南京扬贺扬
HeYangTek

HY SPI 2G

Serial Peripheral Interface (SPI)
NAND Flash

Parts No.	Density	Voltage	Package	MID	DID	Page Size	Pages/Block
HYF2GQ4UTACAE	2Gb/256MB	3.3V	LGA8	01	25	2K	64
HYF2GQ4UTDCAE	2Gb/256MB	3.3V	BGA24	01	25	2K	64

Version: 1.3.1

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Features

☆ Standard Dual and Quad SPI
- Standard SPI: SCLK, CS#, SI, SO, WP#, HOLD#
- Dual SPI: SCLK, CS#, SIO0, SIO1, WP#, HOLD#
- Quad SPI: SCLK, CS# ,SIO0, SIO1, SIO2, SIO3

☆ Flash Features
- Block Size : (Page size)×(64 page/block)
- Page Size : 2048 + 128 bytes
- SPI Capacity : 2Gb (2048 blocks)

☆ Performance
- Read Page Time: 45 μs (Typ)
- Program time: 350 μs (Typ)
- Block Erase time: 4.0 ms (Typ)

☆ SPI power supply voltage
- Full voltage range for 3.3V : 2.7 to 3.6V

☆ Reliability
- On-chip ECC correction Program
- Operating Temperature: -40 °C to 85 °C
- Blocks 0-7 are good at the time of shipment
- 100,000 Program / Erase cycles (Typ)
- 10 Year Data Retention (Typ)

☆ Security Features
- One Time Programmable (OTP) area
- Serial number (unique ID) (Contact factory for support)
- Hardware program/erase disabled during power transition
- Volatile and Permanent Block Protection

☆ SPI Max. Clock Frequency
- 104MHz @ 3.3V

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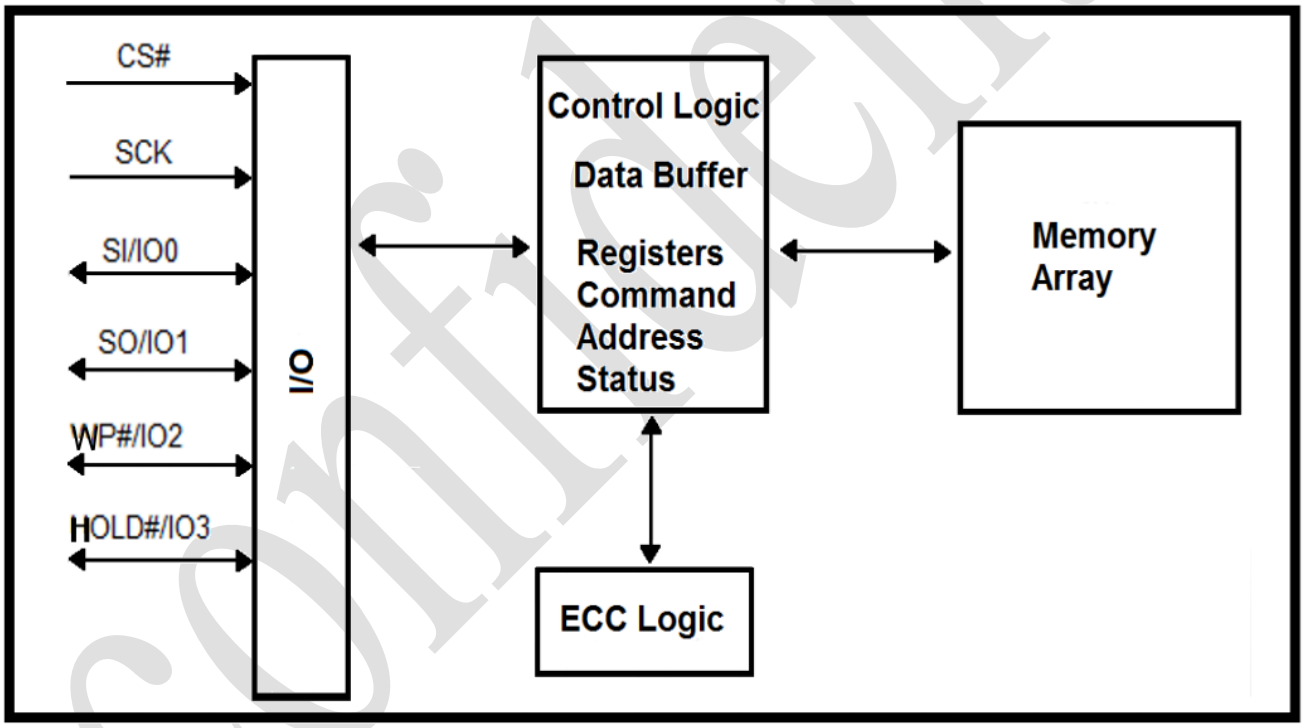
General Description

SPI (Serial Peripheral Interface) NAND Flash provides a low cost and low pin count solution to alternate SPI-NOR in high density non-volatile memory storage solution for embedded systems.

SPI NAND Flash is an SLC NAND Flash memory device based on the standard parallel NAND Flash. The serial electrical interface follows the industry-standard serial peripheral interface. The command sets is similar to the SPI-NOR command sets but with some modifications to handle NAND specific functions and new features are added to extend applications. The SPI NAND flash device has total 8 pin count, including six signal lines plus VCC and GND.

Each block of the serial NAND Flash device is subdivided into 64 programmable pages. Each page consists of a data storage region and a spare area. The data storage region is used to storage data user programmed and the spare area is typically used for memory management and error correction functions.

Functional Block Diagram



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Pin Description

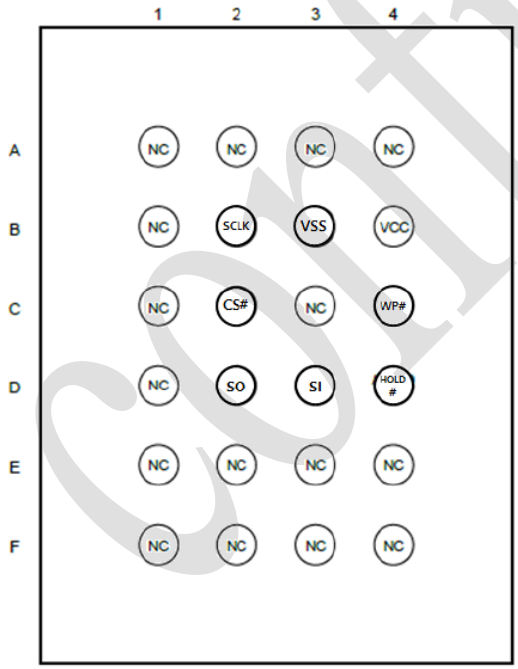
Pin Name	Type	Description
SCLK	In	Serial Clock
SI/SIO0	I/O	Serial Data Input / Serial Data I/O0
SO/SIO1	I/O	Serial Data Output / Serial Data I/O1
WP#/SIO2	I/O	Write Protect / Serial Data I/O2
Hold#/SIO3	I/O	Hold / Serial Data I/O3
CS#	In	Chip Select
VCC	Supply	Power Supply
GND	Ground	Ground

Notes:

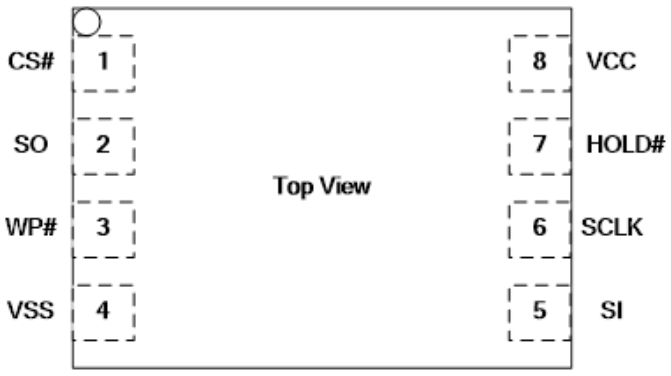
1) A 0.1 μF capacitor should be connected between the VCC Supply Voltage pin and the Vss Ground pin to decouple the current surges from the power supply. The PCB track widths must be sufficient to carry the currents required during program and erase operations.

2) An internal voltage detector disables all functions whenever VCC is below 1.8V to protect the device from any involuntary program/erase during power transitions.

Connection Diagram



BGA24

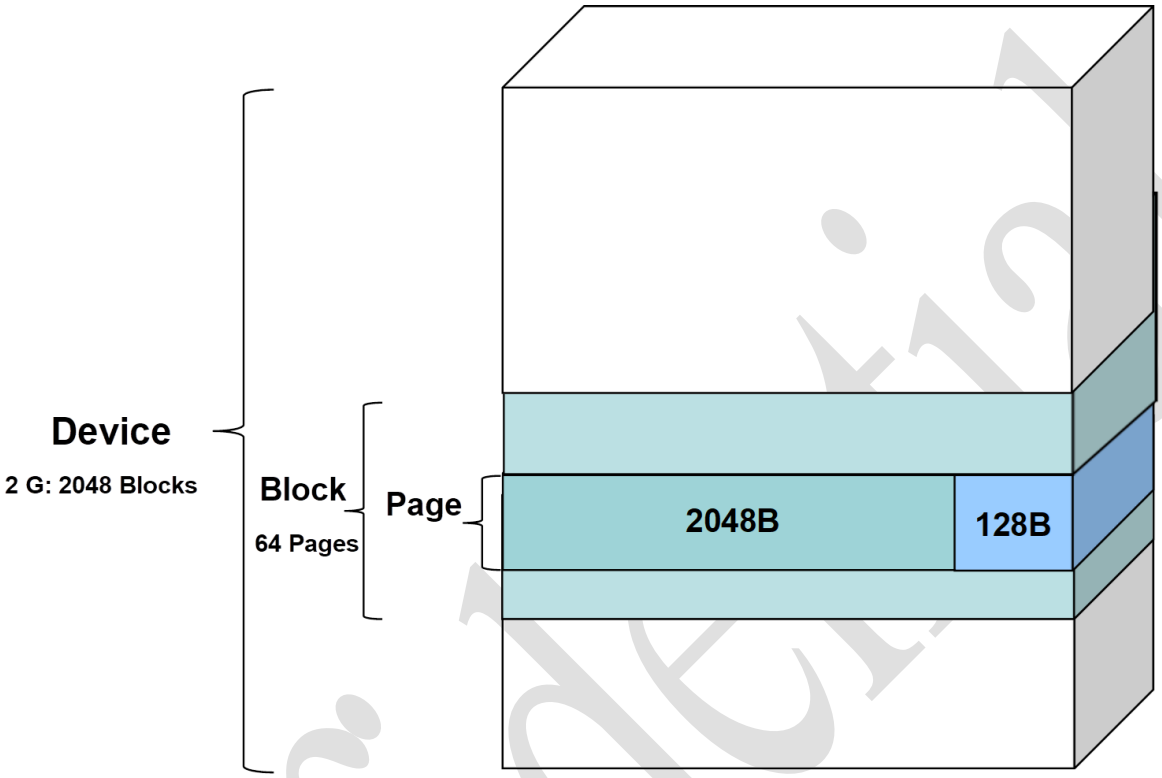


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Array Organization

Device	Number of Blocks	Number of Pages	Page Size	Device Size
2G	2048	64	2K+128B	256MB+16MB



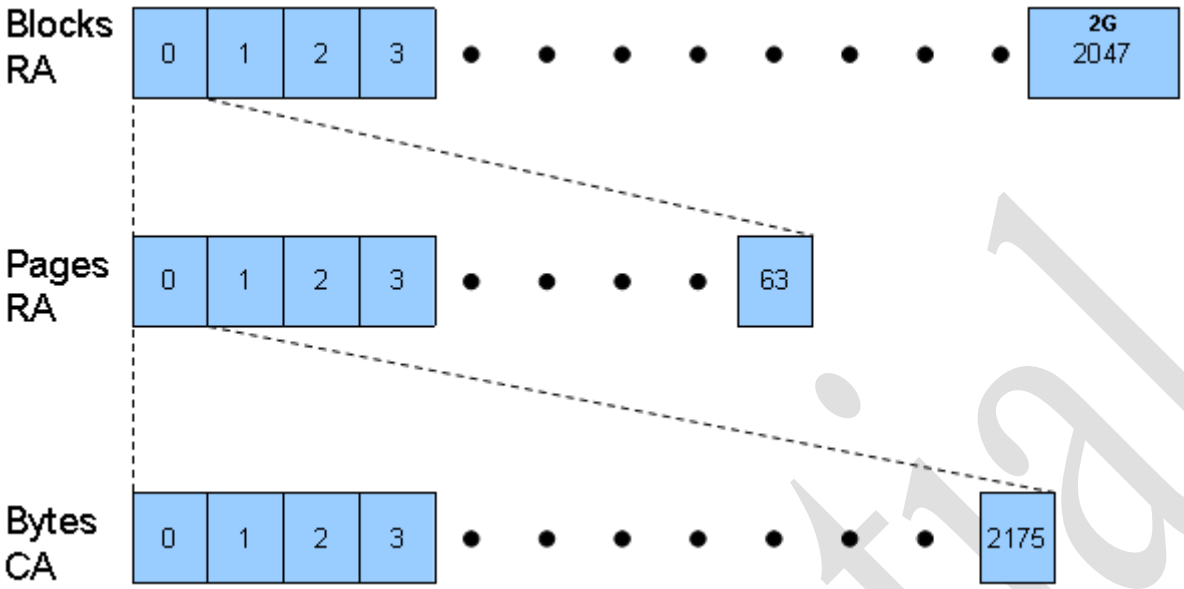
1 page (program unit) = (2K+128) bytes

1 block (Erase unit) = (2K+128)*64 pages = (128K+8K) bytes

2 G device = (128K+8K)*2048 blocks = (256MB+16MB)

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Memory Mapping



Note:

1. RA: Row Address. The RA can to index and select the block.

   RA[5:0]: for Page Range 0~63.

   RA[16:6] : for 2G, have 0~2047 blocks range.

2. CA: Column Address. The CA[11:0] can only access 0~2175 bytes, include 2K(2048)bytes and 128Byte *OOB.

*OOB : Each page of a NAND flash has an "out of band" (OOB) area to hold Error Correcting Code (ECC) and other metadata.

