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## Wilk Elektronik S.A.

### GOODRAM Industrial SD (SLC)

### Version 1.0

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# 1. Introduction

## 1.1. General Description

The Secure Digital (SD) card version 3.0 is fully compliant with the specification released by SD Card Association. The Command List supports [Part 1 Physical Layer Specification Ver3.01 Final] definitions. Card capacities of non-secure area and secure area support [Part 3 Security Specification Ver3.0 Final] Specifications.

The SD 3.0 card is based on 9-pin interface, designed to operate at a maximum operating frequency of 100MHz. It can alternate communication protocol between the SD mode and SPI mode. It performs data error detection and correction with very low power consumption. The Card capacity could be more than 64GB and up to 2TB in the future with ex-FAT which is called SDXC (Extended Capacity SD Memory Card).

Secure Digital 3.0 card is one of the most popular cards today based on its high performance, good reliability and wide compatibility.

## 1.2. Flash Management

- **Error Correction Code (ECC)**

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, PS8035 applies the BCH ECC Algorithm, which can detect and correct errors occur during Read process, ensure data been read correctly, as well as protect data from corruption.

- **Wear Leveling**

NAND Flash devices can only undergo a limited number of program/erase cycles, and in most cases, the flash media are not used evenly. If some area get updated more frequently than others, the lifetime of the device would be reduced significantly. Thus, Wear Leveling technique is applied to extend the lifespan of NAND Flash by evenly distributing write and erase cycles across the media.

It provides advanced Wear Leveling algorithm, which can efficiently spread out the flash usage through the whole flash media area. Moreover, by implementing both dynamic and static Wear Leveling algorithms, the life expectancy of the NAND Flash is greatly improved.

- **Bad Block Management**

Bad blocks are blocks that include one or more invalid bits, and their reliability is not guaranteed. Blocks that are identified and marked as bad by the manufacturer are referred to as “Initial Bad Blocks”. Bad blocks that are developed during the lifespan of the flash are named “Later Bad Blocks”. SD implements an efficient bad block management algorithm to detect the factory-produced bad blocks and manages any bad blocks that appear with use. This practice further prevents data being stored into bad blocks and improves the data reliability.

- **Smart Function**

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is a special function that allows a memory device to automatically monitor its health. It provides a program named SmartInfo Tool to observe 's SD cards. **Note that this tool can only support 's PS8035 controller and industrial SD cards.** This tool will display the controller version, flash type, firmware version, endurance life ratio, good block ratio, and so forth. In addition, a warning message will appear under the following 3 conditions:

- (1) When the life ratio remained is less than **10%**,
- (2) When the amount of abnormal power on is more than **3,500** cycles, and
- (3) When there are less than **5** usable blocks for replacing bad blocks.

- **Auto-Read Refresh**

Auto-Read Refresh is especially applied on devices that read data mostly but rarely write data, such as GPS. When blocks are continuously read, then the device cannot activate wear leveling since it can only be applied while writing data. Thus, errors will accumulate and become uncorrectable. Accordingly, to avoid errors exceed the amount ECC can correct and blocks turn bad, 's firmware will automatically refresh the bit errors when the error number in one block approaches the threshold, ex., 24 bits.

## 2. Product Specifications

- Capacity
    - SLC: 128MB up to 2GB (Diamond & Gold)
  - Operation Temp. Range
    - Gold Series: -25~85°C (SLC)
    - Diamond Series: -40~+85°C (SLC)
  - Storage Temp. Range
    - -40~+85°C
  - Support SD system specification version 3.0
  - Card capacity of non-secure area and secure area support [Part 3 Security Specification Ver3.0 Final] Specifications
  - Support SD SPI mode
  - Designed for read-only and read/write cards
  - Bus Speed Mode (use 4 parallel data lines)
    - Non-UHS Mode:
      - Default speed mode: 3.3V signaling, frequency up to 25MHz, up to 12.5 MB/sec
      - High speed mode: 3.3V signaling, frequency up to 50MHz, up to 25 MB/sec
- NOTES:** SDSC card (capacity less than and including 2GB) only supports non-UHS mode.
- The command list supports [Part 1 Physical Layer Specification Ver3.1 Final] definitions
  - Copyrights Protection Mechanism
    - Compliant with the highest security of SDMI standard
  - Support CPRM (Content Protection for Recordable Media) of SD Card
  - Card removal during read operation will never harm the content
  - Password Protection of cards (optional)

- Write Protect feature using mechanical switch
- Built-in write protection features (permanent and temporary)
- +4KV/-4KV ESD protection in contact pads
- Operation voltage range: 2.7 ~ 3.6V
- Performance

Capacity	Mode	Flash Structure	Sequential	
			Read (MB/s)	Write (MB/s)
128MB	Non-UHS	TSB 24nm 128MB x 1	16	4
256MB	Non-UHS	TSB 24nm 256MB x 1	16	10
512GB	Non-UHS	TSB 32nm 512MB x 1	21	15
1GB	Non-UHS	TSB 32nm 1GB x 1	21	15
2GB	Non-UHS	TSB 32nm 2GB x 1	21	18

**NOTES:**

1. The performance is obtained from TestMetrix Test.
2. Samples are made of Toshiba 24nm/32nm SLC NAND Flash.
3. Performance may vary from flash configuration and platform.
4. The table above is for your reference only. The criteria for MP (mass production) and for accepting goods shall be discussed based on different flash configuration.



