



SMART
Embedded
Products

**SMART MODULAR
XL MLC SD Card
4 GB – 32 GB SDHC Memory Cards
64 GB SDXC Memory Cards**

SH9SDxxxGPHExMI01



January 2015, Rev A



REVISION HISTORY

Date	Revision	Section(s)	Description
January 2015	A	All	Initial release.



ESD Caution – Handling

Static electricity may be discharged through this disk subsystem. In extreme cases, this may temporarily interrupt the operation or damage components. To prevent this, make sure you are working in an ESD-safe environment. For example, before handling the disk subsystem, touch a grounded device, such as a computer case, prior to handling.

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1 GENERAL DESCRIPTION

1.1 Overview

SMART's high-performance Industrial Grade XL SD Memory Card product offering is specifically targeted at the needs of OEM markets such as networking, telecommunications, and data communications. SMART's SD products are also a natural fit for mobile and embedded computing, medical, automotive, and industrial applications.

SMART's XL SD products offer reliable, high performance operation in a commercial standard ultrasonic welded SD housing. They are available in 4 GB to 64 GB capacities.

Incorporating on-board error detection and correction algorithms and static and dynamic wear leveling techniques insure SMART's XL SD products provide years of reliable operation.

SMART has built its foundation by providing proven technology and quality products to the most demanding Fortune 100 OEMs. SMART engineers its products to perform at the highest degree of reliability and compatibility while backing these products with outstanding services and technology expertise.

About SMART

SMART is a leading independent manufacturer of memory and embedded modular sub-systems inclusive of board-level through system-level design, manufacturing, test, and fulfillment services. We offer more than 500 standard and custom products to leading OEMs in the computer, industrial, networking, and telecommunications industries worldwide.

1.2 Features

- **Form Factor:** SD
- **Interface:** Commercial standard SD [Part 1 Physical Layer Specification Ver3.01 Final]
- **Supports SD SPI Mode**
- **Bus Widths Supported:** x1 and x4
- **Supported Bus Speed Modes (using x4 bus width)**
 - **Default Speed Mode:** 3.3 V signaling, up to 25 MHz, up to 12.5 MB/s
 - **High Speed Mode:** 3.3 V signaling, up to 50 MHz, up to 25 MB/s
 - **SDR12:** 1.8 V signaling, up to 25 MHz SDR, up to 12.5 MB/s
 - **SDR25:** 1.8 V signaling, up to 50 MHz SDR, up to 25 MB/s
 - **SDR50:** 1.8 V signaling, up to 100 MHz SDR, up to 50 MB/s
 - **SDR104:** 1.8 V signaling, up to 208 MHz, up to 104 MB/s
 - **DDR50:** 1.8 V signaling, up to 50 MHz DDR, up to 50 MB/s
- NOTE: Timing varies between UHS-I (1.8 V) and Standard (3.3 V) signaling.
- **NAND Technology:** Multi-Level Cell (MLC)
- **Capacity:**
 - **SDHC:** 4 GB to 32 GB
 - **SDXC:** 64 GB
- **Low Power Dissipation (64 GB SDR104 Mode):**
 - **Read:** 101 mA (Typ.)
 - **Write:** 146 mA (Typ.)
- **Temperature:**
 - **Operating:** -40°C to 85°C
 - **Storage:** -45°C to 85°C
- **Input Power:** 2.7 V to 3.6 V
- **Dimensions:** 32 mm(L) x 24 mm(W) x 2.1 mm(H)
- **ESD protection:** +4 kV/-4 kV in contact pads

1.3 Unique Features

- Implements Global Static and Dynamic Wear Leveling for longer life
- Bad Block Management improves the SD content reliability
- Supports Advanced Error Detection/Correction for superior data reliability
- Device health information (erase count, bad block and spare count) is available via vendor specific command (Application Note available upon request)
- Customized CMD56 for querying SD health status
- Command list supports [Part 1 Physical Layer Specification Ver3.01 Final] definitions
- Copyright Protection Mechanism: fully-compliant to the highest security SDMI Standard
- Supports CPRM (Content Protection for Recordable Media) for recorded content
- Power Loss Protection
- Password Protection of cards (optional)
- Provides a mechanical switch for Write Protection
- Built-in write protection features (permanent and temporary)
- RoHS compliant and Low Halogen

2 OPERATIONAL CHARACTERISTICS

All listed values are typical unless otherwise stated.

2.1 Performance

Table 1: Performance Characteristics (Sequential)

Item	Bus Configuration	Capacity	Performance (MB/s) ⁽¹⁾
Sequential Read	SDR104	4 GB	90
	DDR50	4 GB	47
	SDR104	8 GB	94
	DDR50	8 GB	47
	SDR104	16 GB	90
	DDR50	16 GB	47
	SDR104	32 GB	90
	DDR50	32 GB	47
	SDR104	64 GB	99
	DDR50	64 GB	47
Sequential Write	SDR104	4 GB	11
	DDR50	4 GB	9
	SDR104	8 GB	21
	DDR50	8 GB	15
	SDR104	16 GB	38
	DDR50	16 GB	22
	SDR104	32 GB	33
	DDR50	32 GB	16
	SDR104	64GB	20
	DDR50	64 GB	14

(1) Performance measured using Testmetrix VTE-4100.

