



SanDisk



Product Manual

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1 Introduction

1.1 General Description

The SanDisk iNAND is a very small, flash storage device, designed specifically for storage applications that put a premium on small form factor, low power and low cost. Flash is the ideal storage medium for portable, battery-powered devices. It features low power consumption and is non-volatile, requiring no power to maintain the stored data. It also has a wide operating range for temperature, shock and vibration.

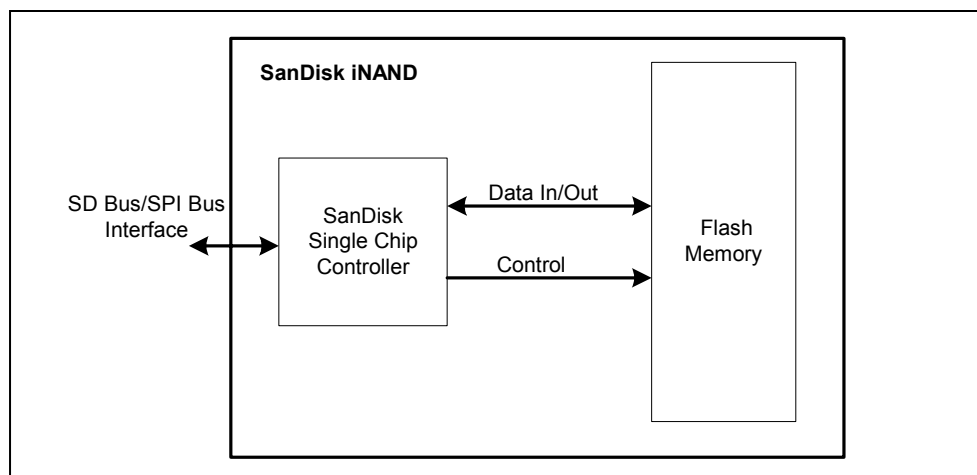
iNAND is well-suited to meet the needs of small, low power, electronic devices. With a form factor measuring 12mm by 18mm by 1.2mm, iNAND is expected to be used in a wide variety of portable devices like mobile phones, pagers, and voice recorders.

To support this wide range of applications, iNAND is offered with an SD Interface. The SD interface product is fully compatible with iNAND products, and provides a 4-bit data bus for maximum performance. For compatibility with existing controllers, the iNAND offers, in addition to these interfaces, an alternate communication-protocol based on the SPI standard.

These interfaces allow for easy integration into any design, regardless of which type of microprocessor is used. All device and interface configuration data (such as maximum frequency and card identification) are stored on the device.

The SanDisk iNAND provides up to 4 GB of memory for use in mass storage applications. In addition to the mass-storage-specific flash memory chip, iNAND includes an intelligent controller, which manages interface protocols, data storage and retrieval, error correction code (ECC) algorithms, defect handling and diagnostics, power management, wear leveling, and clock control. Figure 1-1 is a block diagram of the SanDisk iNAND with SD Interface.

Figure 1-1 SanDisk iNAND Block Diagram



1.2 Features

SanDisk iNAND product features include the following.

- ▶ **Up to 4 GB of data storage**
- ▶ **SD-protocol compatible**
- ▶ **Supports SPI Mode**
- ▶ **Designed for portable and stationary applications that require high performance and reliable data storage**
- ▶ **Voltage range 2.7 to 3.6V**
- ▶ **Variable clock rate 0-25 MHz (default), 0-50MHz (high-speed)**
- ▶ **Up to 25 MB/sec bus transfer rate (using 4 parallel data lines)**
- ▶ **Correction of memory-field errors**
- ▶ **Built-in write protection features (permanent and temporary)**
- ▶ **Application-specific commands**
- ▶ **Standard footprint across all capacities**

1.3 Document Scope

This document describes the key features and specifications of the SanDisk iNAND as well as the information required to interface it to a host system. Chapter 2 describes the physical and mechanical properties of iNAND, Chapter 3 contains the pins and register overview, and Chapter 4 gives a general overview of the SD protocol. Information about SPI Protocol can be referenced in *Section 7* of the *SDA Physical Layer Specification, Version 2.00*.

1.4 iNAND Standard

SanDisk iNAND devices are fully compatible with the *SDA Physical Layer Specification, Version 2.00*. This specification is available from the SD Card Association (SDA).

SD Card Associations

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Fax: +1 (925) 886-4870

E-mail: office@sdcard.org

Website: www.sdcard.org

1.5 Functional Description

The SanDisk iNAND contains a high-level, intelligent subsystem as shown in Figure 1-1. This intelligent (microprocessor) subsystem provides many capabilities not found in other types of memory cards. These capabilities include:

- Host independence from details of erasing and programming flash memory
- Sophisticated system for managing defects (analogous to systems found in magnetic disk drives)
- Sophisticated system for error recovery including a powerful ECC
- Power management for low power operation

1.6 Technology Independence

The 512-byte sector size of the SanDisk iNAND is the same as that in an IDE magnetic disk drive. To write or read a sector (or multiple sectors), the host software simply issues a read or write command to the card. The command contains the address and number of sectors to write or read. The host software then waits for the command to complete.

The host software does not get involved in the details of how the flash memory is erased, programmed or read. This is extremely important because flash devices are expected to get increasingly complex in the future. Because iNAND use an intelligent on-board controller, host system software will not need to be updated as new flash memory evolves. In other words, systems that support iNAND technology today will be able to access future SanDisk devices built with new flash technology without having to update or change host software.