# 3. Environmental Specifications

## 3.1. Environmental Conditions

- **Temperature and Humidity**
  - Storage Temperature Range
    - -40°C ~ 85°C
  - Operation Temperature Range
    - Gold grade: -25°C ~ 85°C
    - Diamond grade: -40°C ~ 85°C

High Temperature Test Condition (Gold Series)

	Temperature	Humidity	Test Time
<b>Operation</b>	85°C	0% RH	168 hours
<b>Storage</b>	85°C	0% RH	500 hours

**Result:** No any abnormality is detected.

High Temperature Test Condition (Diamond Series)

	Temperature	Humidity	Test Time
<b>Operation</b>	85°C	0% RH	300 hours
<b>Storage</b>	85°C	0% RH	500 hours

**Result:** No any abnormality is detected.

Low Temperature Test Condition (Gold Series)

	Temperature	Humidity	Test Time
<b>Operation</b>	-25°C	0% RH	168 hours
<b>Storage</b>	-40°C	0% RH	300 hours

**Result:** No any abnormality is detected.

Low Temperature Test Condition (Diamond Series)

	Temperature	Humidity	Test Time
<b>Operation</b>	-40°C	0% RH	168 hours
<b>Storage</b>	-40°C	0% RH	500 hours

**Result:** No any abnormality is detected.

#### High Humidity Test Condition (Gold Series)

	Temperature	Humidity	Test Time
<b>Operation</b>	40°C	95% RH	4 hours
<b>Storage</b>	40°C	95% RH	500 hours

**Result:** No any abnormality is detected.

#### High Humidity Test Condition (Diamond Series)

	Temperature	Humidity	Test Time
<b>Operation</b>	55°C	95% RH	4 hours
<b>Storage</b>	55°C	95% RH	500 hours

**Result:** No any abnormality is detected.

#### Temperature Cycle Test (Gold Series)

	Temperature	Test Time	Cycle
<b>Operation</b>	-25°C	30 min	20 Cycles
	85°C	30 min	
<b>Storage</b>	-40°C	30 min	20 Cycles
	85°C	30 min	

**Result:** No any abnormality is detected.

#### Temperature Cycle Test (Diamond Series)

	Temperature	Test Time	Cycle
<b>Operation</b>	-40°C	30 min	20 Cycles
	85°C	30 min	
<b>Storage</b>	-40°C	30 min	50 Cycles
	85°C	30 min	

**Result:** No any abnormality is detected.

- Shock

Shock Specification

	Acceleration Force	Half Sin Pulse Duration
Industrial SD card	1500G	0.5ms

**Result:** No any abnormality is detected when power on.

- Vibration

Vibration Specification

	Condition		Vibration Orientation
	Frequency/Displacement	Frequency/Acceleration	
Industrial SD card	20Hz~80Hz/1.52mm	80Hz~2000Hz/20G	X, Y, Z axis/30 min for each

**Result:** No any abnormality is detected when power on.

- Drop

Drop Specification

	Height of Drop	Number of Drop
Industrial SD card	150cm free fall	6 face of each unit

**Result:** No any abnormality is detected when power on.

- Bending

Bending Specification

	Force	Action
Industrial SD card	≥ 10N	Hold 1min/5times

**Result:** No any abnormality is detected when power on.

- Torque

Torque Specification

	Force	Action
Industrial SD card	0.15N-m or +/-2.5 deg	Hold 30 seconds/5times

**Result:** No any abnormality is detected when power on.

- **Electrostatic Discharge (ESD)**

Contact ESD Specification

	<b>Condition</b>	<b>Result</b>
<b>Industrial SD card</b>	Contact: +/- 4KV each item 25 times Air: +/- 8KV 10 times	PASS

- **EMI Compliance**

- FCC: CISPR22
- CE: EN55022
- BSMI 13438

## 4. SD Card Comparison

Comparing SD3.0 Standard and SD3.0 SDHC

	<b>SD3.0 Standard (Backward compatible to 2.0 host)</b>	<b>SD3.0 SDHC (Backward compatible to 2.0 host)</b>
<b>Addressing Mode</b>	Byte (1 byte unit)	Block (512 byte unit)
<b>HCS/CCS bits of ACMD41</b>	Support	Support
<b>CMD8 (SEND_IF_COND)</b>	Support	Support
<b>CMD16 (SET_BLOCKLEN)</b>	Support	Support (Only CMD42)
<b>Partial Read</b>	Support	Not Support
<b>Lock/Unlock Function</b>	Mandatory	Mandatory
<b>Write Protect Groups</b>	Optional	Not Support
<b>Supply Voltage 2.0v – 2.7v (for initialization)</b>	Not Support	Not Support
<b>Total Bus Capacitance for each signal line</b>	40pF	40pF
<b>CSD Version (CSD_STRUCTURE Value)</b>	1.0 (0x0)	2.0 (0x1)
<b>Speed Class</b>	Optional	Mandatory (Class 2 / 4 / 6 / 10)

# 5. Electrical Specifications

## 5.1. Power Consumption

The table below is the power consumption of PS8035 with different flash memory types.

