

***RoHS Recast Compliant***

# **Industrial MicroSD 3.0**

***MicroSDHC Product Specifications (Toshiba 15nm)***

**October 27, 2016**

***Version 1.9***



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## **FEATURES:**

- **Fully Compatible with SD Card Association Specifications**
  - Part 1, Physical Layer Specification, Ver 3.01 Final
  - Part 2, File System Specification, Ver 3.00
  - Part 3, Security Specification, Ver 3.00 Final
- **Capacity Range**
  - 4, 8, 16, 32, 64 GB
- **Performance\***
  - Sustained Read: Up to 44 MB/sec
  - Sustained Write: Up to 36 MB/sec
- **Bus Speed Mode:** Support Class 10 with UHS-I
- **SD-Protocol Compatible**
- **Supports SD SPI Mode**
- **Backward Compatible with 2.0**
- **NAND Flash Type: MLC**
- **Write Protect**
- **Flash Management**
  - Built-in advanced ECC algorithm
  - Wear-leveling
  - Flash bad-block management
  - SMART
  - Power failure management
- **Temperature Range**
  - Operating temperature:
    - Standard: -25°C ~ 85°C
    - Extended: -40°C ~ 85°C
  - Storage temperature: -40°C ~ 85°C
- **Operating Voltage: 2.7V ~ 3.6V**
- **Power Consumption\***
  - Operating: 135 mA
  - Standby: 250 µA
- **Physical Dimensions :**  
15mm (L) x 11mm (W) x 1mm (H)
- **RoHS Recast Compliant**

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

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# 1. General Description

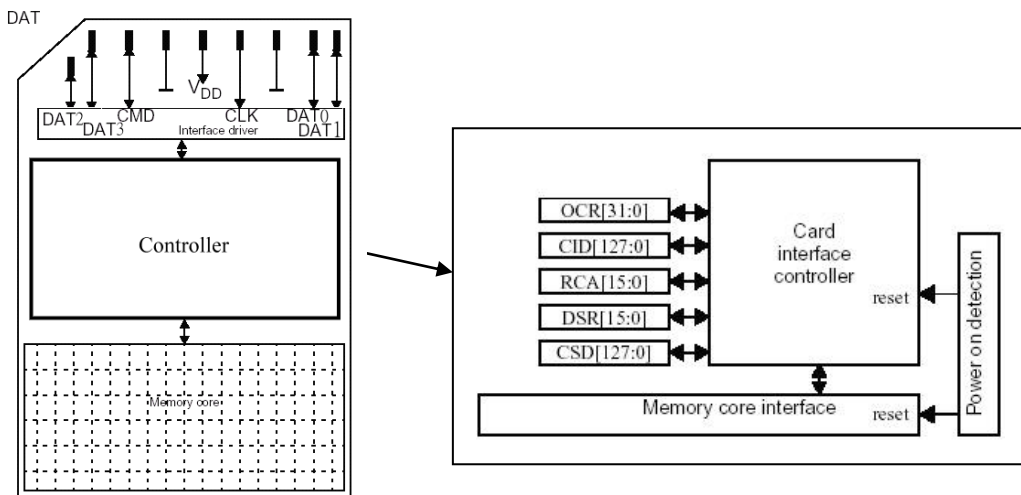
The Micro Secure Digital (MicroSD) card version 3.0 is fully compliant to the specification released by SD Card Association. The Command List supports [Part 1 Physical Layer Specification Ver3.01 Final] definitions. Card Capacity of Non-secure Area, Secure Area Supports [Part 3 Security Specification Ver3.00 Final] Specifications.

The MicroSD 3.0 card comes with 8-pin interface, designed to operate at optimal performance. It can alternate communication protocol between the SD mode and SPI mode. It performs data error detection and correction with very low power consumption.

Apacer Industrial Micro Secure Digital 3.0 card is ideal for its high performance, good reliability and wide compatibility. Not to mention that it's well adapted for hand-held applications in semi-industrial/medical markets already. The new MicroSD 3.0 card is capable of delivering better performance and P/E cycles.

## 1.1 Product Function Block

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



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## **1.2 Flash Management**

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### **1.2.1 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”. Apacer 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.

### **1.2.2 Powerful ECC Algorithms**

Flash memory cells will deteriorate with use, which might generate random bit errors in the stored data. Thus, the MicroSD card 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.

### **1.2.3 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 writes and erase cycles across the media.

Apacer 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.

### **1.2.4 S.M.A.R.T.**

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is a special function that allows a memory device to automatically monitor its health. Apacer provides a program named SmartInfo Tool to observe Apacer’s SD and MicroSD cards. Note that this tool can only support Apacer’s industrial SD and MicroSD cards. This tool will display firmware version, endurance life ratio, good block ratio, and so forth.

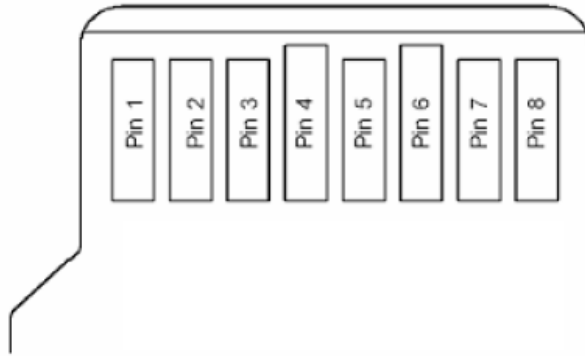
### **1.2.5 Power Failure Management**

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

Table 2-1 Pin Descriptions

Pin	SD Mode		SPI Mode	
	Name	Description	Name	Description
1	DAT2	Data line[bit 2]	Reserved	
2	CD/DAT3	Card Detect/Data line [bit 3]	CS	Chip select
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]	Reserved	

## 2.3 Capacity Specifications

The following table shows the specific capacity for the SD 3.0 card.

**Table 2-2 Capacity**

Capacity	Total Bytes
4 GB	3,971,973,120
8 GB	7,960,756,224
16 GB	16,013,819,904
32 GB	32,098,975,744
64 GB	64,189,235,200

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

## 2.4 Performance

Performances of the SD 3.0 card are shown in the table below.

