RoHS Recast Compliant

Industrial MicroSD

R1 Product Specifications

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Version 1.6

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FEATURES:

- **Fully Compatible with SD Card Specifications 3.0, 2.0 and 1.1**
  - Part 1, Physical Layer Specification, Ver 3.00 Final
  - Part 2, File System Specification, Ver 3.00
  - Part 3, Security Specification, Ver 3.00 Final
- **Capacity**
  - SD 2.0: 1, 2 GB
  - SD 3.0: 4, 8 GB
- **Performance***
  - Sustained Read: Up to 34 MB/sec
  - Sustained Write: Up to 28 MB/sec
- **SD-Protocol Compatible**
- **Supports SD SPI Mode**
- **Standard Interface**
  - 8-pins SD interface
- **NAND Flash Type: SLC**
- **Flash Management**
  - Flash bad-block management
  - Built-in advanced ECC algorithms
  - Power management
  - S.M.A.R.T.
  - Wear-leveling algorithms
  - Page mapping
  - Power failure management
- **Temperature Range**
  - Operating temperature: -40°C to 85°C
  - Storage temperature: -40°C to 85°C
- **Operating Voltage: 2.7V ~ 3.6V**
- **Power Consumption***
  - Operating: 115 mA
  - Standby: 265 µA
- **Dimensions:** 15㎜(L) x 11㎜(W) x 1㎜(H)
- **RoHS Recast Compliant (2011/65/EU)**

*Performance values presented here are typical and may vary depending on settings and platforms.

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1. General Description

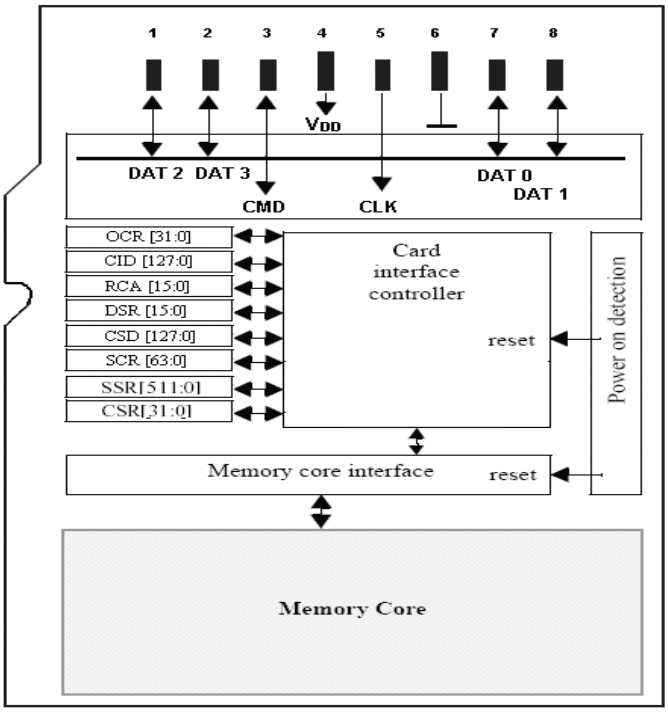
As the demand of reliable and high-performance data storage in a small form factor increases, Apacer's MicroSD card is designed specifically for multiple applications by offering high endurance, reliability, and agility, where extreme flexibility, endurance, data integrity, and exceptionally transmission are required.

The MicroSD card fully complies with SD Card Association standard. The Command List is compatible with [Part 1 Physical Layer Specification Ver3.0 Final] definitions, while the Card Capacity of Non-secure Area, Secure Area supports [Part 3 Security Specification Ver3.0 Final] Specifications. The card allows selection of either SD or SPI mode for compatibility in data communication.

The card also comes with endurance features for data error detection and correction.

1.1 Product Function Block

The MicroSD contains a card controller and a memory core for the SD standard interface.



1.2 Functional Description

The MicroSD device contains a high level, intelligent flash management that provides many capabilities including:

- Flash bad-block management
- ECC algorithms
- Power management
- S.M.A.R.T.
- Wear leveling algorithms
- Power failure management

1.2.1 Flash Management

The SD controller contains logic/physical flash block mapping and bad block management system. It will manage all flash block including user data space and spare block.

The MicroSD also contains a sophisticated defect and error management system. It does a read after write under margin conditions to verify that the data is written correctly (except in the case of write pre-erased sectors). In case that a bit is found to be defective, the SD will replace this bad bit with a spare bit within the sector header. If necessary, the MicroSD will even replace the entire sector with a spare sector. This is completely transparent to the master (host device) and does not consume any user data space.

1.2.2 ECC Algorithms

The powerful ECC algorithms will enhance flash block use rate and whole device life. The SD controller supports up to 68bits ECC circuits to protect data transfer.

1.2.3 Power Management

A power saving feature of the MicroSD is automatic entrance and exit from sleep mode. Upon completion of an operation, the SD will enter the sleep mode to conserve power if no further commands are received within X seconds, where X is programmable by software. The master does not have to take any action for this to occur. The SD is in sleep mode except when the host is accessing it, thus conserving power.

Any command issued by the master to the MicroSD will cause it to exit sleep mode and response to the master.

1.2.4 S.M.A.R.T.

S.M.A.R.T. (SMART), an acronym stands for Self-Monitoring, Analysis and Reporting Technology, is an open standard allowing an individual disk drive in the ATA/IDE or SCSI interface to automatically monitor its own health and report potential problems in order to prevent data loss. This failure warning technology provides predictions from unscheduled downtime by observing and storing critical drive performance and calibration parameters. Ideally, this should allow taking hands-on actions to keep from impending drive failure.

Failures are divided into two categories: those that can be predicted and those that cannot. Predictable failures occur gradually over time, and the decline in performance can be detected; on the other hand, unpredictable failures happen very sudden without any warning. These failures may be caused by power surges or related to electronic components. The purpose of the SMART implementation is to predict near-

term failures of each individual disk drive and generate a warning to prevent unfortunate loss.

