Cactus®
Technologies

Commercial Grade
-290M Series
microSD Card
Product Manual

www.cactus-tech.com

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1.Introduction to Cactus Technologies© Commercial Grade -290M Series microSD Card Products

Features:

- Solid state design with no moving parts

- Up to 128GB of storage

- Compatible with SDA Physical Layer Specifications, Version 3.01

- Supports SPI mode

- Supports 0-25MHz operation(DS) or 0-50MHz operation(DS) and UHS-1 SDR104 bus speed

- Speed grade – UHS-1 Class 1

- Powerful LDPC ECC

- Up to 85MB/s data rate (using 4 data lines)

- Voltage range 2.7V-3.6V

Overview:

Cactus Technologies© microSD products are solid-state flash memory products that comply with the SD Association standard. Cactus Technologies© microSD products provide up to 128GB 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© Commercial Grade microSD Card uses high quality 3D NAND flash memory from Kioxia Corporation. 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© microSD is fully electrically compatible with the following specification:

- SD Card Association Physical Layer Specification, Versions 1.01, 1.1, 2.0 and 3.01

1.2. Product Features

Cactus Technologies© Commercial microSD 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© Commercial microSD 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© Commercial microSD products today will continue to work with future Cactus Technologies© Commercial microSD products built with new flash technology without having to update or change host software.

1.2.2. Defect and Error Management

Cactus Technologies© Commercial microSD 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© Commercial microSD 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© Commercial microSD products extremely high reliability.

1.2.3.   Intelligent Power Management

Cactus Technologies© Commercial microSD 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© Commercial microSD products are single voltage products and 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

		-290M microSD 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

		-290M microSD Card
DC Input Voltage (VCC) 100 mV max. ripple (p-p)		3.3V ±10%
(Maximum Average Value) See Notes.	Sleep: Reading: Writing:	1 mA 135 mA 135 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

Read Transfer Rate		Up to 85 MBytes/sec
Write Transfer Rate **64GB** **128GB**		Up to 30 MBytes/sec Up to 45 MBytes/sec

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2.4. System Reliability

Table 2-4. Reliability

Data Reliability	< 1 non-recoverable error in 10^{15} bits READ
Endurance (estimated TBW): 64GB 128GB	192TB 384TB

Note: TBW rating is based on workload of large block, sequential writes; TBW will be substantially lower for workloads of random, small block writes.

2.5. Physical Specifications

Cactus Technologies© microSD Card has the form factor of 11mm x 15mm x1.0mm and conforms to SD Physical Layer Specifications. Users are referred to official SD Physical Layer Specifications and microSD Addendum version 2.XX for further details.

3.Interface Description

The following sections provide detailed information on the Cactus Technologies© Commercial microSD products interface.

3.1. microSD 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. microSD interface Pin Assignments and Pin Type

Pin #	SD Mode			SPI Mode		
	Signal Name	Pin Type [1]	Description	Signal Name	Pin Type	Description
1	DAT2	I/O/PP	Data Line bit 2	NC		No connect
2	CD/DAT3 [2]	I/O/PP [3]	Card Detect/ Data Line bit 3	CSN	I	Chip Select (active low)
3	CMD	PP	Command/Response	SDI	I	Serial Data In
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

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 3.01*.

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/SDCMD 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.

Signal Name	Dir.	Description
CLK/SDCLK	I	This is clock input to the card.
DAT0	I/O/PP	This pin is input on power up. It will function as a data line once the host has issued a SET_BUS_WIDTH command.
SDO	O	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

Cactus Technologies© microSD products bus protocol is compliant to *SDA Physical Layer Specifications, Version 1.01, 1.1, 2.0 and 3.01*. 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 Cactus Technologies© microSD products. Unless otherwise stated, conditions are:

Vcc = 2.7V – 3.3V
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	6.5	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	I_{CC}			mA
Sleep Mode			1	
@50MHz			140	

3.4.3.   AC Characteristics

3.4.3.1.   Bus Timing

Please refer to official S*DA Physical Layer Specifications* for bus timing specifications for default mode, high speed mode and UHS-1 SDR104 mode.

4. Register Table

This section describes the values in the SD registers of Cactus Technologies© microSD 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]	1.70V – 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]	Card capacity status	
[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	10h	PRV
[55:24]	32	Product Serial Number	XXXXXXXXh	PSN
[23:20]	4	Reserved	----	----
[19:8]	12	Manufacturing Date	YYM	MDT
[7:1]	7	CRC7 check sum	XXXXXXXb	CRC

CID bit	Width	Name	Value	Field
[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.   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	DF7h	*1
[83:80]	4	Max. read data block length	READ_BL_LEN	9 h	512bytes(*3)
[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)

CSD bit	Width	Name	Field	Value	Note
[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 and 11. 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	v1.0-5.0
[59:56]	4	SD Card spec. version	SD_SPEC	0011 b	V2.0 – 6.x
[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	(*1)
[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	SD 2.00 SD 3.00
[46:43]	4	Extended Security Support	EX_SECURITY	0000b	Not Supported
[42]	1	Spec. Version 4.00 or higher	SD_SPEC4	1b	SD 4.x
[41:38]	4	Spec. Version 5.00 or higher	SD_SPECX	0001b 0010b	SD 5.x SD 6.x
[37:36]	2	Reserved			
[35]	1	Extension Register Multi-Block	CMD58/59	0b	
[34]	1	Extension Register Single-Block	CMD48/49	1b	
[33]	1	Set Block Count	CMD23_SUPPORT	0b	
[32]	1	Speed Class Control	CMD20_SUPPORT	1b	
[31:0]	32	Reserved	---	---	---

Note 1: For High Capacity SD card, this field shall be set to 3 (Version 2.0). For Extended Capacity SD card, this field shall be set to 4 (Version 3.xx)

Appendix A.Ordering Information

Model KSXRI-290M

Where: X is drive capacities:

        64G ------------------ 64GB
        128G ---------------- 128GB

Where: I is temperature grade:

        blank -------------- standard
        I --------------------- extended

Example:

(1) 64GB microSD --- KS64GR-290M
(2) 64GB microSD extended temp. ---------------------------------- KS64GRI-290M

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 Commercial Grade products only to be free of any defects in materials or workmanship that would prevent them from functioning properly for two years from the date of purchase or when rated TBW is reached, 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 Commercial 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.

NOTWITHSTANDING ANYTHING ELSE IN THIS LIMITED WARRANTY OR OTHERWISE, THE EXPRESS WARRANTIES AND OBLIGATIONS OF SELLER AS SET FORTH IN THIS LIMITED WARRANTY, ARE IN LIEU OF, AND BUYER EXPRESSLY WAIVES ALL OTHER OBLIGATIONS, GUARANTIES AND WARRANTIES OF ANY KIND, WHETHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR INFRINGEMENT, TOGETHER WITH ANY LIABILITY OF SELLER UNDER ANY CONTRACT, NEGLIGENCE, STRICT LIABILITY OR OTHER LEGAL OR EQUITABLE THEORY FOR LOSS OF USE, REVENUE, OR PROFIT OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION PHYSICAL INJURY OR DEATH, PROPERTY DAMAGE, LOST DATA, OR COSTS OF PROCUREMENT OF SUBSTITUTE GOODS, TECHNOLOGY OR SERVICES. IN NO EVENT SHALL THE SELLER BE LIABLE FOR DAMAGES IN EXCESS OF THE PURCHASE PRICE OF THE PRODUCT, ARISING OUT OF THE USE OR INABILITY TO USE SUCH PRODUCT, TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

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 two 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 with shipping instructions.