**Table 2-3 Performance**

Modes \ Capacity	4 GB	8 GB	16 GB	32 GB	64 GB
Read (MB/s)	43	43	43	43	44
Write (MB/s)	14	26	36	34	22

Note: Results may vary depending on settings and platforms.

## 2.5 Electrical

**Table 2-4 Operating Voltages**

Symbol	Parameter	Min.	Max.	Unit
V <sub>DD</sub>	Power Supply Voltage	2.7	3.6	V

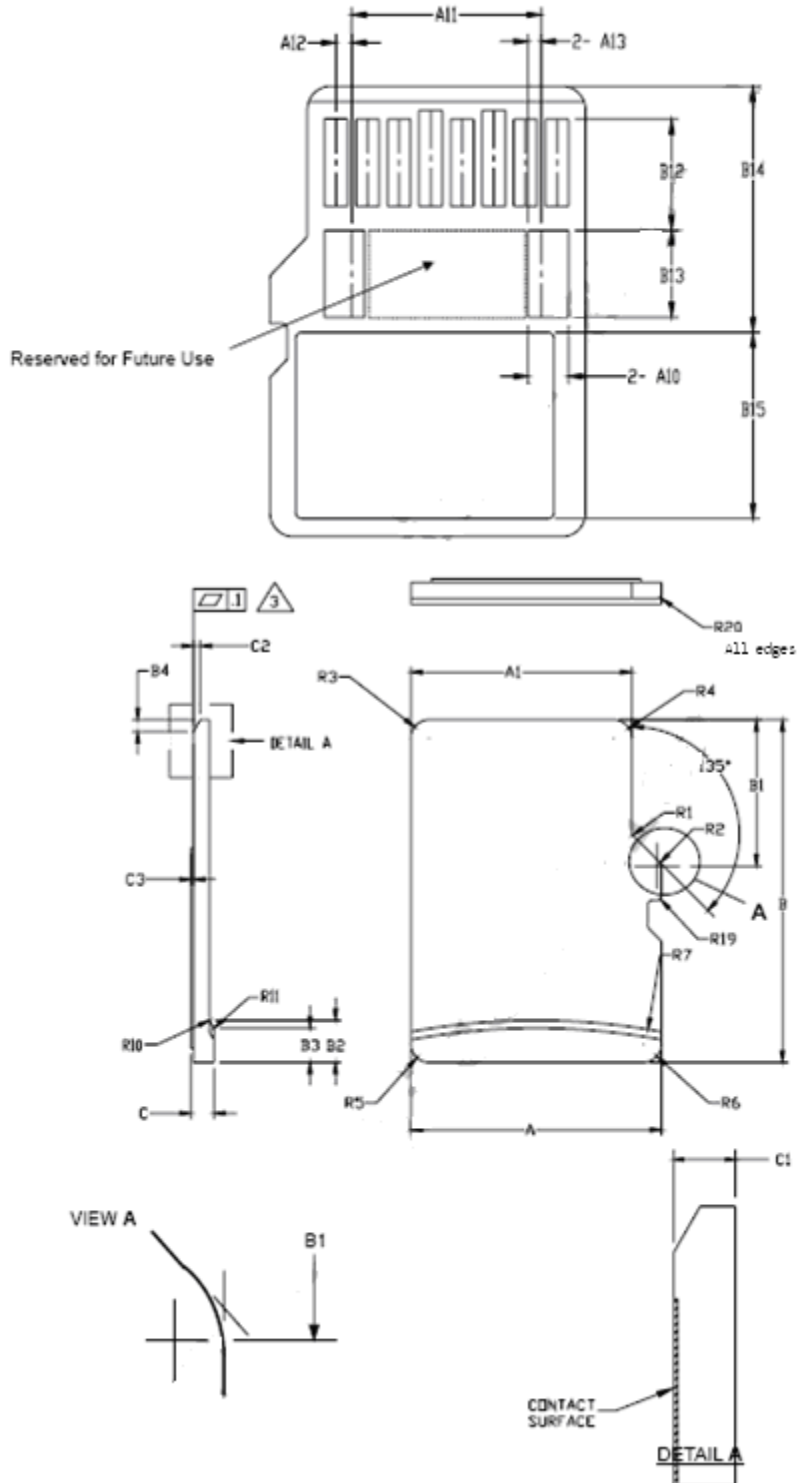
**Table 2-5 Power Consumption**

Modes \ Capacity	4 GB	8 GB	16 GB	32 GB	64 GB
Operating (mA)	60	75	100	130	135
Standby (µA)	175	200	210	240	250

Note: Results may vary depending on settings and platforms.

### 3. Physical Characteristics


#### 3.1 Physical Dimensions



# Industrial MicroSD 3.0 AP-MSDxxGXA-1XTM

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.

