MX25L32356

3V, 32M-BIT [x 1/x 2/x 4]
CMOS MXSMIO® (SERIAL MULTI I/O)
FLASH MEMORY

Key Features

- *Hold Feature*
- *Multi I/O Support - Single I/O, Dual I/O and Quad I/O*
- *Quad Peripheral Interface (QPI) available*
- *Supports clock frequencies up to 133MHz*
- *Program/Erase Suspend and Resume*
- *Additional 8K-bit Secured OTP*

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32M-BIT [x 1 / x 2 / x 4] CMOS MXSMIO® (SERIAL MULTI I/O) FLASH MEMORY

1. FEATURES

GENERAL

- Supports Serial Peripheral Interface -- Mode 0 and Mode 3
- 33,554,432 x 1 bit structure
  or 16,777,216 x 2 bits (two I/O read mode) structure
  or 8,388,608 x 4 bits (four I/O mode) structure
- 1024 Equal Sectors with 4K bytes each
  - Any Sector can be erased individually
- 128 Equal Blocks with 32K bytes each
  - Any Block can be erased individually
- 64 Equal Blocks with 64K bytes each
  - Any Block can be erased individually
- Power Supply Operation
  - 2.65 to 3.6 volts for read, erase, and program operations
- Latch-up protected to 100mA from -1V to Vcc +1V
- Supports Performance Enhance Mode - XIP (execute-in-place)
- Quad Peripheral Interface (QPI) available
- Programming :
  - 256byte page buffer
  - Quad Input/Output page program(4PP) to enhance program performance

PERFORMANCE

- High Performance
  VCC = 2.65 to 3.6V
  - Normal read
    - 50MHz
  - Fast read
    - FAST_READ, DREAD, QREAD:
      133MHz with 8 dummy cycles
    - 2READ:
      80MHz with 4 dummy cycles,
      133MHz with 8 dummy cycles
    - 4READ:
      80MHz with 6 dummy cycles,
      133MHz with 10 dummy cycles
    - Configurable dummy cycle number for 2READ and 4READ operation
  - 8/16/32/64 byte Wrap-Around Burst Read Mode
- Low Power Consumption
- Typical 100,000 erase/program cycles
- 20 years data retention

Software Features

- Input Data Format
  - 1-byte Command code
- Advanced Security Features
  - Block Lock Protection
  The BP0-BP3 and T/B status bits define the site of the area to be protected against program and erase instructions.
  - Advanced sector protection function (Solid Protect)
- Additional 8K bits secured OTP
  - Features unique identifier
  - Factory locked identifiable and customer lockable
- Auto Erase and Auto Program Algorithms
  - Automatically erases and verifies data at selected sector
  - Automatically programs and verifies data at selected page by an internal algorithm that automatically times the program pulse width (Any page to be programmed should have page in the erased state first.)
- Status Register Feature
- Command Reset
- Program/Erase Suspend
- Program/Erase Resume
- Electronic Identification
  - JEDEC 1-byte Manufacturer ID and 2-byte Device ID
  - RES command for 1-byte Device ID
- Supports Serial Flash Discoverable Parameters (SFDP) mode

Hardware Features

- SCLK Input
  - Serial clock input
- SI/SIO0
  - Serial Data Input or Serial Data Input/Output for 2 x I/O mode or Serial Data Input/Output for 4 x I/O mode
- SO/SIO1
  - Serial Data Output or Serial Data Input/Output for 2 x I/O mode or Serial Data Input/Output for 4 x I/O mode
- WP#/SIO2
  - Hardware write protection or Serial Data Input/Output for 4 x I/O mode
- HOLD#/SIO3
  - To pause the device without deselecting the device or serial data Input/Output for 4 x I/O mode
- PACKAGE
  - 8-pin SOP (150mil)
  - 8-pin SOP (200mil)
  - 8-USON (4x3mm)
  - 8-WSON (6x5mm)
  - **All devices are RoHS Compliant and Halogen-free**

2. GENERAL DESCRIPTION

MX25L32356 is 32Mb bits Serial NOR Flash memory, which is configured as 4,194,304 x 8 internally. When it is in four I/O mode, the structure becomes 8,388,608 bits x 4. When it is in two I/O mode, the structure becomes 16,777,216 bits x 2.

MX25L32356 features a serial peripheral interface and software protocol allowing operation on a simple 3-wire bus while it is in single I/O mode. The three bus signals are a clock input (SCLK), a serial data input (SI), and a serial data output (SO). Serial access to the device is enabled by CS# input.

MX25L32356, MXSMIO® (Serial Multi I/O) flash memory, provides sequential read operation on the whole chip and multi-I/O features.

When it is in two I/O read mode, the SI pin and SO pin become SIO0 pin and SIO1 pin for address/dummy bits input and data output. When it is in quad I/O mode, the SI pin, SO pin, WP# pin and HOLD# pin become SIO0 pin, SIO1 pin, SIO2 pin and SIO3 pin for address/dummy bits input and data Input/Output.

After program/erase command is issued, auto program/erase algorithms which program/erase and verify the specified page or sector/block locations will be executed. Program command is executed on byte basis, or page (256 bytes) basis. Erase command is executed on 4K-byte sector, 32K-byte/64K-byte block, or whole chip basis.

To provide user with ease of interface, a status register is included to indicate the status of the chip. The status read command can be issued to detect completion status of a program or erase operation via WIP bit.

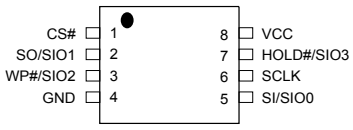
Advanced security features enhance the protection and security functions, please refer to the security features section for more details.

When the device is not in operation and CS# is high, it will remain in standby mode.

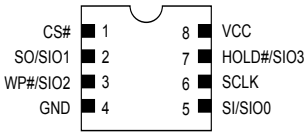
The MX25L32356 utilizes Macronix's proprietary memory cell, which reliably stores memory contents even after 100,000 program and erase cycles.

3. PIN CONFIGURATION

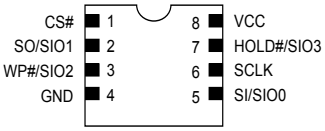
8-PIN SOP (150mil)/8-PIN SOP (200mil)



8-USON (4x3mm)



8-WSON (6x5mm)



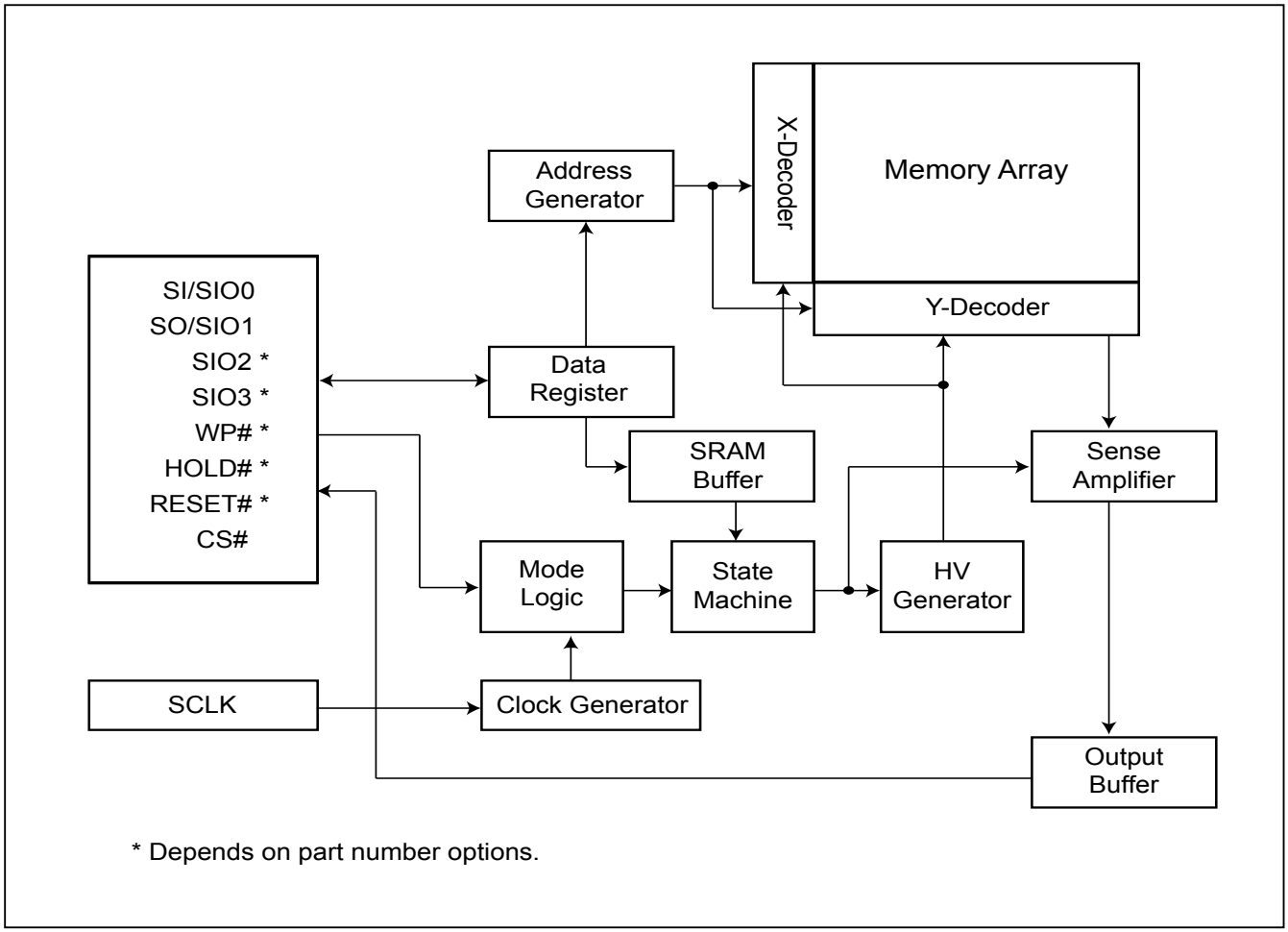
4. PIN DESCRIPTION

SYMBOL	DESCRIPTION
CS#	Chip Select
SI/SIO0	Serial Data Input (for 1xI/O)/ Serial Data Input & Output (for 2xI/O mode and 4xI/O mode)
SO/SIO1	Serial Data Output (for 1xI/O)/Serial Data Input & Output (for 2xI/O mode and 4xI/O mode)
SCLK	Clock Input
WP#/SIO2	Write protection Active Low or Serial Data Input & Output (for 4xI/O mode)
HOLD#/ SIO3	To pause the device without deselecting the device or Serial data Input/Output for 4 x I/O mode
VCC	+ 3.0V Power Supply
GND	Ground
NC	No Connection

Note:

1. The pin of HOLD#/SIO3 or WP#/SIO2 will remain internal pull up function while this pin is not physically connected in system configuration. However, the internal pull up function will be disabled if the system has physical connection to HOLD#/SIO3 or WP#/SIO2 pin.

5. BLOCK DIAGRAM



6. DATA PROTECTION

During power transition, there may be some false system level signals which result in inadvertent erasure or programming. The device is designed to protect itself from these accidental write cycles.

The state machine will be reset as standby mode automatically during power up. In addition, the control register architecture of the device constrains that the memory contents can only be changed after specific command sequences have completed successfully.

In the following, there are several features to protect the system from the accidental write cycles during VCC power-up and power-down or from system noise.

- Valid command length checking: The command length will be checked whether it is at byte base and completed on byte boundary.
- Write Enable (WREN) command: WREN command is required to set the Write Enable Latch bit (WEL) before other commands to change data.
- Deep Power Down Mode: By entering deep power down mode, the flash device also is under protected from writing all commands except Release from Deep Power Down mode command (RDP) and Read Electronic Signature command (RES).
- Advanced Security Features: there are some protection and security features which protect content from inadvertent write and hostile access.

I. Block lock protection

- The Software Protected Mode (SPM) uses (TB, BP3, BP2, BP1, BP0) bits to allow part of memory to be protected as read only. The protected area definition is shown as table of *"Table 1. Protected Area Sizes"*, the protected areas are more flexible which may protect various areas by setting value of TB, BP0-BP3 bits.

- The Hardware Protected Mode (HPM) uses WP#/SIO2 to protect the (BP3, BP2, BP1, BP0, TB) bits and SRWD bit.

Table 1. Protected Area Sizes

Protected Area Sizes (TB bit = 0)

Status bit				Protect Level
BP3	BP2	BP1	BP0	32Mb
0	0	0	0	0 (none)
0	0	0	1	1 (1block, block 63rd)
0	0	1	0	2 (2blocks, block 62nd-63rd)
0	0	1	1	3 (4blocks, block 60th-63rd)
0	1	0	0	4 (8blocks, block 56th-63rd)
0	1	0	1	5 (16blocks, block 48th-63rd)
0	1	1	0	6 (32blocks, block 32nd-63rd)
0	1	1	1	7 (64blocks, protect all)
1	0	0	0	8 (64blocks, protect all)
1	0	0	1	9 (64blocks, protect all)
1	0	1	0	10 (64blocks, protect all)
1	0	1	1	11 (64blocks, protect all)
1	1	0	0	12 (64blocks, protect all)
1	1	0	1	13 (64blocks, protect all)
1	1	1	0	14 (64blocks, protect all)
1	1	1	1	15 (64blocks, protect all)

Protected Area Sizes (TB bit = 1)

Status bit				Protect Level
BP3	BP2	BP1	BP0	32Mb
0	0	0	0	0 (none)
0	0	0	1	1 (1block, block 0th)
0	0	1	0	2 (2blocks, block 0th-1st)
0	0	1	1	3 (4blocks, block 0th-3rd)
0	1	0	0	4 (8blocks, block 0th-7th)
0	1	0	1	5 (16blocks, block 0th-15th)
0	1	1	0	6 (32blocks, block 0th-31st)
0	1	1	1	7 (64blocks, protect all)
1	0	0	0	8 (64blocks, protect all)
1	0	0	1	9 (64blocks, protect all)
1	0	1	0	10 (64blocks, protect all)
1	0	1	1	11 (64blocks, protect all)
1	1	0	0	12 (64blocks, protect all)
1	1	0	1	13 (64blocks, protect all)
1	1	1	0	14 (64blocks, protect all)
1	1	1	1	15 (64blocks, protect all)

Note: The device is ready to accept a Chip Erase instruction if, and only if, all Block Protect (BP3, BP2, BP1, BP0) are 0.

II. **Additional 8K-bit secured OTP** for an unique identifier to provide an 8K-bit one-time program area for setting a device unique serial number. This may be accomplished in the factory or by an end systems customer.

The 8K-bit secured OTP area is composed of two rows of 4K-bit. Customer could lock the first 4K-bit OTP area and factory could lock the other.

- Security register bit 0 indicates whether the second 4K-bit is locked by factory or not.

- Customer may lock-down the customer lockable secured OTP by writing WRSCUR(write security register) command to set customer lock-down bit1 as "1". Please refer to *"Table 11. Security Register Definition"* for security register bit definition and *"Table 2. 8K-bit Secured OTP Definition"* for address range definition.

- The 8K-bit secured OTP area is programmed by entering secured OTP mode (with the Enter Security OTP command), and going through a normal program procedure. Exiting secured OTP mode is done by issuing the Exit Security OTP command.

Note: Once lock-down whatever by factory or customer, the corresponding secured area cannot be changed any more. While in 8K-bit Secured OTP mode, array access is not allowed.

Table 2. 8K-bit Secured OTP Definition

Address range	Size	Customer Lock	Standard Factory Lock
xxx000-xxx1FF	4096-bit	Determined by customer	N/A
xxx200-xxx3FF	4096-bit	N/A	Determined by factory

7. MEMORY ORGANIZATION

Table 3. Memory Organization

Block(64K-byte)	Block(32K-byte)	Sector (4K-byte)	Address Range	
63	127	1023	3FF000h	3FFFFFh
		⋮		
		1016	3F8000h	3F8FFFh
	126	1015	3F7000h	3F7FFFh
		⋮		
		1008	3F0000h	3F0FFFh
62	125	1007	3EF000h	3EFFFFh
		⋮		
		1000	3E8000h	3E8FFFh
	124	999	3E7000h	3E7FFFh
		⋮		
		992	3E0000h	3E0FFFh
61	123	991	3DF000h	3DFFFFh
		⋮		
		984	3D8000h	3D8FFFh
	122	983	3D7000h	3D7FFFh
		⋮		
		976	3D0000h	3D0FFFh
2	5	47	02F000h	02FFFFh
		⋮		
		40	028000h	028FFFh
	4	39	027000h	027FFFh
		⋮		
		32	020000h	020FFFh
1	3	31	01F000h	01FFFFh
		⋮		
		24	018000h	018FFFh
	2	23	017000h	017FFFh
		⋮		
		16	010000h	010FFFh
0	1	15	00F000h	00FFFFh
		⋮		
		8	008000h	008FFFh
	0	7	007000h	007FFFh
		⋮		
		0	000000h	000FFFh

8. DEVICE OPERATION

1. Before a command is issued, status register should be checked to ensure device is ready for the intended operation.

2. When an incorrect command is written to this device, it enters standby mode and stays in standby mode until the next CS# falling edge. In standby mode, This device's SO pin should be High-Z.

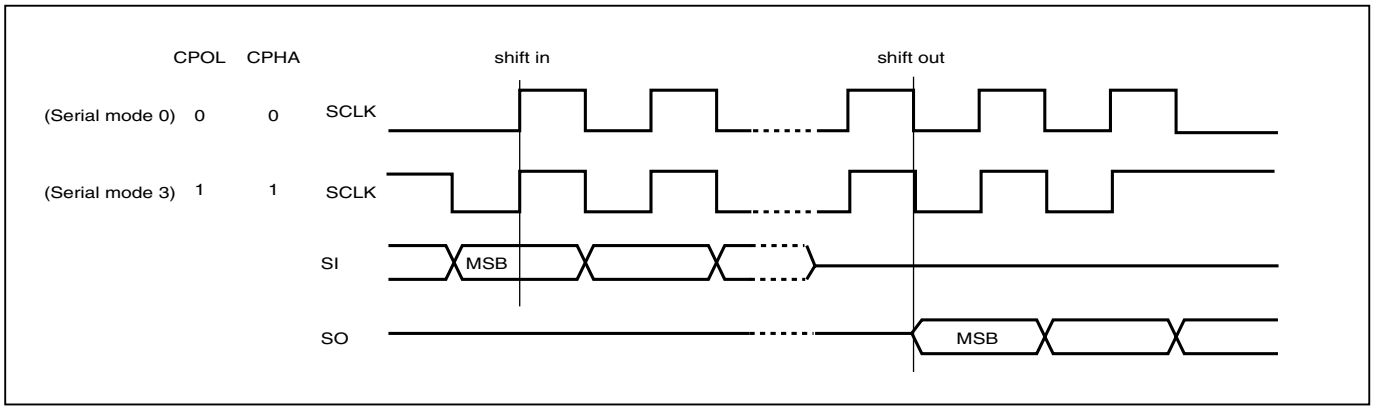
3. When a correct command is written to this device, it enters active mode and stays in active mode until the next CS# rising edge.

4. For standard single data rate serial mode, input data is latched on the rising edge of Serial Clock(SCLK) and data is shifted out on the falling edge of SCLK. The difference of Serial mode 0 and mode 3 is shown as *"Figure 1. Serial Modes Supported (for Normal Serial mode)"*.

5. For the following instructions: READ, FAST_READ, 2READ, DREAD, 4READ, QREAD, RDID, RES, REMS, QPIID, RDSFDP, RDSR, RDCR, RDFMSR, RDSCUR, SBL, RDLR, RDSPB, and RDDPB the shifted-in instruction sequence is followed by a data-out sequence. After any bit of data being shifted out, the CS# can be high. For the following instructions: PP, 4PP, SE, BE32K, BE, CE, WREN, WRDI, WPSEL, EQIO, RSTQIO, SUSPEND, RESUME, DP, RDP, NOP, RSTEN, RST, GBLK, GBULK, FMEN, WRSR/WRCR, WRSCUR, ENSO, EXSO, WRLR, WRSPB, ESSPB, WRDPB, the CS# must go high exactly at the byte boundary; otherwise, the instruction will be rejected and not executed.

6. While a Write Status Register, Program, or Erase operation is in progress, access to the memory array is ignored and will not affect the current operation of Write Status Register, Program, or Erase.

Figure 1. Serial Modes Supported (for Normal Serial mode)



Note:
CPOL indicates clock polarity of Serial master, CPOL=1 for SCLK high while idle, CPOL=0 for SCLK low while not transmitting. CPHA indicates clock phase. The combination of CPOL bit and CPHA bit decides which Serial mode is supported.

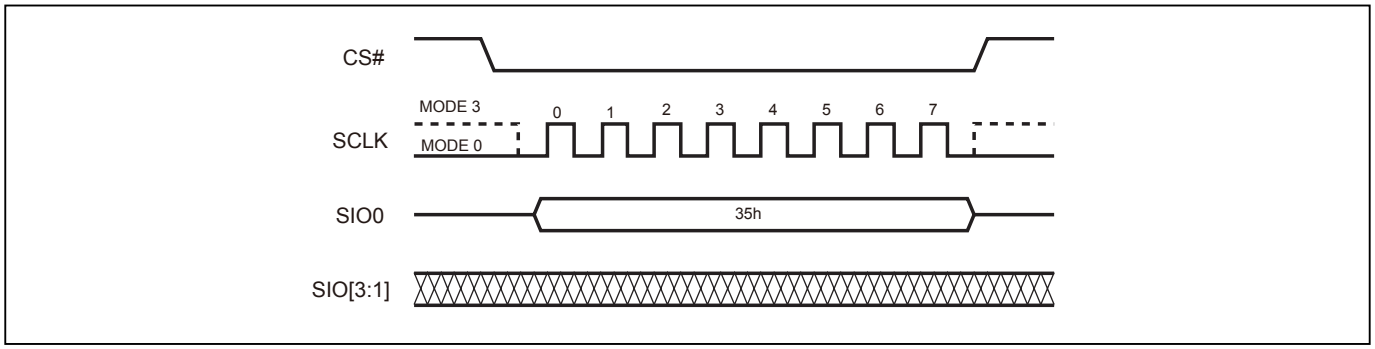
8-1. Quad Peripheral Interface (QPI) Read Mode

QPI protocol enables user to take full advantage of Quad I/O Serial NOR Flash by providing the Quad I/O interface in command cycles, address cycles and as well as data output cycles.

Enable QPI mode

By issuing EQIO command (35h), the QPI mode is enabled. After QPI mode has been enabled, the device enter quad mode (4-4-4) without QE bit status changed.

Figure 2. Enable QPI Sequence

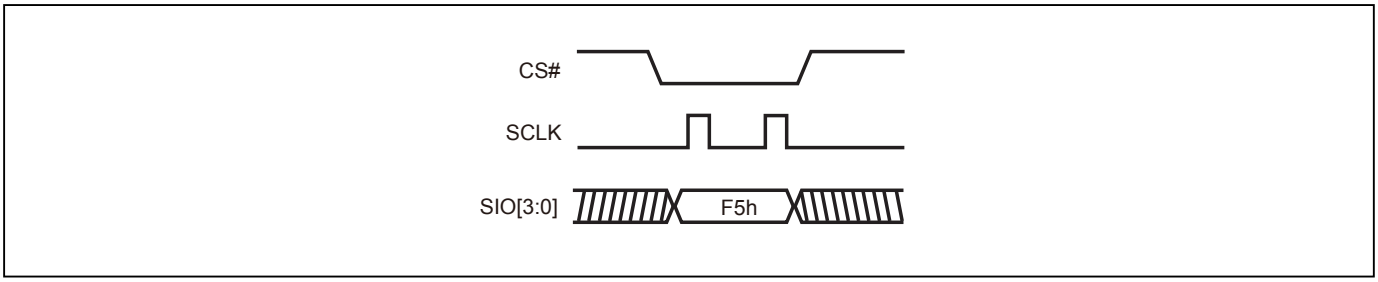


Reset QPI (RSTQIO)

To reset the QPI mode, the RSTQIO (F5h) command is required. After the RSTQIO command is issued, the device returns from QPI mode (4 I/O interface in command cycles) to SPI mode (1 I/O interface in command cycles).

Note:
For EQIO and RSTQIO commands, CS# high width has to follow "From Write/Erase/Program to Read Status Register spec" tSHSL (as defined in *"Table 20. AC Characteristics"*) for next instruction.

Figure 3. Reset QPI Mode

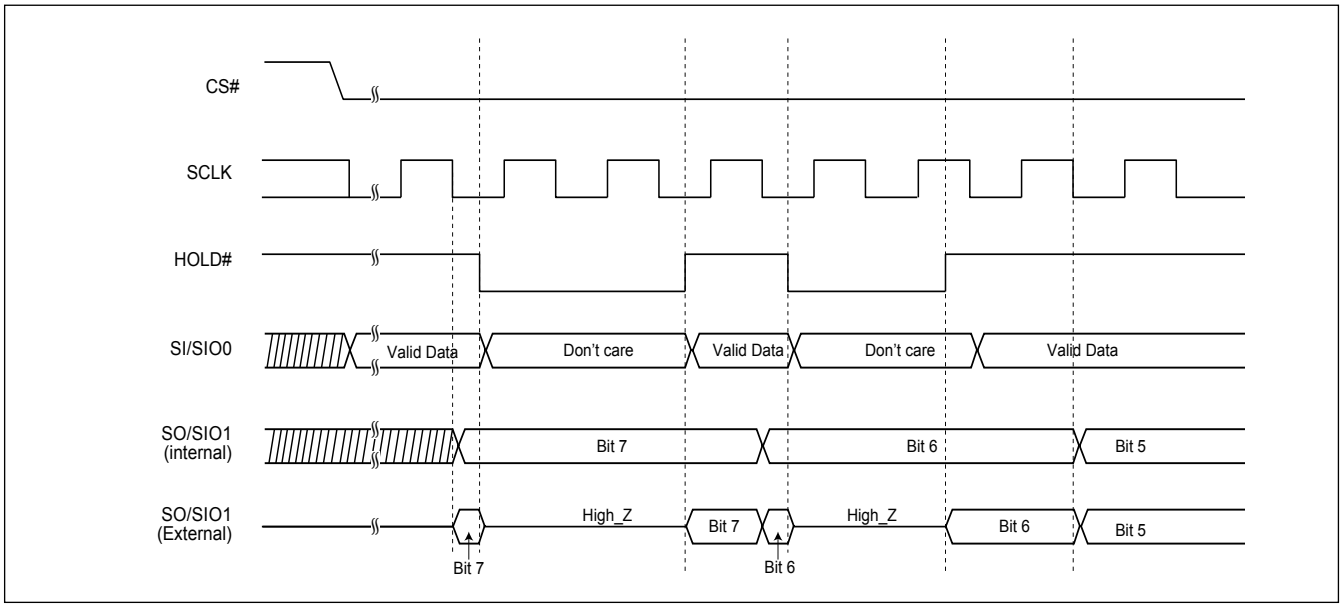


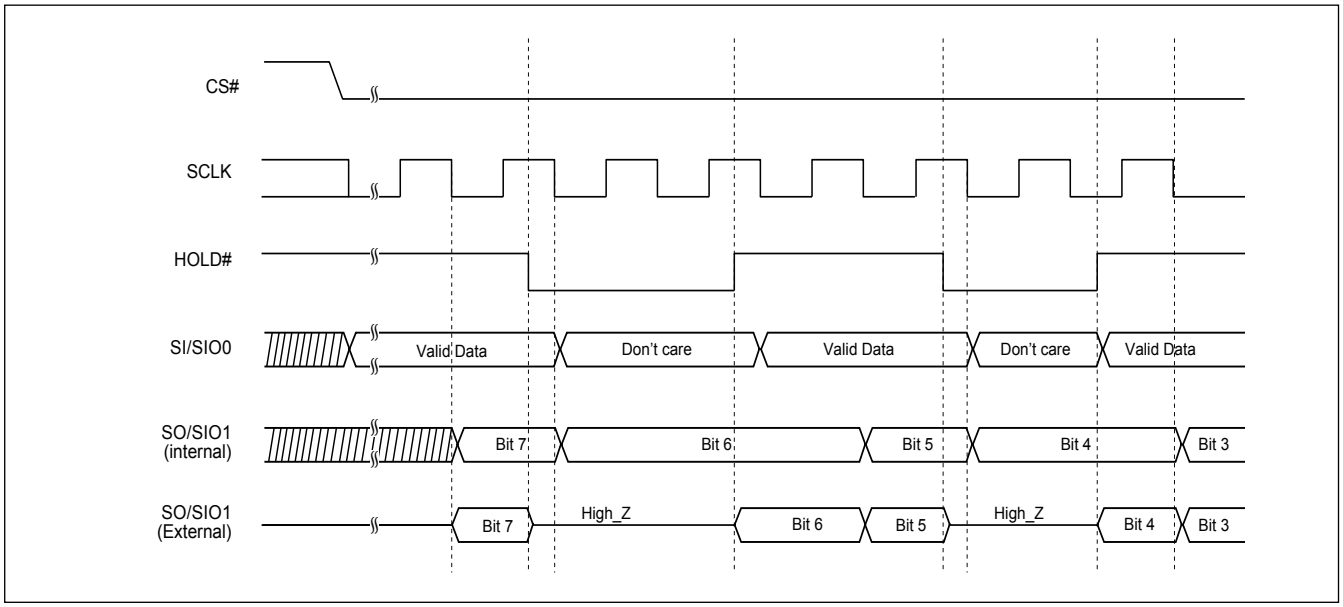
9. HOLD FEATURE

HOLD# pin signal goes low to hold any serial communications with the device. The HOLD feature will not stop the operation of write status register, programming, or erasing in progress.

The operation of HOLD requires Chip Select (CS#) keeping low and starts on falling edge of HOLD# pin signal while Serial Clock (SCLK) signal is being low (if Serial Clock signal is not being low, HOLD operation will not start until Serial Clock signal being low). The HOLD condition ends on the rising edge of HOLD# pin signal while Serial Clock(SCLK) signal is being low (if Serial Clock signal is not being low, HOLD operation will not end until Serial Clock being low).

Figure 4. Hold Condition Operation





During the HOLD operation, the Serial Data Output (SO) is high impedance when Hold# pin goes low and will keep high impedance until Hold# pin goes high. The Serial Data Input (SI) is don't care if both Serial Clock (SCLK) and Hold# pin goes low and will keep the state until SCLK goes low and Hold# pin goes high. If Chip Select (CS#) drives high during HOLD operation, it will reset the internal logic of the device. To re-start communication with chip, the HOLD# must be at high and CS# must be at low.

Note: The HOLD feature is disabled during Quad I/O mode.

10. COMMAND DESCRIPTION

Table 4. Command Sets

	Command Code	SPI	QPI	Address Byte					Dummy Cycle	Data Byte
				Total ADD Byte	Byte 1	Byte 2	Byte 3	Byte 4		
Array access										
READ (normal read)	03 (hex)	V		3	ADD1	ADD2	ADD3		0	1- ∞
FAST READ (fast read data)	0B (hex)	V	V	3	ADD1	ADD2	ADD3		6/8/10*	1- ∞
2READ (2 x I/O read command)	BB (hex)	V		3	ADD1	ADD2	ADD3		4/8*	1- ∞
DREAD (1I 2O read)	3B (hex)	V		3	ADD1	ADD2	ADD3		8	1- ∞
4READ (4 I/O read)	EB (hex)	V	V	3	ADD1	ADD2	ADD3		6/10*	1- ∞
QREAD (1I 4O read)	6B (hex)	V		3	ADD1	ADD2	ADD3		8	1- ∞
PP (page program)	02 (hex)	V	V	3	ADD1	ADD2	ADD3		0	1-256
4PP (quad page program)	38 (hex)	V		3	ADD1	ADD2	ADD3		0	1-256
SE (sector erase)	20 (hex)	V	V	3	ADD1	ADD2	ADD3		0	0
BE 32K (block erase 32KB)	52 (hex)	V	V	3	ADD1	ADD2	ADD3		0	0
BE (block erase 64KB)	D8 (hex)	V	V	3	ADD1	ADD2	ADD3		0	0
CE (chip erase)	60 or C7 (hex)	V	V	0					0	0
Device operation										
WREN (write enable)	06 (hex)	V	V	0					0	0
WRDI (write disable)	04 (hex)	V	V	0					0	0
WPSEL (Write Protect Selection)	68 (hex)	V	V	0					0	0
EQIO (Enable QPI)	35 (hex)	V		0					0	0
RSTQIO (Reset QPI)	F5 (hex)		V	0					0	0
PGM/ERS Suspend (Suspends Program/ Erase)	75 or B0 (hex)	V	V	0					0	0
PGM/ERS Resume (Resumes Program/ Erase)	7A or 30 (hex)	V	V	0					0	0
DP (Deep power down)	B9 (hex)	V	V	0					0	0
RDP (Release from deep power down)	AB (hex)	V	V	0					0	0

* Dummy cycle numbers will be different depending on the bit6 (DC0 & DC1) setting in configuration register.

	Command Code	SPI	QPI	Address Byte					Dummy Cycle	Data Byte
				Total ADD Byte	Byte 1	Byte 2	Byte 3	Byte 4		
NOP (No Operation)	00 (hex)	V	V	0					0	0
RSTEN (Reset Enable)	66 (hex) *(Note 2)*	V	V	0					0	0
RST (Reset Memory)	99 (hex) *(Note 2)*	V	V	0					0	0
GBLK (gang block lock)	7E (hex)	V	V	0					0	0
GBULK (gang block unlock)	98 (hex)	V	V	0					0	0
FMEN (factory mode enable)	41 (hex)	V	V	0					0	0
Register Access										
RDID (read identification)	9F (hex)	V		0					0	3
RES (read electronic ID)	AB (hex)	V	V	0	Dummy	Dummy	Dummy		24	1
REMS (read electronic manufacturer & device ID)	90 (hex)	V	V	1	Dummy	Dummy	ADD *(Note 3)*		16	2
QPIID (QPI ID Read)	AF (hex)		V	0					0	3
RDSFDP (Read SFDP Table)	5A (hex)	V	V	3	ADD1	ADD2	ADD3	Dummy	8	1- ∞
RDSR (read status register)	05 (hex)	V	V	0					0	1
RDCR (read configuration register)	15 (hex)	V	V	0					0	1
RDFMSR (Read Factory Mode Status Register)	44 (hex)	V	V	0					0	1
WRSR (write status/configuration register)	01 (hex)	V	V	0					0	1-2
RDSCUR (read security register)	2B (hex)	V	V	0					0	1
WRSCUR (write security register)	2F (hex)	V	V	0					0	0
SBL (Set Burst Length)	C0 or 77 (hex)	V	V	0					0	1
ENSO (enter secured OTP)	B1 (hex)	V	V	0					0	0
EXSO (exit secured OTP)	C1 (hex)	V	V	0					0	0

	Command Code	SPI	QPI	Address Byte					Dummy Cycle	Data Byte
				Total ADD Byte	Byte 1	Byte 2	Byte 3	Byte 4		
WRLR (write Lock register)	2C (hex)	V		0					0	1
RDLR (read Lock register)	2D (hex)	V		0					0	1
WRSPB (SPB bit program)	E3 (hex)	V		4	ADD1	ADD2	ADD3	ADD4	0	0
ESSPB (all SPB bit erase)	E4 (hex)	V		0					0	0
RDSPB (read SPB status)	E2 (hex)	V		4	ADD1	ADD2	ADD3	ADD4	0	1
WRDPB (write DPB register)	E1 (hex)	V		4	ADD1	ADD2	ADD3	ADD4	0	1
RDDPB (read DPB register)	E0 (hex)	V		4	ADD1	ADD2	ADD3	ADD4	0	1

Note 1: It is not recommended to adopt any other code/address not in the command definition table, which will potentially enter the hidden mode.
Note 2: The RSTEN command must be executed before executing the RST command. If any other command is issued in-between RSTEN and RST, the RST command will be ignored.
Note 3: ADD=00H will output the manufacturer ID first and ADD=01H will output device ID first.
Note 4: Please check Dual I/O Fast Read for the read frequency.
Note 5: Please check Quad IO Fast Read for the read frequency.

10-1. Write Enable (WREN)

The Write Enable (WREN) instruction sets the Write Enable Latch (WEL) bit. Instructions like PP, 4PP, SE, BE, BE32K, CE, and WRSR that are intended to change the device content, should be preceded by the WREN instruction.

The sequence of issuing WREN instruction is: CS# goes low→ send WREN instruction code→ CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care in SPI mode.

Figure 5. Write Enable (WREN) Sequence (Command 06h) (SPI Mode)

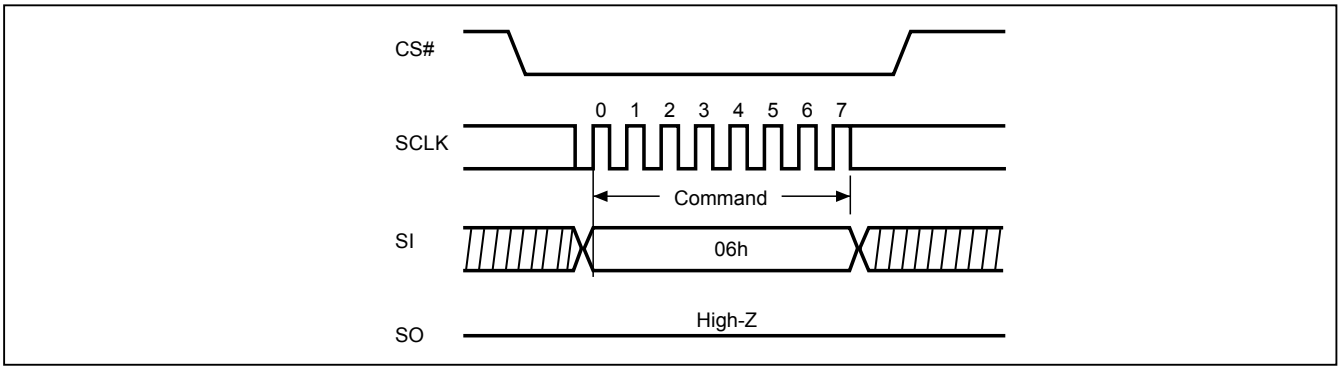
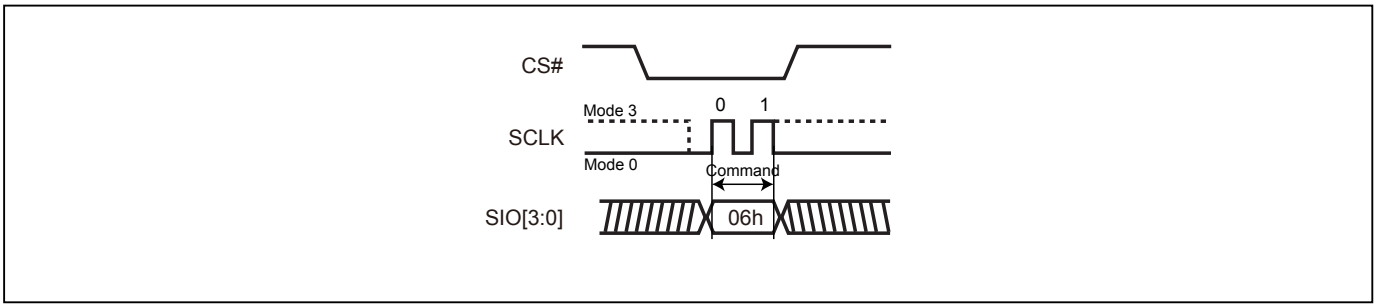


Figure 6. Write Enable (WREN) Sequence (Command 06h) (QPI Mode)



10-2. Write Disable (WRDI)

The Write Disable (WRDI) instruction resets the Write Enable Latch (WEL) bit.

