

**SDカード**  
**MLC:8-256GB**  
**aMLC:4-128GB**  
**(ET1288+SanDisk 15nm MLC)**  
**データシート**

**REVISION HISTORY**

<b>Revision</b>	<b>Description</b>	<b>Date</b>
V1.1	First released	August 2015
V2.1	For SanDisk 1Znm solution	January 2017
V2.2	Updated part number information	May 2017
V2.3	Added sMLC 4GB~32GB	May 2017
V2.4	Added Product Feature information	June 2017
V2.5	Added MLC 128GB/256GB and sMLC 64GB/128GB	October 2017
V2.6	Added ESD Ability and Table 4	March 2018
V2.7	Added waterproof and power consumption information	April 2018
V2.8	Name changed from sMLC to aMLC.	June 2018
V2.9	Added 1.3 TBW (Tera Byte Written).	March 2020
V3.0	Added 1.2 Product Features and 3.8 Dust proof	July 2020

## 1. Product Introduction

### 1.1. Overview

The Industrial SD Card is designed for demanding industrial applications.

Moreover, the Industrial SD Card supports Ultra High Speed (UHS) interface transfer mode, provides high write/read data transfer rate, high random IOPS, sudden Power-Fails protection, adaptive static wear-leveling, read/program disturb management, etc.

It was designed to meet the high quality, high reliability, high performance, and versatile environmental requirements.

### 1.2. Product Features

- Interface: 9 pins SD standard interface
- Compliant SD Card Specification 3.0
- Density support:
  - MLC:8GB~256GB
  - aMLC (Advanced MLC, single bit per cell MLC): 4GB~128GB
- Bus Speed Mode:
  - DS-Default Speed mode: 3.3V signaling, frequency up to 25MHz, up to 12.5MB/sec
  - HS-High Speed mode: 3.3V signaling, frequency up to 50MHz, up to 25MB/sec
  - SDR12: 1.8V signaling, frequency up to 25MHz, up to 12.5MB/sec
  - SDR25: 1.8V signaling, frequency up to 50MHz, up to 25MB/sec
  - SDR50: 1.8V signaling, frequency up to 100MHz, up to 50MB/sec
  - SDR104: 1.8V signaling, frequency up to 208MHz, up to 104MB/sec
  - DDR50: 1.8V signaling, frequency up to 50MHz, sampled on both clock edges, up to 50MB/s
- Operating at -25°C to 85°C
- Flash: MLC NAND Flash (SDTNSGAMA-008G, SDTNSGAMA-016G)
- Controller: ET1288
- Program/Erase Cycle: 3,000 Cycles (MLC)
- Program/Erase Cycle: 20,000 Cycles (aMLC)
- Built-in ECC corrects up to 43 bits/1 KB
- Read disturbance management (Auto-Refresh)
- Adaptive wear leveling
- Management of sudden power-fails
- SMART Function support
- Support CPRM (Content Protection for Recordable Media) of SD Card
- Support Water & Dust proof IEC 60529 IP58
- aMLC (Advanced MLC, single bit per cell MLC) support, enhance the performance and product endurance.

**1.3. TBW (Tera Bytes Written)**

<b>Capacity</b>	<b>4GB</b>	<b>8GB</b>	<b>16GB</b>	<b>32GB</b>	<b>64GB</b>	<b>128GB</b>	<b>256GB</b>
<b>MLC</b>	—	<b>19.6TB</b>	<b>39.2TB</b>	<b>78.4TB</b>	<b>156.8TB</b>	<b>313.6TB</b>	<b>627.2TB</b>
<b>aMLC</b>	<b>65.3TB</b>	<b>130.6TB</b>	<b>261.2TB</b>	<b>522.4TB</b>	<b>1047.3TB</b>	<b>2094.6TB</b>	—

\*The endurance of disk could be varying based on user behavior, NAND endurance cycles, and write amplification factor.  
It is not guaranteed by flash vendor.

\*Client workload by JESD-219A

## 2. SD Card Interface Description

### 2.1 SD Pin Assignment

**Table 1: SD Bus Mode Pin Definition**

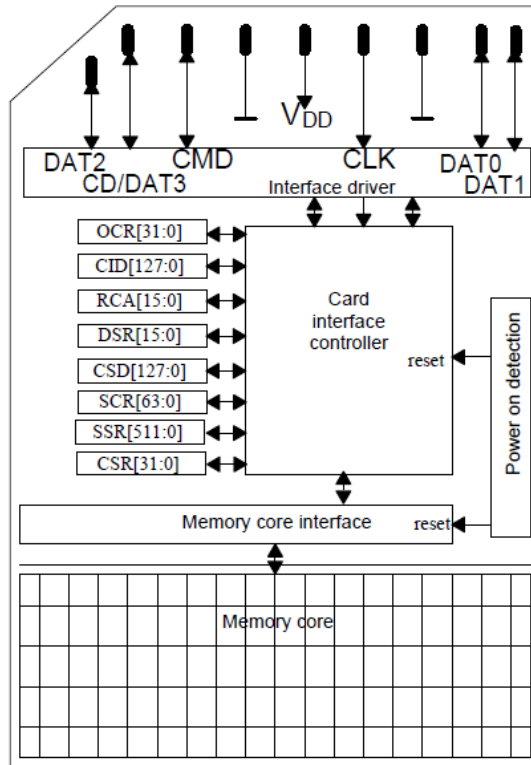
Pin #	Name	Type	SD Description
1	CD/DAT3	I/O	Card Detect / Data Line [Bit3]
2	CMD	PP	Command / Response
3	VS	S	Supply Voltage Ground
4	VDD	S	Supply Voltage
5	CLK	I	Clock
6	VS	S	Supply Voltage Ground
7	DAT0	I/O	Data Line [Bit 0]
8	DAT1	I/O	Data Line [Bit 1]
9	DAT2	I/O	Data Line [Bit 2]