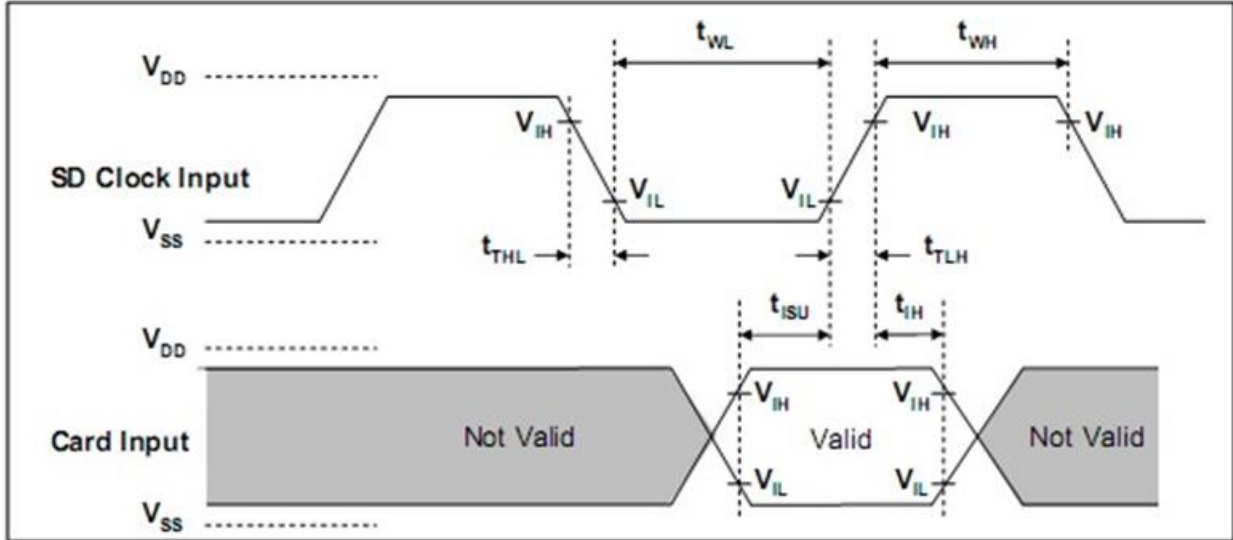
## 3.2 Durability Specifications

**Table 3-1 Durability Specifications**

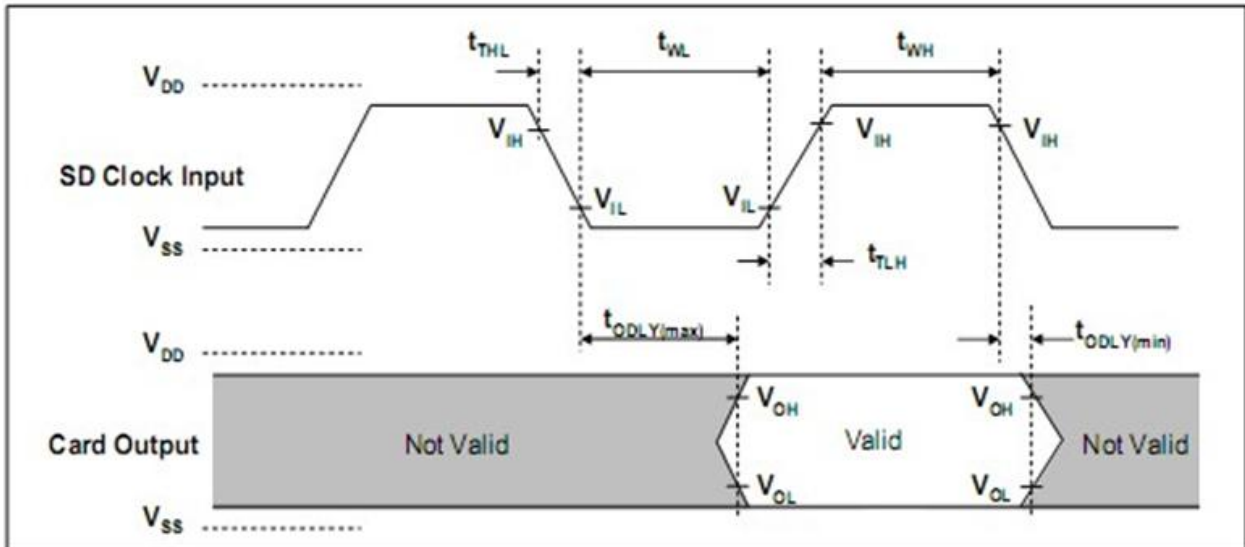
<b>Item</b>	<b>Specifications</b>
Temperature	-25°C to 85°C (Operating) -40°C to 85°C (Extended)
	-40°C to 85°C (Storage)
Shock	1,500G, 0.5ms
Vibration	20Hz~80Hz/1.52mm (frequency/displacement) 80Hz~2000Hz/20G (frequency/displacement) X, Y, Z axis/60mins each
Drop	150cm free fall, 6 face of each
Bending	≥ 10N, hold 1min/5times
Torque	0.1N-m or 2.5deg, hold 5min/5times
Salt spray	Concentration: 3% NaCl at 35°C (storage for 24 hours)
Waterproof	JIS IPX7 compliance Water temperature 25°C Water depth: the lowest point of unit is locating 1000mm below surface (storage for 30 mins)
X-Ray Exposure	0.1 Gy of medium-energy radiation (70 KeV to 140 KeV, cumulative dose per year) to both sides of the card (storage for 30 mins)
Durability	10,000 times mating cycle
ESD	Pass

## 4. AC Characteristics

### 4.1 MicroSD Interface Timing (Default)



Card input Timing (Default Speed Card)

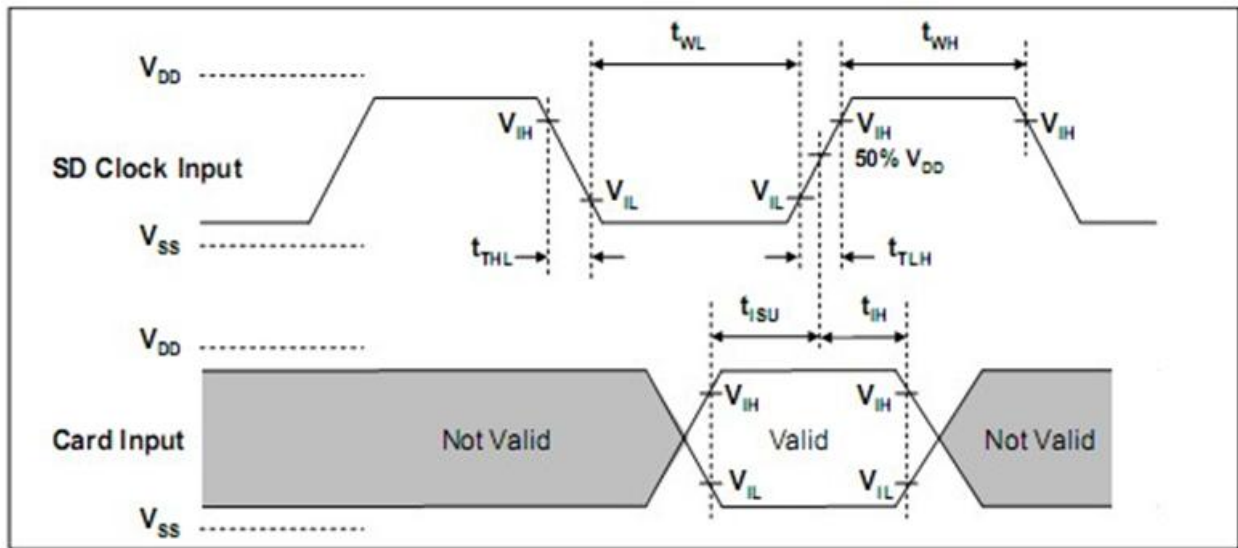


Card Output Timing (Default Speed Mode)

