SanDisk®

(JC64 Package)

Product Manual

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February 2007 Revision 1.1—Added TOC; removed Section 2.6; corrected Fig. 2-2; revised capacitor specifications and part numbers; eliminated warranty section.

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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. It is compatible with the JC64 FBGA 169, 0.5mm ball pitch, package.

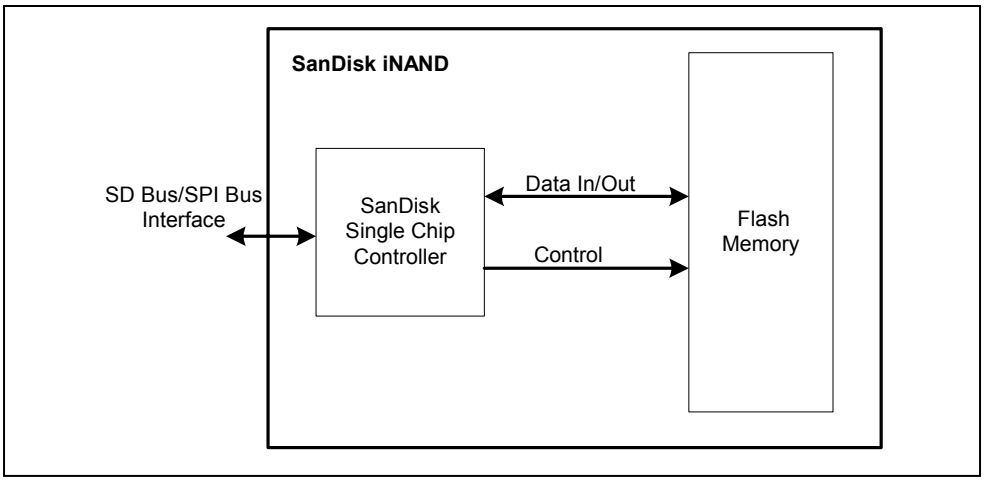
SanDisk iNAND is well-suited to meet the needs of small, low power, electronic devices. With form factors measuring 12mm x 16mm x 1.2 mm and 12mm x 18mm x 1.2mm, iNAND is expected to be used in a wide variety of portable devices like mobile phones, pagers, and voice recorders.

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 8 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 8 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 V to 3.6 V**
- **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).

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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