Power Consumption of PS8035 Industrial SD card

Flash Mode	Max. Power Up Current (uA)	Max. Standby Current (uA)	Max. Read Current (mA)	Max. Write Current (mA)
Single Flash <sup>Note1</sup> (1 x 8bit)	150	150	100	100

**NOTE:**

1. Data transfer mode is single channel.

## 5.2. DC Characteristic

- Bus Operation Conditions for 3.3V Signaling

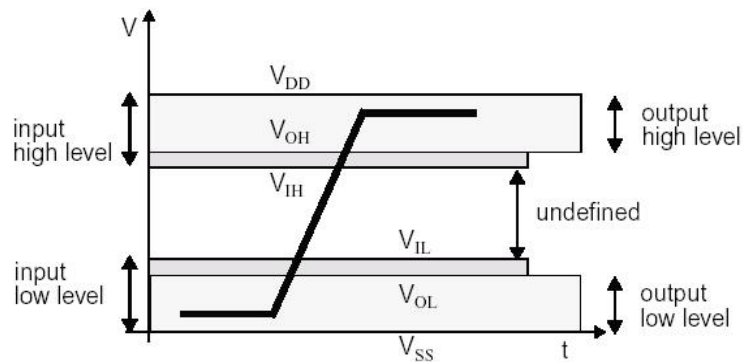
Threshold Level for High Voltage Range

Parameter	Symbol	Min.	Max	Unit	Condition
Supply Voltage	VDD	2.7	3.6	V	
Output High Voltage	VOH	0.75*VDD		V	IOH=-2mA VDD Min
Output Low Voltage	VOL		0.125*VDD	V	IOL=2mA VDD Min
Input High Voltage	VIH	0.625*VDD	VDD+0.3	V	
Input Low Voltage	VIL	VSS-0.3	0.25*VDD	V	
Power Up Time			250	ms	From 0V to VDD min

Peak Voltage and Leakage Current

Parameter	Symbol	Min	Max.	Unit	Remarks
Peak voltage on all lines		-0.3	V <sub>DD</sub> +0.3	V	
<b>All Inputs</b>					
Input Leakage Current		-10	10	uA	
<b>All Outputs</b>					
Output Leakage Current		-10	10	uA	

- **Bus Signal Levels**



**Bus Bus signal levels Diagram**

- **Bus Operation Conditions – Signal Line's Load**

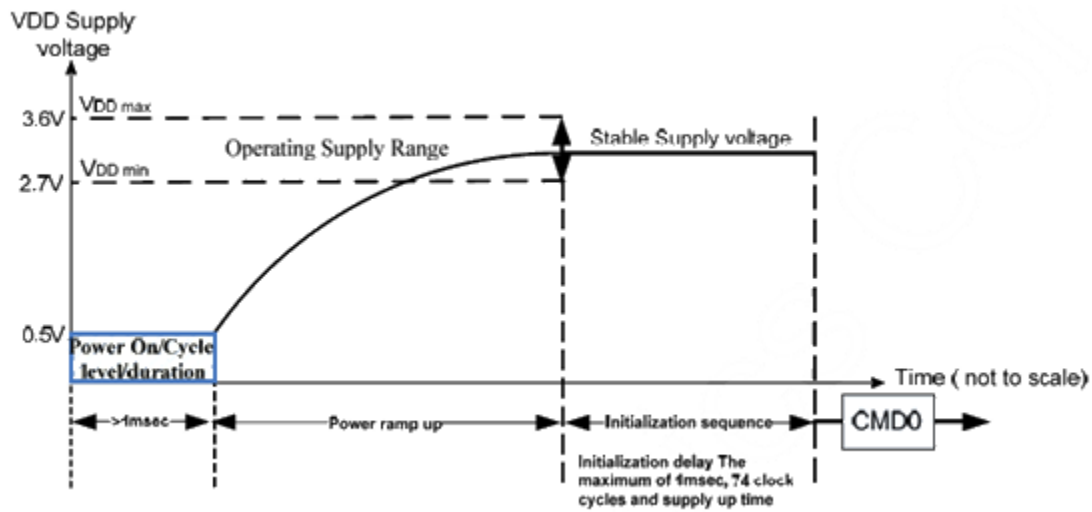
$$\text{Total Bus Capacitance} = \text{CHOST} + \text{CBUS} + N \cdot \text{CCARD}$$

Parameter	symbol	Min	Max	Unit	Remark
Pull-up resistance	$R_{CMD}$ $R_{DAT}$	10	100	k $\Omega$	to prevent bus floating
Total bus capacitance for each signal line	$C_L$		40	pF	1 card CHOST+CBUS shall not exceed 30 pF
Card Capacitance for each signal pin	CCARD		10	pF	
Maximum signal line inductance			16	nH	
Pull-up resistance inside card (pin1)	RDAT3	10	90	k $\Omega$	May be used for card detection
Capacity Connected to Power Line	CC		5	$\mu$ F	To prevent inrush current



- **Power Up Time**

Host needs to keep power line level less than 0.5V and more than 1ms before power ramp up.



- **Power On or Power Cycle**

Followings are requirements for Power on and Power cycle to assure a reliable SD Card hard reset.

- (1) Voltage level shall be below 0.5V.
- (2) Duration shall be at least 1ms.

- **Power Supply Ramp Up**

The power ramp up time is defined from 0.5V threshold level up to the operating supply voltage which is stable between VDD (min.) and VDD (max.) and host can supply SDCLK.

Followings are recommendations of Power ramp up:

- (1) Voltage of power ramp up should be monotonic as much as possible.
- (2) The minimum ramp up time should be 0.1ms.
- (3) The maximum ramp up time should be 35ms for 2.7-3.6V power supply.