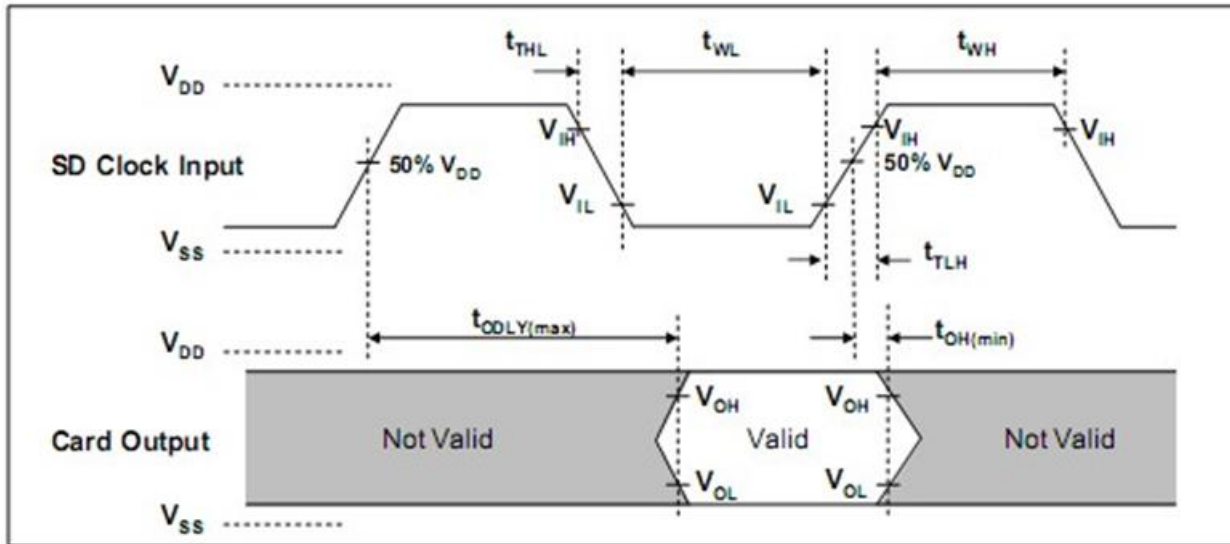
SYMBOL	PARAMETER	MIN	MAX	UNIT	REMARK
<b>Clock CLK (All values are referred to min(V<sub>IH</sub>) and max(V<sub>IL</sub>))</b>					
f <sub>PP</sub>	Clock frequency data transfer	0	25	MHz	C <sub>card</sub> ≤ 10 pF (1 card)
f <sub>OD</sub>	Clock frequency identification	0 <sup>(1)</sup> /100	400	KHz	C <sub>card</sub> ≤ 10 pF (1 card)
t <sub>WL</sub>	Clock low time	10	-	ns	C <sub>card</sub> ≤ 10 pF (1 card)
t <sub>WH</sub>	Clock high time	10	-	ns	C <sub>card</sub> ≤ 10 pF (1 card)
t <sub>TLH</sub>	Clock rise time	-	10	ns	C <sub>card</sub> ≤ 10 pF (1 card)
t <sub>THL</sub>	Clock fall time	-	10	ns	C <sub>card</sub> ≤ 10 pF (1 card)
<b>Inputs CMD, DAT (Referenced to CLK)</b>					
t <sub>ISU</sub>	Input setup time	5	-	ns	C <sub>card</sub> ≤ 10 pF (1 card)
t <sub>IH</sub>	Input hold time	5	-	ns	C <sub>card</sub> ≤ 10 pF (1 card)
<b>Outputs CMD, DAT (Referenced to CLK)</b>					
t <sub>ODLY</sub>	Output delay time during data transfer mode	0	14	ns	C <sub>L</sub> ≤ 40 pF (1 card)
t <sub>OH</sub>	Output hold time	0	50	ns	C <sub>L</sub> ≤ 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)**



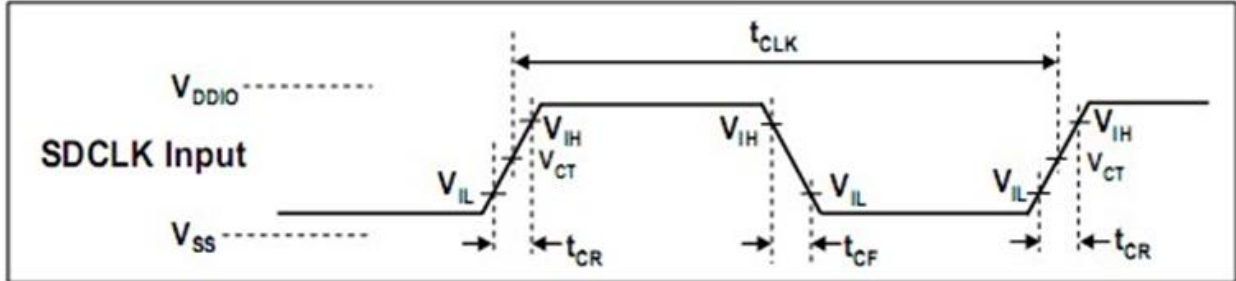
Card Output Timing (High Speed Mode)