**Notes:**

- 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 Multi-media Cards.
- 3) After power up this line (Pin1) is input with 50Kohm pull-up (can be used for card detection or SPI mode selection). The pull-up should be disconnected by user, during regular data transfer, with SET\_CLR\_CARD\_DETECT (ACMD42) command.

**Table 2: SPI Bus Mode Pin Definition**

Pin #	Name	Type	SD Description
1	CS	I	Chip Select (neg true)
2	DI	I	Data In
3	VSS	S	Supply Voltage Ground
4	VDD	S	Supply Voltage
5	SCLK	I	Clock
6	VSS	S	Supply Voltage Ground
7	DO	O	Data Out
8	RSV		Reserved
9	RSV		Reserved



**Figure 1: Functional Diagram**

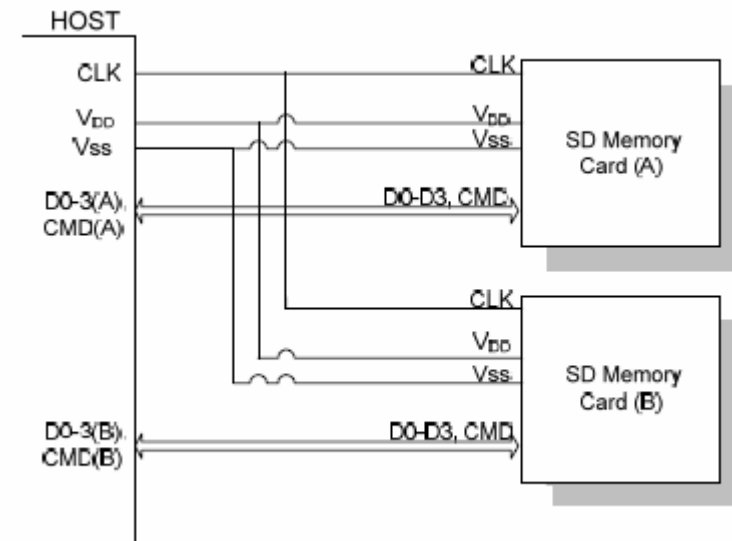
**2.2 SD Bus Topology**

The SD bus has six communication lines and three supply lines:

- CMD: Command is bi-directional signal. (Host and card drivers are operating in push pull mode.)
- DAT0-3: Data lines are bi-directional signals. (Host and card drivers are operating in push pull mode.)
- CLK: Clock is a host to cards signal. (CLK operates in push pull mode.)
- VDD: VDD is the power supply line for all cards.
- VSS: VSS is the power ground line.

During the initialization process, commands are sent to each card individually, allowing the application to detect the cards and assign logical addresses to the physical slots. Data is always sent to each card individually. However, to simplify the handling of the card stack, after initialization, all commands may be sent concurrently to all cards. Addressing information is provided in the command packet.

The following figure shows the bus topology of several cards with one host in SD Bus mode.



**Figure 2: Memory Card System Bus Topology**

### 2.3 SPI Bus Topology

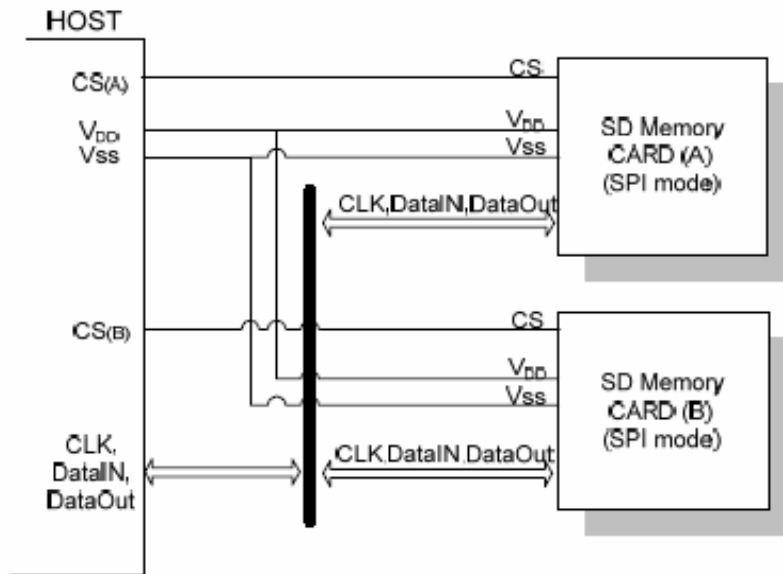
The memory Card SPI interface is compatible with SPI hosts available on the market. As any other SPI device, the SD Memory Card SPI channel consists of the following 4 signals:

- CS: Host to card Chip Select signal.
- CLK: Host to card clock signal.
- Data In: Host to card data signal.
- Data Out: Card to host data signal.

