# MX25L12873F

# DATASHEET

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**3V 128M-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
- Single Power Supply Operation
  - 2.7 to 3.6 volt for read, erase, and program operations
- 128Mb: 134,217,728 x 1 bit structure or 67,108,864 x 2 bits (two I/O mode) structure or 33,554,432 x 4 bits (four I/O mode) structure
- Protocol Support
  - Single I/O, Dual I/O and Quad I/O
- Latch-up protected to 100mA from -1V to Vcc +1V
- Fast read for SPI mode
  - Support clock frequency up to 133MHz for all protocols
  - Support Fast Read, 2READ, DREAD, 4READ, QREAD instructions.
  - Configurable dummy cycle number for fast read operation
- Default Quad I/O enable (QE bit=1), and can not be change
- Quad Peripheral Interface (QPI) available
- Equal Sectors with 4K byte each, or Equal Blocks with 32K byte each or Equal Blocks with 64K byte each
  - Any Block can be erased individually
- Programming :
  - 256byte page buffer
  - Quad Input/Output page program(4PP) to enhance program performance
- 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 bit defines the size of the area to be protection against program and erase instructions
  - Advanced sector protection function (Solid and Password Protect)
- Additional 4K bit security OTP
  - Features unique identifier
  - factory locked identifiable, and customer lockable
- Command Reset
- Program/Erase Suspend and Resume operation
- Electronic Identification
  - JEDEC 1-byte manufacturer ID and 2-byte device ID
  - RES command for 1-byte Device ID
  - REMS command for 1-byte manufacturer ID and 1-byte device ID
- Support Serial Flash Discoverable Parameters (SFDP) mode

### HARDWARE FEATURES

- SCLK Input
  - Serial clock input



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- SI/SIO0
  - Serial Data Input or Serial Data Input/Output for 2 x I/O read mode and 4 x I/O read mode
- SO/SIO1
  - Serial Data Output or Serial Data Input/Output for 2 x I/O read mode and 4 x I/O read mode
- SIO2
  - Serial data Input & Output for 4 x I/O read mode
- SIO3
  - Serial data input & Output for 4 x I/O read mode
- PACKAGE
  - 8-pin SOP (200mil)
  - 16-pin SOP (300mil)
  - 8-land WSON (6x5mm)
  - **All devices are RoHS Compliant and Halogen-free**

## 2. GENERAL DESCRIPTION

MX25L12873F is 128Mb bits serial Flash memory, which is configured as 16,777,216 x 8 internally. When it is in two or four I/O mode, the structure becomes 67,108,864 bits x 2 or 33,554,432 bits x 4. MX25L12873F feature 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.

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 four I/O read mode, the SI pin, SO pin, become SIO0 pin, SIO1 pin, SIO2 pin and SIO3 pin for address/dummy bits input and data output.

The MX25L12873F MXSMIO® (Serial Multi I/O) provides sequential read operation on whole chip.

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, or word basis for erase command is executed on sector (4K-byte), block (32K-byte), or block (64K-byte), 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 see security features section for more details.

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

The MX25L12873F utilizes Macronix's proprietary memory cell, which reliably stores memory contents even after 100,000 program and erase cycles.

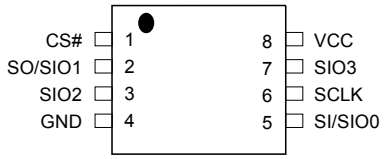
**Table 1. Read performance Comparison**

| Numbers of Dummy Cycles | Fast Read (MHz) | Dual Output Fast Read (MHz) | Quad Output Fast Read (MHz) | Dual IO Fast Read (MHz) | Quad IO Fast Read (MHz) |
|---|---|---|---|---|---|
| 4 | - | - | - | 84* | 70 |
| 6 | 104 | 104 | 84 | 104 | 84* |
| 8 | 104* | 104* | 104* | 104 | 104 |
| 10 | 133 | 133 | 133 | 133 | 133 |

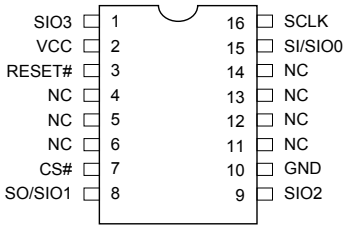
**Note:** * mean default status

## 3. PIN CONFIGURATIONS

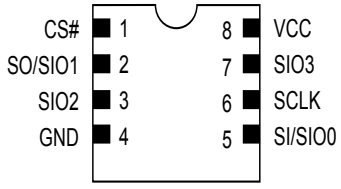
### 8-PIN SOP (200mil)