SYMBOL	PARAMETER	MIN	MAX	UNIT	REMARK
<b>Clock CLK (All values are referred to min(<math>V_{IH}</math>) and max(<math>V_{IL}</math>))</b>					
$f_{PP}$	Clock frequency data transfer	0	50	MHz	$C_{card} \leq 10 \text{ pF}$ (1 card)
$t_{WL}$	Clock low time	7	-	ns	$C_{card} \leq 10 \text{ pF}$ (1 card)
$t_{WH}$	Clock high time	7	-	ns	$C_{card} \leq 10 \text{ pF}$ (1 card)
$t_{TLH}$	Clock rise time	-	3	ns	$C_{card} \leq 10 \text{ pF}$ (1 card)
$t_{THL}$	Clock fall time	-	3	ns	$C_{card} \leq 10 \text{ pF}$ (1 card)
<b>Inputs CMD, DAT (Referenced to CLK)</b>					
$t_{ISU}$	Input setup time	6	-	ns	$C_{card} \leq 10 \text{ pF}$ (1 card)
$t_{TH}$	Input hold time	2	-	ns	$C_{card} \leq 10 \text{ pF}$ (1 card)
<b>Outputs CMD, DAT (Referenced to CLK)</b>					
$t_{ODLY}$	Output delay time during data transfer made	-	14	ns	$CL \leq 40 \text{ pF}$ (1 card)
$t_{OH}$	Output hold time	2.5	-	ns	$CL \geq 15 \text{ pF}$ (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)

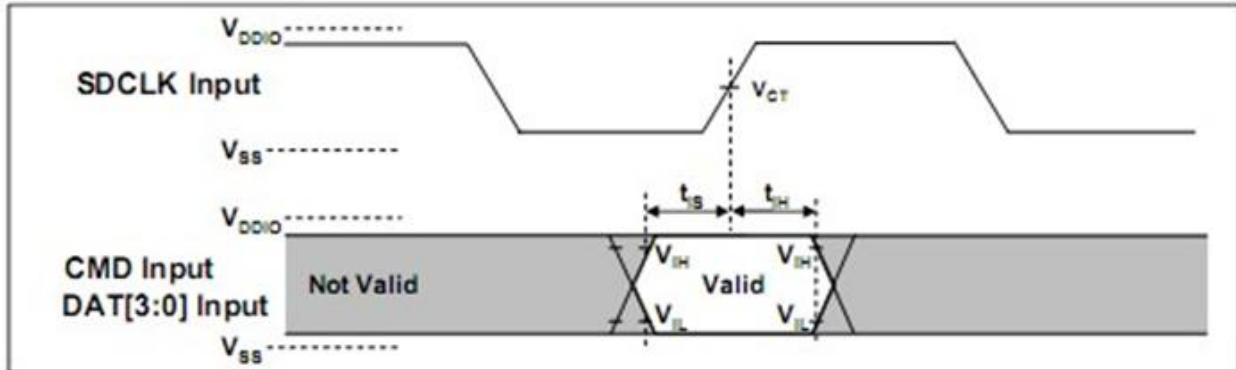
#### 4.3.1 Clock Timing



**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	%	

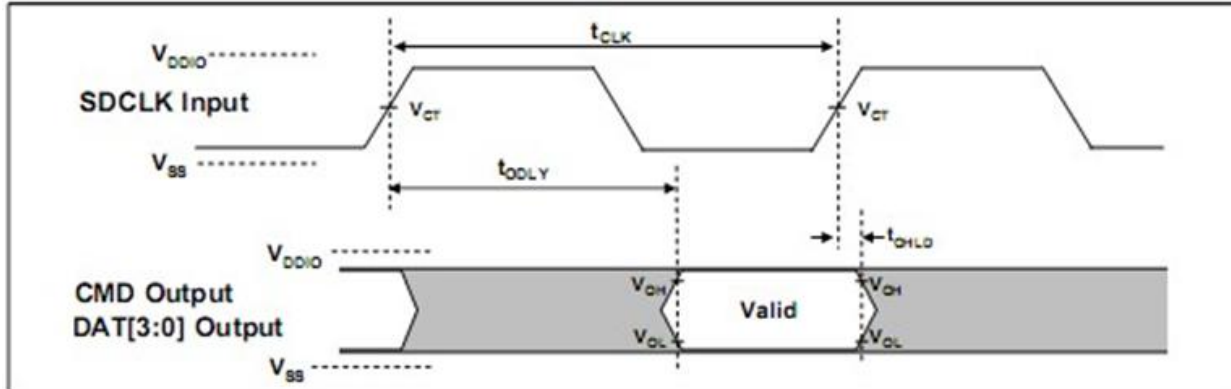
#### 4.3.2 Card Input Timing



**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	$C_{CARD} = 5pF, V_{CT} = 0.975V$

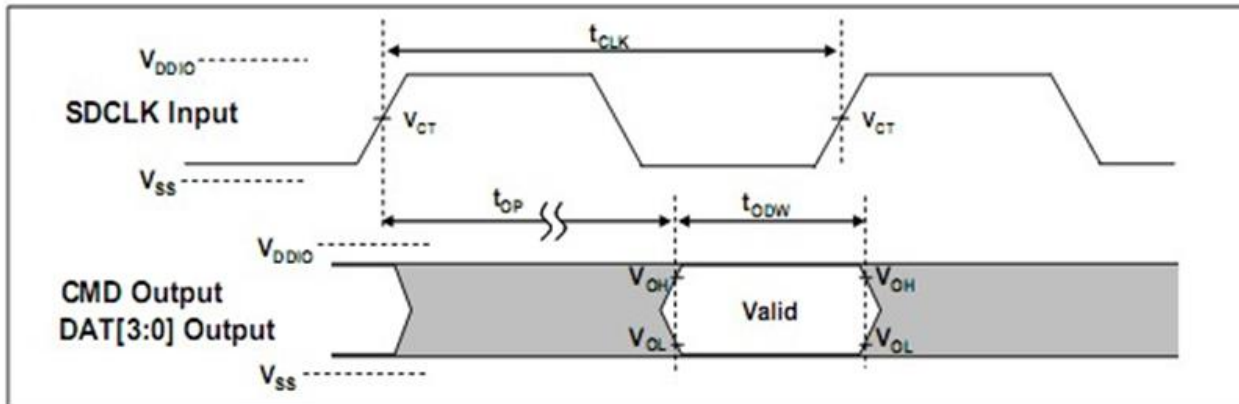
### 4.3.3 Card Output Timing of Fixed Data Window (SDR12, SDR25 and SDR50)