Another SPI common characteristic, which is implemented in the Memory Card as well, is byte transfers. All data tokens are multiples of 8bit bytes and always byte aligned to the CS signal.

The card identification and addressing methods are replaced by a hardware Chip Select (CS) signal. There are no broadcast commands, a card (slave) is selected by asserting (active low) the CS signal. The CS signal shall be continuously active for the duration of the SPI transaction (command, response, and data). The only exception occurs during card programming, when the host can de-assert the CS signal without affecting the programming process.

The SPI interface uses the 7 out of the SD 9 signals (DAT1 and DAT2 are not used, DAT3 is the CS signal) of the SD bus.



**Figure 3: SPI mode SD Memory Card Bus System**



### 3. Specifications

#### 3.1. Performance

Max. Data Transfer Rate

- Read: 90MB/s; Write: 70MB/s

#### 3.2. NAND Flash Memory

Industrial SD Card uses Multi Level Cell (MLC) NAND Flash memory, which is non- volatility, high reliability and highspeed memory storage.

#### 3.3. Power Requirement

##### 3.3.1. DC Input Voltage

- 2.7V to 3.6V

#### 3.4. Temperature Range

- -25°C to +85°C

#### 3.5. Humidity

Relative Humidity: 5-95%, non-condensing

#### 3.6. Waterproof

Waterproof level: IEC 60529 IPX8.

Test Condition	Referred standard
Depth of water 1.5m for 30 mins.	IEC 60529 IPX8

#### 3.7. ESD Ability

Test Condition	Referred standard
● Contact discharge: $\pm 2KV$ , $\pm 4KV$	SD Spec. Appendix D.1
● Air discharge: $\pm 4KV$ , $\pm 8KV$ , $\pm 15KV$	SD Spec. Appendix D.2

#### 3.8. Dust Proof

Dust proof level: IEC 60529 IP5X.

Test Condition	Referred standard
Depression of 2 KPa, Talcum powder 2kg/m <sup>3</sup> , 8 hrs.	IEC 60529 IP5X

## 4. Electrical Specifications

### 4.1. General DC Characteristic

**Table 3: Absolute Maximum Ratings**

Symbol	Parameter	Min.	Max.	Unit	Note
$T_{\text{storage}}$	Storage Temperature	-40	85	°C	-
$T_a$	Ambient Operating Temperature	-25	85	°C	-
$V_i$	3.3V External Input Voltage	-0.3	3.6	V	-

**Table 4: Power Consumption**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$I_{\text{Read}}$	Read Current at 3.3V (High Speed Mode)	-	76	200	mA
	Read Current at 1.8V (UHS-I Mode)	-	220	800	mA
$I_{\text{Write}}$	Write Current at 3.3V (High Speed Mode)	-	80	200	mA
	Write Current at 1.8V (UHS-I Mode)	-	210	800	mA
$I_{\text{STBY}}$	Standby Current	-	0.6	15	mA

### 4.2. Bus Operation Conditions for 3.3V Signaling

#### 4.2.1 Threshold Level for High Voltage Range

**Table 5: Threshold Level for High Voltage**

Parameter	Symbol	Min	Max	Unit	Remark
Supply Voltage	$V_{\text{DD}}$	2.7	3.6	V	
Output High Voltage	$V_{\text{OH}}$	$0.75 * V_{\text{DD}}$		V	$I_{\text{OH}}=2\text{mA } V_{\text{DD min}}$
Output Low Voltage	$V_{\text{OL}}$		$0.125 * V_{\text{DD}}$	V	$I_{\text{OL}}=2\text{mA } V_{\text{DD min}}$
Input High Voltage	$V_{\text{IH}}$	$0.625 * V_{\text{DD}}$	$V_{\text{DD}}+0.3$	V	
Input Low Voltage	$V_{\text{IL}}$	$V_{\text{SS}}-0.3$	$0.25 * V_{\text{DD}}$	V	
Power Up Time			250	ms	From 0V to $V_{\text{DD min}}$

#### 4.2.2 Peak Voltage and Leakage Current

**Table 6: Peak Voltage and Leakage Current**

Parameter	Symbol	Min	Max	Unit	Remark
Peak voltage on all lines		-0.3	$V_{\text{DD}}+0.3$	V	
All Inputs					
Input Leakage Current		-10	10	uA	
All Outputs					
Output Leakage Current		-10	10	uA	

