

RoHS Recast Compliant Secure Digital Card 6.1

Industrial SD-WORM Product Specifications

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Version 1.4



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Specifications Overview:

- **Capacity**
 - 8, 16, 32, 64, 128 GB
- **Performance¹**
 - Sequential read: Up to 75 MB/sec
 - Sequential write: Up to 65 MB/sec
- **Flash Management**
 - Built-in advanced ECC algorithm
 - Global Wear Leveling
 - Flash bad-block management
 - Page Mapping
 - S.M.A.R.T.
 - Power Failure Management
 - SMART Read Refresh™
- **NAND Flash Type: MLC**
- **Temperature Range**
 - Operating: -25°C to 85°C
 - Storage: -40°C to 85°C
- **Operating Voltage: 2.7V ~ 3.6V**
- **Power Consumption¹**
 - Operating (Max.): 225 mA
 - Standby: 315 μA
- **Inherent Characteristics**
 - When writing files, it must adhere to the “one by one” principle. This means that a file must be completely written before starting another one.
 - The "Data Clusters" of the file must be written sequentially.
- **Bus Speed Mode: Support Class 10 with UHS-I²**
 - 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
- **Product Compatibility**
 - Compatible with SD Card Specifications 6.1
 - SD Memory Card Specifications, Part 1, Physical Layer Specification, Ver 6.1 Final
 - SD Memory Card Specifications, Part 2, File System Specification, Ver 3.00
 - SD Memory Card Specifications, Part 3, Security Specification, Ver 3.00
 - Supports SD and SPI modes
 - OS support
 - Windows 7/10
 - Linux Fedora v23 / Ubuntu v16.04
 - Android v7.1 (PC)
 - File system support: FAT32 only
 - Not supported: Erase/Lock/Unlock SD commands
- **Physical Dimensions:**
 - 32mm (L) x 24mm (W) x 2.1mm (H)
- **RoHS Recast Compliant (2011/65/EU)**

Notes:

1. Varies from capacities. Performance values presented here are typical and measured based on USB 3.0 card reader. The results may vary depending on settings and platforms.
2. 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).

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1. General Description

Apacer industrial SD-WORM (Write Once Read Many) Card is a product that provides data storage protection by allowing data to be written once, preventing it from being erased, modified, or overwritten. This write protection function ensures that the data cannot be tampered with once it is written to the device.

Apacer SD-WORM Card complies with SD card version 6.1. The command list is compatible with [Part 1 Physical Layer Specification Ver6.1 Final] definitions, while the Card Capacity of Non-secure Area, Secure Area supports [Part 3 Security Specification Ver3.0 Final] Specifications. Furthermore, the SD card is compatible with SD protocol. With built-in ECC, wear-leveling and bad block management, this industrial SD card serves as an ideal portable storage solution.

Designed specifically for rigorous applications by offering reliability and agility, where extreme traceability, enhanced data integrity, and exceptionally velocity are required, Apacer SD-WORM Card comes with 9-pin interface designed to operate at a maximum operating frequency of 208MHz. It can alternate communication protocol between the SD mode and SPI mode. It performs data error detection and correction with very low power consumption.

With high performance, good reliability, and wide compatibility, Apacer SD-WORM Card is one of the most popular cards well adapted for rugged and embedded applications ranging from industrial, imaging, computing to enterprise markets.

1.1 Product Functional Block

The SD contains a flash controller and flash media with SD standard interface.