### 16-PIN SOP (300mil)




### 8-WSON (6mmx5mm)



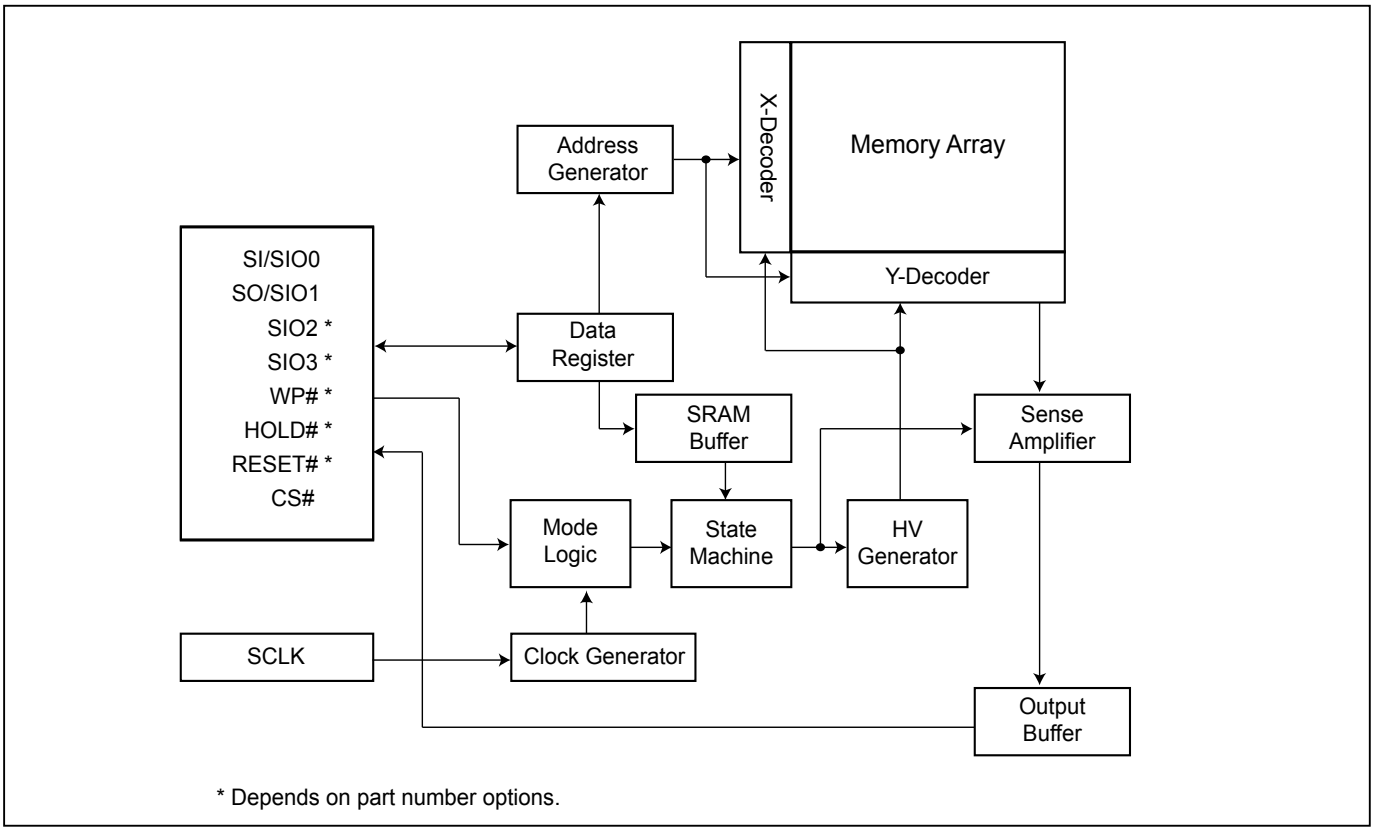

## 4. PIN DESCRIPTION

| SYMBOL | DESCRIPTION |
|---|---|
| CS# | Chip Select |
| SI/SIO0 | Serial Data Input (for 1 x I/O)/ Serial Data Input & Output (for 2xI/O or 4xI/O read mode) |
| SO/SIO1 | Serial Data Output (for 1 x I/O)/ Serial Data Input & Output (for 2xI/O or 4xI/O read mode) |
| SCLK | Clock Input |
| SIO2 | Serial Data Input & Output (for 4xI/O read mode) |
| SIO3 | Serial Data Input & Output (for 4xI/O read mode) |
| RESET# | Hardware Reset Pin Active low |
| VCC | + 3V Power Supply |
| GND | Ground |
| NC | No Connection |

Note:
1. RESET# pin has internal pull up.


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## 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 command 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), and softreset command.
- 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) use (BP3, BP2, BP1, BP0 and T/B) bits to allow part of memory to be protected as read only. The protected area definition is shown as *"Table 2. Protected Area Sizes"*, the protected areas are more flexible which may protect various area by setting value of BP0-BP3 bits.
- In four I/O and QPI mode, the feature of HPM will be disabled.

**Table 2. Protected Area Sizes**

**Protected Area Sizes (T/B bit = 0)**

| Status bit | | | | Protect Level |
|---|---|---|---|---|
| BP3 | BP2 | BP1 | BP0 | 128Mb |
| 0 | 0 | 0 | 0 | 0 (none) |
| 0 | 0 | 0 | 1 | 1 (1 block, protected block 255th) |
| 0 | 0 | 1 | 0 | 2 (2 blocks, block 254th-255th) |
| 0 | 0 | 1 | 1 | 3 (4 blocks, block 252nd-255th) |
| 0 | 1 | 0 | 0 | 4 (8 blocks, block 248th-255th) |
| 0 | 1 | 0 | 1 | 5 (16 blocks, block 240th-255th) |
| 0 | 1 | 1 | 0 | 6 (32 blocks, block 224th-255th) |
| 0 | 1 | 1 | 1 | 7 (64 blocks, block 192nd-255th) |
| 1 | 0 | 0 | 0 | 8 (128 blocks, block 128th-255th) |
| 1 | 0 | 0 | 1 | 9 (256 blocks, protected all) |
| 1 | 0 | 1 | 0 | 10 (256 blocks, protected all) |
| 1 | 0 | 1 | 1 | 11 (256 blocks, protected all) |
| 1 | 1 | 0 | 0 | 12 (256 blocks, protected all) |
| 1 | 1 | 0 | 1 | 13 (256 blocks, protected all) |
| 1 | 1 | 1 | 0 | 14 (256 blocks, protected all) |
| 1 | 1 | 1 | 1 | 15 (256 blocks, protected all) |