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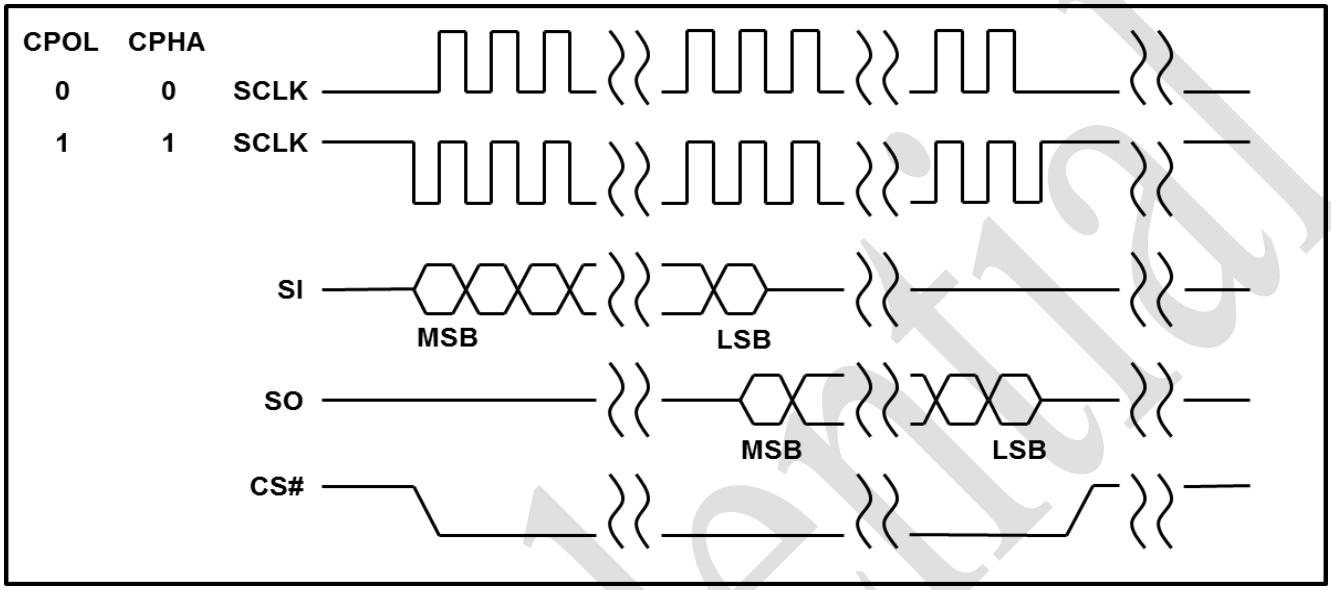
Device Operation

SPI Mode

SPI NAND supports two SPI modes:

- CPOL = 0, CPHA = 0 (Mode 0)
- CPOL = 1, CPHA = 1 (Mode 3)

Input data is latched in on the rising edge of SCLK and output data is available on the falling edge of SCLK for both mode 0 and mode 3. The timing diagrams shown in this data sheet are mode 0.



SCLK	SCLK provides interface timing for SPI NAND. Address, data and commands are latched on the rising edge of SCLK. Data is placed on SO at the falling edge of SCLK.
CS#	When CS# = 0, the device is placed in active mode. When CS# = 1, the device is placed in inactive mode and SO is High-Z.

Standard SPI:

Standard serial peripheral interface on four signals bus: System Clock (SCLK), Chip Select (CS#), Serial Data In (SI) and Serial Data Out (SO).

Dual SPI:

SPI NAND supports dual SPI operation with x2 and dual IO commands. These commands allow data to be transferred to or from SPI NAND at two times of rates of Standard SPI operation. The SI and SO become bi-directional I/O pins : SIO0 and SIO1.

Quad SPI:

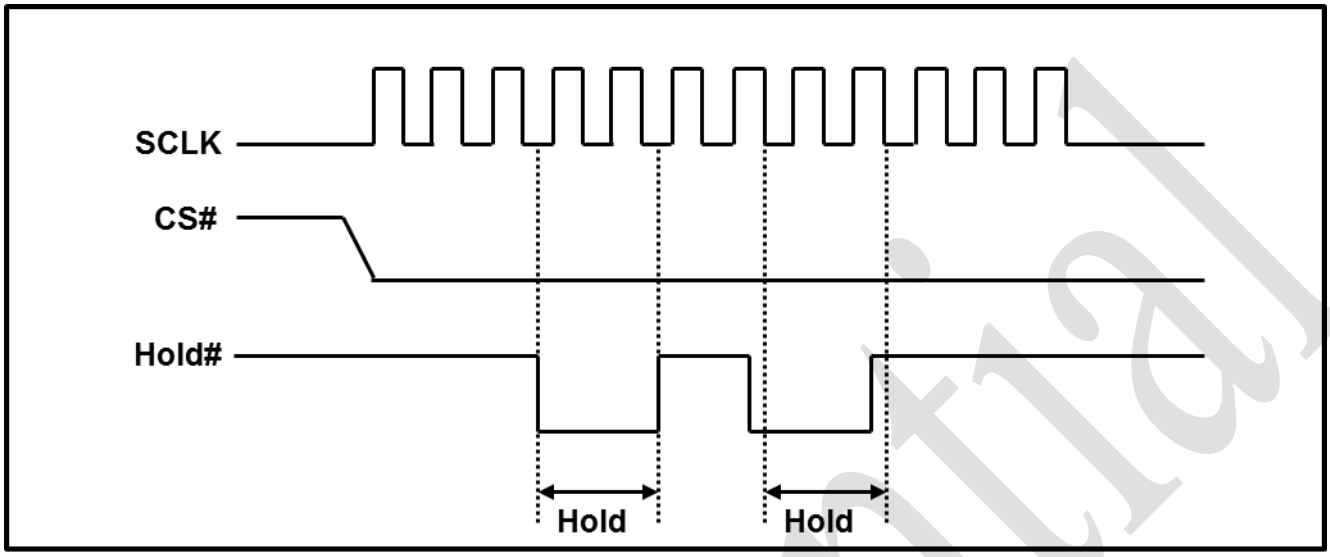
SPI NAND supports the x4 and Quad commands operation. These commands allow data to be transferred to or from SPI NAND at four times of rates of Standard SPI operation. The SI and SO become bi-directional I/O pins: SIO0 and SIO1, the WP# and HOLD# pins become SIO2 and SIO3.

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Hold Mode:

The HOLD# signal goes low to stop any serial communications with the device, but doesn't stop the operation of write status register, programming or erasing in progress.

Hold Condition Diagram



HOLD	Hold mode starts at the falling edge of HOLD# provided SCLK is also LOW. If SCLK is HIGH when HOLD# goes LOW, hold mode begins after the next falling edge of SCLK.

Write Protection Mode:

Two security methods are described below:

・Hardware Write Protection (HWP)

The HWP feature can protect all blocks, or one selected range of contiguous blocks, from erase and program operations. After a power-cycle, all blocks are protected as the BP[3:0] bits are high (see Block protection feature register(A0h).)The SET FEATURE command must be issued to alter the state of block protection. A Reset command will not reset the A0h register and therefore will not modify the block protection state. When a PROGRAM/ERASE command is issued to a locked block, a status register P_Fail bit or E_Fail bit will beset to indicate the operation failure.

・Permanent Block Protection (PBP)

The PBP parameter settings will be maintained after a power cycle. The PBP method can protect up to 64 blocks (blocks 0 to 63) organized in groups of 4 contiguous blocks. Each group can be protected individually and are permanently protected.

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Command Set

SPI NAND Flash Command Set

Command	Op Code	2nd Byte	3rd Byte	4th Byte	5th Byte	6th Byte	Nth Byte
Write Disable	04H	-	-	-	-	-	-
Write Enable	06H	-	-	-	-	-	-
Block Erase (Block size)	D8H	A23-A16	A15-A8	A7-A0	-	-	-
Program Load	02H	A15-A8	A7-A0	D7-D0	Next data	Next data	-
Program Load Random Data	84H(1)	A15-A8	A7-A0	D7-D0	Next data	Next data	-
Program Load x4 IO	32H	A15-A8	A7-A0	(D7-D0)x4	Next data	Next data	-
Program Load Random Data x4 IO	34H(2)	A15-A8	A7-A0	(D7-D0)x4	Next data	Next data	-
Program Execute	10H	A23-A16	A15-A8	A7-A0	-	-	-
Block Protection Status	7AH	A23-A16	A15-A8	A7-A0	Dummy	D7-D0	-
Program PBP Setting	2CH(3)	A23-A16	A15-A8	A7-A0	-	-	-
Page Read (to Cache)	13H	A23-A16	A15-A8	A7-A0	-	-	-
Read from Cache x1 IO	03H/0BH	A15-A8	A7-A0	Dummy	D7-D0	Next data	Wrap
Read from Cache x2 IO	3BH	A15-A8	A7-A0	Dummy	(D7-D0)x2	Next data	Wrap
Read from Cache x4 IO	6BH	A15-A8	A7-A0	Dummy	(D7-D0)x4	Next data	Wrap
Read from Cache Dual IO	BBH	A15-A0	Dummy(4)	(D7-D0)x2	Next data	Next data	Wrap
Read from Cache Quad IO	EBH	A15-A0	Dummy(4)	(D7-D0)x4	Next data	Next data	Wrap
Read ID	9FH	Dummy	MID	DID	Wrap	Wrap	Wrap
Reset	FFH	-	-	-	-	-	-
Get Feature	0FH	A7-A0	D7-D0	-	-	-	-
Set Feature	1FH	A7-A0	D7-D0	-	-	-	-

Notes:

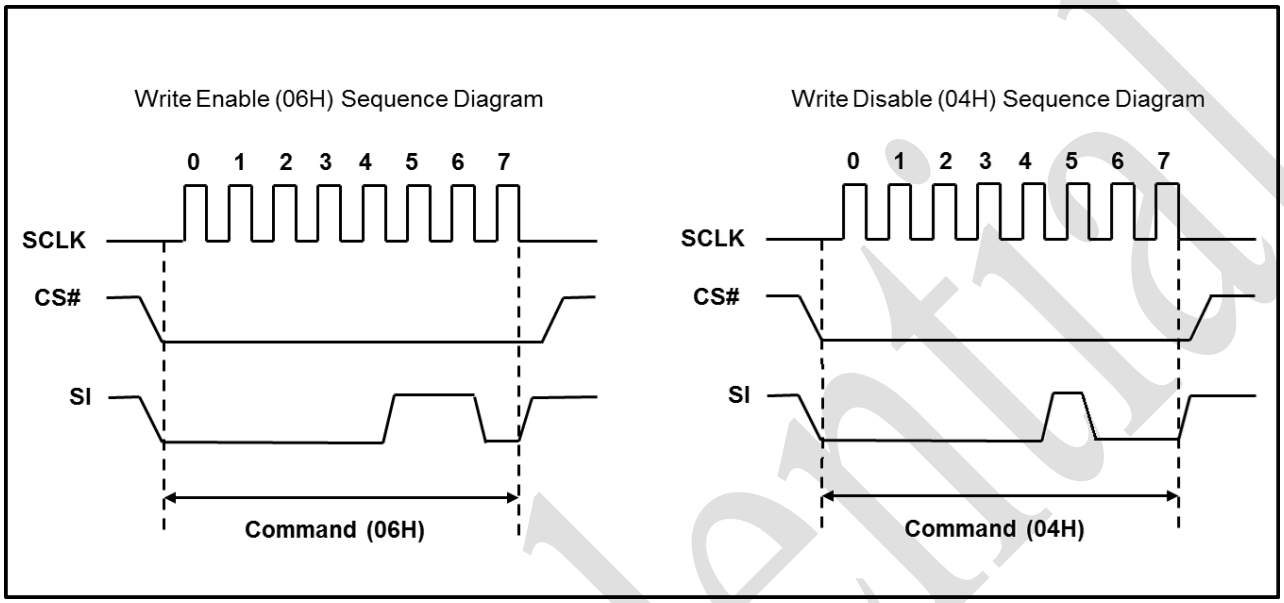
1. The Program Load random data (84h) operation is similar to Program Load (02h). The 84h command does not clear the data buffer to an all FFh value and will only update the data bytes specified by the command input sequence while the rest of the input buffer remains unchanged. The host must always consider chunks of 32 bytes starting from address 0 to accommodate internal ECC requirements.
2. The Program Load x4 IO (32h) operation is similar to Program Load Random Data x4 IO (34h). The 34h command does not clear the data buffer to an all FFh value and will only update the data bytes specified by the command input sequence while the rest of the input buffer remains unchanged. The host must always consider chunks of 32 bytes starting from address 0 to accommodate internal ECC requirements.
3. PBP's A23-A0 address cycle mapping is described in the Security Features section.
4. The number of dummy cycles is 8 cycles.

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Write Enable Operations

The WRITE ENABLE (WREN, 06H) command is for setting the Write Enable Latch (WEL) bit. The WRITE DISABLE (WRDI, 04H) command is for clearing the WEL bit.

As with any command that changes the memory contents, the WRITE ENABLE command must be executed at first in order to set the WEL bit to 1. Refer to the PAGE READ operation sequence, PAGE PROGRAM operation sequence, Internal Data Move operation sequence, BLOCK ERASE operation sequence and OTP operation sequence.