The sequence of issuing WRDI instruction is: CS# goes low→ send WRDI instruction code→ CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care in SPI mode.

The WEL bit is reset in the following situations:
- Power-up
- WRDI command completion
- WRSR command completion
- PP command completion
- 4PP command completion
- SE command completion
- BE32K command completion
- BE command completion
- CE command completion
- PGM/ERS Suspend command completion
- Softreset command completion
- WRSCUR command completion

Figure 7. Write Disable (WRDI) Sequence (Command 04h) (SPI Mode)

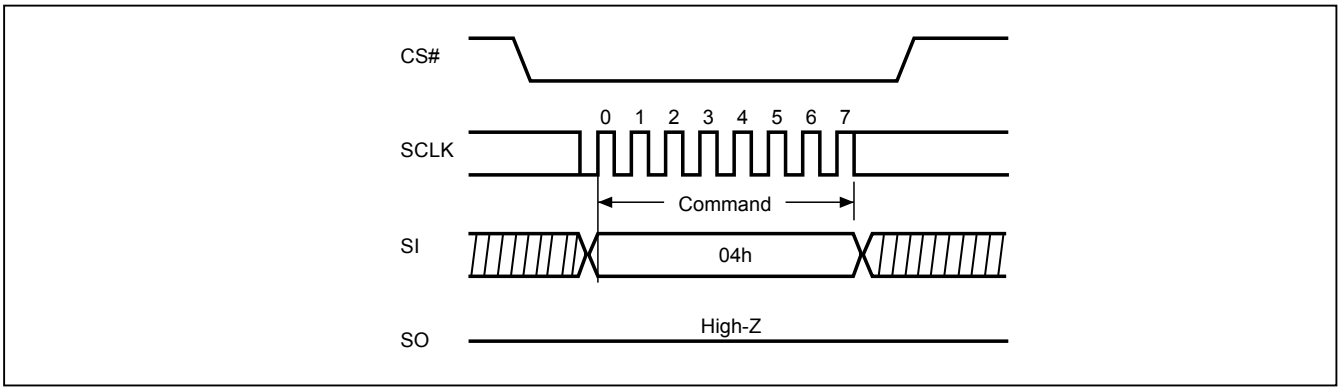
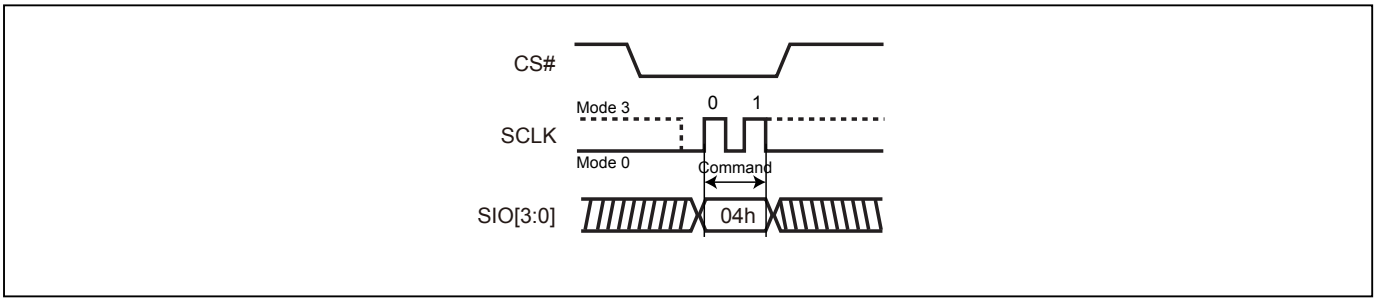


Figure 8. Write Disable (WRDI) Sequence (Command 04h) (QPI Mode)



10-3. Factory Mode Enable (FMEN)

The Factory Mode Enable (FMEN) instruction enhances Program and Erase performance to increase factory production throughput. The FMEN instruction needs to be combined with the instructions which are intended to change the device content, like PP, 4PP, SE, BE32K, BE, and CE.

The sequence of issuing FMEN instruction is: CS# goes low→send FMEN instruction code→ CS# goes high. A valid factory mode operation needs to include three sequences: WREN instruction → FMEN instruction→ Program or Erase instruction.

Suspend command is not acceptable under factory mode.

The FMEN is reset in the following situations

- Power-up
- Reset# pin driven low
- PP command completion
- 4PP command completion
- SE command completion
- BE32K command completion
- BE command completion
- CE command completion
- Softreset command completion

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care in SPI mode.

Figure 9. Factory Mode Enable (FMEN) Sequence(Command 41h) (SPI Mode)

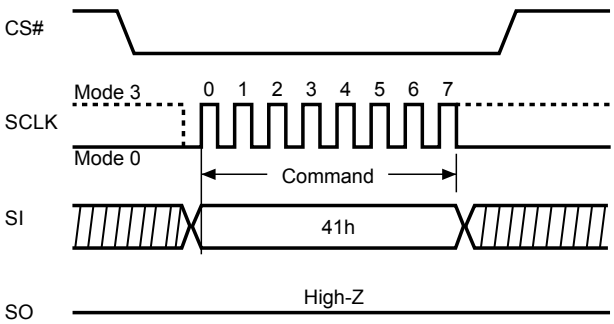
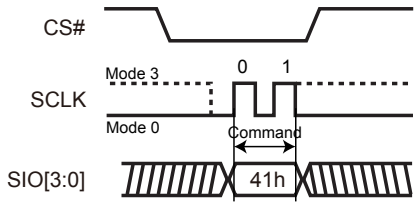


Figure 10. Factory Mode Enable (FMEN) Sequence (Command 41h) (QPI Mode)



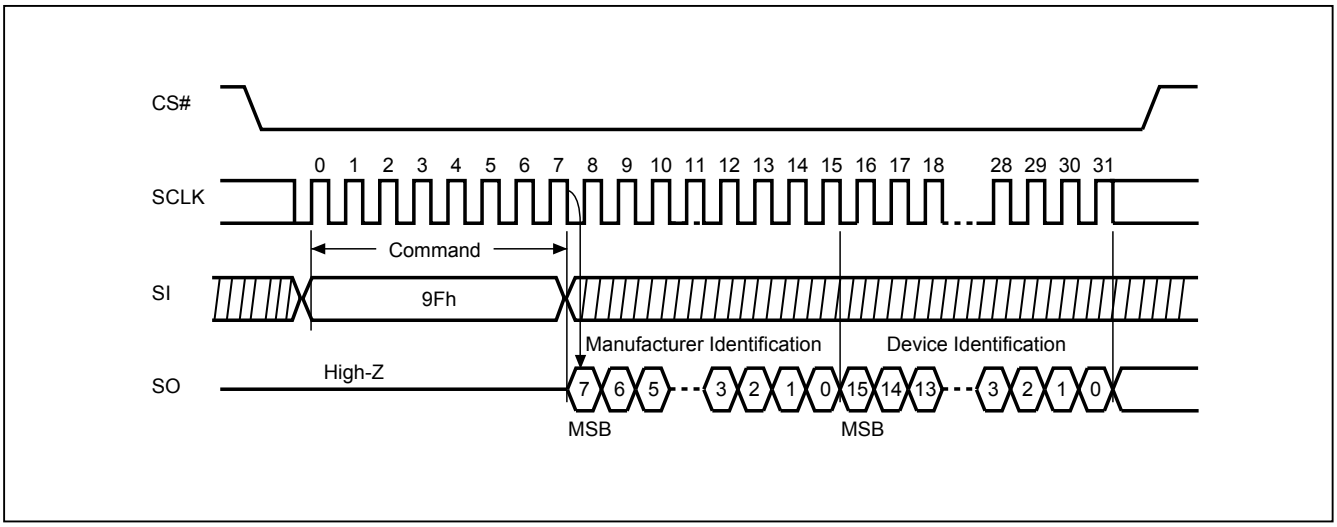
10-4. Read Identification (RDID)

The RDID instruction is for reading the 1-byte manufacturer ID and the 2-byte Device ID that follows. The Macronix Manufacturer ID and Device ID are listed as *"Table 10. ID Definitions"*.

The sequence of issuing RDID instruction is: CS# goes low→ send RDID instruction code → 24-bits ID data out on SO→ to end RDID operation, drive CS# high at any time during data out.

While Program/Erase operation is in progress, it will not decode the RDID instruction, so there's no effect on the cycle of program/erase operation which is currently in progress. When CS# goes high, the device is at standby stage.

Figure 11. Read Identification (RDID) Sequence (Command 9Fh) (SPI mode only)



10-5. Read Status Register (RDSR)

The RDSR instruction is for reading Status Register. The Read Status Register can be read at any time (even in program/erase/write status register condition) and continuously. It is recommended to check the Write in Progress (WIP) bit before sending a new instruction when a program, erase, or write status register operation is in progress.

The sequence of issuing RDSR instruction is: CS# goes low→ send RDSR instruction code→ Status Register data out on SO.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care in SPI mode.

Figure 12. Read Status Register (RDSR) Sequence (Command 05h) (SPI Mode)

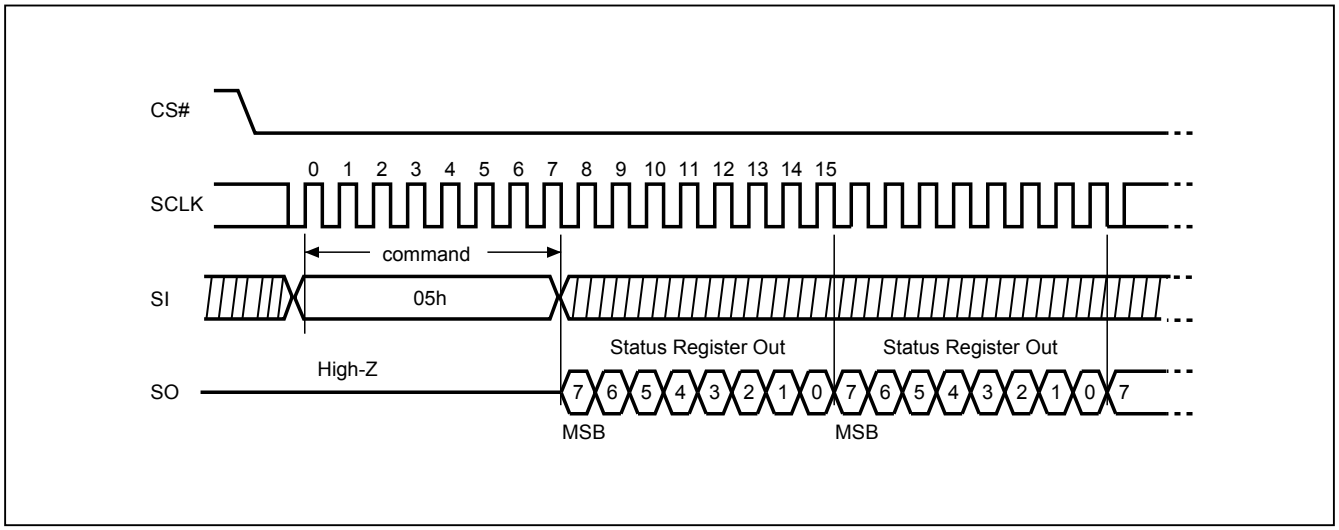
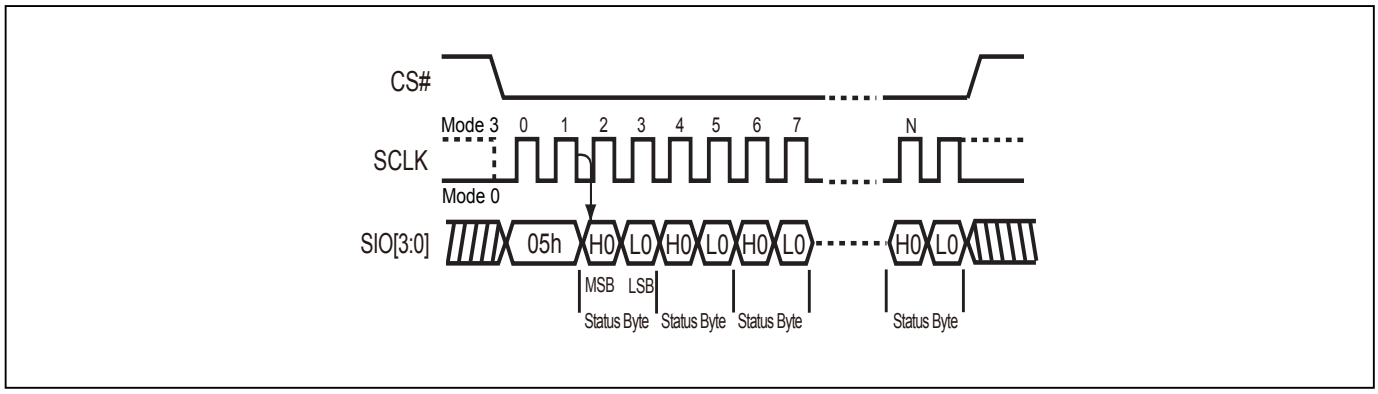


Figure 13. Read Status Register (RDSR) Sequence (Command 05h) (QPI Mode)



10-6. Read Configuration Register (RDCR)

The RDCR instruction is for reading Configuration Register Bits. The Read Configuration Register can be read at any time (even in program/erase/write configuration register condition). It is recommended to check the Write in Progress (WIP) bit before sending a new instruction when a program, erase, or write configuration register operation is in progress.

The sequence of issuing RDCR instruction is: CS# goes low→ send RDCR instruction code→ Configuration Register data out on SO.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

Figure 14. Read Configuration Register (RDCR) Sequence (Command 15h) (SPI Mode)

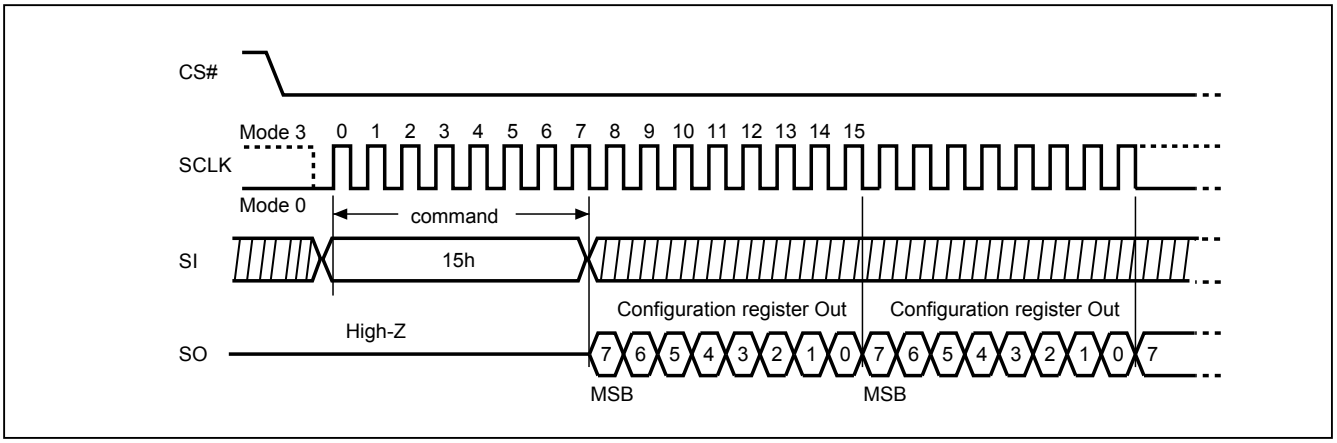
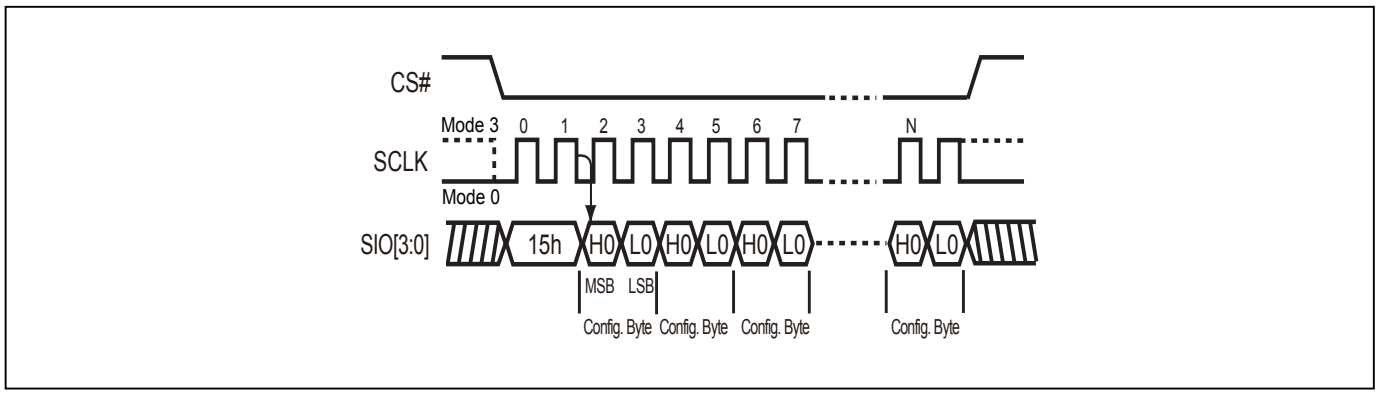


Figure 15. Read Configuration Register (RDCR) Sequence (Command 15h) (QPI Mode)



Status Register

The definition of the status register bits is as below:

WIP bit. The Write in Progress (WIP) bit, a volatile bit, indicates whether the device is busy in program/erase/write status register progress. When WIP bit sets to 1, which means the device is busy in program/erase/write status register progress. When WIP bit sets to 0, which means the device is not in progress of program/erase/write status register cycle.

WEL bit. The Write Enable Latch (WEL) bit is a volatile bit that is set to “1” by the WREN instruction. WEL needs to be set to “1” before the device can accept program and erase instructions, otherwise the program and erase instructions are ignored. WEL automatically clears to “0” when a program or erase operation completes. To ensure that both WIP and WEL are “0” and the device is ready for the next program or erase operation, it is recommended that WIP be confirmed to be “0” before checking that WEL is also “0”. If a program or erase instruction is applied to a protected memory area, the instruction will be ignored and WEL will clear to “0”.

BP3, BP2, BP1, BP0 bits. The Block Protect (BP3, BP2, BP1, BP0) bits, non-volatile bits, indicate the protected area (as defined in *"Table 1. Protected Area Sizes"*) of the device to against the program/erase instruction without hardware protection mode being set. To write the Block Protect (BP3, BP2, BP1, BP0) bits requires the Write Status Register (WRSR) instruction to be executed. Those bits define the protected area of the memory to against Page Program (PP), Sector Erase (SE), Block Erase (BE) and Chip Erase (CE) instructions (only if all Block Protect bits set to 0, the CE instruction can be executed). The BP3, BP2, BP1, BP0 bits are "0" as default, which is un-protected.

QE bit. The Quad Enable (QE) bit is a non-volatile bit with a factory default of “0”. When QE is “0”, Quad mode commands are ignored; pins WP#/SIO2 and HOLD#/SIO3 function as WP# and HOLD#, respectively. When QE is “1”, Quad mode is enabled and Quad mode commands are supported along with Single and Dual mode commands. Pins WP#/SIO2 and HOLD#/SIO3 function as SIO2 and SIO3, respectively, and their alternate pin functions are disabled. Enabling Quad mode also disables the HPM and HOLD features.

SRWD bit. The Status Register Write Disable (SRWD) bit, non-volatile bit, default value is "0". SRWD bit is operated together with Write Protection (WP#/SIO2) pin for providing hardware protection mode. The hardware protection mode requires SRWD sets to 1 and WP#/SIO2 pin signal is low stage. In the hardware protection mode, the Write Status Register (WRSR) instruction is no longer accepted for execution and the SRWD bit and Block Protect bits (BP3, BP2, BP1, BP0) are read only. The SRWD bit defaults to be "0".

Table 5. Status Register

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SRWD (status register write protect)	QE (Quad Enable)	BP3 (level of protected block)	BP2 (level of protected block)	BP1 (level of protected block)	BP0 (level of protected block)	WEL (write enable latch)	WIP (write in progress bit)
1=status register write disabled 0=status register write enabled	1= Quad Enabled 0=not Quad Enabled	*(note 1)*	*(note 1)*	*(note 1)*	*(note 1)*	1=write enabled 0=not write enabled	1=write operation 0=not in write operation
Non-volatile bit	Non-volatile bit	Non-volatile bit	Non-volatile bit	Non-volatile bit	Non-volatile bit	volatile bit	volatile bit

Note 1: Please refer to the *"Table 1. Protected Area Sizes"*.

Configuration Register

The Configuration Register is able to change the default status of Flash memory. Flash memory will be configured after the CR bit is set.

ODS bit
The output driver strength (ODS2, ODS1, ODS0) bits are volatile bits, which indicate the output driver level (as defined in *"Table 7. Output Driver Strength Table"*) of the device. The Output Driver Strength is defaulted as 30 Ohms when delivered from factory. To write the ODS bits requires the Write Status Register (WRSR) instruction to be executed.

TB bit
The Top/Bottom (TB) bit is a OTP bit. The Top/Bottom (TB) bit is used to configure the Block Protect area by BP bit (BP3, BP2, BP1, BP0), starting from TOP or Bottom of the memory array. The TB bit is defaulted as "0", which means Top area protect. When it is set as "1", the protect area will change to Bottom area of the memory device. To write the TB bit requires the Write Status Register (WRSR) instruction to be executed.

Table 6. Configuration Register

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Reserved	DC (Dummy Cycle)	Reserved	Reserved	TB (top/bottom selected)	ODS 2 (output driver strength)	ODS 1 (output driver strength)	ODS 0 (output driver strength)
x	2READ/ 4READ Dummy Cycles *(Note 2)*	x	x	0=Top area protect 1=Bottom area protect (Default=0)	*(Note 1)*	*(Note 1)*	*(Note 1)*
x	volatile bit	x	x	OTP	volatile bit	volatile bit	volatile bit

Note 1: Please refer to *"Table 7. Output Driver Strength Table"*.
Note 2: Please refer to *"Table 8. Dummy Cycles and Frequency Table (MHz)"*.

Table 7. Output Driver Strength Table

ODS2	ODS1	ODS0	Resistance (Ohm)
0	0	0	Reserved
0	0	1	90 Ohms
0	1	0	45 Ohms
0	1	1	45 Ohms
1	0	0	Reserved
1	0	1	15 Ohms
1	1	0	15 Ohms
1	1	1	30 Ohms (Default)

Table 8. Dummy Cycles and Frequency Table (MHz)

DC[1:0]	Numbers of Dummy clock cycles	Fast Read (SPI mode)	Dual Output Fast Read	Quad Output Fast Read
0 (default)	8	133	120/133R	120/133R
1	8	133	120/133R	120/133R

DC[1:0]	Numbers of Dummy clock cycles	Dual IO Fast Read
0 (default)	4	80
1	8	120/133R

DC[1:0]	Numbers of Dummy clock cycles	Quad IO Fast Read	Fast Read (QPI mode)
0 (default)	6	80	80
1	10	120/133R	120/133R

Note: "R" mean VCC range= 3.0V-3.6V.

10-7. Write Status Register (WRSR)

The WRSR instruction is for changing the values of Status Register Bits and Configuration Register Bits. Before sending WRSR instruction, the Write Enable (WREN) instruction must be decoded and executed to set the Write Enable Latch (WEL) bit in advance. The WRSR instruction can change the value of Block Protect (BP3, BP2, BP1, BP0) bits to define the protected area of memory (as shown in *"Table 1. Protected Area Sizes"*). The WRSR also can set or reset the Quad enable (QE) bit and set or reset the Status Register Write Disable (SRWD) bit in accordance with Write Protection (WP#/SIO2) pin signal, but has no effect on bit1(WEL) and bit0 (WIP) of the status register. The WRSR instruction cannot be executed once the Hardware Protected Mode (HPM) is entered.

The sequence of issuing WRSR instruction is: CS# goes low→ send WRSR instruction code→ Status Register data on SI→ Configuration Register data on SI→ CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

Figure 16. Write Status Register (WRSR) Sequence (Command 01h) (SPI Mode)

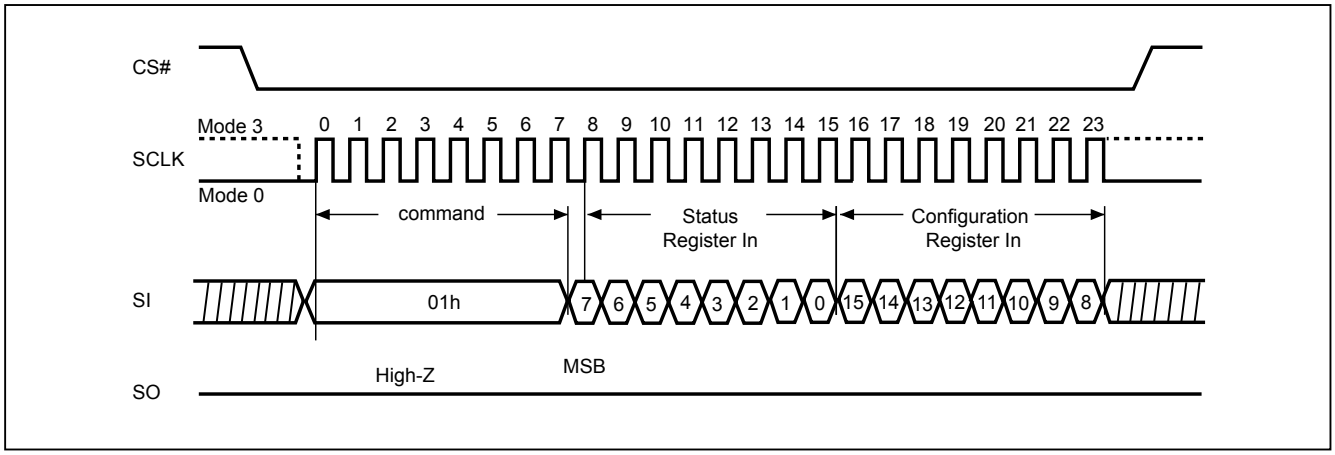
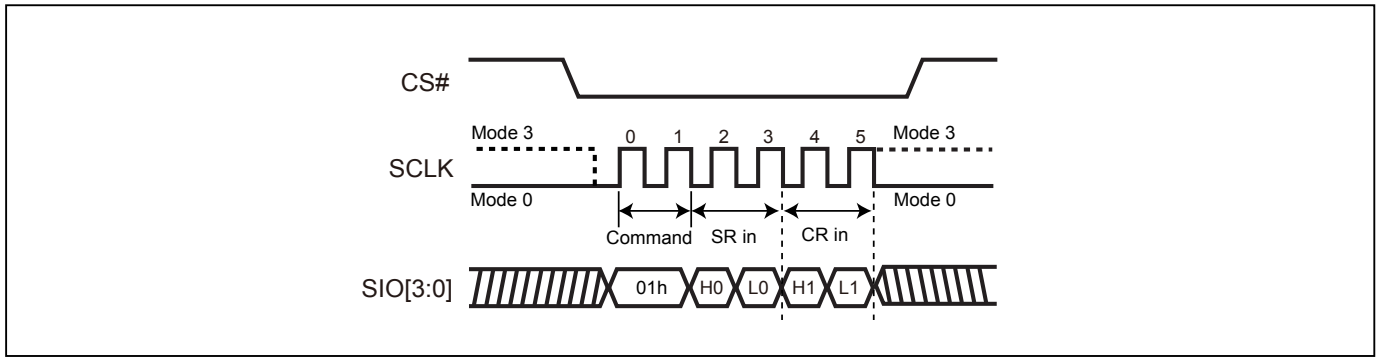


Figure 17. Write Status Register (WRSR) Sequence (Command 01h) (QPI Mode)



The CS# must go high exactly at the byte boundary; otherwise, the instruction will be rejected and not executed. The self-timed Write Status Register cycle time (tW) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked out during the Write Status Register cycle is in progress. The WIP sets 1 during the tW timing, and sets 0 when Write Status Register Cycle is completed, and the Write Enable Latch (WEL) bit is reset.

Table 9. Protection Modes

Mode	Status register condition	WP# and SRWD bit status	Memory
Software protection mode (SPM)	Status register can be written in (WEL bit is set to "1") and the SRWD, BP0-BP3 bits can be changed	WP#=1 and SRWD bit=0, or WP#=0 and SRWD bit=0, or WP#=1 and SRWD=1	The protected area cannot be programmed or erased.
Hardware protection mode (HPM)	The SRWD, BP0-BP3, TB of status register bits cannot be changed	WP#=0, SRWD bit=1	The protected area cannot be programmed or erased.

Note: As defined by the values in the Block Protect (BP3, BP2, BP1, BP0, TB) bits of the Status Register, as shown in *"Table 1. Protected Area Sizes"*.

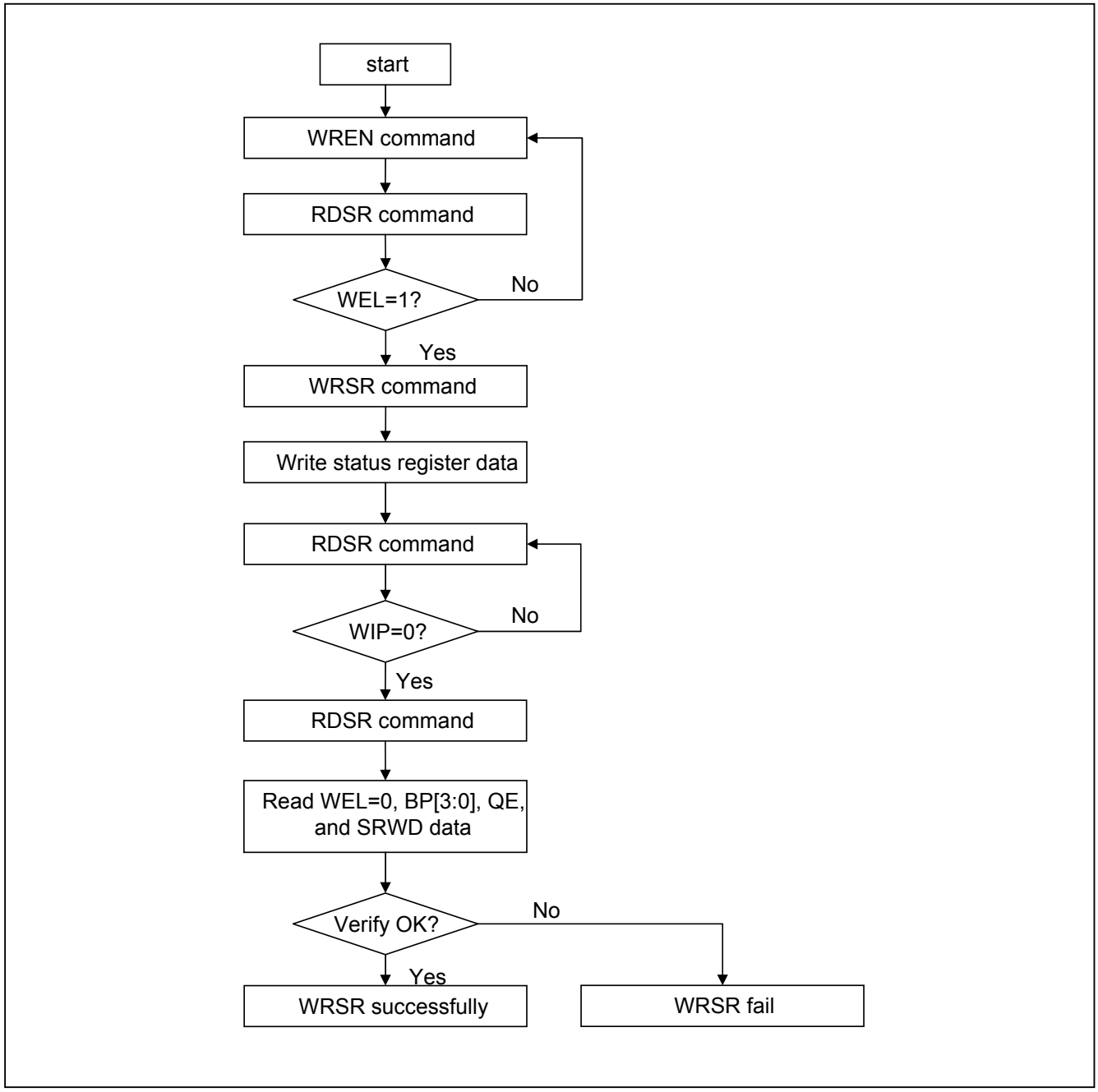
As the table above showing, the summary of the Software Protected Mode (SPM) and Hardware Protected Mode (HPM):

Software Protected Mode (SPM):
- When SRWD bit=0, no matter WP#/SIO2 is low or high, the WREN instruction may set the WEL bit and can change the values of SRWD, BP3, BP2, BP1, BP0. The protected area, which is defined by BP3, BP2, BP1, BP0, is at software protected mode (SPM).
- When SRWD bit=1 and WP#/SIO2 is high, the WREN instruction may set the WEL bit can change the values of SRWD, BP3, BP2, BP1, BP0. The protected area, which is defined by BP3, BP2, BP1, BP0, is at software protected mode (SPM)

Hardware Protected Mode (HPM):
- When SRWD bit=1, and then WP#/SIO2 is low (or WP#/SIO2 is low before SRWD bit=1), it enters the hardware protected mode (HPM). The data of the protected area is protected by software protected mode by BP3, BP2, BP1, BP0, TB and hardware protected mode by the WP#/SIO2 to against data modification.

Note:
To exit the hardware protected mode requires WP#/SIO2 driving high once the hardware protected mode is entered. If the WP#/SIO2 pin is permanently connected to high, the hardware protected mode can never be entered; only can use software protected mode via BP3, BP2, BP1, BP0, TB.
If the system goes into four I/O mode, the feature of HPM will be disabled.

Figure 18. WRSR flow



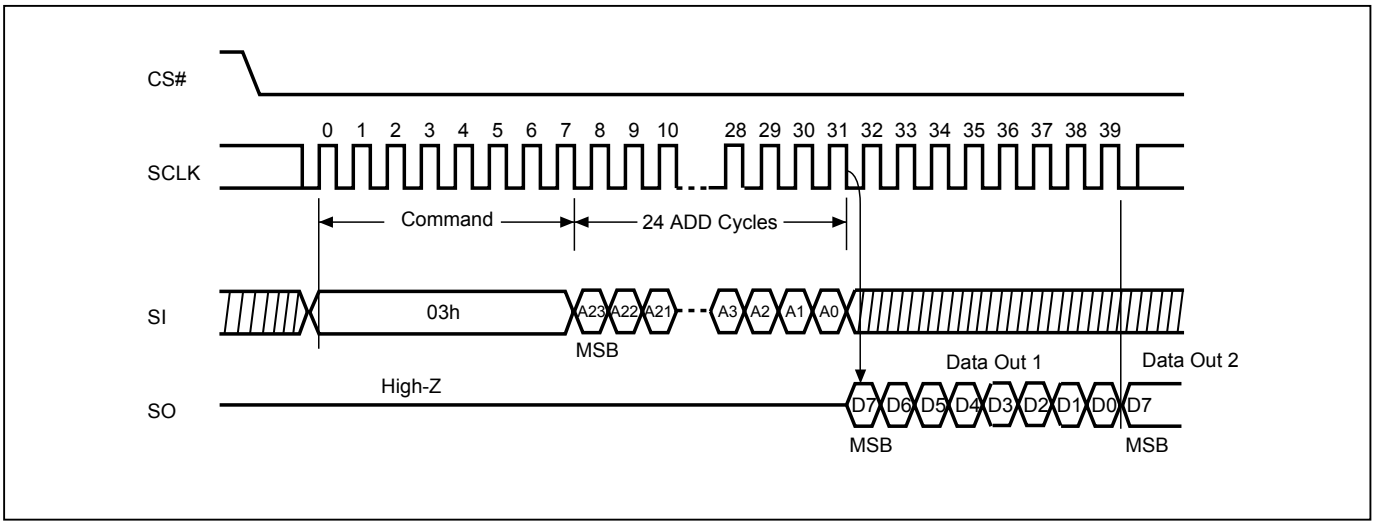
10-8. Read Data Bytes (READ)

The read instruction is for reading data out. The address is latched on rising edge of SCLK, and data shifts out on the falling edge of SCLK at a maximum frequency fR. The first address byte can be at any location. The address is automatically increased to the next higher address after each byte data is shifted out, so the whole memory can be read out at a single READ instruction. The address counter rolls over to 0 when the highest address has been reached.

The sequence of issuing READ instruction is: CS# goes low→ send READ instruction code→3-byte address on SI →data out on SO→ to end READ operation, drive CS# high at any time during data out.

While Program/Erase/Write Status Register cycle is in progress, READ instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

Figure 19. Read Data Bytes (READ) Sequence (Command 03h) (SPI mode only)



10-9. Read Data Bytes at Higher Speed (FAST_READ)

The FAST_READ instruction is for quickly reading data out. The address is latched on rising edge of SCLK, and data of each bit shifts out on the falling edge of SCLK at a maximum frequency fC. The first address byte can be at any location. The address is automatically increased to the next higher address after each byte data is shifted out, so the whole memory can be read out at a single FAST_READ instruction. The address counter rolls over to 0 when the highest address has been reached.