Output Timing of Fixed Date Window

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

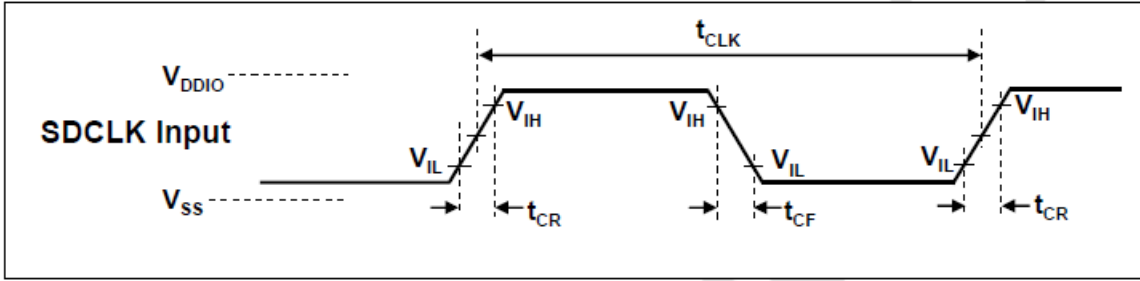
### 4.3.4 Output Timing of Variable Window (SDR104)



Output Timing of Variable Data Window

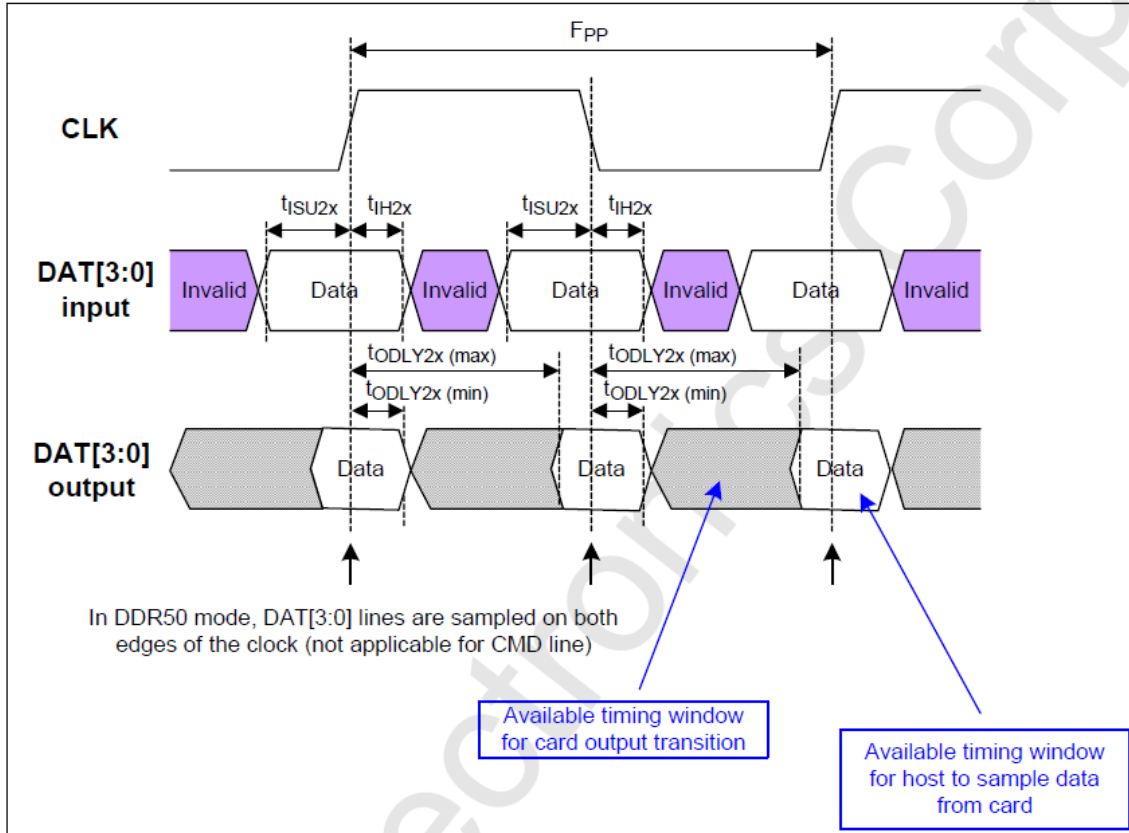
SYMBOL	MIN	MAX	UNIT	REMARK
$t_{OP}$	-	2	UI	Card Output Phase
$\Delta t_{OP}$	-350	+1550	ps	Delay variation due to temperature change after tuning
$t_{ODW}$	0.60	-	UI	$t_{ODW} = 2.88ns$ at 208MHz

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

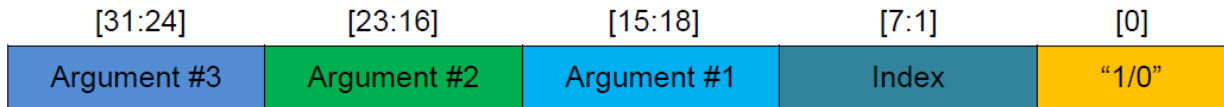
### 4.3.6 Bus Timings – Parameters Values (DDR50 Mode)

Symbol	Parameters	Min	Max	Unit	Remark
<b>Input CMD</b> (referenced to CLK rising edge)					
t <sub>ISU</sub>	Input set-up time	6	-	ns	C <sub>card</sub> ≤ 10 pF (1 card)
t <sub>IH</sub>	Input hold time	0.8	-	ns	C <sub>card</sub> ≤ 10 pF (1 card)
<b>Output CMD</b> (referenced to CLK rising edge)					
t <sub>ODLY</sub>	Output Delay time during Data Transfer Mode	-	13.7	ns	C <sub>L</sub> ≤ 30 pF (1 card)
T <sub>OH</sub>	Output Hold time	1.5	-	ns	C <sub>L</sub> ≥ 15 pF (1 card)
<b>Inputs DAT</b> (referenced to CLK rising and falling edges)					
t <sub>ISU2x</sub>	Input set-up time	3	-	ns	C <sub>card</sub> ≤ 10 pF (1 card)
t <sub>IH2x</sub>	Input hold time	0.8	-	ns	C <sub>card</sub> ≤ 10 pF (1 card)
<b>Outputs DAT</b> (referenced to CLK rising and falling edges)					
t <sub>ODLY2x</sub>	Output Delay time during Data Transfer Mode	-	7.0	ns	C <sub>L</sub> ≤ 25 pF (1 card)
T <sub>OH2x</sub>	Output Hold time	1.5	-	ns	C <sub>L</sub> ≥ 15 pF (1 card)