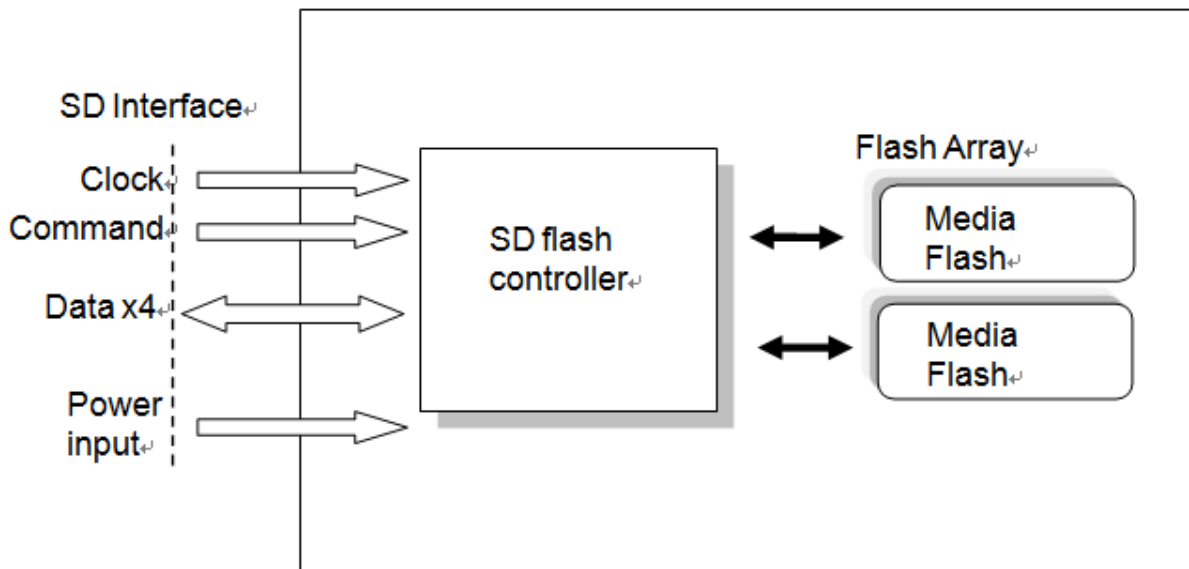


Figure 1-1 Functional Block Diagram

1.2 Flash Management

1.2.1 Bad Block Management

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

The SD 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 replaces this bad bit with a spare bit within the sector header. If necessary, the SD 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 Powerful ECC Algorithms

Flash memory cells can deteriorate with use, which might generate random bit errors in the stored data. Thus, the SD card applies the advanced ECC Algorithm that can detect and correct errors occurring during the read process, ensure data has 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.

Table 1-1 SMART Attribute ID List

ID (Hex)	Attribute Name
12 (0x0C)	Power Cycle Count
162 (0xA2)	Spare Block Count
163 (0xA3)	Maximum Erase Count
164 (0xA4)	Average Erase Count
165 (0xA5)	Initial Bad Block Count
166 (0xA6)	Later Bad Block Count
192 (0xC0)	Abnormal Shutdown Count

1.2.5 Power Failure Management

Power Failure Management plays a crucial role when power supply becomes unstable. Power disruption may occur when users are storing data into the SD card, leading to instability in the drive. However, with Power Failure Management, a firmware protection mechanism will be activated to scan pages and blocks once power is resumed. Valid data will be transferred to new blocks for merging and the mapping table will be rebuilt. Therefore, data reliability can be reinforced, preventing damage to data stored in the NAND Flash.

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.

1.2.7 Flash Translation Layer – Page Mapping

Page mapping is an advanced flash management technology whose essence lies in the ability to gather data, distribute the data into flash pages automatically, and then schedule the data to be evenly written. Page-level mapping uses one page as the unit of mapping. The most important characteristic is that each logical page can be mapped to any physical page on the flash memory device. This mapping algorithm allows different sizes 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. Thus, page mapping is adopted to increase random access speed and improve SD lifespan, reduce block erase frequency, and achieve optimized performance and lifespan.

2. Electrical Characteristics

2.1 Card Architecture

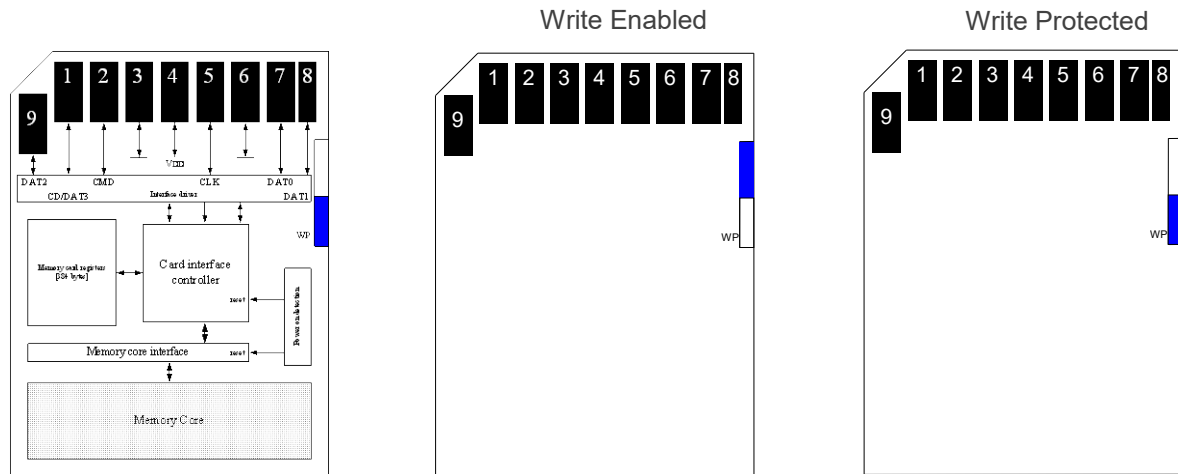


Figure 2-1 Card Architecture

2.2 Pin Assignment

Table 2-1 Pin Assignment

Pin	SD Mode		SPI Mode	
	Name	Description	Name	Description
1	CD/DAT3	Card detect/Data line[Bit 3]	CS	Chip select
2	CMD	Command/Response	DI	Data in
3	VSS1	Supply voltage ground	VSS	Supply voltage ground
4	VDD	Supply voltage	VDD	Supply voltage
5	CLK	Clock	SCLK	Clock
6	VSS2	Supply voltage ground	VSS2	Supply voltage ground
7	DAT0	Data line[Bit 0]	DO	Data out
8	DAT1	Data line[Bit 1]	Reserved	
9	DAT2	Data line[Bit 2]	Reserved	

2.3 Capacity Specifications

The following table shows the specific capacity for the SD-WORM Card.