2.2 Power

Table 2: Power Requirements

Parameter	Symbol	Minimum	Typical	Maximum	Units
Supply Voltage	VCC	2.7	3.3	3.6	V
Operating Current	I _{CC1}	-	101	110	mA
Standby Current	I _{SB}	-	234	240	μA
Input Leakage Current	I _{LI}	-10	-	10	μA
Output Leakage Current	I _{LO}	-10	-	10	μA

2.3 Reliability

Table 3: Reliability Characteristics

Item	Value
Mean Time Between Failures (MTBF)	> 3 Million hours
Data Reliability	< 1 Non-Recoverable Error in 10 ¹⁴ bits read
Data Retention (@ 40°C)	10 years > 90% life remaining
	1 year < 10% life remaining
Endurance ⁽¹⁾	7 TBW (4 GB); 14 TBW (8 GB); 28 TBW (16 GB); 56 TBW (32 GB); 112 TBW (64 GB)
Error Correction / Error Detection	Up to 40 bits for every 1 KB of user data

(1) Endurance is directly related to the application specific workload.

2.4 Endurance

- **Static and Dynamic Wear Leveling:** This feature eliminates overstressing flash media by spreading the data writes across all flash physical address space, including logical areas that are not written by the user. The data is wear leveled across the entire drive.
- **ECC:** SD XL products utilize BCH ECC to provide correction of up to 40 random single-bit errors per 1 KB of user data.
- **Bad Block Management:** This feature tracks all manufacturing and run-time bad blocks of flash media and replaces them with new ones from the spare pool.

2.5 Mean Time Between Failures (MTBF)

SMART Modular Technologies has derived the following reliability statistics using **Telcordia SR-332, Issue 2 - Parts Count Method** and based upon numerous specifics related to and including: internal component packaging, pin configurations, component density, and internal component substrate architecture. Product reliability modeling for SMART Modular Technologies is based upon continual usage of the product, within accepted normal operating parameters. Compromise of the published normal operating parameters will adversely affect the product life-span reliability model.

Table 4: MTBF Values - Telcordia SR-332, Issue 2 - Parts Count Method at 50°C

Drive	MTBF (Hours)
All Capacities	> 3 million

2.6 Environmental Conditions

Table 5: Environmental Conditions and Test Conditions

Parameter	Value
Shock – Non-Operating	1500g half-sine, 0.5 msec, 1 shock along each axis, X,Y,Z in each direction
Shock – Operating	50g half-sine, 11 msec, 3 shocks along each axis, X, Y, and Z
Vibration – Operating	15g rms 10-2000 Hz, 3 axis
Humidity	5% to 95%, non-condensing, relative humidity
Operating Temperature – Industrial	-40°C to 85°C
Storage Temperature	-40°C to 85°C

2.7 Physical Characteristics

Table 6: Physical Characteristics

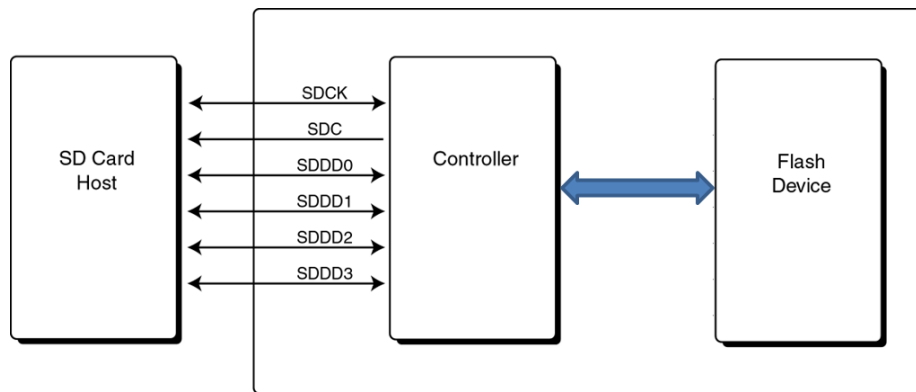
Parameter	Value
Length	32.0 mm [1.26 in]
Width	24.0 mm [0.95 in]
Height	2.1 mm [0.08 in]
Weight (max)	2.0 g [0.07 oz]

3 PRODUCT DESCRIPTION

SMART's SD XL Memory Card product line is offered in an SDA approved housing with an advanced 9-pin connector. It contains a controller and at least one flash memory device. The on-board controller interfaces with a SD Card Host allowing data to be written to and read from the flash memory device(s).

3.1 Functional Block Diagram

Figure 1: SD XL Block Diagram



4 REGULATORY COMPLIANCE

The SMART Modular SD product complies with the regulatory requirements identified in the following table.