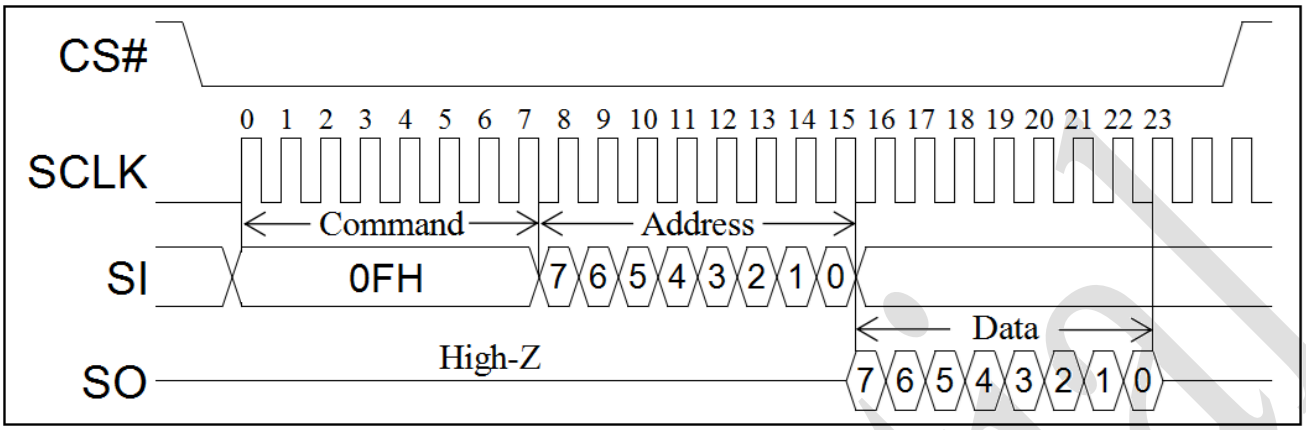


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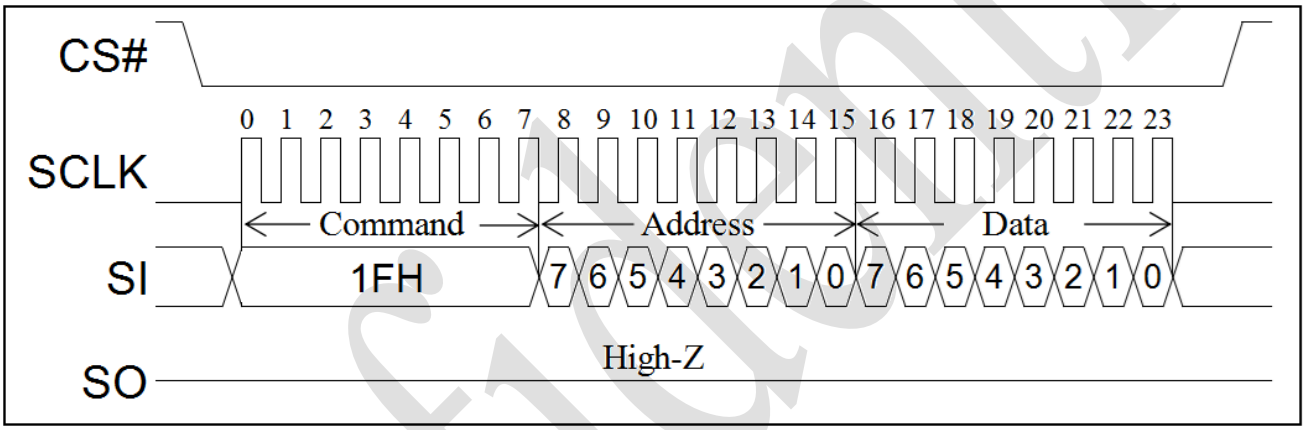
Feature Operation

The GET FEATURE (0FH) and SET FEATURE (1FH) commands are used to monitor the devices status and alter the device behavior.

Get Feature (0FH) Sequence Diagram



Set Feature (1FH) Sequence Diagram



The SET FEATURE command is valid only when WP# pin = 1.

Feature Register Table

Register	Address	Data Bits							
		7	6	5	4	3	2	1	0
Protect	A0H	BRWD	BP3	BP2	BP1	BP0	INV	HWP_EN(1)	Reserved
Configuration	B0H	CFG2	CFG1	HWP_LD(2)	ECC_EN(3)	Reserved	Reserved	CFG0	Reserved
Status	C0H	Reserved	Reserved	ECCS1	ECCS0	P_FAIL	E_FAIL	WEL	OIP

Notes:

1) HWP_EN must be enabled first before block unlock region is set

2) HWP_LD when set to 1, this bit along with the register A0H [6:0] can only be cleared during POR

3) ECC_EN must be always set to 1

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Status Register

The content of status register can be read by issuing the GET FEATURE (0FH) command, followed by the status register address C0H. The meaning of each Bit in status register is as the table below,

Status Register Bit Description

Bit	Name	Description
P_FAIL	Program Fail	This bit indicates that a program failure has occurred. It will also be set if the user attempts to program an invalid address or a protected region, including the OTP area. This bit is cleared during the PROGRAM EXECUTE command sequence or a RESET command.
E_FAIL	Erase Fail	This bit indicates that an erase failure has occurred. It will also be set if the user attempts to erase a locked region. This bit is cleared at the start of the BLOCK ERASE command sequence or the RESET command.
WEL	Write Enable Latch	This bit indicates that the current status of the write enable latch(WEL) and must be set (WEL = 1), prior to issuing a PROGRAM EXECUTE or BLOCK ERASE command. It is set by issuing the WRITE ENABLE command. WEL can also be disabled (WEL = 0), by issuing the WRITE DISABLE command.
OIP	Operation In Progress	This bit is set when a PROGRAM EXECUTE, PAGE READ, BLOCK ERASE or RESET command is executing, indicating the device is busy. When the bit is 0, the interface is in the ready state.
ECCS1, ECCS0	ECC Status	ECC status as follows 00b = No bit errors were detected 01b = 1-2 bits errors corrected 10b = 3-4 bits errors corrected 11b = 5-6 bits errors corrected (Rewrite recommended)

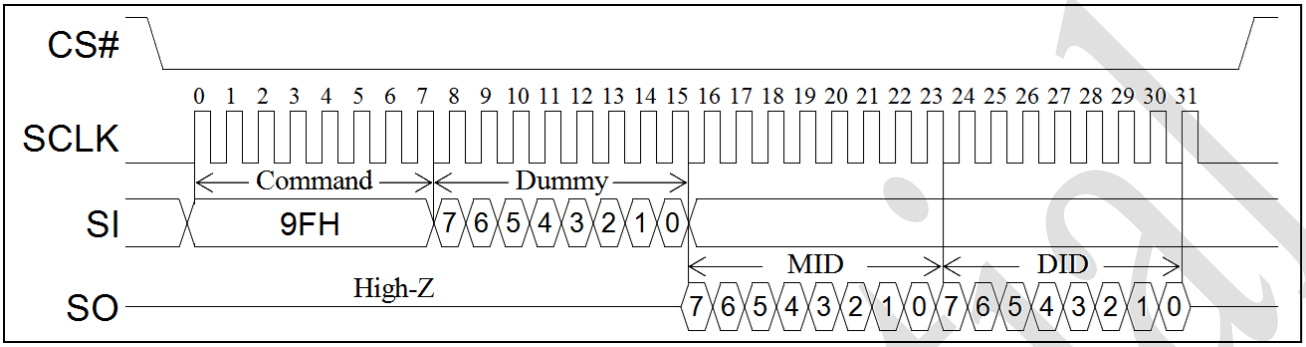
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Read ID Operations

Read ID (9FH)

The READ ID command is used to identify the SPI NAND Flash memory device. The Read ID command outputs the manufacture ID with address byte 00H and outputs the device ID when address byte is 01H.

Read ID (9FH) Sequence Diagram



ID Definition Table

Address	Value	R/W	Description
00H	01h	R	Manufacture ID
01H	25h	R	Device ID

Read Unique ID

Read Unique ID located in OTP page 0

1, Use SET FEATURES command (1Fh) with feature address B0h and data value of 0x50 for ECC enabled

2, Page Read command (13h) with Block/Pageaddress:

- 0x180 for unique ID (OTP page 0)

-GET FEATURE command (0Fh) with feature address C0h to check OIP bit ready

3, Read Buffer (03h) command to read the data out

4, Use SET FEATURES command (1Fh) with feature address B0h and data value with Config[2:0] = 000b to exit.

5, Or use RESET (FFh) command to clear the configuration bits and return to normal mode.

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One-Time Programmable (OTP) function

OTP States

CFG2	CFG1	CFG0	Description
0	0	0	Normal Operation (default)
0	1	0	Access OTP Area / Unique ID
1	1	0	Access to OTP data protection bit to lock OTP area
1	1	1	Access to Permanent Block Protection (PBP) lock-down

The device contains a one-time programmable (OTP) area, that consists of (62 pages), accessed by SET/GET FEATURES commands.

OTP Read

OTP Read: 62 pages accessible for user data located in Block #6 from page 2 to page 63

1, Use SET FEATURES command (1Fh) with feature address B0h and data value of 0x50.

2, Page Read command (13h) with Block/Page address (0x0182-0x019F)

GET FEATURE command (0Fh) with feature address C0h to check OIP bit ready

3, Read Buffer (03h) command to read the dataout

4, Use SET FEATURES command (1Fh) with feature address B0h and data value of 0x10 to exit

5, Or use RESET (FFh) command to clear the configuration bits and return to normal mode.

OTP Program

OTP Program: 62 pages accessible for user data located in Block 6 from page 2 to page 63

1, Use SET FEATURES command (1Fh) with feature address B0h and data value of 0x50 for ECC enabled

2, Use Write Enable command 06h

3, Program using Load command x1 (02h), Quad Program Data Load (32h) or random program data load with data

4, Program Execute command x1 (10h) with Block/Page address(0x0182-0x019F)

5, Use GET FEATURE command (0Fh) with feature address C0h to check OIP bitready

6, Use SET FEATURES command (1Fh) with feature address B0h and value of 0x10 to exit

7, After tPROG time, use GET FEATURE command (0Fh) with feature address C0h to verifyP_Fail bit is not set.

OTP Data Protection and Program Prevention

This mode is used to prevent further programming of the pages in the OTP area. The following sequence is used to protect and prevent further programming of the OTP area:

1, Use SET FEATURES command (1Fh) with feature address B0h and data value of 0xC0

2, Use Write Enable command 06h

3, Program execute command (10h) with row address 00h

4, Verify until OIP bit not busy and P_FAIL bit 0 using GET FEATURE command (0Fh) with status register address (C0h)

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Hardware Write Protection (HWP)

Hardware write protection prevents the block protection state from hardware modifications.

The following command sequence enables hardware write protection: The SET FEATURE command is issued on feature address A0h. Then, the HWP_EN bit-state is set to 0 as the default after power up.

The BRWD bit is operated in conjunction with HWP_EN bit. When BRWD is set to 1 and WP# is LOW, none of the other block protect register A0H bits [7:2] can be set. The block lock state cannot be changed, regardless of what is unlocked or locked. Also, when the WP#/Hold# disable bit is set to 1, the hardware protected mode is disabled. The default value of BRWD and HWP_EN bits = 0 after power up.

Block Protect Bits Table (A0H [6:2])

BP3	BP2	BP1	BP0	INV	Protect Rows
0	0	0	0	X	**All Blocks Unlocked**
0	0	0	1	0	Lower 1/1024 Blocks Locked
0	0	1	0	0	Lower 1/512 Blocks Locked
0	0	1	1	0	Lower 1/256 Blocks Locked
0	1	0	0	0	Lower 1/128 Blocks Locked
0	1	0	1	0	Lower 1/64 Blocks Locked
0	1	1	0	0	Lower 1/32 Blocks Locked
0	1	1	1	0	Lower 1/16 Blocks Locked
1	0	0	0	0	Lower 1/8 Blocks Locked
1	0	0	1	0	Lower 1/4 Blocks Locked
1	0	1	0	0	Lower 1/2 Blocks Locked
1	0	1	1	0	All Blocks Locked
0	0	0	1	1	Upper 1/1024 Blocks Locked
0	0	1	0	1	Upper 1/512 Blocks Locked
0	0	1	1	1	Upper 1/256 Blocks Locked
0	1	0	0	1	Upper 1/128 Blocks Locked
0	1	0	1	1	Upper 1/64 Blocks Locked
0	1	1	0	1	Upper 1/32 Blocks Locked
0	1	1	1	1	Upper 1/16 Blocks Locked
1	0	0	0	1	Upper 1/8 Blocks Locked
1	0	0	1	1	Upper 1/4 Blocks Locked
1	0	1	0	1	Upper 1/2 Blocks Locked
1	0	1	1	1	All Blocks Locked
1	1	X	X	X	All Blocks Locked
1	1	1	1	1	**All Blocks Locked (default)**

The feature registers are volatile. Each POR will reset these registers to the default value (0x7C). The Reset (FFh) only clears the configuration bits (A0H [7,1,0]) to zero.

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Permanent Block Protection (PBP)

The device contains 16 protection parameter setting entries. Each entry enables protection from program and erase of a group of 4 contiguous blocks (64 blocks total) in the main array.

The device ships from the factory with no blocks protected by the PBP method.

Because this block protection is permanent, a power-on to power-off sequence does not affect the block status after the Permanent block protection command is issued.

The PBP method is used to select a group of blocks in the main array to be protected from program and erase operation.Multiple groups of blocks can be protected at the same time. Once a group of blocks is protected, the group of blocks can no longer be unprotected.

Additional unprotected groups can still be protected using the PBP sequence. However, the user must not re-issue a PBP command with a group that has been previously protected.

The following PBP sequence is used:

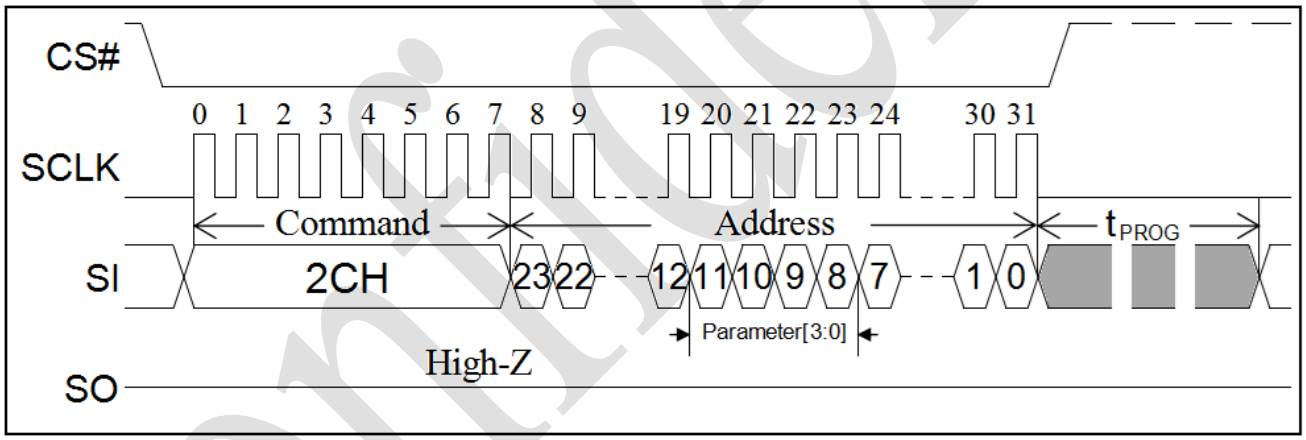
1, 06h (WRITE ENABLE)

2, 2Ch (PBP Command) followed by 24-bit address (Parameter[3:0] is block select: see table below)

3, After tPROG time, use GET FEATURE command (0Fh) with feature address C0h to verify P_Fail bit is not set.