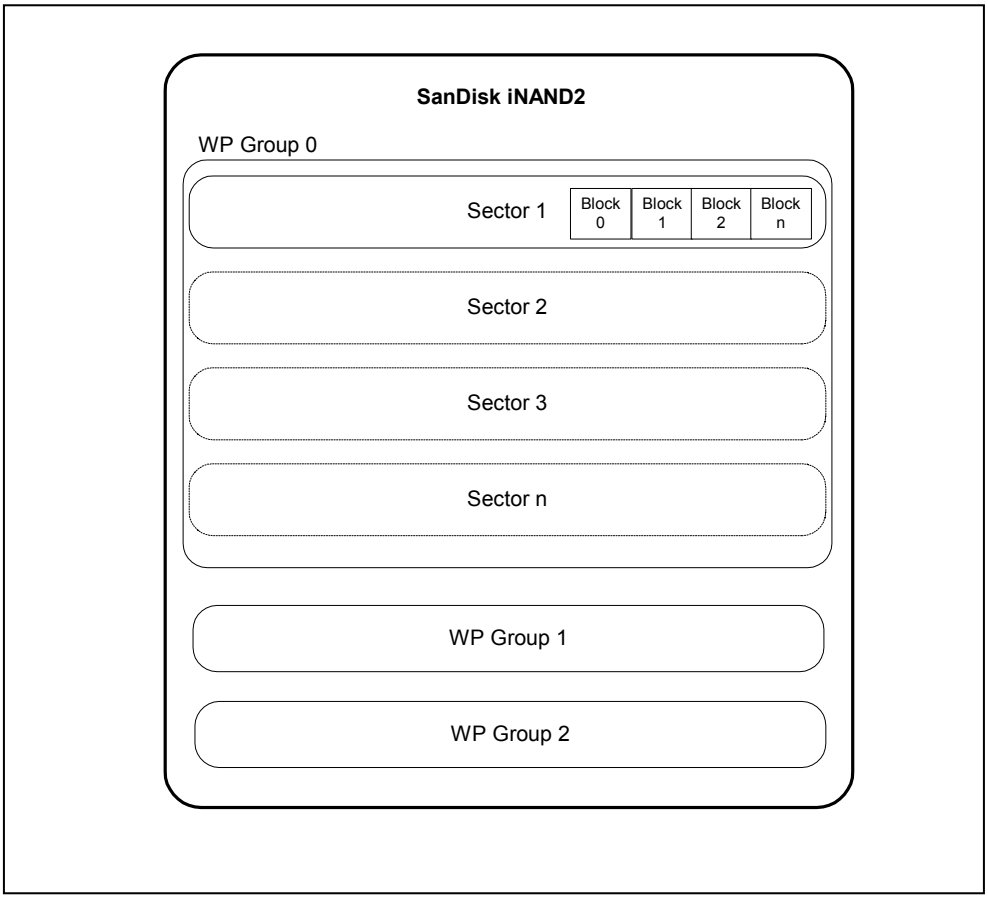


Figure 1-3 Data Transfer Formats

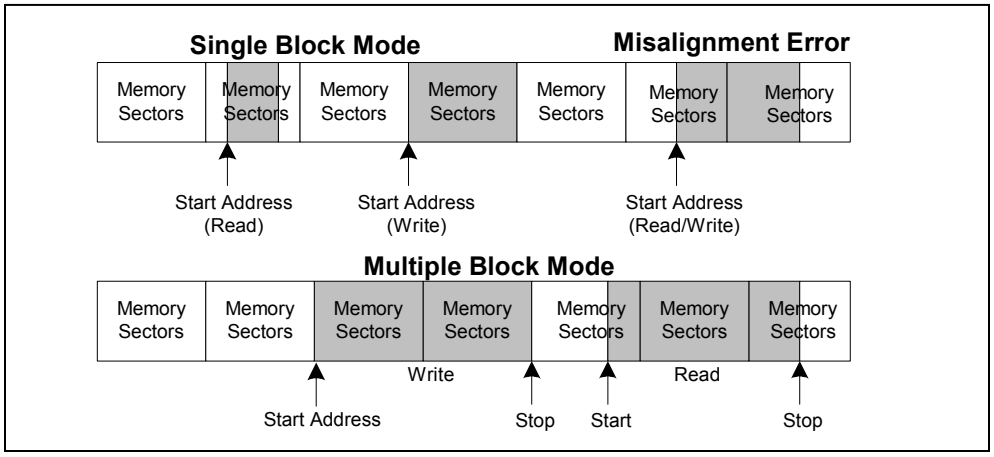


Table 1-1 Mode Definitions

Mode	Description
Single Block	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. 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. The block length for write operations must be identical to the sector size and the start address aligned to a sector boundary.
Multiple Block	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. Misalignment and block length restrictions apply to multiple blocks and are identical to the single block read/write operations.

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			
Default Speed	100	mA	Max.
High-Speed	200	mA	Max.
Write			
Default Speed	100	mA	Max.
High-Speed	200	mA	Max.

Note: Current measurement numbers are average over 1 second.

2.3 Operating Conditions

2.3.1 Operating and Storage Temperature Specifications

Table 2-2 Operating and Storage Temperatures

Temperature	Operating	-25° C to 85° C
	Non-Operating: After soldered onto PC Board	-40° C to 85° C
	Non-Operating: In Tape/Reel	-10° C to 50° C

2.3.2 Moisture Sensitivity

The moisture sensitivity level for iNAND is MSL = 3.

2.4 System Performance

All performance values for iNAND in Table 2-3 were measured using the following conditions:

- Voltage range 2.7 V to 3.6 V
- Temperature -25° C to 85° C

Table 2-3 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

2.5 System Reliability and Maintenance

Table 2-4 Reliability and Maintenance Specifications

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

2.6 Physical Specifications

The SanDisk iNAND is a 169-pin, thin fine-pitched ball grid array (BGA). See Figure 2-1 (169-pin) for physical specifications and dimensions. See Figure 2-5 for a top view of the pin definitions.