Table 2-2 Capacity Specifications

Capacity	Total bytes
8 GB	7,734,296,576
16 GB	15,468,593,152
32 GB	30,941,380,608
64 GB	61,886,955,520
128 GB	123,778,105,344

Note: The statistics may vary depending on file systems of various OS. User data bytes do not indicate total useable bytes. LBA count addressed in the table above indicates total user storage capacity and will remain the same throughout the lifespan of the device. However, the total usable capacity of the SD is most likely to be less than the total physical capacity because a small portion of the capacity is reserved for device maintenance usages.

2.4 Performance Specifications

Performances of the SD-WORM Card are shown in the table below.

Table 2-3 Performance Specifications

Capacity	8 GB	16 GB	32GB	64 GB	128 GB
Performance					
Sequential Read (MB/s)	70	70	70	75	75
Sequential Write (MB/s)	24	25	43	65	60

Notes:

- Results may differ from various flash configurations or host system setting, and the above test results are based on the default file structure with FAT 32 file system.
- Sequential read/write is based on H2testw 1.4 with file size 1,000MB.

2.5 DC Power Supply

Table 2-4 Operating Voltage

Symbol	Parameter	Min.	Typ.	Max.	Unit
V _{DD}	Power Supply Voltage	2.7	3.3	3.6	V

2.6 Power Consumption

Table 2-5 Power Consumption

Capacity	8 GB	16 GB	32GB	64 GB	128 GB
Mode					
Operating (mA) (Max.)	220	200	205	215	225
Standby (µA)	275	255	280	305	315

Notes:

- All values are typical and may vary depending on flash configurations or host system settings.
- Based on USB 3.0 card reader, Power consumption is measured using H2testw 1.4 with file size 1,000MB.

