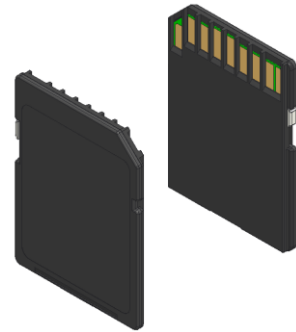


SMART
Embedded
Products

**SMART MODULAR
XL+ SLC SD Card
SDSC Memory Cards**
SH9SDxxxxSBlxSxxx



August 2015, Rev B



www.smartm.com

REVISION HISTORY

Date	Revision	Section(s)	Description
July 2015	A	All	Initial release
August 2015	B	Table 1 Table 23	Performance numbers updated Capacity numbers updated



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 an industry standard ultrasonic welded SD housing. They are available in 512 MB to 2 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 & 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:** Industry standard SD [Part 1 Physical Layer Specification Ver2.0 Final]
- **Supports SD SPI Mode**
- **Bus Widths Supported:** x1 and x4
- **Supported Bus Speed Modes (using x4 bus width)**
 - **DS (Default Speed) Mode:** 3.3 V signaling, up to 25 MHz
 - **HS (High Speed) Mode:** 3.3 V signaling, up to 50 MHz
- **NAND Technology:** Single Level Cell (SLC)
- **Capacity:**
 - SDSC: 512 Mbytes, 1 Gbytes and 2 GBytes
- **Low Power Dissipation (High Speed Mode):**
 - **Read:** 30 mA (Typ.)
 - **Write:** 36 mA (Typ.)
- **Operating Temperature:**
 - **Commercial:** 0°C to +70°C
 - **Industrial:** -40°C to +85°C
- **Input Power:** 2.7 V – 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
- 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)
- Command list supports [Part 1 Physical Layer Specification Ver2.0 Final] definitions
- 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
- Maximum Program State Busy Time (Shutdown Time) $\leq 60\text{msec}$

2. OPERATIONAL CHARACTERISTICS

All listed values are typical unless otherwise stated.

2.1. Performance

Table 1: Performance Characteristics

Item	Bus Configuration	Capacity	Performance ¹ (MB/s)
Sequential Read	High Speed (3.3 V, 50 MHz)	512 MB	24
		1 GB	24
		2 GB	24
Sequential Write	High Speed (3.3 V, 50 MHz)	512 MB	11
		1 GB	12
		2 GB	17

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}	-	34.2	36.6	mA
Standby Current	I _{SB}	-	85	86	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)	>1 Million hours
Data Reliability	< 1 Non-Recoverable Error in 10 ¹⁴ bits read
Data Retention	10 years > 90% life remaining
	1 year < 10% life remaining
Endurance ¹	3 TBW (512MB); 6 TBW (1 GB); 12 TBW (2 GB)
Error Correction / Error Detection	Up to 32 bits for every 1 Kbyte of user data (512 MB and 1 GB) Up to 24 bits for every 1 Kbyte of user data (2 GB)

1. Endurance is directly related to the application specific workload

2.4. Endurance

- **Static & 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 24 (2 GB) or 32 (512 MB and 1 GB) random single-bit errors per 1 KByte 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 Technology 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 Technology 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	> 1 Million hours

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 – Commercial	0°C to 70°C
Operating Temperature - Industrial	-40°C to 85°C
Storage Temperature	-40°C to 85°C