1.7 Defect and Error Management

The SanDisk iNAND contains a sophisticated defect and error management system. This system is analogous to the systems found in magnetic disk drives and in many cases offers enhancements. If necessary, iNAND will rewrite data from a defective sector to a good sector. This is completely transparent to the host and does not consume any user data space. The soft error rate specification for iNAND is much better than the magnetic disk drive specification. In the extremely rare case that a read error does occur, iNAND has innovative algorithms to recover the data. These defect and error management systems, coupled with the solid state construction, give SanDisk iNAND unparalleled reliability.

1.8 Wear Leveling

Wear-leveling is an intrinsic part of the erase pooling functionality of iNAND.

1.9 Automatic Sleep Mode

A unique feature of iNAND is automatic entrance and exit from sleep mode. Upon completion of an operation, cards enter sleep mode to conserve power if no further commands are received in less than 5 milliseconds (ms). The host does not have to take any action for this to occur. However, in order to achieve the lowest sleep current, the host needs to shut down its clock to the card. In most systems, cards are in sleep mode except when accessed by the host, thus conserving power.

When the host is ready to access a card in sleep mode, any command issued to it will cause it to exit sleep, and respond.

1.10 iNAND — SD Bus Mode

The following sections provide valuable information on SanDisk iNAND in SD Bus mode. SanDisk iNAND devices are fully compliant with the SDA *Physical Layer Specification, Version 2.00*. Card Specific Data (CSD) Register structures are compliant with CSD Structure 1.0 and 2.0.

This section covers Negotiating Operating Conditions, Card Acquisition and Identification, Card Status, Memory Array Partitioning, Read/Write Operations, Data Transfer Rate, Data Protection in Flash Cards, Write Protection, Copy Bit, and CSD Register.

Additional practical card detection methods can be found in application notes pertaining to the SDA *Physical Layer Specification, Version 2.00*.