If the host attempts to program data to a protected block, this operation will fail and the status register (with feature address C0h) reads the following values: P_FAIL = 1 and WEL = 1. The timing diagram and address phase cycle of the PBP sequence is provided below:

Program PBP Setting (2CH) Sequence Diagram



Program PBP Parameter Setting Table

Addresss[23:12]	Addresss[11:8] Parameter[3:0]	Addresss[7:0]	Protection Group	Group Block addresses
0	0000b	0	0	0, 1, 2, 3
	0001b		1	4, 5, 6, 7
	…		…	…
	pqstb		n=p*8+q*4+s*2+t	4*n, 4*n+1, 4*n+2, 4*n+3
	…		…	…
	1111b		15	60, 61, 62, 63

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Permanent Block Protection (PBP) lock down

The following command sequence to lock down the Permanent Block Protection is as follow:

1, Use SET FEATURES command (1Fh) with feature address B0h and data value of 0xD2

2, Use Write Enable command (06h)

3, Program Execute command (10h) with block/page address (0x00)

4, Use GET FEATURE command (0Fh) with feature address C0h to check OIP bit ready

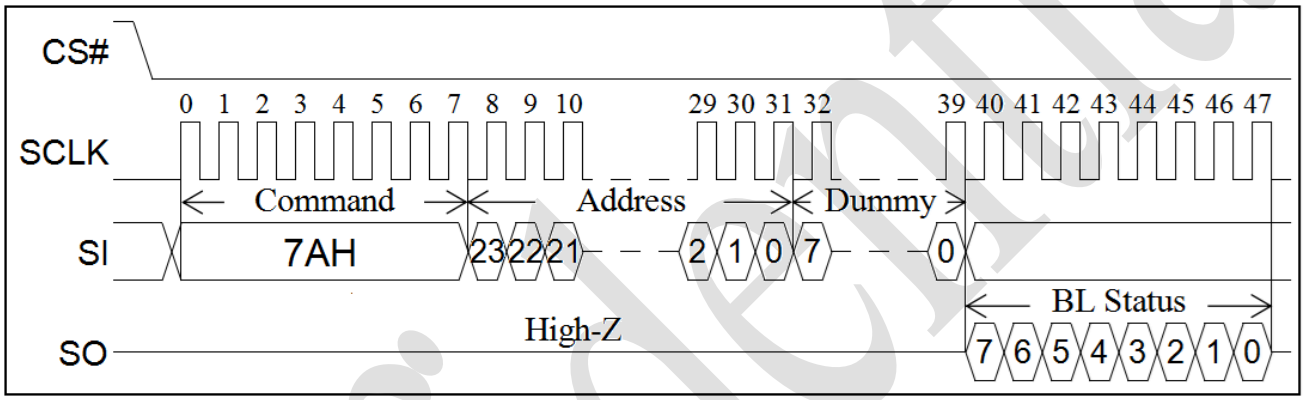
5, Use SET FEATURES command (1Fh) with feature address B0h and data value of 0x10 to exit

6, After tPROG time, use GET FEATURE command (0Fh) with feature address C0h to verify P_Fail bit is not set

Block Protection Status

The Block Protection Status Read command (7Ah) is followed by 3 address cycles (see address mapping section), eight dummy cyles and one data cycle.

Read Block Protection Status (7AH) Sequence Diagram



This register indicates whether a given block (addressed in the Block protection read address command field: BA[13:0]) is locked-down, locked or unlocked using the HWP or PBP).

Block Lock Status Register Table

Data Bits								Description
7	6	5	4	3	2	1	0	
Reserved				PBP_S	HWP_S[2:0]			Define
0				0				Block is Locked by PBP
				1				Block is Unlocked by PBP (Default)
					0	0	1	Block is Locked, Device is locked-down (HWP_LD = 1)
					0	**1**	**0**	Block is Locked (Default) Device is not locked-down (HWP_LD = 0)
					1	0	1	Block is Unlocked, Device is locked-down (HWP_LD = 1)
					1	1	0	Block is Unlocked, Device is not locked-down (HWP_LD = 0)

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Read Operations

The PAGE READ (13H) command transfers the data from the NAND Flash array to the cache memory. The command sequence is follows:

I. 13H (PAGE READ to Cache)

II. 0FH (GET FEATURE command to read the status)

III. Read from Cache memory

- 03H or 0BH (Read from Cache x1 IO)/3BH (Read from Cache x2 IO)/6BH (Read from Cache x4 IO)
- BBH (Read from Cache Dual IO)/EBH (Read from Cache Quad IO)

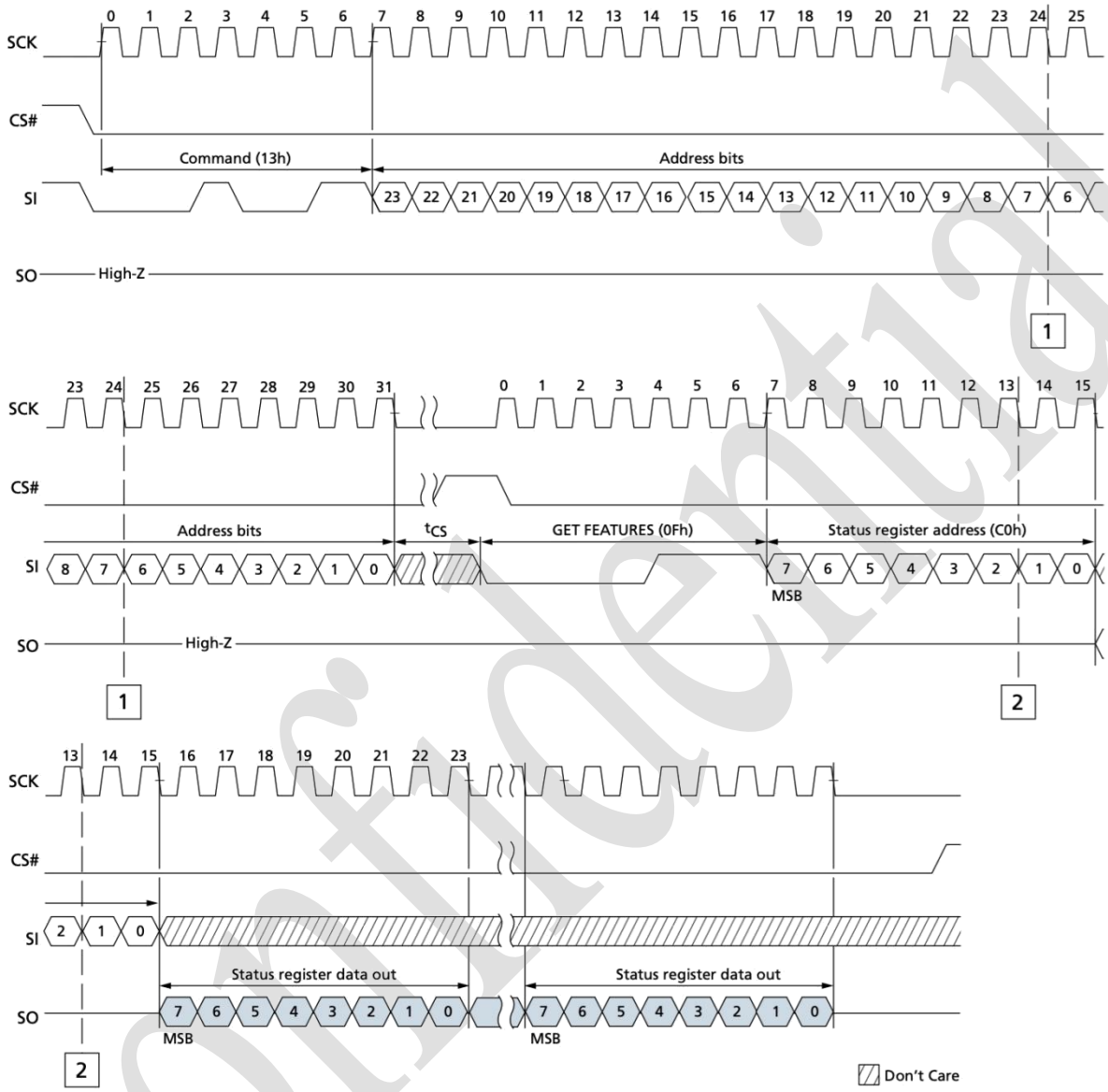
The PAGE READ command requires a 24-bit address consisting of dummy bits and block/page address bits. After the block/page addresses are registered, the device starts the transfer from the main array to the cache register, and is busy for tRD time. During the busy time, the GET FEATURE command needs to be issued to monitor the status of PAGE READ. After finishing the PAGE READ successfully, the Read from Cache command can be issued in order to read the data out of the cache. The Read from Cache command requires 16 bits of column address which is consisting of wrap bits and column address bits. The number of bits of column address is depends on the page size in different flash. Refer to figures below to view the entire READ operation.

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PAGE READ to Cache (13H)

The waveform of PAGE READ to Cache (13H) is as follows, Do not toggle the CS# until the "Status Register" check is completed.

PAGE READ to Cache (13H) Sequence Diagram

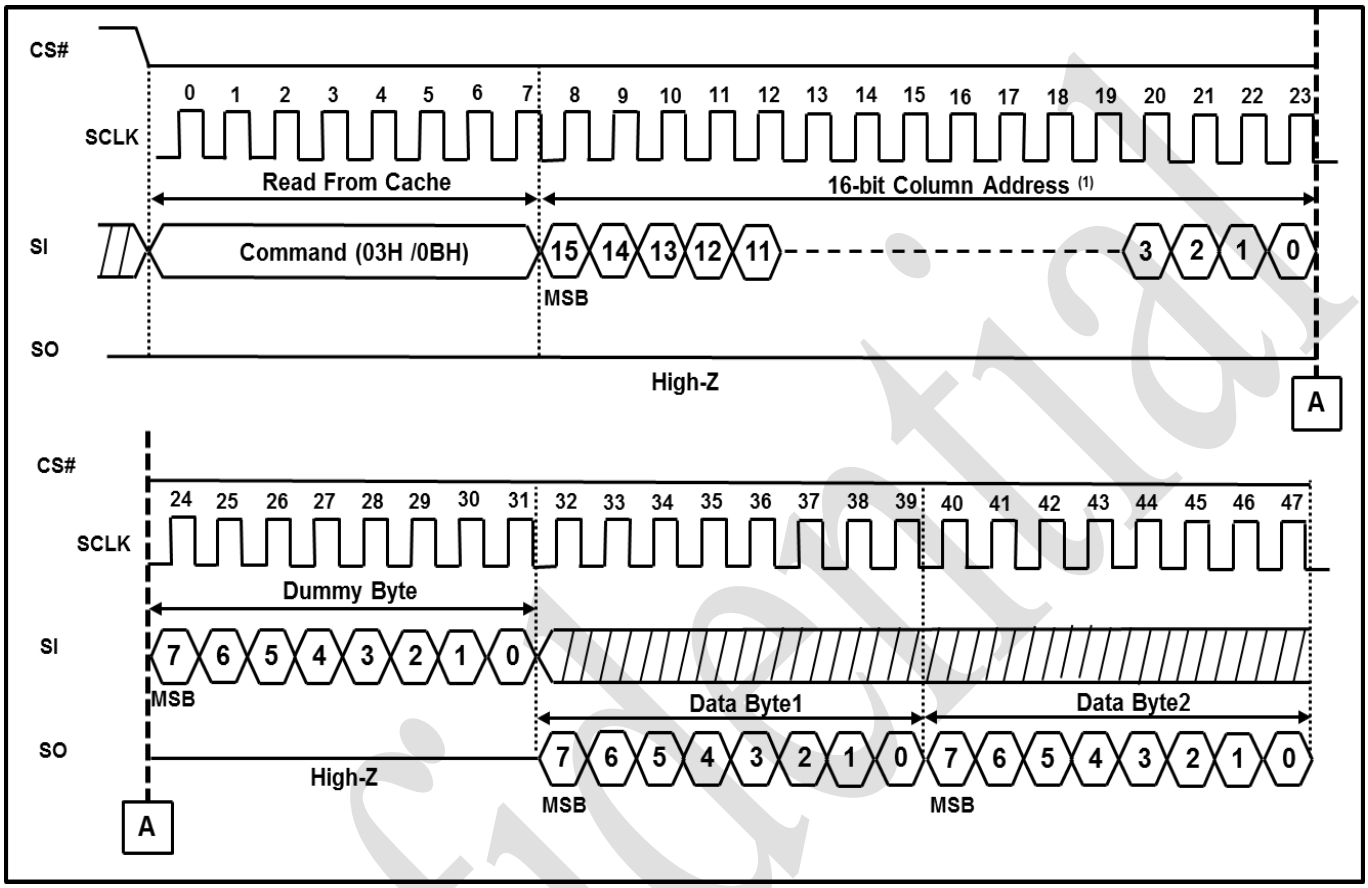


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Read from Cache x1 IO (03H/0BH)

The Read from Cache x1 IO (03H/0BH) consists of an OP code followed by 16-bit column address. The column address is composed of wrap bits and column address bits. Refer the Read from Cache x1 IO sequence diagram as follows,