Figure 2-1 iNAND Specifications

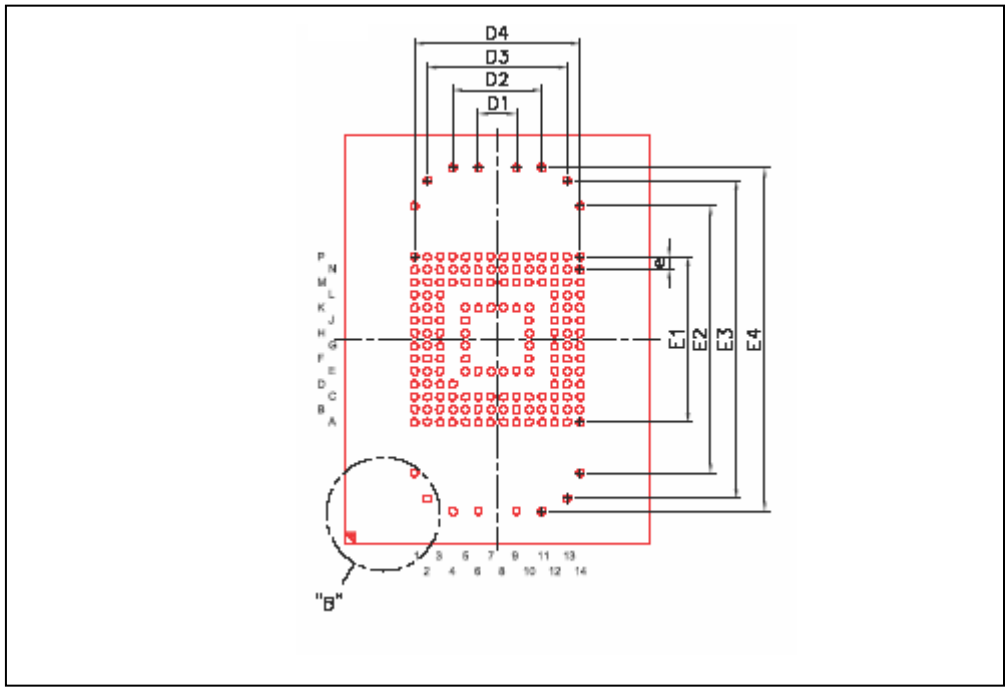


Figure 2-2 iNAND Specifications (Top View)