1.2.5 Wear Leveling

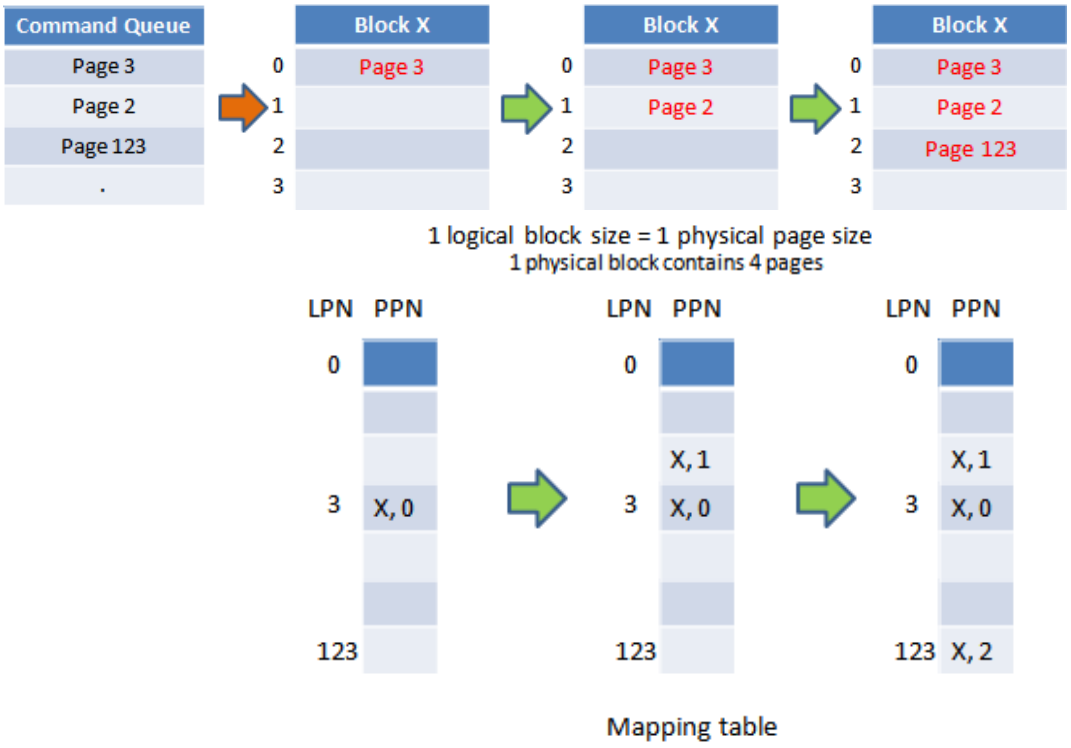
NAND Flash devices can only undergo a limited number of program/erase cycles, and in most cases, the flash media are not used evenly. If some area get updated more frequently than others, the lifetime of the device would be reduced significantly. Thus, Wear Leveling technique is applied to extend the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

Apacer provides 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.

1.2.6 Page Mapping

Page-level mapping uses one page as the unit of mapping. The most important characteristic of page-level mapping is that each logical page can be mapped to any physical page on the flash memory device. This mapping algorithm allows different size of data to be written to a block as if the data is written to a data pool and it does not need to take extra operations to process a write command. The below example shows how page-level mapping performs a write command:

Host instructs three write commands: page 3, 2, and 123. The three pages are written into block X in sequence of command queue. Once all write commands are completed, the mapping table updates itself automatically.



Note: The example only shows the concept of how page-level mapping work and do not necessary happen in an actual case.

This fine-grained page-level mapping scheme makes better capability for handling random data, and increases overall performance and endurance significantly. However, page-level mapping requires SSDs

to incorporate a larger RAM in order to maintain its mapping table.

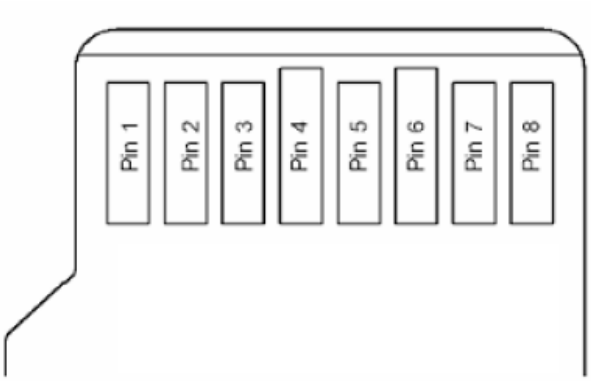
1.2.7 Power Failure Management

Apacer industrial SD and MicroSD cards provide complete data protection mechanism during every abnormal power shutdown situation, such as power failure at programming data, updating system tables, erasing blocks, etc. Apacer Power-Loss Protection mechanism includes:

- Maintaining data correctness and increasing the reliability of the data stored in the NAND Flash memory.
- Protecting F/W table and the data written to flash from data loss in the event of power off.

2. Electrical Characteristics

2.1 Card Architecture



2.2 Pin Assignment

Pin	SD Mode		SPI Mode	
	Name	Description	Name	Description
1	DAT2	Data Line[Bit 2]	RSV	Reserved
2	CD/DAT3 [2]	Card Detect/Data Line[Bit 3]	CS	Chip Select (neg true)
3	CMD	Command/Response	DI	Data In
4	VDD	Supply Voltage	VDD	Supply Voltage
5	CLK	Clock	SCLK	Clock
6	VSS	Supply Voltage Ground	VSS	Supply Voltage Ground
7	DAT0	Data Line[Bit 0]	DO	Data Out
8	DAT1	Data Line[Bit 1]	RSV	Reserved

2.3 Capacity Specifications

The following table shows the specific capacity for the SD card.

Capacity	Total Bytes
1 GB	969,605,120
2 GB	1,938,489,344
4 GB	3,875,504,128
8 GB	7,751,041,024

Note: total bytes are viewed under Windows operating system and were measured by SD format too.

2.4 Performance Specifications

Performances of the SD card are shown in the table below.

Modes \ Capacity	1 GB	2 GB	4 GB	8 GB
Read (MB/s)	23	23	34	33
Write (MB/s)	16	18	28	28

Note: results may vary depending on settings and platforms.