Figure 1-2 Memory Array Partitioning

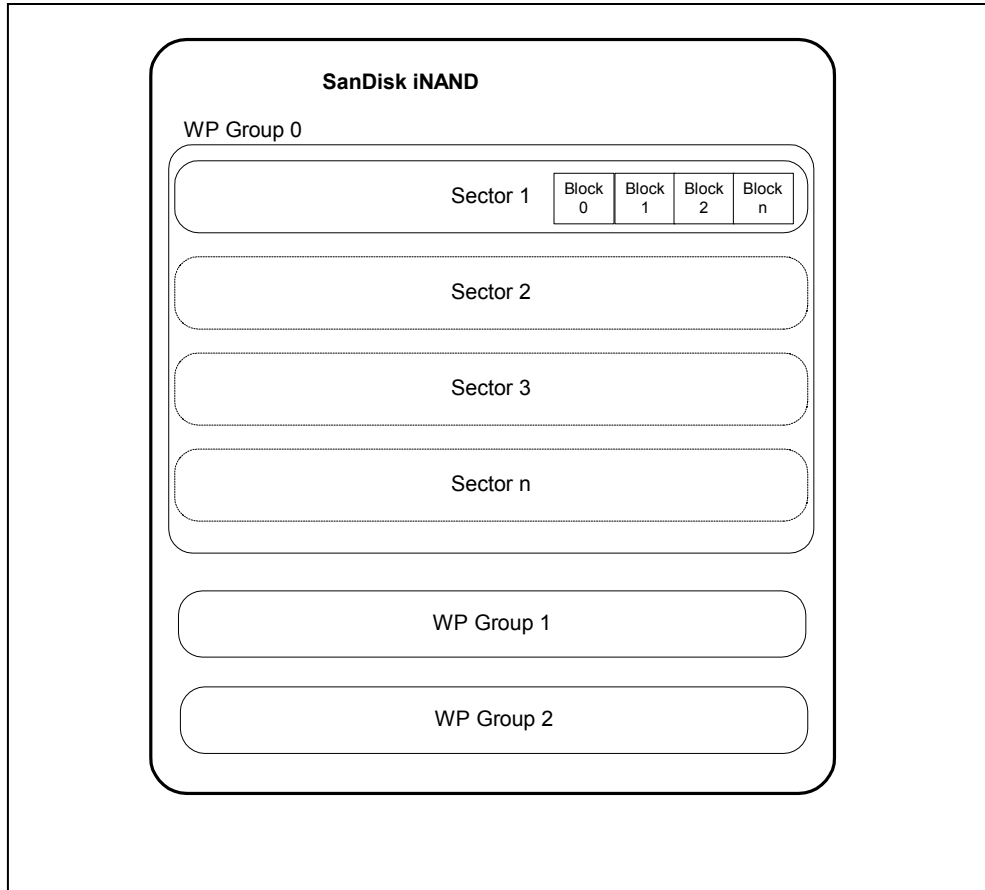


Figure 1-3 Data Transfer Formats

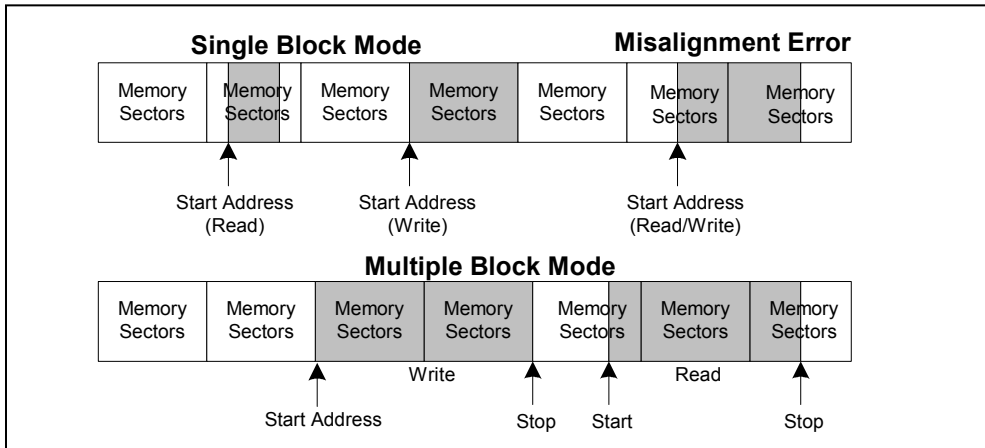


Table 1-1 Mode Definitions

Mode	Description
Single Block	<p>In this mode the host reads or writes one data block in a pre-specified length. The data block transmission is protected with 16-bit CRC that is generated by the sending unit and checked by the receiving unit.</p> <p>The block length for read operations is limited by the device sector size (512 bytes) but can be as small as a single byte. Misalignment is not allowed. Every data block must be contained in a single physical sector.</p> <p>The block length for write operations must be identical to the sector size and the start address aligned to a sector boundary.</p>
Multiple Block	<p>This mode is similar to the single block mode, except for the host can read/write multiple data blocks (all have the same length) that are stored or retrieved from contiguous memory addresses starting at the address specified in the command. The operation is terminated with a stop transmission command.</p> <p>Misalignment and block length restrictions apply to multiple blocks and are identical to the single block read/write operations.</p>

1.11 SPI Mode

The SPI Mode is a secondary communication protocol for iNAND devices. This mode is a subset of the SD Protocol, designed to communicate with an SPI channel, commonly found in Motorola and other vendors' microcontrollers. Table 1-1 contains names and descriptions of SPI Mode functions. More information about SPI Mode can be found in *Section 7* or the *SDA Physical Layer Specification, Version 2.00*.

2 Product Specifications

2.1 Overview

For details about the environmental, reliability and durability specifications, refer to *Section 8.1* of the *SDA Physical Layer Specification, Version 2.00*.

2.2 Typical Card Power Requirements

Table 2-1 iNAND Power Requirements (Ta=25°C@3.0V)

VDD (ripple: max, 60mV peak-to-peak) 2.7 V – 3.6 V			
	Value	Measurement	Average
Sleep	250	uA	Max
Read	100	mA	Max
Write	100	mA	Max

2.3 System Performance

All performance values for iNAND in Table 2-2 were measured using the following conditions:

- Voltage range 2.7 V to 3.6 V
- Temperature -25° C to 85° C
- Independent of the iNAND clock frequency

Table 2-2 System Performance

Timing	Maximum Value
Block Read Access Time	100 ms
Block Write Access Time	250 ms
CMD1 to Ready after Power-up	1000 ms

2.4 System Reliability and Maintenance

Table 2-3 Reliability and Maintenance Specifications

MTBF	>1,000,000 hours
Preventative Maintenance	None
Data Reliability	<1 non-recoverable error in 10 ¹⁴ bits read

2.5 Physical Specifications

The SanDisk iNAND is a 56-pin, thin fine-pitched ball grid array (BGA). See Figure 2-1 (56-pin) for physical specifications and dimensions. See Figure 2-2 for a top view of the pin definitions.

Figure 2-1 iNAND Specifications (18 x 12mm Package)

