Cactus®

Technologies

Industrial Grade
SD Card -807 Series
Product Manual

www.cactus-tech.com

May 16, 2023

1.Introduction to Cactus Technologies® Industrial Grade SD Card -807 Series

Features:

- Solid state design with no moving parts

- 4GB to 32GB of storage

- Compatible with SDA Physical Layer Specifications, Version 2.0, 3.0X

- Supports SD command class 0,2,4,5,6,7,8,10

- Supports SPI mode

- Supports UHS-1 bus modes up to SDR25

- Enhanced error correction, < 1 error in 10^{14} bits read

- Up to 35MB/s data rate (using 4 data lines), Class 10 performance

- Voltage supply -- 2.7V to 3.6V with support for 3.3V and 1.8V signaling

Cactus Technologies® -807 Series SD products are high capacity solid-state flash memory products that complies with the SD Card Association standard. Cactus SD Cards provide up to 32GB of formatted storage capacity and is designed to be used in applications which requires reliable, high performance solid state storage in a small form factor.

Cactus Technologies® Industrial Grade SD Card products use high quality SLC flash memory from Kioxia Corp. In addition, it includes an on-drive intelligent controller that manages interface protocols, data storage and retrieval as well as ECC, defect handling & diagnostics, power management, and clock control.

1.1. Supported Standards

Cactus Technologies® -807 Series SD products are fully electrically compatible with the following specification:

- SD Card Association Physical Layer Specification, Versions 2.0 and 3.0X

1.2. Product Features

Cactus Technologies® Industrial SD products contain a high level, intelligent controller. This intelligent controller provides many capabilities including the following:

- SD Card register and command set handling.
- Management of erasing and programming the flash memory independent of the host system.
- Sophisticated defect managing capabilities (similar to magnetic disk drives).
- Sophisticated system for error recovery using powerful error correction code (ECC).
- Intelligent power management for low power operation.

1.2.1.   Host and Technology Independence

Cactus Technologies® Industrial SD products utilize a 512-byte sector which is the same as that in an IDE magnetic disk drive. To write or read a sector (or multiple sectors), the host computer software simply issues a Read or Write command to the drive and then waits for the command to complete. The host system does not need to know the details of how the flash memory is erased, programmed or read, as this is all managed by the built-in controller in the drive. Also, with the intelligent on-board controller, the host system software will not need to be updated to match new flash technologies. Thus, systems that support the Cactus Technologies® Industrial SD products today will continue to work with future Cactus Technologies® Industrial SD products built with new flash technology without having to update or change host software.

1.2.2.   Defect and Error Management

Cactus Technologies® Industrial SD products contain a sophisticated defect and error management system similar to those found in magnetic disk drives. The defect management is completely transparent to the host and does not consume any user data space.

The bit error rate for Cactus Technologies® Industrial SD products is much lower than that of magnetic disk drives. When a read error does occur, the drive has sophisticated ECC to recover the data.

These defect and error management systems, coupled with the solid-state construction, give Cactus Technologies® Industrial SD products extremely high reliability.

1.2.3. Intelligent Power Management

Cactus Technologies® Industrial SD products employ sophisticated power management algorithms to conserve power. Upon completion of a command, the drive will automatically enter sleep mode if no further commands are received. In most situations, the drive will be in sleep mode except when the host is accessing it, thus conserving power.

When the drive is in sleep mode, any command issued to the drive will cause it to exit sleep and respond.

1.2.4. Power Supply Requirements

Cactus Technologies® Industrial SD products operate at a voltage range of 2.7V – 3.6V.

2.Product Specifications

For all the following specifications, values are defined at ambient temperature and nominal supply voltage unless otherwise stated.