Table 7: Regulatory Description

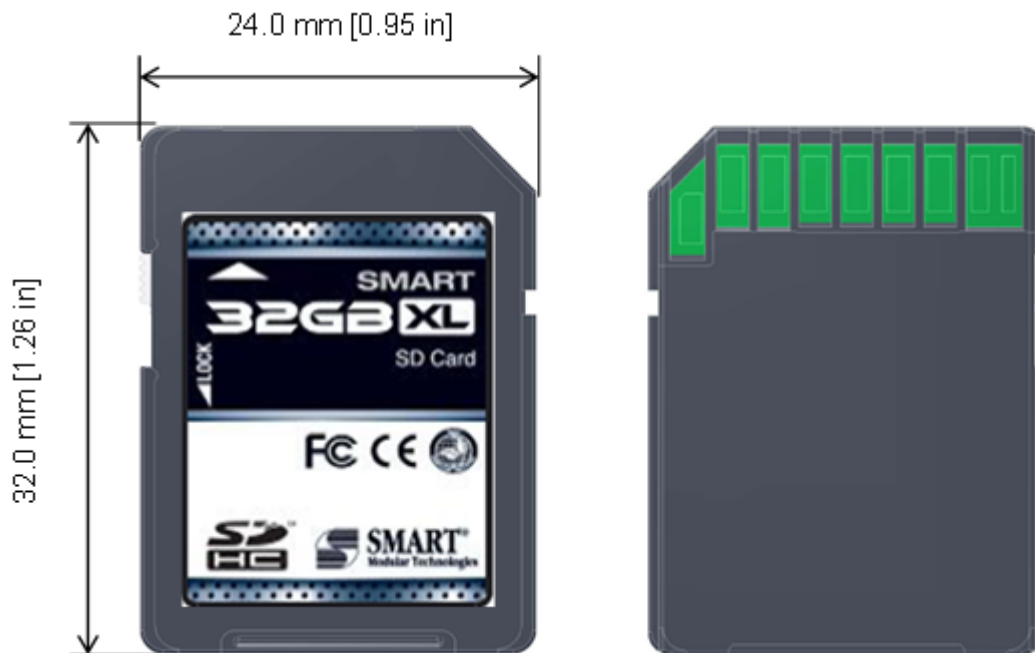
Regulation	Compliance (Country/Region)
EMC	FCC Part 15, Class B (USA); IC ICES-003, Class B (Canada); EMC Directive 2004/108/EC - EN 55022, Class B and EN 55024 (EU), CISPR 22, Class B and CISPR 24 (International)
RoHS	RoHS Directive 2011/65/EU - EN 50581 (EU)



5 MECHANICAL SPECIFICATION

5.1 Mechanical Dimensions

Figure 2: SD XL Dimensions



5.2 Label

Below is an example of the standard label for the SMART XL SD card.

Figure 3: SD XL Label



6 ELECTRICAL SPECIFICATION

6.1 Electrical Interface

The SMART SD XL Memory Cards are fully compliant with the SD specification (V1.1 and V1.01). The following table describes the I/O signals of the card. Signals whose source is the Host are designated as inputs (I) while signals that the SD Card sources are outputs (O). Bi-directional signals are designated as Input/Output (I/O).

Table 8: Pin Out Assignments and Pin Types

Pin	Signal Name	Signal Type	Signal Description
1	SDDD3	I/O,PP	SD Interface Bus [3]
2	SDC	I/O,PP	SD Command Line
3	GND	S	Ground
4	VCC	S	Power Supply for SD Interface
5	SDCK	I	SD Synchronous Clock Input
6	GND	S	Ground
7	SDDD0	I/O,PP	SD Interface Bus [0]
8	SDDD1	I/O,PP	SD Interface Bus [1]
9	SDDD2	I/O,PP	SD Interface Bus [2]

(1) S = power supply; I = input; O = output using push-pull drivers; PP = I/O using push-pull drivers

6.2 Absolute Maximum Ratings

Table 9: Absolute Maximum Ratings⁽¹⁾

Symbol	Parameter	Minimum Value	Maximum Value	Unit
V _{CC3}	3.3 V Supply Voltage	2.7	3.6	V
V _{IN3}	3.3 V Input Voltage	GND - 0.3	V _{CC} + 0.3	V
I _{IN3}	Operating Current	-	250	μA
I _{STB}	Standby Current	-	1000	μA
T _A	Operating Temperature	-40	+85	°C
T _{STG}	Storage Temperature	-40	+85	°C

(1) Stress beyond the Absolute Maximum Rating conditions may result in permanent damage to the device. These are stress ratings only and functional operation should be restricted to those indicated in the operational sections of this specification. Exposure to conditions beyond recommended, up to and including the Absolute Maximum Rating conditions, for extended periods may affect device reliability.