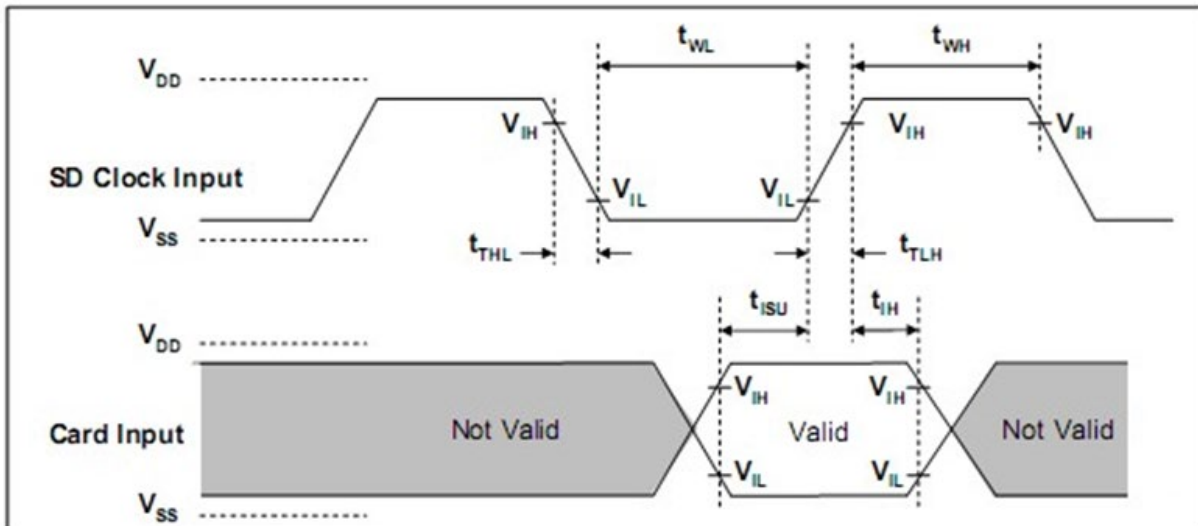
3.2 Durability Specifications

Table 3-1 Durability Specifications

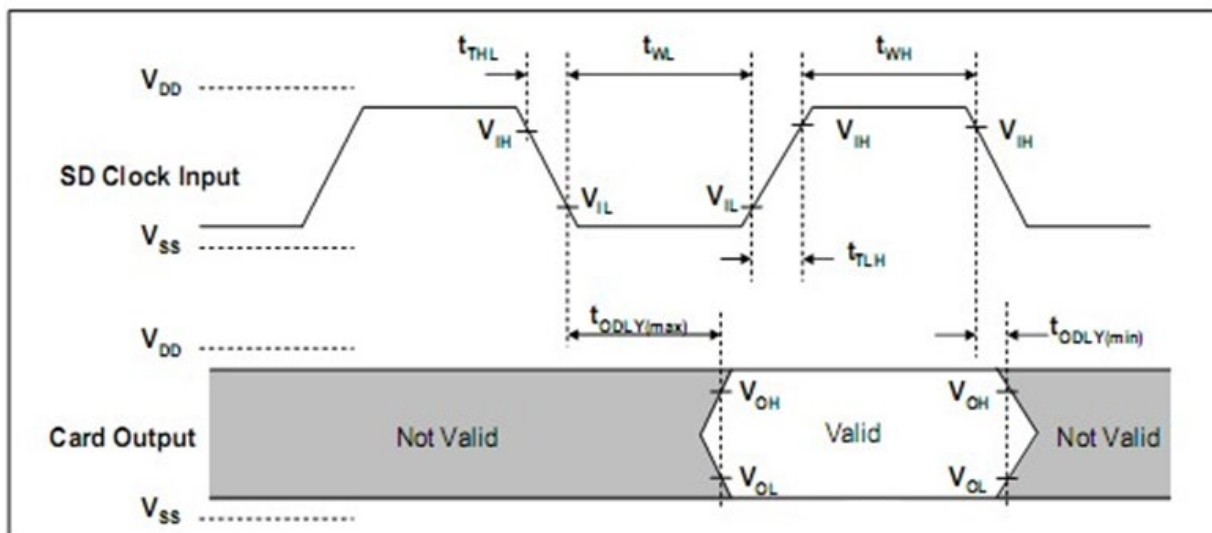
Item	Specifications
Temperature	Operating: -25°C to 85°C Storage: -40°C to 85°C
Shock	1,500G, 0.5ms
Vibration	20Hz~80Hz/1.52mm (frequency/displacement) 80Hz~2000Hz/20G (frequency/displacement) X, Y, Z axis/60mins each
Drop	1.5m free fall, 6 surfaces of each
Bending	≥ 10N, hold 1min/5times
Torque	0.15N-m or 2.5deg, hold 30 seconds/ 5 times
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)
Switch Cycle	0.4~0.5N, 1000 times
Durability	10,000 times mating cycle
ESD	Contact: +/-4KV each item 25 times Air: +/-8KV 10 times

4. DC Characteristics

4.1 SD Interface Timing (Default)



Card input Timing (Default Speed Card)

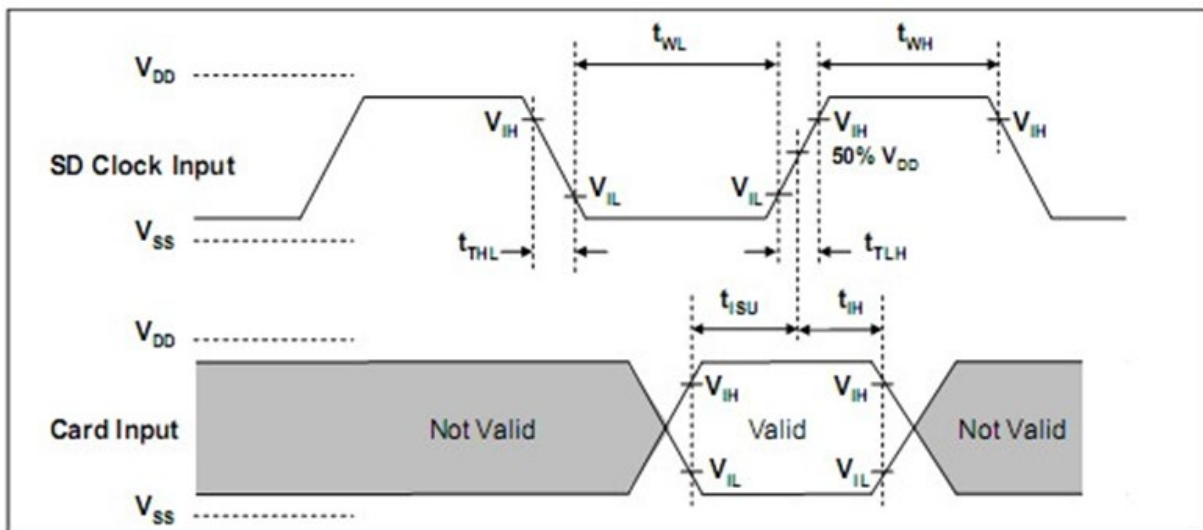


Card Output Timing (Default Speed Mode)