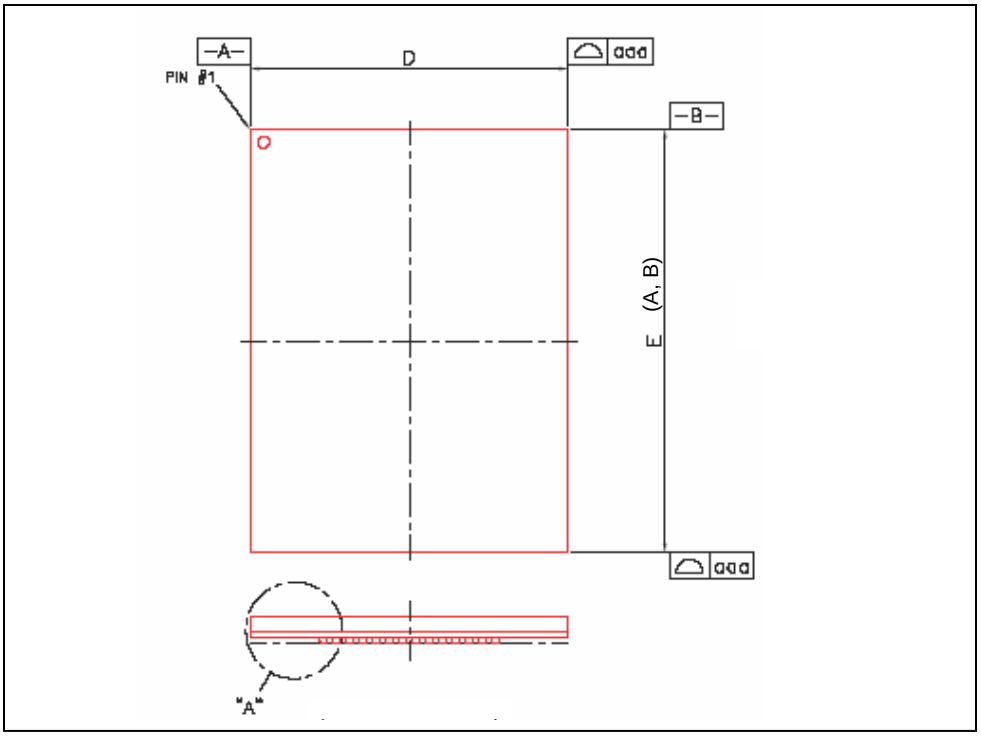


Figure 2-3 iNAND Specifications (Detail A)

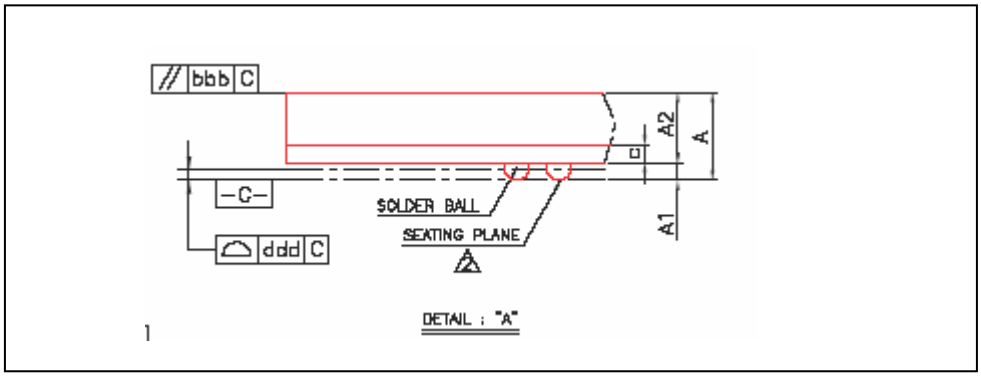


Figure 2-4 iNAND Specifications (Detail B)