Read from Cache x1 IO (03H/0BH) Sequence Diagram

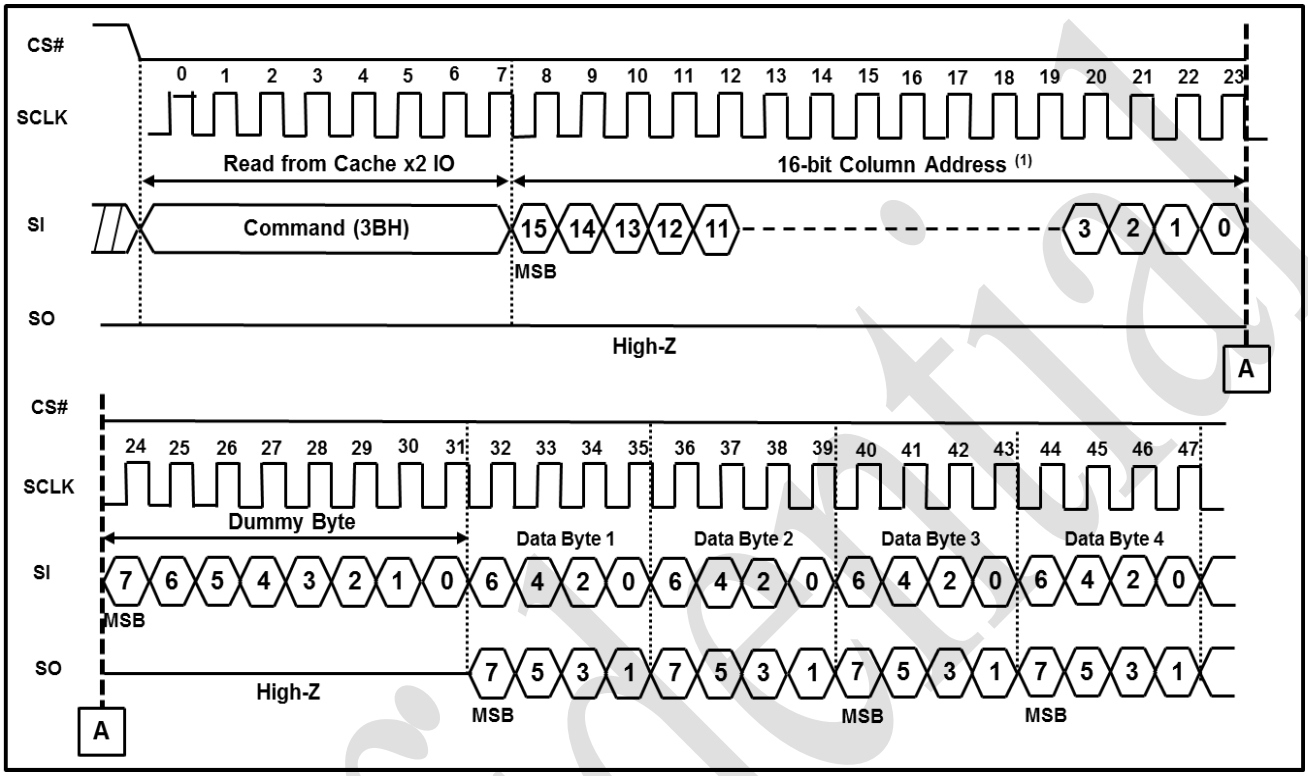


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Read from Cache x2 IO (3BH)

The Read from Cache x2 IO (3BH) command is similar to the Read from Cache x1 IO (03H/0BH) but the command uses two pins to output data. The data output pins include the SI (SIO0) and SO (SIO1). Refer the Read from Cache x2 IO (3BH) sequence diagram bellowed.

Read from Cache x2 IO (3BH) Sequence Diagram

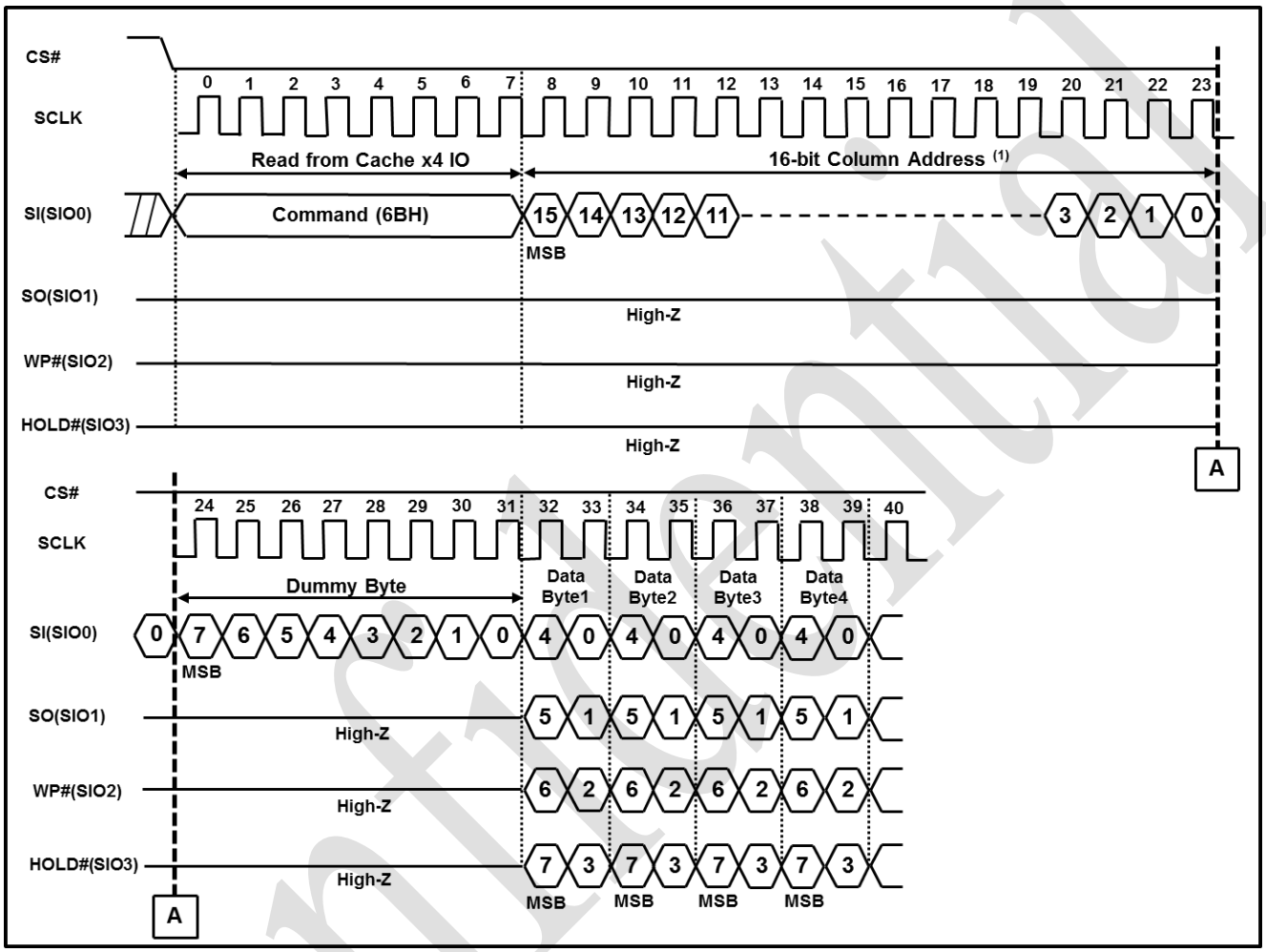


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Read from Cache x4 IO (6BH)

The Read from Cache x4 IO (6BH) command is similar to the Read from Cache x1 IO (03H/0BH) and the Read from Cache x2 IO (3BH) but the command uses four pins to output data. The four pins include the SI (SIO0), SO (SIO1), WP# (SIO2) and HOLD# (SIO3).The Quad Enable bit (QE) of OTP register (B0[0]) must be set to enable the Read from Cache Quad IO (EBH) command . Refer the Read from Cache x4 IO (6BH) sequence diagram bellowed.

Read from Cache x4 IO (6BH) Sequence Diagram

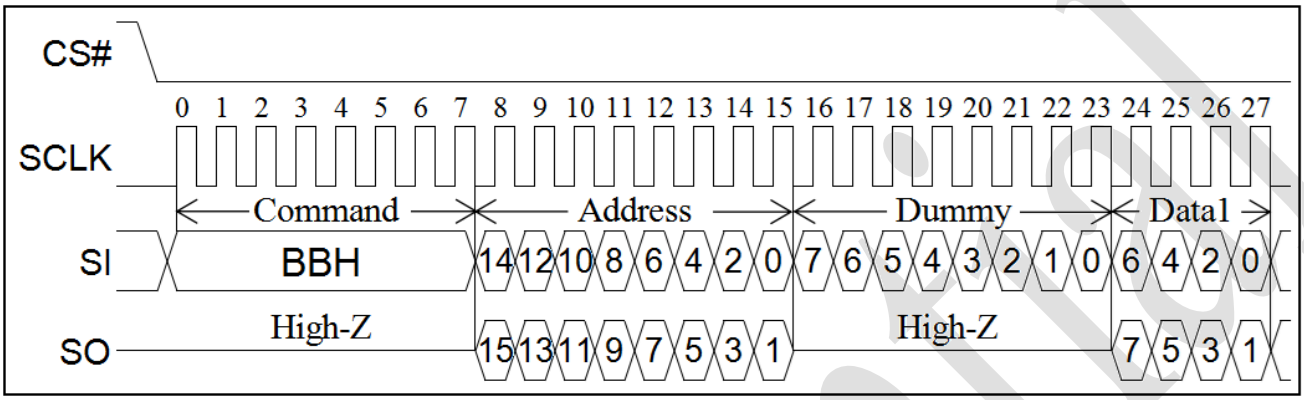


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Read from Cache Dual IO (BBH)

The Read from Cache Dual IO command (BBH) is similar to the Read from Cache x2 IO command (3BH) but using both of SI (SIO0) and SO (SIO1) as input bin. Each bit in 16-bit column address and the followed dummy byte will be latched in during the falling edge of SCLK, then the cache contents will be shifted out 2-bit in a clock cycle through the SI (SIO0) and SO (SIO1).

Read from Cache Dual IO (BBH) Sequence Diagram



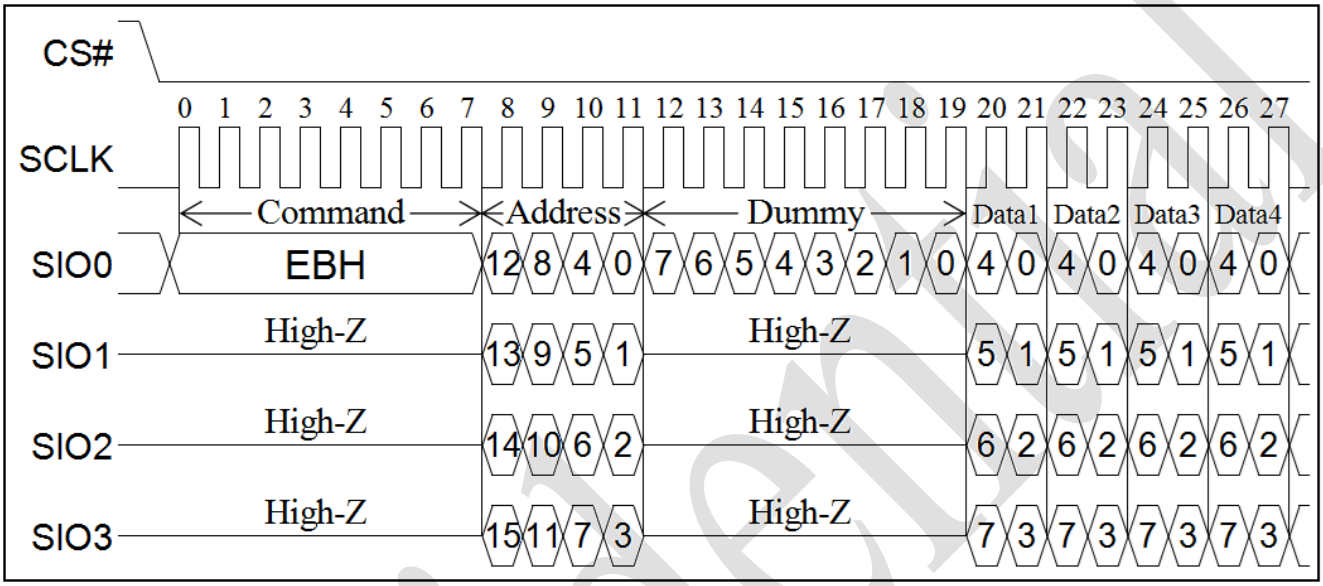
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Read from Cache Quad IO (EBH)

The Read from Cache Quad IO (EBH) command is similar to the Read from Cache x4 IO (6BH) command but with 4 input pins which include SI (SIO0), SO (SIO1), WP# (SIO2) and HOLD# (SIO3). Each bit in 16-bit column address and the followed dummy byte will be latched in during the raising edge of SCLK through these four input pins, and then the cache contents will be shifted out 4-bit in a clock cycle through the SI (SIO0), SO (SIO1), WP# (SIO2) and HOLD# (SIO3).

The Quad Enable bit (QE) of OTP register (B0[0]) must be set to enable the Read from Cache Quad IO (EBH) command .

Read from Cache Quad (EBH) Sequence Diagram



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Program Operations

The PAGE PROGRAM sequence is transfer the data from the host to NAND Flash array through cache memory. The operation sequence programs the first byte to last byte of data within a page. If more than page size, then those additional bytes are ignored by the cache memory. The PAGE PROGRAM sequence is as follows:

I. 06H (WRITE ENABLE when WEL bit is 0)

II. PROGRAM LOAD

- 02H(PROGRAM LOAD) / 32H(PROGRAM LOAD x4)

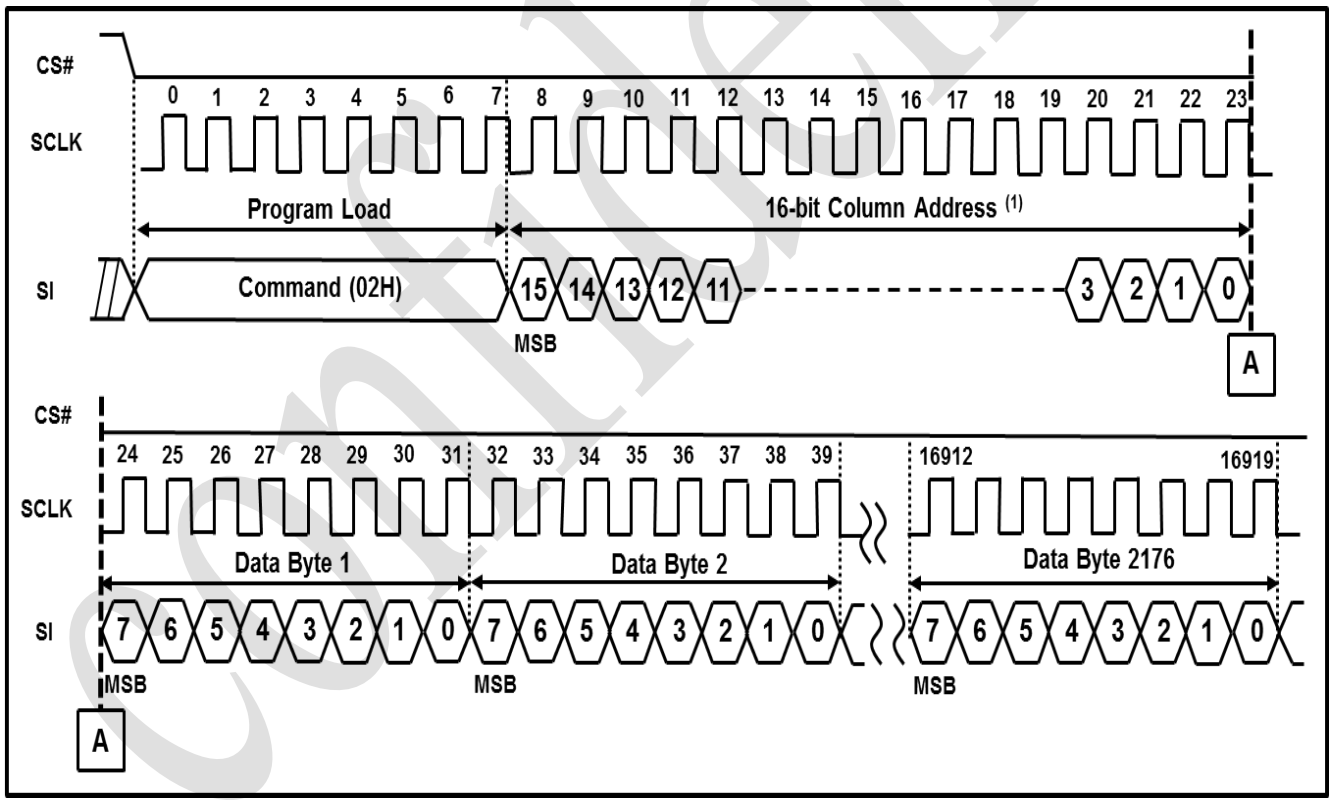
III. 10H (PROGRAM EXECUTE)