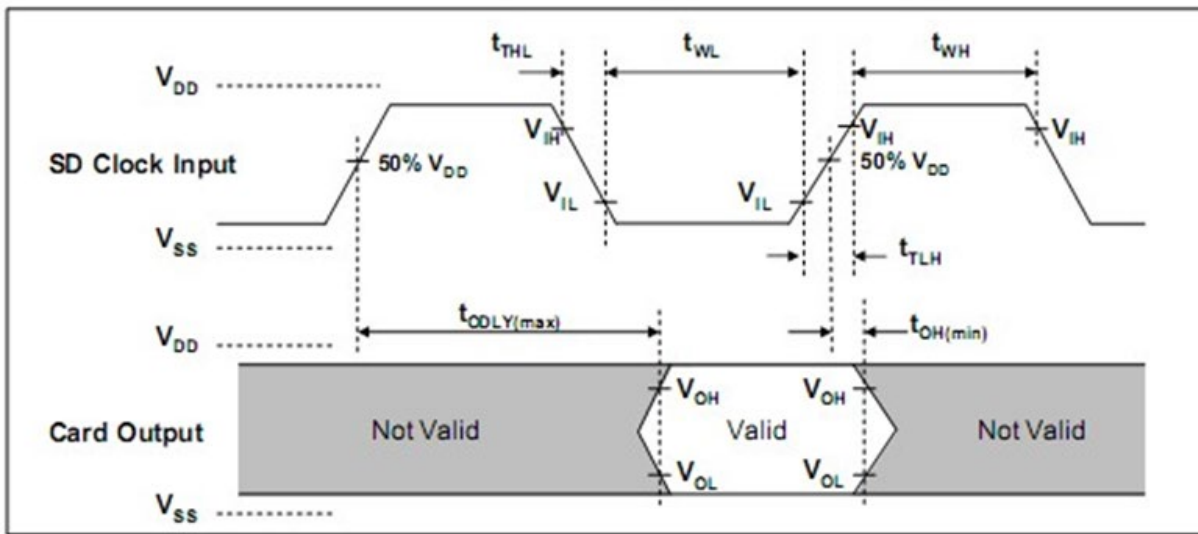
Symbol	Parameter	Min	Max	Unit	Remark
Clock CLK (All values are referred to min(V_{IH}) and max(V_{IL}))					
f _{PP}	Clock frequency Data Transfer Mode	0	25	MHz	C _{card} ≤ 10 pF (1 card)
f _{OD}	Clock frequency Identification Mode	0*/100	400	kHz	C _{card} ≤ 10 pF (1 card)
t _{WL}	Clock low time	10		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 _{ODLY}	Output Delay time during Identification Mode	0	50	ns	C _L ≤ 40 pF (1 card)

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

4.2 SD Interface Timing (High-Speed Mode)



Card Input Timing (High Speed Card)



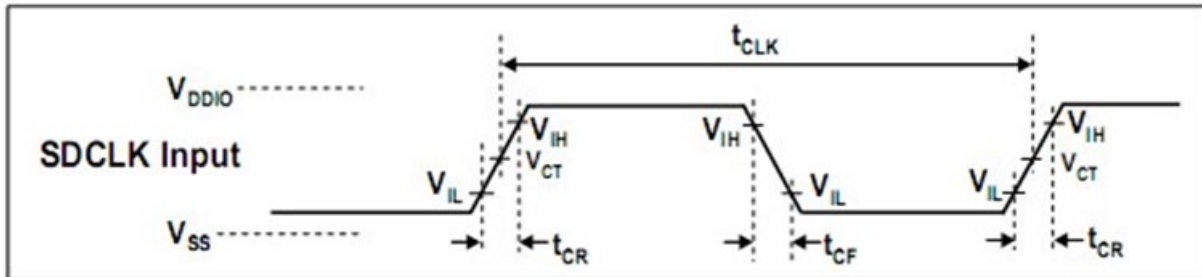
Card Output Timing (High Speed Mode)

Symbol	Parameter	Min	Max	Unit	Remark
Clock CLK (All values are referred to min(VIH) and max(VIL))					
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)
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 SD Interface Timing (SDR12, SDR25, SDR50 and SDR104 Modes)

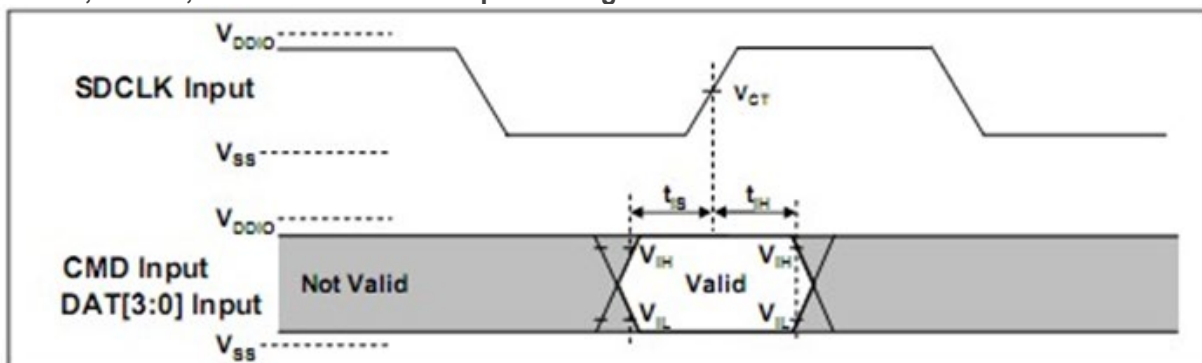
4.3.1 Input



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}	-	$0.2 \cdot t_{CLK}$	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	%	