- **Power Down and Power Cycle**

- (1) When the host shuts down the power, the card VDD shall be lowered to less than 0.5Volt for a minimum period of 1ms. During power down, DAT, CMD, and CLK should be disconnected or driven to logical 0 by the host to avoid a situation that the operating current is drawn through

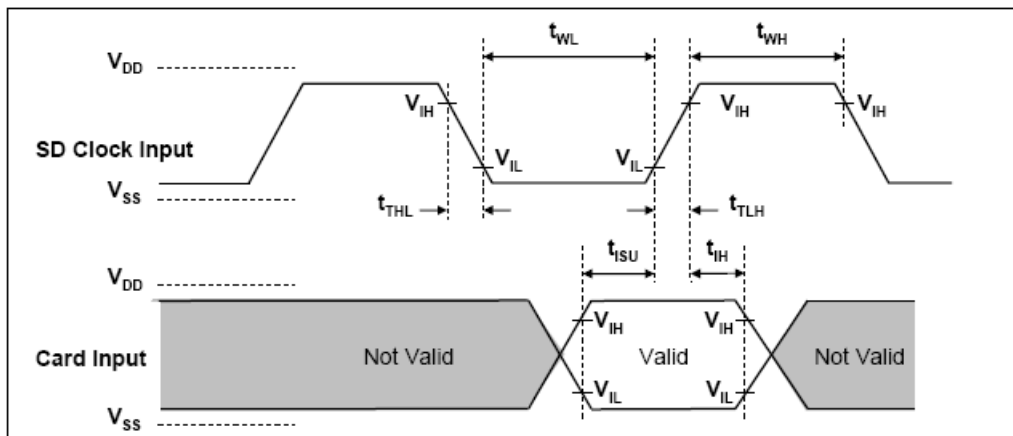


the signal lines.

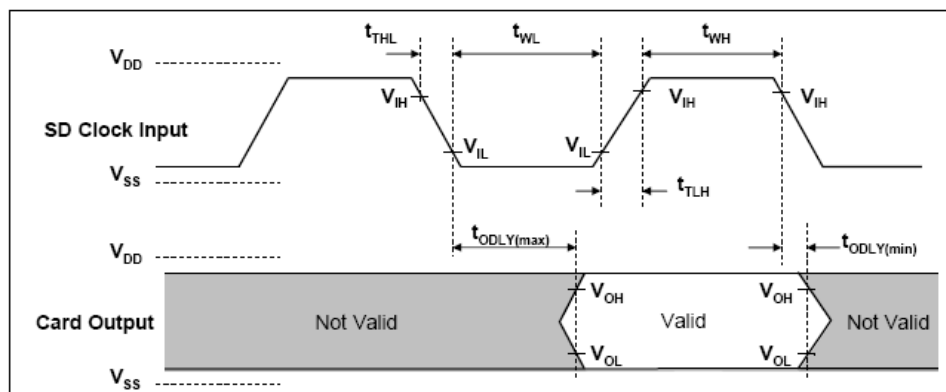
- (2) If the host needs to change the operating voltage, a power cycle is required. Power cycle means the power is turned off and supplied again. Power cycle is also needed for accessing cards that are already in *Inactive State*. To create a power cycle the host shall follow the power down description before power up the card (i.e. the card VDD shall be once lowered to less than 0.5Volt for a minimum period of 1ms).

### 5.3. AC Characteristic

- SD Interface Timing (Default)



Card Input Timing (Default Speed Card)

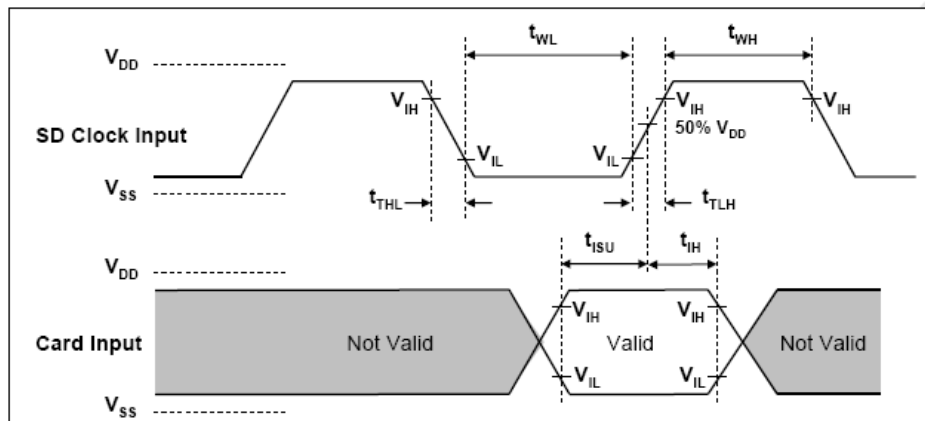


Card Output Timing (Default Speed Mode)