IV. 0FH (GET FEATURE command to read the status)

At first, the WRITE ENABLE (06H) command is used to set the Write Enable Latch (WEL) bit The Write Enable Latch (WEL) bit must be set prior to program execute (10h). The PROGRAM LOAD (02H/32H) command is issued then and the PROGRAM LOAD command can only be issued one time in a PAGE PROGRAM sequence. Secondly, the PROGRAM EXECUTE (10H) command is issued to program the data into the page. During the busy time, the GET FEATURE command needs to be issued to monitor the status of PAGE PROGRAM. After finishing the PAGE PROGRAM successfully, the OIP and WEL bit in status register (C0H) will be set to 0.

Program Load (02H)

Program Load (02H) Sequence Diagram

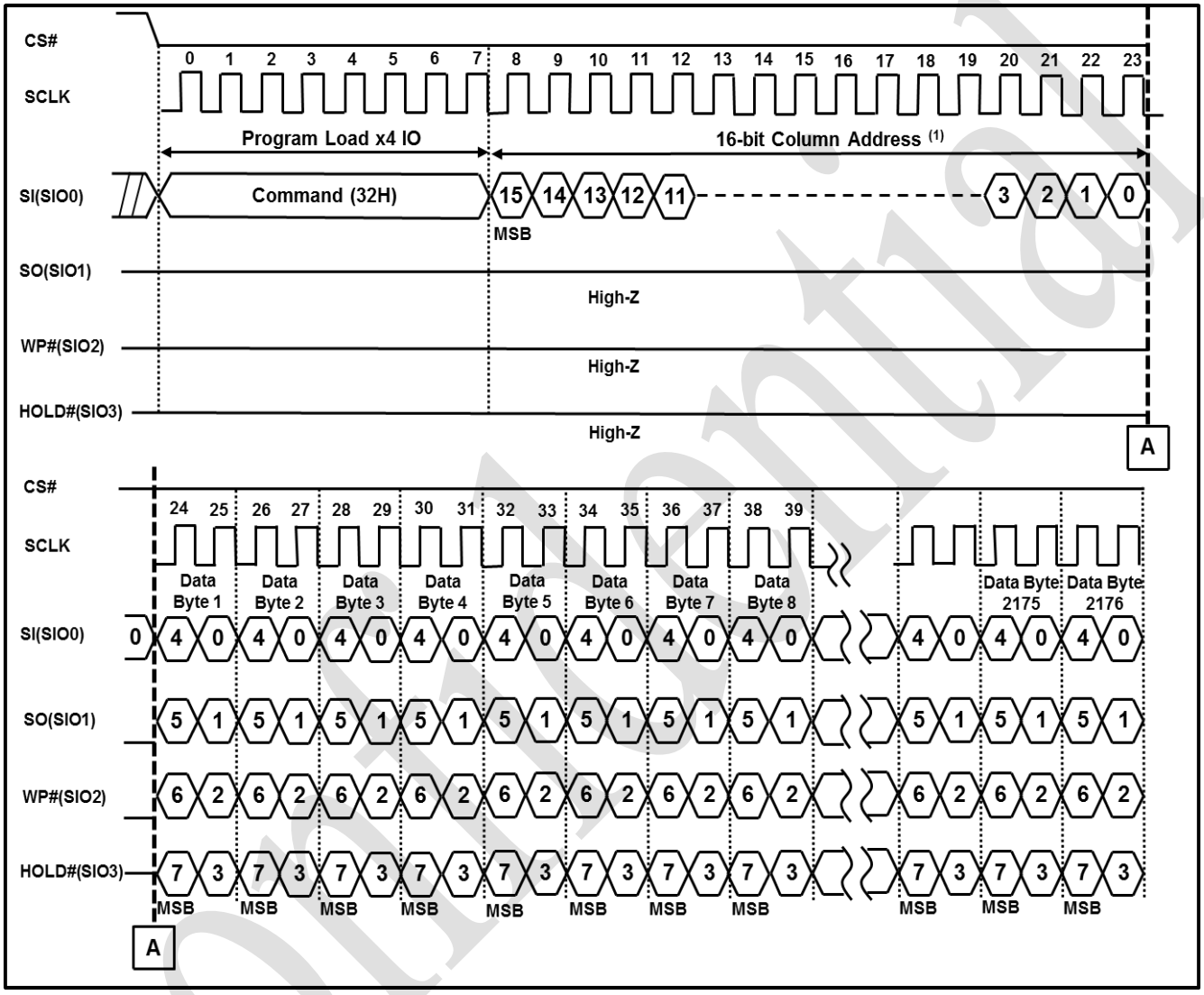


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Program Load x4 IO (PL x4) (32H)

The PROGRAM LOAD x4 IO (32H) command is similar to the PROGRAM LOAD (02H) command but with four input pins to transfer data in. The four input pins are SI (SIO0), SO (SIO1), WP# (SIO2) and HOLD# (SIO3). The Quad Enable bit (QE) of OTP register (B0[0]) must be set to enable the PROGRAM LOAD x4 IO (32H) command. The command sequence is shown below,

Program Load x4 IO (32H) Sequence Diagram

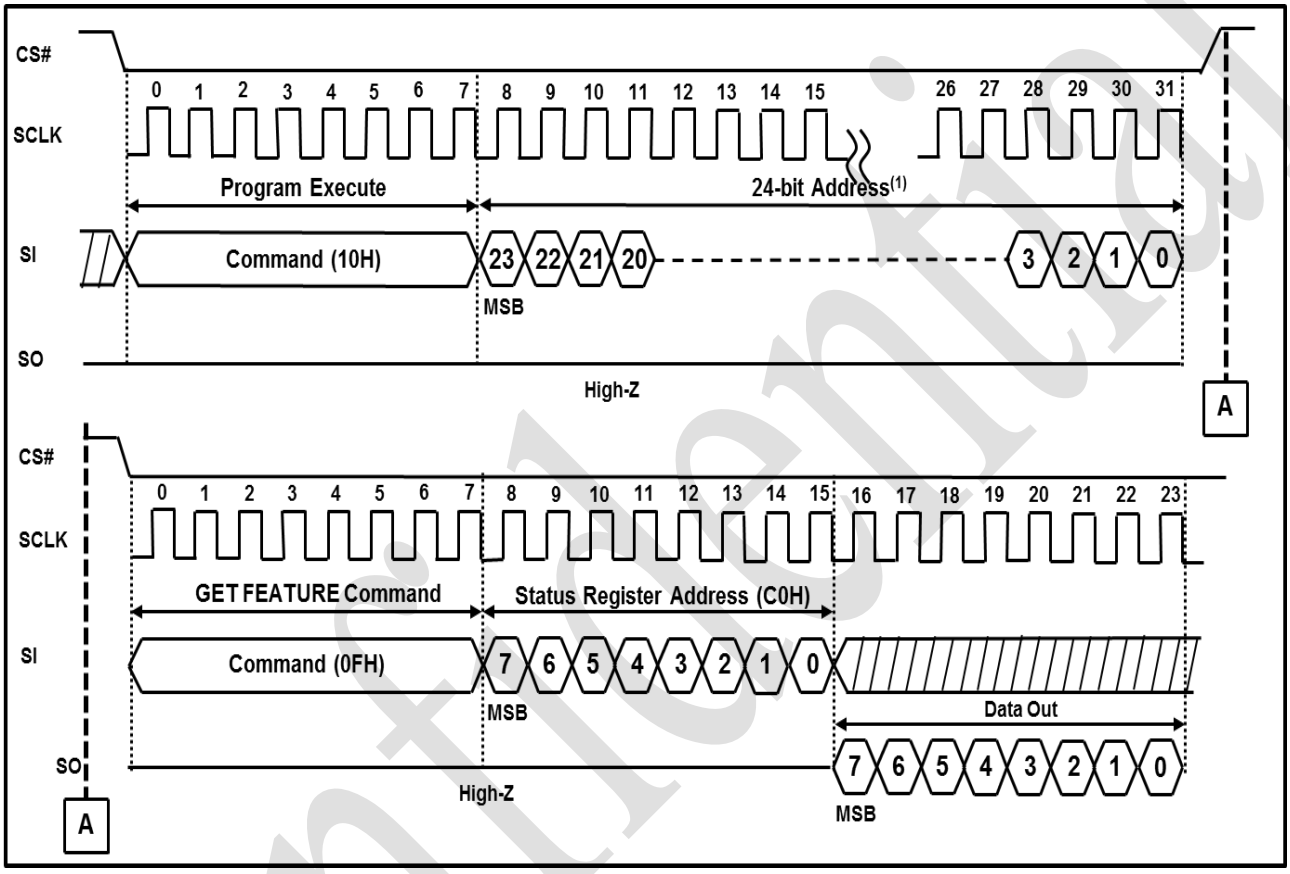


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Program Execute (10H)

PROGRAM EXECUTE (10H) command must be issued after the data is loaded and the WEL bit be set to HIGH. The PROGRAM EXECUTE (10H) command will transfer data from the cache to the main array. The PROGRAM EXECUTE (10H) consists of an 8-bit Op code, followed by a 24-bit address which including dummy bits and page/block address. This operation needs to wait the busy time. The OIP bit in status register (C0H) will be HIGH until controller finishes the program. The P_FAIL bit in status register (C0H) will be set HIGH if program fail.

Program Execute (10H) Sequence Diagram



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Internal Data Move Operation

The Internal Data Move operation sequence programs or replaces data in a page with existing data.

The Internal Data Move operation sequence is as follows:

I. 13H (PAGE READ to cache)

II. 0FH (GET FEATURE command to read the status).

III. Optional 84H/C4H/34H/72H **(PROGRAM LOAD RANDOM DATA. The command of Program load random data can be operated several times in this step.)

IV. 06H (WRITE ENABLE)

V. 10H (PROGRAM EXECUTE)

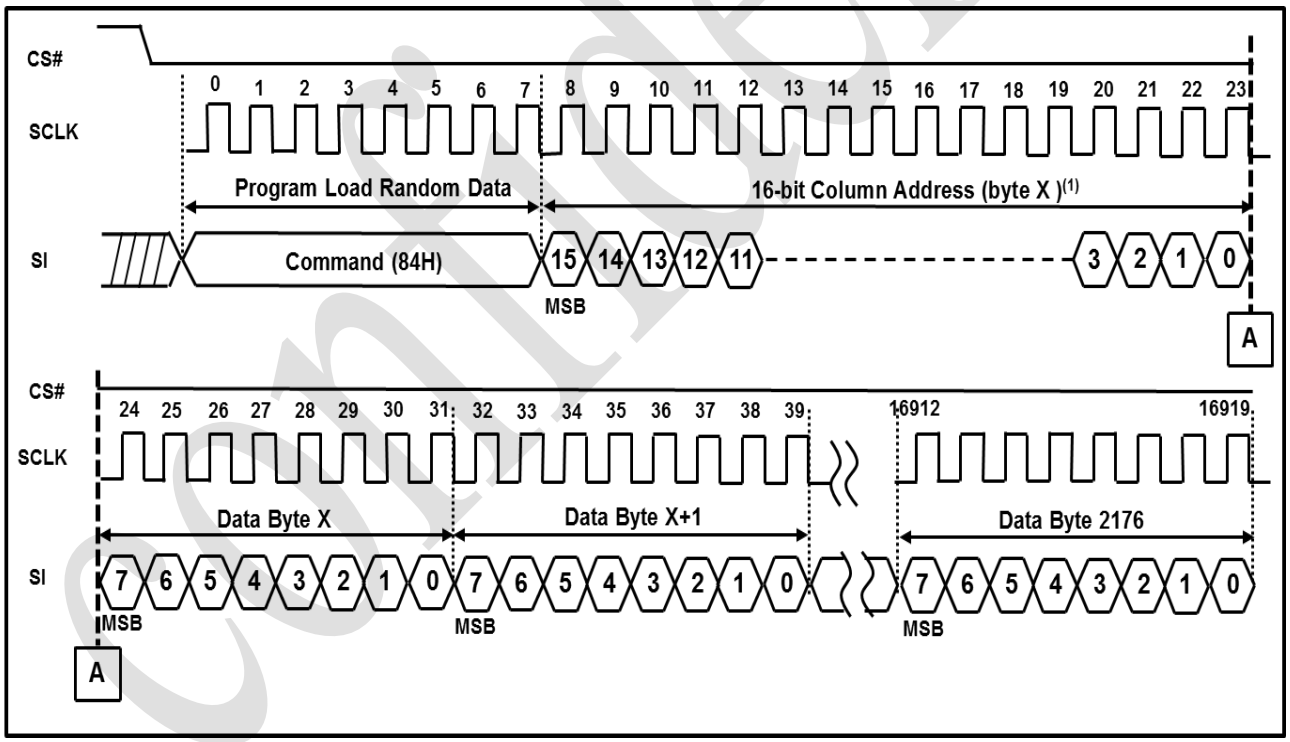
VI. 0FH (GET FEATURE command to read the status)

** 84H/C4H/34H/72H commands are only available in Internal Data Move operation.

Program Load Random Data (84H)

Program Load Random Data (84H) command consists of an OP code, followed by 16 bit column address which composed of dummy bits and column address bits. This command can only be used in Internal Data Move operation sequence.

