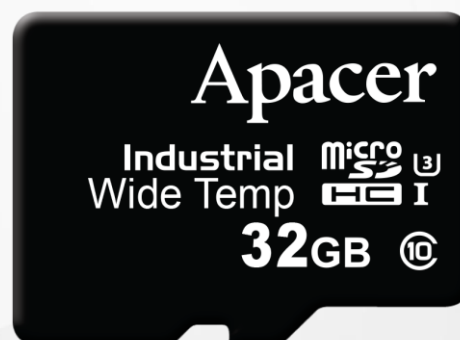


RoHS Recast Compliant

Industrial MicroSD 5.1

MicroSDHC H2-M Product Specifications
(Toshiba 15nm)



October 16, 2020

Version 1.2



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Specifications Overview:

- **Fully Compatible with SD Card Association Specifications**
 - Physical Layer Specification Ver5
 - Security Specification Ver5
- **Capacity**
 - 4, 8, 16, 32 GB
- **Performance***
 - Sequential read: Up to 90 MB/sec
 - Sequential write: Up to 55 MB/sec
 - Random read (4K): Up to 1,900 IOPS
 - Random write (4K): Up to 900 IOPS
- **Flash Management**
 - Built-in advanced ECC algorithm
 - Global Wear Leveling
 - Flash bad-block management
 - S.M.A.R.T.
 - Power Failure Management
 - SMART Read Refresh™
- **NAND Flash Type:** MLC
- **SD-Protocol Compatible**
- **Supports SD SPI Mode**
- **Backward Compatible with 3.0 and 2.0**
- **Endurance (in Terabytes Written: TBW)**
 - 4 GB: 2 TBW
 - 8 GB: 4 TBW
 - 16 GB: 7 TBW
 - 32 GB: 17 TBW
- **Temperature Range**
 - Operating:
 - Standard: -25°C to 85°C
 - Wide: -40°C to 85°C
 - Storage: -40°C to 85°C
- **Operating Voltage: 2.7V ~ 3.6V**
- **Power Consumption***
 - Operating: 140 mA
 - Standby: 240 μA
- **Bus Speed Mode:** Support Class 10 with UHS-I**
 - DS: Default Speed up to 25MHz 3.3V signaling
 - HS: High Speed up to 50MHz 3.3V signaling
 - SDR12: SDR up to 25MHz 1.8V signaling
 - SDR25: SDR up to 50MHz 1.8V signaling
 - SDR50: SDR up to 100MHz 1.8V signaling
 - SDR104: SDR up to 208MHz 1.8V signaling
 - DDR50: DDR up to 50MHz 1.8V signaling
- **Physical Dimensions:**
 - 15mm (L) x 11mm (W) x 1mm (H)
- **Supports Video Speed Class: V10**
- **Supports Application Performance Class: A1**
- **RoHS Recast Compliant**

*Performance values presented here are typical and measured based on USB 3.0 card reader. The results may vary depending on settings and platforms.

**Timing in 1.8V signaling is different from that of 3.3V signaling. Operation mode selection command is compliant with SD 3.0, referring to SDA's Part 1, Physical Layer Specification, Ver 3.01 (Section 3.9)

Table of Contents

1. General Descriptions	4
1.1 Functional Block.....	4
1.2 Flash Management	5
1.2.1 Bad Block Management.....	5
1.2.2 Powerful ECC Algorithms	5
1.2.3 Global Wear Leveling	5
1.2.4 S.M.A.R.T.	5
1.2.5 Power Failure Management.....	5
1.2.6 SMART Read Refresh™.....	5
2. Product Specifications.....	6
2.1 Card Architecture	6
2.2 Pin Assignment	6
2.3 Capacity.....	7
2.4 Performance.....	7
2.5 Electrical.....	7
2.6 Endurance	8
3. Physical Characteristics.....	9
3.1 Physical Dimensions.....	9
3.2 Durability Specifications.....	11
4. AC Characteristics	12
4.1 MicroSD Interface Timing (Default)	12
4.2 MicroSD Interface Timing (High Speed Mode)	13
4.3 MicroSD Interface Timing (SDR12, SDR25, SDR50 and SDR104 Modes)	15
4.3.1 Clock Timing	15
4.3.2 Card Input Timing	15
4.3.3 Card Output Timing of Fixed Data Window (SDR12, SDR25 and SDR50)	16
4.3.4 Output Timing of Variable Window (SDR104)	16
4.3.5 SD Interface Timing (DDR50 Mode).....	17
4.3.6 Bus Timings – Parameters Values (DDR50 Mode)	18
5. S.M.A.R.T.	19
5.1 Direct Host Access to SMART Data via SD General Command (CMD56).....	19
5.2 Process for Retrieving SMART Data	19

6. Product Ordering Information	22
6.1 Product Code Designations	22
6.2 Valid Combinations	23

1. General Descriptions

Apacer microSD H2-M is compatible with the microSD card version 5.1. The command list supports [Physical Layer Specification Ver5] definitions. Card Capacity of Non-secure Area, Secure Area Supports [Security Specification Ver5] Specifications. Random performance of microSD H2-M is much more enhanced than before. The maximum transfer speed can be achieved along with UHS-I compliant devices. Besides, Video Speed Class is compliant with V10 and V30, which are mainly useful for camcorders, video recorders and other devices with video recording capabilities. With V10 and V30 speed mode, microSD card is recommended for high resolution and high quality 4K video recording. Apacer microSD H2-M card is also compliant with Application Performance Class A1, optimized for 4K small file random read/write IOPS, delivering minimum read/write performance at 1500/500 IOPS at least.

The microSD 5.1 card comes with 8-pin interface, designed to operate at maximum operating frequency of 50MHz or 100MHz. It can alternate communication protocol between the SD mode and SPI mode and is backward compatible with SD 2.0 devices. It performs data error detection and correction with very low power consumption.