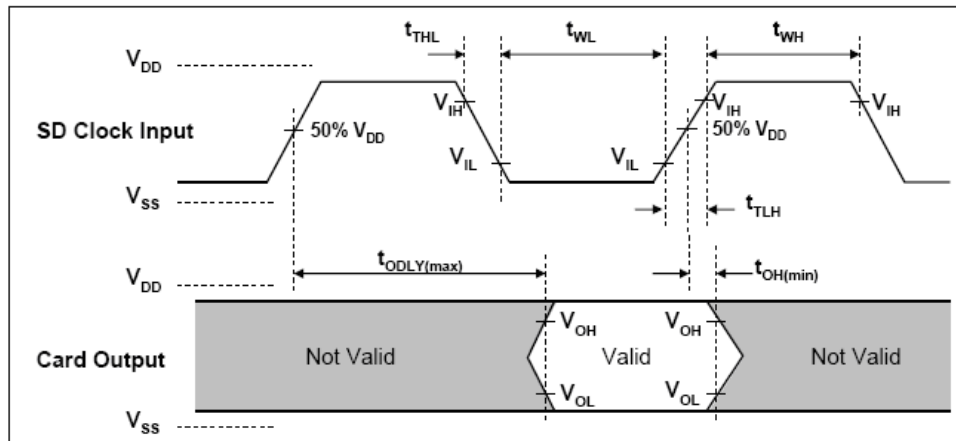
Parameter	Symbol	Min	Max	Unit	Remark
<b>Clock CLK (All values are referred to min(<math>V_{IH}</math>) and max(<math>V_{IL}</math>))</b>					
Clock frequency Data Transfer Mode	$f_{PP}$	0	25	MHz	$C_{card} \leq 10$ pF (1 card)
Clock frequency Identification Mode	$f_{OD}$	0(1)/100	400	kHz	$C_{card} \leq 10$ pF (1 card)
Clock low time	$t_{WL}$	10		ns	$C_{card} \leq 10$ pF (1 card)
Clock high time	$t_{WH}$	10		ns	$C_{card} \leq 10$ pF (1 card)
Clock rise time	$t_{TLH}$		10	ns	$C_{card} \leq 10$ pF (1 card)
Clock fall time	$t_{THL}$		10	ns	$C_{card} \leq 10$ pF (1 card)
<b>Inputs CMD, DAT (referenced to CLK)</b>					
Input set-up time	$t_{ISU}$	5		ns	$C_{card} \leq 10$ pF (1 card)
Input hold time	$t_{IH}$	5		ns	$C_{card} \leq 10$ pF (1 card)
<b>Outputs CMD, DAT (referenced to CLK)</b>					
Output Delay time during Data Transfer Mode	$t_{ODLY}$	0	14	ns	$C_L \leq 40$ pF (1 card)
Output Delay time during Identification Mode	$t_{ODLY}$	0	50	ns	$C_L \leq 40$ pF (1 card)

(1) 0Hz means to stop the clock. The given minimum frequency range is for cases where continuous clock is required.

- SD Interface Timing (High-Speed Mode)



Card Input Timing (High Speed Card)



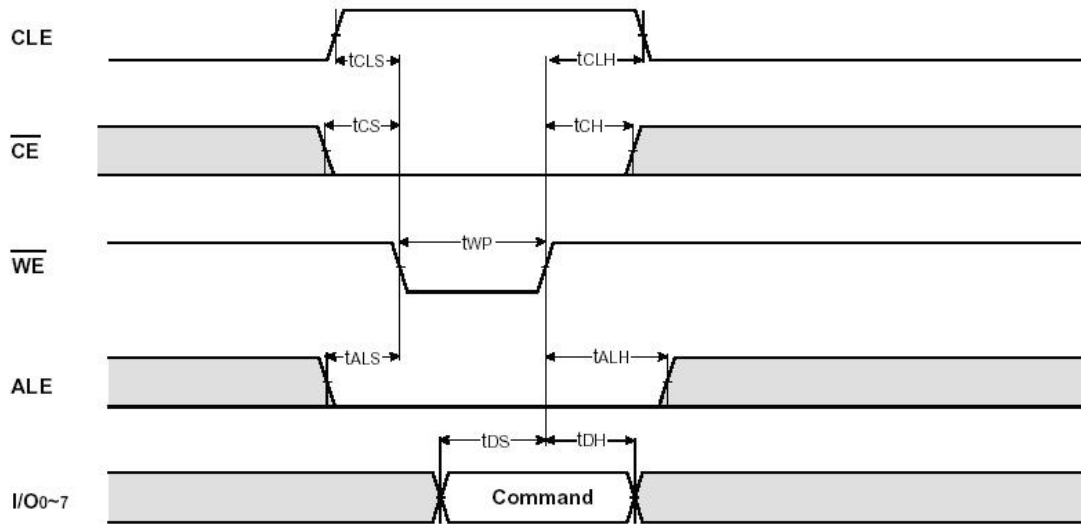
Card Output Timing (High Speed Mode)

Parameter	Symbol	Min	Max	Unit	Remark
<b>Clock CLK (All values are referred to min(<math>V_{IH}</math>) and max(<math>V_{IL}</math>))</b>					
Clock frequency Data Transfer Mode	$f_{pp}$	0	50	MHz	$C_{card} \leq 10$ pF (1 card)
Clock low time	$t_{WL}$	7		ns	$C_{card} \leq 10$ pF (1 card)
Clock high time	$t_{WH}$	7		ns	$C_{card} \leq 10$ pF (1 card)
Clock rise time	$t_{TLH}$		3	ns	$C_{card} \leq 10$ pF (1 card)
Clock fall time	$t_{THL}$		3	ns	$C_{card} \leq 10$ pF (1 card)
<b>Inputs CMD, DAT (referenced to CLK)</b>					
Input set-up time	$t_{ISU}$	6		ns	$C_{card} \leq 10$ pF (1 card)
Input hold time	$t_{IH}$	2		ns	$C_{card} \leq 10$ pF (1 card)
<b>Outputs CMD, DAT (referenced to CLK)</b>					
Output Delay time during Data Transfer Mode	$t_{ODLY}$		14	ns	$C_L \leq 40$ pF (1 card)
Output Hold time	$T_{OH}$	2.5		ns	$C_L \leq 15$ pF (1 card)
Total System capacitance of each line <sup>1</sup>	$C_L$		40	pF	$C_L \leq 15$ pF (1 card)