2.5 Electrical Specifications

Operating Voltage

Symbol	Parameter	Min.	Max.	Unit
V_{DD}	Power Supply Voltage	2.7	3.6	V

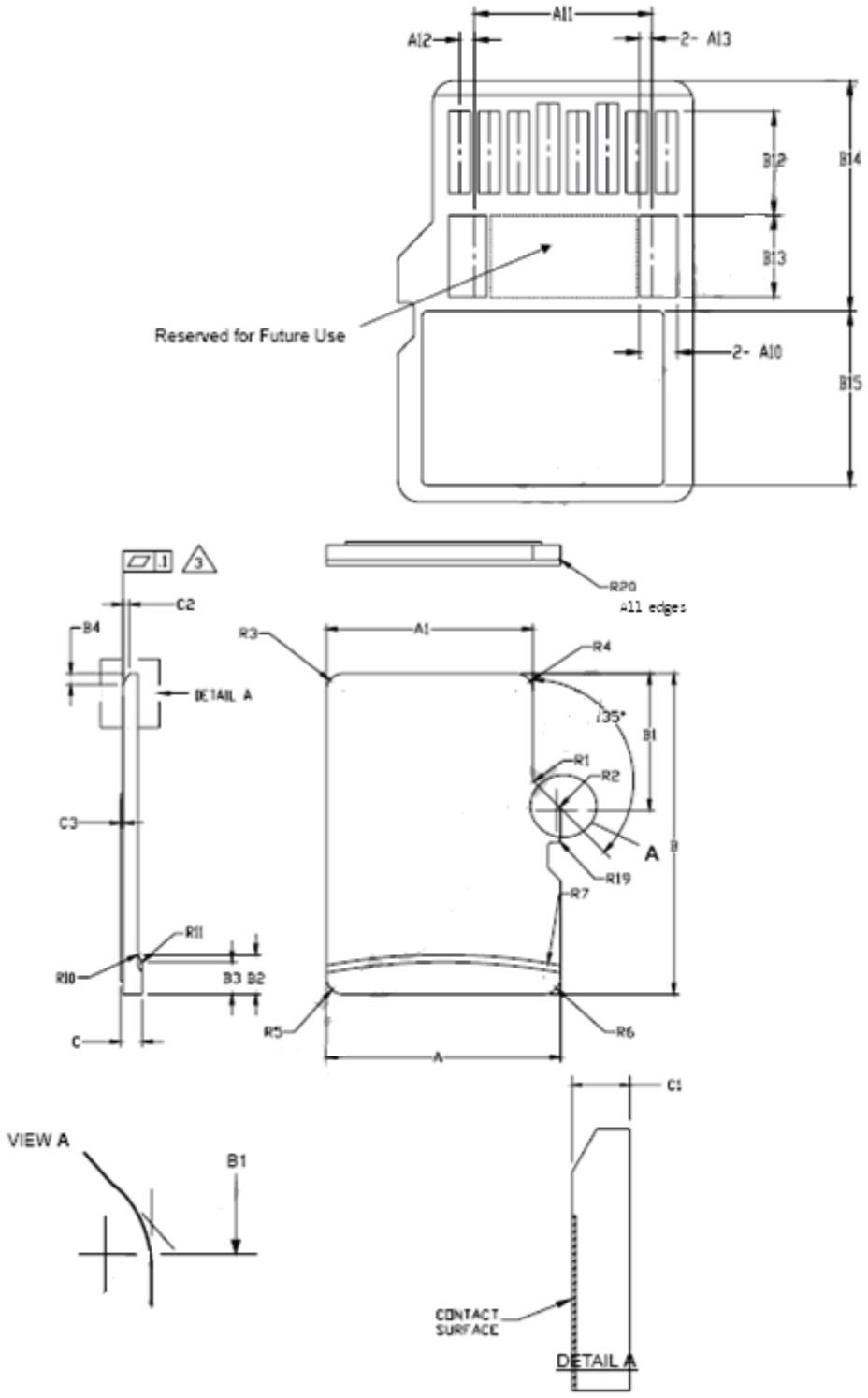
Power Consumption

Modes \ Capacity	1 GB	2 GB	4 GB	8 GB
Operating (mA)	110	110	110	115
Standby (µA)	160	160	260	265

Note: results may vary depending on settings and platforms.

3. Physical Characteristics

3.1 Physical Dimensions



	COMMON DIMENSIONS			
SYMBOL	MIN	NOM	MAX	NOTE
A	10.90	11.00	11.10	
A1	9.60	9.70	9.80	
A2	-	3.85	-	BASIC
A3	7.60	7.70	7.80	
A4	-	1.10	-	BASIC
A5	0.75	0.80	0.85	
A6	-	-	8.50	
A7	0.90	-	-	
A8	0.60	0.70	0.80	
A9	0.80	-	-	
A10	1.35	1.40	1.45	
A11	6.50	6.60	6.70	
A12	0.50	0.55	0.60	
A13	0.40	0.45	0.50	
B	14.90	15.00	15.10	
B1	6.30	6.40	6.50	
B2	1.64	1.84	2.04	
B3	1.30	1.50	1.70	
B4	0.42	0.52	0.62	
B5	2.80	2.90	3.00	
B6	5.50	-	-	
B7	0.20	0.30	0.40	
B8	1.00	1.10	1.20	
B9	-	-	9.00	
B10	7.80	7.90	8.00	
B11	1.10	1.20	1.30	
B12	3.60	3.70	3.80	
B13	2.80	2.90	3.00	
B14	8.20	-	-	
B15	-	-	6.20	
C	0.90	1.00	1.10	
C1	0.60	0.70	0.80	
C2	0.20	0.30	0.40	
C3	0.00	-	0.15	
D1	1.00	-	-	
D2	1.00	-	-	
D3	1.00	-	-	
R1	0.20	0.40	0.60	
R2	0.20	0.40	0.60	
R3	0.70	0.80	0.90	
R4	0.70	0.80	0.90	
R5	0.70	0.80	0.90	
R6	0.70	0.80	0.90	
R7	29.50	30.00	30.50	
R10	-	0.20	-	
R11	-	0.20	-	
R17	0.10	0.20	0.30	
R18	0.20	0.40	0.60	
R19	0.05	-	0.20	
R20	0.02	-	0.15	

Notes:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.