## 5. S.M.A.R.T.

### 5.1 Direct Host Access to SMART Data via SD General Command (CMD56)

CMD 56 is structured as a 32-bit argument. The implementation of the general purpose functions will arrange the CMD56 argument into the following format:



- Bit [0]: Indicates Read Mode when bit is set to [1] or Write Mode when bit is cleared [0]. Depending on the function, either Read Mode or Write Mode can be used.
- Bit [7:1]: Indicates the index of the function to be executed:
  - Read Mode: Index = 0x10 Get SMART Command Information
  - Write Mode: Index = 0x08 Pre-Load SMART Command Information
- Bit [15:8]: Function argument #1 (1-byte)
- Bit [23:16]: Function argument #2 (1-byte)
- Bit [31:24]: Function argument #3 (1-byte)

### 5.2 Process for Retrieving SMART Data

Retrieving SMART data requires the following two commands executed in sequence and in accordance with the SD Association standard flowchart for CMD56 (see below).

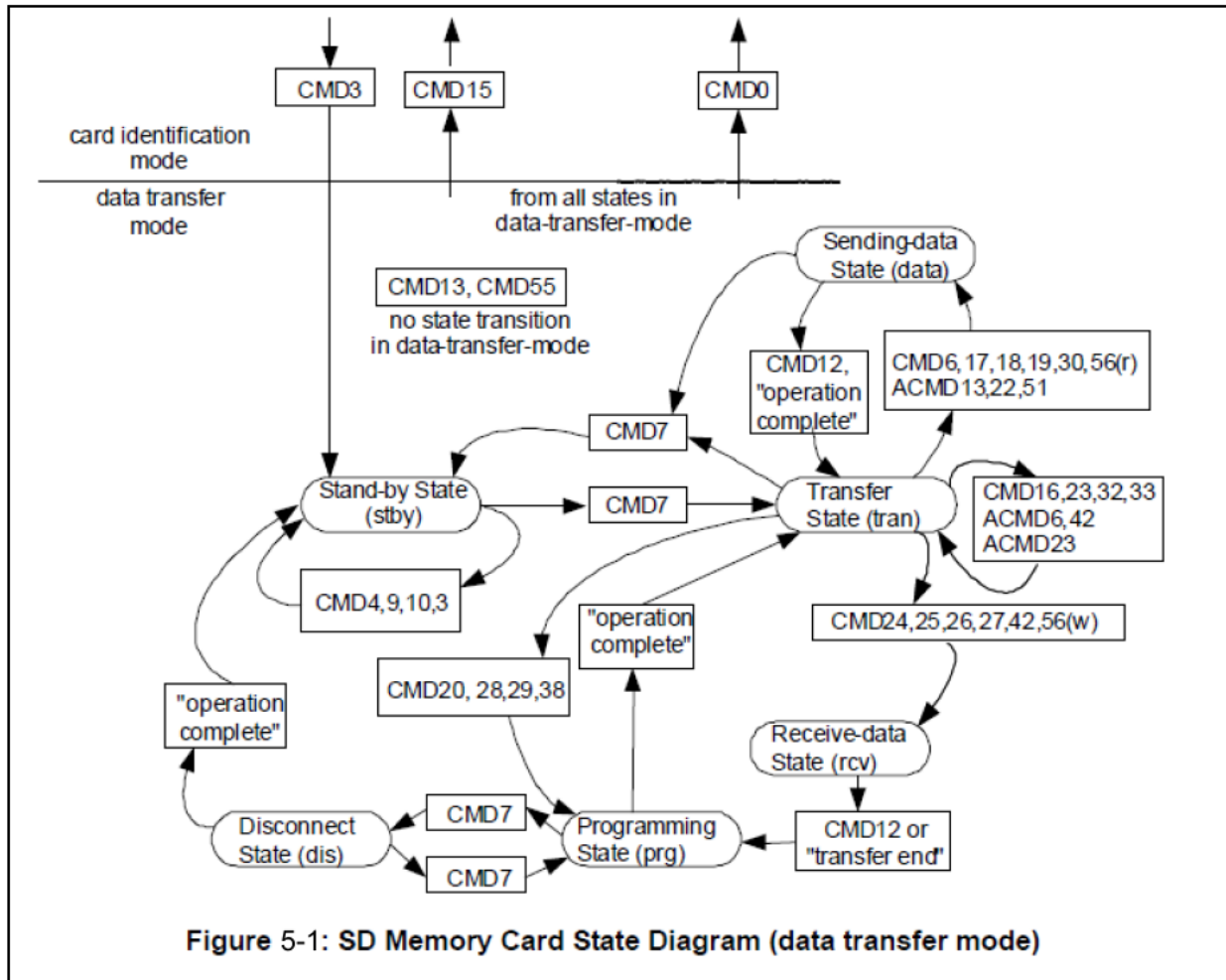
#### Step 1: Write Mode – [0x08] Pre-Load SMART Command Information

Sequence	Command	Argument	Expected Data
Pre-Load SMART Command Information	CMD56	[0] "0" (Write Mode) [1:7] "0001 000" (Index = 0x08) [8:511] All '0' (Reserved)	No expected data