Read on SPI Mode The sequence of issuing FAST_READ instruction is: CS# goes low→ send FAST_READ instruction code→ 3-byte address on SI→8-bit dummy cycle address on SI→ data out on SO→ to end FAST_READ operation, drive CS# high at any time during data out. (Please refer to *"Figure 20. Read at Higher Speed (FAST_READ) Sequence (Command 0Bh) (SPI Mode)"*)

Read on QPI Mode The sequence of issuing FAST_READ instruction in QPI mode is: CS# goes low→ send FAST_READ instruction, 2 cycles→ 24-bit address interleave on SIO3, SIO2, SIO1 & SIO0→6-bit dummy cycle address on SI (Default)→data out interleave on SIO3, SIO2, SIO1 & SIO0→ to end QPI FAST_READ operation, drive CS# high at any time during data out. (Please refer to *"Figure 21. Read at Higher Speed (FAST_READ) Sequence (QPI Mode)"*)

While Program/Erase/Write Status Register cycle is in progress, FAST_READ instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

Figure 20. Read at Higher Speed (FAST_READ) Sequence (Command 0Bh) (SPI Mode)

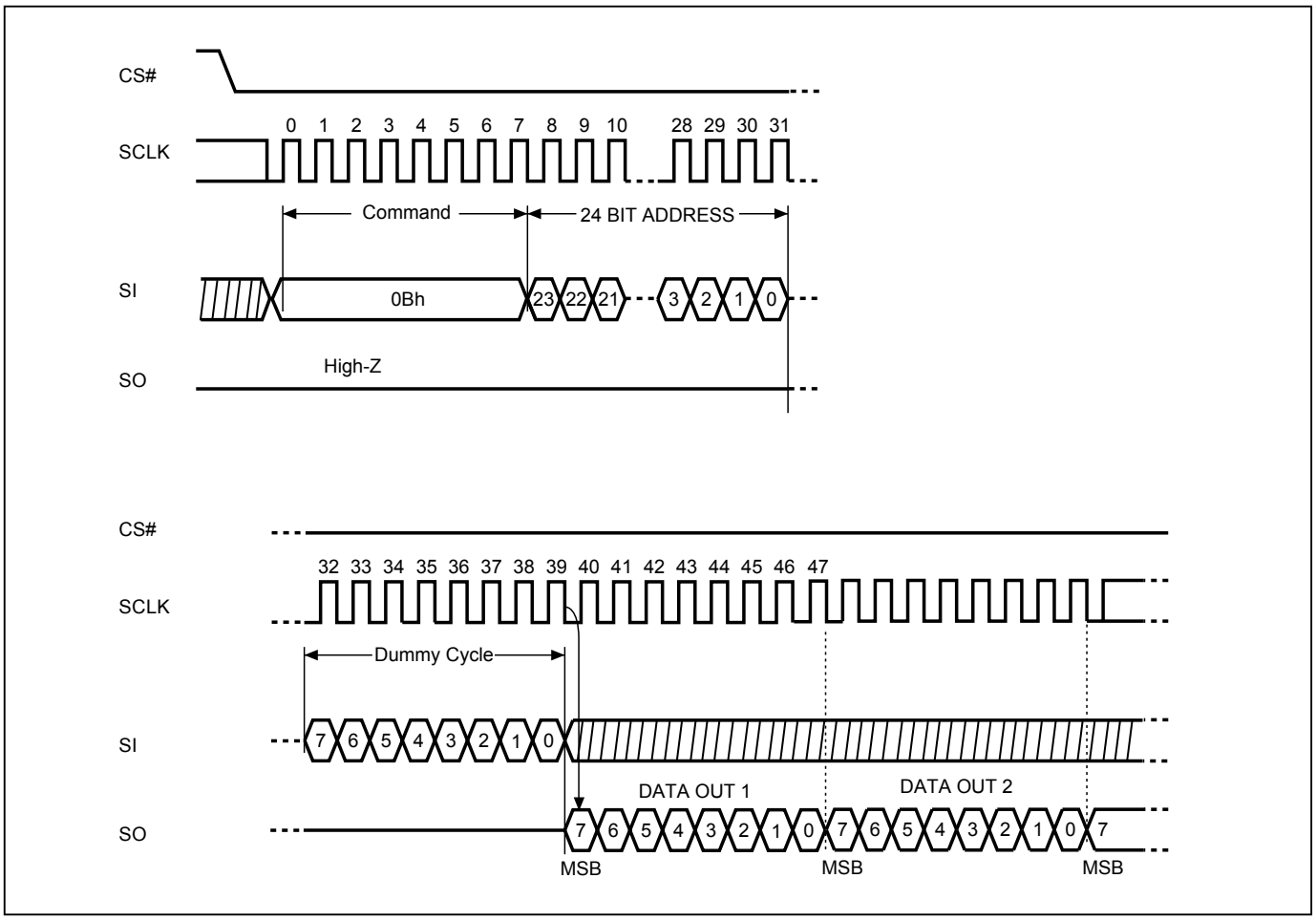
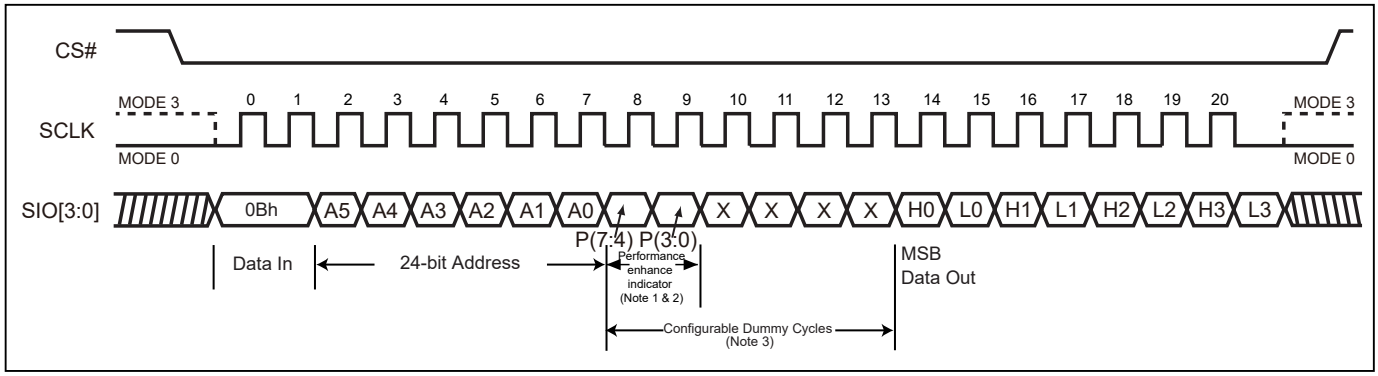


Figure 21. Read at Higher Speed (FAST_READ) Sequence (Command 0Bh) (QPI Mode)



Notes:
1. Hi-impedance is inhibited for the two clock cycles.
2. P7≠P3, P6≠P2, P5≠P1 & P4≠P0 (Toggling) will result in entering the performance enhance mode.
3. Configuration Dummy cycle numbers will be different depending on the bit6 (DC0 & DC1) setting in configuration register.

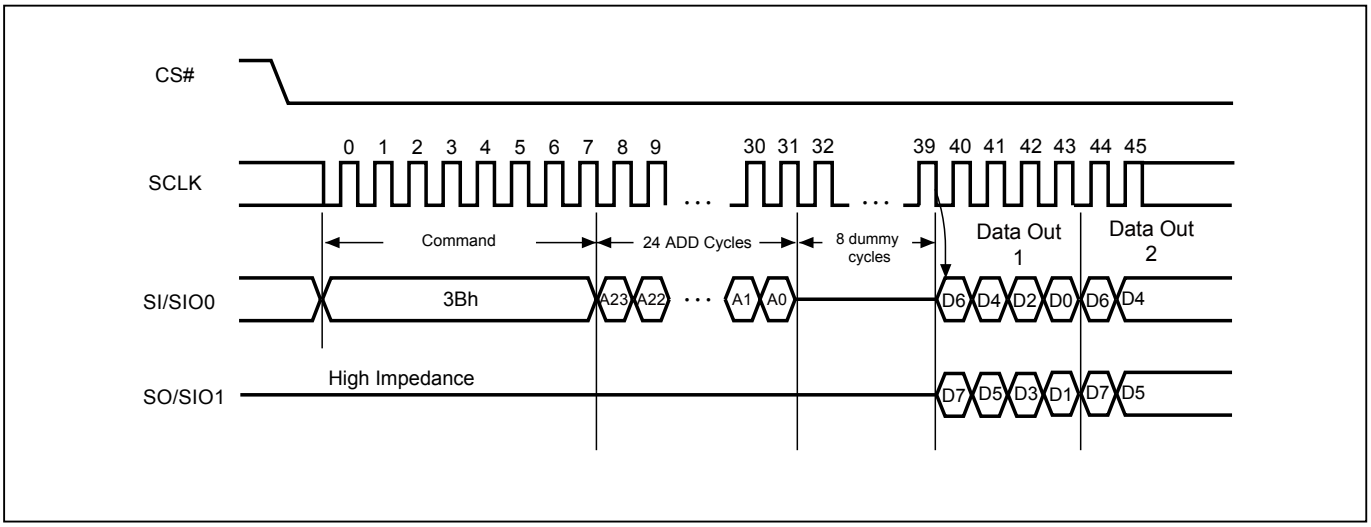
10-10. Dual Read Mode (DREAD)

The DREAD instruction enables double throughput of the Serial NOR Flash in read mode. The address is latched on rising edge of SCLK, and data of every two bits (interleave on 2 I/O pins) shift out on the falling edge of SCLK at a maximum frequency fT. The first address byte can be at any location. The address is automatically increased to the next higher address after each byte data is shifted out, so the whole memory can be read out at a single DREAD instruction. The address counter rolls over to 0 when the highest address has been reached. Once writing DREAD instruction, the following data out will perform as 2-bit instead of previous 1-bit.

The sequence of issuing DREAD instruction is: CS# goes low → send DREAD instruction → 3-byte address on SI → 8-bit dummy cycle → data out interleave on SIO1 & SIO0 → to end DREAD operation, drive CS# high at any time during data out.

While Program/Erase/Write Status Register cycle is in progress, DREAD instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

Figure 22. Dual Read Mode Sequence (Command 3Bh) (SPI mode only)



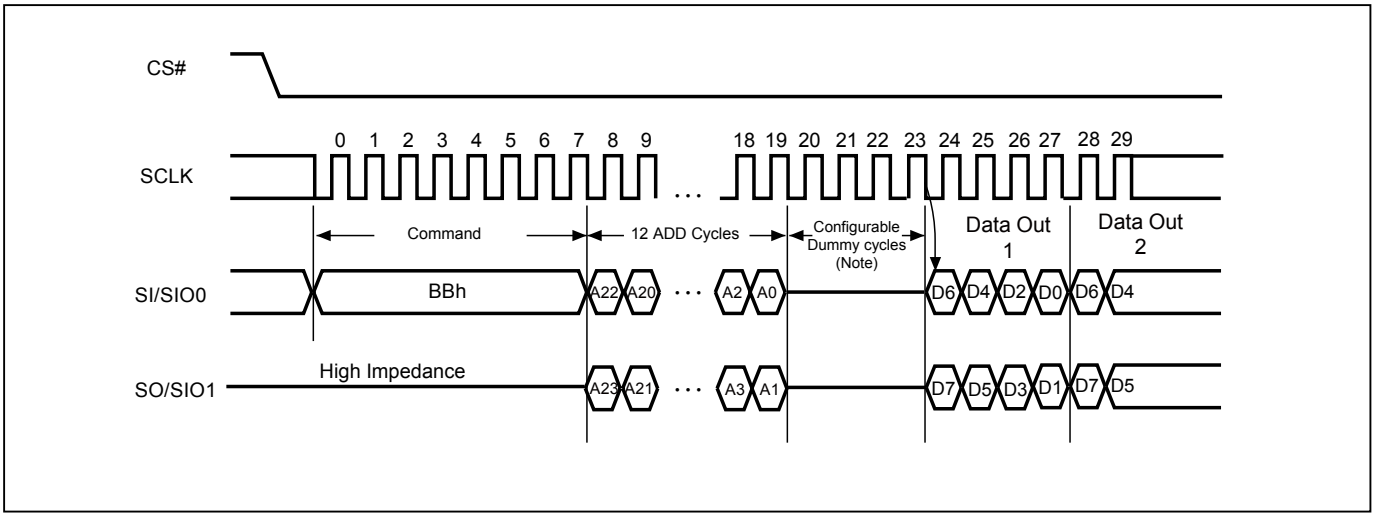
10-11. 2 x I/O Read Mode (2READ)

The 2READ instruction enables Double Transfer Rate of the Serial NOR Flash in read mode. The address is latched on rising edge of SCLK, and data of every two bits (interleave on 2 I/O pins) shift out on the falling edge of SCLK at a maximum frequency fT. The first address byte can be at any location. The address is automatically increased to the next higher address after each byte data is shifted out, so the whole memory can be read out at a single 2READ instruction. The address counter rolls over to 0 when the highest address has been reached. Once writing 2READ instruction, the following address/dummy/data out will perform as 2-bit instead of previous 1-bit.

The sequence of issuing 2READ instruction is: CS# goes low→ send 2READ instruction→ 24-bit address interleave on SIO1 & SIO0→ 4 dummy cycles(default) on SIO1 & SIO0→ data out interleave on SIO1 & SIO0→ to end 2READ operation, drive CS# high at any time during data out.

While Program/Erase/Write Status Register cycle is in progress, 2READ instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

Figure 23. 2 x I/O Read Mode Sequence (Command BBh) (SPI mode only)



Note: The Configurable Dummy Cycle is set by Configuration Register Bit. Please refer to *"Table 8. Dummy Cycles and Frequency Table (MHz)"*.

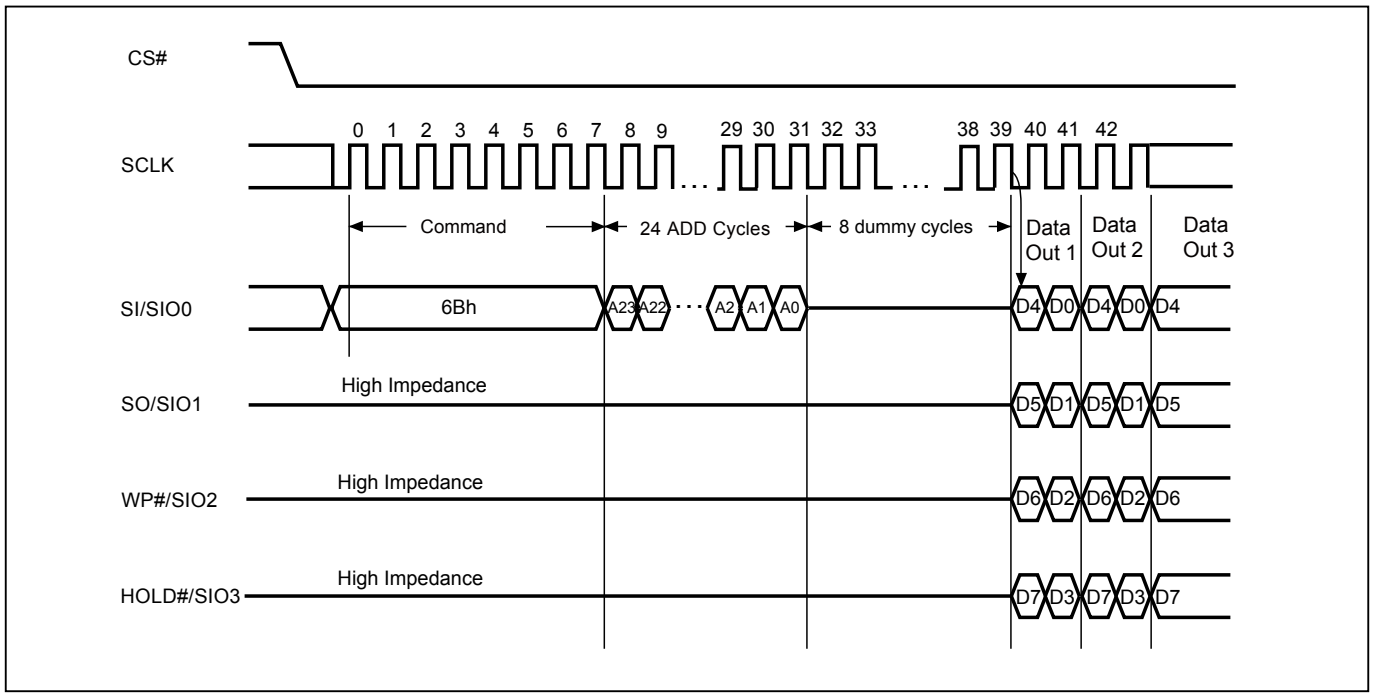
10-12. Quad Read Mode (QREAD)

The QREAD instruction enables quad throughput of the Serial NOR Flash in read mode. A Quad Enable (QE) bit of status Register must be set to "1" before sending the QREAD instruction. The address is latched on rising edge of SCLK, and data of every four bits (interleave on 4 I/O pins) shift out on the falling edge of SCLK at a maximum frequency fQ. The first address byte can be at any location. The address is automatically increased to the next higher address after each byte data is shifted out, so the whole memory can be read out at a single QREAD instruction. The address counter rolls over to 0 when the highest address has been reached. Once writing QREAD instruction, the following data out will perform as 4-bit instead of previous 1-bit.

The sequence of issuing QREAD instruction is: CS# goes low→ send QREAD instruction → 3-byte address on SI → 8-bit dummy cycle → data out interleave on SIO3, SIO2, SIO1 & SIO0→ to end QREAD operation, drive CS# high at any time during data out.

While Program/Erase/Write Status Register cycle is in progress, QREAD instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

Figure 24. Quad Read Mode Sequence (Command 6Bh) (SPI mode only)



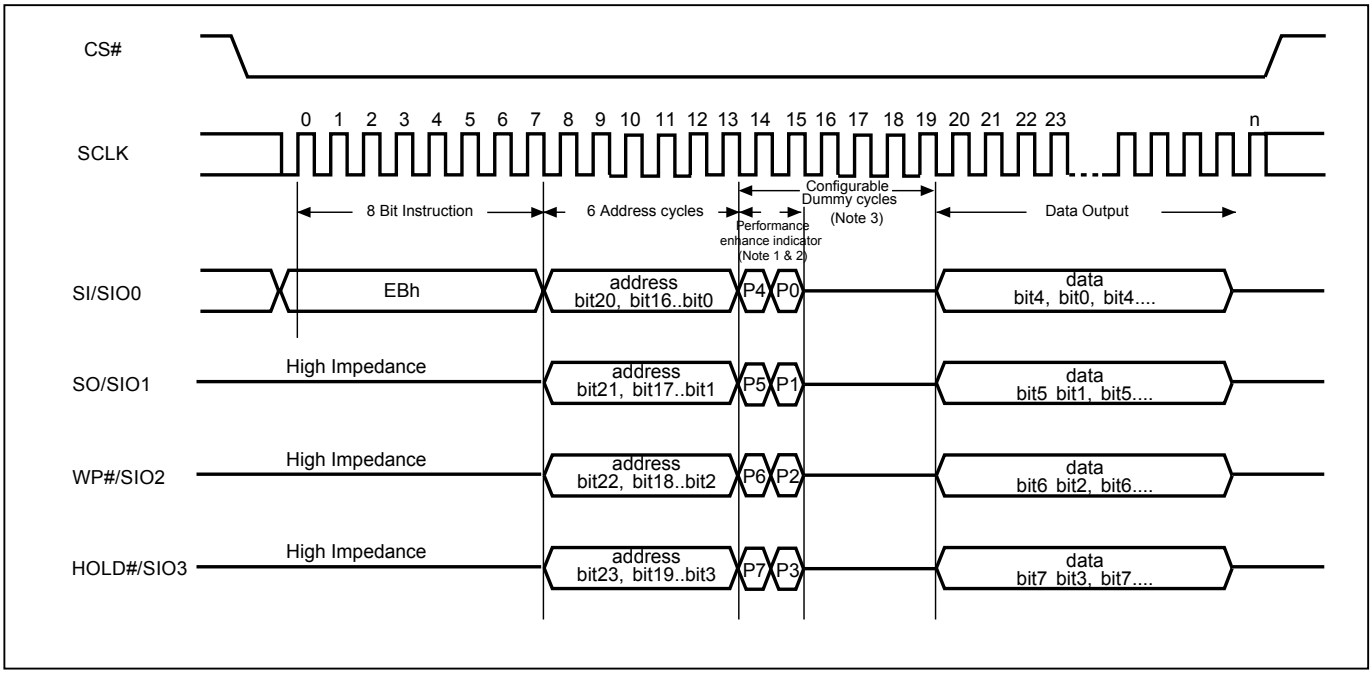
10-13. 4 x I/O Read Mode (4READ)

The 4READ instruction enables quad throughput of the Serial NOR Flash in read mode. A Quad Enable (QE) bit of status Register must be set to "1" before sending the 4READ instruction. The address is latched on rising edge of SCLK, and data of every four bits (interleave on 4 I/O pins) shift out on the falling edge of SCLK at a maximum frequency fQ. The first address byte can be at any location. The address is automatically increased to the next higher address after each byte data is shifted out, so the whole memory can be read out at a single 4READ instruction. The address counter rolls over to 0 when the highest address has been reached. Once writing 4READ instruction, the following address/dummy/data out will perform as 4-bit instead of previous 1-bit.

4 x I/O Read on SPI Mode (4READ) The sequence of issuing 4READ instruction is: CS# goes low→ send 4READ instruction→ 3-byte address interleave on SIO3, SIO2, SIO1 & SIO0→ 2+4 dummy cycles (Default) →data out interleave on SIO3, SIO2, SIO1 & SIO0→ to end 4READ operation, drive CS# high at any time during data out.

4 x I/O Read on QPI Mode (4READ) The 4READ instruction also support on QPI command mode. The sequence of issuing 4READ instruction QPI mode is: CS# goes low→ send 4READ instruction→ 3-byte address interleave on SIO3, SIO2, SIO1 & SIO0→ 2+4 dummy cycles (Default) →data out interleave on SIO3, SIO2, SIO1 & SIO0→ to end 4READ operation, drive CS# high at any time during data out.

Figure 25. 4 x I/O Read Mode Sequence (Command EBh) (SPI Mode)



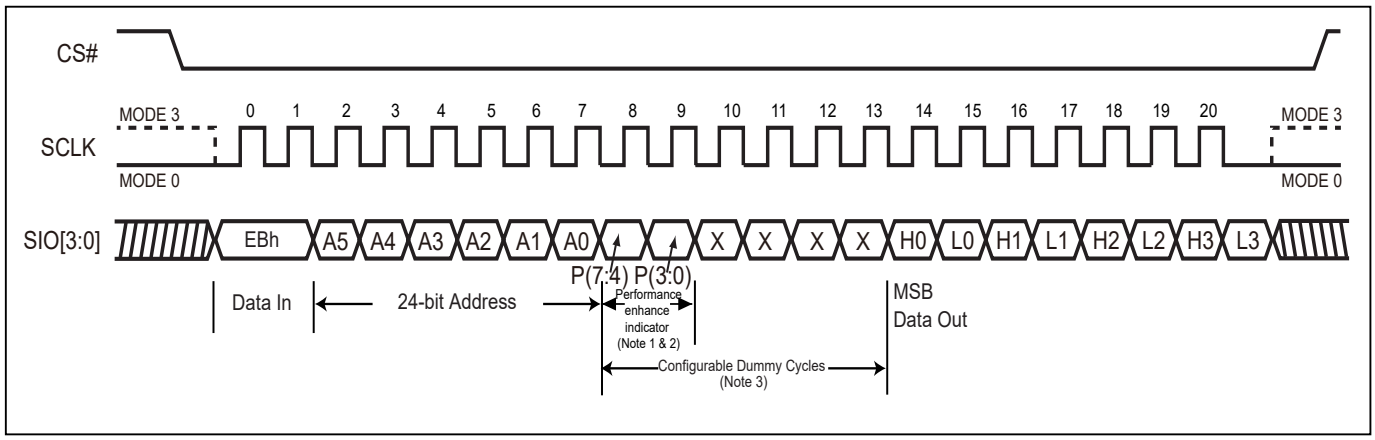
Notes:
1. Hi-impedance is inhibited for the two clock cycles.
2. P7≠P3, P6≠P2, P5≠P1 & P4≠P0 (Toggling) will result in entering the performance enhance mode.
3. The Configurable Dummy Cycle is set by Configuration Register Bit. Please refer to *"Table 8. Dummy Cycles and Frequency Table (MHz)"*.

Another sequence of issuing 4READ instruction especially useful in random access is: CS# goes low→send 4READ instruction→3-bytes address interleave on SIO3, SIO2, SIO1 & SIO0→performance enhance toggling bit P[7:0]→4 dummy cycles →data out until CS# goes high → CS# goes low (The following 4READ instruction is not allowed, hence 8 cycles of 4READ can be saved comparing to normal 4READ mode) → 24-bit random access address (Please refer to *"Figure 27. 4 x I/O Read Performance Enhance Mode Sequence (Command EBh) (SPI Mode)"*).

In the performance-enhancing mode (Notes of *"Figure 27. 4 x I/O Read Performance Enhance Mode Sequence (Command EBh) (SPI Mode)"*), P[7:4] must be toggling with P[3:0]; likewise P[7:0]=A5h, 5Ah, F0h or 0Fh can make this mode continue and reduce the next 4READ instruction. Once P[7:4] is no longer toggling with P[3:0]; likewise P[7:0]=FFh, 00h, AAh or 55h. These commands will reset the performance enhance mode. And afterwards CS# is raised and then lowered, the system then will return to normal operation.

While Program/Erase/Write Status Register cycle is in progress, 4READ instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

Figure 26. 4 x I/O Read Mode Sequence (Command EBh) (QPI Mode)



Notes:
1. Hi-impedance is inhibited for the two clock cycles.
2. P7≠P3, P6≠P2, P5≠P1 & P4≠P0 (Toggling) will result in entering the performance enhance mode.
3. Configuration Dummy cycle numbers will be different depending on the bit6 (DC0 & DC1) setting in configuration register.

10-14. Performance Enhance Mode - XIP (execute-in-place)

The device could waive the command cycle bits if the two cycle bits after address cycle toggles. (Please note *"Figure 27. 4 x I/O Read Performance Enhance Mode Sequence (Command EBh) (SPI Mode)" & "Figure 21. Read at Higher Speed (FAST_READ) Sequence (Command 0Bh) (QPI Mode)"*)

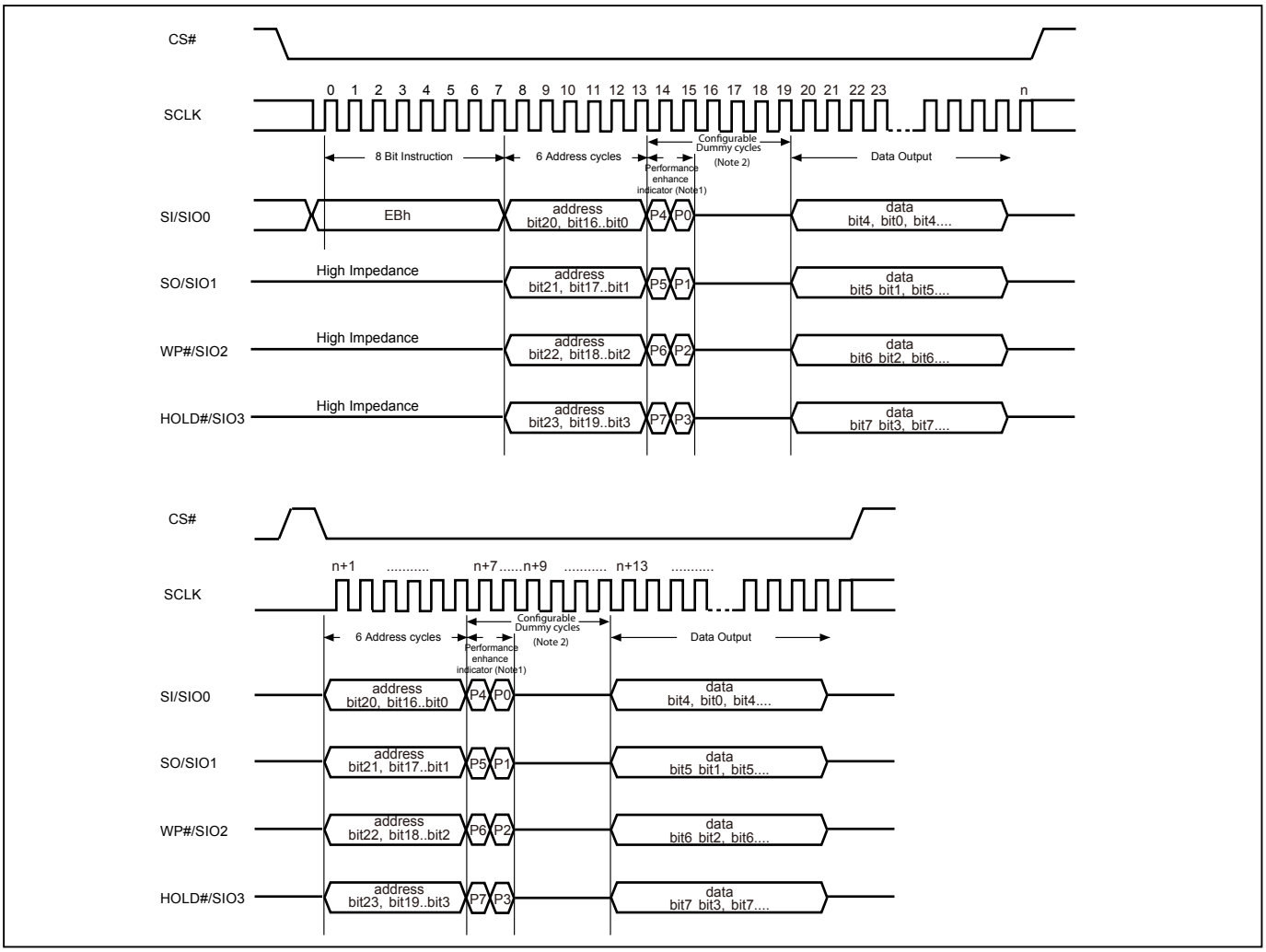
Performance enhance mode is supported in both SPI and QPI mode.

Performance enhance mode is supported for 4READ(SPI/QPI) mode and FAST_READ(QPI) mode.
"EBh(SPI/QPI) mode" and "0Bh(QPI) mode" commands support enhance mode.

After entering enhance mode, following CS# go high, the device will stay in the read mode and treat CS# go low of the first clock as address instead of command cycle.

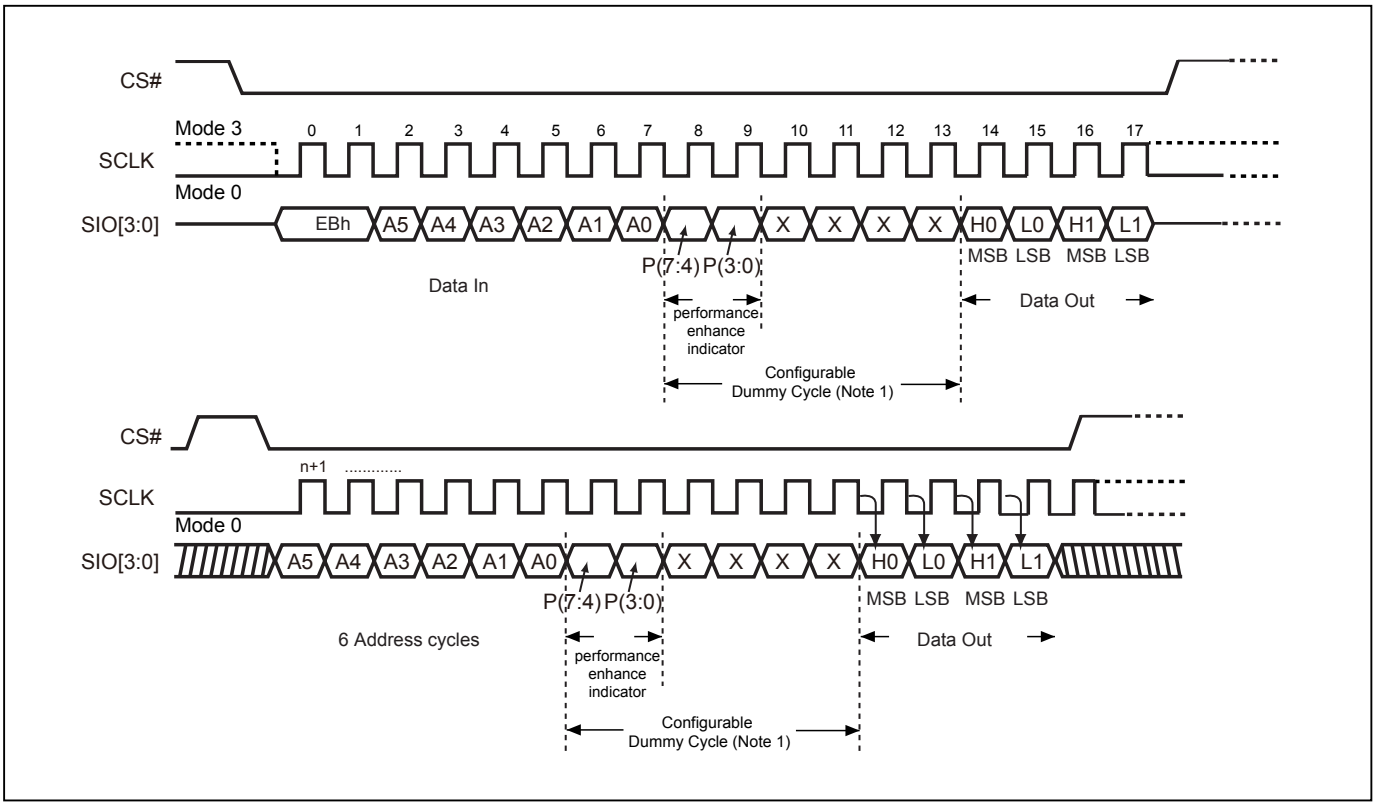
To exit enhance mode, a new fast read command whose first two dummy cycles is not toggle then exit. Or issue "FFh" data cycles to exit enhance mode.

Figure 27. 4 x I/O Read Performance Enhance Mode Sequence (Command EBh) (SPI Mode)



Notes:
1. Performance enhance mode, if P7≠P3 & P6≠P2 & P5≠P1 & P4≠P0 (Toggling), ex: A5, 5A, 0F, if not using performance enhance recommend to keep 1 or 0 in performance enhance indicator.
   Reset the performance enhance mode, if P7=P3 or P6=P2 or P5=P1 or P4=P0, ex: AA, 00, FF.
2. The Configurable Dummy Cycle is set by Configuration Register Bit. Please refer to *"Table 8. Dummy Cycles and Frequency Table (MHz)"*.

Figure 28. 4 x I/O Read performance enhance Mode Sequence (Command EBh) (QPI Mode)



Notes:
1. Configuration Dummy cycle numbers will be different depending on the bit6 & bit 7 (DC0 & DC1) setting in configuration register.
2. Reset the performance enhance mode, if P7=P3 or P6=P2 or P5=P1 or P4=P0, ex: AA, 00, FF.

10-15. Burst Read

The Burst Read feature allows applications to fill a cache line with a fixed length of data without using multiple read commands. Burst Read is disabled by default at power-up or reset. Burst Read is enabled by setting the Burst Length. When the Burst Length is set, reads will wrap on the selected boundary (8/16/32/64-bytes) containing the initial target address. For example if an 8-byte Wrap Depth is selected, reads will wrap on the 8-byte-page-aligned boundary containing the initial read address.

To set the Burst Length, drive CS# low → send SET BURST LENGTH instruction code (C0h or 77h) → send WRAP CODE → drive CS# high. Refer to the table below for valid 8-bit Wrap Codes and their corresponding Wrap Depth.

Data	Wrap Around	Wrap Depth
00h	Yes	8-byte
01h	Yes	16-byte
02h	Yes	32-byte
03h	Yes	64-byte
1xh	No	X

Once Burst Read is enabled, it will remain enabled until the device is power-cycled or reset. The 4READ read command supports the wrap around feature after Burst Read is enabled. To change the wrap depth, resend the Burst Read instruction with the appropriate Wrap Code. To disable Burst Read, send the Burst Read instruction with Wrap Code 1xh. “EBh" supports wrap around feature after wrap around is enabled. Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

Figure 29. Burst Read (Command C0h or 77h) (SPI Mode)

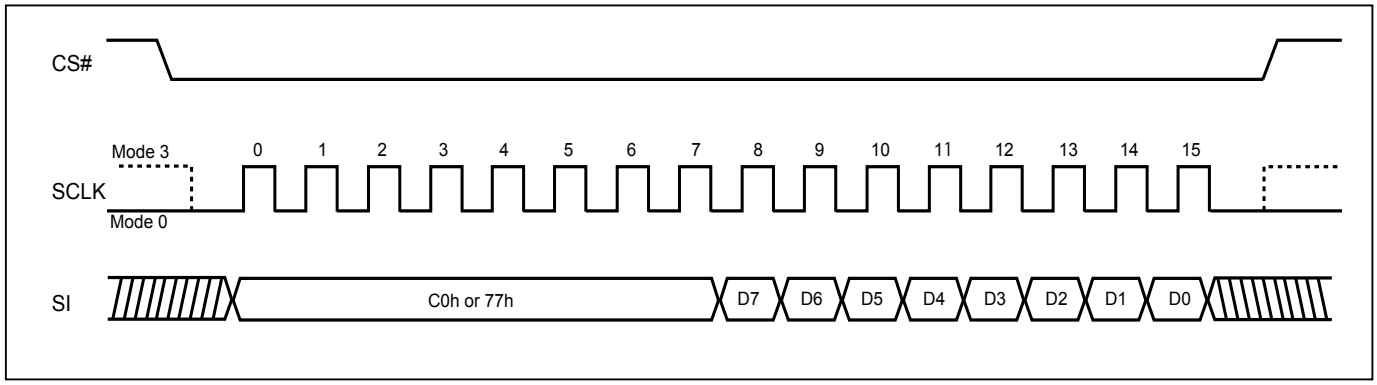
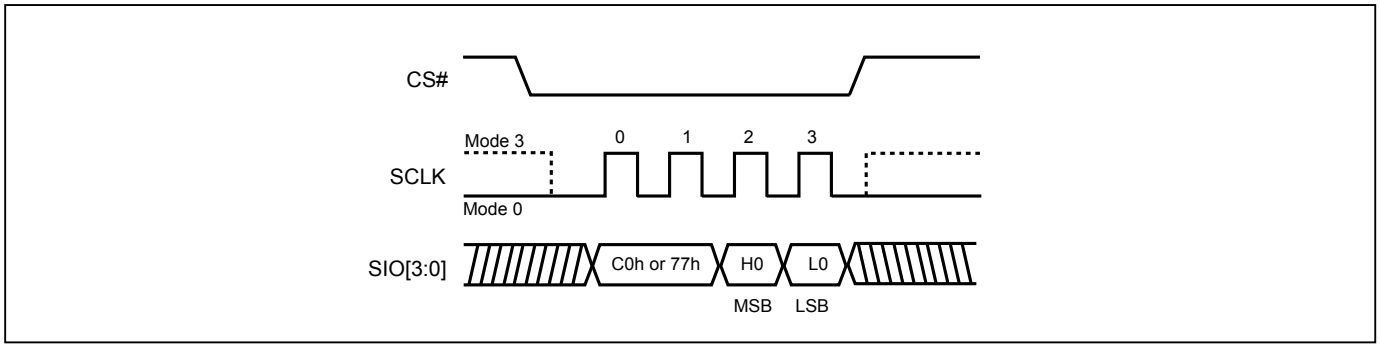


Figure 30. Burst Read (Command C0h or 77h) (QPI Mode)



Note: MSB=Most Significant Bit
LSB=Least Significant Bit

10-16. Sector Erase (SE)

The Sector Erase (SE) instruction is for erasing the data of the chosen sector to be "1". The instruction is used for any 4K-byte sector. A Write Enable (WREN) instruction must be executed to set the Write Enable Latch (WEL) bit before sending the Sector Erase (SE). Any address of the sector (Please refer to *"Table 3. Memory Organization"*) is a valid address for Sector Erase (SE) instruction. The CS# must go high exactly at the byte boundary (the least significant bit of the address has been latched-in); otherwise, the instruction will be rejected and not executed.