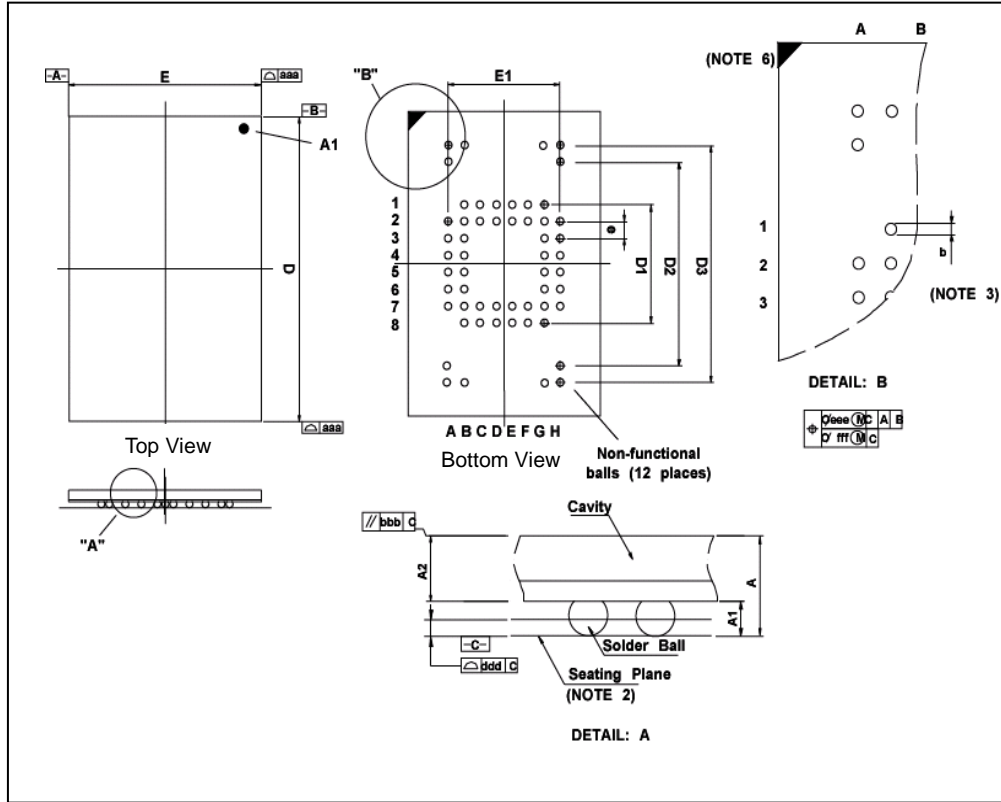
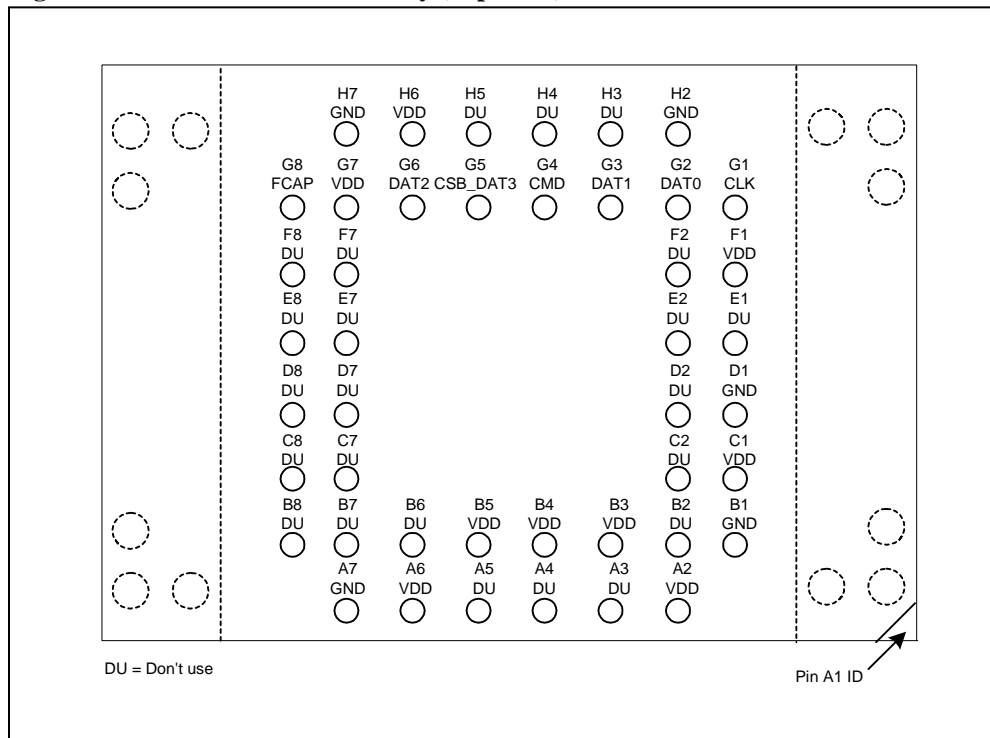


Table 2-4 iNAND Package Specifications (18 x 12mm Package)

Symbol	Dimension in millimeters			Dimension in inches		
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum
A	---	---	1.20 or 1.40	---	---	0.047
A1	0.30	0.35	0.38	0.012	0.014	0.015
A2	0.69	0.74	0.79	0.027	0.029	0.031
D	17.90	18.00	18.10	0.705	0.709	0.713
E	11.90	12.00	12.10	0.469	0.472	0.476
D1	---	7.00	---	---	0.276	---
D2	---	11.00	---	---	0.433	---
D3	---	13.00	---	---	0.512	---
E1	---	7.00	---	---	0.276	---
e	---	1.00	---	---	0.039	---
b	0.45	0.50	0.55	0.018	0.020	0.022
aaa	0.10			0.004		
bbb	0.10			0.004		
ddd	0.15			0.006		
eee	0.25			0.010		
fff	0.10			0.004		
MD/ME	12/11			12/11		

Figure 2-2 iNAND Ball Array (Top View)



2.6 Capacity Specifications

Table 2-5 Model Capacity Summary*

Model No.	Capacity
SDINB1-256	256 MB
SDINB1-512	512 MB
SDINB1-1024	1024 MB
SDINB1-2048	2048 MB
SDINB1-4096	4096 MB

* 1 megabyte (MB) = 1 million bytes; 1 gigabyte (GB) = 1 billion bytes. Some of the listed capacity is used for formatting and other functions, and thus is not available for data storage.

3 iNAND Interface Description

3.1 Pins and Registers

Table 3-1 contains the SanDisk iNAND functional ball assignment

Table 3-1 iNAND Pin Assignment

Pin No.	Name	Type ¹	Description	Comment
SD Bus Mode				
H6, F1, C1, A2, A6	VDD	S	Supply Voltage	
H7, H2, D1, B1, A7	VSS	S	Supply Voltage Ground	
G2	DAT0	I/O	Data Line [Bit 0]	
G3	DAT1	I/O	Data Line [Bit 1]	
G6	DAT2	I/O	Data Line [Bit 2]	
G5	DAT3	I/O	Data Line [Bit 3]	
G1	CLK	I	Clock	
G4	CMD	I/O	Command/Response	
B5	WPB	I	Defines I/F	Connect to VDD
G7	RSTB	I	Defines I/F	Connect to VDD
B2	RDY/BSY		NC	
B3	SEL_A	I	Defines I/F	Connect to VDD
B4	SEL_B	I	Defines I/F	Connect to VDD
G8	FCAP	--	Grounded filter capacitor	
SPI Mode				
H6, F1, C1, A2, A6	VDD	S	Supply Voltage	
H7, H2, D1, B1, A7	VSS	S	Supply Voltage Ground	
G2	DataOut	I/O	Device to Host Data and Status	
G3	DAT1	I/O	Unused	Pull up to VDD
G6	DAT2	I/O	Unused	Pull up to VDD
G5	CS	I	Chip Select (Active low)	
G1	CLK	I	Clock	
G4	DataIn	I	Host to Device Commands and Data	