**Protected Area Sizes (T/B bit = 1)**

| Status bit | | | | Protect Level |
|---|---|---|---|---|
| BP3 | BP2 | BP1 | BP0 | 128Mb |
| 0 | 0 | 0 | 0 | 0 (none) |
| 0 | 0 | 0 | 1 | 1 (1 block, protected block 0th) |
| 0 | 0 | 1 | 0 | 2 (2 blocks, protected block 0th~1st) |
| 0 | 0 | 1 | 1 | 3 (4 blocks, protected block 0th~3rd) |
| 0 | 1 | 0 | 0 | 4 (8 blocks, protected block 0th~7th) |
| 0 | 1 | 0 | 1 | 5 (16 blocks, protected block 0th~15th) |
| 0 | 1 | 1 | 0 | 6 (32 blocks, protected block 0th~31st) |
| 0 | 1 | 1 | 1 | 7 (64 blocks, protected block 0th~63rd) |
| 1 | 0 | 0 | 0 | 8 (128 blocks, protected block 0th~127th) |
| 1 | 0 | 0 | 1 | 9 (256 blocks, protected all) |
| 1 | 0 | 1 | 0 | 10 (256 blocks, protected all) |
| 1 | 0 | 1 | 1 | 11 (256 blocks, protected all) |
| 1 | 1 | 0 | 0 | 12 (256 blocks, protected all) |
| 1 | 1 | 0 | 1 | 13 (256 blocks, protected all) |
| 1 | 1 | 1 | 0 | 14 (256 blocks, protected all) |
| 1 | 1 | 1 | 1 | 15 (256 blocks, protected all) |


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**II. Additional 4K-bit secured OTP** for unique identifier: to provide 4K-bit one-time program area for setting device unique serial number - Which may be set by factory or system customer.

- Security register bit 0 indicates whether the chip is locked by factory or not.

- To program the 4K-bit secured OTP by entering 4K-bit secured OTP mode (with Enter Security OTP command), and going through normal program procedure, and then exiting 4K-bit secured OTP mode by writing Exit Security OTP command.

- 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 9. Security Register Definition"* for security register bit definition and *"Table 3. 4K-bit Secured OTP Definition"* for address range definition.

- Note: Once lock-down whatever by factory or customer, it cannot be changed any more. While in 4K-bit secured OTP mode, array access is not allowed.

**Table 3. 4K-bit Secured OTP Definition**

| Address range | Size | Standard Factory Lock | Customer Lock |
|---|---|---|---|
| xxx000~xxx00F | 128-bit | ESN (electrical serial number) | Determined by customer |
| xxx010~xxx1FF | 3968-bit | N/A | |

## 7. Memory Organization

### Table 4. Memory Organization

| Block(64K-byte) | Block(32K-byte) | Sector | Address Range | |
|---|---|---|---|---|
| 255 | 511 | 4095 | FFF000h | FFFFFFh |
| | | ⋮ | | |
| | | 4088 | FF8000h | FF8FFFh |
| | 510 | 4087 | FF7000h | FF7FFFh |
| | | ⋮ | | |
| | | 4080 | FF0000h | FF0FFFh |
| 254 | 509 | 4079 | FEF000h | FEFFFFh |
| | | ⋮ | | |
| | | 4072 | FE8000h | FE8FFFh |
| | 508 | 4071 | FE7000h | FE7FFFh |
| | | ⋮ | | |
| | | 4064 | FE0000h | FE0FFFh |
| 253 | 507 | 4063 | FDF000h | FDFFFFh |
| | | ⋮ | | |
| | | 4056 | FD8000h | FD8FFFh |
| | 506 | 4055 | FD7000h | FD7FFFh |
| | | ⋮ | | |
| | | 4048 | FD0000h | FD0FFFh |
| 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 |

individual 16 sectors lock/unlock unit:4K-byte

individual block lock/unlock unit:64K-byte

individual block lock/unlock unit:64K-byte

individual block lock/unlock unit:64K-byte

individual 16 sectors lock/unlock unit:4K-byte

## 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 incorrect command is inputted to this device, this device becomes standby mode and keeps the standby mode until next CS# falling edge. In standby mode, SO pin of this device should be High-Z.