Apacer Industrial microSD 5.1 card with high performance, reliability and compatibility is well adapted for hand-held applications, medical, surveillance systems and automotive markets.

1.1 Functional Block

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

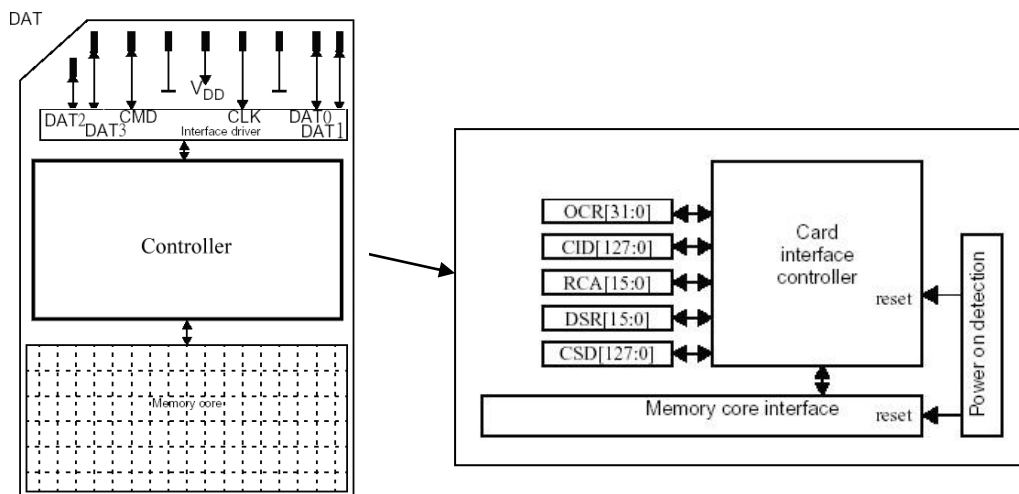


Figure 1-1 Functional Block Diagram

1.2 Flash Management

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 Global 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, Global Wear Leveling technique is applied to extend the lifespan of NAND Flash by evenly distributing writes and erase cycles across the media.

Apacer provides Global Wear Leveling algorithm, which can efficiently spread out the flash usage through the whole flash media area. Moreover, by implementing Global Wear Leveling algorithm, 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.

1.2.6 SMART Read Refresh™

Apacer’s SMART Read Refresh plays a proactive role in avoiding read disturb errors from occurring to ensure health status of all blocks of NAND flash. Developed for read-intensive applications in particular, SMART Read Refresh is employed to make sure that during read operations, when the read operation threshold is reached, the data is refreshed by re-writing it to a different block for subsequent use.

2. Product Specifications

2.1 Card Architecture

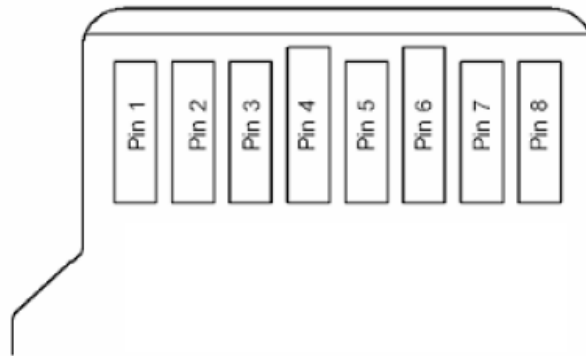


Figure 2-1 Card Architecture

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

The following table shows the specific capacity for the SD 5.1 card.

Table 2-2 Capacity Specifications

Capacity	Total bytes*
4 GB	3,967,811,584
8 GB	7,944,011,776
16 GB	15,896,412,160
32 GB	31,797,018,624

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

2.4 Performance

Performances of the SD 5.1 card are shown in the table below.

Table 2-3 Performance Specifications

Capacity	4 GB	8 GB	16 GB	32 GB
Performance				
Sequential Read* (MB/s)	80	90	90	90
Sequential Write* (MB/s)	15	26	45	55
Random Read IOPS** (4K)	1,900	1,800	1,800	1,900
Random Write IOPS** (4K)	100	800	900	800

Note:

Results may differ from various flash configurations or host system setting.

*Sequential performance is based on CrystalDiskMark 5.2.1 with file size 1,000MB.

**Random performance measured using IOMeter with Queue Depth 32.

***Performance results are measured based on USB 3.0 card reader.

2.5 Electrical

Table 2-4 Operating Voltages

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

Table 2-5 Power Consumption

Capacity	4 GB	8 GB	16 GB	32 GB
Mode				
Operating (mA)	60	75	105	140
Standby (µA)	185	175	210	240

Note:

*All values are typical and may vary depending on flash configurations or host system settings.

**Active power is an average power measurement performed using CrystalDiskMark with 128KB sequential read/write transfers.

***Power is measured based on USB 3.0 card reader.

2.6 Endurance

The endurance of a storage device is predicted by TeraBytes Written based on several factors related to usage, such as the amount of data written into the drive, block management conditions, and daily workload for the drive. Thus, key factors, such as Write Amplifications and the number of P/E cycles, can influence the lifespan of the drive.