¹ Type Key: S=power supply; I=input; O=output using push-pull drivers; PP=I/O using push-pull drivers

Pin No.	Name	Type ¹	Description	Comment
B5	WPB	I	Write Protect (Active low)	Connect to VDD
G7	RSTB	I	Reset (Active low)	Connect to VDD
B2	RDY/BSY		NC	
B3	SEL_A	I	Defines I/F	Connect to VDD
B4	SEL_B	I	Defines I/F	Connect to VDD
G8	FCAP	--	Grounded filter capacitor	

SanDisk iNAND contains a set of information registers. Register descriptions and SDA references are provided in *Section 5.0 of the SDA Physical Layer Specification, Version 2.00*.

Table 3-2 iNAND Register Overview

Register Abbreviation	Width (in bits)	Register Name
CID	128	Card Identification Number
RCA	16	Relative Card Address
CSD	128	Card Specific Data
SCR	64	SD Configuration
OCR	32	Operation Conditions
SSR	512	SD Status
CSR	32	Card status; information about the card status.

3.2 Bus Topologies

SanDisk iNAND products support two communication protocols: SD and SPI. For more details, refer to *Section 3.5 of the SDA Physical Layer Specification, Version 2.00*. Section 6 of the specification contains a bus circuitry diagram for reference.

3.2.1 SD Bus

For more details, refer to *Section 3.5.1 of the SDA Physical Layer Specification, Version 2.00*.

3.2.2 SPI Bus

For more details, refer to *Section 3.5.2 of the SDA Physical Layer Specification, Version 2.00*.

3.3 Electrical Interface

The power scheme of SanDisk iNAND is handled locally in each card and in the bus master. Refer to *Section 6.4* of the *SDA Physical Layer Specification, Version 2.00*.

3.3.1 Power Up

Refer to *Section 6.4.1* of the *SDA Physical Layer Specification, Version 2.00*.

3.3.2 Bus Operating Conditions

SPI Mode bus operating conditions are identical to SD Bus Mode operating conditions. For details, see *Section 6.6* of the *SDA Physical Layer Specification, Version 2.00*.

3.3.3 Bus Timing (Default)

See *Section 6.7* of the *SDA Physical Layer Specification, Version 2.00*.

3.3.4 Bus Timing (High-Speed Mode)

See *Section 6.8* of the *SDA Physical Layer Specification, Version 2.00*.

3.4 iNAND Registers

There is a set of eight registers within the iNAND interface. For specific information about each register, refer to *Section 5* of the *SDA Physical Layer Specification, Version 2.00*.

3.4.1 Operating Conditions Register

The **Operation Conditions Register (OCR)** stores the VDD voltage profile for iNAND. Refer to *Section 5.1* of the *SDA Physical Layer Specification, Version 2.00*.

3.4.2 Card Identification Register

The **Card Identification (CID) Register** is 16 bytes long and contains the unique card identification number. It is programmed during manufacturing and cannot be changed by iNAND hosts. See Table 3-3.

Table 3-3 CID Register Definitions

Name	Type	Width	CID Value	Comments
Manufacturer ID (MID)	Binary	8	0x03	Manufacturer IDs are controlled and assigned by the SD-3C, LLC
OEM/Application ID (OID)	ASCII	16	SD ASCII Code 0x53, 0x44	Identifies the card OEM and/or the card contents. The OID is controlled and assigned by the SD-3C, LLC
Product Name (PNM)	ASCII	40	ST04G ST02G ST01G ST512 ST256	Five ASCII characters long
Product Revision (PRV)	BCD	8	Product Revision xx	See Section 5.2 in the <i>SDA Physical Layer Specification, Version 2.00</i>
Serial Number (PSN)	Binary	32	Product Serial Number	32-bit unsigned integer
Reserved	---	4	---	---
Manufacture Date Code (MDT)	BCD	12	Manufacture date (for ex. April 2001= 0x014)	Manufacturing date—yym (offset from 2000)
CRC7 checksum (CRC)	Binary	7	CRC7*	Calculated
Not used, always	---	1	---	---

Note: SD-3C, LLC is a limited liability company established by Matsushita Electric Industrial Co. Ltd., SanDisk Corporation and Toshiba Corporation.

*The CRC checksum is computed by using the following formula: CRC Calculation: $G(x)$

$$= x^7 + x^3 + 1$$

$$M(x) = (\text{MID-MSB}) * x^{119} + \dots + (\text{CIN-LSB}) * x^0$$

$$\text{CRC}[6..0] = \text{Remainder}[(M(x) * x^7) / G(x)]$$

3.4.3 Card Specific Data Register

The **Card Specific Data (CSD) Register** configuration information is required to access iNAND data. The CSD defines the data format, error correction type, maximum data access time, etc. The field structures of the CSD Register vary depending on the physical specifications and card capacity. The *CSD_STRUCTURE* field in the CSD Register indicates which structure version is used. Table 3-4 shows the version number as it relates to the CSD structure. Refer to *Section 5.3.1* of the *SDA Physical Layer Specification, Version 2.00* for more information.

Table 3-4 CSD Register Structures

CSD_STRUCTURE	CSD Structure Version	Valid for SD Memory Card Physical Specification Version / Card Capacity
0	CSD Version 1.0	Version 1.01 to 1.10 Version 2.00 / Standard Capacity
1	CSD Version 2.0	Version 2.00 / High Capacity
2-3	Reserved	---

Table 3-5 provides an overview of the CSD Register. More field-specific information can be found in *Section 5.3.2, Table 5-4* of the *SDA Physical Layer Specification, Version 2.00*.