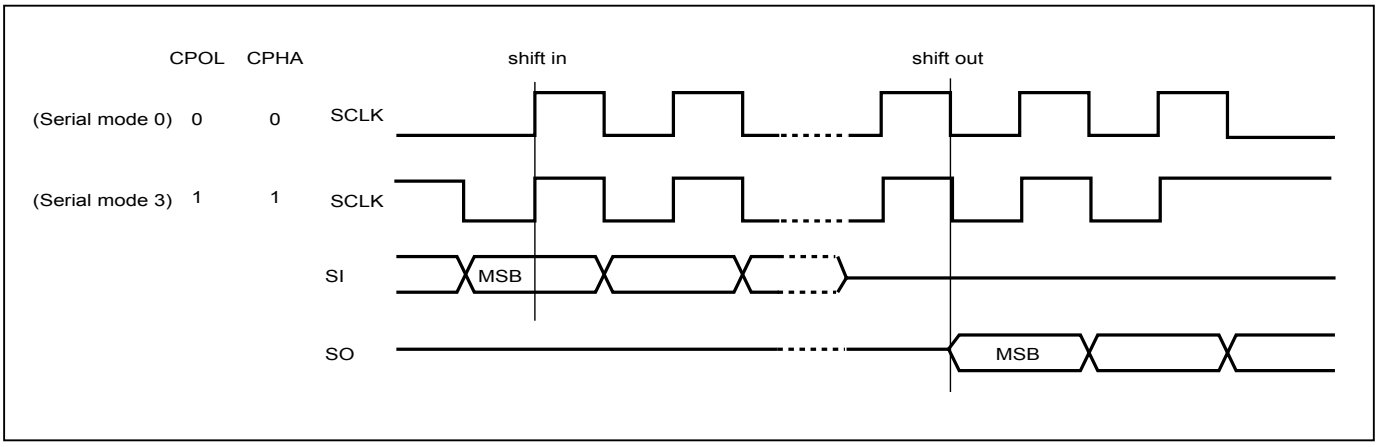
3. When correct command is inputted to this device, this device becomes active mode and keeps the active mode until next CS# rising edge.

4. Input data is latched on the rising edge of Serial Clock (SCLK) and data shifts out on the falling edge of SCLK. The difference of Serial mode 0 and mode 3 is shown as "Serial Modes Supported".

5. For the following instructions: RDID, RDSR, RDSCUR, READ, FAST_READ, 2READ, DREAD, 4READ, QREAD, RDSFDP, RES, REMS, QPIID, RDDPB, RDSPB, RDPASS, RDLR, RDFBR, RDSPBLK, RDCR 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: WREN, WRDI, WRSR, SE, BE32K, BE, CE, PP, 4PP, DP, ENSO, EXSO, WRSCUR, WPSEL, GBLK, GBULK, SPBLK, SUSPEND, RESUME, NOP, RSTEN, RST, EQIO, RSTQIO the CS# must go high exactly at the byte boundary; otherwise, the instruction will be rejected and not executed.

6. During the progress of Write Status Register, Program, Erase operation, to access the memory array is neglected and not affect the current operation of Write Status Register, Program, Erase.

**Figure 1. Serial Modes Supported**




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.

**Figure 2. Serial Input Timing**

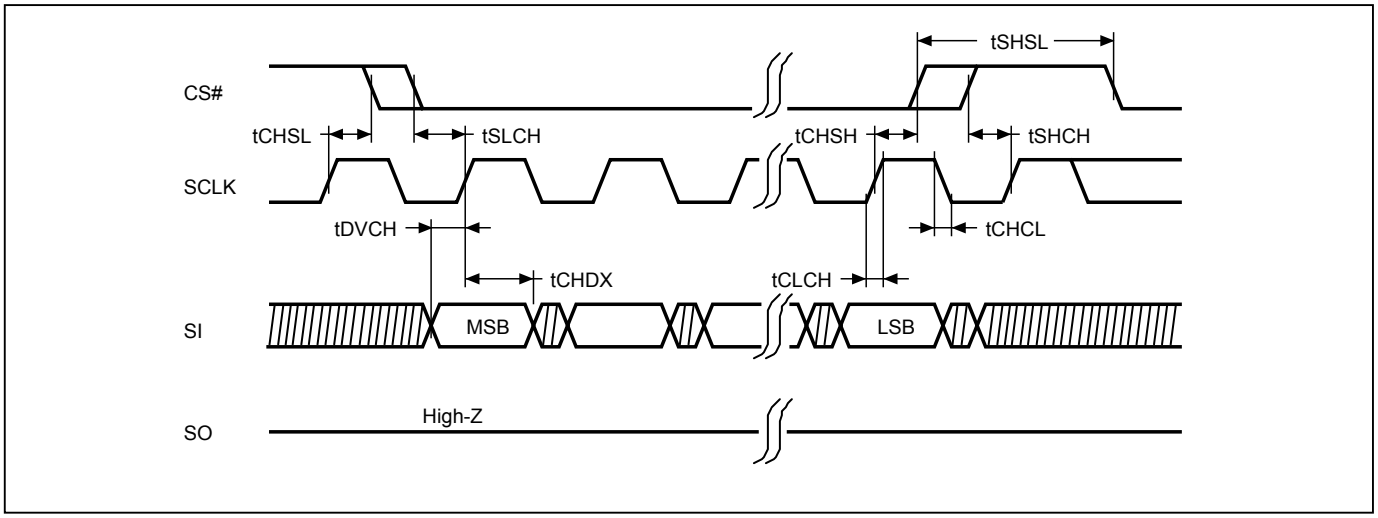
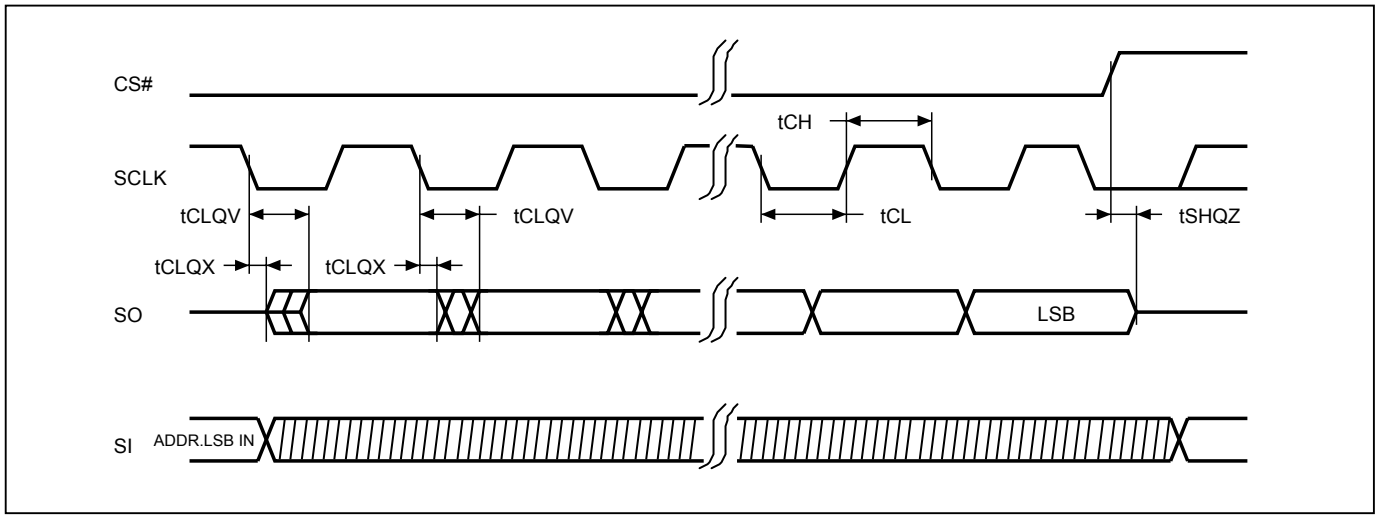