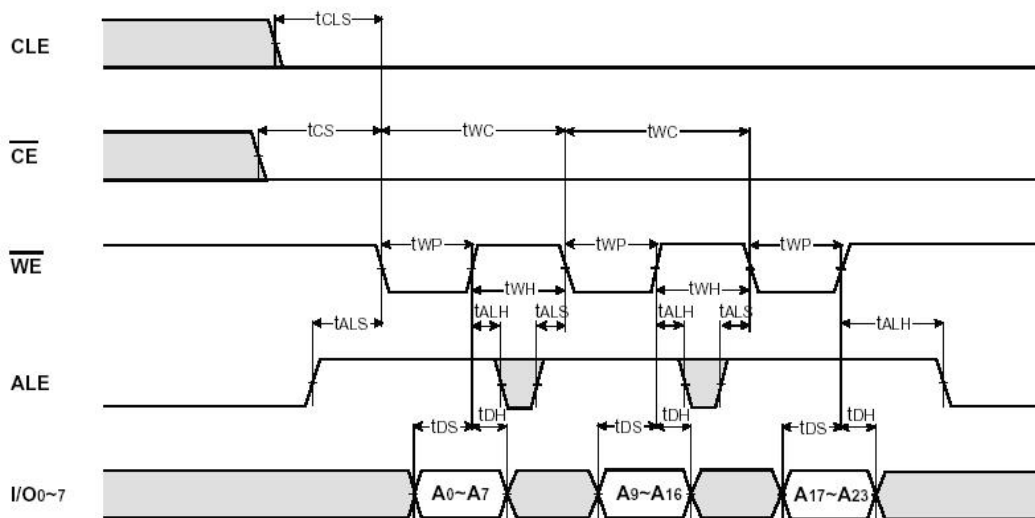
(1) In order to satisfy severe timing, the host shall drive only one card.