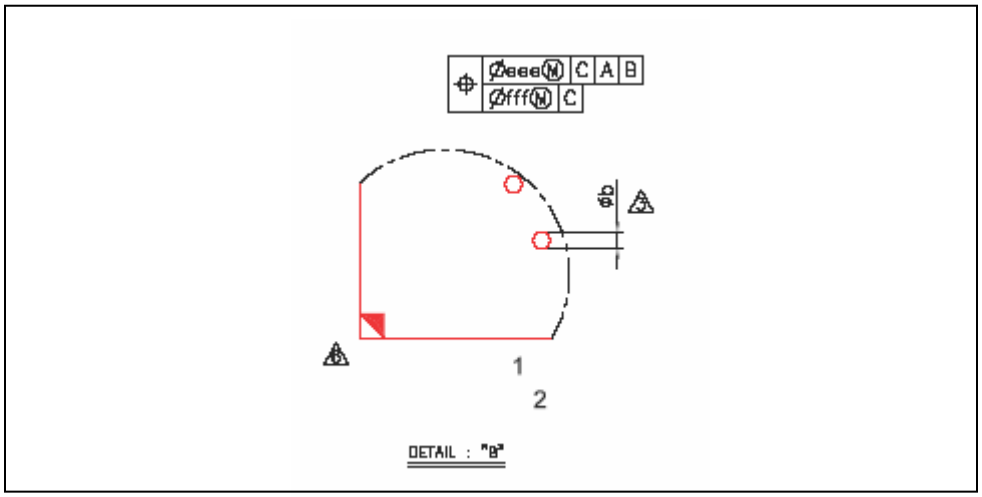
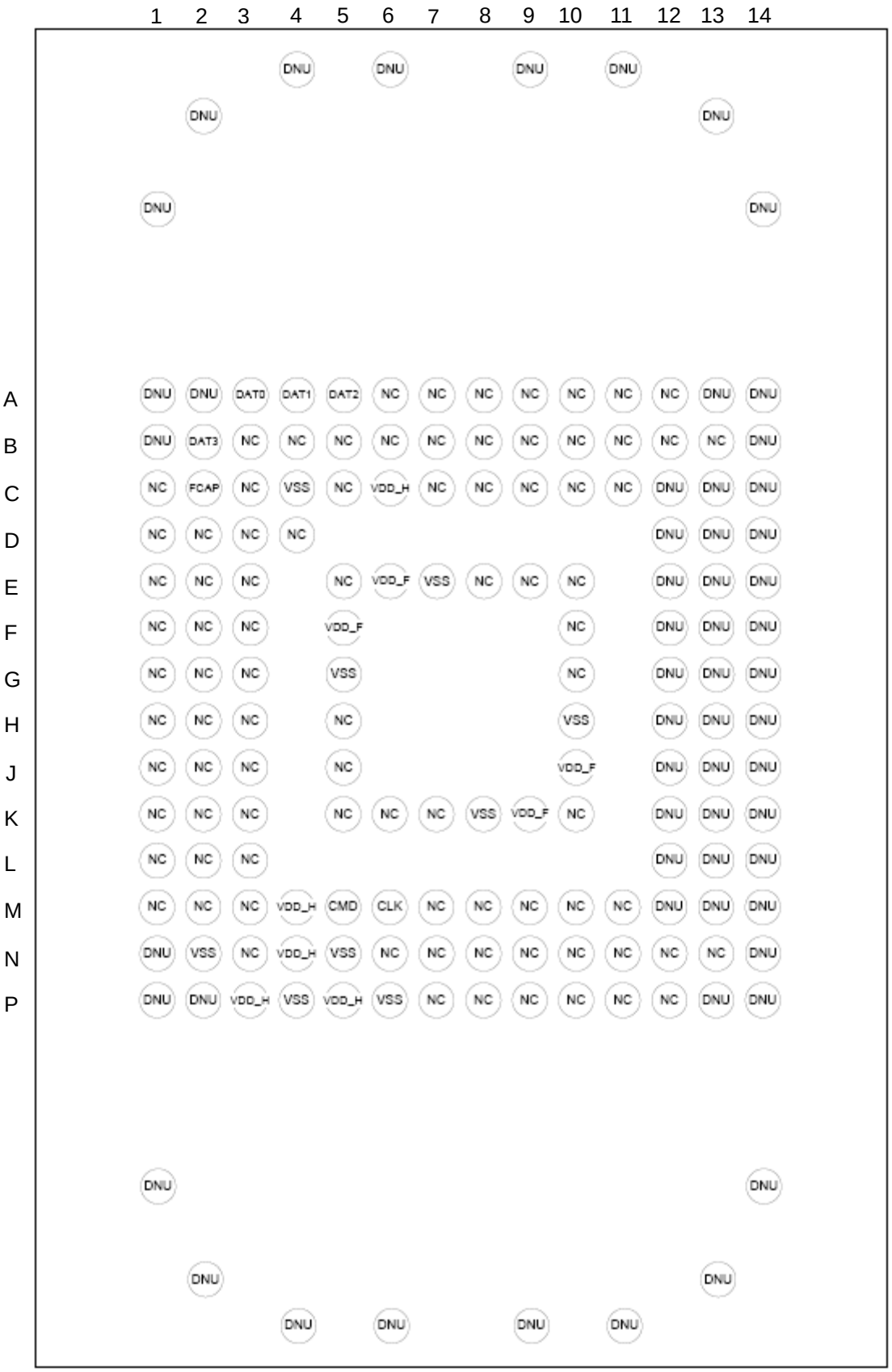