**Figure 3. Output Timing**



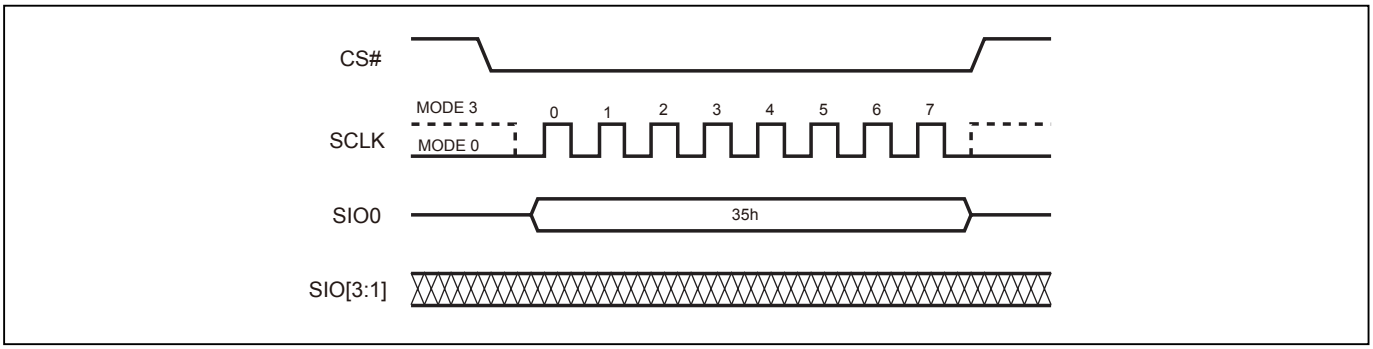
### 8-1. Quad Peripheral Interface (QPI) Read Mode

QPI protocol enables user to take full advantage of Quad I/O Serial 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 35H command, the QPI mode is enable. After QPI mode enable, the device enter quad mode (4-4-4) without QE bit status changed.

**Figure 4. Enable QPI Sequence**

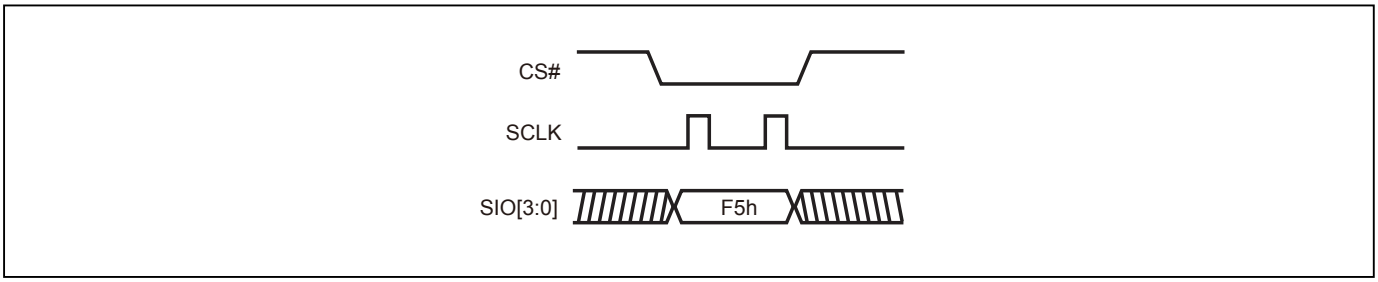



#### Reset QPI (RSTQIO)

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 "write spec" tSHSL for next instruction.