2.1. System Environmental Specifications

Table 2-1. Environmental Specifications

		-807 SD Card
Temperature	Operating:	-25° C to +85° C (Standard)
		-40° C to +85° C (extended)
Humidity	Operating & Non-Operating:	8% to 95%, non-condensing
Acoustic Noise		0 dB
Vibration	Operating & Non-Operating:	15 G peak to peak maximum
Shock	Operating & Non-Operating:	50G max. operating; 1,000 G max. non-operating
Altitude (relative to sea level)	Operating & Non-Operating:	100,000 feet maximum

2.2. System Power Requirements

Table 2-2. Power Requirements

		-807 SD Card	
DC Input Voltage (VCC) 100 mV max. ripple (p-p)		2.7V – 3.6V	
		SD2.0	SD3.0
(Maximum Average Value) See Notes.	Sleep: Reading: Writing:	0.1mA 75mA 95mA	0.2mA 120mA 125mA

NOTES: All values quoted are typical values at room temperature and nominal supply voltage unless otherwise stated.

Sleep mode is specified under the condition that all drive inputs are static CMOS levels and in a "Not Busy" operating state and with the input clock stopped.

2.3. System Performance

All performance timings are typical values under normal operating conditions and assuming the drive controller is in the default (i.e., fastest) mode.

Table 2-3. Performance

	SD2.0	SD3.0
Read Transfer Rate	Up to 20MB/s	Up to 35MB/s
Write Transfer Rate	Up to 18MB/s	Up to 30MB/s

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2.4. System Reliability

Table 2-4. Reliability

Data Reliability	< 1 non-recoverable error in 10^{14} bits READ
Endurance (estimated TBW):	
4GB	Up to 240TB
8GB	Up to 480TB
16GB	Up to 960TB
32GB	Up to 1920TB

Note: estimated TBW is based on large block sequential writes; frequent random, small block writes may result in significantly lower TBW.

2.5. Physical Specifications

The following sections provide the physical specifications for Cactus Technologies® Industrial SD products.

2.5.1.   SD Card Physical Specifications

The Cactus Technologies® -807 Series SD Card has the form factor or 24mm x 32mm x2.1mm.

Please refer to SD Card Association Physical Specifications for details.

2.6. Card Capacity

Cactus Technologies® -807 Series SD Card products are available in capacities of 4,8,16 and 32 GBytes.

3.Interface Description

The following sections provide detailed information on the Cactus Technologies® Industrial SD Card interface.

3.1. SD Card Pin Assignments and Pin Type

The signal/pin assignments are listed in Table 3-5. Signals are active high unless otherwise specified.

Table 3-5. SD Card Pin Assignments and Pin Type

Pin #	SD Mode			SPI Mode		
	Signal Name	Pin Type [1]	Description	Signal Name	Pin Type	Description
1	CD/DAT3 [2]	I/O/PP [3]	Card Detect/ Data Line bit 3	CSN	I	Chip Select (active low)
2	CMD	PP	Command/Response	SDI	I	Serial Data In
3	VSS1	S	Supply Ground	VSS	S	Supply Ground
4	VDD	S	Supply Power	VDD	S	Supply Power
5	CLK	I	Clock	SCLK	I	Serial Clock
6	VSS2	S	Supply Ground	VSS2	S	Supply Ground
7	DAT0	I/O/PP	Data Line bit 0	SDO	O	Serial Data Out
8	DAT1	I/O/PP	Data Line bit 1	RSV		Reserved
9	DAT2	I/O/PP	Data Line bit 2	RSV		Reserved

1) S: Power; I: Input; O: output; PP: Bidirectional
2) DAT[1:3] are inputs on power up.
3) After power up, this pin is input with 50Kohm pullup. The host can disconnect the pullup by issuing a SET_CLR_CARD_DETECT command.

3.2. Signal Description

Table 3-6 describes the I/O signals. Signals whose source is the host are designated as inputs while signals that the SD Card sources are outputs. The SD Card logic levels conform to those specified in the *SDA Physical Layer Specification, version 1.1*.