**Step 2: Read Mode – [0x10] Get SMART Command Information**

Sequence	Command	Argument	Expected Data
Get SMART Command Information	CMD56	[0] "1" (Read Mode) [1:7] "0010 000" (Index = 0x10) [8:31] All '0' (Reserved)	1 sector (512 bytes) of response data  byte[0-8] Flash ID byte[9-10] IC Version byte[11-12] FW Version byte[13] Reserved byte[14] CE Number byte[15] Reserved byte[16-17] Bad Block Replace Maximum byte[18] Reserved byte[32-63] Bad Block count per Die byte[64-65] Good Block Rate(%) byte[66-79] Reserved byte[80-83] Total Erase Count byte[84-95] Reserved byte[96-97] Endurance (Remain Life) (%) byte[98-99] Average Erase Count – L* byte[100-101] Minimum Erase Count – L* byte[102-103] Maximum Erase Count – L* byte[104-105] Average Erase Count – H* byte[106-107] Minimum Erase Count – H* byte[108-109] Maximum Erase Count – H* byte[110-111] Reserved byte[112-115] Power Up Count byte[116-127] Reserved byte[128-129] Abnormal Power Off Count byte[130-159] Reserved byte[160-161] Total Refresh Count byte[176-183] Product "Marker" byte[184-215] Bad Block count per Die byte[216-511] Reserved

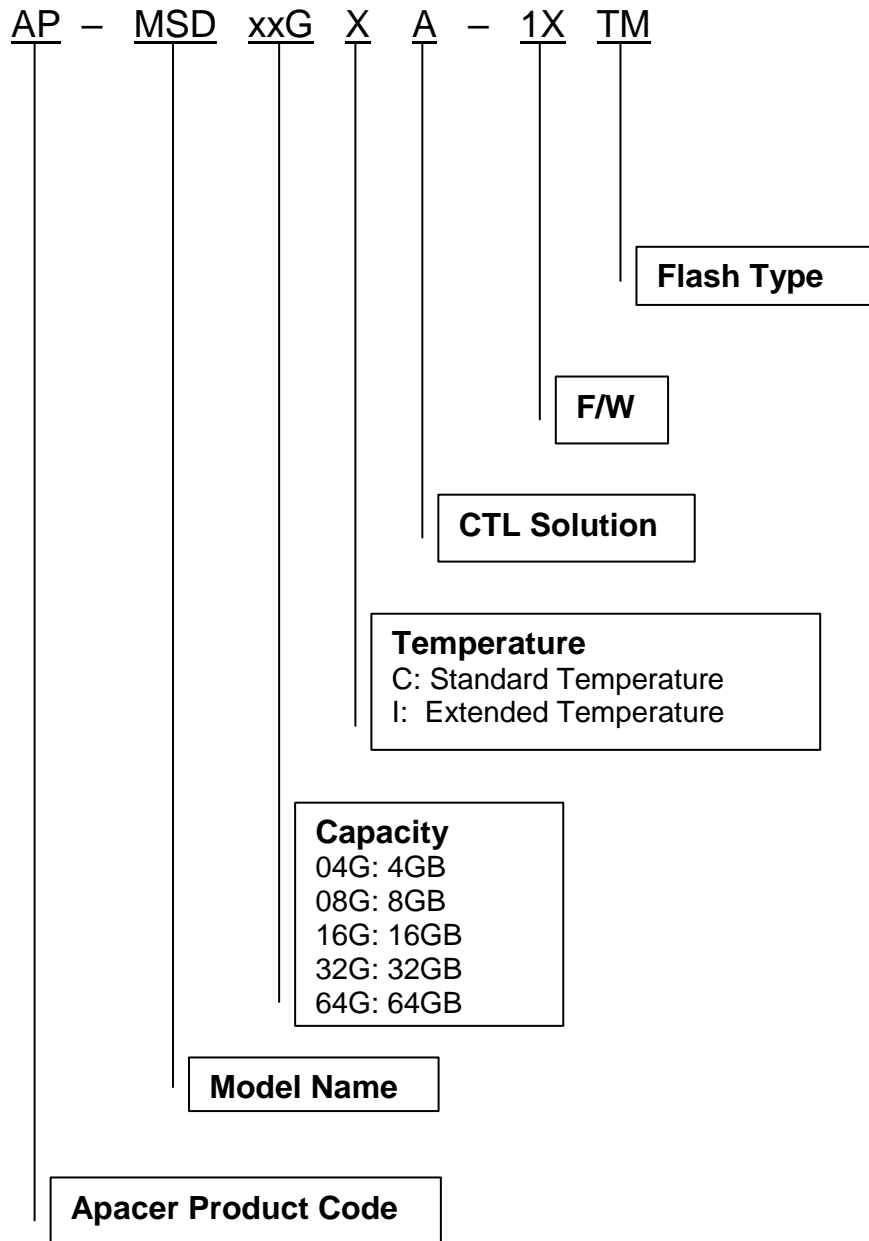
\*Please refer to technical note for High/Low byte definition.



Extracted from the SD Specifications Part 1 Physical Layer Simplified Specification Version 3.01.

## 6. Product Ordering Information

### 6.1 Product Code Designations



## 6.2 Valid Combinations

### 6.2.1 Standard Temperature

Capacity	AP/N
4GB	AP-MSD04GCA-1HTM
8GB	AP-MSD08GCA-1HTM
16GB	AP-MSD16GCA-1HTM
32GB	AP-MSD32GCA-1HTM
64GB	AP-MSD64GCA-1FTM

### 6.2.2 Extended Temperature

Capacity	AP/N
4GB	AP-MSD04GIA-1HTM
8GB	AP-MSD08GIA-1HTM
16GB	AP-MSD16GIA-1HTM
32GB	AP-MSD32GIA-1HTM
64GB	AP-MSD64GIA-1FTM

**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	11/16/2015
1.1	Removed switch cycle from Durability Specifications	12/7/2015
1.2	Added CMD56 argument for SMART	12/16/2015
1.3	Added SMART section	12/23/2015
1.4	Added 4GB support	2/2/2016
1.5	Revised product ordering information for 4GB, 8GB, 16GB and 32GB due to FW update	3/15/2016
1.6	Revised product ordering information for 4GB-32GB due to FW change (82.105)	7/29/2016
1.7	Added Power Failure Management to Features and General Description	10/3/2016
1.8	Removed "The data written at the exact moment power off will be lost, and the max data loss is 16 sectors." from 1.2.5 Power Failure Management	10/7/2016
1.9	Modified the argument of Step 2: Read Mode – [0x10] Get SMART Command Information for S.M.A.R.T.	10/27/2016

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