The sequence of issuing SE instruction is: CS# goes low → send SE instruction code→ 3-byte address on SI →CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

The self-timed Sector Erase Cycle time (tSE) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked while the Sector Erase cycle is in progress. The WIP sets during the tSE timing, and clears when Sector Erase Cycle is completed, and the Write Enable Latch (WEL) bit is cleared. If the sector is protected by BP3-0 bits (WPSEL=0; Block Lock (BP) protection mode) or SPB/DPB (WPSEL=1; Advanced Sector Protection mode), the array data will be protected (no change) and the WEL bit still be reset and the Sector Erase (SE) instruction will not be executed on the block.

Figure 31. Sector Erase (SE) Sequence (Command 20h) (SPI Mode)

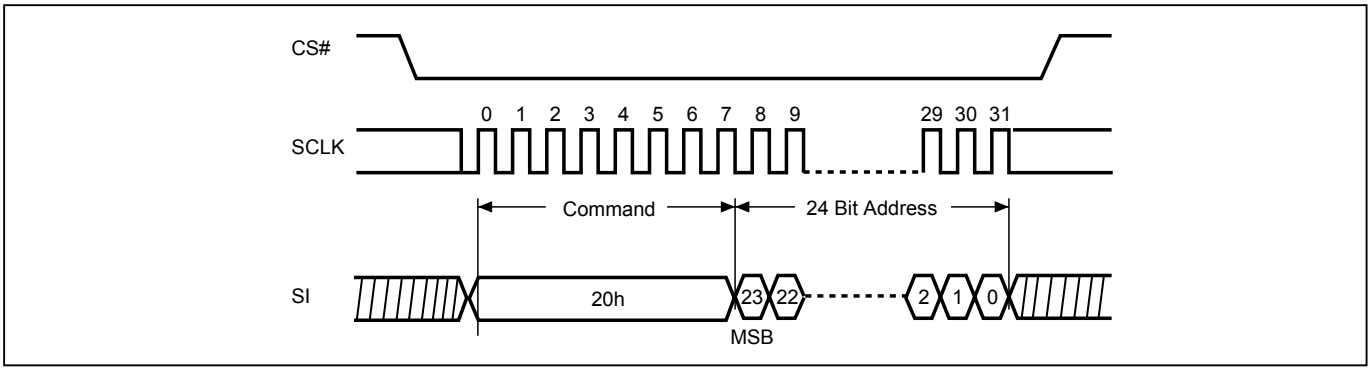
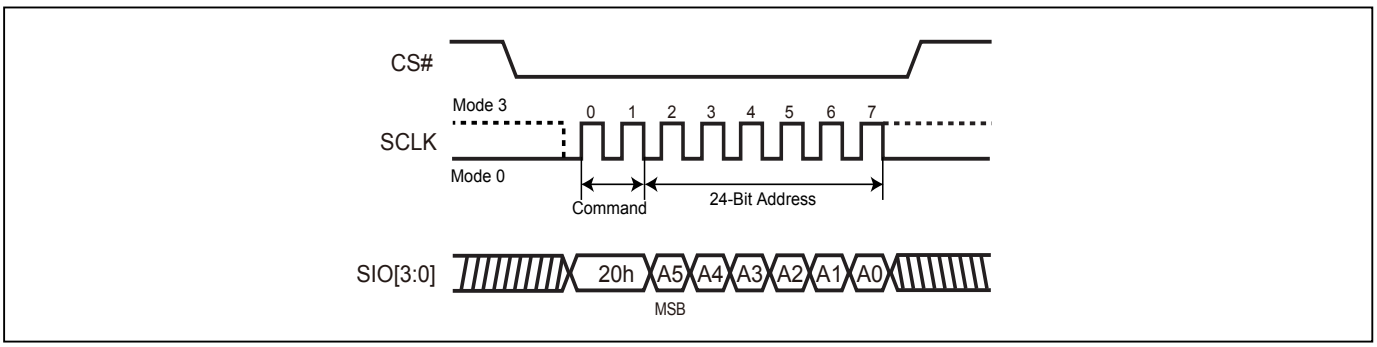


Figure 32. Sector Erase (SE) Sequence (Command 20h) (QPI Mode)



10-17. Block Erase (BE)

The Block Erase (BE) instruction is for erasing the data of the chosen block to be "1". The instruction is used for 64K-byte block erase operation. A Write Enable (WREN) instruction must be executed to set the Write Enable Latch (WEL) bit before sending the Block Erase (BE). Any address of the block (Please refer to *"Table 3. Memory Organization"*) is a valid address for Block Erase (BE) instruction. The CS# must go high exactly at the byte boundary (the least significant bit of address byte has been latched-in); otherwise, the instruction will be rejected and not executed.

The sequence of issuing BE instruction is: CS# goes low → send BE instruction code → 3-byte address on SI → CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

The self-timed Block Erase Cycle time (tBE) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked while the Block Erase cycle is in progress. The WIP sets during the tBE timing, and clears when Block Erase Cycle is completed, and the Write Enable Latch (WEL) bit is cleared. If the Block is protected by BP3-0 bits (WPSEL=0; Block Lock (BP) protection mode) or SPB/DPB (WPSEL=1; Advanced Sector Protection mode), the array data will be protected (no change) and the WEL bit still be reset and the Block Erase (BE) instruction will not be executed on the block.

Figure 33. Block Erase (BE) Sequence (Command D8h) (SPI Mode)

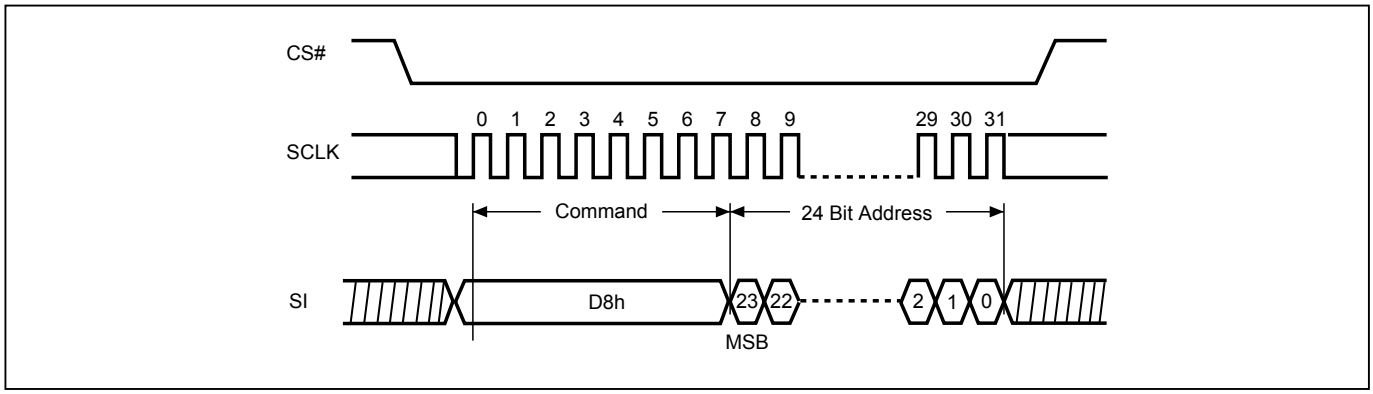
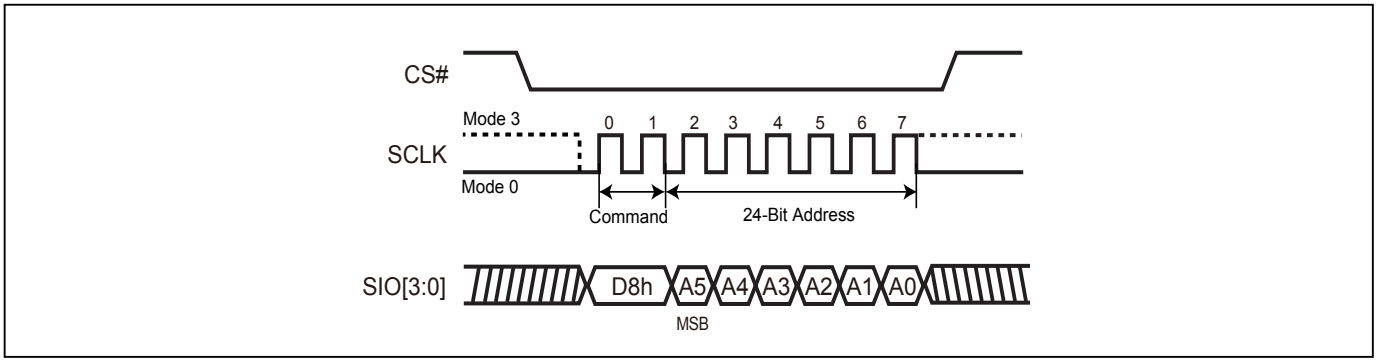


Figure 34. Block Erase (BE) Sequence (Command D8h) (QPI Mode)



10-18. Block Erase (BE32K)

The Block Erase (BE32K) instruction is for erasing the data of the chosen block to be "1". The instruction is used for 32K-byte block erase operation. A Write Enable (WREN) instruction must be executed to set the Write Enable Latch (WEL) bit before sending the Block Erase (BE32K). Any address of the block (Please refer to *"Table 3. Memory Organization"*) is a valid address for Block Erase (BE32K) instruction. The CS# must go high exactly at the byte boundary (the least significant bit of address byte has been latched-in); otherwise, the instruction will be rejected and not executed.

The sequence of issuing BE32K instruction is: CS# goes low → send BE32K instruction code → 3-byte address on SI → CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

The self-timed Block Erase Cycle time (tBE32K) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked while the Block Erase cycle is in progress. The WIP sets during the tBE32K timing, and clears when Block Erase Cycle is completed, and the Write Enable Latch (WEL) bit is cleared. If the Block is protected by BP3-0 bits (WPSEL=0; Block Lock (BP) protection mode) or SPB/DPB (WPSEL=1; Advanced Sector Protection mode), the array data will be protected (no change) and the WEL bit still be reset and the the Block Erase (BE32K) instruction will not be executed on the block.

Figure 35. Block Erase 32KB (BE32K) Sequence (Command 52h) (SPI Mode)

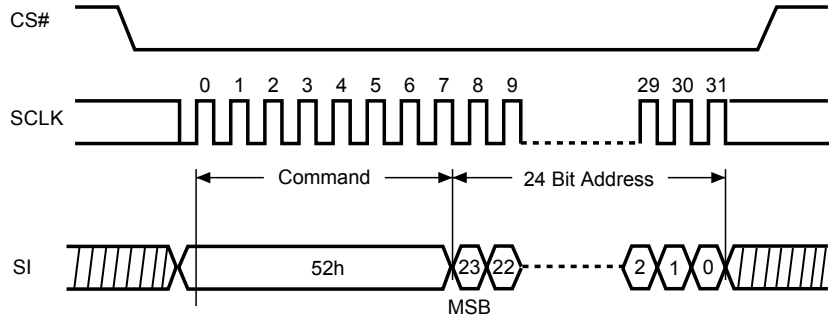
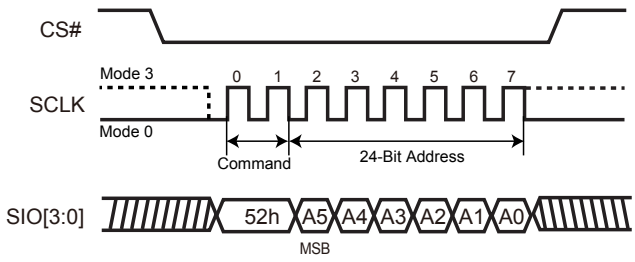


Figure 36. Block Erase 32KB (BE32K) Sequence (Command 52h) (QPI Mode)



10-19. Chip Erase (CE)

The Chip Erase (CE) instruction is for erasing the data of the whole chip to be "1". A Write Enable (WREN) instruction must be executed to set the Write Enable Latch (WEL) bit before sending the Chip Erase (CE). The CS# must go high exactly at the byte boundary; otherwise, the instruction will be rejected and not executed.

The sequence of issuing CE instruction is: CS# goes low → send CE instruction code → CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

The self-timed Chip Erase Cycle time (tCE) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked while the Chip Erase cycle is in progress. The WIP sets during the tCE timing, and clears when Chip Erase Cycle is completed, and the Write Enable Latch (WEL) bit is cleared. If the chip is protected the Chip Erase (CE) instruction will not be executed, but WEL will be reset.

When the chip is under "Block Lock (BP) protection mode" (WPSEL=0): The Chip Erase(CE) instruction will not be executed, if one (or more) sector is protected by BP3-BP0 bits. It will be only executed when BP3-BP0 all set to "0".

When the chip is under "Advanced Sector Protection mode" (WPSEL=1): The Chip Erase (CE) instruction will be executed on unprotected block. The protected Block will be skipped. If one (or more) 4K byte sector was protected in top or bottom 64K byte block, the protected block will also skip the chip erase command.

Figure 37. Chip Erase (CE) Sequence (Command 60h or C7h) (SPI Mode)

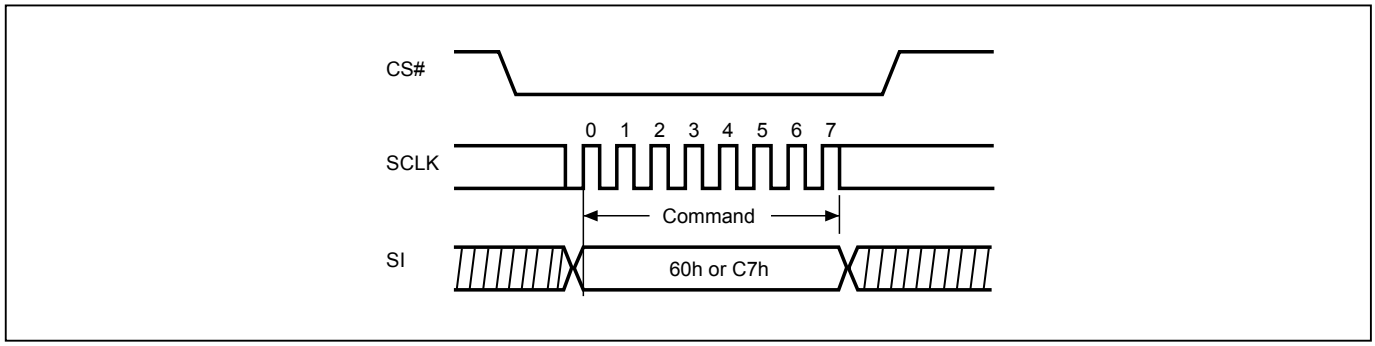
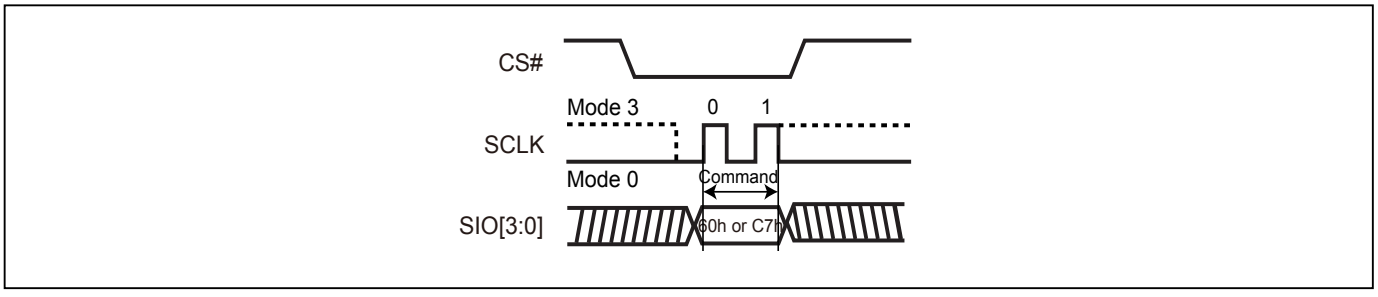


Figure 38. Chip Erase (CE) Sequence (Command 60h or C7h) (QPI Mode)



10-20. Page Program (PP)

The Page Program (PP) instruction is for programming memory bits to "0". One to 256 bytes can be sent to the device to be programmed. A Write Enable (WREN) instruction must be executed to set the Write Enable Latch (WEL) bit before sending the Page Program (PP). If more than 256 data bytes are sent to the device, only the last 256 data bytes will be accepted and the previous data bytes will be disregarded. The Page Program instruction requires that all the data bytes fall within the same 256-byte page. The low order address byte A[7:0] specifies the starting address within the selected page. Bytes that will cross a page boundary will wrap to the beginning of the selected page. The device can accept (256 minus A[7:0]) data bytes without wrapping. If 256 data bytes are going to be programmed, A[7:0] should be set to 0.

The sequence of issuing PP instruction is: CS# goes low→ send PP instruction code→ 3-byte address on SI→ at least 1-byte on data on SI→ CS# goes high.

The CS# must be kept to low during the whole Page Program cycle; The CS# must go high exactly at the byte boundary (the latest eighth bit of data being latched in), otherwise, the instruction will be rejected and will not be executed.

The self-timed Page Program Cycle time (tPP) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked while the Page Program cycle is in progress. The WIP sets during the tPP timing, and clears when Page Program Cycle is completed, and the Write Enable Latch (WEL) bit is cleared. If the Block is protected by BP bits (WPSEL=0; Block Lock (BP) protection mode) or SPB/DPB (WPSEL=1; Advanced Sector Protection mode) the Page Program (PP) instruction will not be executed.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can accept by this instruction. The SIO[3:1] are don't care during SPI mode.

Figure 39. Page Program (PP) Sequence (Command 02h) (SPI Mode)

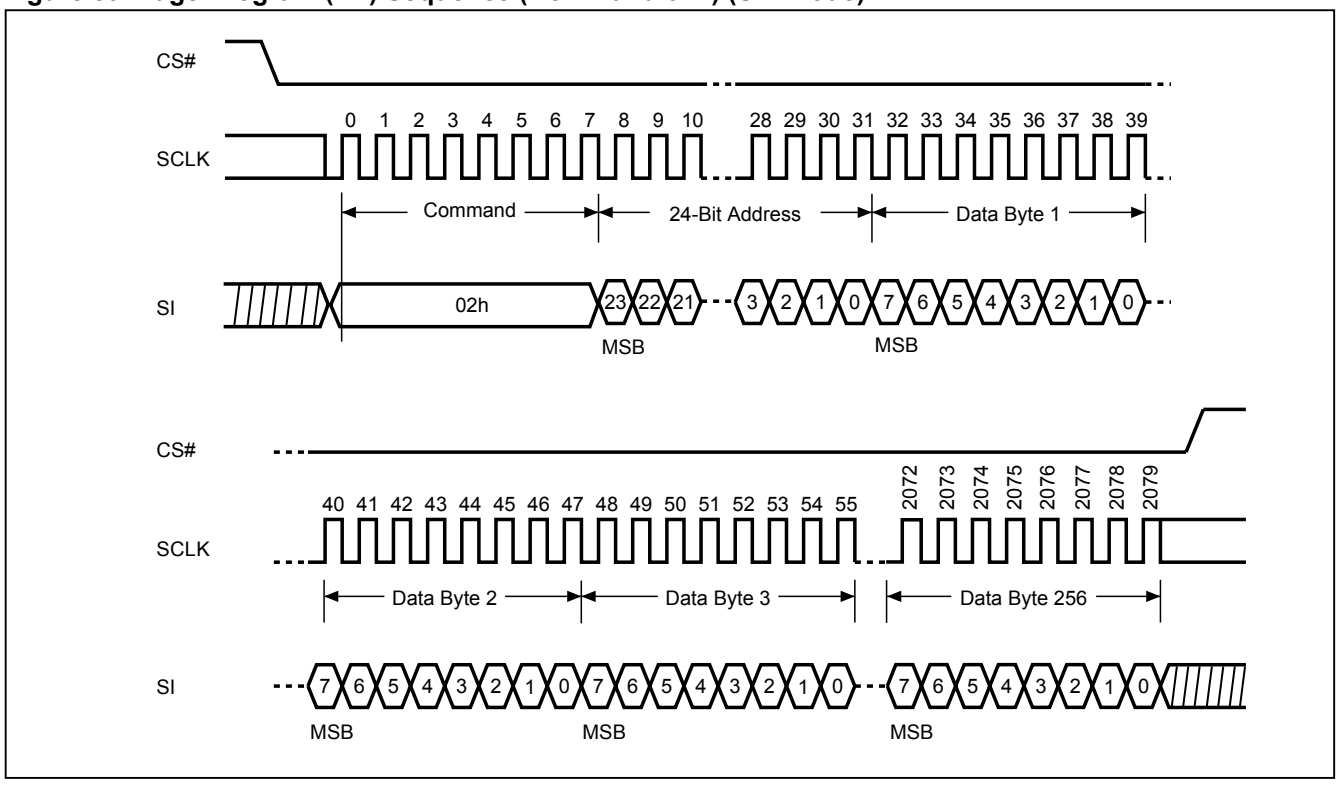
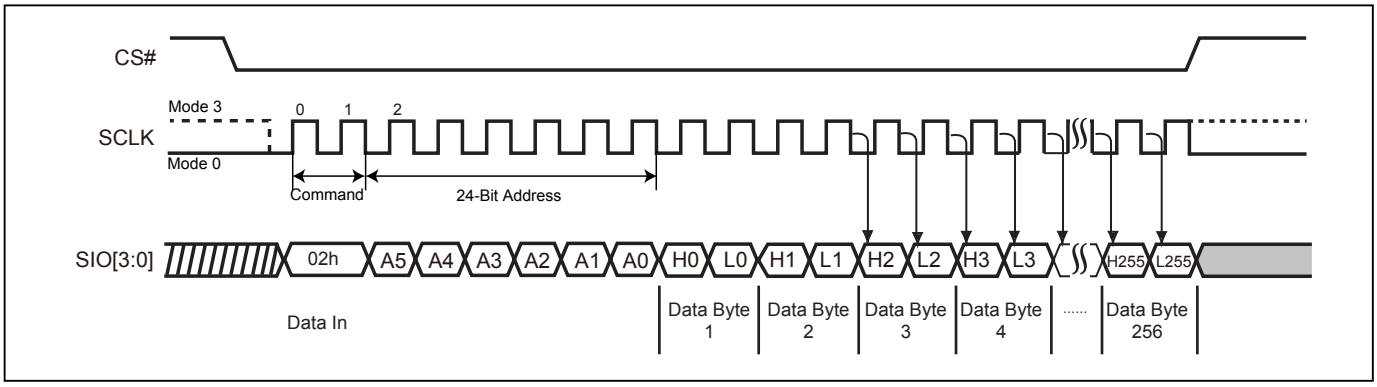


Figure 40. Page Program (PP) Sequence (Command 02h) (QPI Mode)



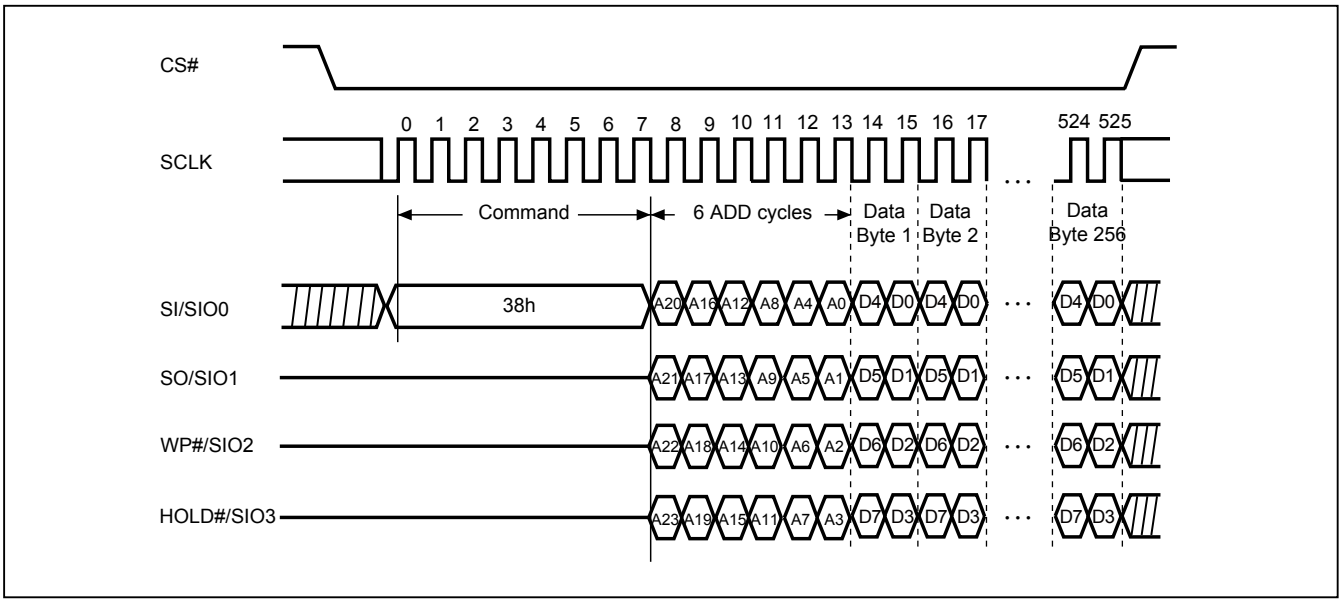
10-21. 4 x I/O Page Program (4PP)

The Quad Page Program (4PP) instruction is for programming the memory to be "0". A Write Enable (WREN) instruction must be executed to set the Write Enable Latch (WEL) bit and Quad Enable (QE) bit must be set to "1" before sending the Quad Page Program (4PP). The Quad Page Programming takes four pins: SIO0, SIO1, SIO2, and SIO3, which can raise programmer performance and the effectiveness of application of lower clock less than f4PP. For system with faster clock, the Quad page program cannot provide more performance, because the required internal page program time is far more than the time data flows in. Therefore, we suggest that while executing this command (especially during sending data), user can slow the clock speed down to f4PP below. The other function descriptions are as same as standard page program.

The sequence of issuing 4PP instruction is: CS# goes low→ send 4PP instruction code→ 3-byte address on SIO[3:0]→ at least 1-byte on data on SIO[3:0]→ CS# goes high.

If the page is protected by BP bits (WPSEL=0; Block Lock (BP) protection mode) or SPB/DPB (WPSEL=1; Advanced Sector Protection mode), the Quad Page Program (4PP) instruction will not be executed.

Figure 41. 4 x I/O Page Program (4PP) Sequence (Command 38h) (SPI mode only)



10-22. Factory Mode Erase/Program Operations

10-22-1. Factory Mode Sector Erase / 32KB Block Erase / 64KB Block Erase/ Chip Erase

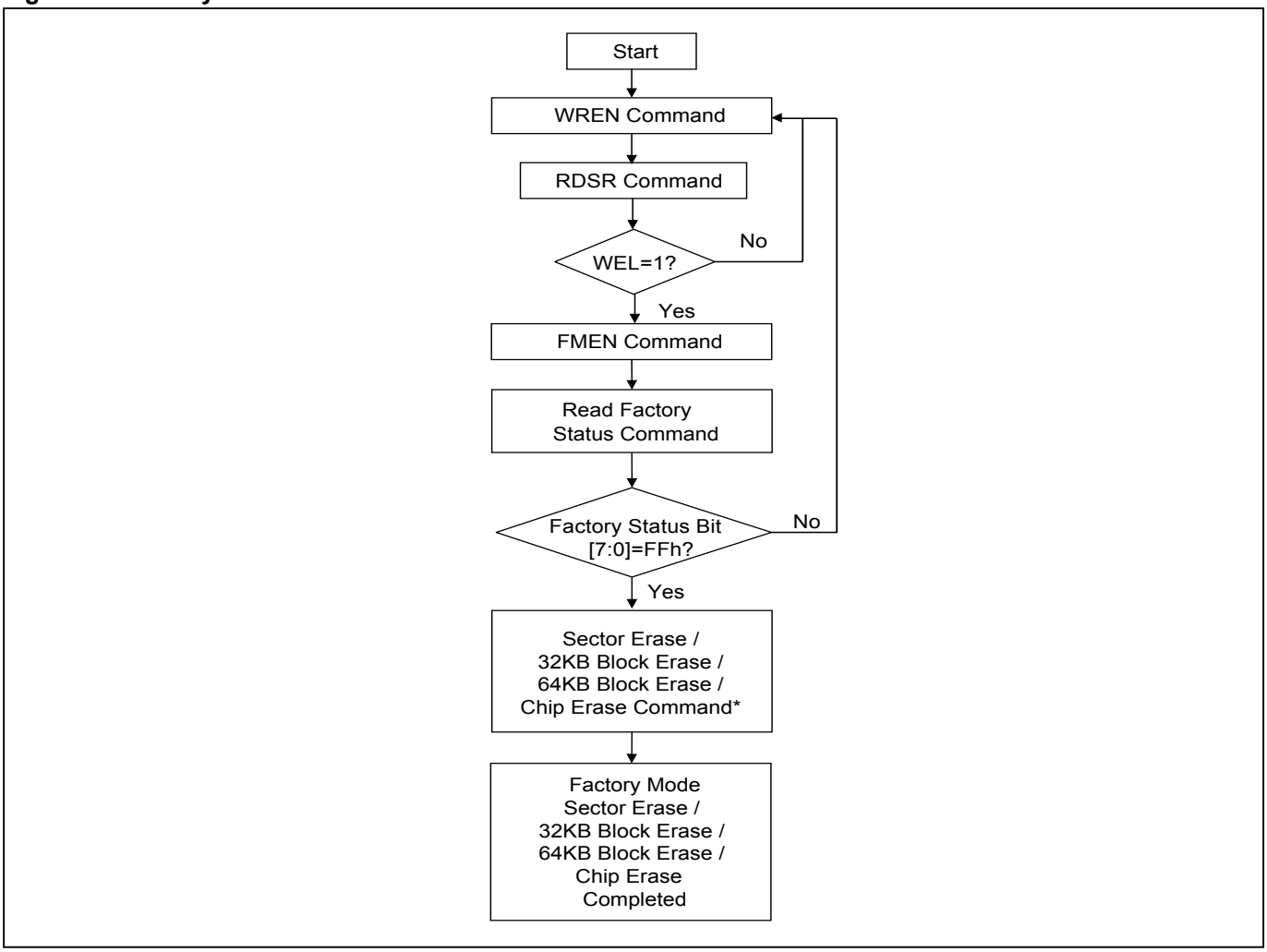
To apply Factory Mode Sector Erase / 32KB Block Erase / 64KB Block Erase / Chip Erase, customers need to follow the operation below:

Factory Mode Enable (FMEN): The Factory Mode Enable (FMEN) instruction is for enhancing Sector Erase / 32KB Block Erase / 64KB Block Erase / Chip Erase performance, which increase factory production throughput. The FMEN instruction will need to be combined with the SE / BE32K / BE / CE instruction when user intends to change the device content.

A valid factory mode operation need to include three sequences: WREN instruction → FMEN instruction→ SE / BE32K / BE / CE instruction. The sequence of issuing FMEN instruction is: CS# goes low→send FMEN instruction code→ CS# goes high. Please note that Suspend command is not acceptable during factory mode.

The FMEN will be reset in following situations: Power-up, SE / BE32K / BE / CE command completion, and Softreset command completion.

Figure 42. Factory Mode Erase Flow



Note: * Please refer to *"Figure 46. Program/Erase Flow(1) with read array data"* and *"Figure 47. Program/Erase Flow(2) without read array data"*.

10-22-1. Factory Mode Page Program

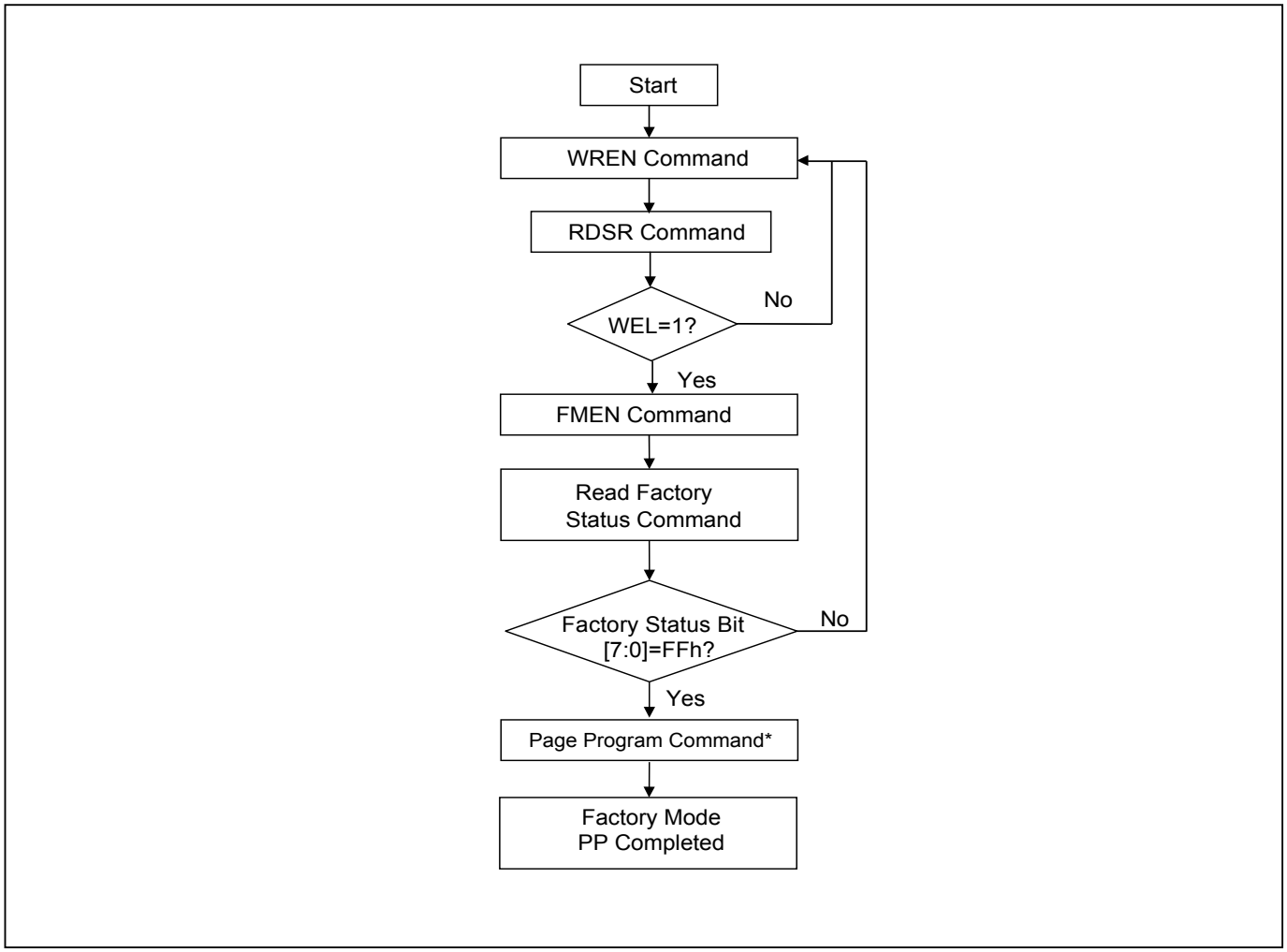
To apply Factory Mode Page Program, customers need to follow the operation below:

Factory Mode Enable (FMEN): The Factory Mode Enable (FMEN) instruction is for enhancing Page Program performance, which increase factory production throughput. The FMEN instruction will need to be combined with the PP instruction when user intends to change the device content.

A valid factory mode operation need to include three sequences: WREN instruction → FMEN instruction→ PP instruction. The sequence of issuing FMEN instruction is: CS# goes low→send FMEN instruction code→ CS# goes high. Please note that Suspend command is not acceptable during factory mode.

The FMEN will be reset in following situations: Power-up, Reset# pin driven low, PP command completion, and Softreset command completion.

Figure 43. Factory Mode Page Program Flow



Note: * Please refer to *"Figure 46. Program/Erase Flow(1) with read array data"* and *"Figure 47. Program/Erase Flow(2) without read array data"*.

10-23. Read Factory Mode Status

- Read Factory Mode Status Register command is used to read chip status and check it is at factory mode or not.
- Like RDSR (Read Status Register, 05h), Factory Mode status will be outputted to the SO pin following this Read Factory Mode Status Register command (RDFMSR command, 44h). Please note that Read Factory Mode Status Register command is only available in read mode and it is not workable in program/erase process.
- Factory Mode status bit [7:0] shows Factory mode indicators. FMEN command can set them to 1, and the bits will automatically be reset after the end of erase or program operation.