Table 3-5 CSD Register (CSD Version 1.0)

Field	CSD Value	Description
CSD_STRUCTURE	1.0	CSD structure
---	---	Reserved
TAAC	1.5 msec	Data read access time-1
NSAC	0	Data read access time-2 in CLK cycles (NSAC*100)
TRANS_SPEED	Default 25MHz High-speed 50MHz	Max. data transfer rate
CCC	All (inc. WP, lock/unlock)	Card command classes
READ_BL_LEN	2G Up to 1G	Max. read data block length
READ_BL_PARTIAL	Yes	Partial blocks for read allowed
WRITE_BLK_MISALIGN	No	Write block misalignment
READ_BLK_MISALIGN	No	Read block misalignment
DSR_IMP	No	DSR implemented
---	---	Reserved
C_SIZE	2 GB 1 GB 512 MB 256 MB	Device size
VDD_R_CURR_MIN	100 mA	Max. read current @VDD min.
VDD_R_CURR_MAX	80 mA	Max. read current @VDD max.

Field	CSD Value	Description
VDD_W_CURR_MIN	100 mA	Max. write current @VDD min.
VDD_W_CURR_MAX	80 mA	Max. write current @VDD max.
C_SIZE_MULT	2G=2048 1G=1024 512=512 256=256	Device size multiplier
ERASE_BLK_EN	Yes	Erase single block enable
SECTOR_SIZE	32 blocks	Erase sector size
WP_GRP_SIZE	128 sectors	Write protect group size
WP_GRP_ENABLE	Yes	Write protect group enable
Reserved	---	Reserved for MMC compatibility
R2W_FACTOR	x16	Write speed factor
WRITE_BL_LEN	2G Up to 1G	Max. write data block length
WRITE_BL_PARTIAL	No	Partial blocks for write allowed
---	---	Reserved
FILE_FORMAT_GRP	0	File format group
COPY	Has been copied	Copy flag (OTP)
PERM_WRITE_PROTECT	Not protected	Permanent write protection
TMP_WRITE_PROTECT	Not protected	Temporary write protection
FILE_FORMAT	HD w/partition	File format
Reserved	---	Reserved
CRC	CRC7	CRC
---	---	Not used, always "1"

Refer to *Section 5.3.3, Table 5-16 of the SDA Physical Layer Specification, Version 2.00* for more detailed information.

Table 3-6 CSD Register (CSD Version 2.0)

Field	CSD Value	Description
CSD_STRUCTURE	2.0	CSD structure
---	---	Reserved
TAAC	1.5 ms	Data read access time-1
NSAC	0	Data read access time-2 in CLK cycles (NSAC*100)
TRANS_SPEED	Default 25MHz High-speed 50MHz	Max. data transfer rate
CCC	010110110101b All (inc. WP, lock/unlock)	Card command classes
READ_BLK_LEN	---	Max. read data block length
READ_BLK_PARTIAL	Yes	Partial blocks for read allowed
WRITE_BLK_MISALIGN	No	Write block misalignment
READ_BLK_MISALIGN	No	Read block misalignment
DSR_IMP	No	DSR implemented
---	0	Reserved
C_SIZE	32 GB 16 GB 8 GB 4 GB	Device size
---	0	Reserved
ERASE_BLK_EN	1	Erase single block enable
SECTOR_SIZE	32 blocks	Erase sector size
WP_GRP_SIZE	128 sectors	Write protect group size
WP_GRP_ENABLE	Yes	Write protect group enable
Reserved	---	Reserved for MMC compatibility
R2W_FACTOR	x16	Write speed factor
WRITE_BLK_LEN	---	Max. write data block length
WRITE_BLK_PARTIAL	No	Partial blocks for write allowed
---	---	Reserved
FILE_FORMAT_GRP	0	File format group
COPY	Has been copied	Copy flag (OTP)
PERM_WRITE_PROTECT	Not protected	Permanent write protection

Field	CSD Value	Description
TMP_WRITE_PROTECT	No protected	Temporary write protection
FILE_FORMAT	HD w/partition	File format
Reserved	---	Reserved
CRC	CRC7	CRC
---	---	Not used, always "1"

3.4.4 Card Status Register

The **Card Status Register (CSR)** transmits the card's status information (which may be stored in a local status register) to the host. The CSR is defined in Section 4.10.1 in the *SDA Physical Layer Specification, Version 2.00*.

3.4.5 SD Status Register

The **SD Status Register (SSR)** contains status bits that are related to iNAND proprietary features and may be used for future applications. The SD Status structure is described in Section 4.10.2 in the *SDA Physical Layer Specification, Version 2.00*.

3.4.6 Relative Card Address Register

The 16-bit **Relative Card Address (RCA)** Register carries the card address published by the card during the card identification. Refer to Section 5.4 in the *SDA Physical Layer Specification, Version 2.00* for more information.

3.4.7 SD Card Configuration Register

The **SD Card Configuration Register (SCR)** is in addition to the CSD Register. The SCR provides information about special features in SanDisk iNAND. For more information, refer to Section 5.6 in the *SDA Physical Layer Specification, Version 2.00*.

3.4.8 SD Card Registers in SPI Mode

All registers are accessible in SPI Mode. Their format is identical to the format in the SD Bus Mode, however a few fields are irrelevant in SPI Mode. In SPI Mode, the Card Status Register has a different, shorter, format as well. Refer to Section 7.4 in the *SDA Physical Layer Specification, Version 2.00* for more details.

