PERM_WRITE_PROTECT	1	R/W(1)	[13:13]
temporary write protection	TMP_WRITE_PROTECT	1	R/W	[12:12]
File format	FILE_FORMAT	2	R/W(1)	[11:10]
reserved		2	R/W	[9:8]
CRC	CRC	7	R/W	[7:1]
not used, always'1'	-	1	-	[0:0]

TAAC 定义了数据访问的异步时间部分．NSAC 为数据访问最坏需要的异步时间．

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	time value 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

TRAN_SPEED 定义了单条 DAT 线上的最快速度：

TRAN_SPEED bit	code
2:0	transfer rate unit 0=100kbit/s, 1=1Mbit/s, 2=10Mbit/s, 3=100Mbit/s, 4... 7=reserved
6:3	time value 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

CCC:SD 卡支持的命令集

CCC bit	Supported card command class
0	class 0
1	class 1
....	
11	class 11

READ_BL_LEN:最大读块长度．WRITE_BL_LEN 等于 READ_BL_LEN

READ_BL_LEN	Block length	Remark
0-8	reserved	
9	2^9 = 512 Bytes	
......		
11	2^{11} = 2048 Bytes	
12-15	reserved	

DSR_IMP：DSR 寄存器是否允许配置，1 为允许,0 为不允许．

FILE_FORMAT：SD 卡上的文件格式．

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

4. RCA 保存有卡的地址信息.

5. DSR 用于配置卡，默认值为 0x404

6. SCR 寄存器也保存有卡的特定信息.

Description	Field	Width	Cell Type	SCR Slice
SCR Structure	SCR_STRUCTURE	4	R	[63:60]
SD Memory Card - Spec. Version	SD_SPEC	4	R	[59:56]
data_status_after erases	DATA_STAT_AFTER_ERASE	1	R	[55:55]
SD Security Support	SD_SECURITY	3	R	[54:52]
DAT Bus width supported	SD_BUS_WIDTHS	4	R	[51:48]
reserved	-	16	R	[47:32]
reserved for manufacturer usage	-	32	R	[31:0]

SD_BUS_WIDTHS 指明卡支持的传输类型.

SD_BUS_WIDTHS	Supported Bus Widths
Bit 0	1 bit (DAT0)
Bit 1	reserved
Bit 2	4 bit (DAT0-3)
Bit 3 [MSB]	reserved

第二部分 S3C2410 SD 卡控制器

一 SDI 操作

1.CPU 寄存器设置过程.

1)正确设置 SDICON 寄存器.

2)正确设置 SDIPRE 寄存器.

3)等待 74 个时钟信号初始卡.

2.CMD 命令发送过程.

1)向 SDICARG 寄存器中写入发送的参数.

2)确定命令类型并且通过设置 SDICCON[8]来启动命令.

3)确定命令是否发送完成. 没应答的话看 SDICSTA[11]，有应答的话看 SDICSTA[9].

4)清除 SDICSTA 中的相应位.

3. 数据传输过程.

1)向 SDITIMER 中写入超时值.

2)向 SDIBSIZE 中写入块大小的值.

3)设置块模式, 总线宽度等, 通过 SDIDCON 启动传输.

4)通过 SDIFSTA 检查 TxFIFO 是否可用, 再通过 SDIDAT 写入发送数据.

5)通过 SDIFSTA 检查 RxFIFO 是否可用, 再通过 SDIDAT 读入接收数据.

6)通过检查 SDIDSTA[4]确定传输过程已完成.

7)清除 SDIDSTA 中的相应位.

4. SDIO 有两种工作模式,中断和读等待模式.

二. SDI 寄存器.

1.SDICON:SDI 控制寄存器

SDICON	Bit	Description	Initial Value
Byte Order Type (ByteOrder)	[4]	Determine byte order type when you read (write) data from (to) SD host FIFO with word boundary. 0 = Type A, 1 = Type B	0
Receive SDIO Interrupt from card (RcvIOInt)	[3]	Determine whether SD host receives SDIO Interrupt from the card or not (for SDIO). 0 = ignore, 1 = receive SDIO Interrupt	0
Read Wait Enable (RWaitEn)	[2]	Determine read wait request signal generate when SD host waits the next block in multiple block read mode. This bit needs to delay the next block to be transmitted from the card (for SDIO). 0 = disable (no generate), 1 = Read wait enable (use SDIO)	0
FIFO Reset (FRST)	[1]	Reset FIFO value. This bit is automatically cleared. 0 = normal mode, 1 = FIFO reset	0
Clock Type (CTYP)	[0]	Determines which clock type is used as SDCLK. 0 = MMC Type, 1 = SD Type	0

字节序类型:

Type A: D[7:0]   D[15:8]   D[23:16]   D[31:24]

Type B: D[31:24]   D[23:16]   D[15:8]   D[7:0]

2.SDIPRE:波特率预分频寄存器.