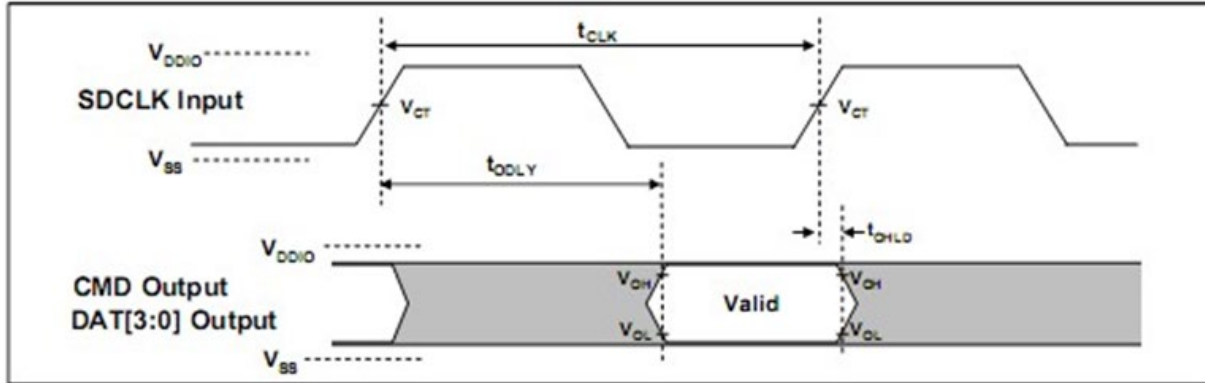
SDR12, SDR25, SDR50 and SDR104 Input Timing



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

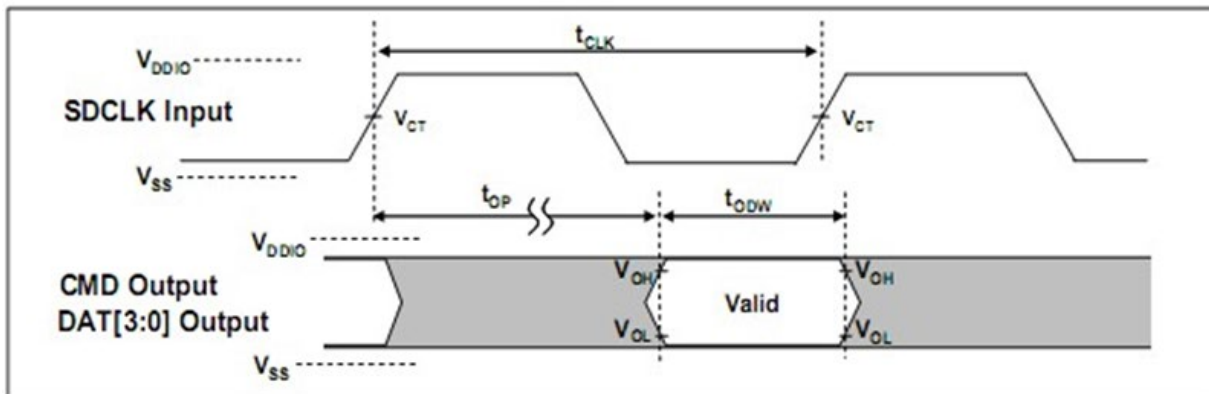
4.3.2 Output



Output Timing of Fixed Data Window

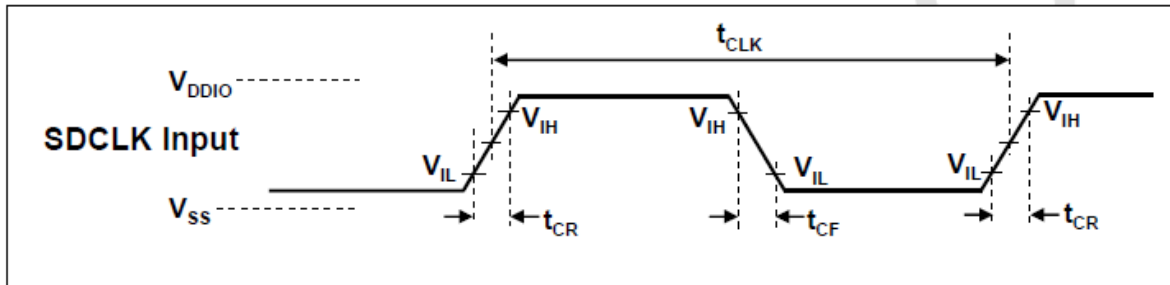
Symbol	Min	Max	Unit	Remark
t_{ODLY}	-	7.5	ns	$t_{CLK} \geq 10.0\text{ns}$, $C_L=30\text{pF}$, using driver Type B, for SDR50.
t_{ODLY}	-	14	ns	$t_{CLK} \geq 20.0\text{ns}$, $C_L=40\text{pF}$, using driver Type B, for SDR25 and SDR12
T_{OH}	1.5	-	ns	Hold time at the t_{ODLY} (min.). $C_L=15\text{pF}$