2.7. Physical Characteristics

Table 6: Physical Characteristics

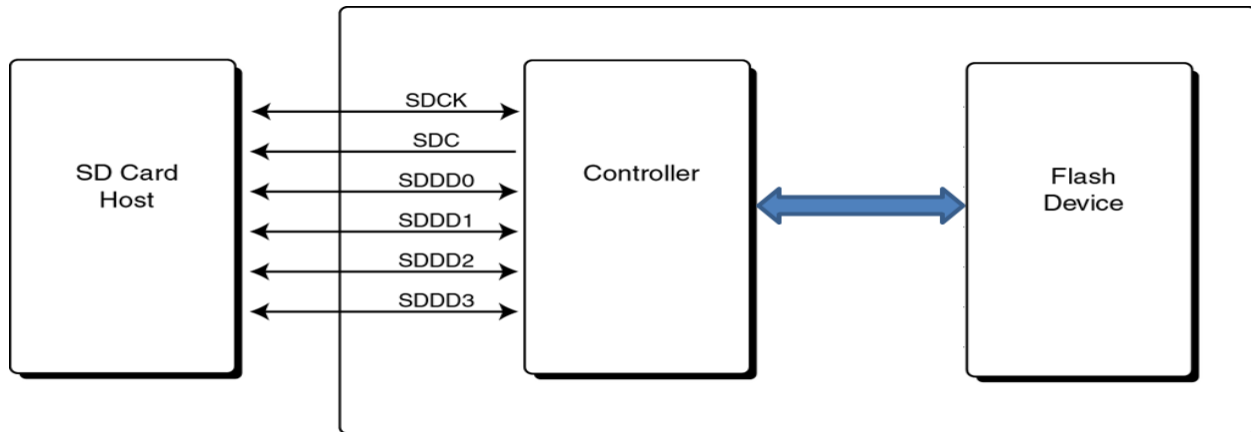
Parameter	Value
Length	32.0 mm [1.26 in]
Width	24.0 mm [0.95 in]
Height	2.1 mm [0.08 in]
Weight (max)	2.0 g [0.07 oz]

3. PRODUCT DESCRIPTION

SMART's SD XL+ Memory Card product line is offered in a UL 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 XL+ SD product complies with the regulatory requirements identified in the following table.

Table 7: Regulatory Description

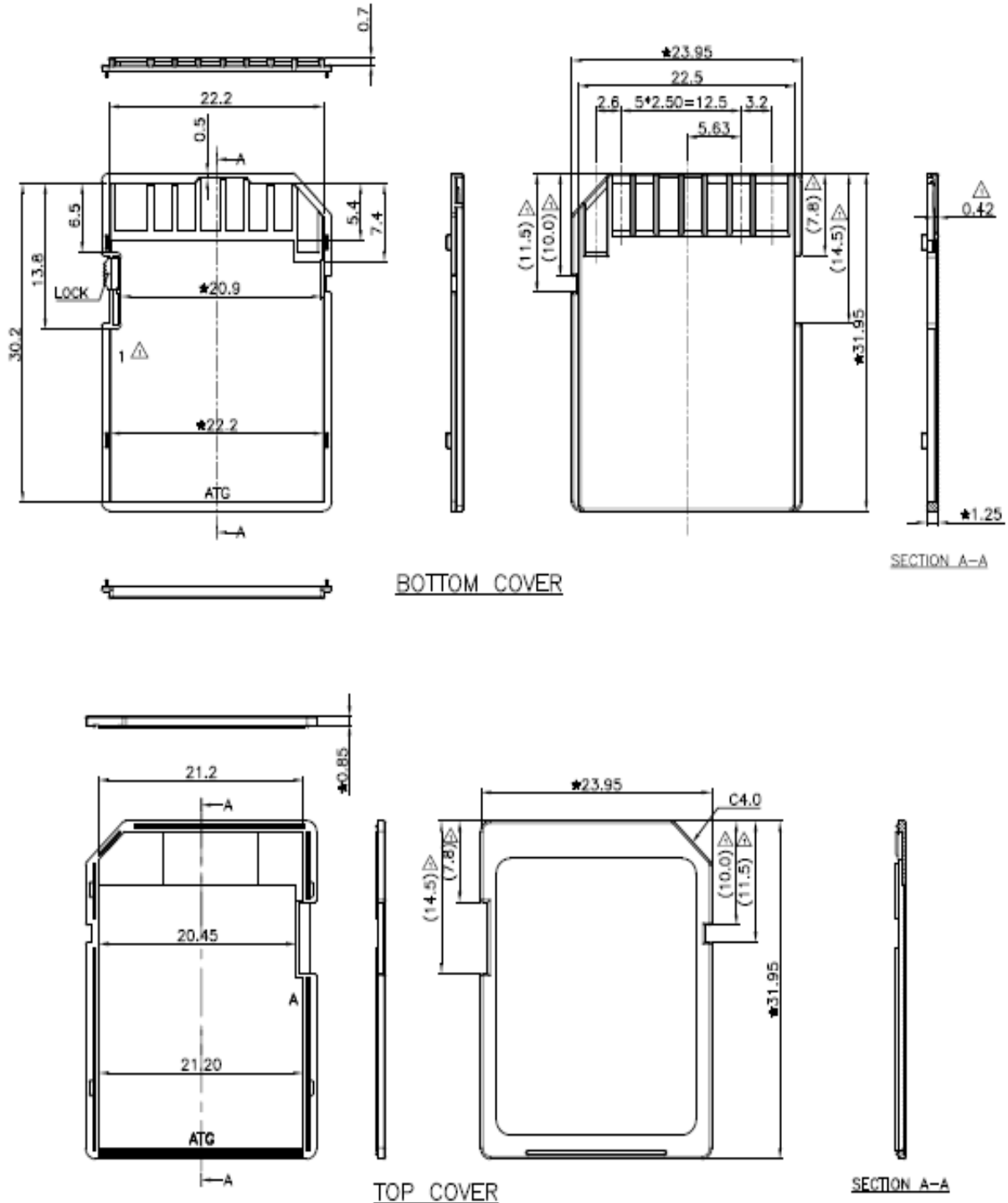
Regulation	Compliance (Country/Region)
EMC	FCC Part 15, Class B (USA); IC ICES-003, Class B (Canada); EMC Directive 2004/108/EC - EN 55022, Class B and EN 55024 (EU), CISPR 22, Class B and CISPR 24 (International)
Safety	UL Listed E153169, UL 60950-1 (USA); cUL Listed E153169, CSA C22.2 No. 60950-1-07 (Canada); LV Directive 2006/95/EC - EN 60950-1, CB Certificate (EU), IEC 60950-1, CB Certificate (International)
RoHS	RoHS Directive 2011/65/EU - EN 50581 (EU)