Program Load Random Data (84H) Sequence Diagram

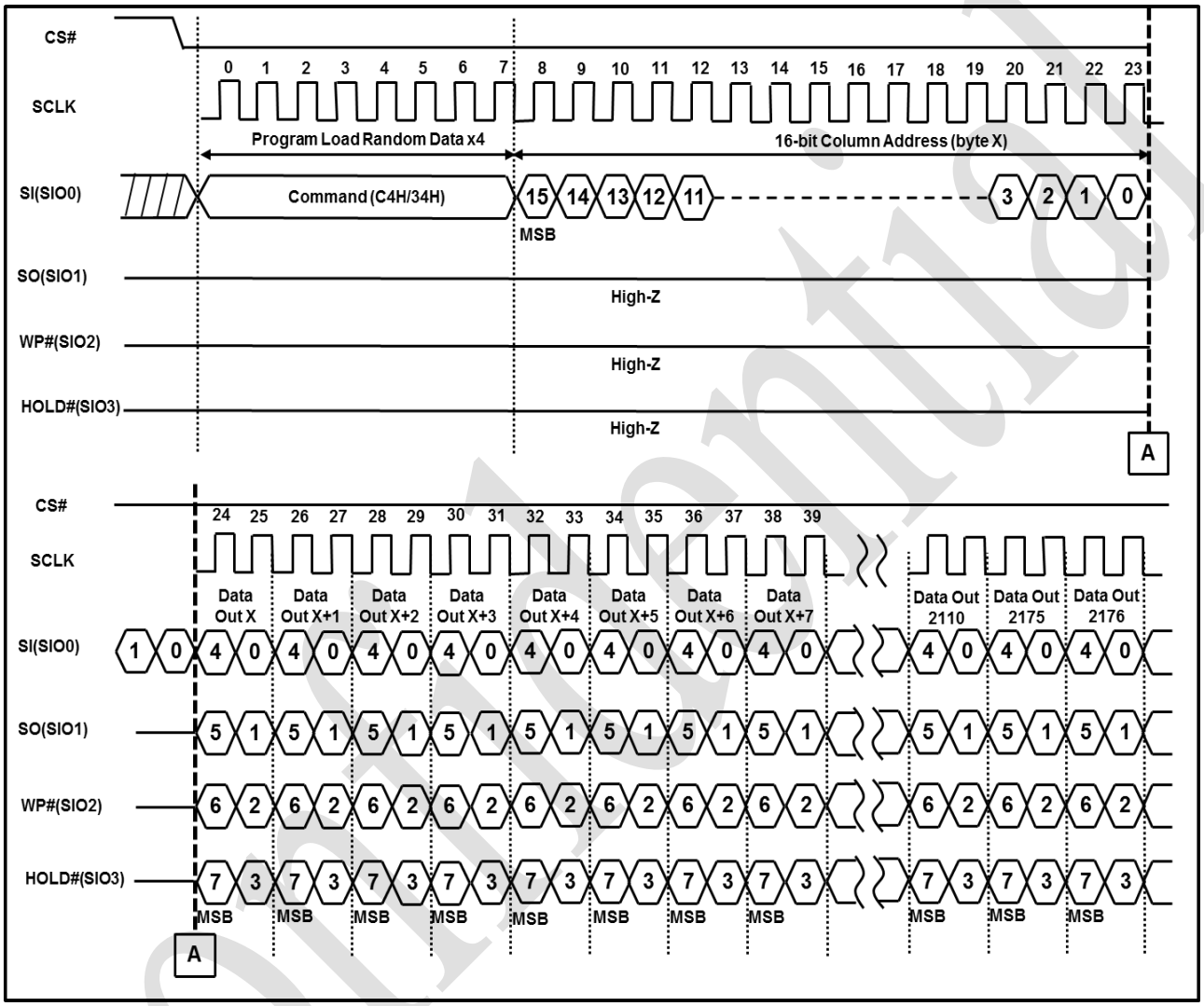


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Program Load Random Data x4 (34H)

The Program Load Random Data x4 (34H) command is similar to the Program Load Random Data Command (84H) but with four input pins. The four input pins are SI(SIO0), SO(SIO1), WP#(SIO2) and HOLD#(SIO3). The Quad Enable bit needs to be set before the Program Load Random Data x4 command be used. The command is only available during the Internal Data Move sequence operation sequence.

Program Load Random Data x4 (C4H/34H) Sequence Diagram



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Erase Operation

Block Erase (D8H)

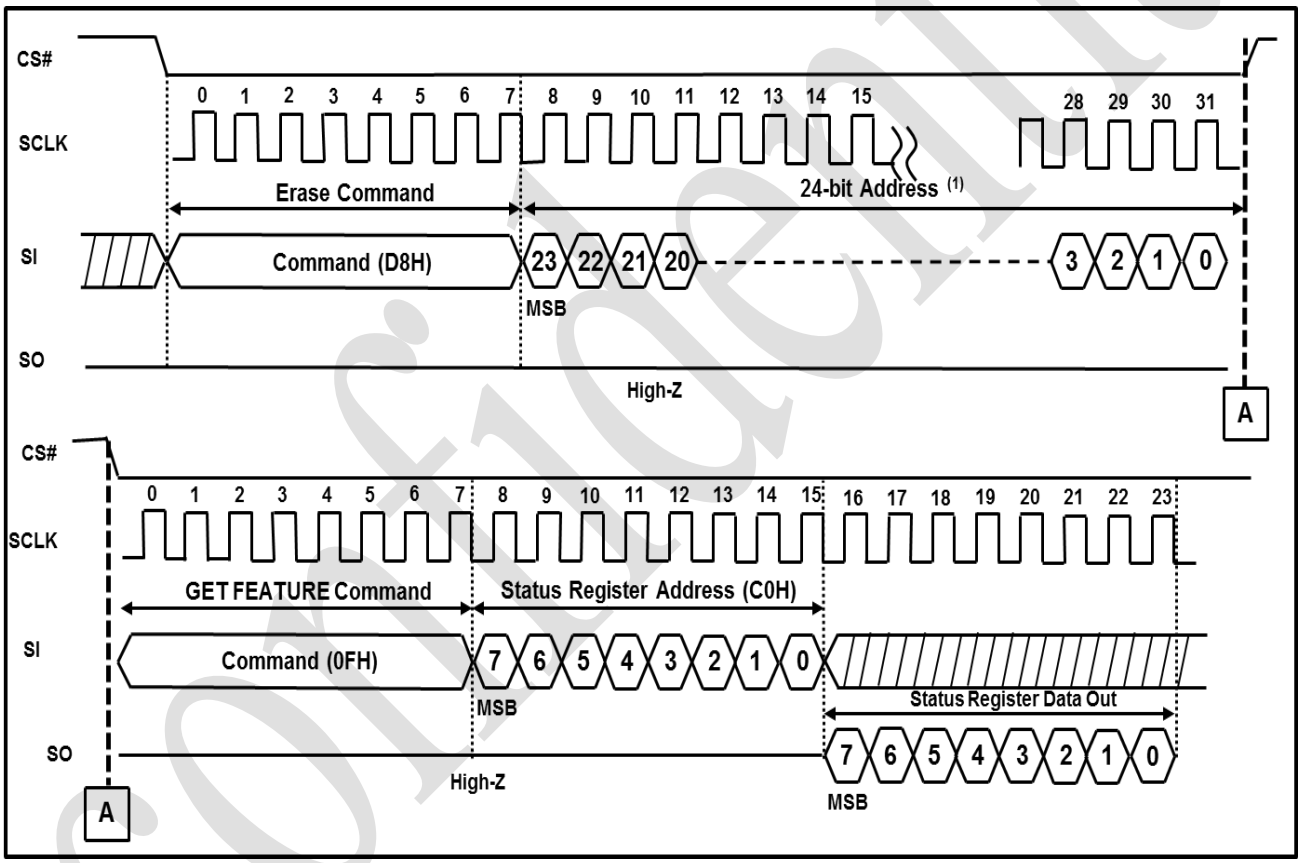
The BLOCK ERASE (D8H) command is used to erase at block level. The command sequence for BLOCK ERASE operation is as follows,

- 06H (WRITE ENABLE command)
- D8H (BLOCK ERASE command)
- 0FH (GET FEATURE command to read the status register)

Erase Operation sequence starts from a WRITE ENABLE (06H) command to set WEL bit to 1. After executing the WRITE ENABLE command, BLOCK ERASE (D8H) command can be issued. BLOCK ERASE (D8H) requires a 24-bit address which consists of dummy bits and row address (page address in row address will be ignored automatically).

Issue the GET FEATURE (0FH) command to monitor the erase operation after issuing the BLOCK ERASE. The E_FAIL bit in status register can reflect whether the block be erased successfully or not.

Block Erase (D8H) Sequence Diagram



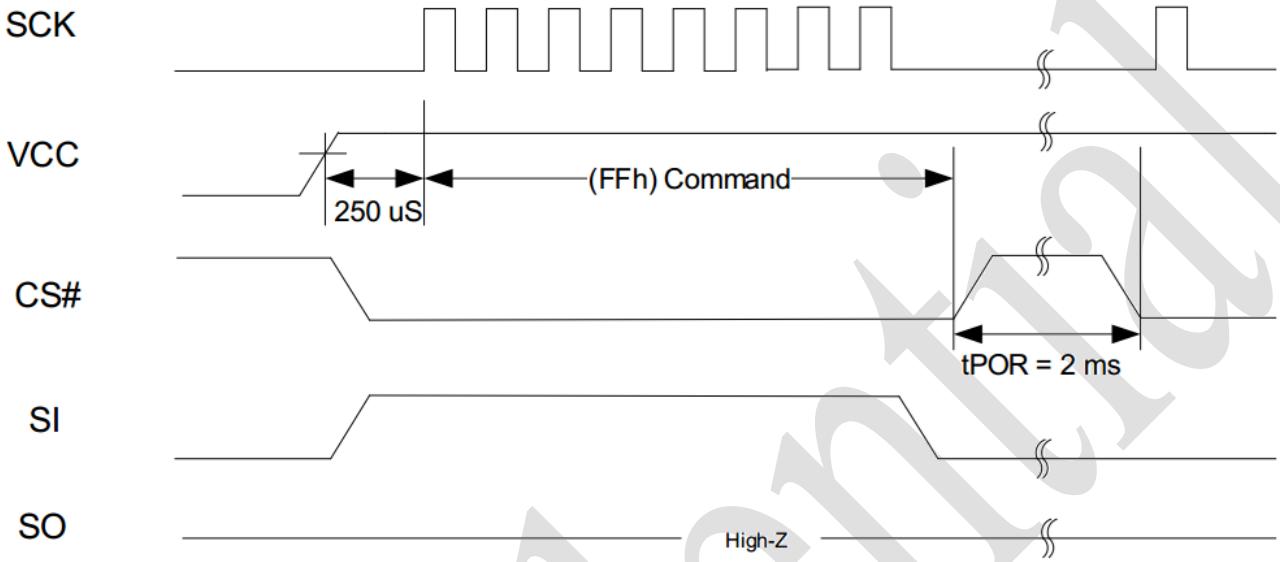
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Power-On Process and Reset Operation

During Power on Reset, the first page data of page 0 is auto-loaded to the buffer register.

The reset command FFh, does not clear the feature registers but does clear the configuration register bits CFG[2:0] placing the device in normal operation.

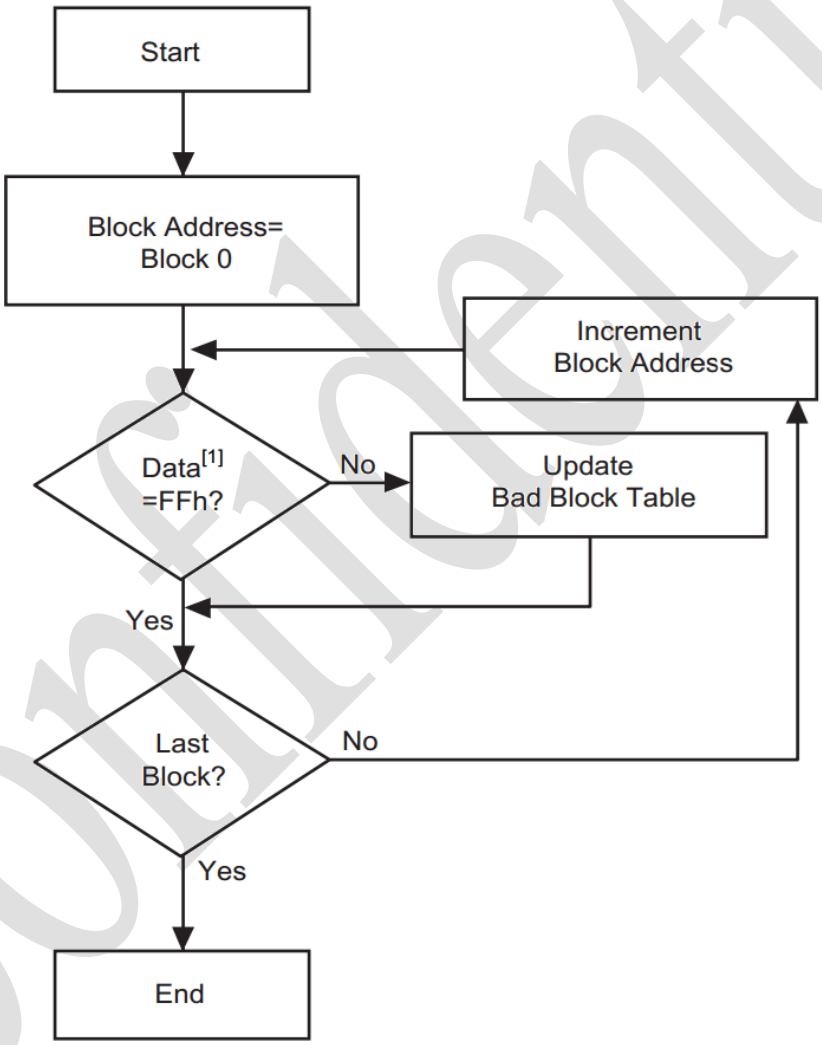
Power Up Timing Diagram



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Bad Block Management

Devices with Bad Blocks have the same quality level and the same AC and DC characteristics as devices where all the blocks are valid. A Bad Block does not affect the performance of valid blocks because it is isolated from the bit line and common source line by a select transistor. The devices are supplied with all the locations inside valid blocks erased (FFh). The Bad Block Information is written before shipping. Any block where the 1st byte in the spare area of the 1st or 2nd or last page does not contain FFh is a Bad Block. That is, if the first page has an FF value and should have been a non-FF value, then the non-FF value in the second page or the last page will indicate a bad block. The Bad Block Information must be read before any erase is attempted, as the Bad Block Information may be erased. For the system to be able to recognize the Bad Blocks based on the original information, it is recommended to create a Bad Block table following the flowchart. The host is responsible to detect and track bad blocks, both factory bad blocks and blocks that may go bad during operation. Once a block is found to be bad, data should not be written to that block. Blocks 0-7 are guaranteed good at the time of shipment.