Table 3-6. Signal Description

Signal Name	Dir.	Description
CD/DAT3 (SD mode) CSN (SPI mode)	I/O/PP I	This pin is an input with 50Kohm pullup at power up time and can be used for card detection or SPI mode selection. For regular data transfer, the host should disconnect the pullup by issuing a SET_CLR_CARD_DETECT command to the card. In SPI mode, this is an input for chip select.
CMD SDI	PP I	This pin is used by the host to send command to the card and is used by the card to send response back to the host. In SPI mode, this is serial data input to the card.
CLK	I	This is clock input to the card.
DAT0 SDO	I/O/PP O	This pin is input on power up. It will function as a data line once the host has issued a SET_BUS_WIDTH command. In SPI mode, this pin is serial data out from the card.
DAT1 DAT2	I/O/PP	These pins are inputs on power up. They will function as data lines once the host hast issued a SET_BUS_WIDTH command.

3.3. Bus Protocol

The Cactus -807 Series SD products bus protocol is compliant to *SDA Physical Layer Specifications, Version 2.0 and 3.0X*. Please refer to those documents for details about bus protocol and timing.

3.4. Electrical Specification

The following table defines all D.C. Characteristics for the Cactus -807 Series SD products. Unless otherwise stated, conditions are:

Vcc = 2.7V – 3.6V
Ta = -40°C to 85°C

3.4.1.   Absolute Maximum Ratings

Parameter	Symbol	MIN	MAX	Units
Storage Temperature	Ts	-55	100	ºC
Operating Temperature	T_A	-40	85	ºC
Vcc with respect to GND	Vcc	-0.3	3.6	V

3.4.2.   DC Characteristics

Parameter	Symbol	MIN	MAX	Units
Input Voltage	Vin	-0.5	Vcc + 0.5	V
Output Voltage	Vout	-0.3	Vcc + 0.3	V
Input Leakage Current	I_{LI}	-10	10	uA
Output Leakage Current	I_{LO}	-10	10	uA
Input/Output Capacitance	C_I/C_o		10	pF
Operating Current Idle @50MHz	I_{CC}		 1 130	mA

3.4.3.   AC Characteristics

3.4.3.1.   Bus Timing

Please refer to S*DA Physical Layer Specifications, Version 3.0X* for bus timing specifications for default mode and high speed mode.

4. Register Table

This section describes the values in the SD registers of Cactus SD products.

4.1. Operation Condition Register (OCR)

This 32-bit register stores the VDD voltage profile of the card. In addition, bit 31 is a status bit which is set to '1' if the card power up procedure has completed. When bit 31 is set, bit 30 will be valid and identifies whether the card is a Standard ('0') or High Capacity ('1') SD card.

OCR bit	VDD range	Standard SD	UHS-1 SD
[6:0]	Reserved	000 0000 b	000 0000 b
[7]	1.65V – 1.95V	0 b	0 b
[14:8]	2.0V – 2.6V	000 0000 b	000 0000 b
[23:15]	2.7V – 3.6V	1 1111 1111 b	1 1111 1111 b
[24] *	Switch to 1.8V accepted	0	1
[29:25]	Reserved	0 0000 b	0 0000 b
[30]	Card capacity status		
[31]	Card power status		

* This bit is set to 0 by default. If the card receives an ACMD41 with HCS=1(bit 3) and S18R=1 (bit 24), this bit will be set to 1.

4.2. Card Identification Register (CID)

This 128-bit register contains the identification information used during the card identification phase.

CID bit	Width	Name	Value	Field
[127:120]	8	Manufacturer ID	63h	MID
[119:104]	16	OEM/Application ID	4360h	OID
[103:64]	40	Product Name	CACTU	PNM
[63:56]	8	Product Revision	1	PRV
[55:24]	32	Product Serial Number	XXXXXXXXh	PSN

CID bit	Width	Name	Value	Field
[23:20]	4	Reserved	----	----
[19:8]	12	Manufacturing Date	MM YY	MDT
[7:1]	7	CRC7 check sum	XXXXXXXb	CRC
[0]	1	Not used, always '1'	1	----

4.3. Relative Card Address Register (RCA)

This 16-bit register stores the card address assigned by the host during the card identification phase. The default value is 0xB368. In SD mode, the value in this register is generated by a random number generator as per SDA specifications.