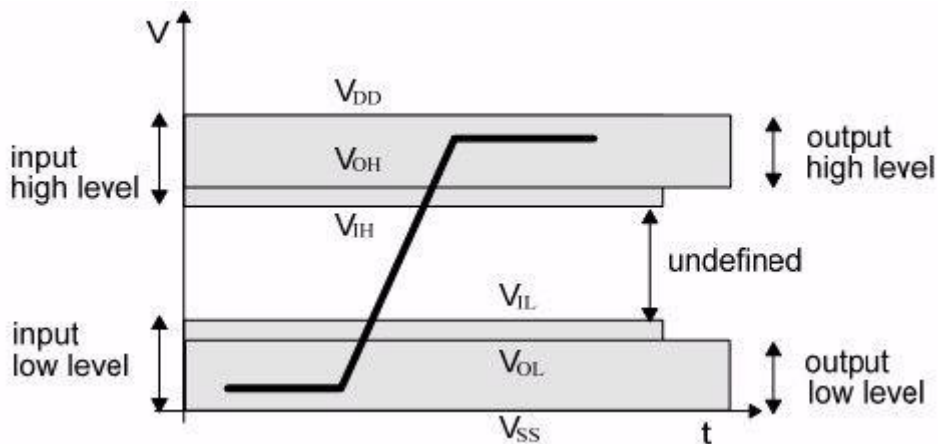
**4.2.3 Bus Signal Line Load**

**Table 7: Bus Operating Conditions - Signal Line's Load**

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 $C_{HOST}+C_{BUS}$ shall not exceed 30pF
Card capacitance for each signal pin	$C_{CARD}$		10	pF	
Maximum signal inductance			16	nH	
Pull-up resistance inside card(pin1)	$R_{DAT3}$	10	90	K $\Omega$	May be used for card detection
Capacity Connected to Power Line	$C_C$		5	$\mu$ F	To prevent inrush current

**4.2.4 Bus Signal Levels**

As the bus can be supplied with a variable supply voltage, all signal levels are related to the supply voltage.



**Figure 4: Bus Signal Levels**

To meet the requirements of the JEDEC specification JESD8-1A and JESD8-7, the card input and output voltages shall be within the specified ranges shown in Table 6 for any VDD of the allowed voltage range.

4.2.5 Bus Timing (Default)

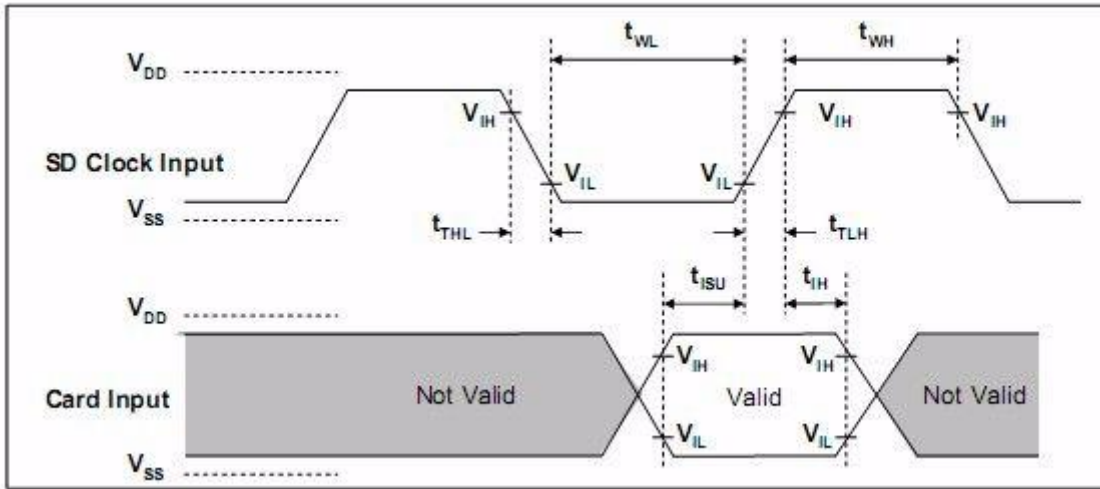


Figure 5: Card input Timing (Default Speed Card)

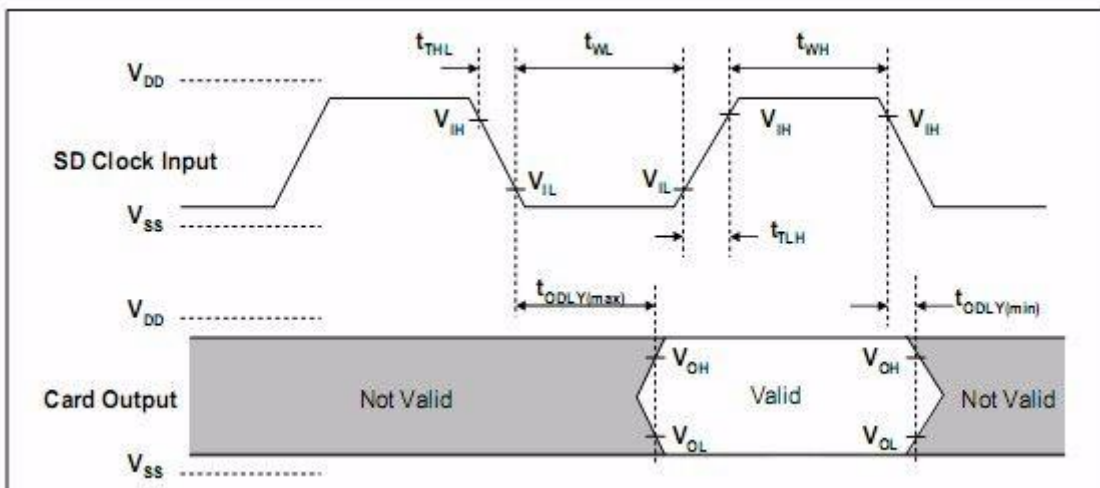


Figure 6: Card Output Timing (Default Speed Mode)