6.3 Recommended Operating Conditions

Table 10: Recommended Operating Conditions

Symbol	Parameter	Minimum Value	Nominal Value	Maximum Value	Units
V _{CC3}	3.3 V Supply Voltage	2.7	3.3	3.6	V
T _A	Operating Temperature	-40	room	+85	°C

6.4 DC Characteristics (High Speed Mode)

Table 11: DC Characteristics

Parameter	Typical ⁽¹⁾	Max	Units
Active Read Current	101	110	mA
Active Write Current	146	156	mA
Pre-Initialization Standby Current	20	25	μA
Post-Initialization Standby Current	234	240	μA

(1) Typical values are for High Speed operation mode.

7 POWER CYCLING

To insure the highest level of data reliability during an unexpected loss of power, SMART's XL SD cards require the host systems to comply with the slew rate specification noted below.

Figure 4: SD XL Slew Rate

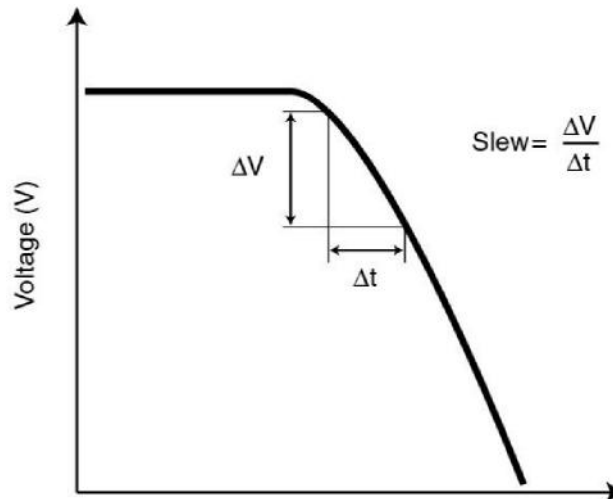


Table 12: Power Cycling

Parameter	Max Value	Unit
Slew Rate	4.2	V/ms

8 DC CHARACTERISTICS

8.1 Bus Signal Line Loading

Table 13: Bus Signal Line Loading

Symbol	Parameter	Ratings	Unit
R_{CMD}	Pull-Up Resistor value for SDC Line	10 – 100	k Ω
R_{DAT}	Pull-Up Resistor value for SDD Line	10 – 100	k Ω
C_L	Bus Line Capacitance	40	pF
C_{card}	Card Pin Capacitance	10	pF
L_{SI}	Signal Line Inductance	16	nH

Figure 5: Bus Signal Level

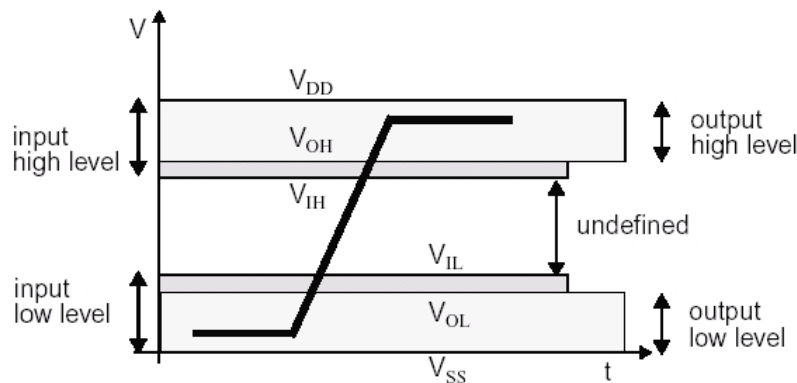


Table 14: Bus Operating Conditions for 3.3 V Signaling

Symbol	Parameter	Min	Max	Unit
V_{DD}	Supply Voltage	2.7	3.6	V
V_{OH}	Output High Voltage	$0.75 * V_{DD}$	-	V
V_{OL}	Output Low Voltage	-	$0.125 * V_{DD}$	V
V_{IH}	Input High Voltage	$0.625 * V_{DD}$	$V_{CC} + 0.3$	V
V_{IL}	Input Low Voltage	$V_{SS} - 0.3$	$0.25 * V_{DD}$	V
t_{PUP}	Power Up Time (0 V to V_{DD} min)	-	250	ms

9 AC CHARACTERISTICS

9.1 Interface Timing

Figure 6: Bus Timing (High Speed)