**Figure 5. Reset QPI Mode**



## 9. COMMAND DESCRIPTION

### Table 5. Command Set

**Read/Write Array Commands**

| Command (byte) | READ (normal read) | FAST READ (fast read data) | 2READ (2 x I/O read command) | DREAD (1I 2O read) | 4READ (4 I/O read) | QREAD (1I 4O read) |
|---|---|---|---|---|---|---|
| Mode | SPI | SPI | SPI | SPI | SPI/QPI | SPI |
| 1st byte | 03 (hex) | 0B (hex) | BB (hex) | 3B (hex) | EB (hex) | 6B (hex) |
| 2nd byte | ADD1 | ADD1 | ADD1 | ADD1 | ADD1 | ADD1 |
| 3rd byte | ADD2 | ADD2 | ADD2 | ADD2 | ADD2 | ADD2 |
| 4th byte | ADD3 | ADD3 | ADD3 | ADD3 | ADD3 | ADD3 |
| 5th byte | | Dummy* | Dummy* | Dummy* | Dummy* | Dummy* |
| Data Cycles | | | | | | |
| Action | n bytes read out until CS# goes high | n bytes read out until CS# goes high | n bytes read out by 2 x I/O until CS# goes high | n bytes read out by Dual output until CS# goes high | n bytes read out by 4 x I/O until CS# goes high | n bytes read out by Quad output until CS# goes high |

| Command (byte) | PP (page program) | 4PP (quad page program) | SE (sector erase) | BE 32K (block erase 32KB) | BE (block erase 64KB) | CE (chip erase) |
|---|---|---|---|---|---|---|
| Mode | SPI/QPI | SPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI |
| 1st byte | 02 (hex) | 38 (hex) | 20 (hex) | 52 (hex) | D8 (hex) | 60 or C7 (hex) |
| 2nd byte | | ADD1 | ADD1 | ADD1 | ADD1 | |
| 3rd byte | | ADD2 | ADD2 | ADD2 | ADD2 | |
| 4th byte | | ADD3 | ADD3 | ADD3 | ADD3 | |
| 5th byte | | | | | | |
| Data Cycles | 1-256 | 1-256 | | | | |
| Action | to program the selected page | quad input to program the selected page | to erase the selected sector | to erase the selected 32K block | to erase the selected block | to erase whole chip |

* Dummy cycle numbers will be different depending on the bit6 & bit 7 (DC0 & DC1) setting in configuration register.

## Register/Setting Commands

| Command (byte) | WREN (write enable) | WRDI (write disable) | RDSR (read status register) | RDCR (read configuration register) | WRSR (write status/ configuration register) | WPSEL (Write Protect Selection) | EQIO (Enable QPI) |
|---|---|---|---|---|---|---|---|
| Mode | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI |
| 1st byte | 06 (hex) | 04 (hex) | 05 (hex) | 15 (hex) | 01 (hex) | 68 (hex) | 35 (hex) |
| 2nd byte | | | | | Values | | |
| 3rd byte | | | | | Values | | |
| 4th byte | | | | | | | |
| 5th byte | | | | | | | |
| Data Cycles | | | | | 1-2 | | |
| Action | sets the (WEL) write enable latch bit | resets the (WEL) write enable latch bit | to read out the values of the status register | to read out the values of the configuration register | to write new values of the status/ configuration register | to enter and enable individal block protect mode | Entering the QPI mode |

| Command (byte) | RSTQIO (Reset QPI) | PGM/ERS Suspend (Suspends Program/ Erase) | PGM/ERS Resume (Resumes Program/ Erase) | DP (Deep power down) | RDP (Release from deep power down) | SBL (Set Burst Length) | RDFBR (read fast boot register) |
|---|---|---|---|---|---|---|---|
| Mode | QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI |
| 1st byte | F5 (hex) | B0 (hex) | 30 (hex) | B9 (hex) | AB (hex) | C0 (hex) | 16(hex) |
| 2nd byte | | | | | | | |
| 3rd byte | | | | | | | |
| 4th byte | | | | | | | |
| 5th byte | | | | | | | |
| Data Cycles | | | | | | | 1-4 |
| Action | Exiting the QPI mode | | | enters deep power down mode | release from deep power down mode | to set Burst length | |

| Command (byte) | WRFBR (write fast boot register) | ESFBR (erase fast boot register) |
|---|---|---|
| Mode | SPI | SPI |
| 1st byte | 17(hex) | 18(hex) |
| 2nd byte | | |
| 3rd byte | | |
| 4th byte | | |
| 5th byte | | |
| Data Cycles | 4 | |
| Action | | |


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## ID/Security Commands

| Command (byte) | RDID (read identific-ation) | RES (read electronic ID) | REMS (read electronic manufacturer & device ID) | QPIID (QPI ID Read) | RDSFDP | ENSO (enter secured OTP) | EXSO (exit secured OTP) |
|---|---|---|---|---|---|---|---|
| Mode | SPI | SPI/QPI | SPI | QPI | SPI/QPI | SPI/QPI | SPI/QPI |
| Address Bytes | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| 1st byte | 9F (hex) | AB (hex) | 90 (hex) | AF (hex) | 5A (hex) | B1 (hex) | C1 (hex) |
| 2nd byte | | x | x | | ADD1 | | |
| 3rd byte | | x | x | | ADD2 | | |
| 4th byte | | x | ADD1 (Note 1) | | ADD3 | | |
| 5th byte | | | | | Dummy (8) | | |
| Action | outputs JEDEC ID: 1-byte Manufacturer ID & 2-byte Device ID | to read out 1-byte Device ID | output the Manufacturer ID & Device ID | ID in QPI interface | Read SFDP mode | to enter the 4K-bit secured OTP mode | to exit the 4K-bit secured OTP mode |