2. DIMENSIONS ARE IN MILLIMETERS.

3. COPLANARITY IS ADDITIVE TO C1 MAX THICKNESS.

3.2 Environmental Specifications

3.2.1 Climatic Testing

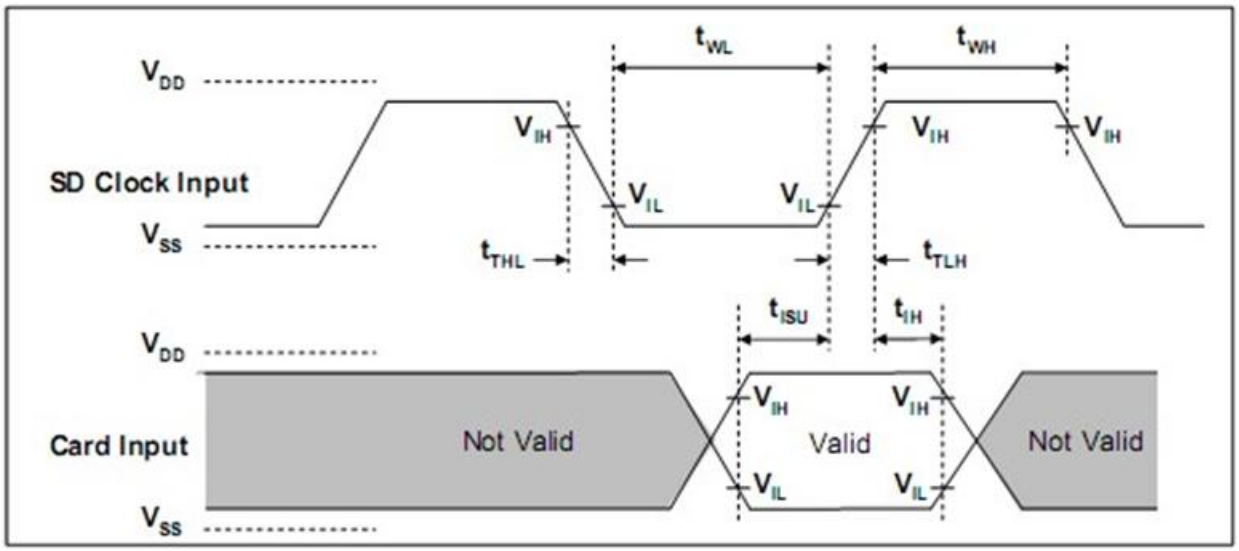
Test Item	DUT State	Test Condition	
		Temperature	Duration
High Temperature	Storage	85℃	500 Hours
Low Temperature	Storage	-40℃	500 Hours
Temperature Cycling	Storage	-40℃ ~ 85℃ 30min hold each	50 Cycles

3.2.2 Durability Testing

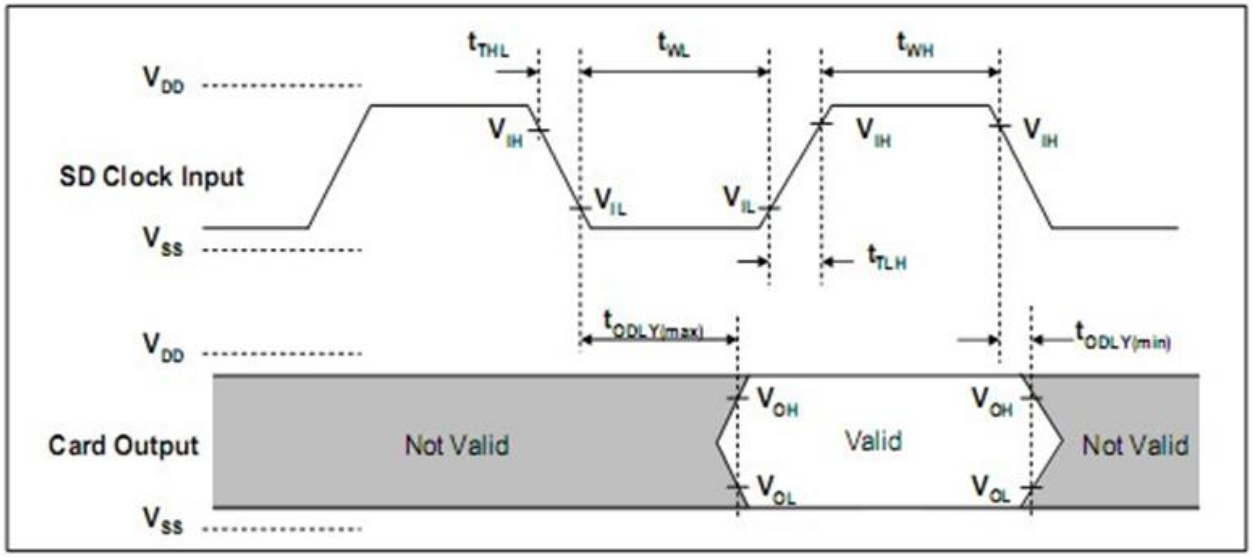
Test Item	Descriptions
Insertion/Removal	10,000 cycles
Bending	10nt/5 times for 6 faces and 4 corners (each drop was performed 3 times, total of 30 drops)
Electrostatic Discharge	Contact discharge: HCP & VCP Air discharge: ALL – VSS (±), ALL – VCC (±), VCC – VSS (±), ALL – ALL (±)
Ultraviolet Radiation	Units are non-operating. UVB bandwidth：313 nm. Test irradiation：0.63 w/m²/nm. Radiation cycle：Radiation on for 4 hours at temperature 60°C, then radiation off for 4 hours at temperature 60°C. Number of cycle：6 cycles. Duration of test：48 hours
Drop	1.5 m free fall, 10 times
Salt Water Spray	3+/-1%NaCl; 35℃; 24hrs
Torque	0.1 N-m or ± 2.5 degree 5 time; 30 sec/direction

4. AC Characteristics

4.1 MicroSD Interface Timing (Default)



Card input Timing (Default Speed Card)