5. MECHANICAL SPECIFICATION

5.1. Mechanical Dimensions

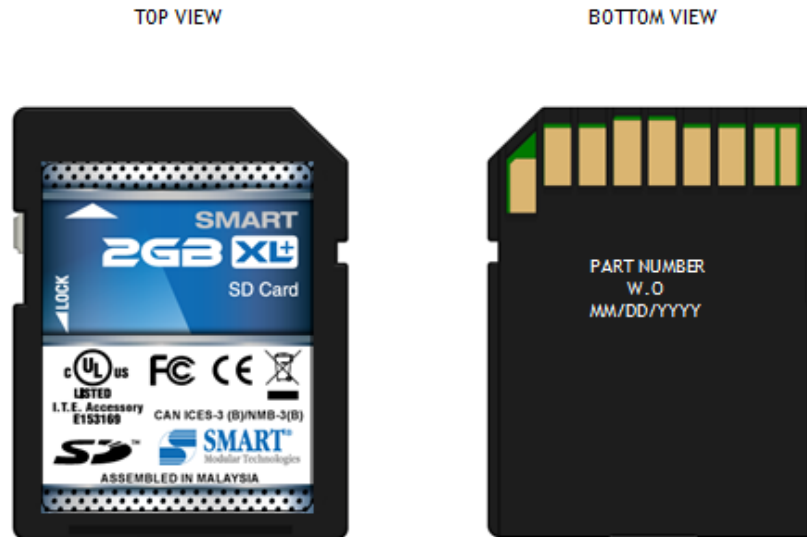
Figure 2: SD XL+ Dimensions (in mm)



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: Pinout 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	SDCLK	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]

Type Key: S=power supply; I=input; O=output using push-pull drivers; PP=I/O using push-pull drivers

When the industrial-temperature card is driving the I/O, the drive strength outputs are set to 0x01.

6.2. Absolute Maximum Ratings

Table 9: Absolute Maximum Ratings¹

Symbol	Parameter	Minimum Value	Maximum Value	Unit
V_{CC3}	3.3 V Supply Voltage	-0.3	3.6	V
V_{IN3}	3.3 V Input Voltage	GND – 0.3	$V_{CC} + 0.3$	V
I_{IN3}	Operating Current	-	40.6	mA
I_{STB}	Standby Current	-	86	μ A
T_A	Operating Temperature – (Commercial)	0	+70	$^{\circ}$ C
T_A	Operating Temperature – (Industrial)	-40	+85	$^{\circ}$ C
T_{STG}	Storage Temperature	-40	+85	$^{\circ}$ 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 (Commercial)	0	room	+70	°C
	Operating Temperature (Industrial)	-40	room	+85	°C