4.4. Card Specific Data Register (CSD)

This 128-bit register provides information on how to access the card content. It defines such information as the data format, error correction type, maximum access time, data transfer speed, etc. The various fields in the register differ depending on whether the card is high capacity (4GB or more) or standard capacity (2GB or less).

4.4.1.   High Capacity Card CSD

CSD bit	Width	Name	Field	Value	Note
[127:126]	2	CSD Structure	CSD_STRUCTURE	01 b	v.2.0
[125:120]	6	Reserved	---	---	---
[119:112]	8	Data read access time 1	TAAC	0E h	1ms (*3)
[111:104]	8	Data read access time 2	NSAC	00 h	(*3)
[103:96]	8	Max. data transfer rate	TRAN_SPEED	32 h 5Ah 0Bh 2Bh	
[95:84]	12	Card command classes	CCC	5F5h	*1
[83:80]	4	Max. read data block length	READ_BL_LEN	9 h	512bytes(*3)

CSD bit	Width	Name	Field	Value	Note
[79]	1	Partial block read allowed	READ_BL_PARTIAL	0 b	Not Supported(*3)
[78]	1	Write block misalignment	WRITE_BLK_MISALIGN	0 b	Not Supported (*3)
[77]	1	Read block misalignment	READ_BLK_MISALIGN	0 b	Not Supported (*3)
[76]	1	DSR implemented	DSR_IMP	0 b	Not supported (*3)
[75:70]	6	Reserved	---	---	---
[69:48]	22	Device size	C_SIZE	*2	*2
[47]	1	Reserved	---	0 b	---
[46]	1	Erase single block enable	ERASE_BLK_EN	1 b	Allowed (*3)
[45:39]	7	Erase sector size	SECTOR_SIZE	7Fh	64KB (*3)
[38:32]	7	Write protect group size	WP_GRP_SIZE	00h	(*3)
[31]	1	Write protect group enable	WP_GRP_ENABLE	0 b	Not Supported (*3)
[30:29]	2	Reserved	---	---	---
[28:26]	3	Write speed factor	R2W_FACTOR	010 b	4X (*3)
[25:22]	4	Max. write data block length	WRITE_BL_LEN	9 h	512bytes (*3)
[21]	1	Partial block write allowed	WRITE_BL_PARTIAL	0 b	Not Supported (*3)
[20:16]	5	Reserved	---	---	---
[15]	1	File format group	FILE_FORMAT_GRP	0 b	HD FAT (*3)
[14]	1	Copy flag	COPY	0 b	Not copied
[13]	1	Permanent write protection	PERM_WRITE_PROTECT	0 b	Not protected
[12]	1	Temporary write protection	TMP_WRITE_PROTECT	0 b	Not protected
[11:10]	2	File format	FILE_FORMAT	00 b	HD FAT (*3)
[9:8]	2	Reserved	---	00 b	None
[7:1]	7	CRC	CRC	---	---
[0]	1	Not used	---	1 b	---

1. Support command class 0,2,4,5,6,7,8,10. Not supported command class 1,3.
2. Varies according to memory type.
3. These parameters are set to fixed values to allow compatibility to v1.0 CSD.
4. Varies according to memory type.

4.5. SD Card Configuration Register (SCR)

This 64-bit register provides additional information about special features configured into the card.