Table 2-6 Endurance Specifications

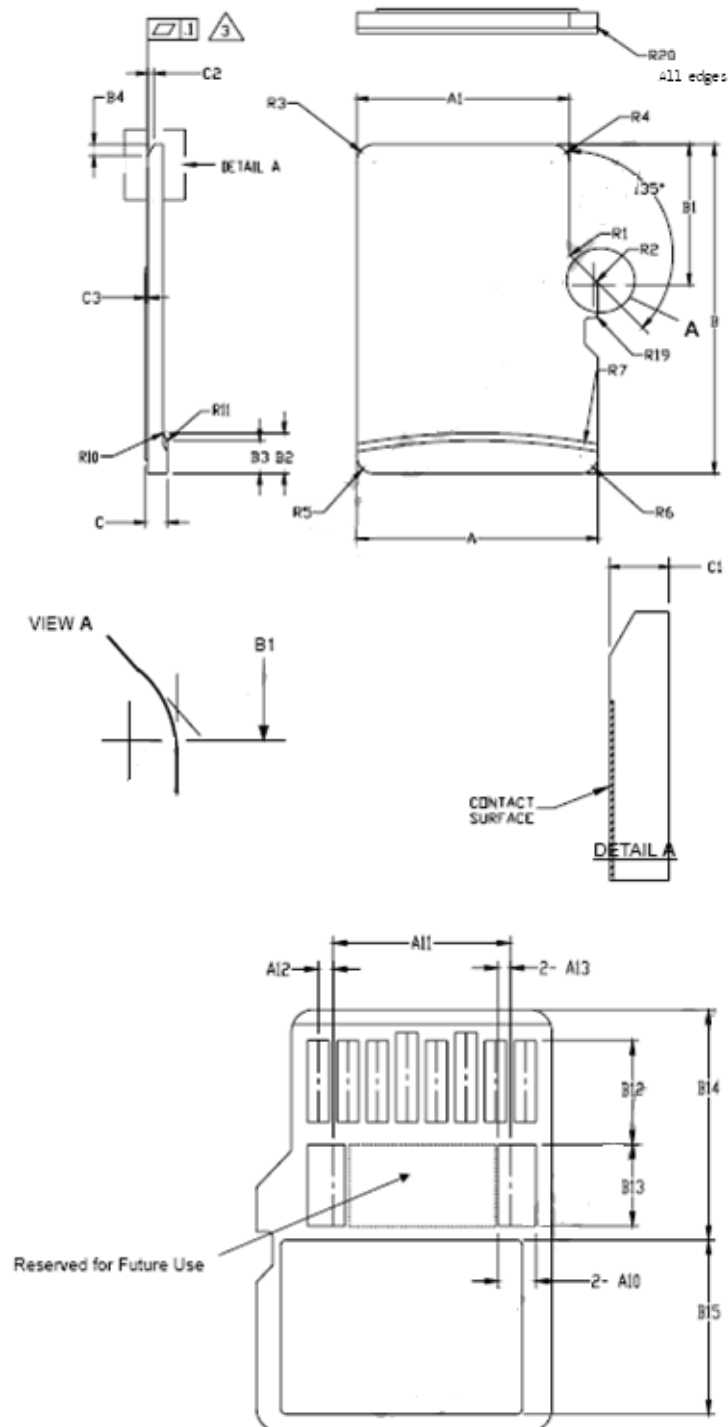
Capacity	TeraBytes Written
4 GB	2
8 GB	4
16 GB	7
32 GB	17

Note:

- The measurement assumes the data written to the SSD for test is under a typical and constant rate.
- The measurement follows the standard metric: 1 TB (Terabyte) = 1,000 GB.
- The estimated values are based on JEDEC Enterprise endurance workload comprised of random data with the payload size distribution with sequential write behavior.


3. Physical Characteristics

3.1 Physical Dimensions



SYMBOL	COMMON DIMENSIONS			NOTE
	MIN	NOM	MAX	
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.