- Flash memory timing

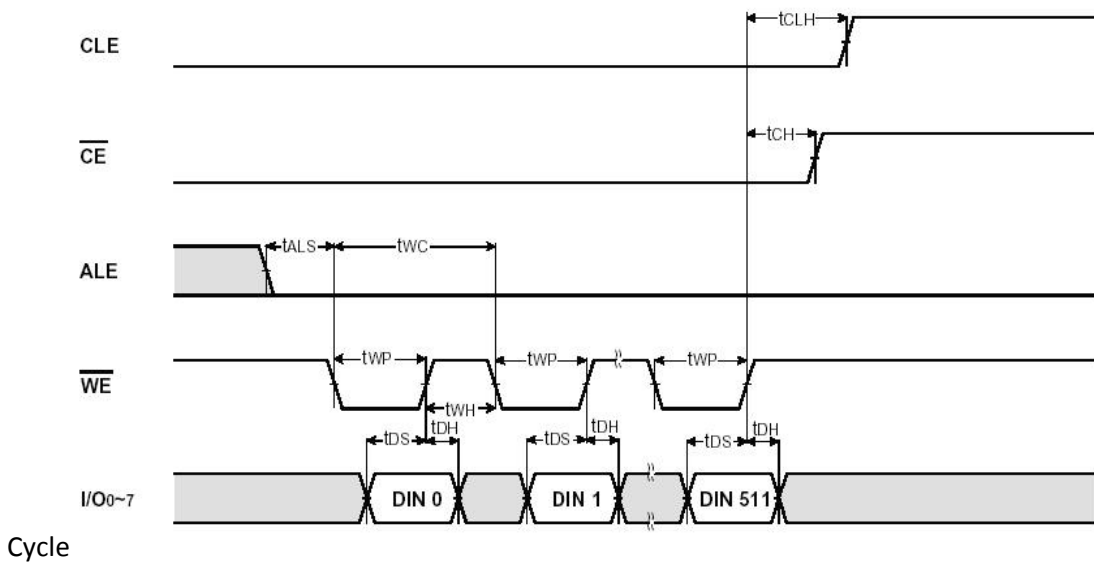
(a) Command Latch Cycle



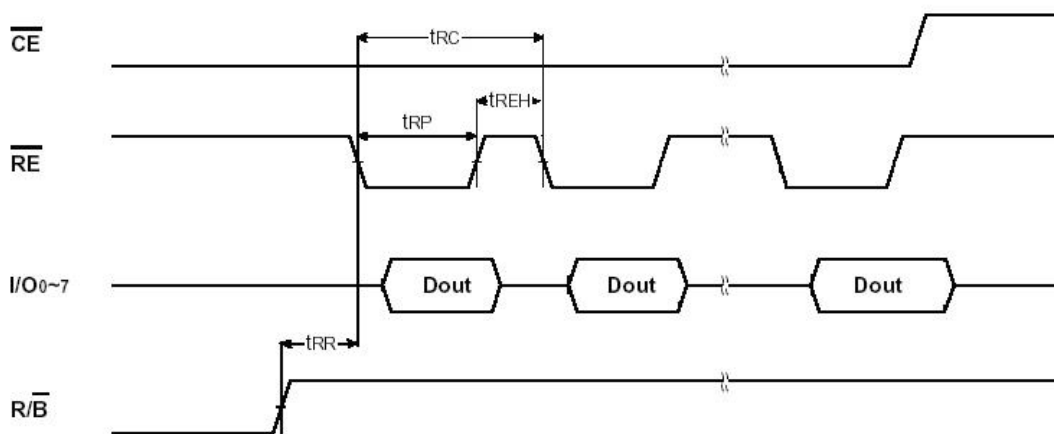
(b) Address Latch Cycle



(c) Input Data Latch

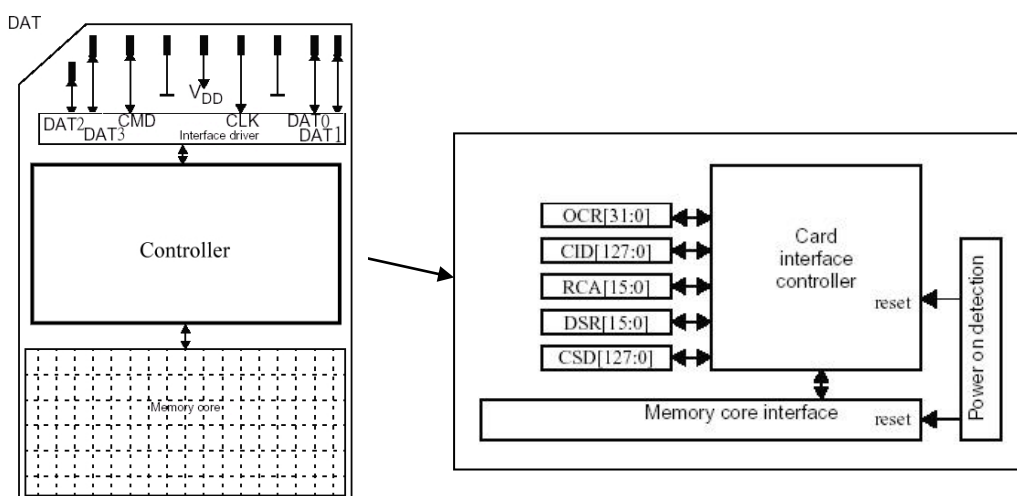


(d) Sequential Out Cycle after Read (CLE=L,  $\overline{WE}$ =H, ALE=L)



# 6. Interface

## 6.1. Pad Assignment and Descriptions



SD Memory Card Pad Assignment

pin	SD Mode			SPI Mode		
	Name	Type <sup>1</sup>	Description	Name	Type	Description
1	CD/DAT3 <sup>2</sup>	I/O/PP <sup>3</sup>	Card Detect/ Data Line[bit3]	CS	I <sup>3</sup>	Chip Select (net true)
2	CMD	PP	Command/Response	DI	I	Data In
3	V <sub>SS1</sub>	S	Supply voltage ground	VSS	S	Supply voltage ground
4	V <sub>DD</sub>	S	Supply voltage	VDD	S	Supply voltage
5	CLK	I	Clock	SCLK	I	Clock
6	V <sub>SS2</sub>	S	Supply voltage ground	VSS2	S	Supply voltage ground
7	DAT0	I/O/PP	Data Line[bit0]	DO	O/PP	Data Out
8	DAT1	I/O/PP	Data Line[bit1]	RSV		
9	DAT2	I/O/PP	Data Line[bit2]	RSV		

- (1) S: power supply, I: input; O: output using push-pull drivers; PP: I/O using push-pull drivers.
- (2) The extended DAT lines (DAT1-DAT3) are input on power up. They start to operate as DAT lines after SET\_BUS\_WIDTH command. The Host shall keep its own DAT1-DAT3 lines in input mode as well while they are not used. It is defined so in order to keep compatibility to MultiMedia Cards.
- (3) At power up, this line has a 50KOhm pull up enabled in the card. This resistor serves two functions: Card detection and Mode Selection. For Mode Selection, the host can drive the line high or let it be pulled high to select SD mode. If the host wants to select SPI mode, it should drive the line low. For

Card detection, the host detects that the line is pulled high. This pull-up should be disconnected by the user during regular data transfer with SET\_CLR\_CARD\_DETECT (ACMD42) command.