Output (SDR104 mode)



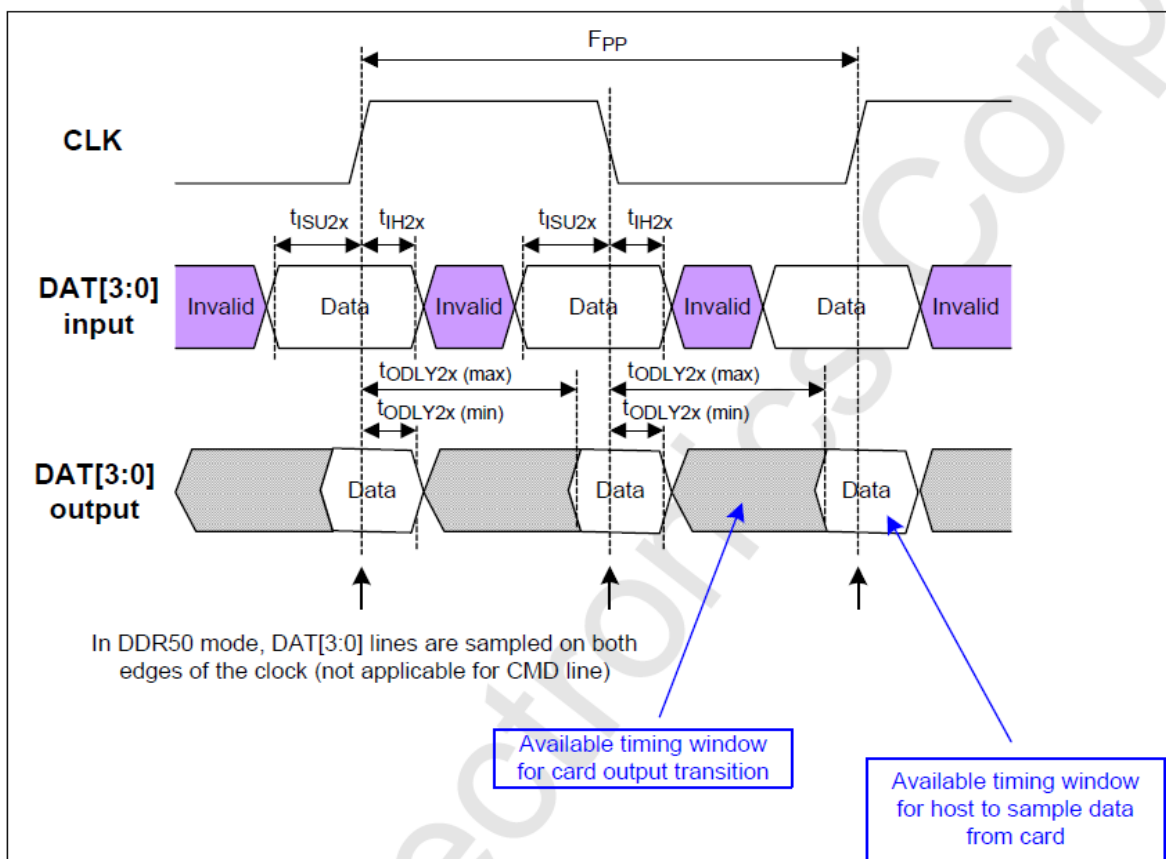
Symbol	Min	Max	Unit	Remark
t_o	0	2	UI	Card Output Phase
Δt_{OP}	-350	+1550	ps	Delay variable due to temperature change after tuning
t_{ODW}	0.60	-	UI	$t_{ODW} = 2.88\text{ns}$ at 208MHz

4.4 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, $C_{CARD}=10pF$
Clock Duty	45	55	%	