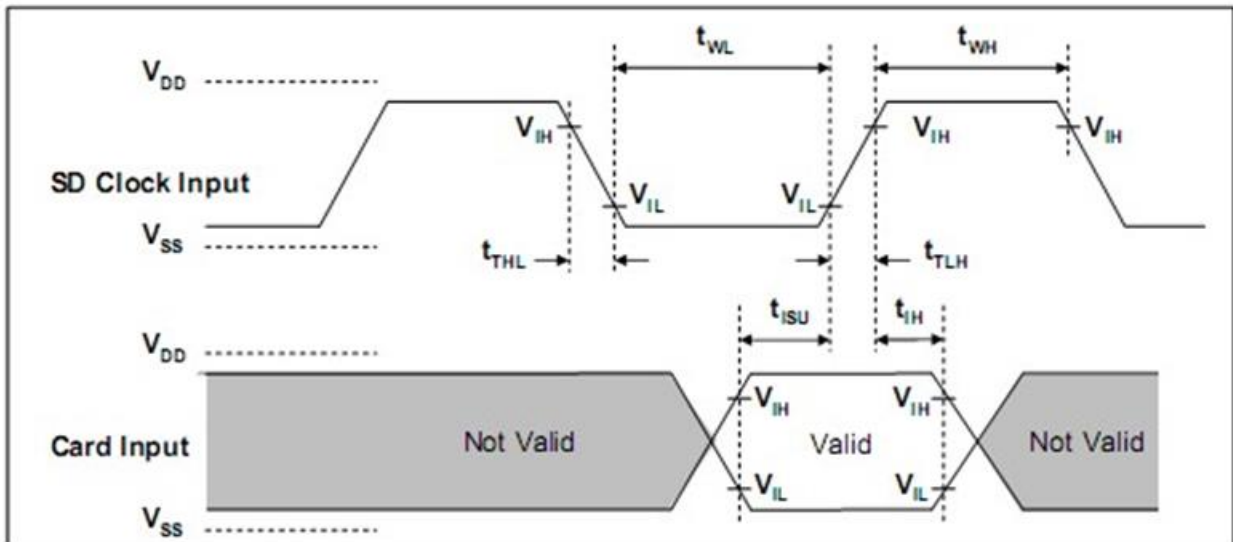
3.2 Durability Specifications

Table 3-1 Durability Specifications

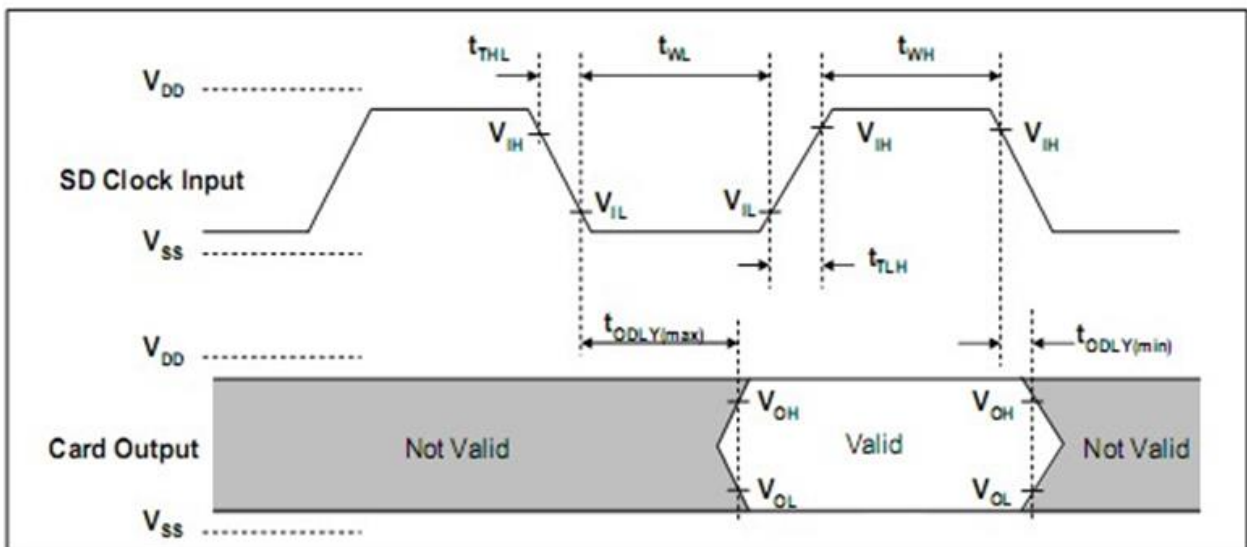
Item	Specifications
Temperature	-25°C to 85°C (Operating) -40°C to 85°C (Wide)
	-40°C to 85°C (Storage)
Shock	1,500G, 0.5ms
Vibration	20Hz~80Hz/1.52mm (frequency/displacement) 80Hz~2000Hz/20G (frequency/displacement) X, Y, Z axis/60mins each
Drop	150cm free fall, 6 face of each
Bending	≥ 10N, hold 1min/5times
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)

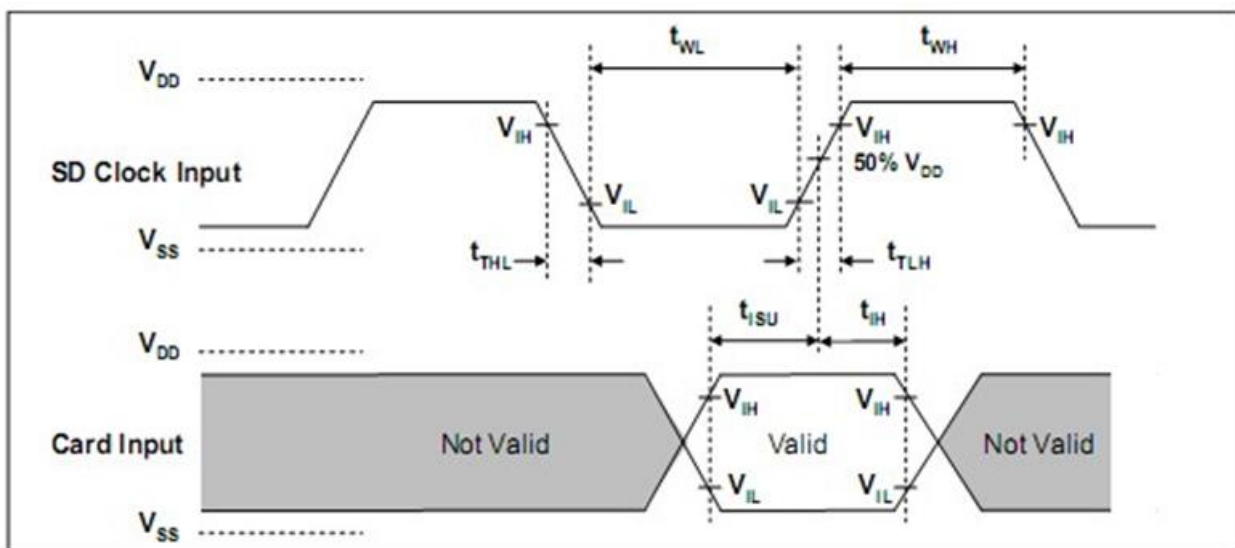


Card Output Timing (Default Speed Mode)