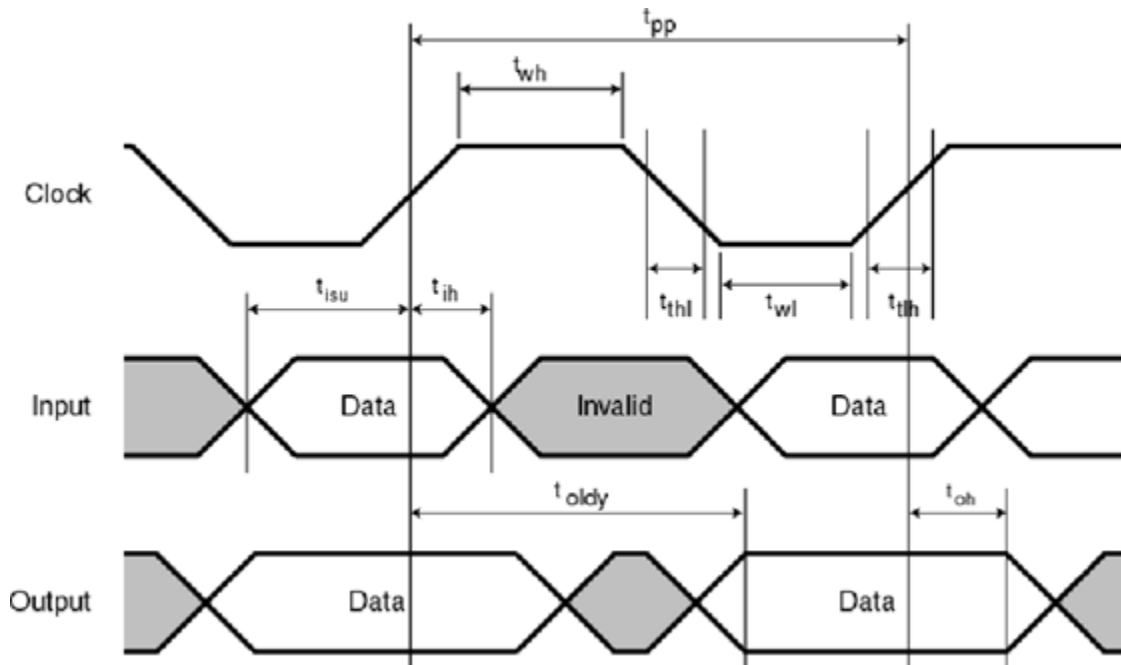
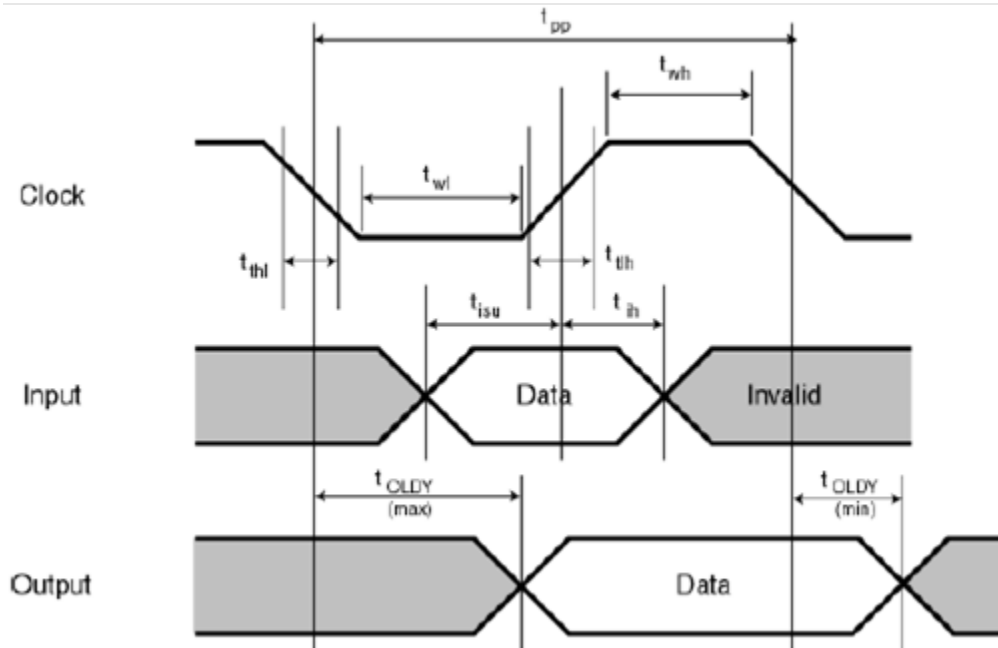


Table 15: Bus Timing (High Speed)

Symbol	Parameter	Min	Max	Unit	Remark
t_{pp}	Clock frequency data transfer mode	0	50	MHz	$C_L \leq 10$ pF
t_{wl}	Clock low time	7		ns	$C_L \leq 10$ pF
t_{wh}	Clock high time	7		ns	$C_L \leq 10$ pF
t_{tlh}	Clock rise time		3	ns	$C_L \leq 10$ pF
t_{thl}	Clock fall time		3	ns	$C_L \leq 10$ pF
t_{isu}	Input setup time	6		ns	$C_L \leq 10$ pF
t_{ih}	Input hold time	2		ns	$C_L \leq 10$ pF
t_{oldy}	Output delay time		14	ns	$C_L \leq 10$ pF
t_{oh}	Output hold time	2.5		ns	$C_L \leq 10$ pF

Figure 7: Bus Timing (Default Mode)

Table 16: Bus Timing (Default Mode)