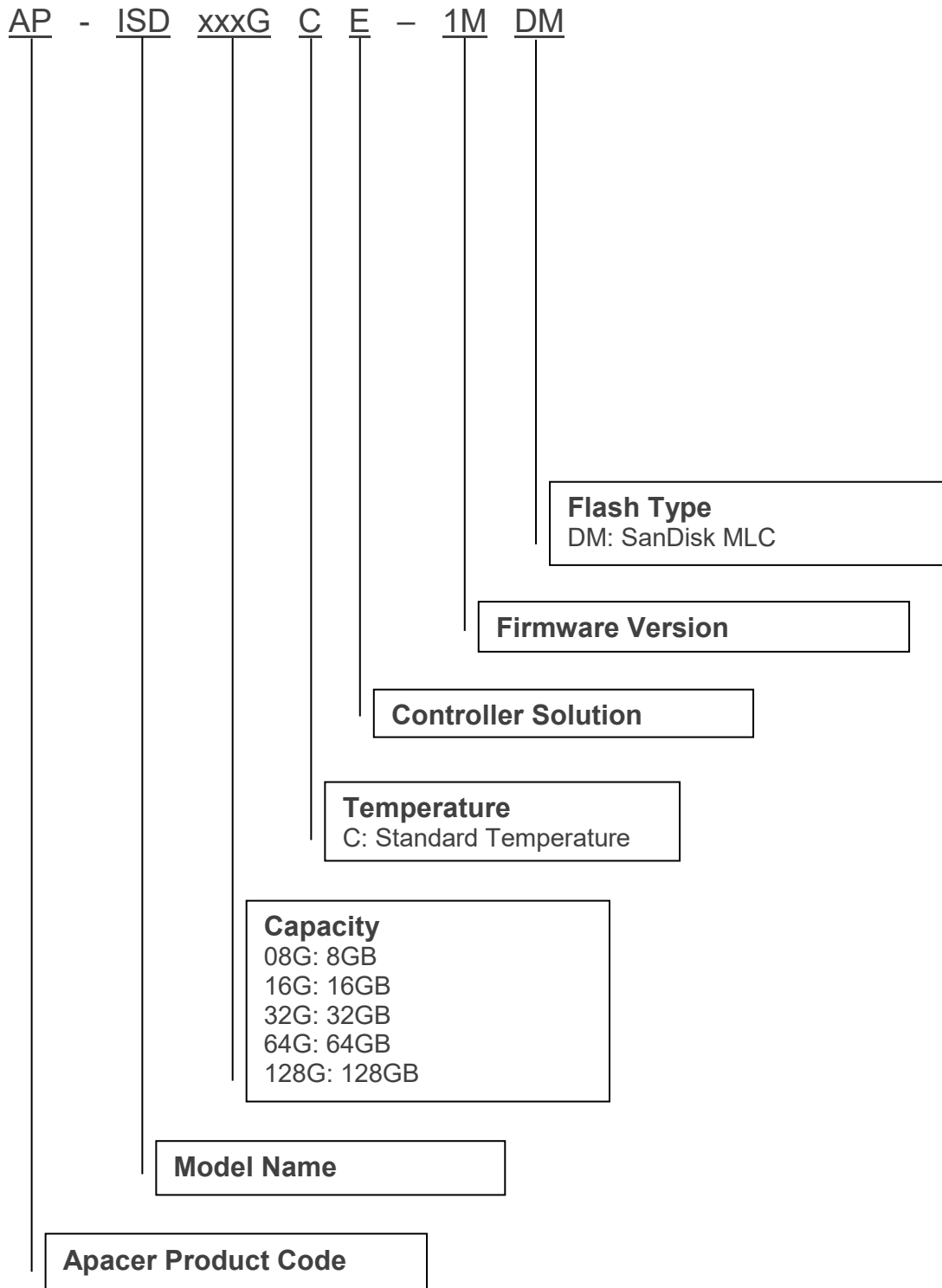
Timing Diagram DAT Inputs/Outputs Referenced to CLK in DDR50 Mode

Bus Timings – Parameters Values (DDR50 Mode)

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

5. Product Ordering Information

5.1 Product Code Designations



5.2 Valid Combinations

The following table lists the available models of the Apacer SD-WORM Card series which are 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.

Capacity	Valid Combination
8GB	AP-ISD08GCE-1MDM
16GB	AP-ISD16GCE-1MDM
32GB	AP-ISD32GCE-1MDM
64GB	AP-ISD64GCE-1MDM
128GB	AP-ISD128GCE-1MDM

Revision History

Revision	Description	Date
1.0	Initial release	10/5/2023
1.1	Added Table 1-1 to 1.2.4 S.M.A.R.T.	10/23/2023
1.2	Removed “R1-M” from the file name and cover page	11/17/2023
1.3	Revised Product Limitations on Specifications Overview page by breaking it down into OS Support and Inherent Characteristics	12/27/2023
1.4	Changes to Specifications Overview include the following: - Removed “Backward Compatible with 3.0 and 2.0” - Removed “Write performance is 50% lower compared to a standard USB” from Inherent Characteristics - Consolidated compatible specifications and support items to a new section Product Compatibility	1/9/2024

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