| Command (byte) | RDSCUR (read security register) | WRSCUR (write security register) | GBLK (gang block lock) | GBULK (gang block unlock) | WRLR (write Lock register) | RDLR (read Lock register) | WRPASS (write password register) | RDPASS (read password register) |
|---|---|---|---|---|---|---|---|---|
| Mode | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI | SPI | SPI | SPI |
| Address Bytes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1st byte | 2B (hex) | 2F (hex) | 7E (hex) | 98 (hex) | 2C (hex) | 2D (hex) | 28 (hex) | 27 (hex) |
| 2nd byte | | | | | | | | |
| 3rd byte | | | | | | | | |
| 4th byte | | | | | | | | |
| 5th byte | | | | | | | | |
| Data Cycles | | | | | 2 | 2 | 1-8 | 1-8 |
| Action | to read value of security register | to set the lock-down bit as "1" (once lock-down, cannot be updated) | whole chip write protect | whole chip unprotect | | | | |

| Command (byte) | PASSULK (password unlock) | WRSPB (SPB bit program) | ESSPB (all SPB bit erase) | RDSPB (read SPB status) | SPBLK (SPB lock set) | RDSPBLK (SPB lock register read) | WRDPB (write DPB register) | RDDPB (read DPB register) |
|---|---|---|---|---|---|---|---|---|
| Mode | SPI | SPI | SPI | SPI | SPI | SPI | SPI | SPI |
| Address Bytes | 0 | 4 | 0 | 4 | 0 | 0 | 4 | 4 |
| 1st byte | 29 (hex) | E3 (hex) | E4 (hex) | E2 (hex) | A6 (hex) | A7 (hex) | E1 (hex) | E0 (hex) |
| 2nd byte | | ADD1 | | ADD1 | | | ADD1 | ADD1 |
| 3rd byte | | ADD2 | | ADD2 | | | ADD2 | ADD2 |
| 4th byte | | ADD3 | | ADD3 | | | ADD3 | ADD3 |
| 5th byte | | ADD4 | | ADD4 | | | ADD4 | ADD4 |
| Data Cycles | 8 | | | 1 | | 2 | 1 | 1 |
| Action | | | | | | | | |


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### Reset Commands

| Command (byte) | NOP (No Operation) | RSTEN (Reset Enable) | RST (Reset Memory) |
|---|---|---|---|
| Mode | SPI/QPI | SPI/QPI | SPI/QPI |
| 1st byte | 00 (hex) | 66 (hex) | 99 (hex) |
| 2nd byte | | | |
| 3rd byte | | | |
| 4th byte | | | |
| 5th byte | | | |
| Action | | | |

Note 1: The count base is 4-bit for ADD(2) and Dummy(2) because of 2 x I/O. And the MSB is on SO/SIO1 which is different from 1 x I/O condition.
Note 2: ADD=00H will output the manufacturer ID first and AD=01H will output device ID first.
Note 3: It is not recommended to adopt any other code not in the command definition table, which will potentially enter the hidden mode.
Note 4: Before executing RST command, RSTEN command must be executed. If there is any other command to interfere, the reset operation will be disabled.
Note 5: The number in parentheses after "ADD" or "Data" stands for how many clock cycles it has. For example, "Data(8)" represents there are 8 clock cycles for the data in.


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### 9-1. Write Enable (WREN)

The Write Enable (WREN) instruction is for setting Write Enable Latch (WEL) bit. For those instructions like PP, 4PP, SE, BE32K, BE, CE, and WRSR, which are intended to change the device content WEL bit should be set every time after the WREN instruction setting the WEL bit.

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

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

**Figure 6. Write Enable (WREN) Sequence (SPI Mode)**

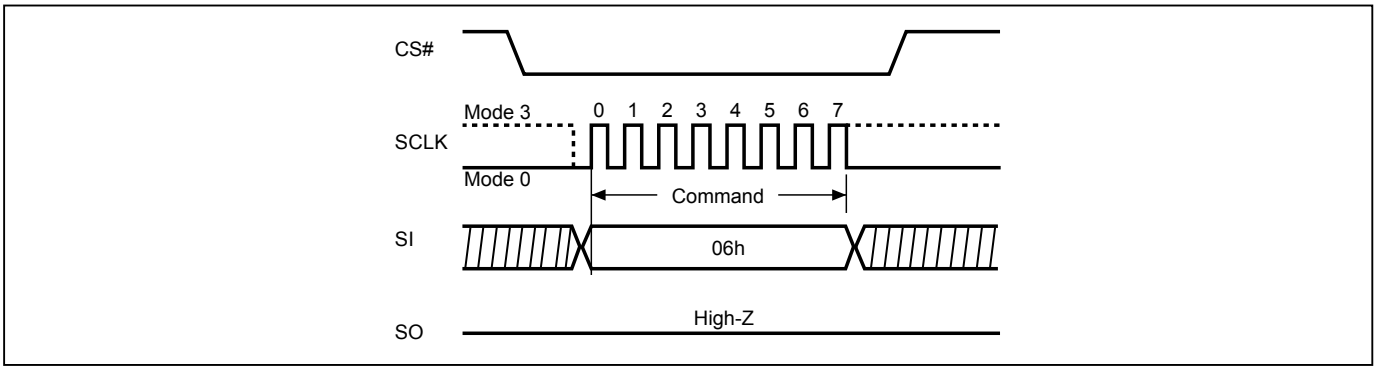
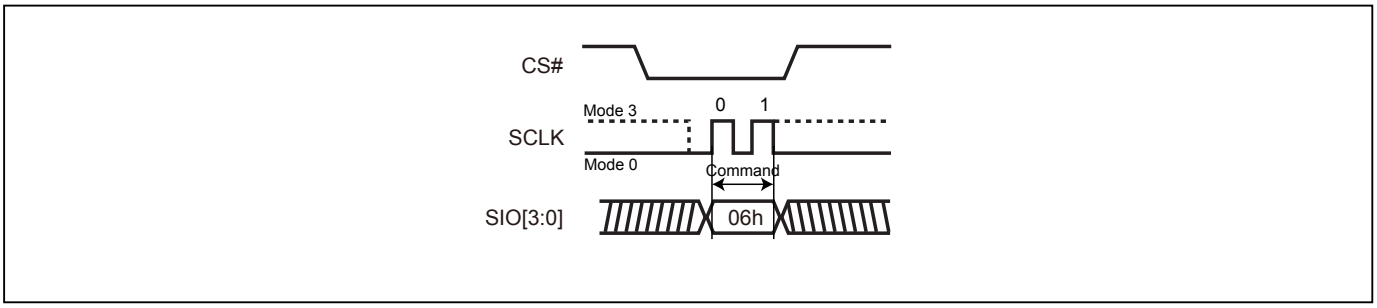