Table 2-5 iNAND Package Specifications

	Dimension in millimeters			Dimension in inches		
Symbol	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum
A	---	---	1.20	---	---	0.047
A1	0.16	0.21	0.26	0.006	0.008	0.010
A2	0.785	0.835	0.885	0.031	0.033	0.035
c	0.17	0.21	0.25	0.007	0.008	0.010
D	11.90	12.00	12.10	0.469	0.472	0.476
E (A)[1]	15.90	16.00	16.10	0.626	0.630	0.634
E (B)[2]	17.90	18.00	18.10	.7047	.7087	.7126
D1	---	1.50	---	---	0.059	---
D2	---	3.50	---	---	0.138	---
D3	---	5.50	---	---	0.217	---
D4	---	6.50	---	---	0.256	---
E1	---	6.50	---	---	0.256	---
E2	---	10.50	---	---	0.413	---
E3	---	12.50	---	---	0.492	---
E4	---	13.50	---	---	0.531	---
e	---	.50	---	---	0.020	---
b	0.25	0.30	0.35	0.010	0.012	0.014
aaa	0.10			0.004		
bbb	0.10			0.004		
ddd	0.08			0.003		
eee	0.15			0.006		
fff	0.05			0.002		
MD/ME	14/14			14/14		

[1] These measurements are for the 16 x 12mm package.
[2] These measurements are for the 18 x 12mm package.

Figure 2-5 iNAND Ball Array (Top View)



3 iNAND Interface Description

3.1 Pins and Registers

Table 3-1 contains the SanDisk iNAND functional pin assignment

Table 3-1 iNAND Pin Assignment

Pin No.	Name	Pin No.	Name	Pin No.	Name	Pin No.	Name
A1	DNU	**D2**	NC	**J2**	NC	**N5**	VSS
A2	DNU	**D3**	NC	**J3**	NC	**N6**	NC
A3	DAT0	**D4**	NC	**J5**	NC	**N7**	NC
A4	DAT1	**D12**	DNU	**J10**	VDD_F	**N8**	NC
A5	DAT2	**D13**	DNU	**J12**	DNU	**N9**	NC
A6	NC	**D14**	DNU	**J13**	DNU	**N10**	NC
A7	NC	**E1**	NC	**J14**	DNU	**N11**	NC
A8	NC	**E2**	NC	**K1**	NC	**N12**	NC
A9	NC	**E3**	NC	**K2**	NC	**N13**	NC
A10	NC	**E5**	NC	**K3**	NC	**N14**	DNU
A11	NC	**E6**	VDD_F	**K5**	NC	**P1**	DNU
A12	NC	**E7**	VSS	**K6**	NC	**P2**	DNU
A13	DNU	**E8**	NC	**K7**	NC	**P3**	VDD_H
A14	DNU	**E9**	NC	**K8**	VSS	**P4**	VSS
B1	DNU	**E10**	NC	**K9**	VDD_F	**P5**	VDD_H
B2	DAT3	**E12**	DNU	**K10**	NC	**P6**	VSS
B3	NC	**E13**	DNU	**K12**	DNU	**P7**	NC
B4	NC	**E14**	DNU	**K13**	DNU	**P8**	NC
B5	NC	**F1**	NC	**K14**	DNU	**P9**	NC
B6	NC	**F2**	NC	**L1**	NC	**P10**	NC
B7	NC	**F3**	NC	**L2**	NC	**P11**	NC
B8	NC	**F5**	VDD_F	**L3**	NC	**P12**	NC
B9	NC	**F10**	NC	**L12**	DNU	**P13**	DNU
B10	NC	**F12**	DNU	**L13**	DNU	**P14**	DNU
B11	NC	**F13**	DNU	**L14**	DNU		