3.5 Data Interchange Format and Card Sizes

In general, a file system provides structure for iNAND data. The SD Card File System Specification, published by the SD Association, describes the file format system implemented in the SanDisk iNAND.

Table 3-7 User Area DOS Image Parameters

Capacity*	Total LBAs	Number of Partition System Area Sectors	Total Partition Sectors	User Data Sectors	User Data Bytes
4 GB	8,027,136	8192	8,018,944	8,012,708	4,102,506,496
2 GB	4,013,056	523	4,011,595	4,011,072	2,053,668,864
1 GB	2,006,528	523	2,005,675	2,005,152	1,026,637,824
512 MB	1,003,264	279	1,002,727	1,002,448	513,253,376
256 MB	501,632	157	501,149	500,992	256,507,904

*1 megabyte (MB) = 1 million bytes; 1 gigabyte (GB) = 1 billion bytes. Some of the listed capacity is used for formatting and other functions, and thus is not available for data storage.

4 iNAND Protocol Description

4.1 General

iNAND protocol information is contained in this chapter; information includes bus protocol, card identification, and a functional description.

4.2 SD Bus Protocol

Communication over the SD bus is based on command and data-bit streams initiated by a start bit and terminated by a stop bit. See *Section 3.6.1* of the *SDA Physical Layer Specification, Version 2.00* for details.

4.3 Functional Description

The host controls all communication between itself and iNAND. To demonstrate how this communication works, this section provides a general overview of the card identification and data transfer modes; commands; card dependencies; various card operation modes and restrictions for controlling the clock signal. All iNAND commands, together with corresponding responses, state transitions, error conditions, and timings are also provided. For detailed information, refer to *Section 4* of the *SDA Physical Layer Specification, Version 2.00*.

4.3.1 Card Identification Mode

In Card Identification Mode the host resets all cards, validates operation voltage range, identifies and requests cards to publish a relative card address. For more information see *Section 4.2* in the *SDA Physical Layer Specification, Version 2.00*.

4.3.2 Data Transfer Mode

In Data Transfer Mode, the host may operate iNAND in the f_{pp} frequency range. This section contains information about data read and write, erase, write protect management, card lock/unlock operations, application-specific commands, the switch function command, high-speed mode, the command system, the Send Interface Condition command (CMD8). CMD8 is part of identification mode and command functional differences in high capacity iNAND. For more detailed information, refer to *Section 4.3* of the *SDA Physical Layer Specification, Version 2.00*.

4.3.3 Clock Control

The host can use the bus clock signal in iNAND to switch them to energy saving mode or to control data flow on the bus. See *Section 4.4* of the *SDA Physical Layer Specification, Version 2.00*.

4.3.4 Cyclic Redundancy Codes

The Cyclic Redundancy Check (CRC) protects against transmission errors that may occur on the iNAND bus. Detailed information and examples for CRC7 and CRC16 are provided in *Section 4.5* of the *SDA Physical Layer Specification, Version 2.00*.

4.3.5 Error Conditions

See *Section 4.6* of the *SDA Physical Layer Specification, Version 2.00*.

4.3.6 Commands

See *Section 4.7* of the *SDA Physical Layer Specification, Version 2.00* for detailed information about iNAND commands.

4.3.7 Card State Transition

The state transition is dependent on the received command. The transition is defined in *Section 4.8* of the *SDA Physical Layer Specification, Version 2.00* along with responses sent on the command line.

4.3.8 Timing Diagrams and Values

See *Section 4.12* of the *SDA Physical Layer Specification, Version 2.00*.

4.3.9 Speed Class Specification

The speed class specification classifies card performance by speed class number and offers the method to calculate performance. For more information, refer to *Section 4.13* of the *SDA Physical Layer Specification, Version 2.00*.

4.3.10 Erase Timeout Calculation

See *Section 4.14* of the *SDA Physical Layer Specification, Version 2.00*.

Appendix A Capacitor Specifications

A.1 SanDisk iNAND Operation

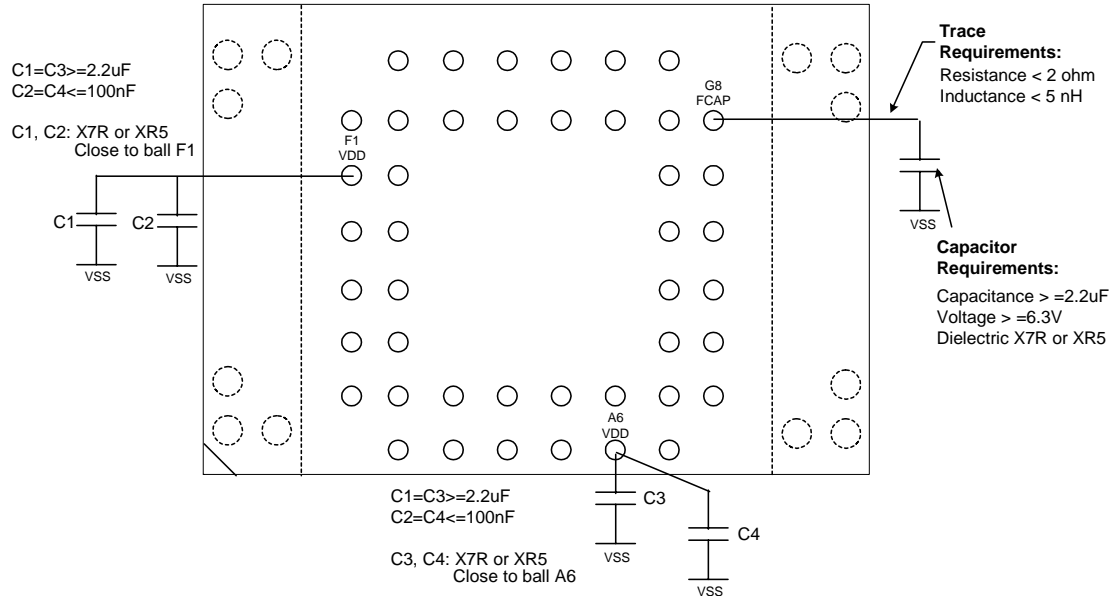
In order for iNAND to operate at 3V, an external capacitor must be added to the FCAP (G8) pin and grounded to VSS. The capacitor's specifications and its placement instructions are detailed below.