Symbol	Parameter	Min	Max	Unit	Remark
f_{PP}	Clock frequency (data transfer mode)	0	25	MHz	$C_L \leq 10 \text{ pF}$
f_{OD}	Clock frequency (identification mode)	0	400	KHz	$C_L \leq 10 \text{ pF}$
t_{WL}	Clock low time	10	-	ns	$C_L \leq 10 \text{ pF}$
t_{WH}	Clock high time	10	-	ns	$C_L \leq 10 \text{ pF}$
t_{TLH}	Clock rise time	-	10	ns	$C_L \leq 10 \text{ pF}$
t_{THL}	Clock fall time	-	10	ns	$C_L \leq 10 \text{ pF}$
t_{ISU}	Input setup time	5	-	ns	$C_L \leq 10 \text{ pF}$
t_{IH}	Input hold time	5	-	ns	$C_L \leq 10 \text{ pF}$
$t_{ODLY-tran}$	Output delay time (data transfer mode)	0	14	ns	$C_L \leq 10 \text{ pF}$
$t_{ODLY-ident}$	Output delay time (identification mode)	0	50	ns	$C_L \leq 10 \text{ pF}$

10 REGISTERS

The registers are used in the SMART SD cards are shown in the table below. These registers are described in the sections that follow.

Table 17: Supported SD Registers

Name	Width	Description
CID	128	Card Identification
RCA	16	Relative Card Address
CSD	128	Card Specific Data
SCR	64	SD Configuration Register
OCR	32	Operation Condition Register
SSR	512	SD Status Register

10.1 Card Identification Register (CID)

The Card Identification (CID) register is 128 bits wide. It contains the information used during the card identification phase. Every individual flash card will have a unique identification number. The fields for the CID register are presented in the following table.

Table 18: Card Identification Register (CID) Fields

Bits	Width	Name	Field	Value
[127:120]	8	Manufacturer ID	MID	0x27
[119:104]	16	OEM/Application ID	OID	0x5048
[103:64]	40	Product Name	PNM	-- ⁽¹⁾
[63:56]	8	Product Revision	PRV	0x30
[55:24]	32	Product Serial Number	PSN	-- ⁽¹⁾
[23:20]	4	Reserved	--	--
[19:8]	12	Manufacturing Date	MDT	-- ⁽¹⁾
[7:1]	7	CRC7 checksum	CRC	--
[0]	1	Not used, always 1	-	0x1

(1) Defined by default setting.

10.2 Relative Card Address (RCA)

The Relative Card Address (RCA) register is 16 bits wide. It contains the card address assigned by the host during the card identification. This address is used for the addressed host-card communication after the identification procedure. The default value of the RCA register is 0x0000.

10.3 Card Specific Data (CSD)

The Card Specific Data (CSD) register is 128 bits wide. It provides information on how to access the card contents. The fields for the CSD register are presented in the following table.

Table 19: Card Specific Data (CSD) Fields

Bits	Width	Name	Field	Value
[127:126]	2	CSD structure	CSD_STRUCTURE	01b
[125:120]	6	Reserved	---	00 0000b
[119:112]	8	Data read access time 1	TAAC	0Eh
[111:104]	8	Data read access time 2	NSAC	00h
[103:96]	8	Max. bus clock frequency	TRAN_SPEED	-- ⁽¹⁾
[95:84]	12	Card command classes	CCC	5B5h ⁽²⁾
[83:80]	4	Max read block data length	READ_BL_LEN	9h ⁽³⁾
[79]	1	Partial block read allowed	READ_BL_PARTIAL	0b
[78]	1	Write block misalignment	WRITE_BLK_MISALIGN	0b
[77]	1	Read block misalignment	READ_BLK_MISALIGN	0b
[76]	1	DSR implemented	DSR_IMP	0b
[75:70]	6	Reserved	---	00 0000b
[69:48]	22	Device size	C_SIZE	-- ⁽⁴⁾
[47]	1	Reserved	---	0b
[46]	1	Erase single block enable	ERASE_BLK_EN	1b
[45:39]	7	Erase sector size	SECTOR_SIZE	0x7F
[38:32]	7	Write protect group size	WP_GRP_SIZE	000 0000b
[31]	1	Write protect group enable	WP_GRP_ENABLE	0b
[30:29]	2	Reserved	---	00b
[28:26]	3	Write speed factor	R2W_FACTOR	010b
[25:22]	4	Max write data block length	WRITE_BL_LEN	9h ⁽³⁾
[21]	1	Partial block write allowed	WRITE_BL_PARTIAL	0b
[20:16]	5	Reserved	---	0 0000b
[15]	1	File format group	FILE_FORMAT_GRP	0b
[14]	1	Copy Flag	COPY	0b
[13]	1	Permanent write protection	PERM_WRITE_PROTECT	0b
[12]	1	Temporary write protection	TMP_WRITE_PROTECT	0b
[11:10]	2	File Format	FILE_FORMAT	0b
[9:8]	2	Reserved	---	00b
[7:1]	7	CRC	CRC	--
[0]	1	Not used, always '1'	---	1

- (1) The default value is 32h. Value depends on the Card Type and mode.
- (2) Support command class: 0, 2, 4, 5, 6, 7, and 8. Include: Basic, Block Read/Write, Erase, Write-Protection, Lock Card, and Application support. Not supported command class: 1 and 3. Include: Stream Read/Write.
- (3) This field is fixed to 9h, which indicates READ_BL_LEN / WRITE_BL_LEN = 512 Byte.
- (4) This field depends upon the flash used with the controller.

