



**Industrial Grade
-809 Series
SD Card
Product Manual**

www.cactus-tech.com

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1.Introduction to Cactus Technologies Industrial Grade -809 Series SD Card Products

Features:

- Solid state design with no moving parts
- Up to 2GB of storage capacity
- Compatible with SDA Physical Layer Specifications, Version 2.0
- Speed class – Class 10
- Supports SPI mode
- S.M.A.R.T. equivalent drive status reporting

Overview:

- Supports 0-25MHz operation(default) or 0-50MHz operation(high speed)
- High reliability, MTBF > 4,000,000 hrs.
- Enhanced error correction, < 1 error in 10^{15} bits read
- Up to 20MB/s data rate (using 4 data lines)
- Voltage range 2.7V-3.6V

Cactus Technologies® SD products are low capacity solid-state flash memory products that complies with the SD Association standard. Cactus SD products provide up to 2GB 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 flash memory from Kioxia Corporation. In addition, they include 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® SD products are fully electrically compatible with the following specification:

- SD Card Association Physical Layer Specification, Versions 1.01, 1.1 and 2.0

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

		-809 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

		-809 SD Card
DC Input Voltage (VCC) 100 mV max. ripple (p-p)		2.7V – 3.6V
(Maximum Average Value) See Notes.	Idle: Reading: Writing:	5mA 75 mA 85 mA

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

Start Up Times	Reset to ready:	200 msec typical
Read Transfer Rate		Up to 20 MBytes/sec
Write Transfer Rate		Up to 20 MBytes/sec

2.4. System Reliability

Table 2-4. Reliability

Data Reliability	< 1 non-recoverable error in 10 ¹⁵ bits READ
Endurance (Estimated TBW):	
512MB	30TB
1GB	60TB
2GB	120TB

Note: TBW estimation is based on a workload of mostly sequential, large block writes. A workload of random, small block writes will reduce TBW significantly. TBW estimation also does not take into account data retention.

2.5. Physical Specifications

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

2.5.1. SD Card Physical Specifications

Cactus Technologies® SD Card has the form factor of 24mm x 32mm x2.1mm and conforms to SD Physical Layer Specifications.

Users are referred to official SD Physical Layer Specifications version 2.XX for further details.

2.6. Capacity Specifications

Cactus Technologies® -809 series SD card products come in capacities of 512M, 1G and 2G.

3. Interface Description

The following sections provide detailed information on the Cactus Technologies® Industrial SD products 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 interface 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 2.0*.

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/SDCLK	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 has issued a SET_BUS_WIDTH command.

3.3. Bus Protocol

The Cactus Technologies® SD products bus protocol is compliant to *SDA Physical Layer Specifications, Version 1.01, 1.1 and 2.0*. 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 Technologies® SD products. Unless otherwise stated, conditions are:

$$V_{cc} = 2.7V \text{ to } 3.6V$$
$$T_a = -40^{\circ}C \text{ to } 85^{\circ}C$$

3.4.1. Absolute Maximum Ratings

Parameter	Symbol	MIN	MAX	Units
Storage Temperature	T _s	-55	100	°C
Operating Temperature	T _A	-40	85	°C
Vcc with respect to GND	Vcc	-0.3	3.6	V

3.4.2. DC Characteristics

Parameter	Symbol	MIN	MAX	Units
Input Voltage	V _{in}	-0.5	V _{cc} + 0.5	V
Output Voltage	V _{out}	-0.3	V _{cc} + 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	I _{cc}			mA
Idle			5	
@50MHz			90	

3.4.3. AC Characteristics

3.4.3.1. Bus Timing

Please refer to *SDA Physical Layer Specifications, Version 2.XX* 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 Technologies® 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	Value
[6:0]	Reserved	000 0000 b
[7]	1.65V – 1.95V	0 b
[14:8]	2.0V – 2.6V	000 0000 b
[23:15]	2.7V – 3.6V	1 1111 1111 b
[29:24]	Reserved	00 0000 b
[30]	0 – Standard Capacity card	
[31]	Card power status	

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	01h	PRV
[55:24]	32	Product Serial Number	XXXXXXXXXh	PSN
[23:20]	4	Reserved	----	----
[19:8]	12	Manufacturing Date	YYM	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 0x0000. 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.