6.4. DC Characteristics (High Speed Mode)

Table 11: DC Characteristics

Parameter	Typical ¹	Max	Units
Active Read Current	30.9	32.9	mA
Active Write Current	36.6	40.6	mA
Standby Current	85	86	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

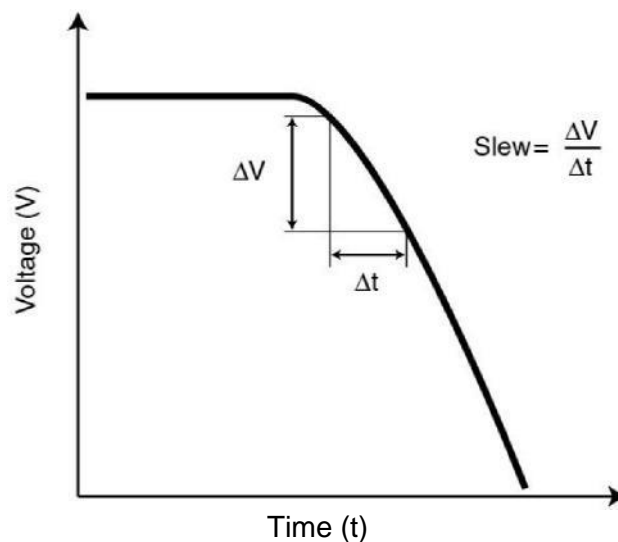


Table 12: Power Cycling

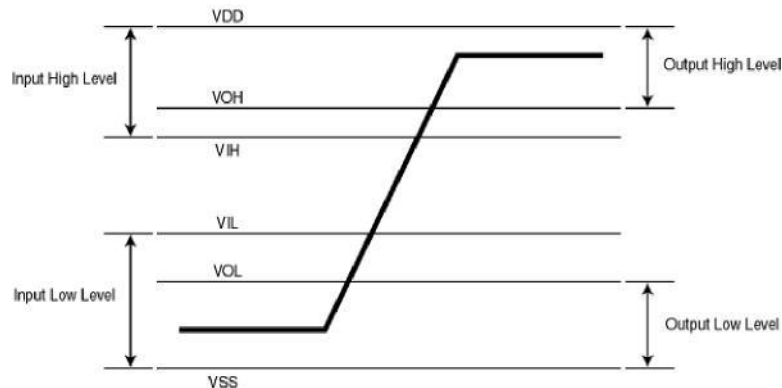
Parameter	Max Value	Unit
Slew Rate	4.3	V/ms
Program State Busy Time (Shutdown Time)	60	ms

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	kΩ
R _{DAT}	Pull-up Resistor value for SDD Line	10 – 100	kΩ
C _L	Bus Line Capacitance	40	pF
L _{SI}	Signal Line Inductance	16	nH

Figure 5: Bus Signal Level

Table 14: Bus Operating Conditions for 3.3V Signaling

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

9. AC CHARACTERISTICS

9.1. Interface Timing

Figure 6: Bus Timing (High Speed)