The trace requirements from the FCAP (G8) pin to the capacitor are as follows:

- Resistance: <2 ohm
- Inductance: <5 nH

The capacitor requirements are as follows:

- Capacitance: $\geq 2.2\mu\text{F}$
- Voltage: $\geq 6.3\text{ V}$
- Dielectric: X7R or X5R



Bottom View

Appendix B Ordering Information

B.1 iNAND

To order SanDisk products directly from SanDisk, call (408) 801-1000.

Part Number	Block Size¹
SDINB1-256	256 MB
SDINB1-512	512 MB
SDINB1-1024	1024 MB
SDINB1-2048	2048 MB
SDINB1-4096	4096 MB

¹ 1 megabyte (MB) = 1 million bytes; 1 gigabyte (GB) = 1 billion bytes. Some of the listed capacity is used for formatting and other functions, and thus is not available for data storage.

Appendix C SanDisk Worldwide Sales Offices

To order SanDisk products directly from SanDisk, call (408) 801-1000.

SanDisk Corporate Headquarters

601 McCarthy Blvd.
Milpitas, CA 95035
Tel: 408-801-1000
Fax: 408-801-8657
<http://www.sandisk.com>

U.S. OEM Sales Offices

Southwest/Northwest USA & Mexico

601 McCarthy Blvd.
Milpitas, CA 95035
Tel: 408-801-1000
Fax: 408-801-8657

Northeastern USA/Canada

620 Herndon Pkwy. Suite 200
Herndon, VA 22070
Tel: 703-481-9828
Fax: 703-437-9215

International OEM Sales Offices

Europe

SanDisk GmbH
Karlsruher Str. 2C
D-30519 Hannover, Germany
Tel: 49-511-875-9131
Fax: 49-511-875-9187

Northern/Central/Southern Europe

Rudolf-Diesel-Str. 3
40822 Mettmann, Germany
Tel: 49-210-495-3433
Fax: 49-210-495-3434

Japan

8F Nisso Bldg. 15
2-17-19 Shin-Yokohama,
Kohoku-ku
Yokohama 222-0033,
Japan
Tel: 81-45-474-0181
Fax: 81-45-474-0371

Asia/Pacific Rim

Suite 902-903
Bank of East Asia Harbour View Centre
56 Gloucester Road
Wanchai Hong Kong
Tel: 852-2712-0501
Fax: 852-2712-9385

Appendix D Limited Warranty

I. WARRANTY STATEMENT

SanDisk warrants its products to be free of any defects in materials or workmanship that would prevent them from functioning properly for one year from the date of purchase. This express warranty is extended by SanDisk Corporation.

II. GENERAL PROVISIONS

This warranty sets forth the full extent of SanDisk's responsibilities regarding the SanDisk iNAND. In satisfaction of its obligations hereunder, SanDisk, at its sole option, will 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.

SanDisk's 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 one year of purchase, SanDisk will have the option of repairing or replacing the defective product, if the following conditions are met:

- A. A warranty registration card for each defective product was submitted and is on file at SanDisk. If not, a warranty registration card must accompany each returned defective product. This card is included in each product's original retail package.
- B. The defective product is returned to SanDisk for failure analysis as soon as possible after the failure occurs.
- C. An incident card filled out by the user, explaining the conditions of usage and the nature of the failure, accompanies each returned defective product.
- D. 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 SanDisk 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.

SanDisk 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.

SanDisk may, at its discretion, ship repaired or rebuilt products identified in the same way as new products, provided such cards meet or exceed the same published specifications as new products. Concurrently, SanDisk 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 SanDisk's warranty procedure, defective product should be returned only with prior authorization from SanDisk Corporation. Please contact SanDisk's Customer Service department at 408-801-1000 with the following information: product model number and description, serial numbers, nature of defect, conditions of use, proof of purchase and purchase date. If approved, SanDisk will issue a Return Material Authorization or Product Repair Authorization number. Ship the defective product to:

SanDisk Corporation
Attn: RMA Returns
(Reference RMA or PRA #)
601 McCarthy Boulevard
Milpitas, CA 95035

V. STATE LAW RIGHTS

SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, OR LIMITATION ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO YOU. This warranty gives you specific rights and you may also have other rights that vary from state to state.

Appendix E Disclaimer of Liability

E.1 SanDisk Corporation Policy

SanDisk Corporation general policy does not recommend the use of its products in life support applications wherein a failure or malfunction of the product may directly threaten life or injury. Accordingly, in any use of products in life support systems or other applications where failure could cause damage, injury or loss of life, the products should only be incorporated in systems designed with appropriate redundancy, fault tolerant or back-up features.

SanDisk shall not be liable for any loss, injury or damage caused by use of the Products in any of the following applications:

- Special applications such as military related equipment, nuclear reactor control, and aerospace
- Control devices for automotive vehicles, train, ship and traffic equipment
- Safety system for disaster prevention and crime prevention
- Medical-related equipment including medical measurement device