Bit	Description	Bit Status	Default
7 to 0	FACTORY_MODE	00h = Not in Factory Mode FFh = In Factory Mode	00h

Figure 44. Read Factory Mode Status Register (SPI Mode)

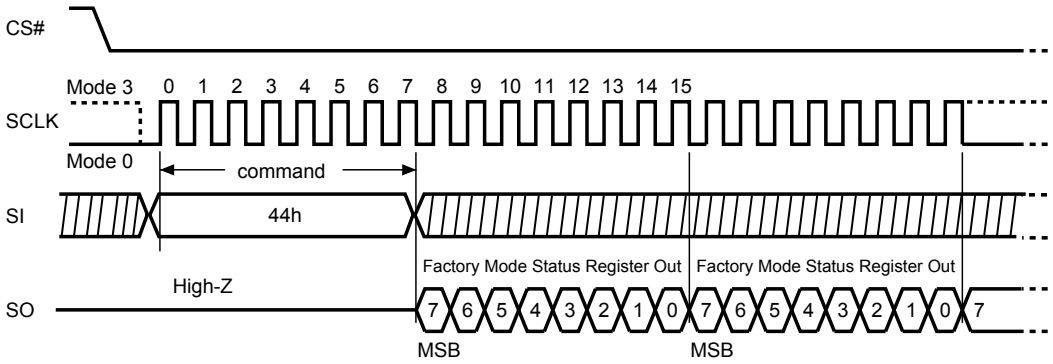
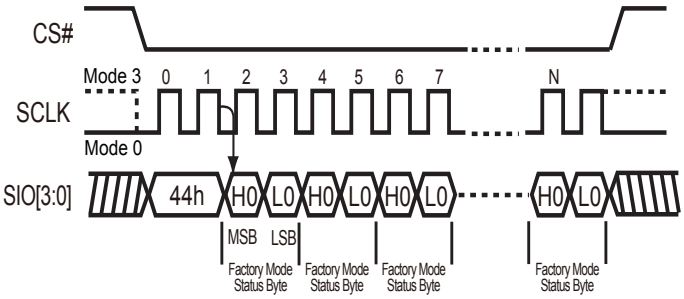


Figure 45. Read Factory Mode Status Register (QPI Mode)



The Program/Erase function instruction function flow is as follows:

Figure 46. Program/Erase Flow(1) with read array data

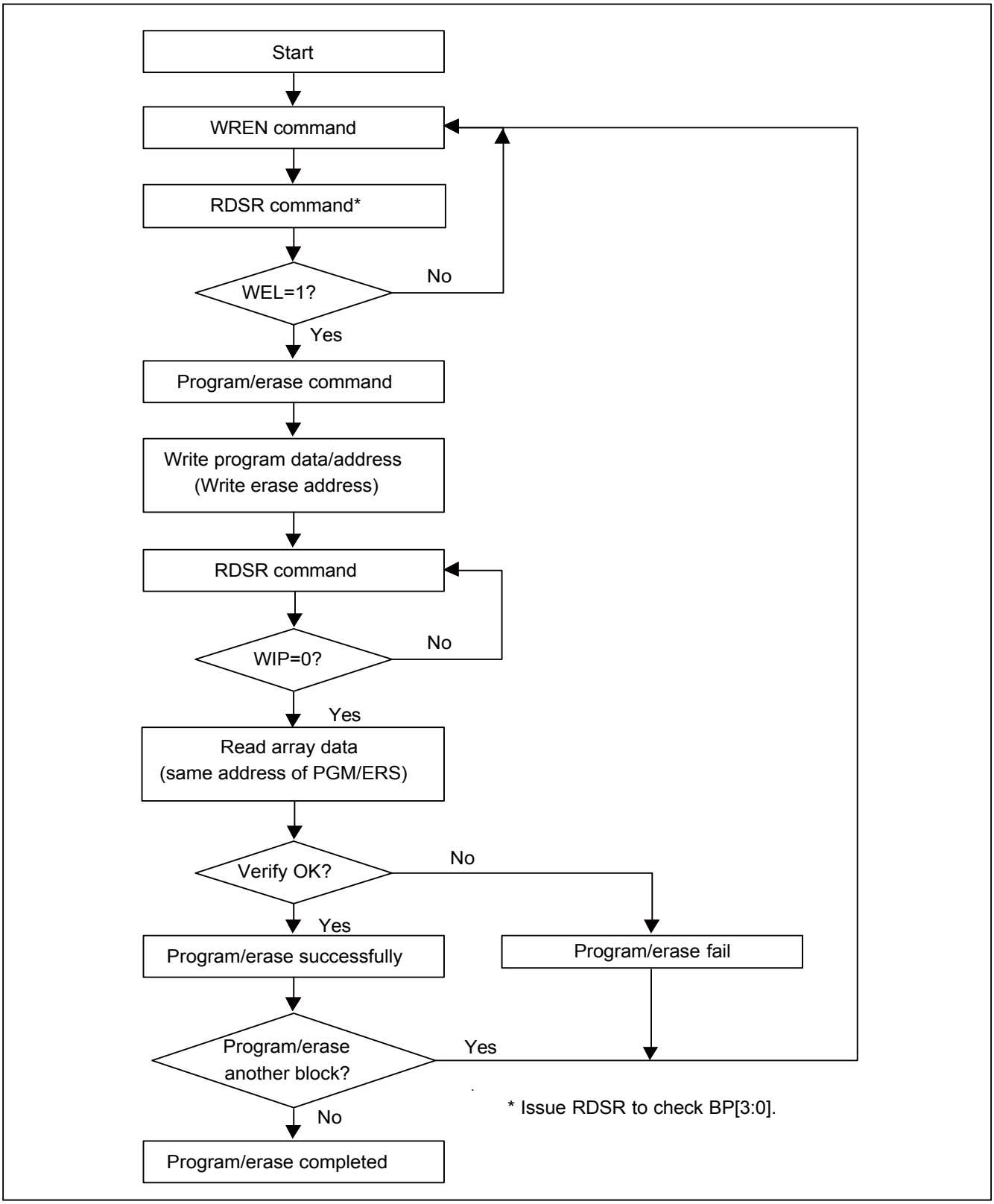
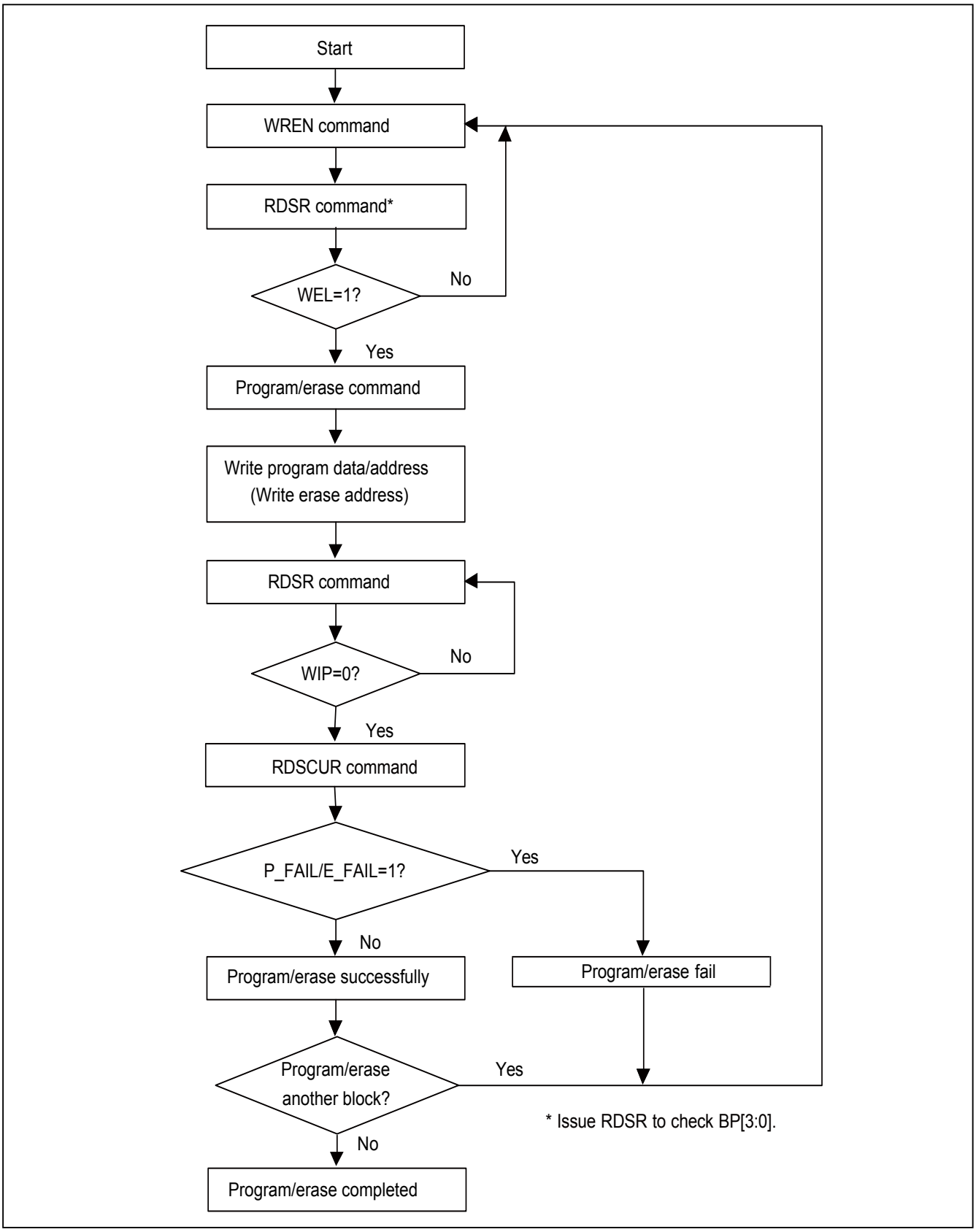


Figure 47. Program/Erase Flow(2) without read array data



10-24. Deep Power-down (DP)

The Deep Power-down (DP) instruction places the device into a minimum power consumption state, Deep Power-down mode, in which the quiescent current is reduced from ISB1 to ISB2.

The sequence of issuing DP instruction: CS# goes low→ send DP instruction code→ CS# goes high. The CS# must go high at the byte boundary (after exactly eighth bits of the instruction code have been latched-in); otherwise the instruction will not be executed. Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. SIO[3:1] are "don't care".

After CS# goes high there is a delay of tDP before the device transitions from Stand-by mode to Deep Powerdown mode and before the current reduces from ISB1 to ISB2. Once in Deep Power-down mode, all instructions will be ignored except Release from Deep Power-down (RDP).

The device exits Deep Power-down mode and returns to Stand-by mode if it receives a Release from Deep Power-down (RDP) instruction, power-cycle, or reset. Please refer to *"Figure 52. Release from Deep Power-down (RDP) Sequence (Command ABh) (SPI Mode)"* and *"Figure 53. Release from Deep Power-down (RDP) Sequence (Command ABh) (QPI Mode)"*.

Figure 48. Deep Power-down (DP) Sequence (Command B9h) (SPI Mode)

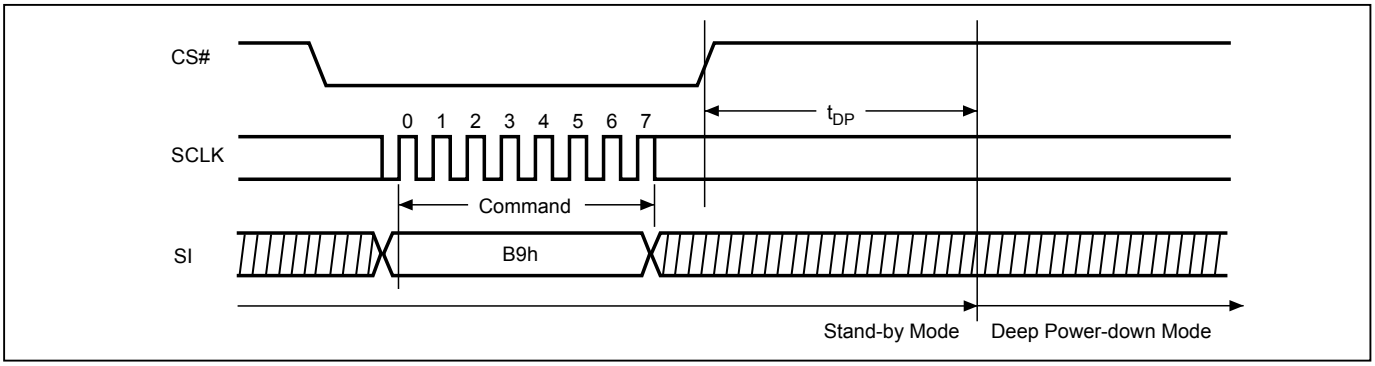
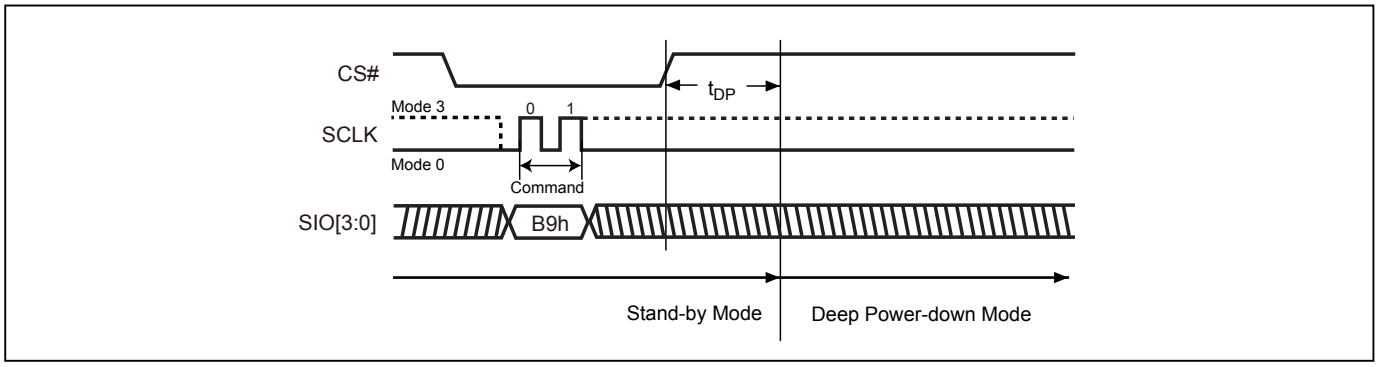


Figure 49. Deep Power-down (DP) Sequence (Command B9h) (QPI Mode)



10-25. Release from Deep Power-down (RDP), Read Electronic Signature (RES)

The Release from Deep Power-down (RDP) instruction is completed by driving Chip Select (CS#) High. When Chip Select (CS#) is driven High, the device is put in the standby Power mode. If the device was not previously in the Deep Power-down mode, the transition to the standby Power mode is immediate. If the device was previously in the Deep Power-down mode, though, the transition to the standby Power mode is delayed by tRES1, and Chip Select (CS#) must remain High for at least tRES1(max), as specified in *"Table 20. AC Characteristics"*. Once in the standby mode, the device waits to be selected, so that it can receive, decode and execute instructions.

RES instruction is for reading out the old style of 8-bit Electronic Signature ID, whose values are shown as *"Table 10. ID Definitions"*. This is not the same as RDID instruction. It is not recommended to use for new design. For new design, please use RDID instruction. The RDP and RES are allowed to execute in Deep power-down mode, except if the device is in progress of program/erase/write cycle; In this case, there is no effect on the current program/erase/write cycle that is in progress.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

The RES instruction ends when CS# goes high, after the ID been read out at least once. The ID outputs repeatedly if continuously send the additional clock cycles on SCLK while CS# is at low. If the device was not previously in Deep Power-down mode, the device transition to standby mode is immediate. If the device was previously in Deep Power-down mode, there's a delay of tRES2 to transit to standby mode, and CS# must remain to high at least tRES2(max). Once in the standby mode, the device waits to be selected, so it can receive, decode, and execute instruction.

The RDP instruction is for releasing from Deep Power-down Mode.

Figure 50. Release from Deep Power-down and Read Electronic Signature (RES) Sequence (Command ABh) (SPI Mode)

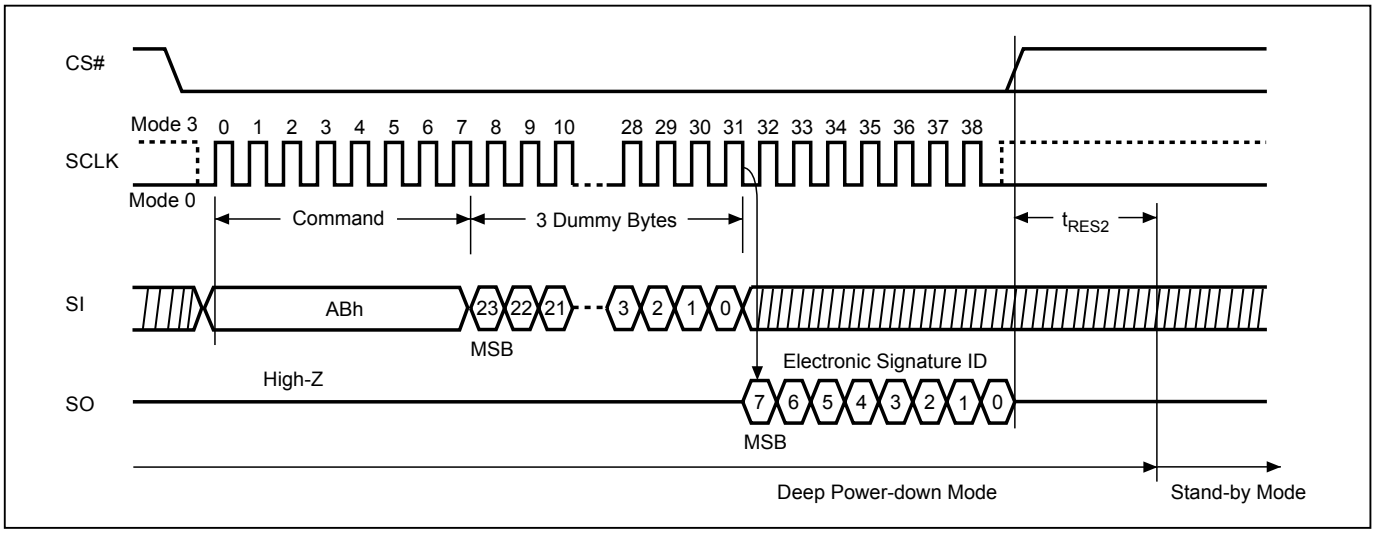


Figure 51. Read Electronic Signature (RES) Sequence (Command ABh) (QPI Mode)

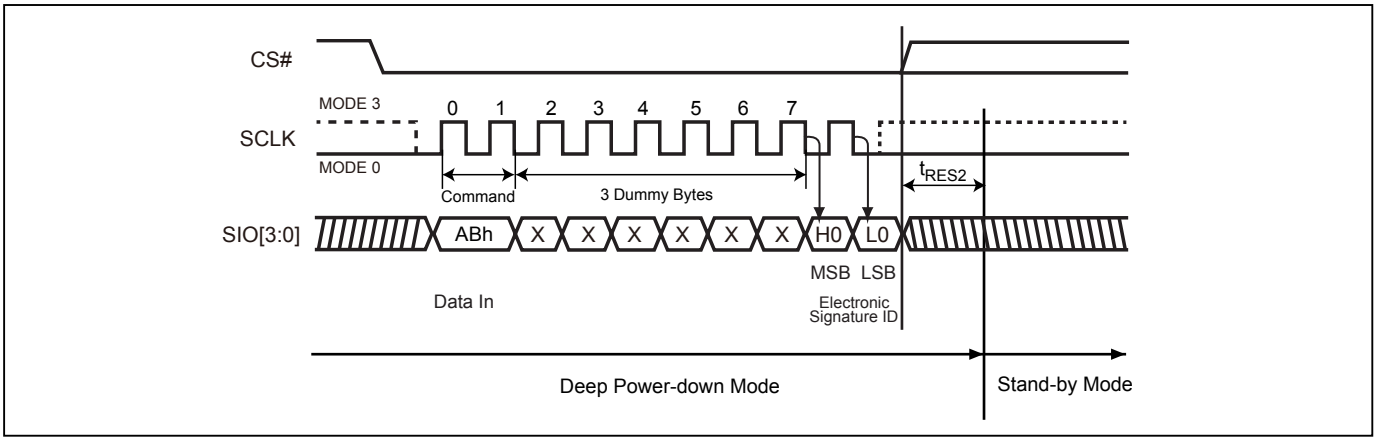


Figure 52. Release from Deep Power-down (RDP) Sequence (Command ABh) (SPI Mode)

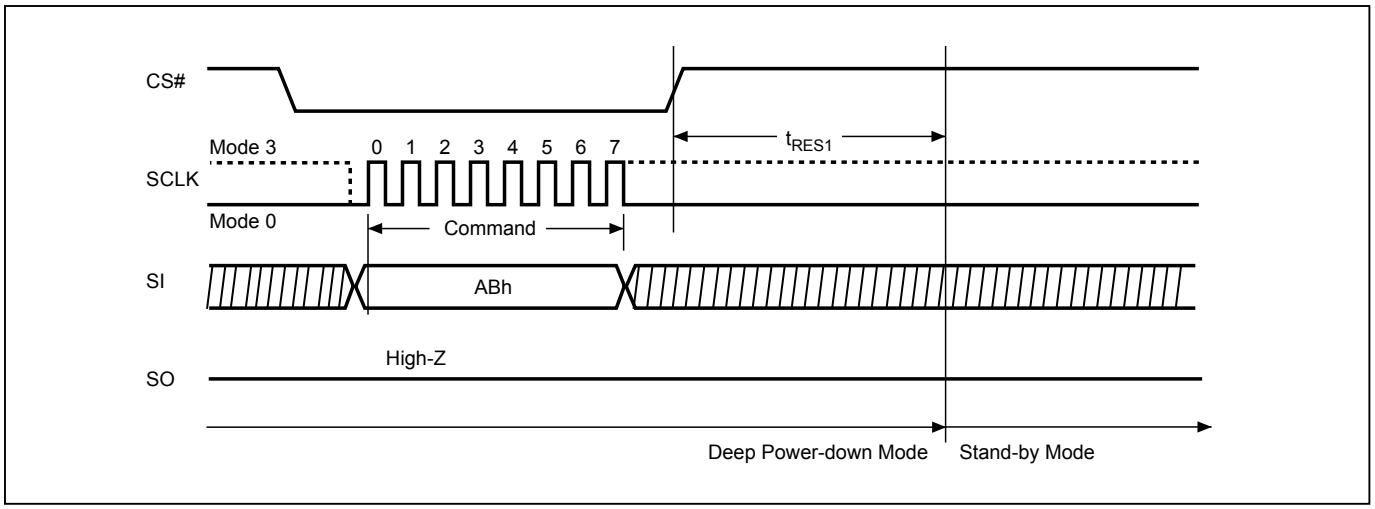
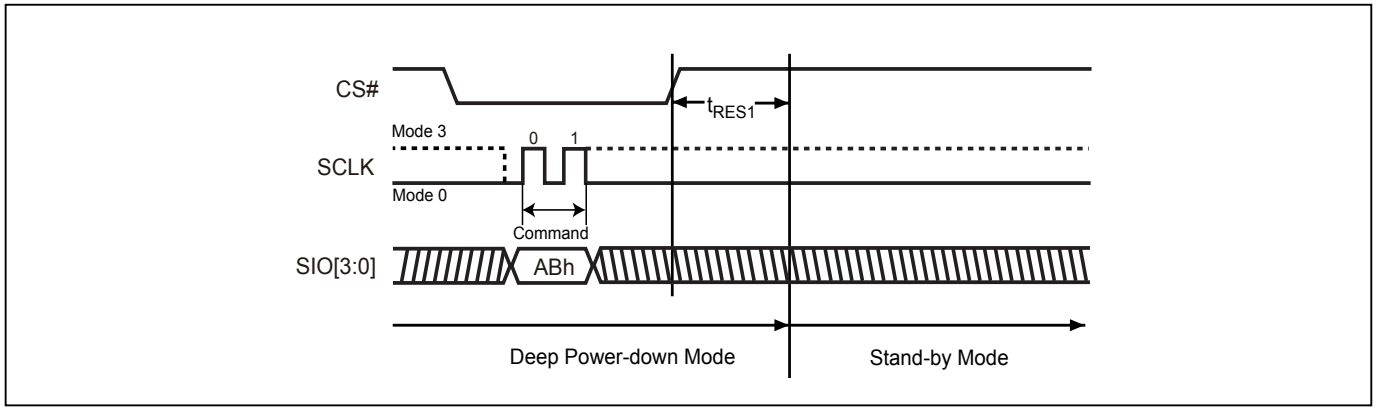


Figure 53. Release from Deep Power-down (RDP) Sequence (Command ABh) (QPI Mode)

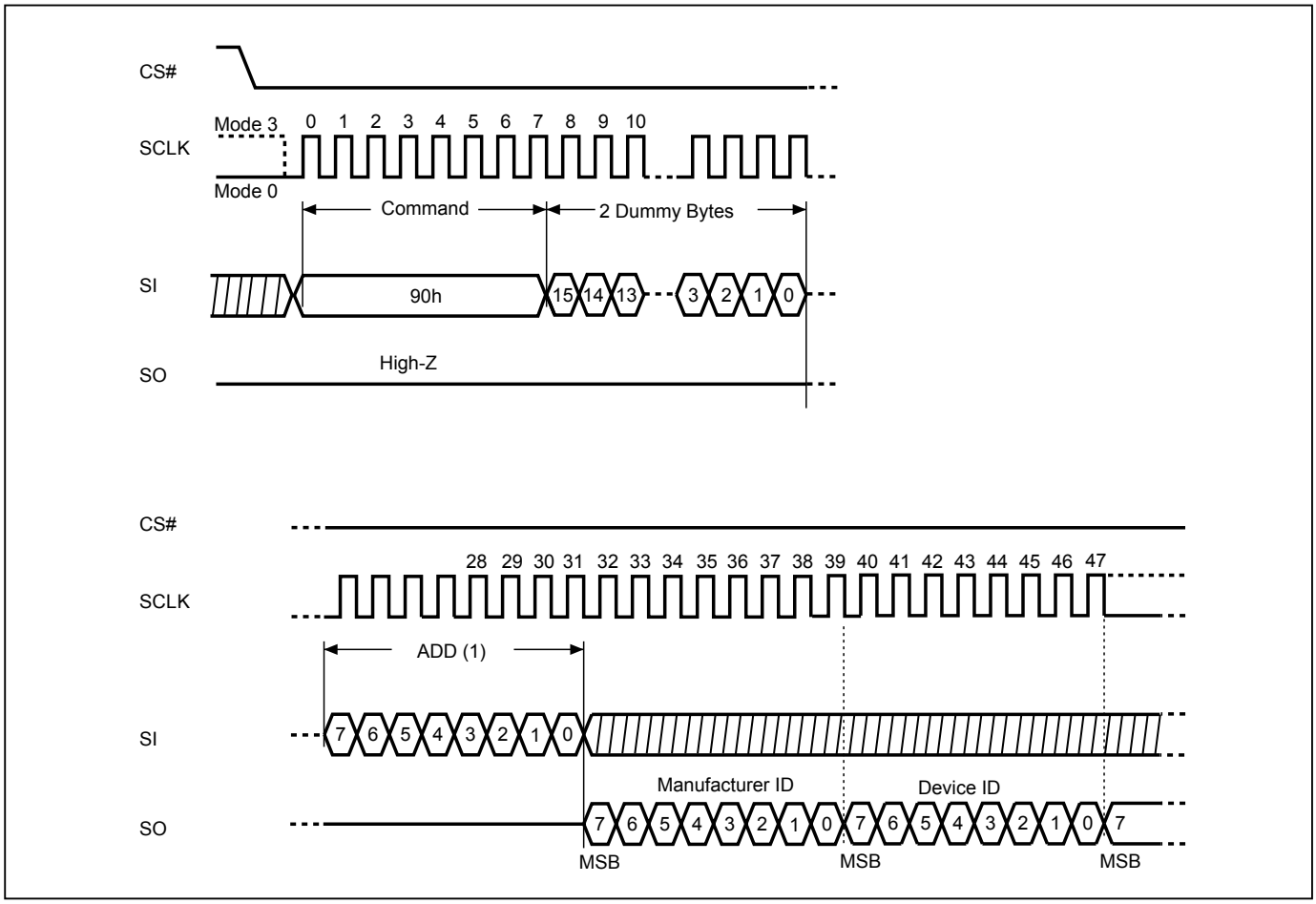


10-26. Read Electronic Manufacturer ID & Device ID (REMS)

The REMS instruction returns both the JEDEC assigned manufacturer ID and the device ID. The Device ID values are listed in *"Table 10. ID Definitions"*.

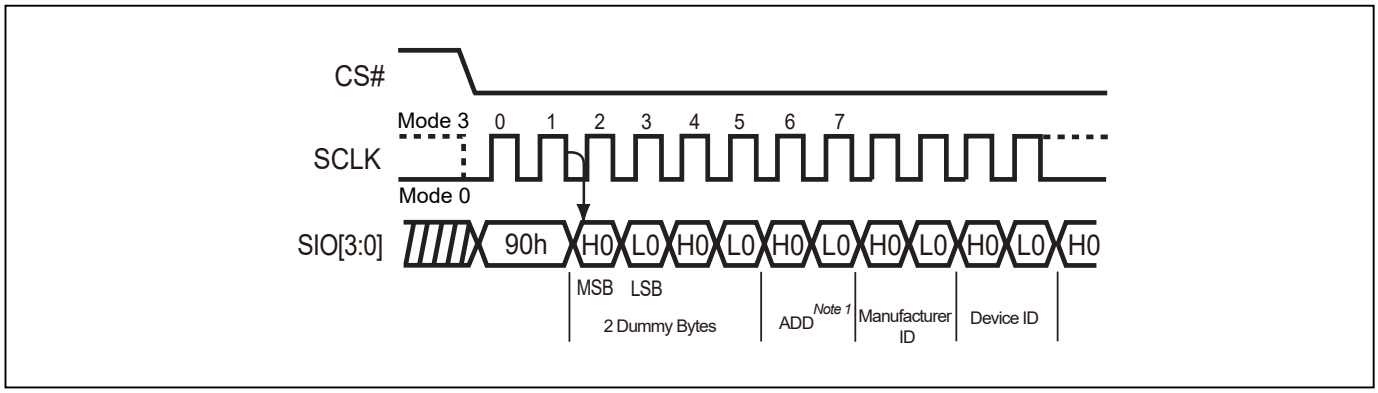
The REMS instruction is initiated by driving the CS# pin low and sending the instruction code "90h" followed by two dummy bytes and one address byte (A7-A0). After which the manufacturer ID for Macronix (C2h) and the device ID are shifted out on the falling edge of SCLK with the most significant bit (MSB) first. If the address byte is 00h, the manufacturer ID will be output first, followed by the device ID. If the address byte is 01h, then the device ID will be output first, followed by the manufacturer ID. While CS# is low, the manufacturer and device IDs can be read continuously, alternating from one to the other. The instruction is completed by driving CS# high.

Figure 54. Read Electronic Manufacturer & Device ID (REMS) Sequence (Command 90h) (SPI Mode)



Notes: (1) ADD=00H will output the manufacturer's ID first and ADD=01H will output device ID first.

Figure 55. Read Electronic Manufacturer ID & Device ID (REMS) Sequence (Command 90h) (QPI Mode)



Notes: (1) ADD=00H will output the manufacturer's ID first and ADD=01H will output device ID first.

10-27. QPI ID Read (QPIID)

The QPIID Read instruction can be used to identify the Device ID and Manufacturer ID. The sequence of issuing the QPIID instruction is as follows: CS# goes low→send QPI ID instruction→Data out on SO→CS# goes high. Most significant bit (MSB) first.

After the command cycle, the device will immediately output data on the falling edge of SCLK. The manufacturer ID, memory type, and memory density data byte will be output continuously, until the CS# goes high.

Table 10. ID Definitions

Command Type		MX25L32356		
RDID	9Fh	Manufacturer ID	Memory Type	Memory Density
		C2	20	16
RES	ABh	Electronic Signature ID		
		15		
REMS	90h	Manufacturer ID	Device ID	
		C2	15	
QPIID	AFh	Manufacturer ID	Memory Type	Memory Density
		C2	20	16

10-28. Enter Secured OTP (ENSO)

The ENSO instruction is for entering the additional 8K-bit Secured OTP mode. While the device is in 8K-bit Secured OTP mode, array access is not available. The additional 8K-bit Secured OTP is independent from main array, and may be used to store unique serial number for system identifier. After entering the Secured OTP mode, follow standard read or program procedure to read out the data or update data. The Secured OTP data cannot be updated again once it is lock-down.

The sequence of issuing ENSO instruction is: CS# goes low→ send ENSO instruction to enter Secured OTP mode→ CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

Please note that WRSR/WRSCUR/CE/BE/SE/BE32K commands are not acceptable during the access of secure OTP region, once Security OTP is locked down, only read related commands are valid.

10-29. Exit Secured OTP (EXSO)

The EXSO instruction is for exiting the additional 8K-bit Secured OTP mode.
The sequence of issuing EXSO instruction is: CS# goes low→ send EXSO instruction to exit Secured OTP mode→ CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

10-30. Write Security Register (WRSCUR)

The WRSCUR instruction is for changing the values of Security Register Bits. Unlike write status register, the WREN instruction is required before sending WRSCUR instruction. The WRSCUR instruction may change the values of bit1 (LDSO bit) for customer to lock-down the 1st 4K-bit Secured OTP area. Once the LDSO bit is set to "1", the Secured OTP area cannot be updated any more.

The sequence of issuing WRSCUR instruction is: CS# goes low→ send WRSCUR instruction → CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

The CS# must go high exactly at the boundary; otherwise, the instruction will be rejected and not executed.

Figure 56. Write Security Register (WRSCUR) Sequence (Command 2Fh) (SPI Mode)

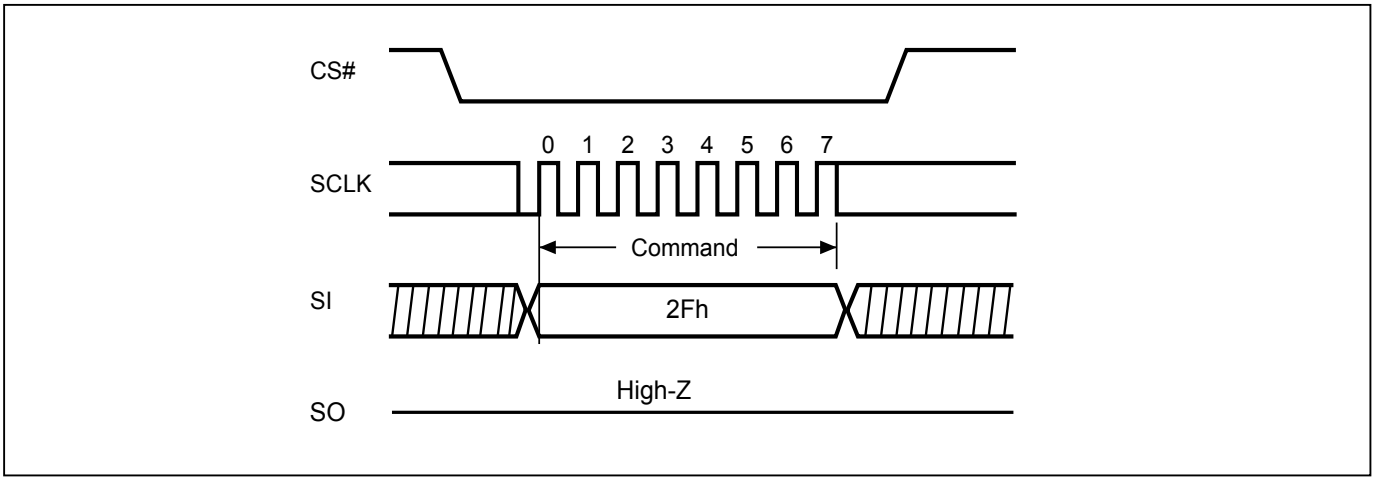
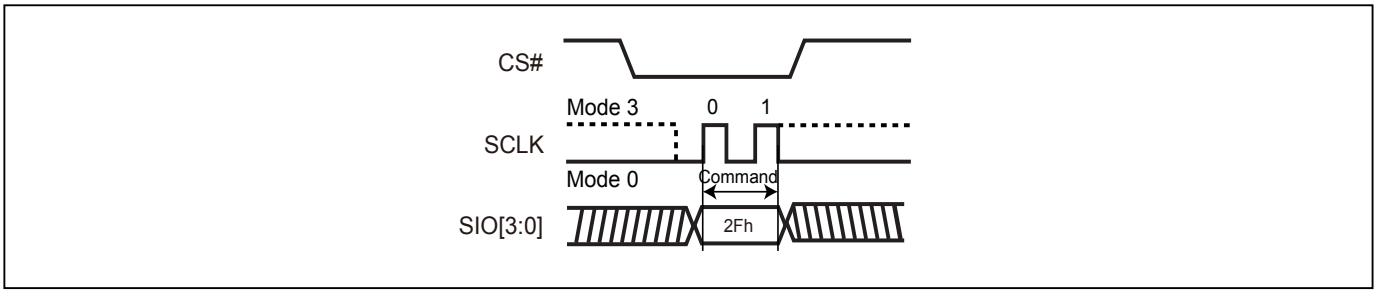


Figure 57. Write Security Register (WRSCUR) Sequence (Command 2Fh) (QPI Mode)



10-31. Read Security Register (RDSCUR)

The RDSCUR instruction is for reading the value of Security Register. The Read Security Register can be read at any time (even in program/erase/write status register/write security register condition) and continuously.

The sequence of issuing RDSCUR instruction is: CS# goes low→ send RDSCUR instruction → Security Register data out on SO→ CS# goes high.

Both SPI (8 clocks) and QPI (2 clocks) command cycles can be accepted by this instruction. The SIO[3:1] are don't care during SPI mode.

Figure 58. Read Security Register (RDSCUR) Sequence (Command 2Bh) (SPI Mode)

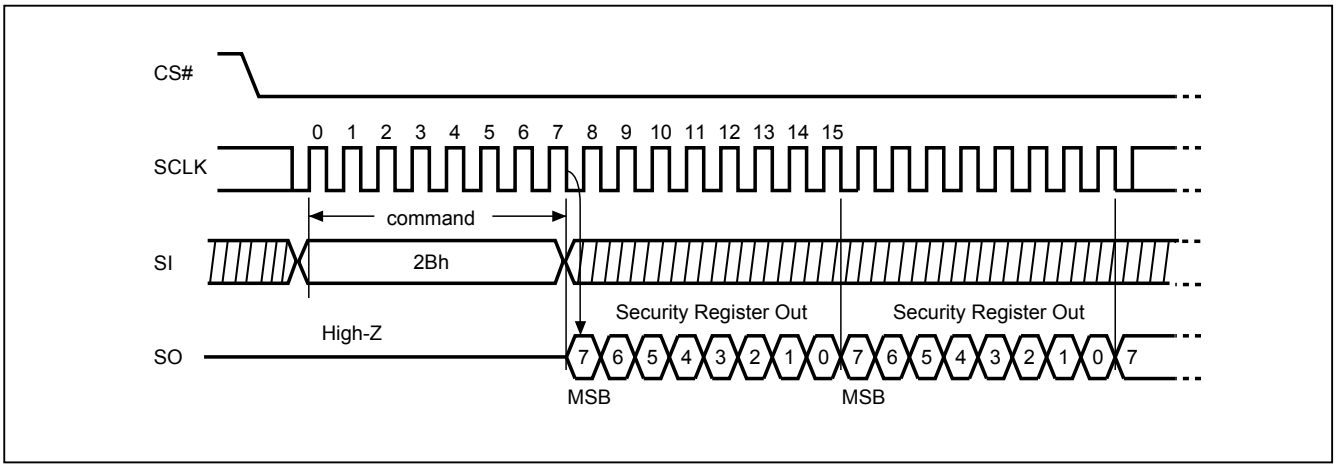
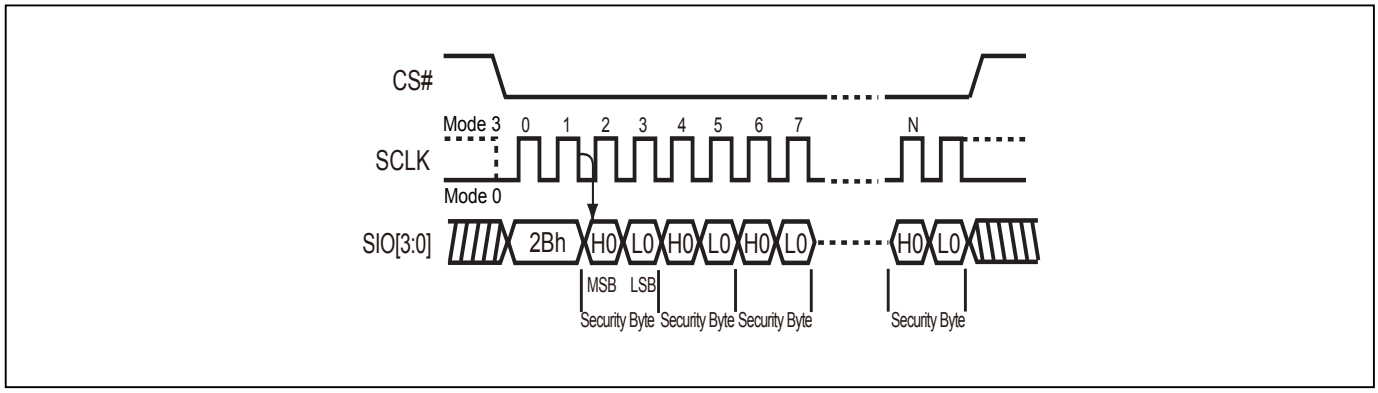


Figure 59. Read Security Register (RDSCUR) Sequence (Command 2Bh) (QPI Mode)



Security Register

The definition of the Security Register is as below:

Secured OTP Indicator bit. The Secured OTP indicator bit shows the Secured OTP area is locked by factory or not. When it is "0", it indicates non-factory lock; "1" indicates factory- lock.