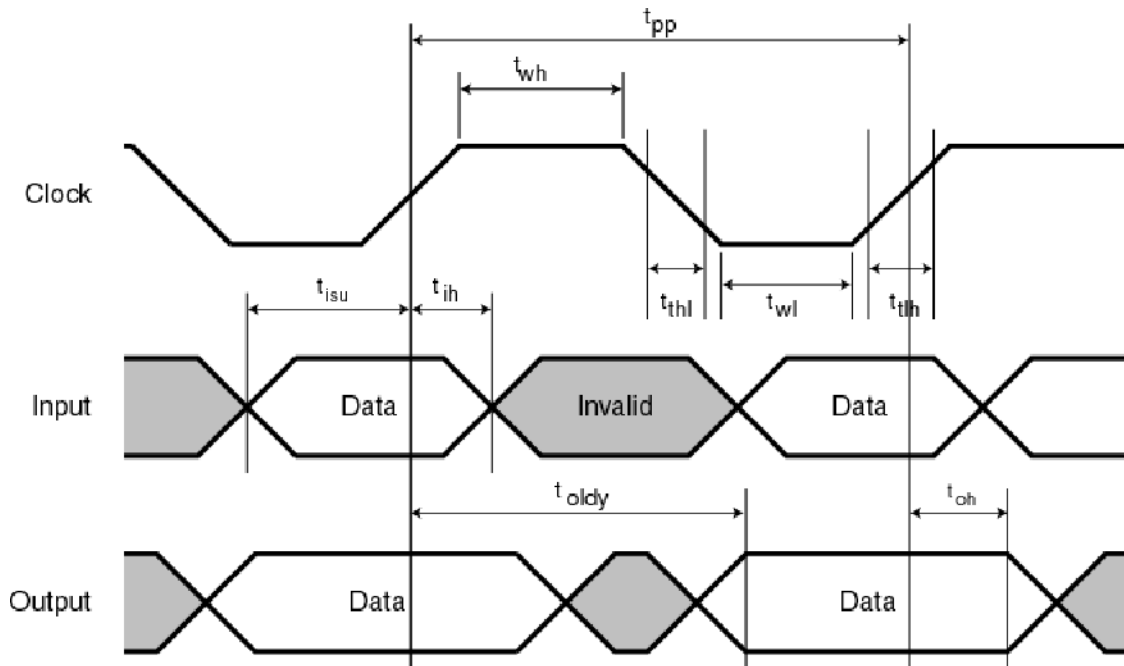
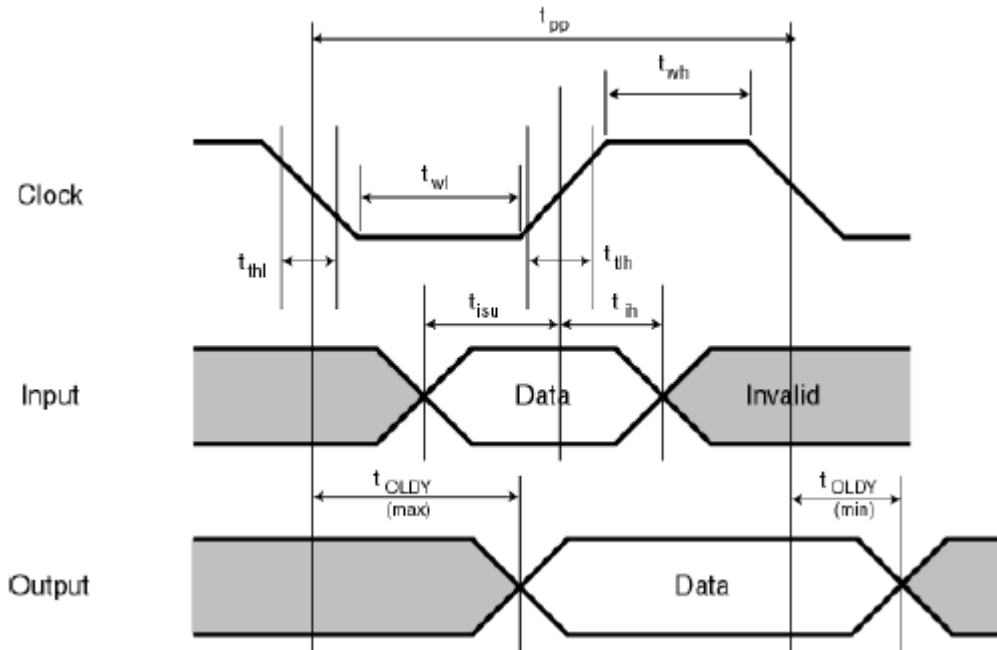


Table 15: Bus Timing (High Speed)

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
t_{PP}	Clock frequency data transfer mode	0	25	MHz	$C_L \leq 10 \text{ pF}$
t_{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	$C_L \leq 10 \text{ pF}$
$t_{OLDY-tran}$	Output delay time (Data Transfer Mode)	0	14	ns	$C_L \leq 10 \text{ pF}$
$t_{OLDY-ident}$	Output delay time (Identification Mode)	0	50	ns	$C_L \leq 10 \text{ pF}$

10. REGISTERS

The registers 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	0x89
[119:104]	16	OEM/Application ID	OID	0x4748
[103:64]	40	Product Name	PNM	SMART(0x534D415254)
[63:56]	8	Product Revision	PRV	0x02
[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	-- ⁽¹⁾
[0]	1	Not used, always 1	-	1b

(1) The value is defined by the 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 0x0001.