SDIPRE	Bit	Description	Initial Value
Prescaler Value	[7:0]	Determine SDI clock (SDCLK) rate as above equation. Baud rate = PCLK / 2 / (Prescaler value + 1)	0x00

3. SDICARG:SDI 命令参数寄存器

SDICARG	Bit	Description	Initial Value
CmdArg	[31:0]	Command Argument	0x00000000

4. SDICCON:SDI 命令控制寄存器.

SDICCON	Bit	Description	Initial Value
Abort Command (AbortCmd)	[12]	Determine whether command type is for abort (for SDIO). 0 = normal command,　1 = abort command (CMD12, CMD52)	0
Command with Data (WithData)	[11]	Determine whether command type is with data (for SDIO). 0 = without data,　1 = with data	0
LongRsp	[10]	Determine whether host receives a 136-bit long response or not. 0 = short response,　1 = long response	0
WaitRsp	[9]	Determine whether host waits for a response or not. 0 = no response,　1 = wait response	0
Command Start(CMST)	[8]	Determine whether command operation starts or not. 0 = command ready,　1 = command start	0
CmdIndex	[7:0]	Command index with start 2-bit (8-bit)	0x00

5. SDICSTA:SDI 命令状态寄存器.

SDICSTA	Bit	Description	Initial Value
Response CRC Fail(RspCrc)	[12] R/W	CRC check failed when command response received. This flag is cleared by setting one to this bit. 0 = not detect,　1 = crc fail	0
Command Sent (CmdSent)	[11] R/W	Command sent (not concerned with response). This flag is cleared by setting one to this bit. 0 = not detect,　1 = command end	0
Command Time Out (CmdTout)	[10] R/W	Command response timeout (64clk). This flag is cleared by setting one to this bit. 0 = not detect,　1 = timeout	0
Response Receive End (RspFin)	[9] R/W	Command response received. This flag is cleared by setting one to this bit. 0 = not detect,　1 = response end	0
CMD line progress On (CmdOn)	[8] R	Command transfer in progress. 0 = not detect,　1 = in progress	0
RspIndex	[7:0] R	Response index 6bit including start 2-bit (8-bit)	0x00

6.SDIRSP0-SDIRSP3:命令响应寄存器

SDIRSP0	Bit	Description	Initial Value
Response0	[31:0]	Card status[31:0](short), card status[127:96](long)	0x00000000

SDIRSP1	Bit	Description	Initial Value
RCRC7	[31:24]	CRC7 (with end bit, short), card status[95:88](long)	0x00
Response1	[23:0]	Unused (short), card status[87:64](long)	0x000000

SDIRSP2	Bit	Description	Initial Value
Response2	[31:0]	Unused (short), card status[63:32](long)	0x00000000

SDIRSP3	Bit	Description	Initial Value
Response3	[31:0]	Unused (short), card status[31:0](long)	0x00000000

7. SDIDTIMER:SDI 超时寄存器.

SDIDTIMER	Bit	Description	Initial Value
DataTimer	[15:0]	Data / busy timeout period (0~65535 cycle)	0x2000

8. SDIBSIZE:SDI 块大小寄存器.

SDIBSIZE	Bit	Description	Initial Value
BlkSize	[11:0]	Block size value (0~4095 byte). Do not care when stream mode	0x000

9. SDIDCON:SDI 数据控制寄存器

SDIDCON	Bit	Description	Initial Value
SDIO Interrupt Period Type (PrdType)	[21]	Determine whether SDIO Interrupt period is 2 cycle or extend more cycle when last data block is transferred (for SDIO). 0 = exactly 2 cycle,　　　　1 = more cycles(like single block)	0
Transmit After Response (TARSP)	[20]	Determine when data transmit start after response receive or not. 0 = directly after DatMode set, 1 = after response receive(assume DatMode sets to 2'b11)	0
Receive After Command (RACMD)	[19]	Determine when data receive start after command sent or not. 0 = directly after DatMode set, 1 = after command sent (assume DatMode sets to 2'b10)	0
Busy After Command (BACMD)	[18]	Determine when busy receive start after command sent or not. 0 = directly after DatMode set, 1 = after command sent (assume DatMode sets to 2'b01)	0
Block mode (BlkMode)	[17]	Data transfer mode. 0 = stream data transfer,　　1 = block data transfer	0
Wide bus enable (WideBus)	[16]	Determine enable wide bus mode. 0 = standard bus mode(only SDIDAT[0] used), 1 = wide bus mode(SDIDAT[3:0] used)	0
DMA Enable (EnDMA)	[15]	Enable DMA. 0 = disable(polling),　　　　1 = dma enable When DMA operation is completed, this bit should be disabled.	0
Stop by force (STOP)	[14]	Determine whether data transfer stop by force or not. 0 = normal,　　　　　　　1 = stop by force	0
Data Transfer Mode (DatMode)	[13:12]	Determine the direction of data transfer. 00 = ready,　　　　　　　01 = only busy check start 10 = data receive start,　　11 = data transmit start	00
BlkNum	[11:0]	Block Number (0~4095). Do not care when stream mode.	0x000