Lock-down Secured OTP (LDSO) bit. By writing WRSCUR instruction, the LDSO bit may be set to "1" for customer lock-down purpose. However, once the bit is set to "1" (lock-down), the LDSO bit and the 4K-bit Secured OTP area cannot be updated any more.

Program Suspend Status bit. Program Suspend Bit (PSB) indicates the status of Program Suspend operation. Users may use PSB to identify the state of flash memory. After the flash memory is suspended by Program Suspend command, PSB is set to "1". PSB is cleared to "0" after program operation resumes.

Erase Suspend Status bit. Erase Suspend Bit (ESB) indicates the status of Erase Suspend operation. Users may use ESB to identify the state of flash memory. After the flash memory is suspended by Erase Suspend command, ESB is set to "1". ESB is cleared to "0" after erase operation resumes.

Program Fail Flag bit. While a program failure happened, the Program Fail Flag bit would be set. If the program operation fails on a protected memory region or locked OTP region, this bit will also be set. This bit can be the failure indication of one or more program operations. This fail flag bit will be cleared automatically after the next successful program operation.

Erase Fail Flag bit. While an erase failure happened, the Erase Fail Flag bit would be set. If the erase operation fails on a protected memory region or locked OTP region, this bit will also be set. This bit can be the failure indication of one or more erase operations. This fail flag bit will be cleared automatically after the next successful erase operation.

Table 11. Security Register Definition

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
WPSEL	E_FAIL	P_FAIL	Reserved	ESB (Erase Suspend status)	PSB (Program Suspend status)	LDSO (lock-down 4K-bit Secured OTP)	Secured OTP Indicator bit (4K-bit Secured OTP)
0= Block Lock (BP) protection mode 1= Advanced Sector Protection mode (default=0)	0=normal Erase succeed 1=indicate Erase failed (default=0)	0=normal Program succeed 1=indicate Program failed (default=0)	Reserved	0=Erase is not suspended 1=Erase is suspended (default=0)	0=Program is not suspended 1=Program is suspended (default=0)	0 = not lockdown 1 = lock-down (Secured OTP can no longer be programmed)	0 = nonfactory lock 1 = factory lock
Non-volatile bit (OTP)	volatile bit	volatile bit	volatile bit	volatile bit	volatile bit	non-volatile bit	non-volatile bit
Reserved	Read Only	Read Only		Read Only	Read Only	OTP	Read Only

10-32. Write Protection Selection (WPSEL)

There are two write protection methods provided on this device, (1) Block Protection (BP) mode or (2) Advanced Sector Protection mode. The protection modes are mutually exclusive. The WPSEL bit selects which protection mode is enabled. If WPSEL=0 (factory default), BP mode is enabled and Advanced Sector Protection mode is disabled. If WPSEL=1, Advanced Sector Protection mode is enabled and BP mode is disabled. The WPSEL command is used to set WPSEL=1. A WREN command must be executed to set the WEL bit before sending the WPSEL command. Please note that the WPSEL bit is an OTP bit. Once WPSEL is set to "1", it cannot be programmed back to "0".

When WPSEL = 0: Block Lock (BP) protection mode,
The memory array is write protected by the BP3-BP0 bits.

When WPSEL =1: Advanced Sector Protection mode,
Blocks are individually protected by their own SPB or DPB. On power-up, all blocks are write protected by the Dynamic Protection Bits (DPB) by default. The Advanced Sector Protection instructions WRLR, RDLR, WRSPB, ESSPB, WRDPB, RDDPB, GBLK, and GBULK are activated. The BP3-BP0 bits of the Status Register are disabled and have no effect. Hardware protection is performed by driving WP#=0. Once WP#=0 all blocks and sectors are write protected regardless of the state of each SPB or DPB.

The sequence of issuing WPSEL instruction is: CS# goes low → send WPSEL instruction to enable the Advanced Sector Protection mode → CS# goes high.

Figure 60. Write Protection Selection

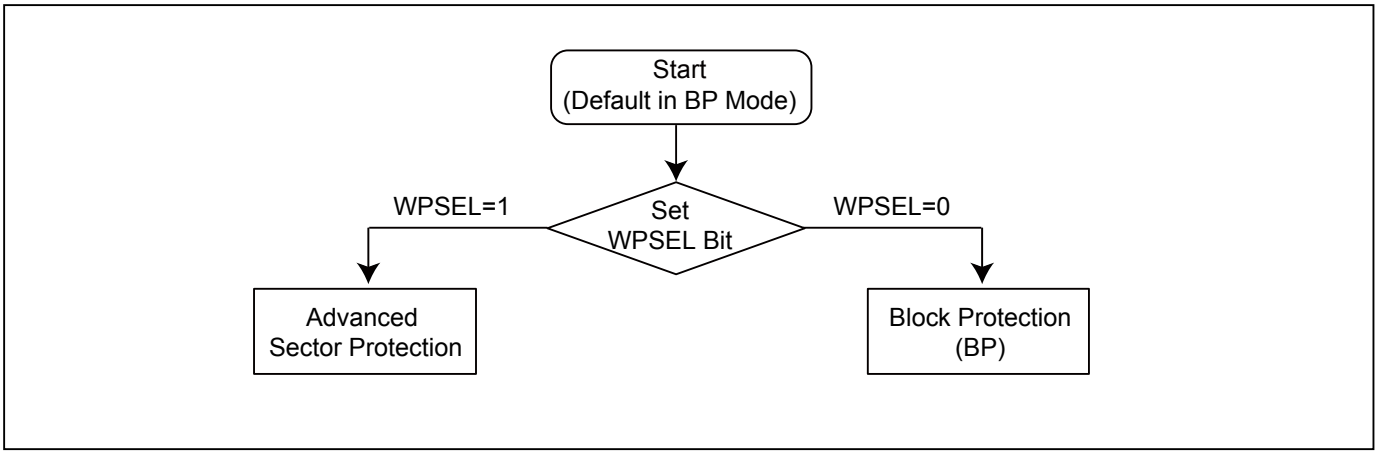
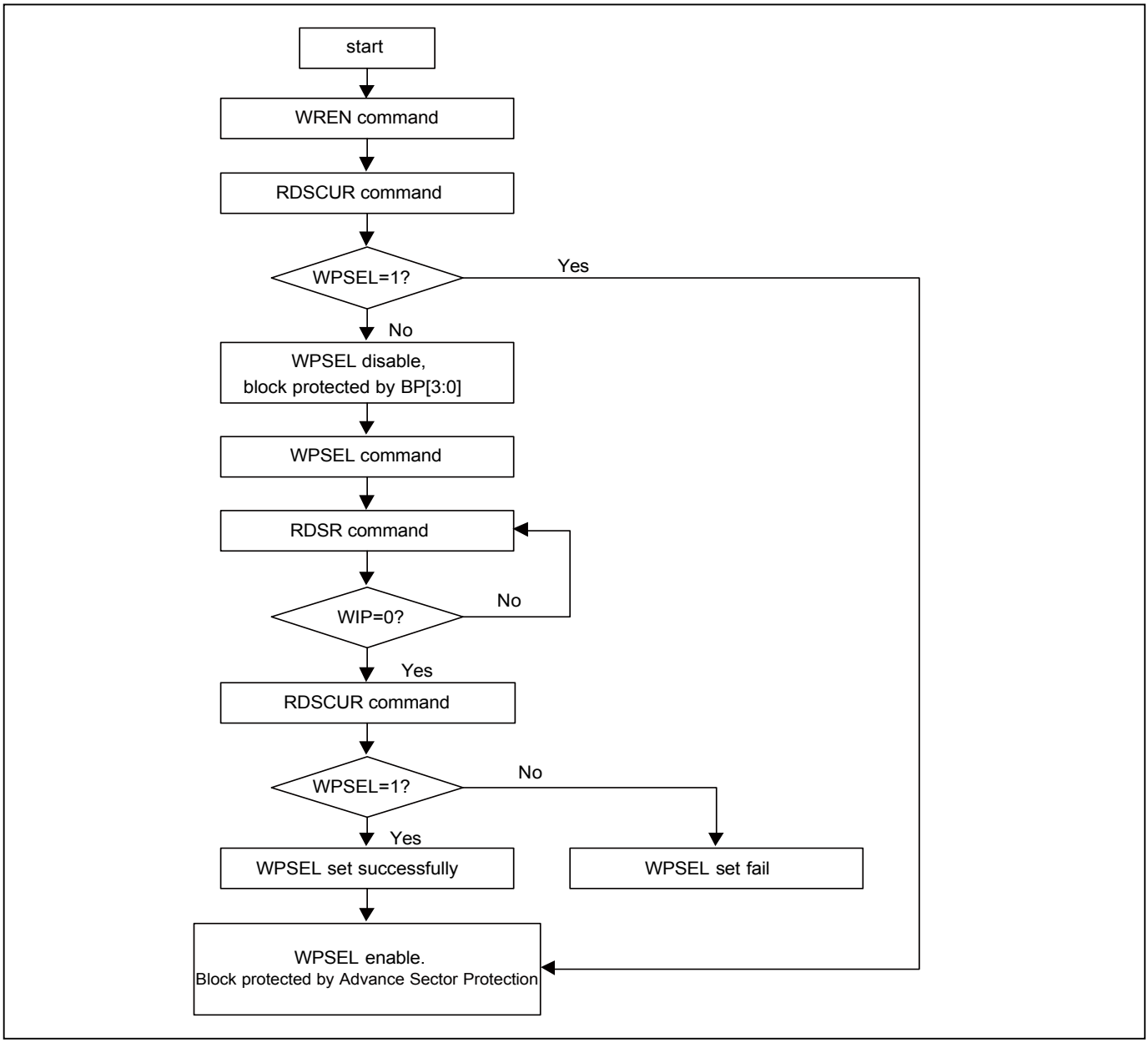


Figure 61. WPSEL Flow



10-33. Advanced Sector Protection

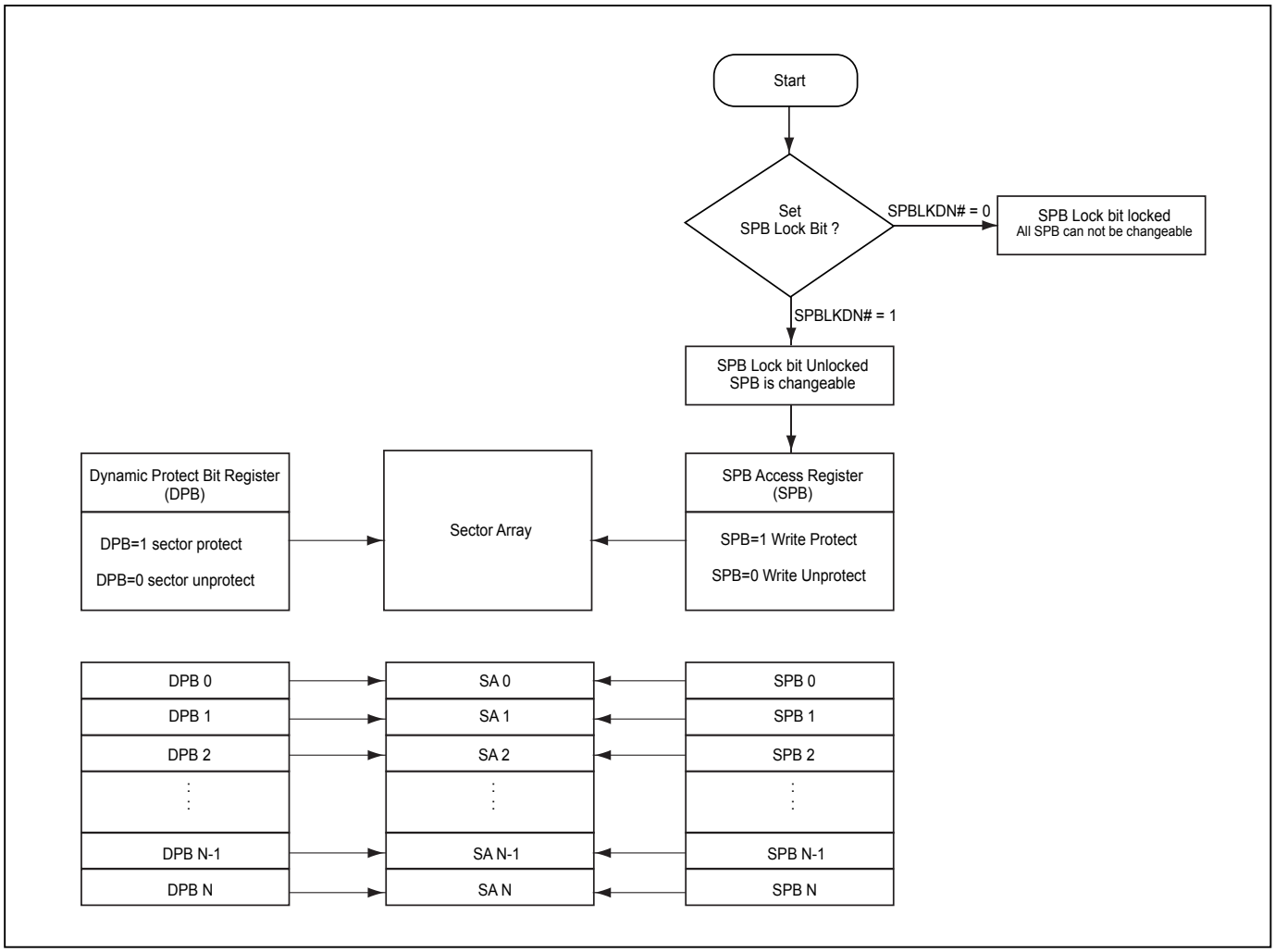
Advanced Sector Protection can protect individual 4KB sectors in the bottom and top 64KB of memory and protect individual 64KB blocks in the rest of memory.

There is one non-volatile Solid Protection Bit (SPB) and one volatile Dynamic Protection Bit (DPB) assigned to each 4KB sector at the bottom and top 64KB of memory and to each 64KB block in the rest of memory. A sector or block is write-protected from programming or erasing when its associated SPB or DPB is set to “1”.

The figure below helps describing an overview of these methods. The device is default to the Solid mode when shipped from factory. The detail algorithm of advanced sector protection is shown as follows:

Solid Protection mode permits the SPB bits to be modified after power-on or a reset. The figure below is an overview of Advanced Sector Protection.

Figure 62. Advanced Sector Protection Overview



10-33-1. Lock Register

The Lock Register is a 16-bit one-time programmable register. Lock Register bit [6] is SPB Lock Down Bit (SPBLKDN) which is an unique bit assigned to control all SPB bit status.

When SPBLKDN is 1, SPB can be changed. When it is locked as 0, all SPB can not be changed anymore, and SPBLKDN bit itself can not be altered anymore, either.

The Lock Register is programmed using the WRLR (Write Lock Register) command. A WREN command must be executed to set the WEL bit before sending the WRLR command.

Table 12. Lock Register

Bits	Field Name	Function	Type	Default State	Description
15 to 7	RFU	Reserved	OTP	1	Reserved for Future Use
6	SPBLKDN	SPB Lock Down	OTP	1	1 = SPB changeable 0 = freeze SPB
5 to 0	RFU	Reserved	OTP	1	Reserved for Future Use

Figure 63. Read Lock Register (RDLR) Sequence (Command 2Dh) (SPI mode only)

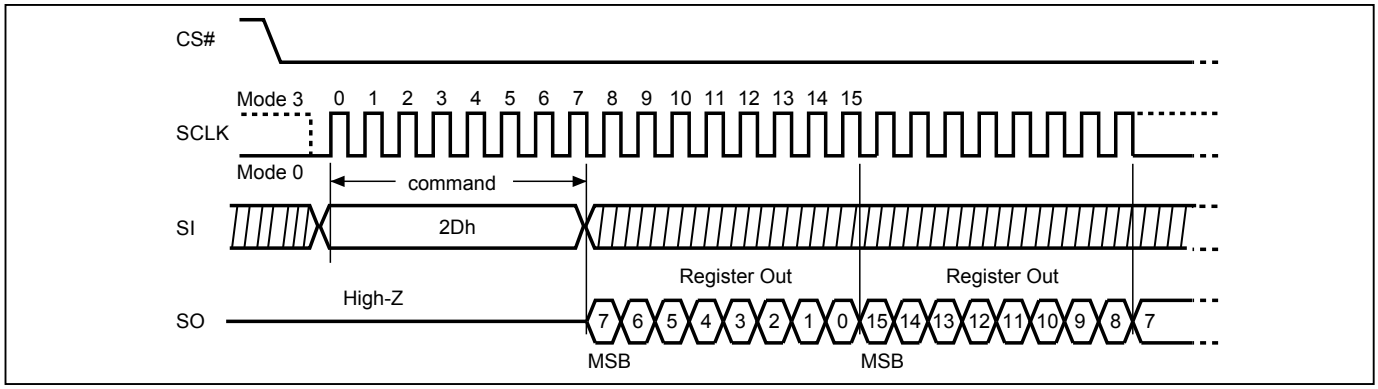
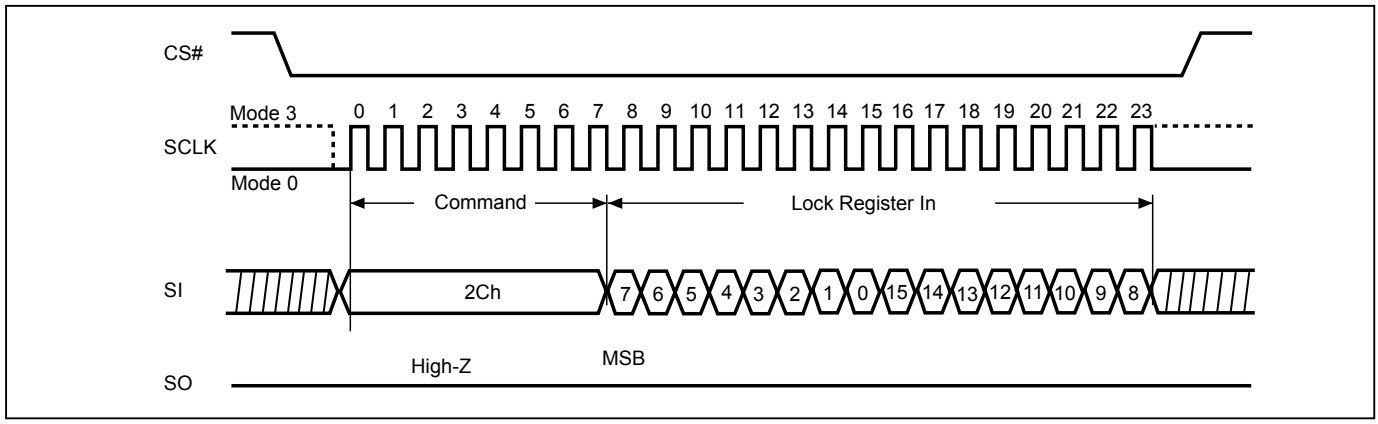


Figure 64. Write Lock Register (WRLR) Sequence (Command 2Ch) (SPI mode only)



10-33-2. Solid Protection Bits

The Solid Protection Bits (SPBs) are nonvolatile bits for enabling or disabling write-protection to sectors and blocks. The SPB bits have the same endurance as the Flash memory. An SPB is assigned to each 4KB sector in the bottom and top 64KB of memory and to each 64KB block in the remaining memory. The factory default state of the SPB bits is “0”, which has the sector/block write-protection disabled.

When an SPB is set to “1”, the associated sector or block is write-protected. Program and erase operations on the sector or block will be inhibited. SPBs can be individually set to “1” by the WRSPB command. However, the SPBs cannot be individually cleared to “0”. Issuing the ESSPB command clears all SPBs to “0”. A WREN command must be executed to set the WEL bit before sending the WRSPB or ESSPB command.

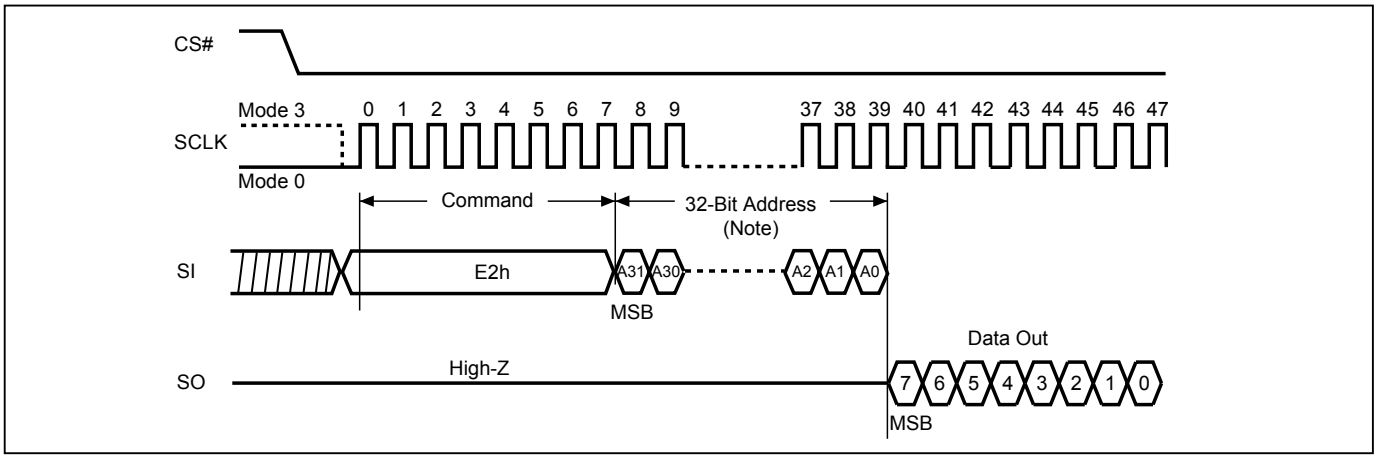
The RDSPB command reads the status of the SPB of a sector or block. The RDSPB command returns 00h if the SPB is “0”, indicating write-protection is disabled. The RDSPB command returns FFh if the SPB is “1”, indicating write-protection is enabled.

Note: If SPBLKDN=0, commands to set or clear the SPB bits will be ignored.

Table 13. SPB Register

Bit	Description	Bit Status	Default	Type
7 to 0	SPB (Solid Protection Bit)	00h = Unprotect Sector / Block FFh = Protect Sector / Block	00h	Non-volatile

Figure 65. Read SPB Status (RDSPB) Sequence (Command E2h) (SPI mode only)



Note: A31-A24 are don't care.

Figure 66. SPB Erase (ESSPB) Sequence (Command E4h) (SPI mode only)

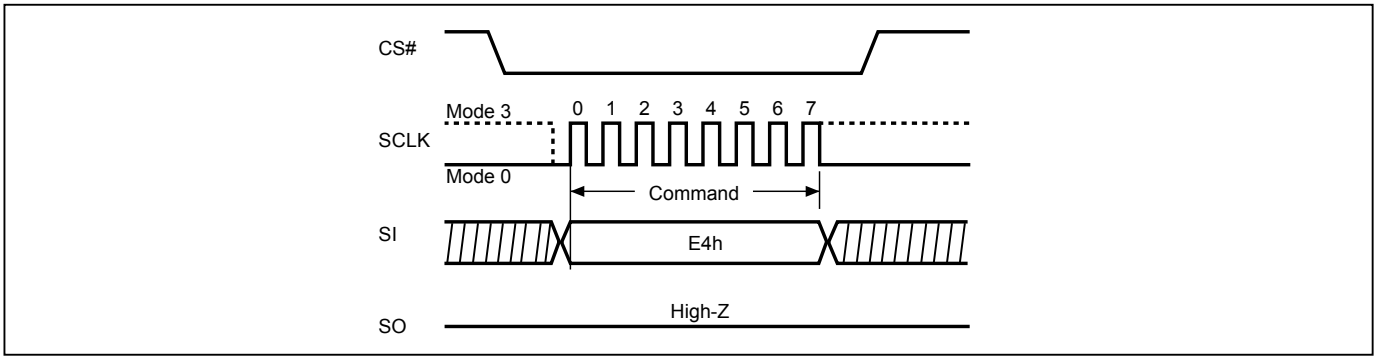
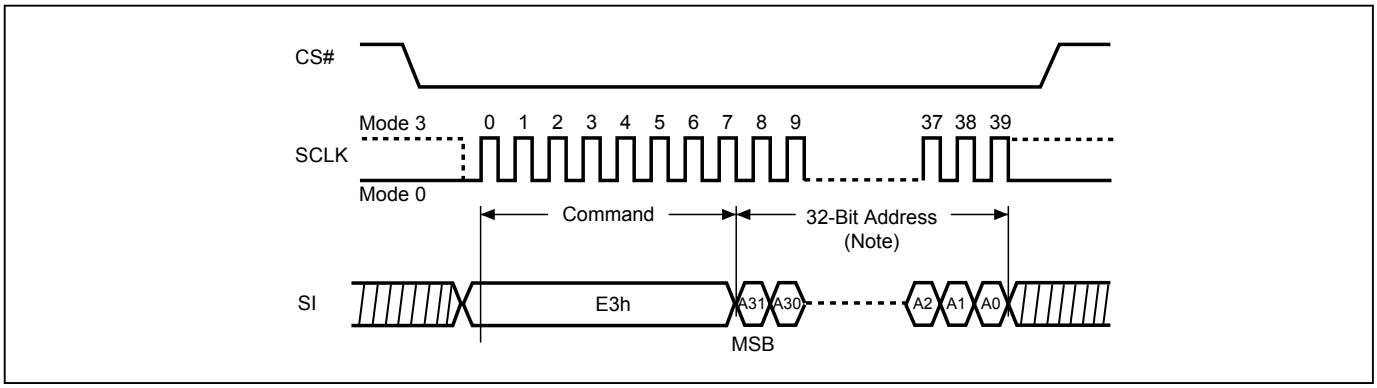


Figure 67. SPB Program (WRSPB) Sequence (Command E3h) (SPI mode only)



Note: A31-A24 are don't care

10-33-3. Dynamic Protection Bits

The Dynamic Protection Bits (DPBs) are volatile bits for quickly and easily enabling or disabling write-protection to sectors and blocks. A DPB is assigned to each 4KB sector in the bottom and top 64KB of memory and to each 64KB block in the rest of the memory. The DBPs can enable write-protection on a sector or block regardless of the state of the corresponding SPB. However, the DPB bits can only unprotect sectors or blocks whose SPB bits are “0” (unprotected).

When a DPB is “1”, the associated sector or block will be write-protected, preventing any program or erase operation on the sector or block. All DPBs default to “1” after power-on or reset. When a DPB is cleared to “0”, the associated sector or block will be unprotected if the corresponding SPB is also “0”.

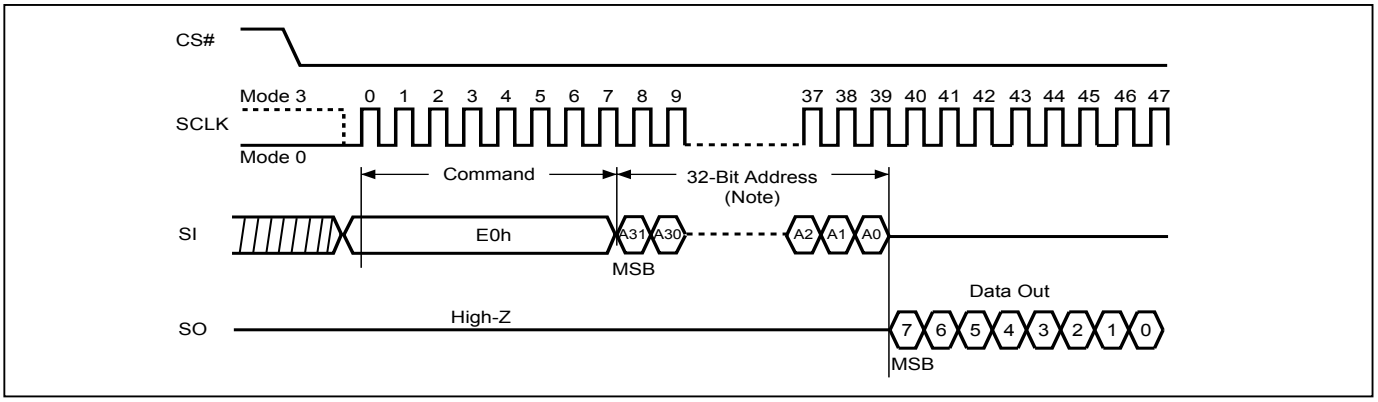
DPB bits can be individually set to “1” or “0” by the WRDPB command. The DBP bits can also be globally cleared to “0” with the GBULK command or globally set to “1” with the GBLK command. A WREN command must be executed to set the WEL bit before sending the WRDPB, GBULK, or GBLK command.

The RDDPB command reads the status of the DPB of a sector or block. The RDDPB command returns 00h if the DPB is “0”, indicating write-protection is disabled. The RDDPB command returns FFh if the DPB is “1”, indicating write-protection is enabled.

Table 14. DPB Register

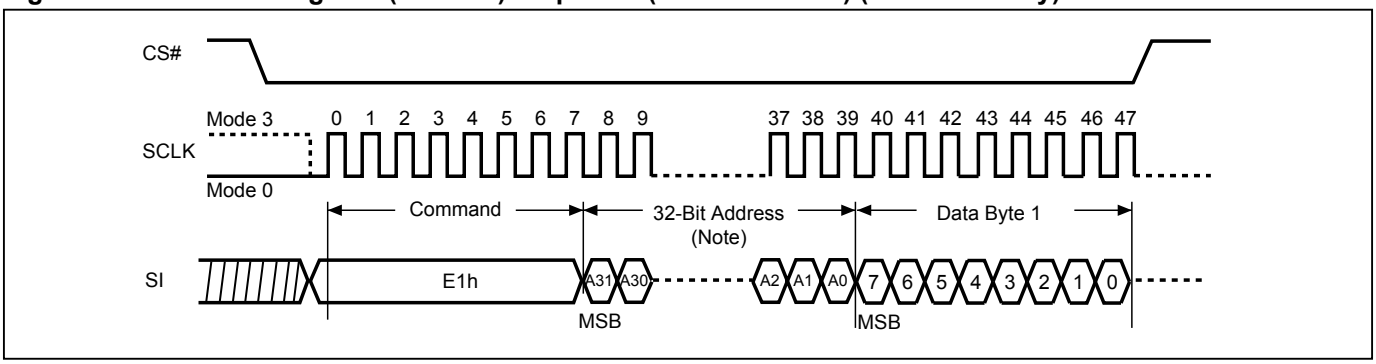
Bit	Description	Bit Status	Default	Type
7 to 0	DPB (Dynamic Protection Bit)	00h = Unprotect Sector / Block FFh = Protect Sector / Block	FFh	Volatile

Figure 68. Read DPB Register (RDDPB) Sequence (Command E0h) (SPI mode only)



Note: A31-A24 are don't care.

Figure 69. Write DPB Register (WRDPB) Sequence (Command E1h) (SPI mode only)



Note: A31-A24 are don't care.

10-33-4. Gang Block Lock/Unlock (GBLK/GBULK)

These instructions are only effective if WPSEL=1. The GBLK and GBULK instructions provide a quick method to set or clear all DPB bits at once.

The WREN (Write Enable) instruction is required before issuing the GBLK/GBULK instruction.
The sequence of issuing GBLK/GBULK instruction is: CS# goes low → send GBLK/GBULK (7Eh/98h) instruction →CS# goes high.

The GBLK and GBULK commands are accepted in both SPI and QPI mode.

The CS# must go high exactly at the byte boundary, otherwise, the instruction will be rejected and not be executed.

10-33-5. Sector Protection States Summary Table

Protection Status		Sector/Block Protection State
DPB	SPB	
0	0	Unprotected
0	1	Protected
1	0	Protected
1	1	Protected

10-34. Program Suspend and Erase Suspend

The Suspend instruction interrupts a Page Program, Sector Erase, or Block Erase operation to allow access to the memory array. After the program or erase operation has entered the suspended state, the memory array can be read except for the page being programmed or the sector or block being erased (*"Table 15. Readable Area of Memory While a Program or Erase Operation is Suspended"*).

Table 15. Readable Area of Memory While a Program or Erase Operation is Suspended

Suspended Operation	Readable Region of Memory Array
Page Program	All but the Page being programmed
Sector Erase (4KB)	All but the 4KB Sector being erased
Block Erase (32KB)	All but the 32KB Block being erased
Block Erase (64KB)	All but the 64KB Block being erased

When the serial flash receives the Suspend instruction, there is a latency of tPSL or tESL (*"Figure 70. Suspend to Read Latency"*) before the Write Enable Latch (WEL) bit clears to “0” and the PSB or ESB sets to “1”, after which the device is ready to accept one of the commands listed in *"Table 16. Acceptable Commands During Program/Erase Suspend after tPSL/tESL"* (e.g. FAST READ). Refer to *"Table 20. AC Characteristics"* for tPSL and tESL timings. *"Table 17. Acceptable Commands During Suspend (tPSL/tESL not required)"* lists the commands for which the tPSL and tESL latencies do not apply. For example, RDSR, RDSCUR, RSTEN, and RST can be issued at any time after the Suspend instruction.

Security Register bit 2 (PSB) and bit 3 (ESB) can be read to check the suspend status. The PSB (Program Suspend Bit) sets to “1” when a program operation is suspended. The ESB (Erase Suspend Bit) sets to “1” when an erase operation is suspended. The PSB or ESB clears to “0” when the program or erase operation is resumed.

Figure 70. Suspend to Read Latency

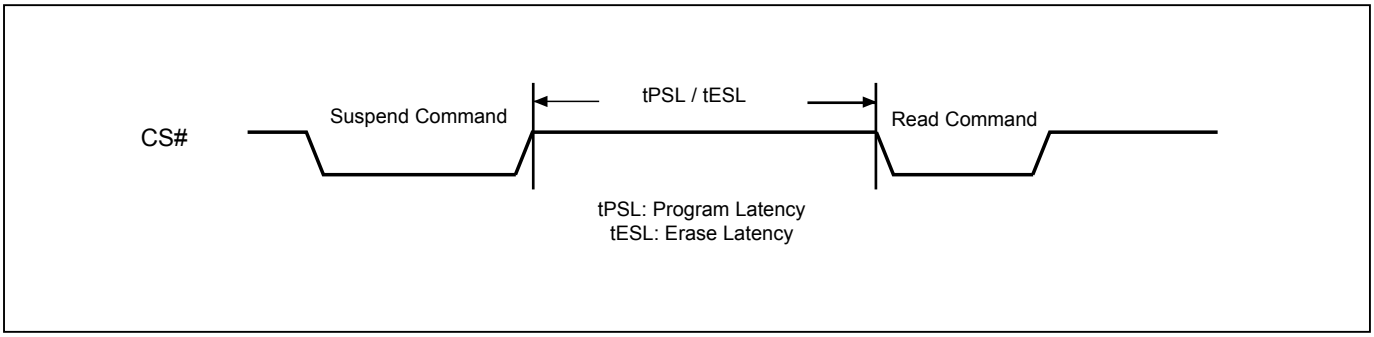


Table 16. Acceptable Commands During Program/Erase Suspend after tPSL/tESL

Command Name	Command Code	Suspend Type	
		Program Suspend	Erase Suspend
READ	03h	•	•
FAST READ	0Bh	•	•
DREAD	3Bh	•	•
QREAD	6Bh	•	•
2READ	BBh	•	•
4READ	EBh	•	•
RDSFDP	5Ah	•	•
RDID	9Fh	•	•
QPIID	AFh	•	•
REMS	90h	•	•
EQIO	35h	•	•
RSTQIO	F5h	•	•
ENSO	B1h	•	•
EXSO	C1h	•	•
SBL	C0h or 77h	•	•
RDSPB	E2h	•	•
RDDPB	E0h	•	•
WREN	06h		•
RESUME	7Ah or 30h	•	•
PP	02h		•
4PP	38h		•

Table 17. Acceptable Commands During Suspend (tPSL/tESL not required)

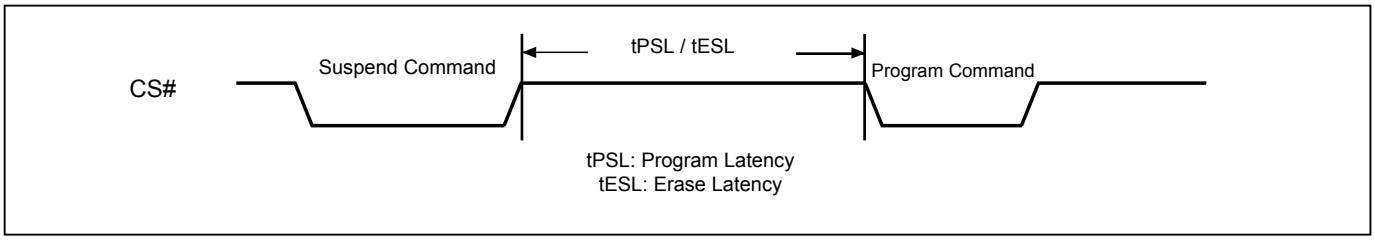
Command Name	Command Code	Suspend Type	
		Program Suspend	Erase Suspend
WRDI	04h	•	•
RDSR	05h	•	•
RDCR	15h	•	•
RDSCUR	2Bh	•	•
RES	ABh	•	•
RSTEN	66h	•	•
RST	99h	•	•
NOP	00h	•	•

10-34-1. Erase Suspend to Program

The “Erase Suspend to Program” feature allows Page Programming while an erase operation is suspended. Page Programming is permitted in any unprotected memory except within the sector of a suspended Sector Erase operation or within the block of a suspended Block Erase operation. The Write Enable (WREN) instruction must be issued before any Page Program instruction.