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	00b
[125:120]	6	Reserved	---	---
[119:112]	8	Data read access time 1	TAAC	7Fh
[111:104]	8	Data read access time 2	NSAC	00h
[103:96]	8	Max. bus clock frequency	TRAN_SPEED	32h
[95:84]	12	Card command classes	CCC ⁽¹⁾	5B5h
[83:80]	4	Max read block data length	READ_BL_LEN ⁽²⁾	9h ^{512MB/1GB} Ah ^{2GB}
[79]	1	Partial block read allowed	READ_BL_PARTIAL	1b
[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
[75:74]	2	Reserved	---	---
[73:62]	12	Device size	C_SIZE ⁽³⁾	--
[61:59]	3	max. read current @VDD min	VDD_R_CURR_MIN	101b
[58:56]	3	max. read current @VDD max	VDD_R_CURR_MAX	101b
[55:53]	3	max. write current @VDD min	VDD_W_CURR_MIN	101b
[52:50]	3	max. write current @VDD max	VDD_W_CURR_MAX	101b
[49:47]	3	device size multiplier	C_SIZE_MULT	--
[46]	1	Erase single block enable	ERASE_BLK_EN	1b
[45:39]	7	Erase sector size	SECTOR_SIZE	--
[38:32]	7	Write protect group size	WP_GRP_SIZE	--
[31]	1	Write protect group enable	WP_GRP_ENABLE	0b
[30:29]	2	Reserved	---	---
[28:26]	3	Write speed factor	R2W_FACTOR	010b
[25:22]	4	Max write data block length	WRITE_BL_LEN ⁽²⁾	9h ^{512MB/1GB} Ah ^{2GB}
[21]	1	Partial block write allowed	WRITE_BL_PARTIAL	0b
[20:16]	5	Reserved	---	---
[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	00b
[9:8]	2	Reserved	---	---
[7:1]	7	CRC	CRC	---
[0]	1	Not used, always '1'	---	1b

(1) 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

(2) READ_BL_LEN / WRITE_BL_LEN: 9h = 512 Byte; Ah = 1024 Byte.

(3) 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	010b
[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	00b
[31:0]	32	Reserved for manufacturer usage	-	-

(1) SD_SPEC3 is 0 for Version 1.XX.

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
[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
[24:29]	6	Reserved	00 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.

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	
[508:496]	13	Reserved	--	
[495:480]	16	SD_CARD_TYPE	0x0000	
[479:448]	32	SIZE_OF_PROTECTED_AREA	512MB	00000014h
			1GB	00000024h
			2GB	00000028h
[447:440]	8	SPEED_CLASS ⁽¹⁾	512MB	01h or 03h
			1GB	
			2GB	03h
[439:432]	8	PERFORMANCE_MOVE	512MB	03h
			1GB	
			2GB	03h
[431:428]	4	AU_SIZE	9h	
[427:424]	4	Reserved	--	
[423:408]	16	ERASE_SIZE	0008h	
[407:402]	6	ERASE_TIMEOUT	00 0100b	
[401:400]	2	ERASE_OFFSET	01b	
[399:396]	4	UHS_SPEED_GRADE ⁽²⁾	0h	
[395:392]	4	UHS_AU_SIZE	0h	
[391:312]	80	Reserved	--	
[311:0]	312	Reserved for manufacturer	--	

- (1) Class 6 devices = 03h. Class 2 devices = 01h.
 (2) Inherent device performance exceeds SD spec. v3.01 UHS Speed Grade 1 criteria.