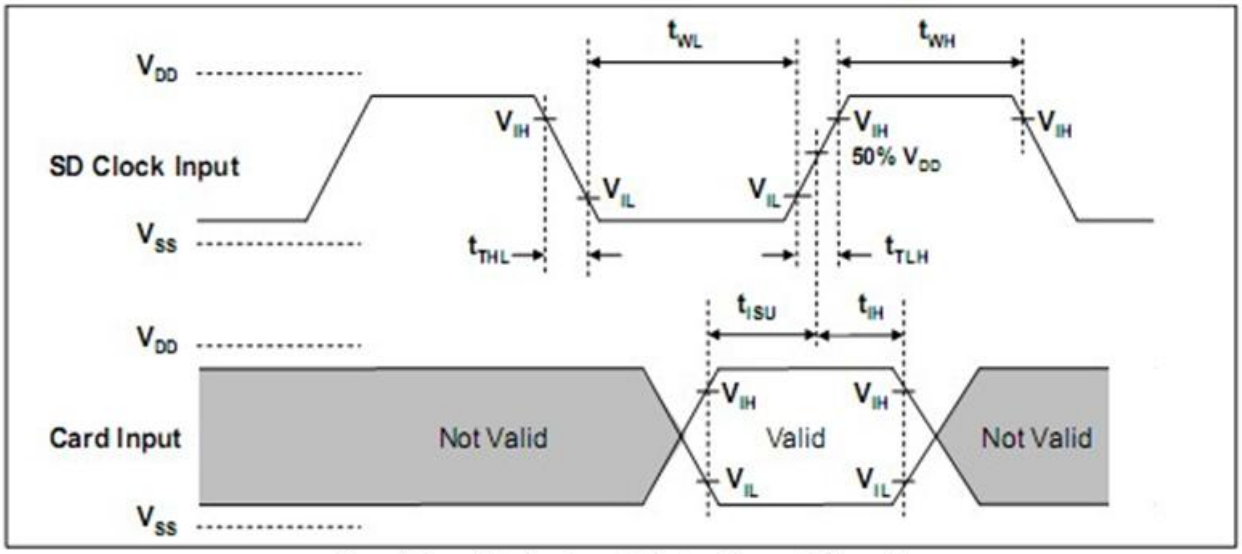


Card Output Timing (Default Speed Mode)

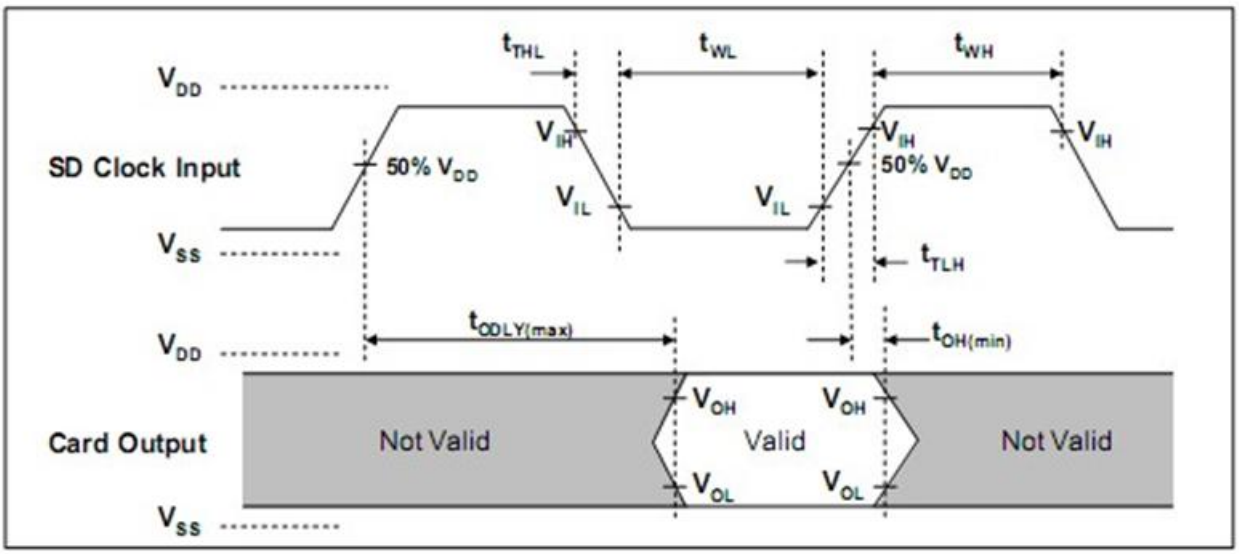
SYMBOL	PARAMETER	MIN	MAX	UNIT	REMARK
Clock CLK (All values are referred to min(V_{IH}) and max(V_{IL}))					
f_{PP}	Clock frequency data transfer	0	25	MHz	C_{card} ≤ 10 pF (1 card)
f_{OD}	Clock frequency identification	0[(1)]/100	400	KHz	C_{card} ≤ 10 pF (1 card)
t_{WL}	Clock low time	10	-	ns	C_{card} ≤ 10 pF (1 card)
t_{WH}	Clock high time	10	-	ns	C_{card} ≤ 10 pF (1 card)
t_{TLH}	Clock rise time	-	10	ns	C_{card} ≤ 10 pF (1 card)
t_{THL}	Clock fall time	-	10	ns	C_{card} ≤ 10 pF (1 card)
Inputs CMD, DAT (Referenced to CLK)					
t_{ISU}	Input setup time	5	-	ns	C_{card} ≤ 10 pF (1 card)
t_{TH}	Input hold time	5	-	ns	C_{card} ≤ 10 pF (1 card)
Outputs CMD, DAT (Referenced to CLK)					
t_{ODLY}	Output delay time during data transfer mode	0	14	ns	C_L ≤ 40 pF (1 card)
t_{OH}	Output hold time	0	50	ns	C_L ≤ 40 pF (1 card)

(1)0Hz means to stop the clock. The given minimum frequency range is for cases that require the clock to be continued.

4.2 MicroSD Interface Timing (High Speed Mode)



Card Input Timing (High Speed Card)



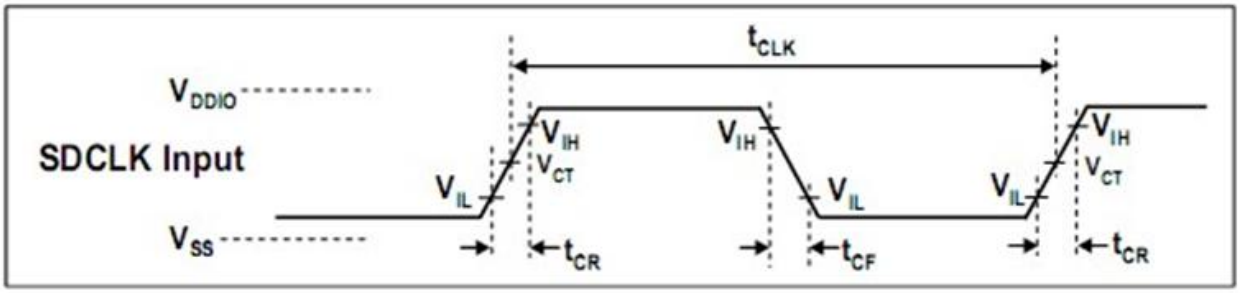
Card Output Timing (High Speed Mode)