Table 8: Bus Timing-Parameters Values (Default Speed)

Parameter	Symbol	Min.	Max	Unit	Remark
<b>Clock CLK</b> ( All values are referred to min ( V <sub>IH</sub> ) and max ( V <sub>IL</sub> ) )					
Clock frequency data transfer	f <sub>pp</sub>	0	25	MHz	C <sub>CARD</sub> ≤ 10pF (1 card)
Clock frequency Identification	f <sub>OD</sub>	0 <sup>(1)</sup> /100	400	KHz	C <sub>CARD</sub> ≤ 10pF (1 card)
Clock low time	t <sub>WL</sub>	10		ns	C <sub>CARD</sub> ≤ 10pF (1 card)
Clock high time	t <sub>WH</sub>	10		ns	C <sub>CARD</sub> ≤ 10pF (1 card)
Clock rise time	t <sub>TLH</sub>		10	ns	C <sub>CARD</sub> ≤ 10pF (1 card)
Clock fall time	t <sub>THL</sub>		10	ns	C <sub>CARD</sub> ≤ 10pF (1 card)

Inputs CMD, DAT (referenced to CLK)					
Input set-up time	$t_{ISU}$	5		ns	$C_{CARD} \leq 10\text{pF}$ (1 card)
Input hold time	$t_{IH}$	5		ns	$C_{CARD} \leq 10\text{pF}$ (1 card)
Outputs CMD, DAT (referenced to CLK)					
Output Delay time during Data Transfer Mode	$t_{ODLY}$	0	14	ns	$C_L \leq 40\text{pF}$ (1 card)
Output Hold time	$t_{OH}$	0	50	ns	$C_L \leq 40\text{pF}$ (1 card)

(1) 0 Hz means to stop the clock. The given minimum frequency range is for cases where continuous clock is required (refer to Chapter 4.4-Clock Control)

### 4.2.6 Bus Timing (High-Speed Mode)

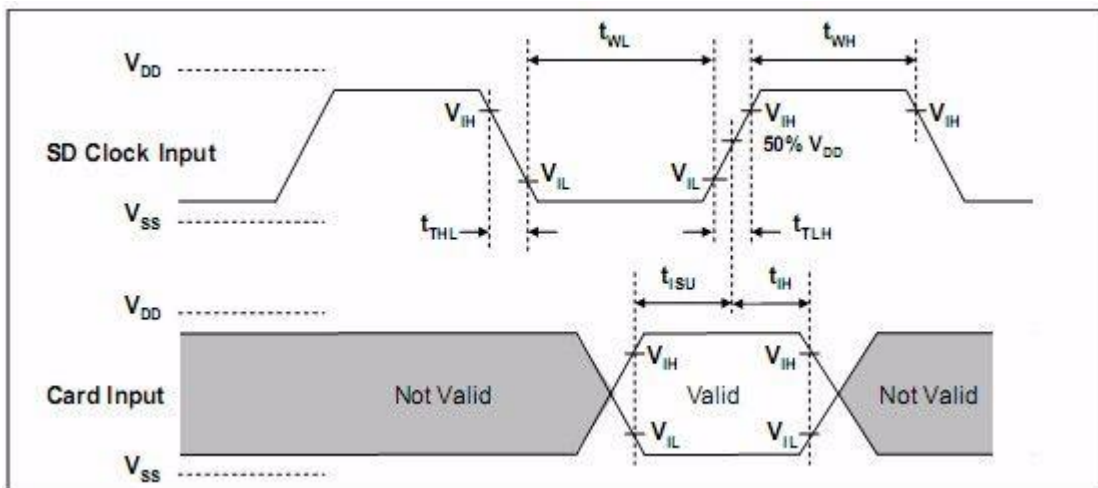


Figure 7: Card Input Timing (High Speed Card)