10.4 SD Configuration Register (SCR)

The SD Configuration Register (SCR) is 64 bits wide. It is another configuration register. SCR provides information about the SD card's special features that were configured into the given card. The fields for the SCR register are presented in the following table.

Table 20: SD Configuration Register (SCR) Fields

Bits	Width	Name	Field	Value
[63:60]	4	SCR structure	SCR_STRUCTURE	0000b
[59:56]	4	SD card spec. version	SD_SPEC	0010b
[55]	1	Data status after erase	DATA_STAT_AFTER_ERASE	0b
[54:52]	3	SD security support	SD_SECURITY	011b ^{4-32GB}
				100b ^{64GB}
[51:48]	4	DAT bus width support	SD_BUS_WIDTHS	0101b
[47]	1	Spec. version 3.00 or higher	SD_SPEC3	1b
[46:43]	4	Extended Security Support	EX_SECURITY	0000b
[42:34]	9	Reserved	-	-
[33:32]	2	Command Support bits	CMD_SUPPORT	10b ^{4-32GB}
				11b ^{64GB}
[31:0]	32	Reserved	-	-

10.5 Operation Condition Register (OCR)

The Operation Condition Register (OCR) register is 32 bits wide. The fields for the OCR register are presented in the following table.

Table 21: Operation Condition Register (OCR) Fields

Bits	Width	VDD Voltage Window	Value (Binary)
[0:3]	4	Reserved	0000
[4]	1	Reserved	0
[5]	1	Reserved	0
[6]	1	Reserved	0
[7]	1	Reserved for Low Voltage Range	0
[8]	1	Reserved	0
[9]	1	Reserved	0
[10]	1	Reserved	0
[11]	1	Reserved	0
[12]	1	Reserved	0
[13]	1	Reserved	0
[14]	1	Reserved	0
[15]	1	2.7-2.8	1

Bits	Width	VDD Voltage Window	Value (Binary)
[16]	1	2.8-2.9	1
[17]	1	2.9-3.0	1
[18]	1	3.0-3.1	1
[19]	1	3.1-3.2	1
[20]	1	3.2-3.3	1
[21]	1	3.3-3.4	1
[22]	1	3.4-3.5	1
[23]	1	3.5-3.6	1
[24]	1	Switching to 1.8V Accepted (S18A)	--- ⁽³⁾
[25:29]	5	Reserved	0 0000
[30]	1	Card Capacity Status (CCS)	1 ⁽¹⁾
[31]	1	Card power up status bit	1 ⁽²⁾

- (1) This bit is valid only when the card power up status bit is set.
- (2) This bit is set to LOW if the card has not finished the power up routine.
- (3) Only UHS-I card supports this bit.

10.6 SD Status Register

The SD Status Register (SSR) is 512 bits wide and provides information about the SD card's proprietary and may be used for application-specific usage. The fields for the SSR register are presented in the following table.

Table 22: SD Status Register (SSR) Fields

Bits	Width	Field	Value
[511:510]	2	DAT_BUS_WIDTH	10b
[509]	1	SECURED_MODE	0b
[508:502]	7	Reserved	--
[501:496]	6	Reserved	--
[495:480]	16	SD_CARD_TYPE	0000b
[479:448]	32	SIZE_OF_PROTECTED_AREA	-- ⁽¹⁾
[447:440]	8	SPEED_CLASS	0x04
[439:432]	8	PERFORMANCE_MOVE	0x00
[431:428]	4	AU_SIZE	0x9 (4MB) ^{4-32GB}
			0xF (64MB) ^{64GB}
[427:424]	4	Reserved	--
[423:408]	16	ERASE_SIZE	0x0200 (512 AU)
[407:402]	6	ERASE_TIMEOUT	0x2A (42 sec)
[401:400]	2	ERASE_OFFSET	10b (2 sec)
[399:396]	4	UHS_SPEED_GRADE	0001b (10MB/s and above) ^{4/8GB}
			0003b (30MB/s and above) ^{16/32/64GB}
[395:392]	4	UHS_AU_SIZE	0xF (64MB)
[391:312]	80	Reserved	--
[311:0]	312	Reserved	Reserved for manufacturer

(1) Value depends on the Card Type and mode.