Note:

1) Check for FFh at the 1st byte in the spare area of the 1st,2nd, and last pages.

Valid Blocks

	Symbol	Min	Typ	Max	Unit
Valid Block Number	N_{VB}	2008		2048	Blocks

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Opreation Characteristics

Parameters	Min	Typical	Max	Unit
Erase one block		4	10	ms
Program from cache to flash		350	600	us
Read from flash into cache		45	250	us
Reset Time (Ready /Read /Program /Erase)			5 /6 /10 /500	us

DC Characteristics

Parameters	Symbol	Min	Typical	Max	Unit
SPI Supply Voltage	V_IH	2.7	3.3	3.6	V
Standby current	I_SB		20	100	uA
Input Leakage Current	I_LI			10	uA
Output Leakage Current	I_LO			10	uA
Read current	I_R		25	35	mA
Program / Erase current	I_P / I_E		20	25	mA
Erase / program lockout voltage	V_LKO		1.8		V

AC Time Characteristics

(T = -40 ~ 85°C,V = 2.7~ 3.6V, C_L = 30pF)

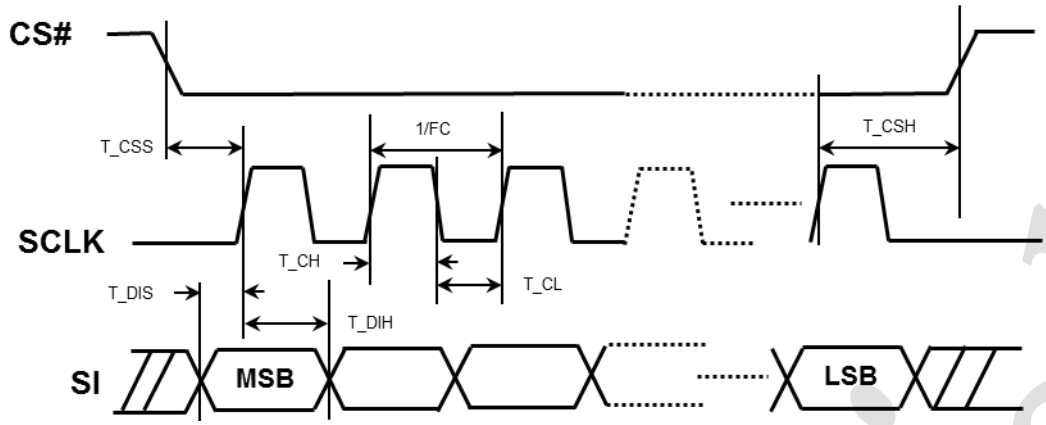
Parameters	Symbol	Min	Typical	Max	Unit
Clock Frequency for 3.3v	FC			104	MHz
Clock High Time	T_CH	4.316			ns
Clock Low Time	T_CL	4.316			ns
CS# Setup Time	T_CSS	4.316			ns
CS# Hold Time	T_CSH	4.316			ns
Data In Setup Time	T_DIS	2.5			ns
Data In Hold Time	T_DIH	1.75			ns
Clock Low to Output Valid	T_CLO			7	ns
CS# High to Output Invalid	T_CSDI			10	ns
CS# High Time	T_CS	30			ns
WP# Setup Time Before CS# Low	T_WPS	20			ns
WP# Hold Time After CS# High	T_WPH	100			ns

Absolute Maximum Ratings

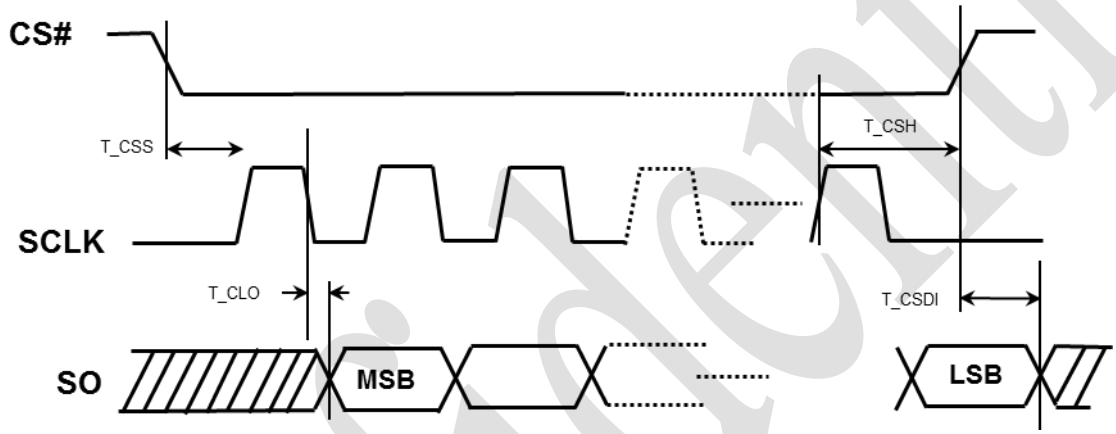
Parameter	Value	Unit
Ambient Operating Temperature	-40 ~ 85	℃
Storage Temperature	-55 ~ 125	℃
Applied Input/Output Voltage	VCC + 0.4	V
Vertical bending strength	170	MPa

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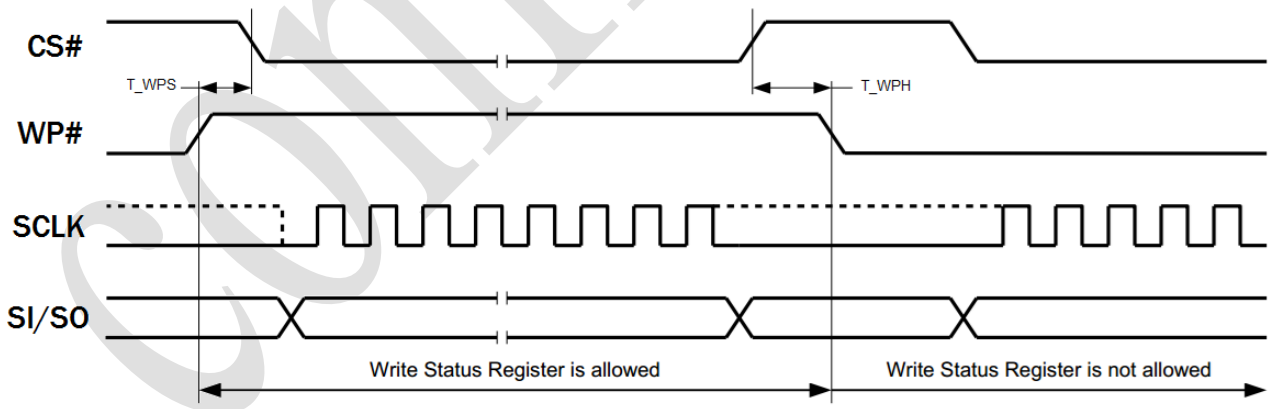
Serial Input Timing



Serial Output Timing



WP# Timing



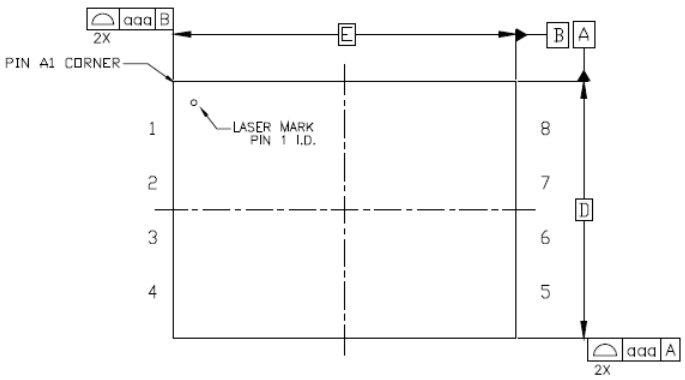
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Package Outline

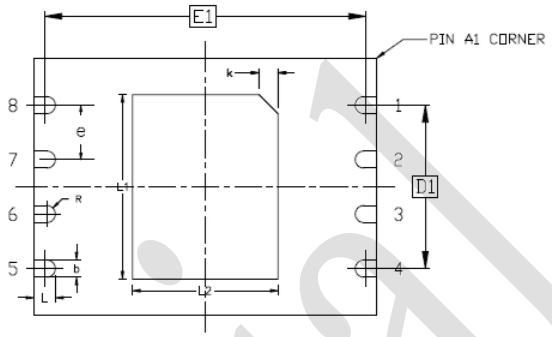
LGA8

LCC (Leadless Chip Carrier)

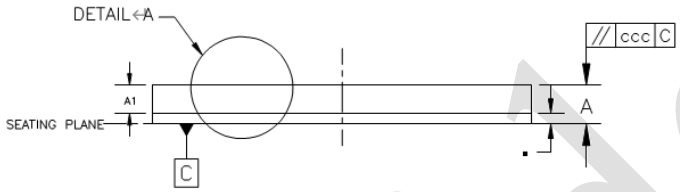
:



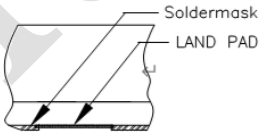
TOP VIEW



BOTTOM VIEW



SIDE VIEW

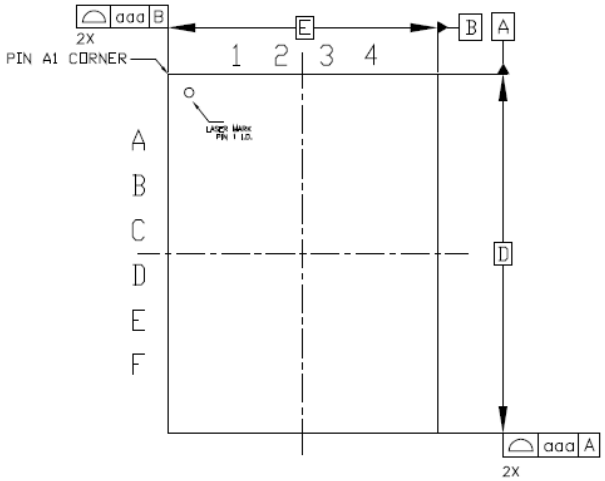


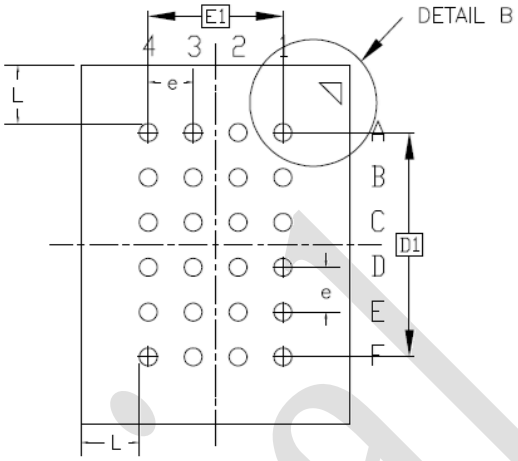
DETAIL A

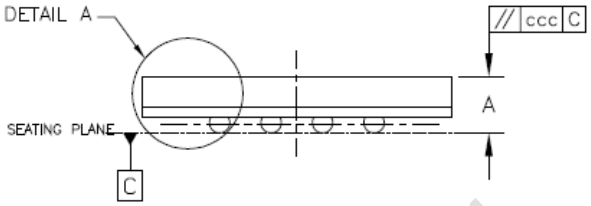
SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1		0.53 BASIC	
c	0.19	0.22	0.25
D	5.90	6.00	6.10
D1		3.81 BASIC	
E	7.90	8.00	8.10
E1		7.50 BASIC	
e		1.27 BASIC	
b	0.35	0.40	0.45
L	0.45	0.50	0.55
L1	4.25	4.30	4.35
L2	3.35	3.40	3.45
R		0.20 REF	
k		0.45 REF	
aaa		0.10	
ccc		0.10	

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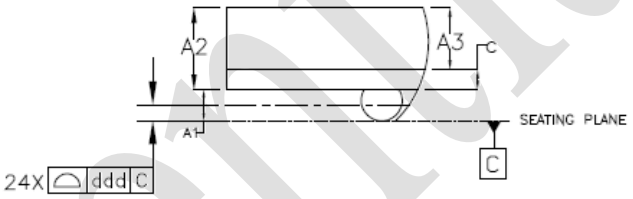
BGA24





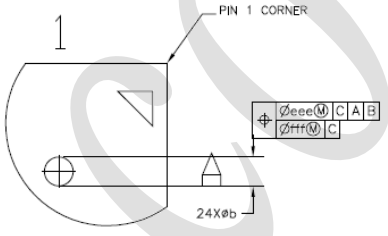


SIDE VIEW



DETAIL A(2:1)

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	1.02	1.10	1.20
A1	0.25	0.30	0.35
A2	0.75	0.80	0.85
A3	0.55	0.60	0.65
c	0.17	0.20	0.23
D	7.90	8.00	8.10
D1	4.90	5.00	5.10
E	5.90	6.00	6.10
E1	2.90	3.00	3.10
e	0.95	1.00	1.05
b	0.35	0.40	0.45
L	1.30 REF		
aaa	0.10		
ccc	0.20		
ddd	0.12		
eee	0.15		
fff	0.08		



DETAIL B(2:1)

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Revision History

Publication Version:	Note
V1.0 06/17/2022	Initial release
V1.1 11/07/2022	Add BGA24 package information/ update LCC type2
V1.2 11/16/2022	Delete WSON8 package
V1.3 12/6/2022	Error correction
V1.3.1 28/04/2023	Update Page Read to Cache(13H) Sequence Diagram

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