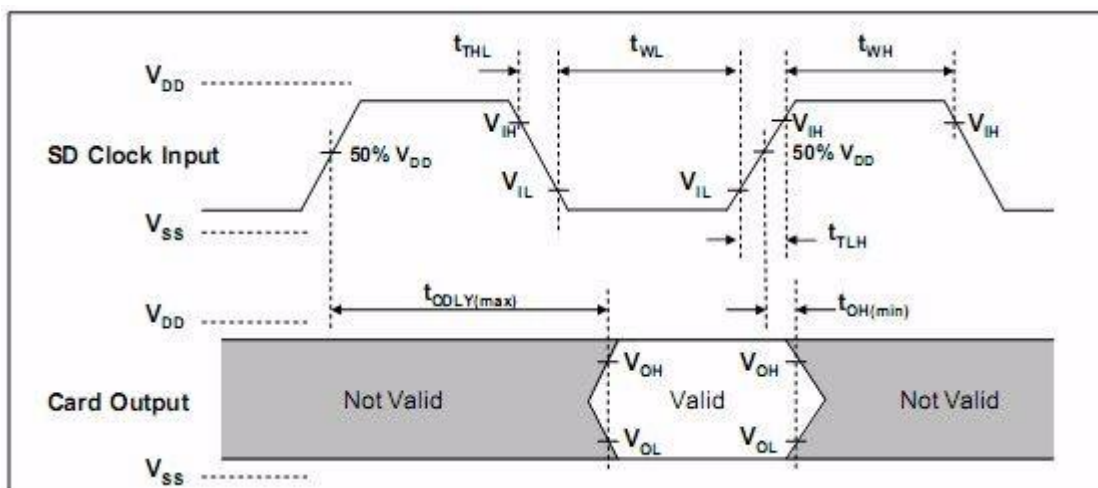


Figure 8: Card Output Timing (High Speed Mode)

**Table 9 : Bus Timing - Parameters Values(High Speed)**

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

1) In order to satisfy sever timing, host shall drive only one card.

### 4.3 Bus Operation Conditions for 1.8V Signaling

#### 4.3.1 Threshold Level for High Voltage Range

**Table 10: Threshold Level for High Voltage**

Parameter	Symbol	Min	Max	Unit	Remark
Supply Voltage	$V_{DD}$	2.7	3.6	V	
Regulator Voltage	$V_{DDIO}$	1.7	1.95	V	Generated by $V_{DD}$
Output High Voltage	$V_{OH}$	1.4		V	$I_{OH}=2mA$ $V_{DD}$ min
Output Low Voltage	$V_{OL}$		0.45	V	$I_{OL}=2mA$ $V_{DD}$ min
Input High Voltage	$V_{IH}$	1.27	2.0	V	
Input Low Voltage	$V_{IL}$	$V_{SS}-0.3$	0.58	V	

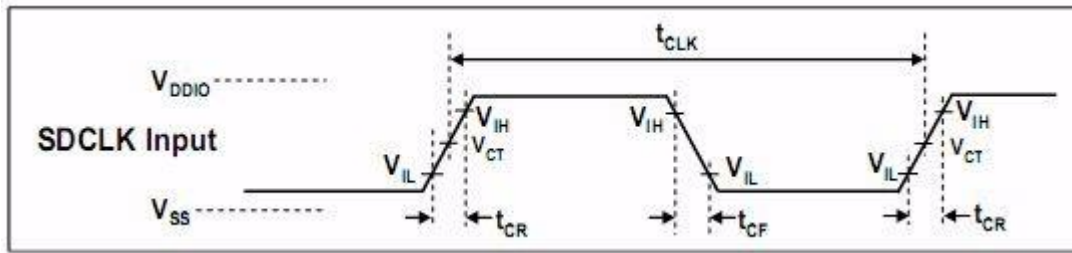
#### 4.3.2 Peak Voltage and Leakage Current

**Table 11: Peak Voltage and Leakage Current**

Parameter	Symbol	Min	Max	Unit	Remark
Input Leakage Current		-2	2	$\mu A$	DAT3 pull-up is disconnected

**4.3.3 Bus Timing Specification in SDR12, SDR25, SDR50 and SDR104 Modes**

**4.3.3.1 Clock Timing**

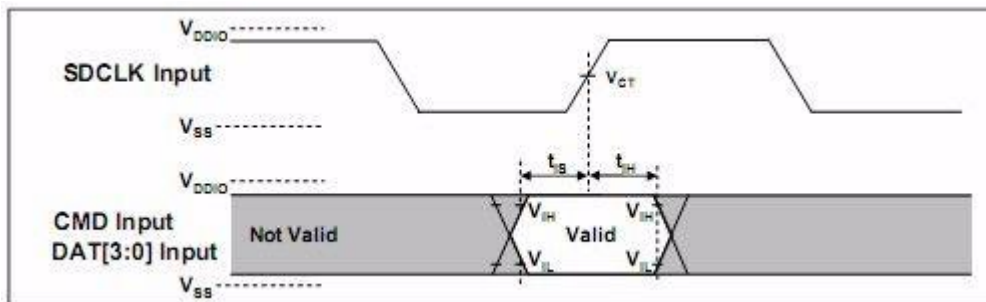


**Figure 9: Clock Signal Timing**

**Table 12: Clock Signal Timing**

Symbol	Min	Max	Unit	Remark
$t_{CLK}$	4.8	-	ns	208MHz (Max.), Between rising edge, $V_{CT}=0.975V$
$t_{CR}, t_{CF}$	-	$0.2 * t_{CLK}$	ns	$t_{CR}, t_{CF} < 2.00ns$ (max.) at 208MHz, $C_{CARD}=10pF$ $t_{CR}, t_{CF} < 2.00ns$ (max.) at 100MHz, $C_{CARD}=10pF$ The absolute maximum value of $t_{CR}, t_{CF}$ is 10ns regardless of clock frequency
Clock Duty	30	70	%	