11. PART NUMBERS

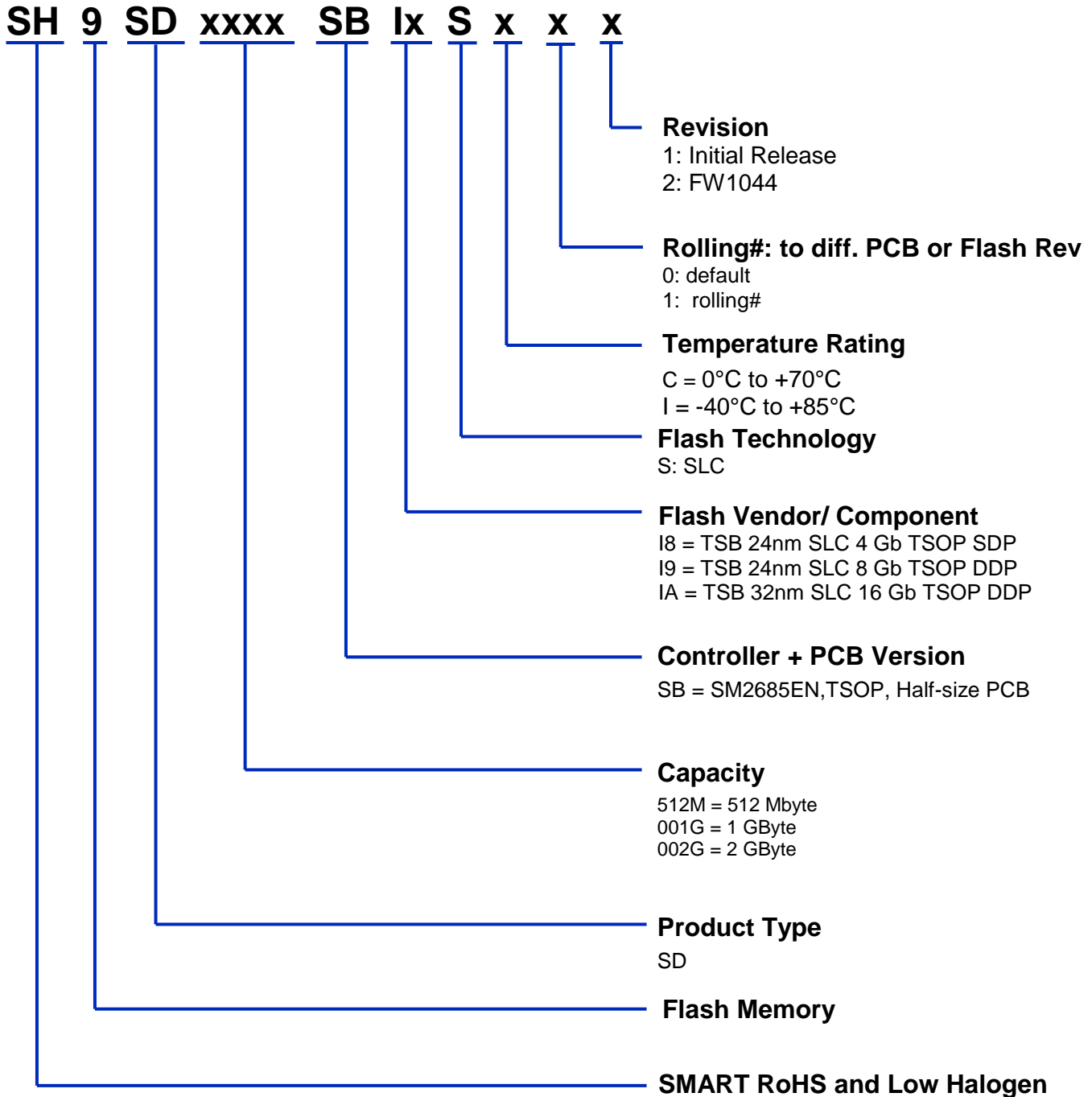
11.1. Part Numbering Information

Table 23: Part Numbering Information

SMART Part Number	Capacity	Speed Class	Logical Capacity	Sectors per Card
SH9SD512MSBI8Sx02	512 MB	6	474,742,784	927,232
SH9SD001GSBI9Sx02	1 GB	6	951,762,944	1,858,912
SH9SD002GSBIASx01	2 GB	6	2,007,629,824	3,921,152
SH9SD512MSBI8Sx01	512 MB	2	500,957,184	978,432
SH9SD001GSBI9Sx01	1 GB	2	1,004,142,592	1,961,216

x = I for Industrial Temperature, C for Commercial Temperature

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:

SH9SDxxxxSBIxSxxx

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: August 13, 2015 8:47 PM

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

Mr. Graham Kyle
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