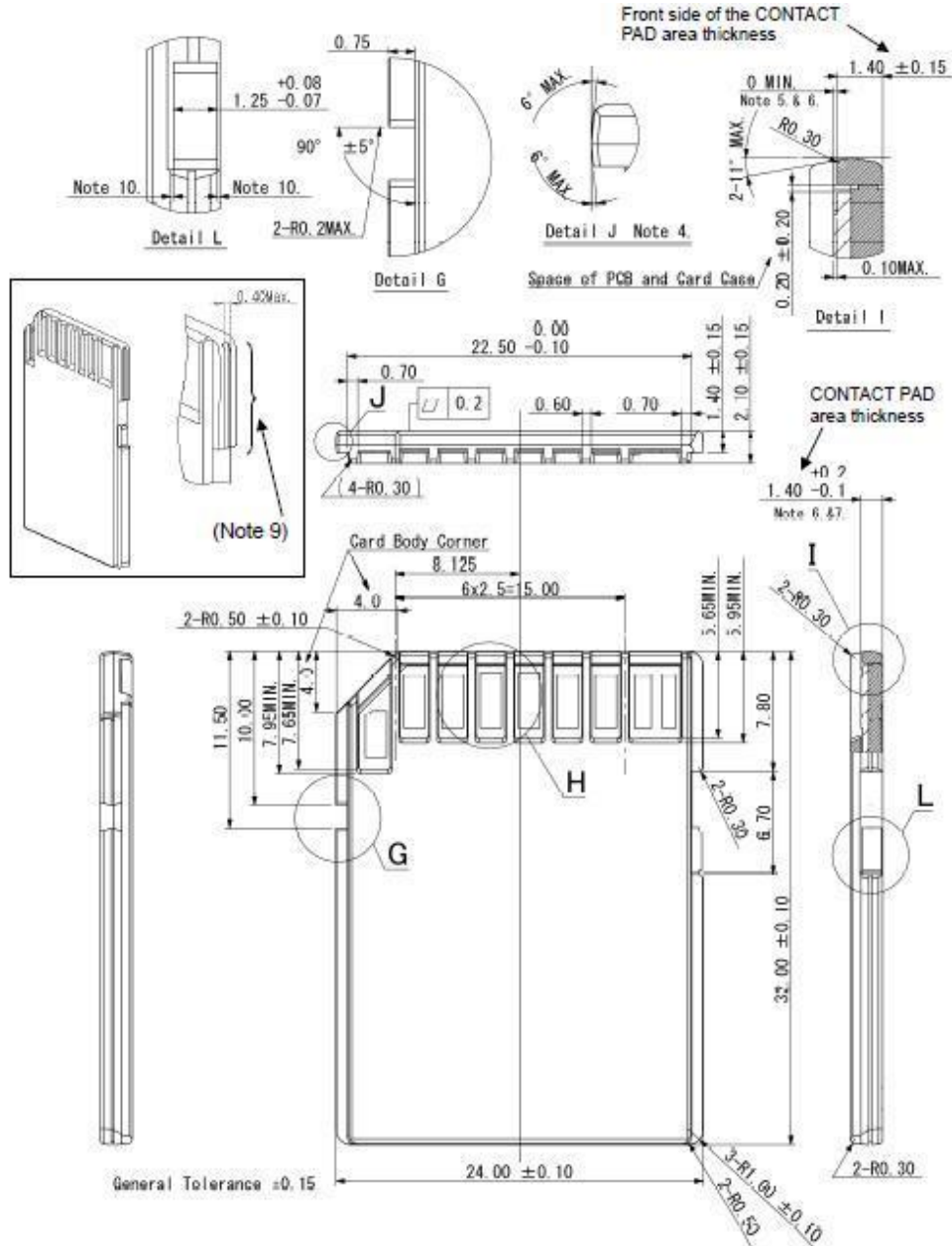
Name	Width	Description
CID	128bit	Card identification number; card individual number for identification. <b>Mandatory</b>
RCA1	16bit	Relative card address; local system address of a card, dynamically suggested by the card and approved by the host during initialization. <b>Mandatory</b>
DSR	16bit	Driver Stage Register; to configure the card's output drivers. <b>Optional</b>
CSD	128bit	Card Specific Data; information about the card operation conditions. <b>Mandatory</b>
SCR	64bit	SD Configuration Register; information about the SD Memory Card's Special Features capabilities <b>Mandatory</b>
OCR	32bit	Operation conditions register. <b>Mandatory.</b>
SSR	512bit	SD Status; information about the card proprietary features <b>Mandatory</b>
OCR	32bit	Card Status; information about the card status <b>Mandatory</b>

(1) RCA register is not used (or available) in SPI mode.



# 7. Physical Dimension

Dimension: 32mm(L) x 24mm(W) x 2.1mm(H)





### **Warning**

- Do not bend, crush, drop, or place heavy objects on top of the Product. Do not use tweezers, pliers, or similar items that could damage the Product. Take particular care when inserting or removing the Product. Stop using the Product when the Product does not work properly. Failure to follow these instructions could result in fire, damage to the Product and/or other property, and/or personal injury including burns and electric shock.
- Keep out of reach of small children. Accidental swallowing may cause suffocation or injury. Contact a doctor immediately if you suspect a child has swallowed the Product. .
- Do not directly touch the interface pins, put them in contact with metal, strike them with hard objects, or cause them to short. Do not expose to static electricity.
- Do not disassemble or modify the Product. This may cause electric shock, damage to the Product, or fire.

### **Notes on usage**

- The Product contains nonvolatile semiconductor memory. Do not use the Product in accordance with a method of usage other than that written in the manual. This may cause the destruction or loss of data.
- To protect against accidental data loss, you should back up your data frequently on more than one type of storage media. \*\*\*\* Corporation assumes no liability for destruction or loss of data recorded on the Card for any reason.
- When used over a long period of time or repeatedly, the reading, writing and deleting capabilities of the Product will eventually fail, and the performance speed of the Product may decrease below the original speed specific to the Product's applicable class.
- If the Product is to be transferred or destroyed, note that the data it contained may still be recoverable unless it is permanently deleted by third-party deletion software or similar means beforehand.

### **Product applications and design.**

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