A Page Program operation initiated within a suspended erase cannot itself be suspended and must be allowed to finish before the suspended erase can be resumed. The Status Register can be polled to determine the status of the Page Program operation. The WEL and WIP bits of the Status Register will remain “1” while the Page Program operation is in progress and will both clear to “0” when the Page Program operation completes.

Figure 71. Suspend to Program Latency



10-35. Program Resume and Erase Resume

The Resume instruction resumes a suspended Page Program, Sector Erase, or Block Erase operation. Before issuing the Resume instruction to restart a suspended erase operation, make sure that there is no Page Program operation in progress.

Immediately after the serial flash receives the Resume instruction, the WEL and WIP bits are set to “1” and the PSB or ESB is cleared to “0”. The program or erase operation will continue until finished (*"Figure 72. Resume to Read Latency"*) or until another Suspend instruction is received. A resume-to-suspend latency of tPRS or tERS must be observed before issuing another Suspend instruction (*"Figure 73. Resume to Suspend Latency"*).

Please note that the Resume instruction will be ignored if the serial flash is in “Performance Enhance Mode”. Make sure the serial flash is not in “Performance Enhance Mode” before issuing the Resume instruction.

Figure 72. Resume to Read Latency

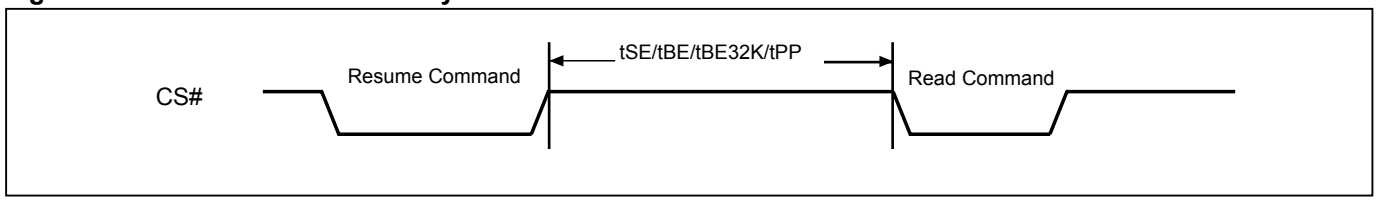
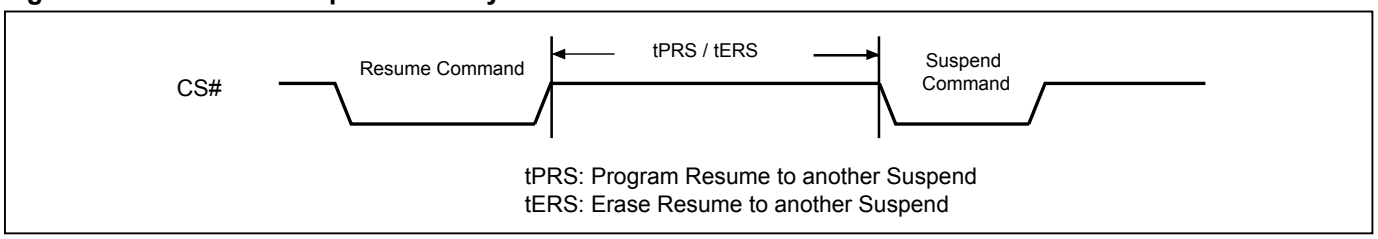


Figure 73. Resume to Suspend Latency



10-36. No Operation (NOP)

The "No Operation" command is only able to terminate the Reset Enable (RSTEN) command and will not affect any other command.

10-37. Software Reset (Reset-Enable (RSTEN) and Reset (RST))

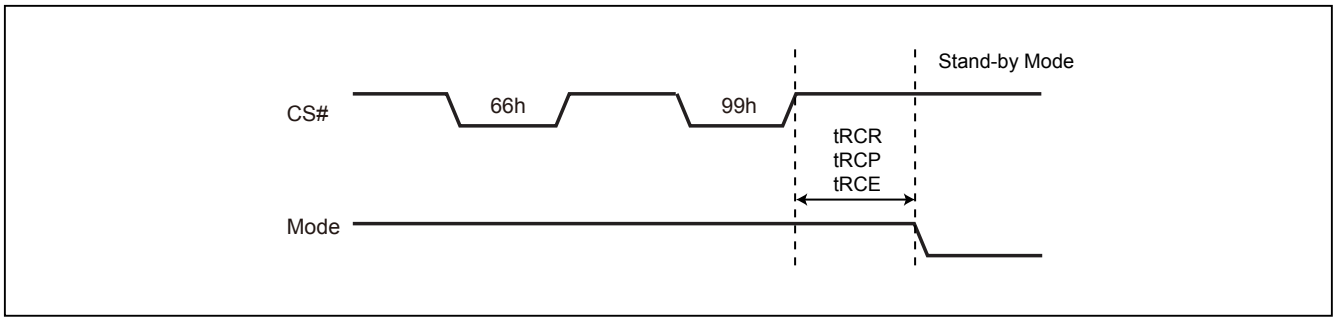
The Software Reset operation combines two instructions: Reset-Enable (RSTEN) command and Reset (RST) command. It returns the device to a standby mode. All the volatile bits and settings will be cleared then, which makes the device return to the default status as power on.

To execute Reset command (RST), the Reset-Enable (RSTEN) command must be executed first to perform the Reset operation. If there is any other command to interrupt after the Reset-Enable command, the Reset-Enable will be invalid.

If the Reset command is executed during program or erase operation, the operation will be disabled, the data under processing could be damaged or lost.

The reset time is different depending on the last operation. Longer latency time is required to recover from a program operation than from other operations.

Figure 74. Software Reset Recovery



10-38. In-Band-Reset

In-Band RESET is JEDEC-JESD252.01 compliance, which specifies a signaling protocol to perform a hardware reset by using only the CS#, SCLK, and the SI pin without a dedicated hardware RESET# pin.

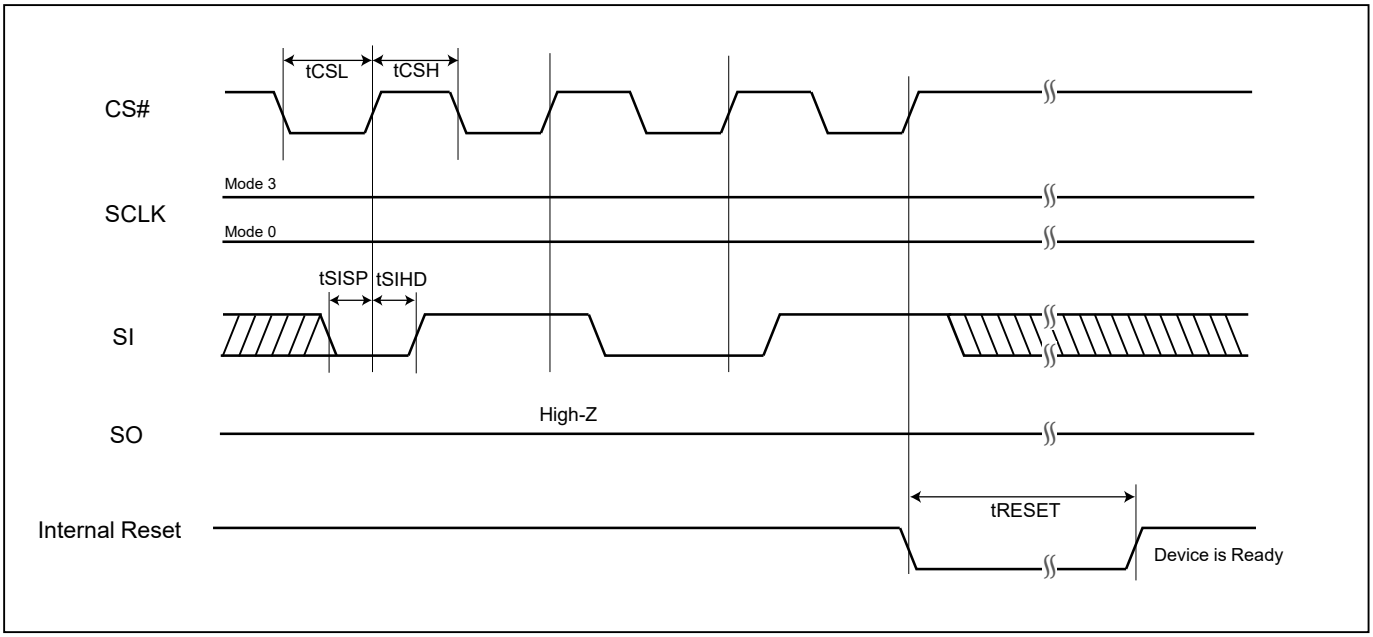
The procedure of initiating the reset request is: CS# goes low → SCLK remains stable in either a high or low state → SI pin goes low by the host, simultaneously with CS# going low → CS# goes high.

After the fourth CS# pulse, the flash device triggers its internal reset. Please note that SI is low on the first CS# pulse, high on the second CS# pulse, low on the third CS# pulse, high on the fourth CS# pulse. This provides a 5h pattern to differentiate it from random noise.

Table 18. In-Band-Reset Parameters

Symbol	Parameter	Min.	Typ.	Max.	Unit
tCSL	CS# Low hold Time	500			ns
tCSH	CS# High hold time	500			ns
tSISP	Serial Data Input Setup Time	5			ns
tSIHD	Serial Data Input Hold Time	5			ns
tRESET	RESET Recovery Time			100	ms

Figure 75. Reset Signaling Protocol



10-39. Read SFDP Mode (RDSFDP)

The Serial Flash Discoverable Parameter (SFDP) standard provides a consistent method of describing the functional and feature capabilities of serial flash devices in a standard set of internal parameter tables. These parameter tables can be interrogated by host system software to enable adjustments needed to accommodate divergent features from multiple vendors. The concept is similar to the one found in the Introduction of JEDEC Standard, JESD68 on CFI.

The sequence of issuing RDSFDP instruction is CS# goes low→send RDSFDP instruction (5Ah)→send 3 address bytes on SI pin→send 1 dummy byte on SI pin→read SFDP code on SO→to end RDSFDP operation can use CS# to high at any time during data out.

SFDP is a JEDEC Standard, JESD216.

For SFDP register values detail, please contact local Macronix sales channel for Application Note.

Figure 76. Read Serial Flash Discoverable Parameter (RDSFDP) Sequence (Command 5Ah) (SPI Mode)

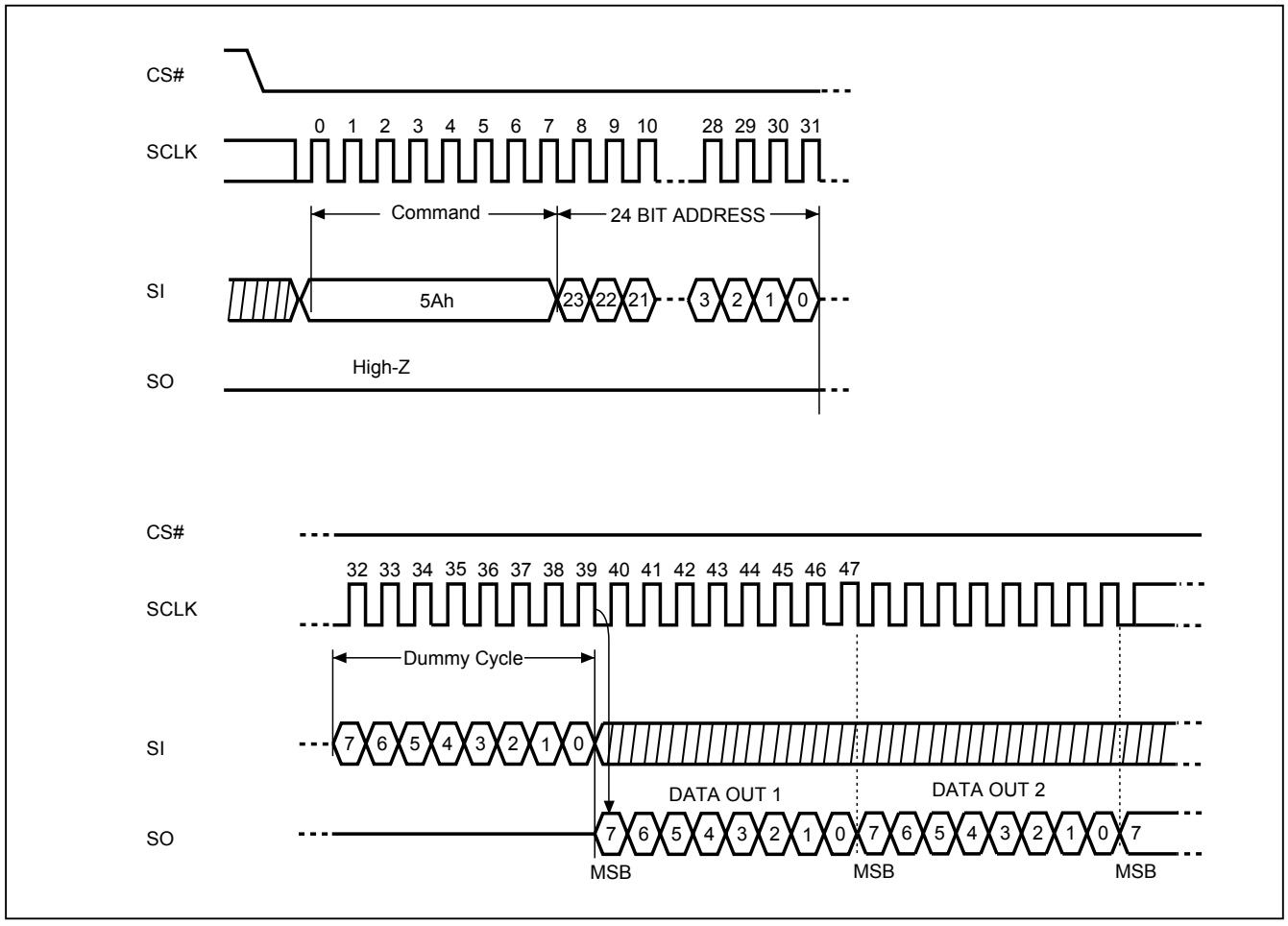
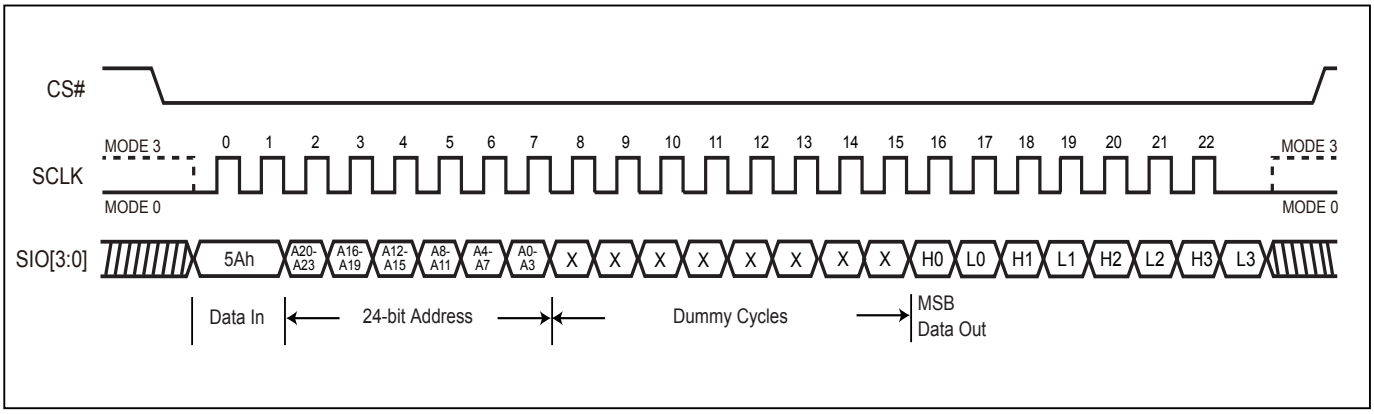


Figure 77. Read Serial Flash Discoverable Parameter (RDSFDP) Sequence (Command 5Ah) (QPI Mode)



11. POWER-ON STATE

The device is in the states below when power-up:
- Standby mode
- Write Enable Latch (WEL) bit is reset

The device must not be selected during power-up and power-down stage until the VCC reaches the following levels:
- VCC minimum at power-up stage and then after a delay of tVSL
- GND at power-down

Please note that a pull-up resistor on CS# may ensure a safe and proper power-up/down level.

An internal Power-on Reset (POR) circuit may protect the device from data corruption and inadvertent data change during power up state.

For further protection on the device, if the VCC does not reach the VCC minimum level, the correct operation is not guaranteed. The read, write, erase, and program command should be sent after the time delay:
- tVSL after VCC reached VCC minimum level

The device can accept read command after VCC reached VCC minimum and a time delay of tVSL.

Note:
- To stabilize the VCC level, the VCC rail decoupled by a suitable capacitor close to package pins is recommended. (generally around 0.1uF)

12. Electrical Specifications

12-1. Absolute Maximum Ratings

RATING		VALUE
Ambient Operating Temperature	Industrial grade	-40°C to 85°C
Storage Temperature		-65°C to 150°C
Applied Input Voltage		-0.5V to VCC+0.5V
Applied Output Voltage		-0.5V to VCC+0.5V
VCC to Ground Potential		-0.5V to 4.0V

NOTICE:

1. Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is stress rating only and functional operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended period may affect reliability.
2. Specifications contained within the following tables are subject to change.
3. During voltage transitions, all pins may overshoot Vss to -2.0V and Vcc to +2.0V for periods up to 20ns, see the figures below.

Figure 78. Maximum Negative Overshoot Waveform

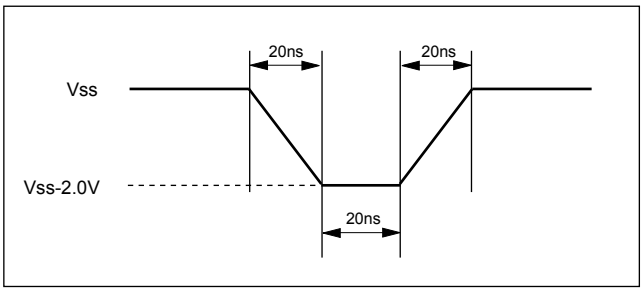
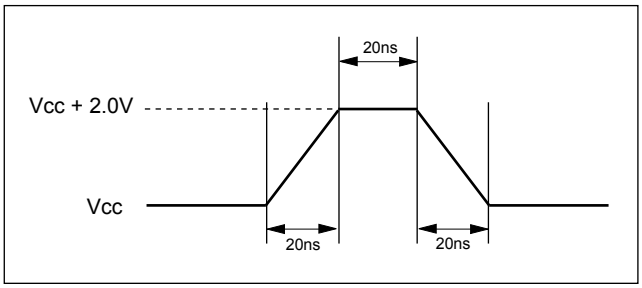


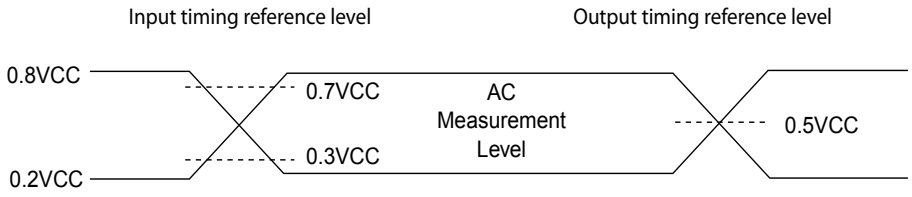
Figure 79. Maximum Positive Overshoot Waveform



12-2. Capacitance TA = 25°C, f = 1.0 MHz

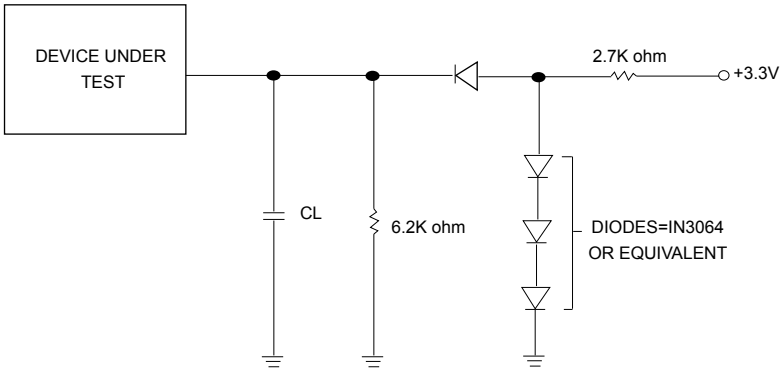
Symbol	Parameter	Min.	Typ.	Max.	Unit	Conditions
CIN	Input Capacitance			6	pF	VIN = 0V
COUT	Output Capacitance			8	pF	VOUT = 0V

Figure 80. Data Input Test Waveforms and Measurement Level



Note: Input pulse rise and fall time are <2.4ns

Figure 81. Output Loading



CL=30/15pF Including jig capacitance

Figure 82. SCLK TIMING DEFINITION

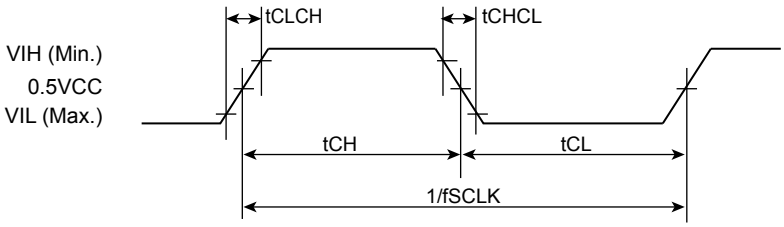


Table 19. DC Characteristics

Temperature = -40°C to 85°C for Industrial grade

Symbol	Parameter	Notes	Min.	Typ.	Max.	Units	Test Conditions
ILI	Input Load Current	1			± 2	uA	VCC = VCC Max, VIN = VCC or GND
ILO	Output Leakage Current	1			± 2	uA	VCC = VCC Max, VOUT = VCC or GND
ISB1	VCC Standby Current	1		10	50	uA	VIN = VCC or GND, CS# = VCC
ISB2	Deep Power-down Current			3	20	uA	VIN = VCC or GND, CS# = VCC
ICC1	VCC Read	1		2.5	5	mA	f=50MHz, SCLK=0.1VCC/0.9VCC, SO=Open
				10	17	mA	fQ=133MHz (4 x I/O read) SCLK=0.1VCC/0.9VCC, SO=Open
ICC2	VCC Program Current (PP)	1		10	15	mA	Program in Progress, CS# = VCC
ICC3	VCC Write Status Register (WRSR) Current			10	15	mA	Program status register in progress, CS#=VCC
ICC4	VCC Sector Erase Current (SE)	1		10	15	mA	Erase in Progress, CS#=VCC
ICC5	VCC Chip Erase Current (CE)	1		10	15	mA	Erase in Progress, CS#=VCC
VIL	Input Low Voltage		-0.5		0.8	V	
VIH	Input High Voltage		0.7VCC		VCC+0.4	V	
VOL	Output Low Voltage				0.4	V	IOL = 1.6mA
VOH	Output High Voltage		VCC-0.2			V	IOH = -100uA

Notes :
1. Typical values at VCC = 3.3V, T = 25°C. These currents are valid for all product versions (package and speeds).
2. Typical value is calculated by simulation.
3. The value guaranteed by characterization, not 100% tested in production.

Table 20. AC Characteristics

Temperature = -40°C to 85°C for Industrial grade

Symbol	Alt.	Parameter			Min.	Typ.	Max.	Unit
fSCLK	fC	Clock Frequency for the following instructions: FAST_READ, PP, SE, BE32K, BE, CE, RES, WREN, WRDI, RDID, RDSR, WRSR			D.C.		133	MHz
fTSCLK	fT	Clock Frequency for 2READ/DREAD instructions			Please refer to *"Table 8. Dummy Cycles and Frequency Table (MHz)"*			MHz
	fQ	Clock Frequency for 4READ/QREAD instructions						MHz
f4PP		Clock Frequency for 4PP (Quad page program)					133	MHz
fRSCLK	fR	Clock Frequency for READ instructions					50	MHz
tCH[1]	tCLH	Clock High Time	Others (fSCLK/fTSCLK)	> 50MHz	45% x (1/fSCLK)			ns
					45% x (1/fTSCLK)			ns
				≤ 50MHz	9			ns
			Normal Read (fRSCLK)		9			ns
tCL[1]	tCLL	Clock Low Time	Others (fSCLK/fTSCLK)	> 50MHz	45% x (1/fSCLK)			ns
					45% x (1/fTSCLK)			ns
				≤ 50MHz	9			ns
			Normal Read (fRSCLK)		9			ns
tCLCH[2]		Clock Rise Time (peak to peak)			0.1			V/ns
tCHCL[2]		Clock Fall Time (peak to peak)			0.1			V/ns
tSLCH	tCSS	CS# Active Setup Time (relative to SCLK)			4			ns
tCHSL		CS# Not Active Hold Time (relative to SCLK)			4			ns
tDVCH	tDSU	Data In Setup Time			2			ns
tCHDX	tDH	Data In Hold Time			3			ns
tCHSH		CS# Active Hold Time (relative to SCLK)			4			ns
tSHCH		CS# Not Active Setup Time (relative to SCLK)			4			ns
tSHSL	tCSH	CS# Deselect Time	From Read to next Read		15			ns
			From Write/Erase/Program to Read Status Register		50			ns
tSHQZ[2]	tDIS	Output Disable Time	2.65V-3.6V				10	ns
			3.0V-3.6V				8	ns
tHLCH		HOLD# Setup Time (relative to SCLK)			5			ns
tCHHH		HOLD# Hold Time (relative to SCLK)			5			ns
tHHCH		HOLD Setup Time (relative to SCLK)			5			ns
tCHHL		HOLD Hold Time (relative to SCLK)			5			ns
tHHQX	tLZ	HOLD to Output Low-Z Loading=30pF	2.65V-3.6V				10	ns
			3.0V-3.6V				8	ns
tHLQZ	tHZ	HOLD# to Output High-Z Loading=30pF	2.65V-3.6V				10	ns
			3.0V-3.6V				8	ns
tCLQV	tV	Clock Low to Output Valid VCC=2.65V-3.6V	Loading: 15pF				6	ns
			Loading: 30pF				8	ns
tCLQX	tHO	Output Hold Time			1			ns
tWHSL[3]		Write Protect Setup Time			20			ns
tSHWL[3]		Write Protect Hold Time			100			ns
tESL[4]		Erase Suspend Latency					20	us
tPSL[4]		Program Suspend Latency					20	us
tPRS[5]		Latency between Program Resume and next Suspend			0.3	100		us
tERS[6]		Latency between Erase Resume and next Suspend			0.3	200		us

AC Characteristics - Continued:

Symbol	Alt.	Parameter	Min.	Typ.	Max.	Unit
tRCR		Recovery Time from Read	20			us
tRCP		Recovery Time from Program	20			us
tRCE		Recovery Time from Erase	12			ms
tDP		CS# High to Deep Power-down Mode			10	us
tRES1		CS# High to Standby Mode without Electronic Signature Read			100	us
tRES2		CS# High to Standby Mode with Electronic Signature Read			100	us
tW		Write Status Register Cycle Time			40	ms
tBP		Byte-Program		10	280	us
tPP		Page Program Cycle Time		0.33	2.4	ms
tSE		Sector Erase Cycle Time (4KB)		25	400	ms
tBE32K		Block Erase Cycle Time (32KB)		0.14/ 0.05(7)	0.85	s
tBE		Block Erase Cycle Time (64KB)		0.25/ 0.09(7)	1.6	s
tCE		Chip Erase Cycle Time		3(7)	17.5	s
tWSR		Write Security Register Time			1	ms

Notes:

1. *tCH + tCL must be greater than or equal to 1/ fC.*
2. *The value guaranteed by characterization, not 100% tested in production.*
3. *Only applicable as a constraint for a WRSR instruction when SRWD is set at 1.*
4. *Latency time is required to complete Erase/Program Suspend operation until WIP bit is "0".*
5. *For tPRS, minimum timing must be observed before issuing the next program suspend command. However, a period equal to or longer than the typical timing is required in order for the program operation to make progress.*
6. *For tERS, minimum timing must be observed before issuing the next erase suspend command. However, a period equal to or longer than the typical timing is required in order for the erase operation to make progress.*
7. *Blank to Blank pattern.*

13. TIMING ANALYSIS

Figure 83. Serial Input Timing

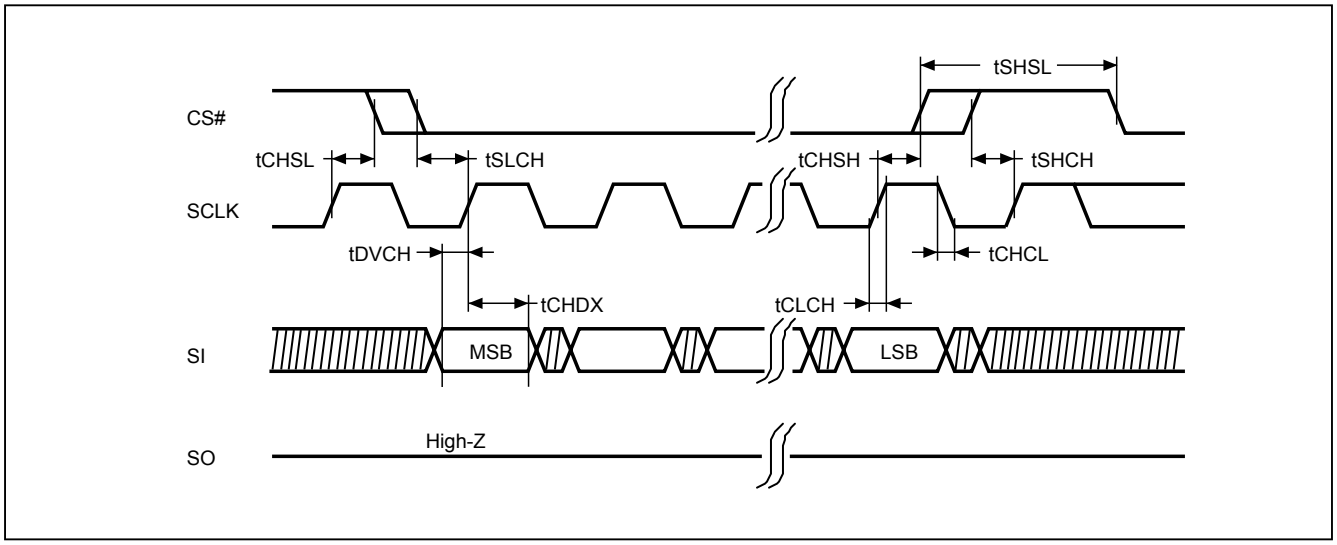


Figure 84. Output Timing

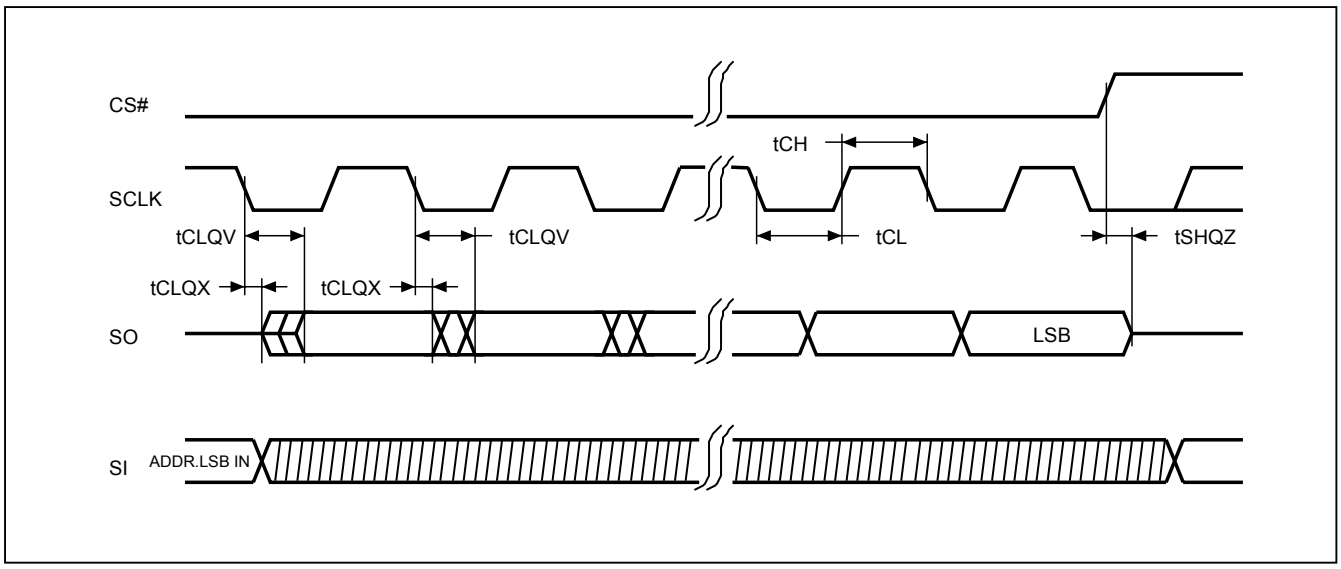


Figure 85. Hold Timing

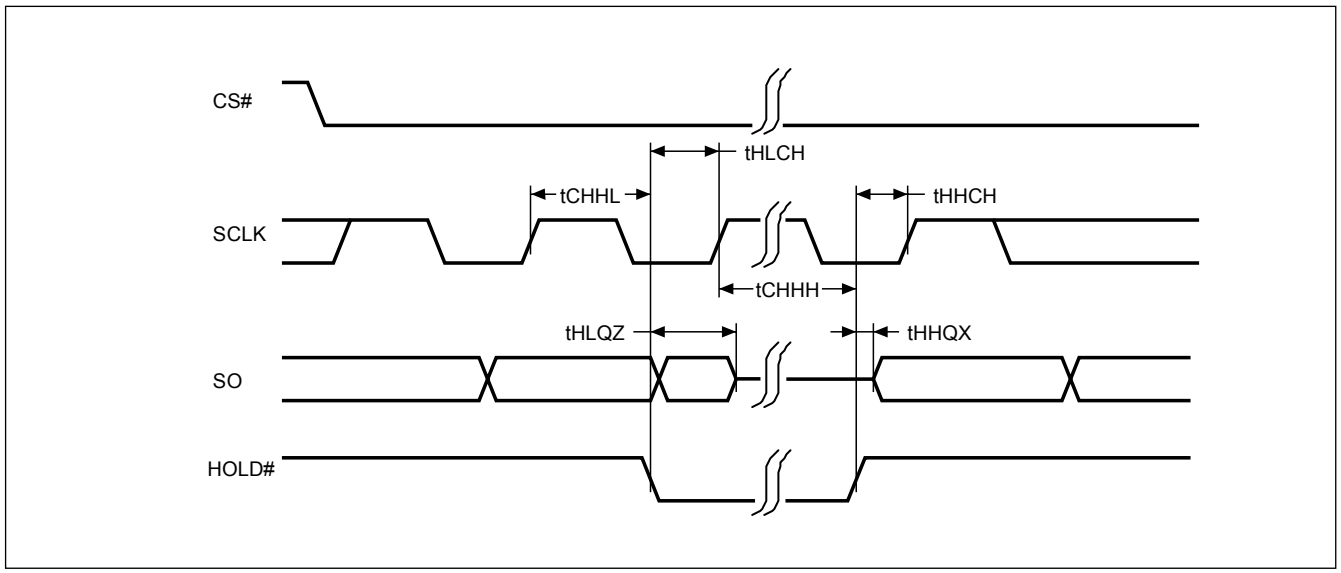
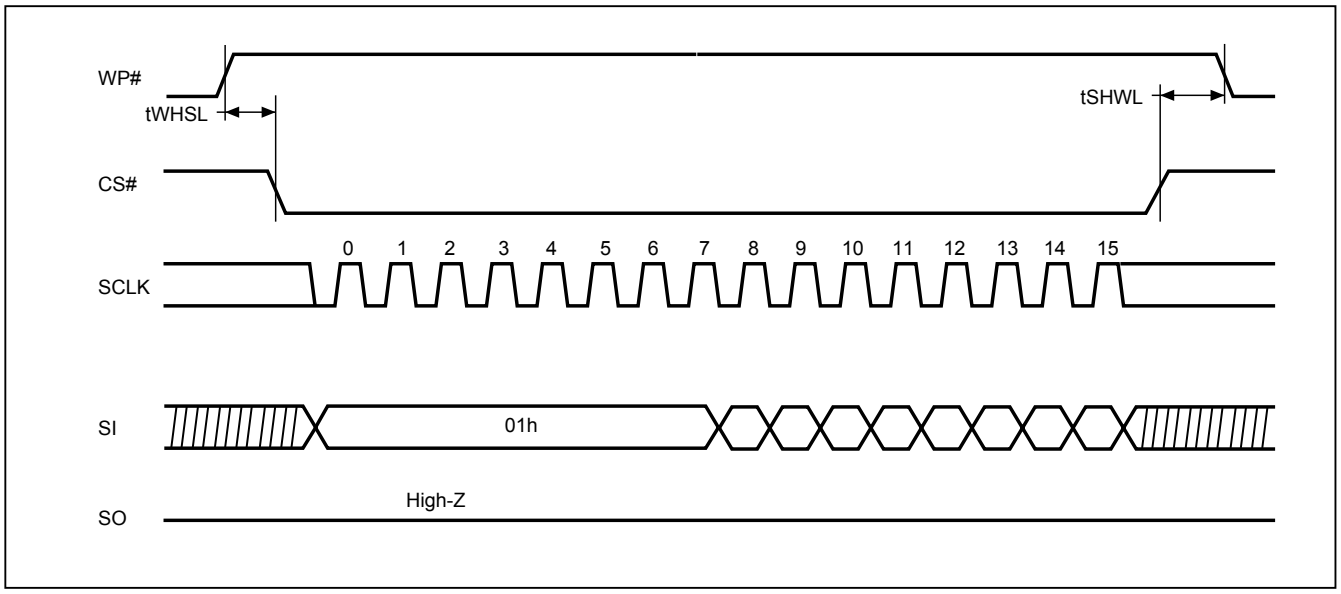


Figure 86. WP# Setup Timing and Hold Timing during WRSR when SRWD=1



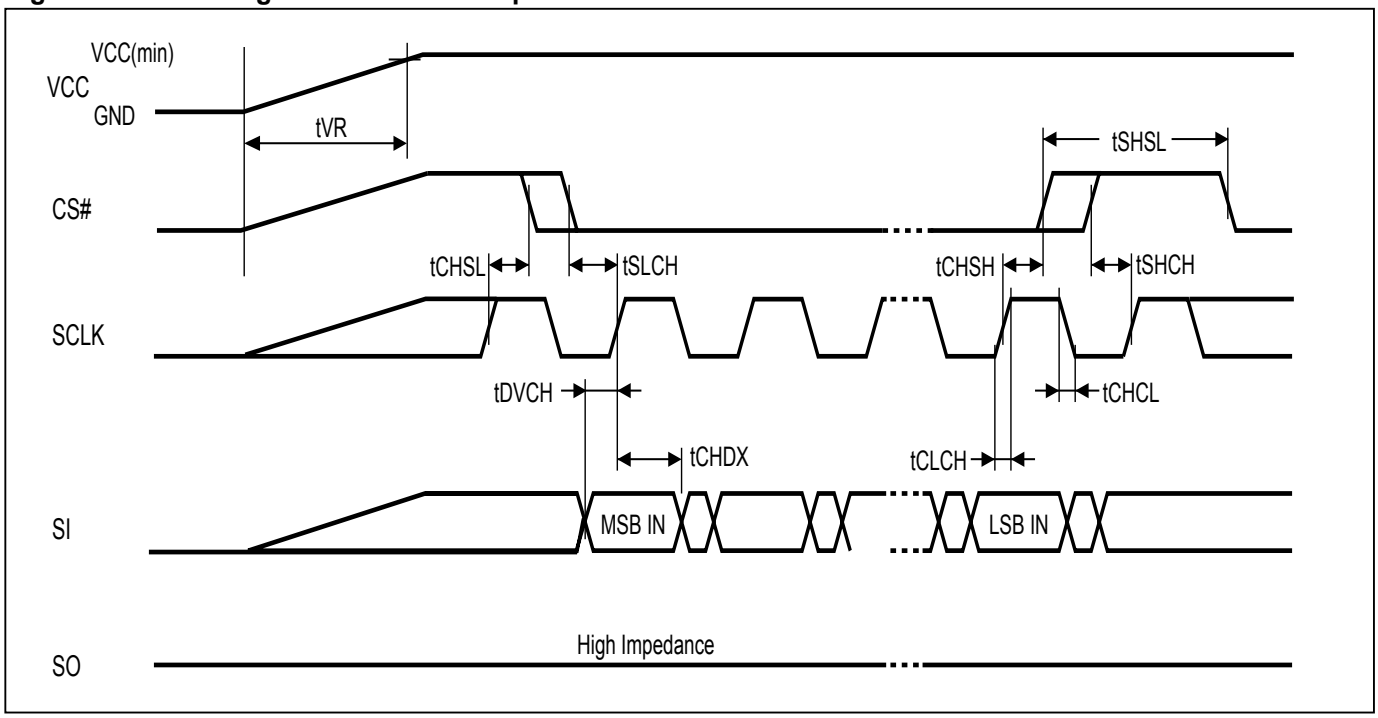
14. OPERATING CONDITIONS

At Device Power-Up and Power-Down

AC timing illustrated in *"Figure 87. AC Timing at Device Power-Up"* and *"Figure 88. Power-Down Sequence"* are for the supply voltages and the control signals at device power-up and power-down. If the timing in the figures is ignored, the device will not operate correctly.