**4.3.3.2 Card Input Timing**



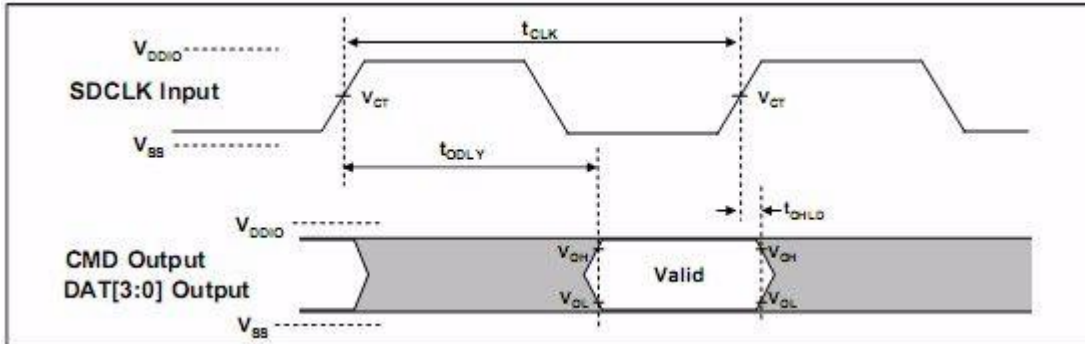
**Figure 10: Card Input Timing**

**Table 13: SDR50 and SDR104 Input Timing**

Symbol	Min	Max	Unit	SDR104 mode
$t_{IS}$	1.40	-	ns	$C_{CARD} = 10pF, V_{CT} = 0.975V$
$t_{IH}$	0.80	-	ns	$C_{CARD} = 5pF, V_{CT} = 0.975V$
Symbol	Min	Max	Unit	SDR12, SDR25 and SDR50 modes
$t_{IS}$	3.00	-	ns	$C_{CARD} = 10pF, V_{CT} = 0.975V$
$t_{IH}$	0.80	-	ns	$C_{CARD} = 5pF, V_{CT} = 0.975V$

**4.3.3.3 Card Output Timing**

**4.3.3.3.1 Output Timing of Fixed Data Window (SDR12, SDR25 and SDR50)**

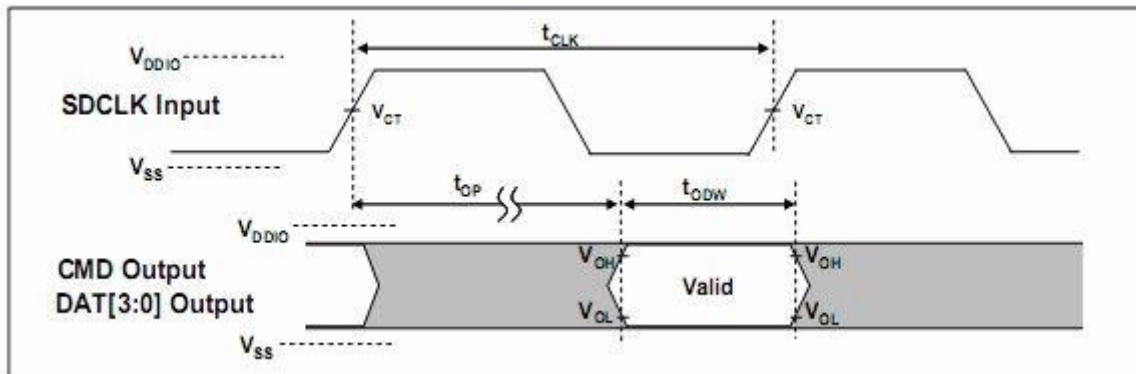


**Figure 11: Output Timing of Fixed Date Window**

**Table 14: Output Timing of Fixed Data Window**

Symbol	Min	Max	Unit	Remark
t <sub>ODLY</sub>	—	7.5	ns	t <sub>CLK</sub> ≥ 10.0ns, CL=30pF, using driver Type B, for SDR50.
t <sub>ODLY</sub>		14	ns	t <sub>CLK</sub> ≥ 20.0ns, CL=40pF, using driver Type B, for SDR25 and SDR12.
t <sub>OH</sub>	1.5	—	ns	Hold time at the t <sub>ODLY</sub> (min.). CL=15pF

**4.3.3.3.2 Output Timing of Variable Window (SDR104)**



**Figure 12: Output Timing of Variable Data Window**

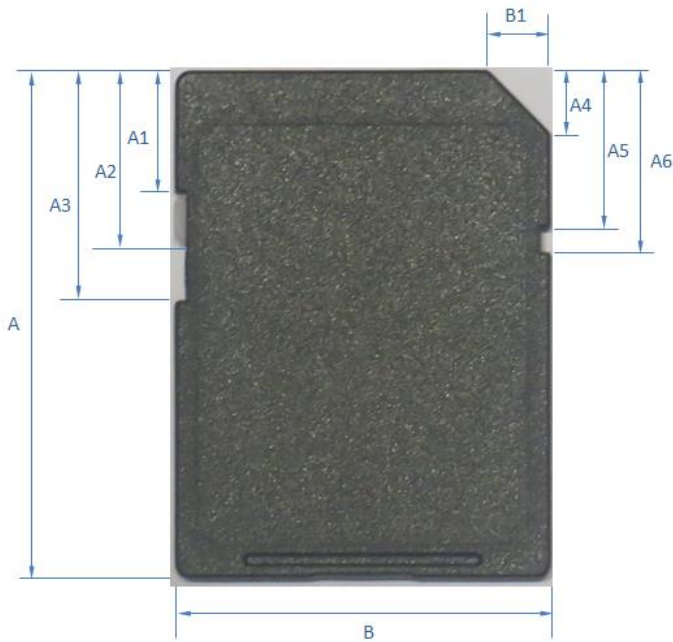
**Table 15: Output Timing of Variable Data Window**