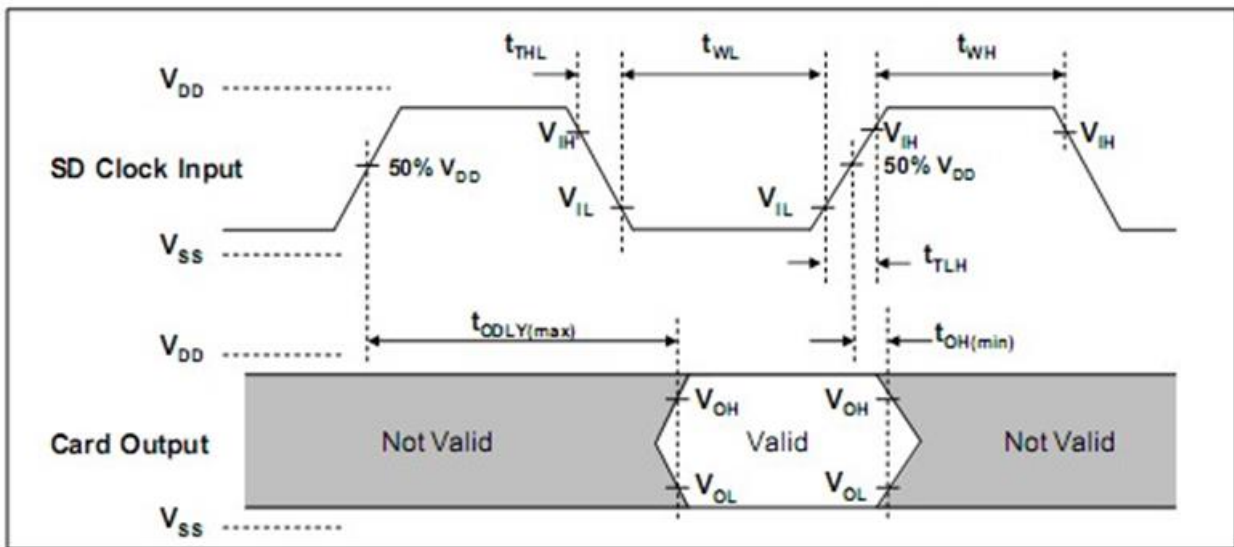
SYMBOL	PARAMETER	MIN	MAX	UNIT	REMARK
Clock CLK (All values are referred to min(V_{IH}) and max(V_{IL}))					
f _{PP}	Clock frequency data transfer	0	25	MHz	C _{card} ≤ 10 pF (1 card)
f _{OD}	Clock frequency identification	0 ⁽¹⁾ /100	400	KHz	C _{card} ≤ 10 pF (1 card)
t _{WL}	Clock low time	10	-	ns	C _{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 _{IH}	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)



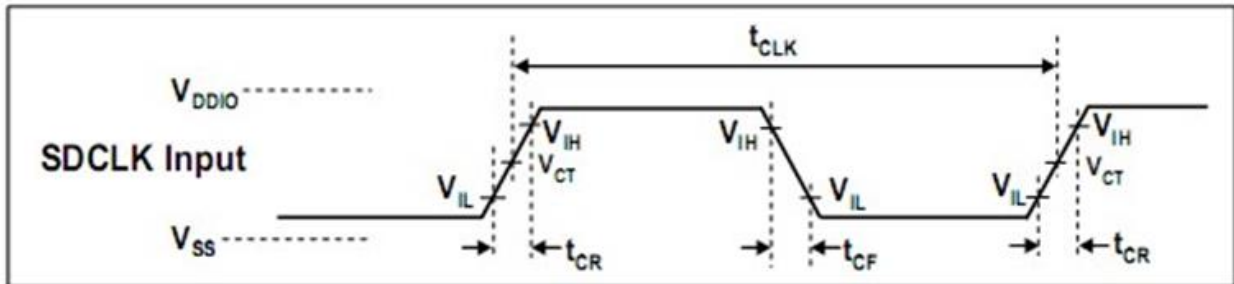
Card Output Timing (High Speed Mode)

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	$C_{card} \leq 10 \text{ pF}$ (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)
Inputs CMD, DAT (Referenced to CLK)					
t_{ISU}	Input setup time	6	-	ns	$C_{card} \leq 10 \text{ pF}$ (1 card)
t_{IH}	Input hold time	2	-	ns	$C_{card} \leq 10 \text{ pF}$ (1 card)
Outputs CMD, DAT (Referenced to CLK)					
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)
CL	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)