SCR bit	Width	Name	Field	Value	Note
[63:60]	4	SCR structure	SCR_STRUCTURE	0000 b	V1.0-3.01
[59:56]	4	SD Card spec. version	SD_SPEC	0010 b	v2.0 or 3.0X
[55]	1	Data status after erase	DATA_STAT_AFTER_ERASE	0 b	zero after erase
[54:52]	3	SD security support	SD_SECURITY	010 b 011b 100b	
[51:48]	4	DAT bus width support	SD_BUS_WIDTH	0101 b	Support 1 / 4 bits
[47] *	1	Spec. Version 3.0 or higher	SD_SPEC3	0b 1b	SD2.0 SD3.0
[46:34]	9	Reserved	---	---	---
[33]	1	Set Block Count	CMD23_SUPPORT	0 or 1 b	Mandatory for UHS-1
[32]	1	Speed Class Control	CMD20_SUPPORT	0 or 1 b	Mandatory for SDXC
[31:0]	32	Reserved	---	---	---

* This bit is set to 0 for Standard SD card and 1 for SDXC card.

Appendix A.Ordering Information

Model KSXRY-807

Where:X is drive capacities:

```
4G ---------------- 4GB
8G ---------------- 8GB
16G -------------- 16GB
32G -------------- 32GB
```

Where: Y is temperature grade:

```
blank ------------ standard temp.
I ------------------- extended temp.
```

Example:

(1) 16GB SD standard temp. --- KS16GR-807
(2) 16GB SD extended temp. --- KS16GRI-807

Appendix B.Technical Support Services

B.1.Direct Cactus Technical Support

Email: tech@cactus-tech.com

Appendix C.Cactus Worldwide Sales Offices

Email: sales@cactus-tech.com

Email: americas@cactus-tech.com

Appendix D.Limited Warranty

I. WARRANTY STATEMENT

Cactus Technologies® warrants its Industrial Grade products only to be free of any defects in materials or workmanship that would prevent them from functioning properly for five years from the date of purchase or when rated TBW is exhausted, whichever occurs first. This express warranty is extended by Cactus Technologies Limited

II. GENERAL PROVISIONS

This warranty sets forth the full extent of Cactus Technologies®' responsibilities regarding the Cactus Technologies® Industrial Grade Flash Storage Products. Cactus Technologies®, at its sole option, will repair, replace or refund the purchase price of the defective product. Cactus Technologies® guarantees our products meet all specifications detailed in our product manuals. Although Cactus Technologies®' products are designed to withstand harsh environments and have the highest specifications in the industry, they are not warranted to never have failure and Cactus Technologies® does not warranty against incidental or consequential damages. Accordingly, in any use of products in life support systems or other applications where failure could cause injury or loss of life, the products should only be incorporated in systems designed with appropriate redundancy, fault tolerant or backup features.

III. WHAT THIS WARRANTY COVERS

For products found to be defective, Cactus Technologies® will have the option of repairing or replacing the defective product, if the following conditions are met:

A. The defective product is returned to Cactus Technologies® for failure analysis as soon as possible after the failure occurs.

B. An incident drive filled out by the user, explaining the conditions of usage and the nature of the failure, accompanies each returned defective product.

C. No evidence is found of abuse or operation of products not in accordance with the published specifications, or of exceeding storage or maximum ratings or operating conditions.

All failing products returned to Cactus Technologies® under the provisions of this limited warranty shall be tested to the product's functional and performance specifications. Upon confirmation of failure, each product will be analyzed, by whatever means necessary, to determine the root cause of failure. If the root cause of failure is found to be not covered by the above provisions, then the product will be returned to the customer with a report indicating why the failure was not covered under the warranty.

This warranty does not cover defects, malfunctions, performance failures or damages to the unit resulting from use in other than its normal and customary manner, misuse, accident or neglect; or improper alterations or repairs.

Cactus Technologies® reserves the right to repair or replace, at its discretion, any product returned by its customers, even if such product is not covered under warranty, but is under no obligation to do so.

IV. RECEIVING WARRANTY SERVICE

According to Cactus's warranty procedure, defective product should be returned only with prior authorization from Cactus Technologies Limited Please contact Cactus's Customer Service department with the following information: product model number and description, nature of defect, conditions of use, proof of purchase and purchase date. If approved, Cactus Technologies® will issue a Return Material Authorization or Product Repair Authorization number with return shipping instructions.