Symbol	Min	Max	Unit	Remark
t <sub>OP</sub>	-	2	UI	Card Output Phase
Δt <sub>OP</sub>	-350	+1550	ps	Delay variation due to temperature change after tuning
t <sub>ODW</sub>	0.60	-	UI	t <sub>ODW</sub> = 2.88ns at 208MHz

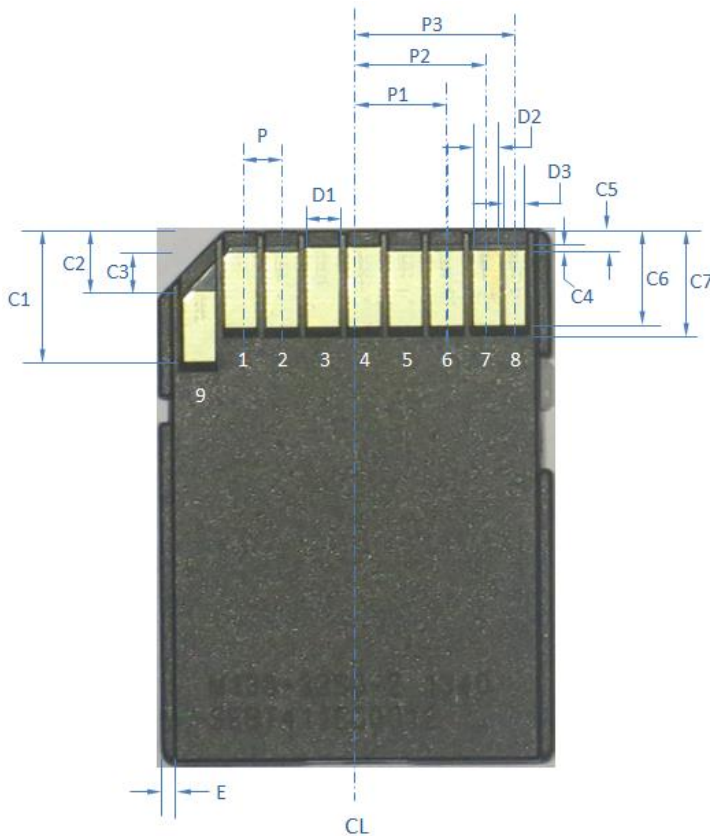


### 5. Mechanical Dimensions

The mechanical dimensions of industrial SD card were basically followed the mechanical form factor definitions on SD-Memory card specifications which constructed by SD card association.

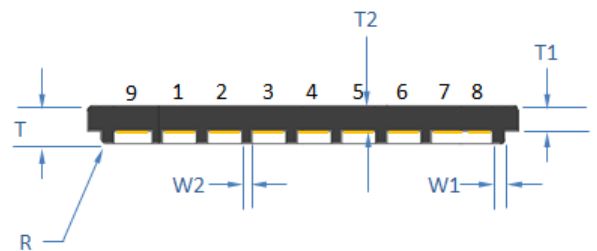


**Figure 13: Top View**



**Figure 14: Bottom View**

Criteria of SD				Unit: mm
Dimensions	Min	TYP	Max	Note
A	31.90	32.00	32.10	
B	23.90	24.00	24.10	
A1	7.65	7.80	7.95	
A2	10.70	10.85	11.00	
A3	14.35	14.50	14.65	
A4	3.85	4.00	4.15	
A5	9.85	10.00	10.15	
A6	11.35	11.50	11.65	
B1	3.85	4.00	4.15	
C1	7.00			
C2			4.00	
C3	2.20	2.30	2.40	
C4	0.20			
C5			1.60	
C6	5.00			
C7	5.95			
D1	1.40			
D2	1.10			
D3	0.90			
E	0.60	0.75	0.90	
P	2.35	2.50	2.65	
P1	5.475	5.625	5.775	
P2	7.90	8.05	8.20	
P3	9.60	9.75	9.90	
T	1.95	2.10	2.25	
T1	1.25	1.40	1.55	
T2	1.30	1.40	1.60	
W1	0.55	0.70	0.85	
W2	0.45	0.60	0.75	
R	0.15	0.30	0.45	



**Figure 15: Side View**

## 6. Ordering Information

Flash Type	Part Number	Capacity
MLC	EHC08GMBWGBECD	8GB
	EHC16GMBWHBECD	16GB
	EHC32GMBWHBECD	32GB
	EXC64GMBWHBECD	64GB
	EXC12GMBWHBECD	128GB
	EXC25GMBWHBECD	256GB
aMLC	EHC04GPBWGBECD	4GB
	EHC08GPBWHBECD	8GB
	EHC16GPBWHBECD	16GB
	EHC32GPBWHBECD	32GB
	EXC64GPBWHBECD	64GB
	EXC12GPBWHBECD	128GB