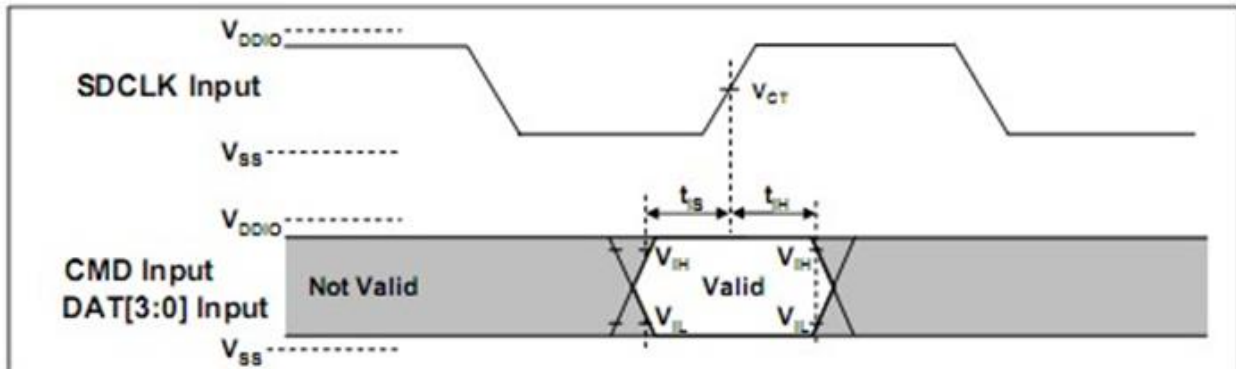
4.3.1 Clock Timing



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	%	

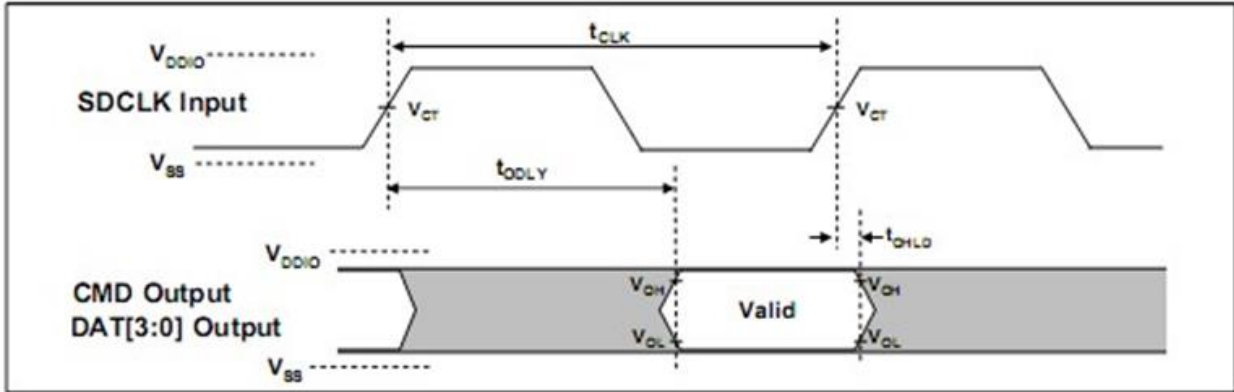
4.3.2 Card Input Timing



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

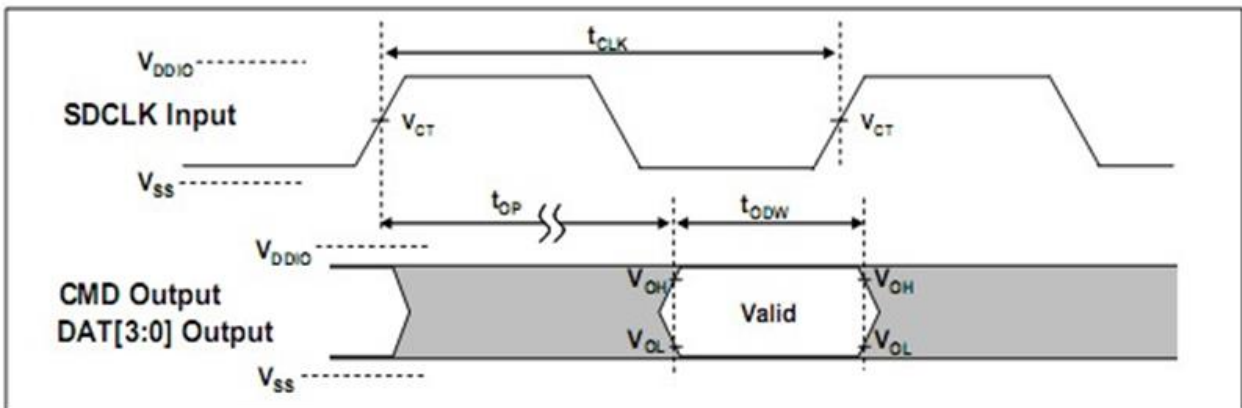
4.3.3 Card Output Timing of Fixed Data Window (SDR12, SDR25 and SDR50)



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.). $CL=15pF$

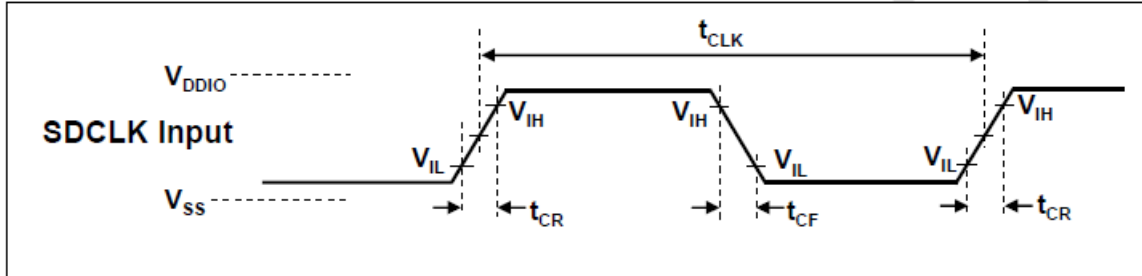
4.3.4 Output Timing of Variable Window (SDR104)