During power-up and power-down, CS# needs to follow the voltage applied on VCC to keep the device not to be selected. The CS# can be driven low when VCC reach Vcc(min.) and wait a period of tVSL.

Figure 87. AC Timing at Device Power-Up



Symbol	Parameter	Notes	Min.	Max.	Unit
tVR	VCC Rise Time	1		500000	us/V

Notes :
1. Sampled, not 100% tested.
2. For AC spec tCHSL, tSLCH, tDVCH, tCHDX, tSHSL, tCHSH, tSHCH, tCHCL, tCLCH in the figure, please refer to *"Table 20. AC Characteristics"*.

Figure 88. Power-Down Sequence

During power-down, CS# needs to follow the voltage drop on VCC to avoid mis-operation.

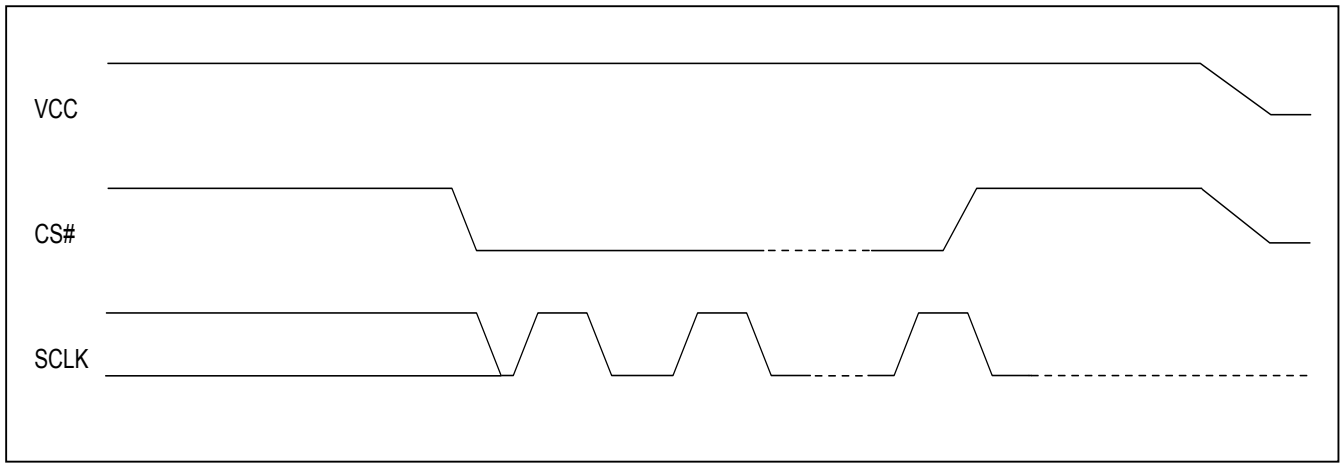


Figure 89. Power-up Timing

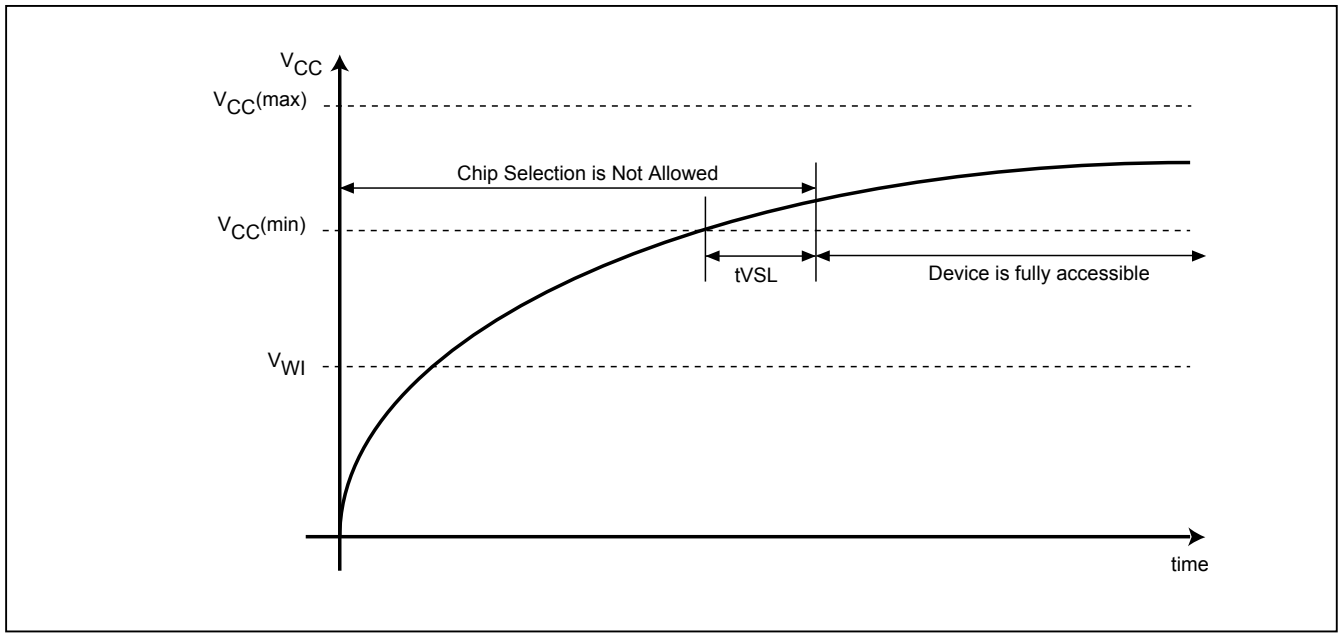


Figure 90. Power Up/Down and Voltage Drop

When powering down the device, VCC must drop below V_{PWD} for at least tPWD to ensure the device will initialize correctly during power up. Please refer to *"Figure 90. Power Up/Down and Voltage Drop"* and *"Table 21. Power-Up/Down Voltage and Timing"* below for more details.

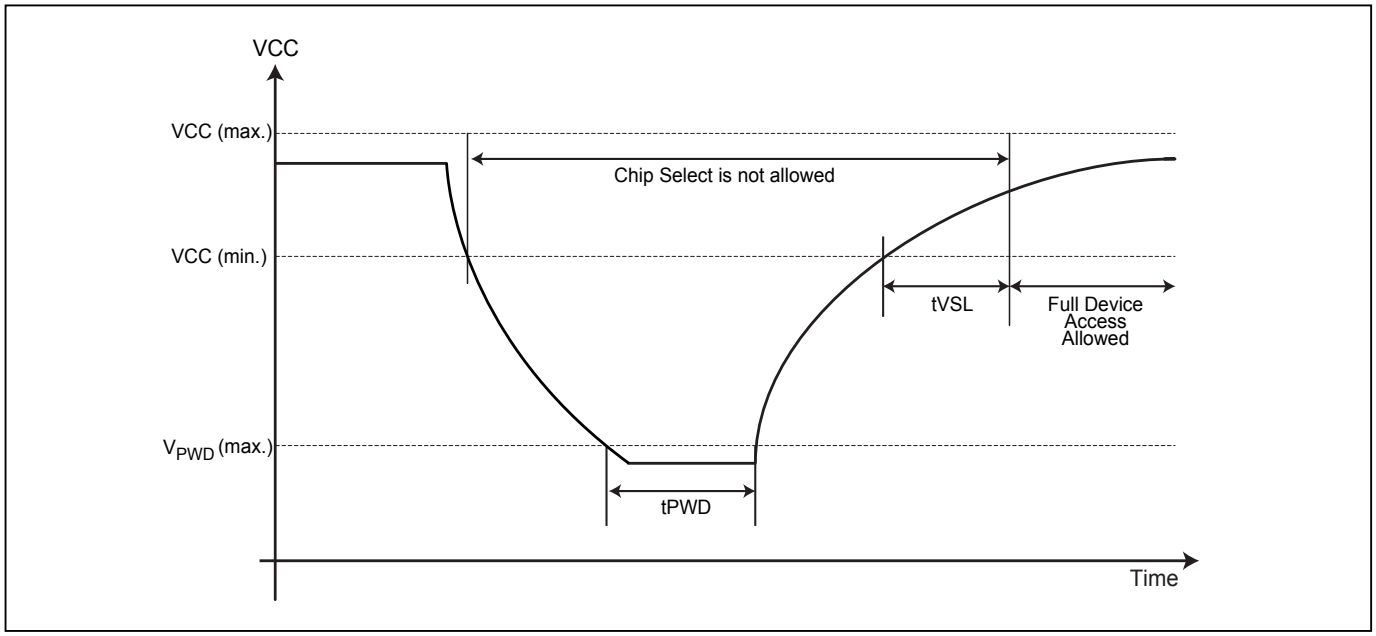


Table 21. Power-Up/Down Voltage and Timing

Symbol	Parameter	Min.	Max.	Unit
tVSL	VCC(min.) to device operation	800		us
VWI	Write Inhibit Voltage	1.5	2.5	V
V_{PWD}	VCC voltage needed to below V_{PWD} for ensuring initialization will occur		0.9	V
tPWD	The minimum duration for ensuring initialization will occur	300		us
VCC	VCC Power Supply	2.65	3.6	V

Note: These parameters are characterized only.

14-1. Initial Delivery State

The device is delivered with the memory array erased: all bits are set to 1 (each byte contains FFh). The Status Register contains 00h (all Status Register bits are 0).

15. ERASE AND PROGRAMMING PERFORMANCE

Parameter	Typ.(1)	Max.(2)	Unit
Write Status Register Cycle Time		40	ms
Sector Erase Time (4KB)	25	400	ms
Block Erase Time (32KB)	0.14/0.05(4)	0.85	s
Block Erase Time (64KB)	0.25/0.09(4)	1.6	s
Chip Erase Time	3(4)	17.5	s
Byte Program Time (via page program command)	10	280	us
Page Program Time	0.33	2.4	ms
Erase/Program Cycle	100,000		cycles

Notes:
1. Typical program and erase time assumes the following conditions: 25°C, 3.3V, and checkerboard pattern.
2. Under worst conditions of 2.65V, highest operation temperature, post program/erase cycling and random code pattern.
3. System-level overhead is the time required to execute the first-bus-cycle sequence for the programming command.
4. Blank to Blank pattern.

16. ERASE AND PROGRAMMING PERFORMANCE (Factory Mode)

Parameter	Min.	Typ.	Max.	Unit
Sector Erase Cycle Time (4KB)		11.8		ms
Block Erase Cycle Time (32KB)		0.095/0.03(4)		s
Block Erase Cycle Time (64KB)		0.19/0.07(4)		s
Chip Erase Cycle Time		3(4)		s
Page Program Time		0.19		ms
Erase/Program Cycle			50	cycles

Notice:
1. Factory Mode must be operated in 20°C to 45°C and VCC 3.0V-3.6V.
2. In Factory mode, the Erase/Program operation should not exceed 50 cycles, and "ERASE AND PROGRAMMING PERFORMANCE" 100k cycles will not be affected.
3. During factory mode, Suspend command (B0h) cannot be executed.
4. Blank to Blank pattern.

17. DATA RETENTION

Parameter	Condition	Min.	Max.	Unit
Data retention	55˚C	20		years

18. LATCH-UP CHARACTERISTICS

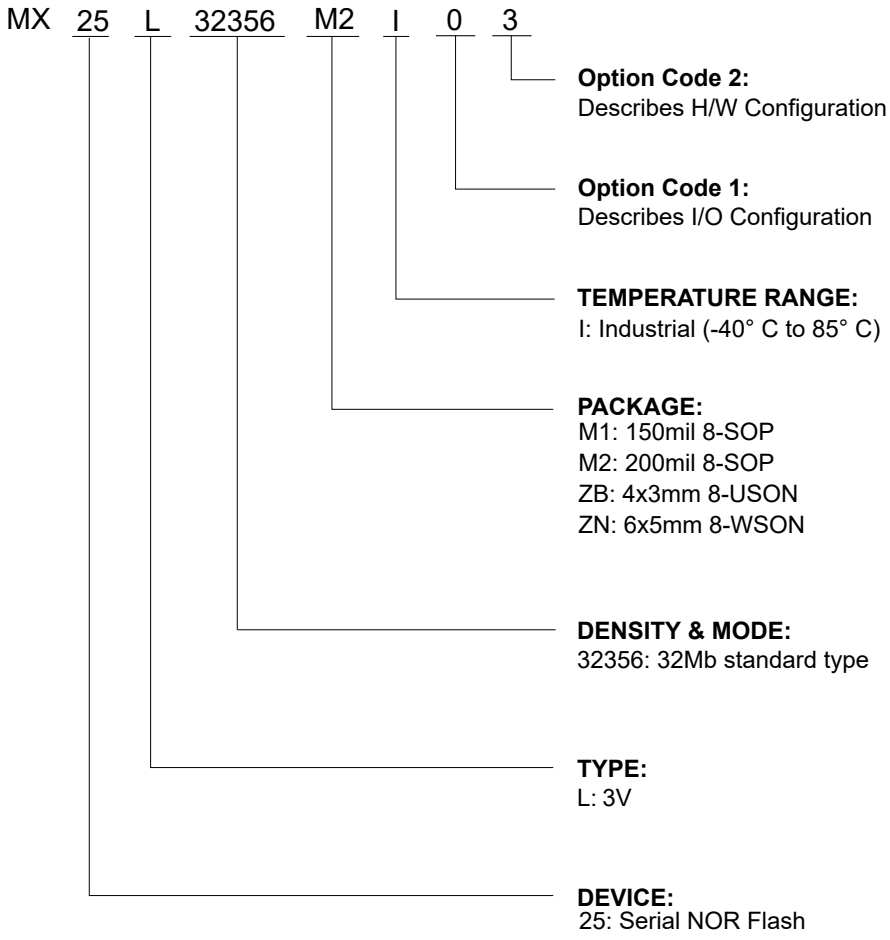
	Min.	Max.
Input Voltage with respect to GND on all power pins		1.5 VCCmax
Input Current on all non-power pins	-100mA	+100mA
Test conditions: VCC = VCCmax, one pin at a time (compliant to JEDEC JESD78 standard).		

19. ORDERING INFORMATION

Please contact Macronix regional sales for the latest product selection and available form factors.

PART NO.	CLOCK (MHz)	TEMPERATURE	PACKAGE	Remark
MX25L32356M2I03	133	-40°C to 85°C	8-SOP (200mil)	
MX25L32356M1I03	133	-40°C to 85°C	8-SOP (150mil)	
MX25L32356ZBI03	133	-40°C to 85°C	8-USON (4x3mm)	
MX25L32356ZNI03	133	-40°C to 85°C	8-WSON (6x5mm)	

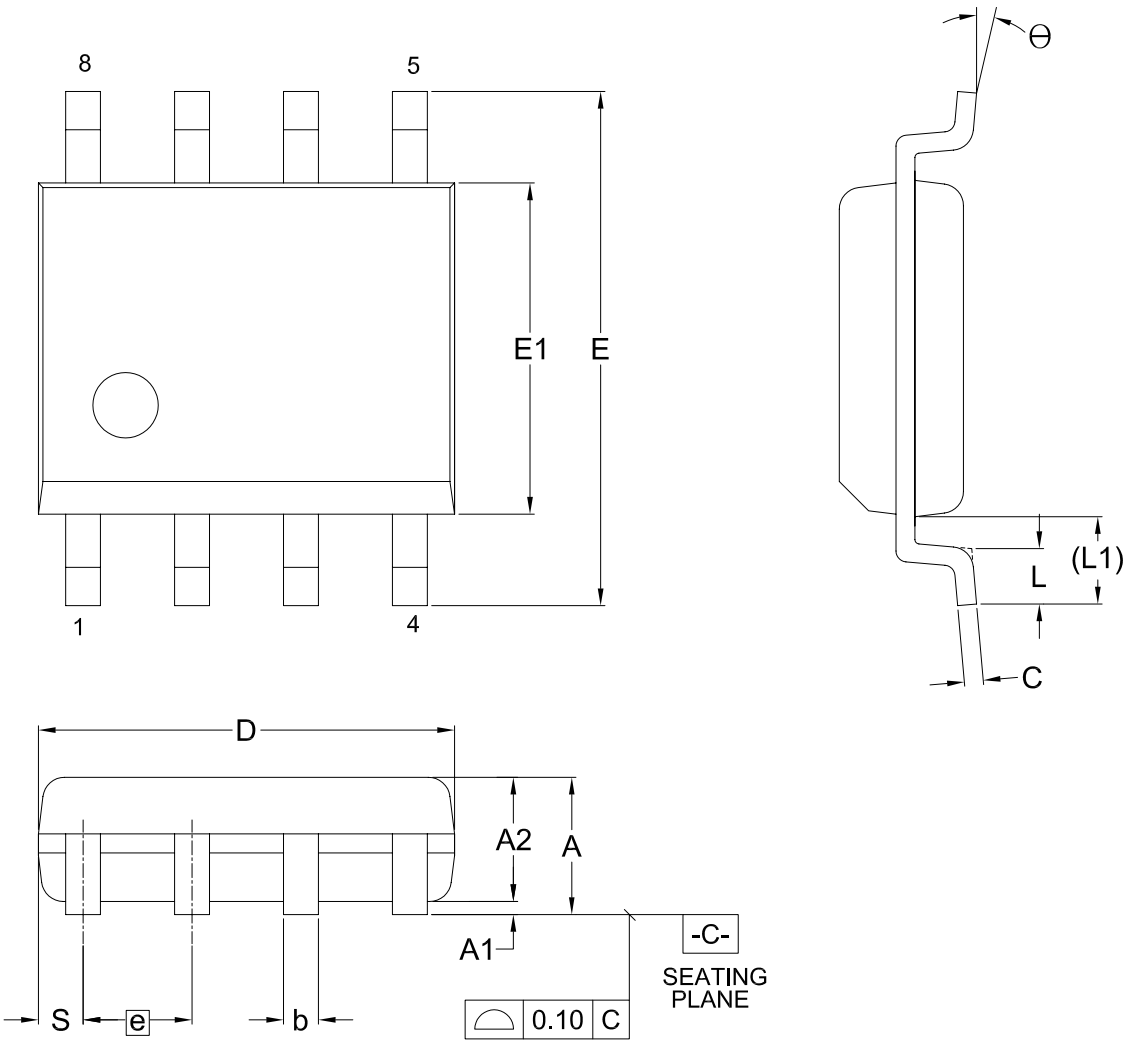
20. PART NAME DESCRIPTION



21. PACKAGE INFORMATION

21-1. 8-pin SOP (150mil)

Doe. Title: Package Outline for SOP 8L (150MIL)

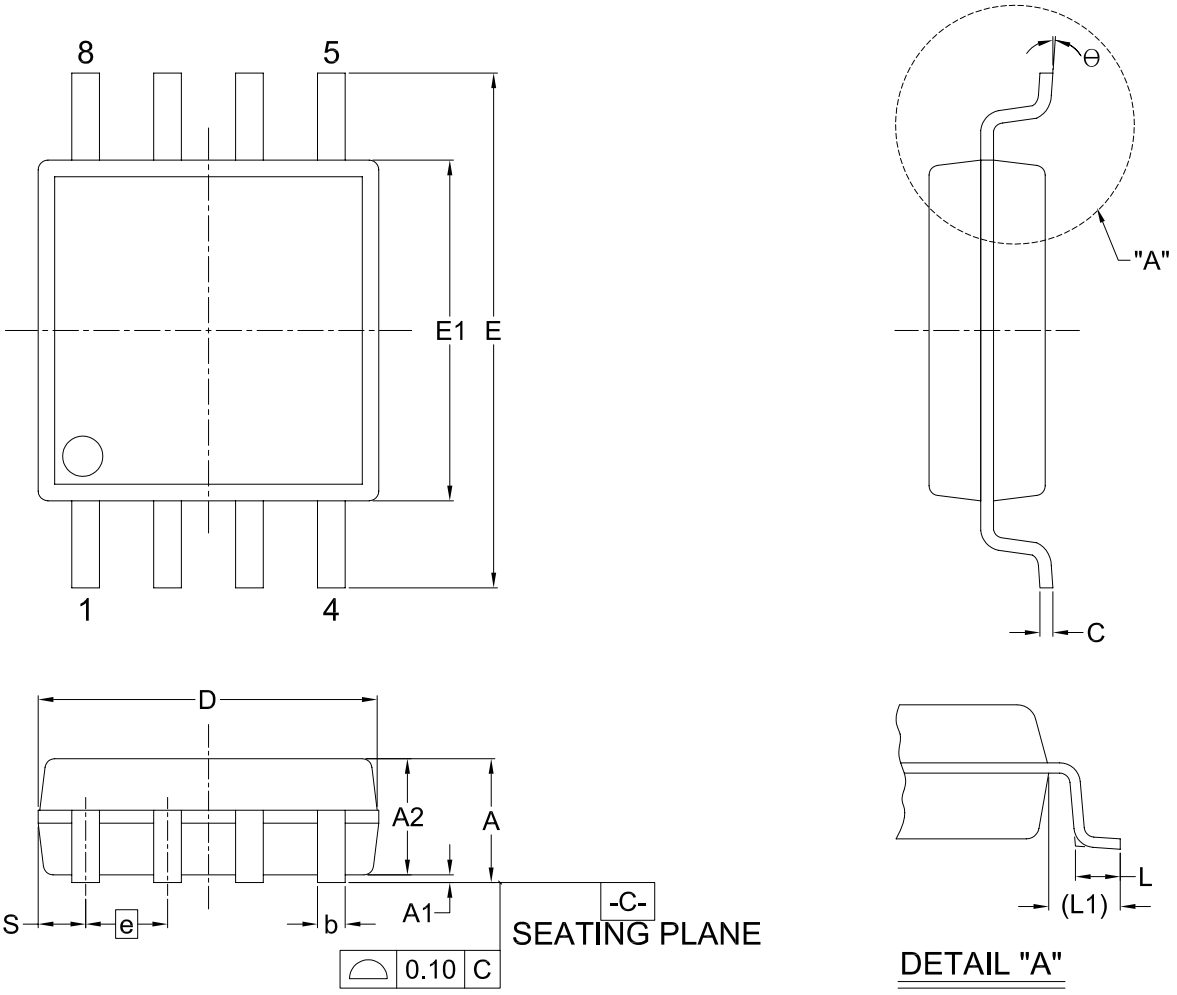


Dimensions (inch dimensions are derived from the original mm dimensions)

SYMBOL / UNIT		A	A1	A2	b	C	D	E	E1	e	L	L1	S	θ
mm	Min.	—	0.10	1.35	0.36	0.15	4.77	5.80	3.80	—	0.46	0.85	0.41	0°
	Nom.	—	0.15	1.45	0.41	0.20	4.90	5.99	3.90	1.27	0.66	1.05	0.54	5°
	Max.	1.75	0.20	1.55	0.51	0.25	5.03	6.20	4.00	—	0.86	1.25	0.67	8°
Inch	Min.	—	0.004	0.053	0.014	0.006	0.188	0.228	0.150	—	0.018	0.033	0.016	0°
	Nom.	—	0.006	0.057	0.016	0.008	0.193	0.236	0.154	0.050	0.026	0.041	0.021	5°
	Max.	0.069	0.008	0.061	0.020	0.010	0.198	0.244	0.158	—	0.034	0.049	0.026	8°

21-2. 8-pin SOP (200mil)

Doc. Title: Package Outline for SOP 8L 200MIL

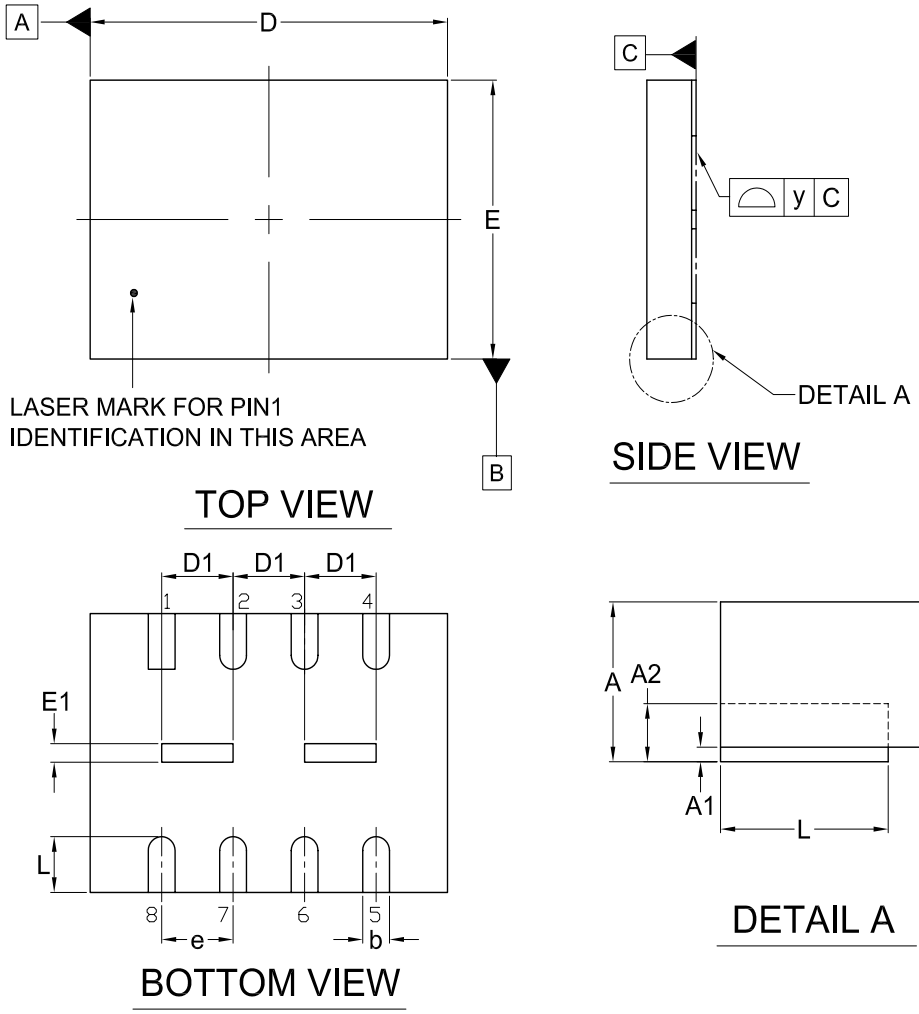


Dimensions (inch dimensions are derived from the original mm dimensions)

SYMBOL / UNIT		A	A1	A2	b	C	D	E	E1	e	L	L1	S	θ
mm	Min.	1.75	0.05	1.70	0.36	0.19	5.13	7.70	5.18	—	0.50	1.21	0.62	0°
	Nom.	1.95	0.15	1.80	0.41	0.20	5.23	7.90	5.28	1.27	0.65	1.31	0.74	5°
	Max.	2.16	0.20	1.91	0.51	0.25	5.33	8.10	5.38	—	0.80	1.41	0.88	8°
Inch	Min.	0.069	0.002	0.067	0.014	0.007	0.202	0.303	0.204	—	0.020	0.048	0.024	0°
	Nom.	0.077	0.006	0.071	0.016	0.008	0.206	0.311	0.208	0.050	0.026	0.052	0.029	5°
	Max.	0.085	0.008	0.075	0.020	0.010	0.210	0.319	0.212	—	0.031	0.056	0.035	8°

21-3. 8-land USON (4x3mm)

Package Outline for USON 8L (4x3x0.60MM, LEAD PITCH 0.8MM)



Note:

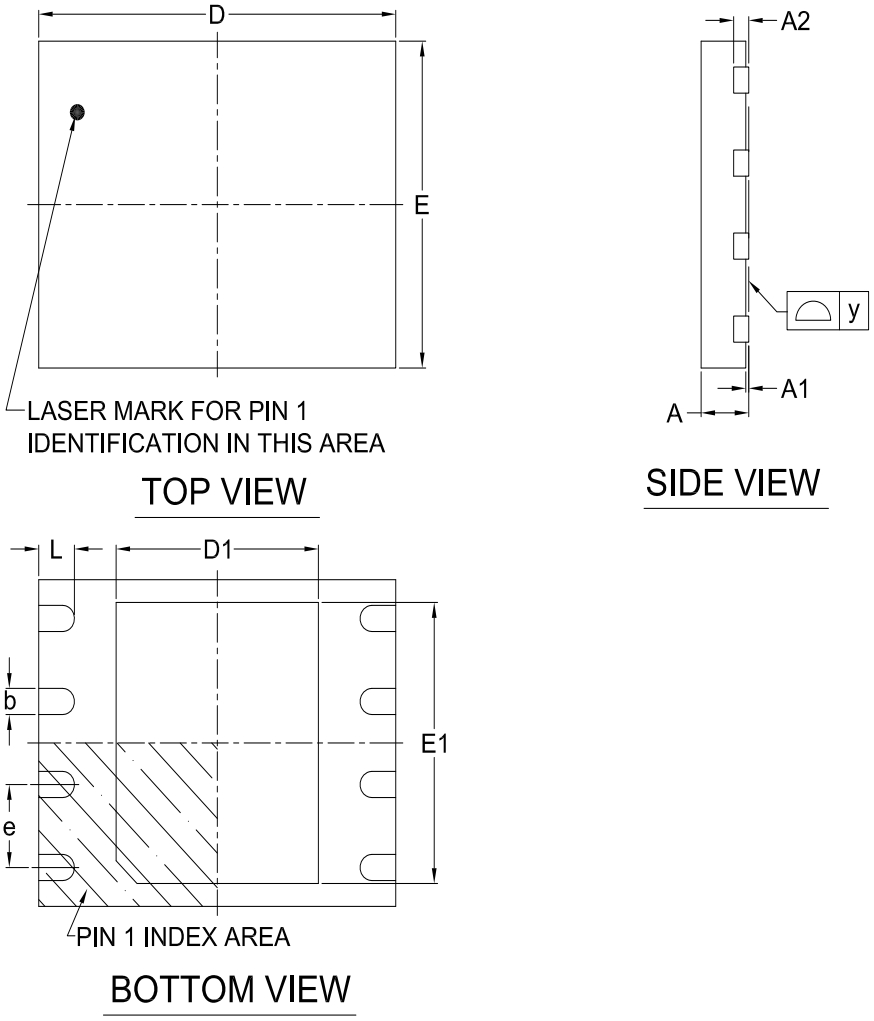
This package has an exposed metal pad underneath the package. It is recommended to leave the metal pad floating or to connect it to the same ground as the GND pin of the package. Do not connect the metal pad to any other voltage or signal line on the PCB. Avoid placing vias or traces underneath the metal pad. Connection of this metal pad to any other voltage or signal line can result in shorts and/or electrical malfunction of the device.

Dimensions (inch dimensions are derived from the original mm dimensions)

SYMBOL / UNIT		A	A1	A2	b	D	D1	E	E1	L	e	y
mm	Min.	0.50	---	---	0.25	3.90	0.70	2.90	0.10	0.55	---	0.00
	Nom.	0.55	0.02	0.15	0.30	4.00	0.80	3.00	0.20	0.60	0.80	---
	Max.	0.60	0.05	---	0.35	4.10	0.90	3.10	0.30	0.65	---	0.08
Inch	Min.	0.020	---	---	0.010	0.154	0.028	0.114	0.004	0.022	---	0.00
	Nom.	0.022	0.001	0.006	0.011	0.158	0.032	0.118	0.008	0.024	0.031	---
	Max.	0.024	0.002	---	0.014	0.161	0.035	0.122	0.012	0.026	---	0.003

21-4. 8-WSON (6x5mm)

Doc. Title: Package Outline for WSON 8L (6x5x0.8MM, LEAD PITCH 1.27MM)



Note:

This package has an exposed metal pad underneath the package. It is recommended to leave the metal pad floating or to connect it to the same ground as the GND pin of the package. Do not connect the metal pad to any other voltage or signal line on the PCB. Avoid placing vias or traces underneath the metal pad. Connection of this metal pad to any other voltage or signal line can result in shorts and/or electrical malfunction of the device.

Dimensions (inch dimensions are derived from the original mm dimensions)

SYMBOL / UNIT		A	A1	A2	b	D	D1	E	E1	L	e	y
mm	Min.	0.70	---	---	0.35	5.90	3.35	4.90	3.95	0.55	---	0.00
	Nom.	---	---	0.20	0.40	6.00	3.40	5.00	4.00	0.60	1.27	---
	Max.	0.80	0.05	---	0.48	6.10	3.45	5.10	4.05	0.65	---	0.05
Inch	Min.	0.028	---	---	0.014	0.232	0.132	0.193	0.156	0.022	---	0.00
	Nom.	---	---	0.008	0.016	0.236	0.134	0.197	0.157	0.024	0.05	---
	Max.	0.032	0.002	---	0.019	0.240	0.136	0.201	0.159	0.026	---	0.002

22. REVISION HISTORY

Revision	Descriptions	Page
May 06, 2021		
0.00	1. Initial Release.	All
July 27, 2021		
0.01	1. Added QPI Mode.	All
	2. Added Factory mode.	P18, 22, 49-51, P90
	3. Added WPSEL and Advanced Sector Protection.	P9, 17-19, 42-46, 48, 63-71
	4. Added *"10-38. In-Band-Reset"* information.	P76
	5. Modified General Feature descriptions.	P5
	6. Added two I/O read mode descriptions in General Descriptions.	P6
	7. Revised Secured OTP mode descriptions.	P60-61
	8. Description modifications.	P11, 43-44, 63, P91
	9. Added *"Table 7. Output Driver Strength Table"* and modified *"Table 8. Dummy Cycles and Frequency Table (MHz)"*.	P28, 83
	10. Format modifications of *"Table 4. Command Sets"*, *"10-34. Program Suspend and Erase Suspend"* and *"10-35. Program Resume and Erase Resume"*.	P17-19, 73-74
	11. Modified RES descriptions.	P55, 59
September 07, 2021		
0.02	1. Modified FAST_READ descriptions.	P32
	2. Revised *"Table 6. Configuration Register"* and *"Table 8. Dummy Cycles and Frequency Table (MHz)"*.	P27-28
	3. Modified the descripitons on the cover page.	P1
	4. Description modifications.	P54
	5. Revised Command Code of SBL	P18
	6. Modified Block Erase Cycle Time-32KB (Factory Mode) values	P90
January 06, 2022		
0.03	1. Changed document status as "PRELIMINARY".	ALL
	2. Modified *"8. DEVICE OPERATION"* descriptions.	P13
	3. Modified Command Sets Table of FAST READ, 2READ, DREAD, 4READ, QREAD and RDSFDP	P17,18
	4. Modified FAST_READ (QPI Mode) Dummy Cycles	P17,28,32,33
	5. Added Notes of *"Figure 21. Read at Higher Speed (FAST_READ) Sequence (Command 0Bh) (QPI Mode)"*	P33
	6. Modified *"12-1. Absolute Maximum Ratings"* table	P80
	7. Content correction.	P34,38,51,74
April 14, 2022		
0.04	1. Modified tBP, tPP, tSE, tBE32K, tBE and tCE values	P84,90
	2. Modified note 2 description of Erase and Programming Performance table	P90
	3. Corrected Data Byte number of RDSCUR	P18
	4. Content correction.	P76

Revision	Descriptions	Page
July 01, 2022		
0.05	1. Modified tBE32K, tBE, tCE values and added notes	P84,90
	2. Corrected "Performance Enhance Mode - XIP (execute-in-place)" description	P39
August 01, 2022		
1.0	1. Removed "PRELIMINARY" to align with the product status.	ALL
	2. Modified tBE(typ.) value	P84,90
	3. Description modifications.	P76

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