10. SDIDCNT:SDI 数据维持寄存器.

SDIDCNT	Bit	Description	Initial Value
BlkNumCnt	[23:12]	Remaining block number	0x000
BlkCnt	[11:0]	Remaining data byte of 1 block	0x000

11. SDIDSTA:SDI 数据状态寄存器

SDIDSTA	Bit	Description	Initial Value
Read Wait Request Occur (RWaitReq)	[10] R/W	Read wait request signal transmits to SD card. The request signal is stopped and this flag is cleared by setting one to this bit.(for SDIO) 0 = not occur, 1 = Read wait request occur	0
SDIO Interrupt Detect (IOIntDet)	[9] R/W	SDIO interrupt detects. This flag is cleared by setting one to this bit.(for SDIO) 0 = not detect, 1 = SDIO interrupt detect	0
FIFO Fail error (FFfail)	[8] R/W	FIFO fail error when FIFO occurs overrun / underrun / misaligned data saving. This flag is cleared by setting one to this bit. 0 = not detect, 1 = FIFO fail	0
CRC Status Fail (CrcSta)	[7] R/W	CRC Status error when data block sent (CRC check failed - returned from card). This flag is cleared by setting one to this bit. 0 = not detect, 1 = crc status fail	0
Data Receive CRC Fail (DatCrc)	[6] R/W	Data block received error (CRC check failed - calculated by host). This flag is cleared by setting one to this bit. 0 = not detect, 1 = receive crc fail	0
Data Time Out (DatTout)	[5] R/W	Data / Busy receive timeout. This flag is cleared by setting one to this bit. 0 = not detect, 1 = timeout	0
Data Transfer Finish (DatFin)	[4] R/W	Data transfer completes (data counter is zero). This flag is cleared by setting one to this bit. 0 = not detect, 1 = data finish detect	0
Busy Finish (BusyFin)	[3] R/W	Only busy check finish. This flag is cleared by setting one to this bit. 0 = not detect, 1 = busy finish detect	0
Reserved	[2]		0
Tx Data progress On (TxDatOn)	[1] R	Data transmit in progress. 0 = not active, 1 = data Tx in progress	0
Rx Data Progress On (RxDatOn)	[0] R	Data receive in progress. 0 = not active, 1 = data Rx in progress	0

12. SDIFSTA:SDI FIFO 状态寄存器

SDIFSTA	Bit	Description	Initial State
FIFO available Detect for Tx (TFDET)	[13]	Indicate that FIFO data is available for transmission when DatMode (SDIDCON[12]) is data transmit mode. If DMA mode is enable, SD host requests DMA operation. 0 = not detect (FIFO full), 1 = detect(0 ≤ FIFO ≤ 63)	0
FIFO available Detect for Rx (RFDET)	[12]	Indicate that FIFO data is available for reception when DatMode (SDIDCON[12]) is data receive mode. If DMA mode is enable, SD host requests DMA operation. 0 = not detect(FIFO empty), 1 = detect(1 ≤ FIFO ≤ 64)	0
Tx FIFO Half Full (TFHalf)	[11]	Set to 1 whenever Tx FIFO is less than 33byte. 0 = 33 ≤ Tx FIFO ≤ 64, 1 = 0 ≤ Tx FIFO ≤ 32	0
Tx FIFO Empty (TFEmpty)	[10]	Set to 1 whenever Tx FIFO is empty. 0 = 1 ≤ Tx FIFO ≤ 64, 1 = Empty(0byte)	0
Rx FIFO Last Data Ready (RFLast)	[9]	Set to 1 whenever Rx FIFO has last data of all block. 0 = not received yet, 1 = Last data ready	0
Rx FIFO Full (RFFull)	[8]	Set to 1 whenever Rx FIFO is full. 0 = 0 ≤ Rx FIFO ≤ 63, 1 = Full(64byte)	0
Rx FIFO Half Full (RFHalf)	[7]	Set to 1 whenever Rx FIFO is more than 31byte. 0 = 0 ≤ Rx FIFO ≤ 31, 1 = 32 ≤ Rx FIFO ≤ 64	0
FIFO Count (FFCNT)	[6:0]	Number of data (byte) in FIFO	0000000

13. SDIDAT:SDI 数据寄存器

SDIDAT	Bit	Description	Initial State
Data Register	[31:0]	This field contains the data to be transmitted or received over the SDI channel.	0x00000000