SYMBOL	PARAMETER	MIN	MAX	UNIT	REMARK
Clock CLK (All values are referred to min(V_{IH}) and max(V_{IL}))					
f_{PP}	Clock frequency data transfer	0	50	MHz	Ccard ≤ 10 pF (1 card)
t_{WL}	Clock low time	7	-	ns	Ccard ≤ 10 pF (1 card)
t_{WH}	Clock high time	7	-	ns	Ccard ≤ 10 pF (1 card)
t_{TLH}	Clock rise time	-	3	ns	Ccard ≤ 10 pF (1 card)
t_{THL}	Clock fall time	-	3	ns	Ccard ≤ 10 pF (1 card)
Inputs CMD, DAT (Referenced to CLK)					
t_{ISU}	Input setup time	6	-	ns	Ccard ≤ 10 pF (1 card)
t_{TH}	Input hold time	2	-	ns	Ccard ≤ 10 pF (1 card)
Outputs CMD, DAT (Referenced to CLK)					
t_{ODLY}	Output delay time during data transfer made	-	14	ns	CL ≤ 40 pF (1 card)
t_{OH}	Output hold time	2.5	-	ns	CL ≥ 15 pF (1 card)
C_L	Total system capacitance for each line*	-	40	pF	1 card

*In order to satisfy severe timing, host shall run on only one card

4.3 MicroSD Interface Timing (SDR12, SDR25, SDR50 and SDR104 Modes) Input

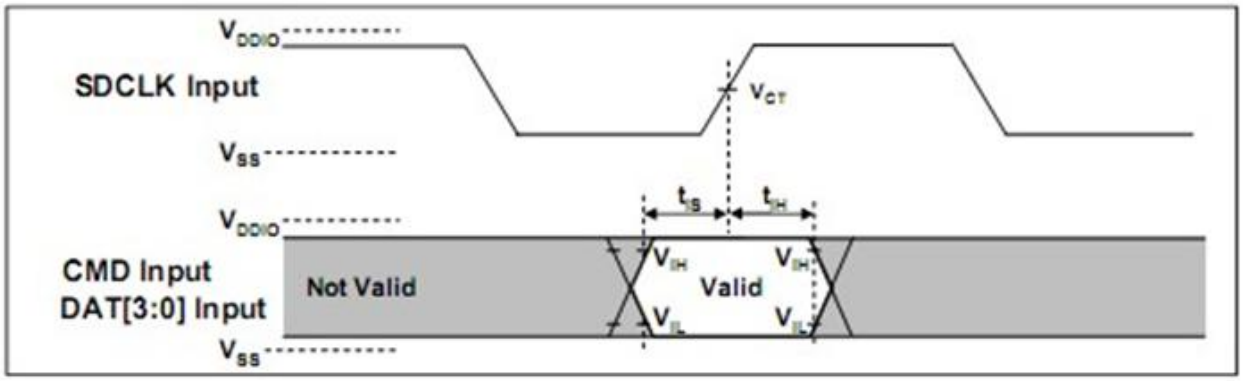
4.3.1 Clock Timing



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	%	

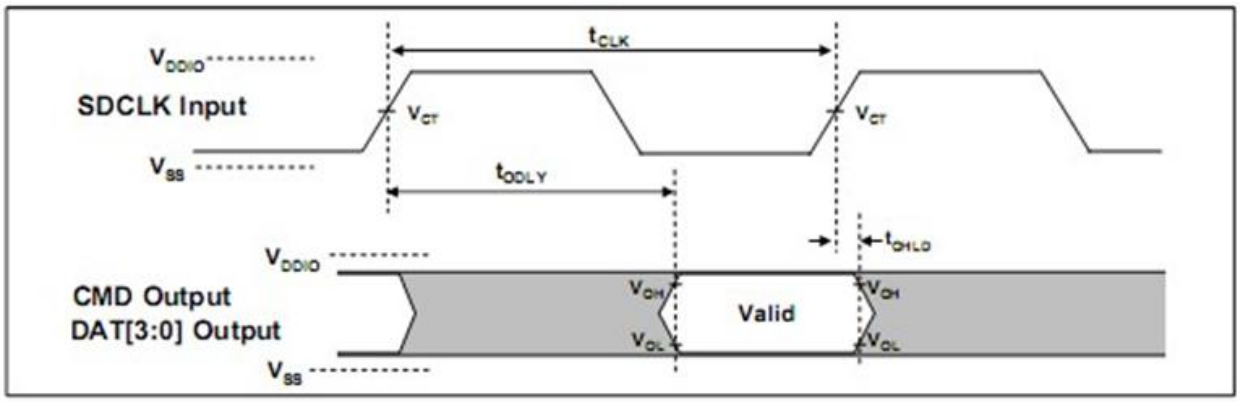
4.3.2 Card Input Timing



Card 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

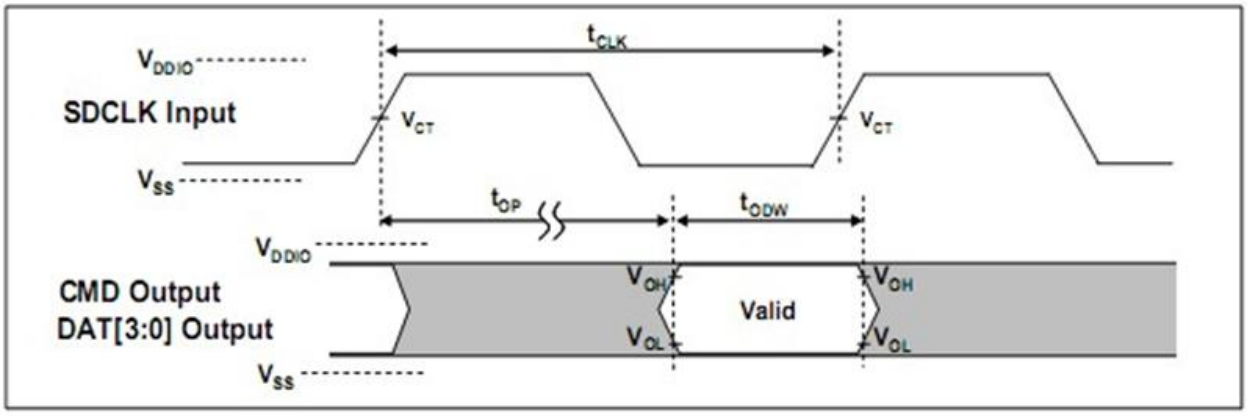
4.3.3 Card Output Timing of Fixed Data Window (SDR12, SDR25 and SDR50)