4.4.1. Standard Capacity Card CSD

CSD bit	Width	Name	Field	Value	Note
[127:126]	2	CSD Structure	CSD_STRUCTURE	00 b	v1.0-v1.1 v2.0 (<= 2GB)
[125:120]	6	Reserved	---	---	---
[119:112]	8	Data read access time 1	TAAC	2F h	20ms
[111:104]	8	Data read access time 2	NSAC	00 h	0 clocks
[103:96]	8	Max. data transfer rate	TRAN_SPEED	5A h	50Mbps/s
[95:84]	12	Card command classes	CCC	5F5h	*1
[83:80]	4	Max. read data block length	READ_BL_LEN	9 h	512bytes
[79]	1	Partial block read allowed	READ_BL_PARTIAL	1 b	Supported
[78]	1	Write block misalignment	WRITE_BLK_MISALIGN	0 b	Not Supported
[77]	1	Read block misalignment	READ_BLK_MISALIGN	0 b	Not Supported
[76]	1	DSR implemented	DSR_IMP	0 b	Not supported
[75:74]	2	Reserved	---	--	---
[73:62]	12	Device size	C_SIZE	*2	*2
[61:59]	3	Max. R_curr @ Vdd min	VDD_R_CURR_MIN	110 b	60mA
[58:56]	3	Max R_curr @ Vdd max	VDD_R_CURR_MAX	110 b	80mA
[55:53]	3	Max. W_curr @ Vdd min	VDD_W_CURR_MIN	110 b	60mA
[52:50]	3	Max W_curr @ Vdd max	VDD_W_CURR_MAX	110 b	80mA
[49:47]	3	Device size multiplier	C_SIZE_MULT	111 b	512
[46]	1	Erase single block enable	ERASE_BLK_EN	1 b	Allowed
[45:39]	7	Erase sector size	SECTOR_SIZE	111 b	8 write blocks

CSD bit	Width	Name	Field	Value	Note
[38:32]	7	Write protect group size	WP_GRP_SIZE	0 b	1 erase sector
[31]	1	Write protect group enable	WP_GRP_ENABLE	1 b	Supported
[30:29]	2	Reserved	---	---	---
[28:26]	3	Write speed factor	R2W_FACTOR	010 b	4X
[25:22]	4	Max. write data block length	WRITE_BL_LEN	9 h	512bytes
[21]	1	Partial block write allowed	WRITE_BL_PARTIAL	0 b	Not Supported
[20:16]	5	Reserved	---	---	---
[15]	1	File format group	FILE_FORMAT_GRP	0 b	HD FAT
[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
[9:8]	2	ECC code	ECC	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 1,3,9,11.

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	v1.0-2.0
[59:56]	4	SD Card spec. version	SD_SPEC	0010 b	v2.0
[55]	1	Data status after erase	DATA_STAT_AFTER_ERASE	1 b	one after erase
[54:52]	3	SD security support	SD_SECURITY	000 b	No security
[51:48]	4	DAT bus width support	SD_BUS_WIDTH	0101 b	Support 1 / 4 bits
[47]	1	Version 3.00 or higher	SD_SPEC3	1 b	Version 3.0x
[46-43]	4	Extended Security Support	EX_SECURITY	0000 b	None
[42:36]	7	Reserved	---	---	---

SCR bit	Width	Name	Field	Value	Note
[35:32]	4	Command Support Bits	CMD_SUPPORT	011 b	CMD20 – Speed Class Control CMD23 – Set Block Count
[31:0]	32	Reserved	---	---	---

5.SMART Information

Cactus Technologies® -809 series SD products provides remaining life information similar to the SMART feature in ATA drives. This information is provided in the 'reserved for manufacturers' section of the status register that can be read using ACMD13. The structure of the SMART information is as follows:

Offset	Description
25	Data structure version identifier, currently 1
27-26	Number of manufacturer marked defect blocks
29-28	Number of initial spare blocks (worst interleave unit)
31-30	Number of initial spare blocks (sum over all interleave units)
32	Percentage of remaining spare blocks (worst interleave unit)
33	Percentage of remaining spare blocks (all interleave unit)
35-34	Number of uncorrectable ECC errors (not including startup)
39-36	Number of correctable ECC errors (not including startup)
41-40	Lowest wear level class
43-42	Highest wear level class
45-44	Wear level threshold
51-46	Total number of block erases
53-52	Number of flash blocks, in units of 256blocks
55-54	Maximum flash block erase count target, in wear level class units
59-56	Power on count
63-60	Firmware version

Appendix A. Ordering Information

Model KSXRZT-809

Where: X is drive capacities:

512M ----- 512MB
1G ----- 1GB
2G ----- 2GB

Where Z is temperature:

Blank ----- Standard temperature (-25° C to +85° C)
I ----- Extended temperature (-40° C to +85° C)

Example:

(1) 512MB SD -----KS512MR-809
(2) 1GB SD Extended Temp ----- KS1GRI-809

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. 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 Industrial Grade SD products. In satisfaction of its obligations hereunder, Cactus Technologies®, at its sole option, will either repair, replace or refund the purchase price of the product.

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Cactus Technologies® products are not warranted to operate without failure. 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 back-up features.

III. WHAT THIS WARRANTY COVERS

For products found to be defective within five years of purchase, 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.

Cactus Technologies® may, at its discretion, ship repaired or rebuilt products identified in the same way as new products, provided such drives meet or exceed the same published specifications as new products. Concurrently, Cactus Technologies® also reserves the right to market any products, whether new, repaired, or rebuilt, under different specifications and product designations if such products do not meet the original product's specifications.

IV. RECEIVING WARRANTY SERVICE

According to Cactus Technologies® warranty procedure, defective product should be returned only with prior authorization from Cactus Technologies Limited. Please contact Cactus Technologies® 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 and instructions to ship the product back to us for service.