Pin No.	Name	Pin No.	Name	Pin No.	Name	Pin No.	Name
B12	NC	**F14**	DNU	**M1**	NC		
B13	NC	**G1**	NC	**M2**	NC		
B14	DNU	**G2**	NC	**M3**	NC		
C1	NC	**G3**	NC	**M4**	VDD_H		
C2	FCAP	**G5**	VSS	**M5**	CMD		
C3	NC	**G10**	NC	**M6**	CLK		
C4	VSS	**G12**	DNU	**M7**	NC		
C5	NC	**G13**	DNU	**M8**	NC		
C6	VDD_H	**G14**	DNU	**M9**	NC		
C7	NC	**H1**	NC	**M10**	NC		
C8	NC	**H2**	NC	**M11**	NC		
C9	NC	**H3**	NC	**M12**	DNU		
C10	NC	**H5**	NC	**M13**	DNU		
C11	NC	**H10**	VSS	**M14**	DNU		
C12	DNU	**H12**	DNU	**N1**	DNU		
C13	DNU	**H13**	DNU	**N2**	VSS		
C14	DNU	**H14**	DNU	**N3**	NC		
D1	NC	**J1**	NC	**N4**	VDD_H		

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 3-4.

Table 3-4 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	ST08G ST04G ST02G ST01G ST512	Five ASCII characters long
Product Revision (PRV)	BCD	8	Product Revision xx	See Section 5.2 in the SDA *Physical Layer Specification*, *Version 2.00*
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: $G(x) = x^7+x^3+1$

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

$CRC[6\ldots0]=Remainder[(M(x)*x^7)/G(x)]$

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 3-5 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 3-5 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 3-6 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 3-6 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	Device size
VDD_R_ CURR_MIN	According to card performance	Max. read current @VDD min.
VDD_R_ CURR_MAX	According to card	Max. read current @VDD max.

Field	CSD Value	Description
	performance	
VDD_W_ CURR_MIN	According to card performance	Max. write current @VDD min.
VDD_W_ CURR_MAX	According to card performance	Max. write current @VDD max.
C_SIZE_ MULT	2G=2048 1G=1024 512=512	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 3-7 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	Card command classes
READ_BL_ LEN	---	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
---	0	Reserved
C_SIZE	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_BL_ LEN	---	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	No protected	Temporary write protection
FILE_ FORMAT	HD w/partition	File format
Reserved	---	Reserved

Field	CSD Value	Description
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 3-8 User Area DOS Image Parameters

Capacity*	Total LBAs	Number of Partition System Area Sectors	Total Partition Sectors	User Data Sectors	User Data Bytes
8 GB	16,055,296	8192	16,047,104	16,038,912	3,073,376,256
4 GB	8,026,112	8192	8,017,920	8,009,728	4,100,980,736
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

***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 Description

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 Power Delivery and Capacitor Specifications

A.1 SanDisk iNAND Power Domains

SanDisk iNAND has three power domains assigned to VDD_H, VDD_F, and FCAP as shown in Table 1.

Table 1. Power Domains

Pin	Power Domain	Comments
VDD_H	Host Interface	Supported voltage ranges: High Voltage Region: 3.3V (nominal) Low Voltage Region: 1.8V (nominal)
VDD_F	Memory	Supported voltage range: High Voltage Region: 3.3V (nominal)
FCAP	Internal	FCAP is the internal regulator connection to an external decoupling capacitor.

A.2 Capacitor Connection Guidelines

A.2.1 FCAP Connections

The FCAP (C2) ball must only be connected to an external capacitor that is connected to VSS. This signal may not be left floating. The capacitor's specifications and its placement instructions are detailed below.

The capacitor is part of an internal voltage regulator that provides power to the controller.

Caution: ***Failure to follow the guidelines below or connecting the FCAP ball to any external signal or power supply may cause the device to malfunction.***

The trace requirements from the FCAP (C2) ball to the capacitor are as follows:

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

The capacitor requirements are as follows:

- Capacitance: >=2.2 uF
- Voltage Rating: >=6.3 V
- Dielectric: X7R or X5R

A.2.2 VDD_H and VDD_F Connections

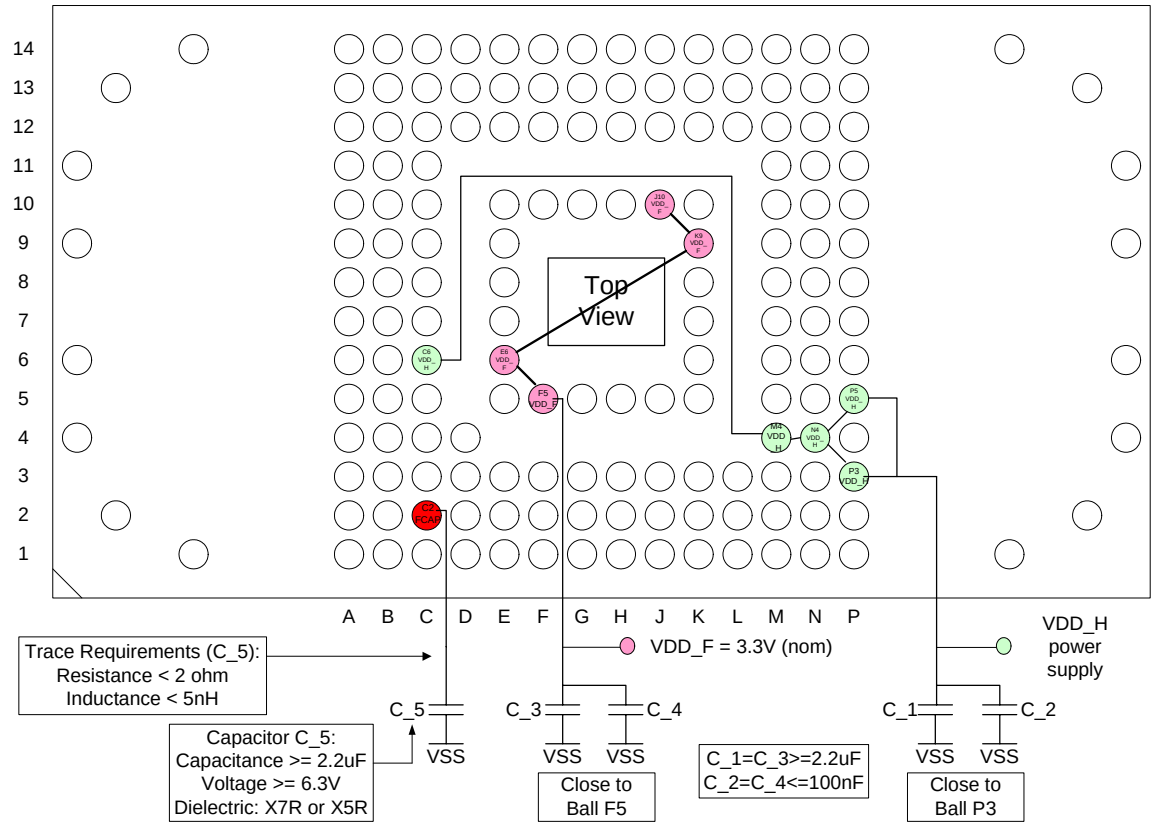
The iNAND has two power domains labeled: VDD_H and VDD_F. Currently both power domains can be connected to the same 3.3V (nom) power supply. However, in order to provide maximum flexibility and support low power operation in future iNAND devices, the PCB should be designed as follows:

- All VDD_F balls should be connected to a 3.3V supply
- All VDD_H balls should have the option of being connected either to a 3.3V or 1.8V supply

SanDisk recommends providing separate bypass capacitors for each power domain as shown in Figure 1.

Note: *Signal routing in the diagram is for illustration purposes only and the final routing depends on your PCB layout. Also, for clarity, the diagram does not show the VSS connection. All balls marked VSS should be connected to a ground (GND) plane.*

Figure 1. Recommended Power Domain Connections



Appendix B Ordering Information

B.1 iNAND (JC64 Package)

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

Part Number	Block Size[1]
12 mm x 16 mm x 1.2 mm Package	
SDIN2C1-512M	512 MB
SDIN2C2-1G	1 GB
SDIN2C2-2G	2 GB
12 mm x 18 mm x 1.2 mm Package	
SDIN2B2-2G	2 GB
SDIN2B2-4G	4 GB
SDIN2B2-8G	8 GB

Note: If parts will be shipped by tape/reel, add "T" to the end of the part number. For example, SDIN2B2-8G would become SDIN2B2-8G-T.

[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 Disclaimer of Liability

C.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