Output Timing of Fixed Date Window

SYMBOL	MIN	MAX	UNIT	REMARK
t_{ODLY}	-	7.5	ns	t_{CLK} ≥10.0ns, CL=30pF, using driver Type B, for SDR50.
t_{ODLY}		14	ns	t_{CLK} ≥20.0ns, CL=40pF, using driver Type B, for SDR25 and SDR12.
t_{OH}	1.5	-	ns	Hold time at the t_{ODLY} (min.). CL=15pF

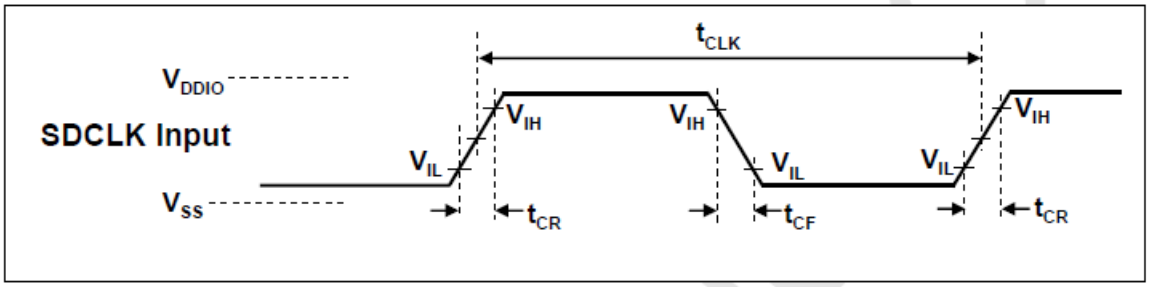
4.3.4 Output Timing of Variable Window (SDR104)



Output Timing of Variable Data Window

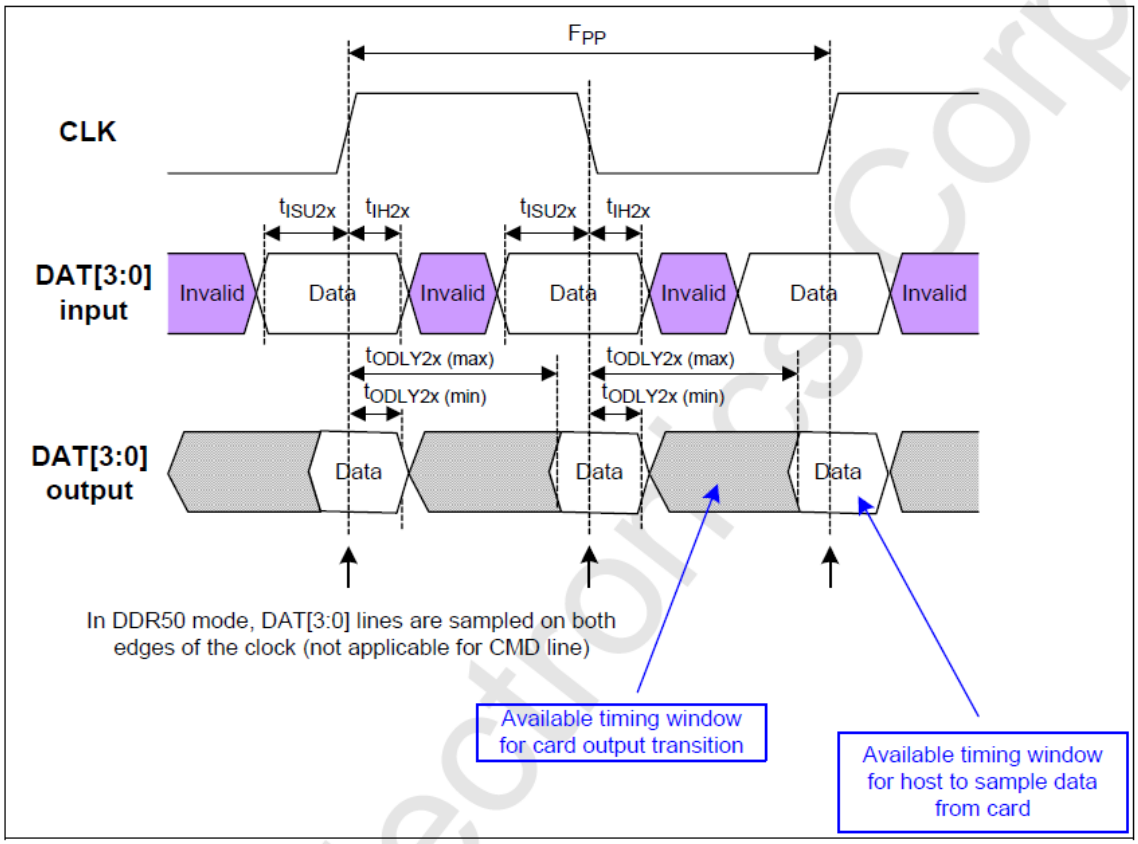
SYMBOL	MIN	MAX	UNIT	REMARK
t_{OP}	-	2	UI	Card Output Phase
Δt_{OP}	-350	+1550	ps	Delay variation due to temperature change after tuning
t_{ODW}	0.60	-	UI	t_{ODW} = 2.88ns at 208MHz

4.3.5 SD Interface Timing (DDR50 Mode)



Clock Signal Timing

SYMBOL	MIN	MAX	UNIT	REMARK
t_{CLK}	20	-	ns	50MHz (Max.), Between rising edge
t_{CR}, t_{CF}	-	0.2* t_{CLK}	ns	t_{CR}, t_{CF} < 4.00ns (max.) at 50MHz, CCARD=10pF
Clock Duty	45	55	%	