Output Timing of Variable Data Window⁺

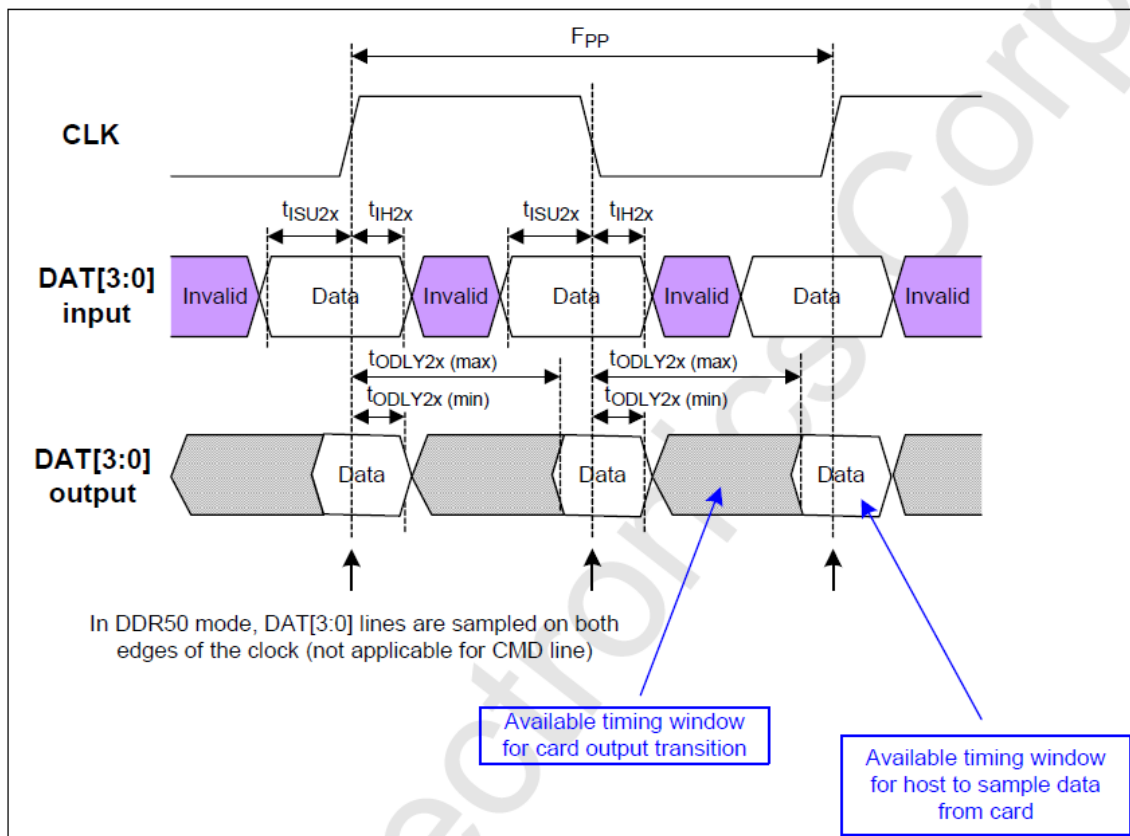
SYMBOL	MIN	MAX	UNIT	REMARK
t_{OP}	-	2	UI	Card Output Phase
Δt_{OP}	-350	+1550	ps	Delay variation due to temperature change after tuning
t_{ODW}	0.60	-	UI	$t_{ODW} = 2.88ns$ at 208MHz

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}	-	$0.2 \cdot t_{CLK}$	ns	$t_{CR}, t_{CF} < 4.00\text{ns (max.)}$ at 50MHz, CCARD=10pF
Clock Duty	45	55	%	



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

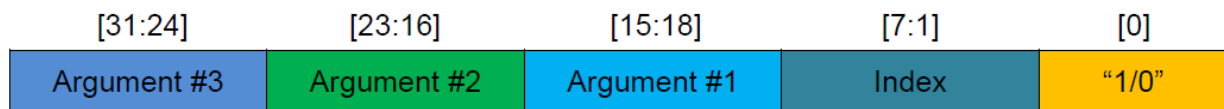
4.3.6 Bus Timings – Parameters Values (DDR50 Mode)

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. 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		1 sector (512 bytes) of response data
		[0] "1" (Read Mode) [1:7] "0010 000" (Index = 0x10) [8:31] All '0' (Reserved)	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.