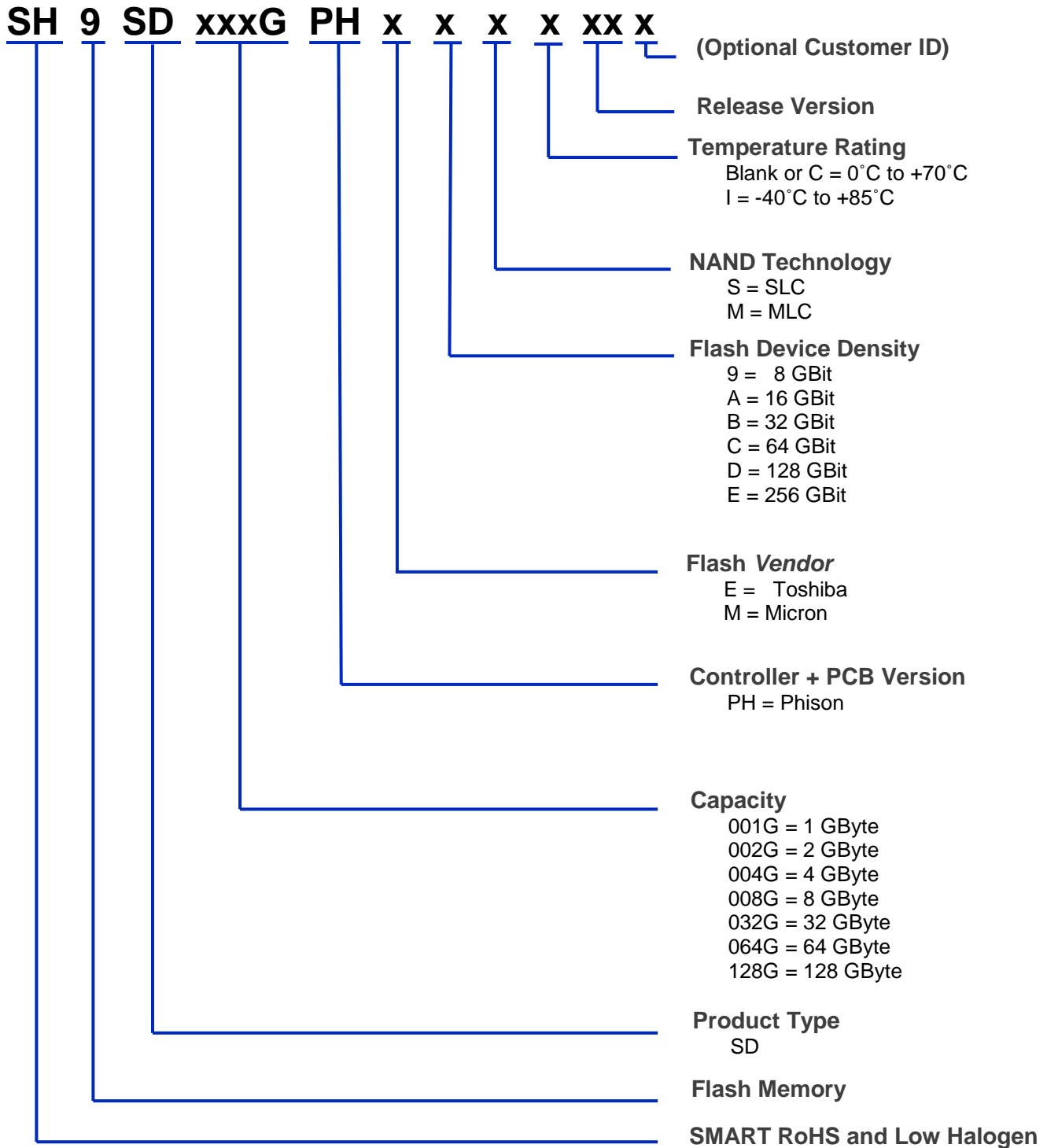
11 PART NUMBERS

11.1 Part Numbering Information

Table 23: Part Numbering Information

SMART Part Number	Capacity	Logical Capacity	Unformatted Capacity
SH9SD004GPHEBMI01	4 GB	3,887,104	7,592
SH9SD008GPHECMI01	8 GB	7,782,400	15,200
SH9SD016GPHEDMI01	16 GB	15,646,720	30,560
SH9SD032GPHEEMI01	32 GB	31,342,592	61,216
SH9SD064GPHEEMI01	64 GB	62,717,952	122,496

11.2 Part Number Decoder



DECLARATION OF CONFORMITY

Responsible Party Name: SMART Modular Technologies, Inc.
Address: 39870 Eureka Drive
Newark, CA 94560-4809, USA
Phone: +1-510-623-1231

Hereby declares that the products:

SH9SDxxxGPHExMxxx

to which this declaration relates are in conformity with the following Directives and other normative documents:

RoHS Directive 2011/65/EU

Restriction of the use of certain hazardous substances in electrical and electronic equipment

- **EN 50581:2012**
Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

Name: Jeffrey Milano
Title: Director, Worldwide Quality
Date: January 28, 2015 11:04 AM

Representative in the European Union (for regulatory topics only):

Mr. Graham Kyle
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