Timing Diagram DAT Inputs/Outputs Referenced to CLK in DDR50 Mode

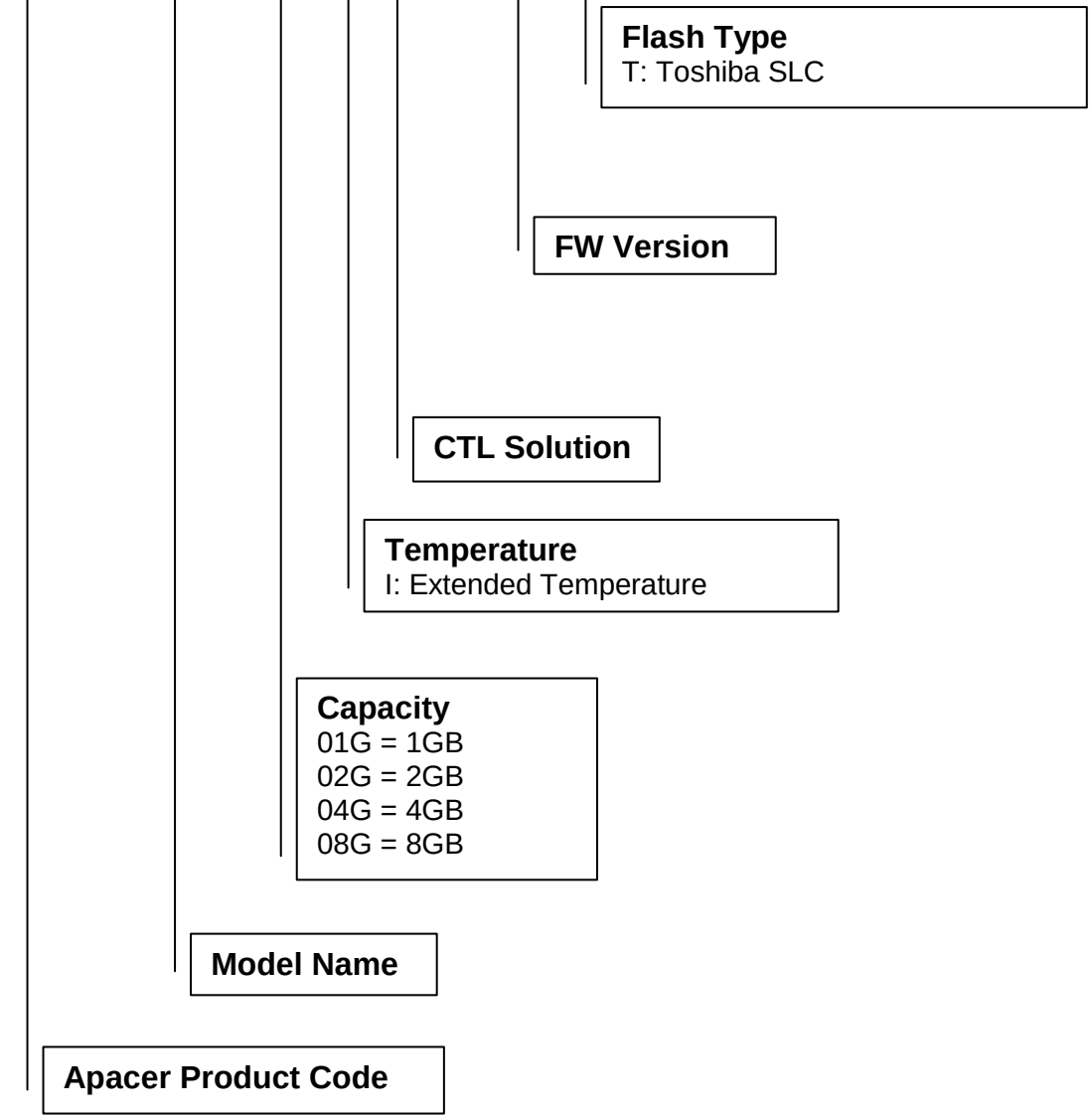
4.3.6 Bus Timings – Parameters Values (DDR50 Mode)

Symbol	Parameters	Min	Max	Unit	Remark
Input CMD (referenced to CLK rising edge)					
t_{ISU}	Input set-up time	6	-	ns	C_{card}≤ 10 pF (1 card)
t_{IH}	Input hold time	0.8	-	ns	C_{card}≤ 10 pF (1 card)
Output CMD (referenced to CLK rising edge)					
t_{ODLY}	Output Delay time during Data Transfer Mode	-	13.7	ns	C_L≤30 pF (1 card)
T_{OH}	Output Hold time	1.5	-	ns	C_L≥15 pF (1 card)
Inputs DAT (referenced to CLK rising and falling edges)					
t_{ISU2x}	Input set-up time	3	-	ns	C_{card}≤ 10 pF (1 card)
t_{IH2x}	Input hold time	0.8	-	ns	C_{card}≤ 10 pF (1 card)
Outputs DAT (referenced to CLK rising and falling edges)					
t_{ODLY2x}	Output Delay time during Data Transfer Mode	-	7.0	ns	C_L≤25 pF (1 card)
T_{OH2x}	Output Hold time	1.5	-	ns	C_L≥15 pF (1 card)

5. Product Ordering Information

5.1 Product Code Designations

AP – MSD xxG I E – AA T



5.2 Valid Combinations

Capacity	AP/N
1GB	AP-MSD01GIE-AAT
2GB	AP-MSD02GIE-AAT
4GB	AP-MSD04GIE-AAT
8GB	AP-MSD08GIE-AAT

Note: Valid combinations are those products in mass production or will be in mass production. Consult your Apacer sales representative to confirm availability of valid combinations and to determine availability of new combinations.

Revision History

Revision	Description	Date
1.0	Official release	12/22/2015
1.1	- Added S.M.A.R.T. chapter - Revised product ordering information	1/13/2016
1.2	Specified supported capacity for SD 2.0 and SD 3.0 respectively	1/18/2016
1.3	Removed S.M.A.R.T. chapter	2/1/2016
1.4	Added support for page mapping	6/7/2016
1.5	Added Power Failure Management to Features and General Description	10/3/2016
1.6	Removed “The data written at the exact moment power off will be lost, and the max data loss is 16 sectors.” from 1.2.7 Power Failure Management	10/7/2016

Global Presence

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