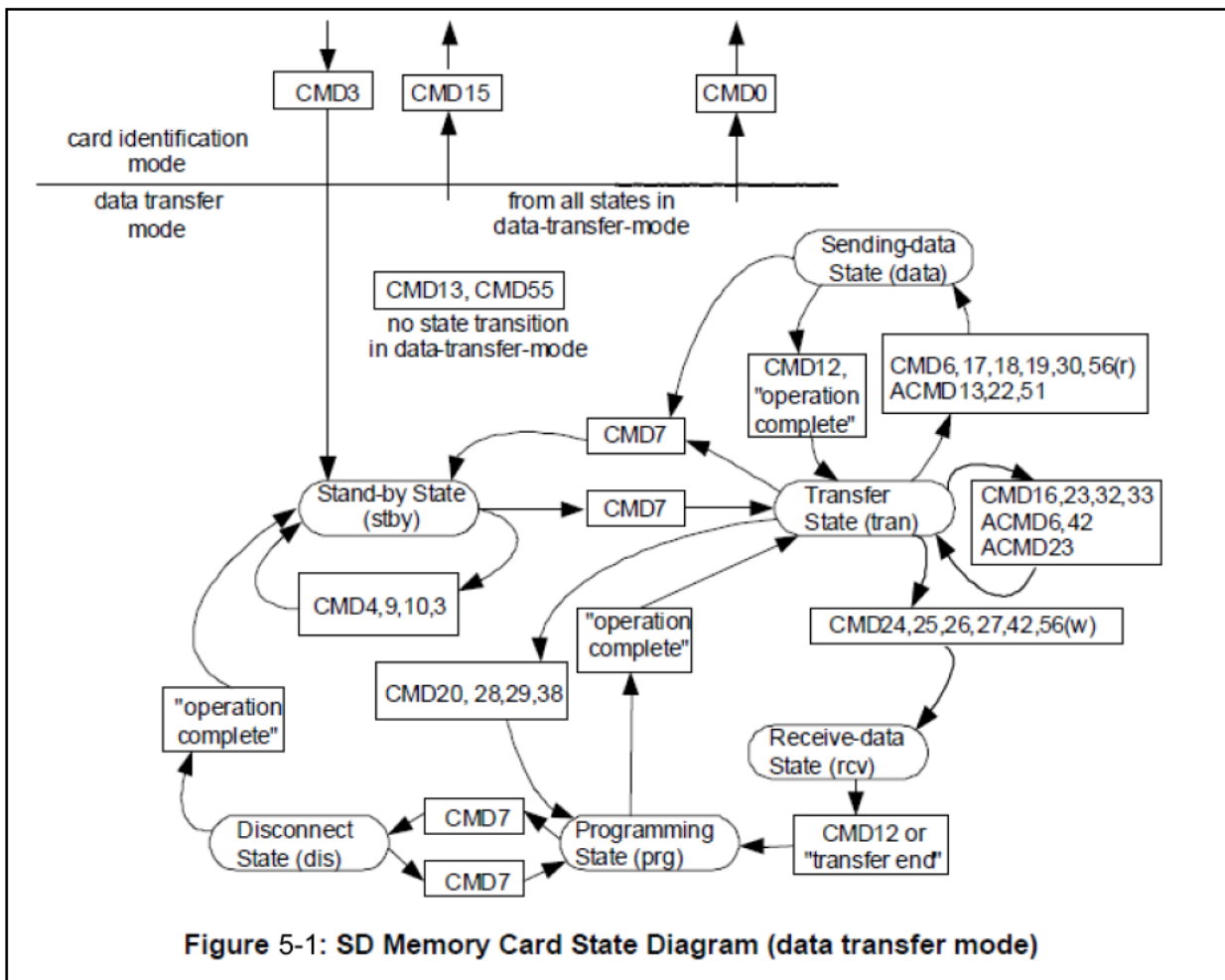
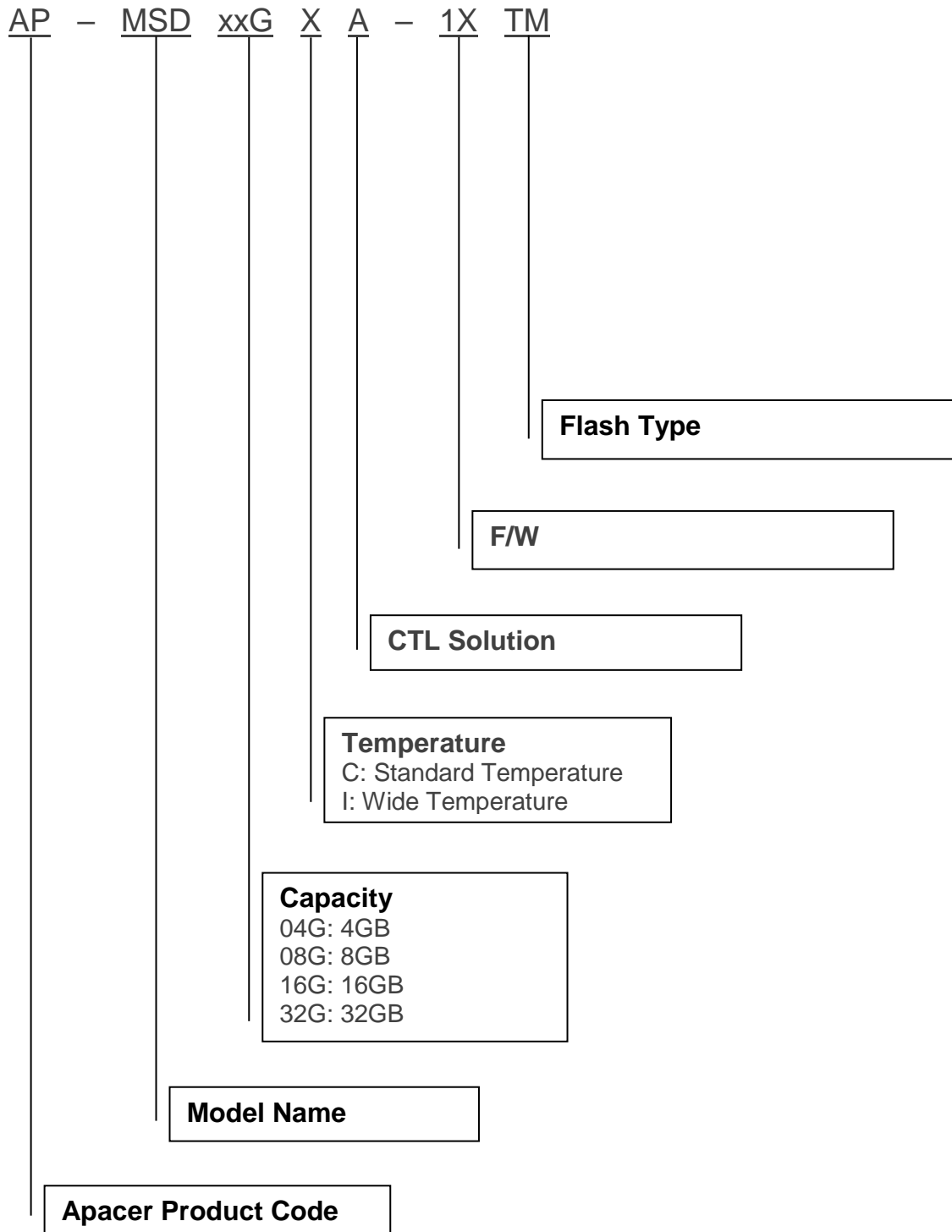


Figure 5-1: SD Memory Card State Diagram (data transfer mode)

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

Capacity	Standard Temperature	Wide Temperature
4GB	AP-MSD04GCA-1RTM	AP-MSD04GIA-1RTM
8GB	AP-MSD08GCA-1RTM	AP-MSD08GIA-1RTM
16GB	AP-MSD16GCA-1RTM	AP-MSD16GIA-1RTM
32GB	AP-MSD32GCA-1RTM	AP-MSD32GIA-1RTM

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
0.1	Preliminary release	11/13/2017
0.2	Modified power consumption unit to μA for standby mode	12/13/2017
1.0	- Added the Endurance section to Specifications Overview - Added 2.6 Endurance	6/1/2018
1.1	Updated 6. Product Ordering Information due to FW change	6/7/2018
1.2	Renamed extended temperature and Read Disturb Management to wide temperature and SMART Read Refresh respectively	10/16/2020

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