**Figure 7. Write Enable (WREN) Sequence (QPI Mode)**



### 9-2. Write Disable (WRDI)

The Write Disable (WRDI) instruction is to reset Write Enable Latch (WEL) bit.

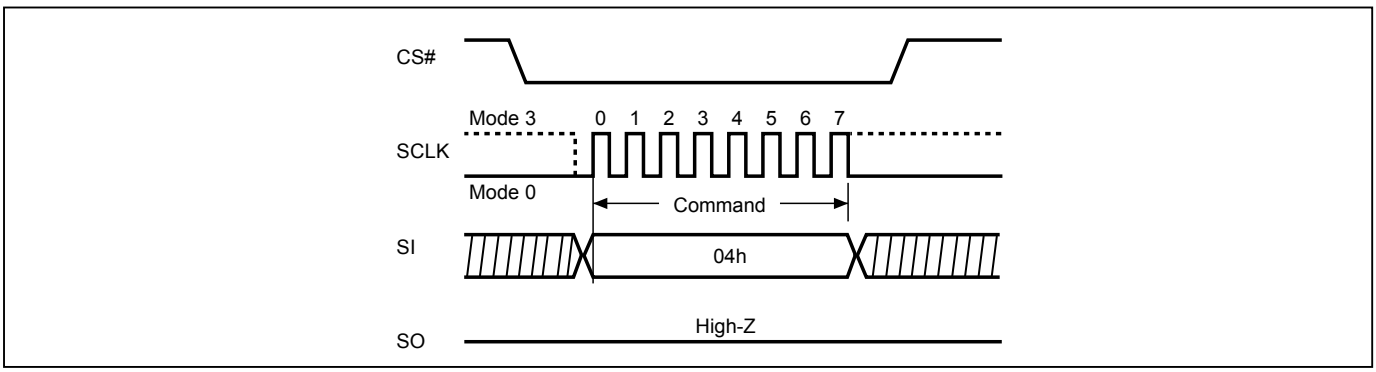
The sequence of issuing WRDI instruction is: CS# goes low→sending WRDI instruction code→CS# goes high.

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

The WEL bit is reset by following situations:

- Power-up
- Reset# pin driven low
- 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
- WPSEL command completion
- GBLK command completion
- GBULK command completion
- WRLR command completion
- WRPASS command completion
- PASSULK command completion
- SPBLK command completion
- WRSPB command completion
- ESSPB command completion
- WRDPB command completion
- WRFBR command completion
- ESFBR command completion

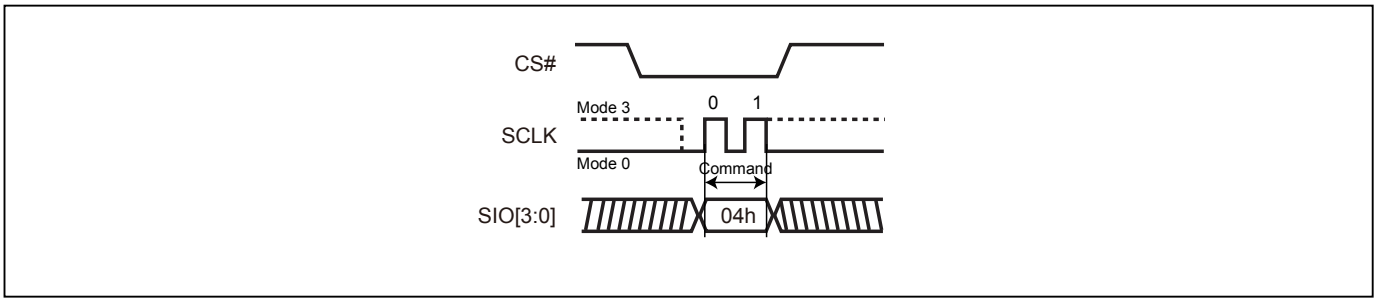
**Figure 8. Write Disable (WRDI) Sequence (SPI Mode)**





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**Figure 9. Write Disable (WRDI) Sequence (QPI Mode)**



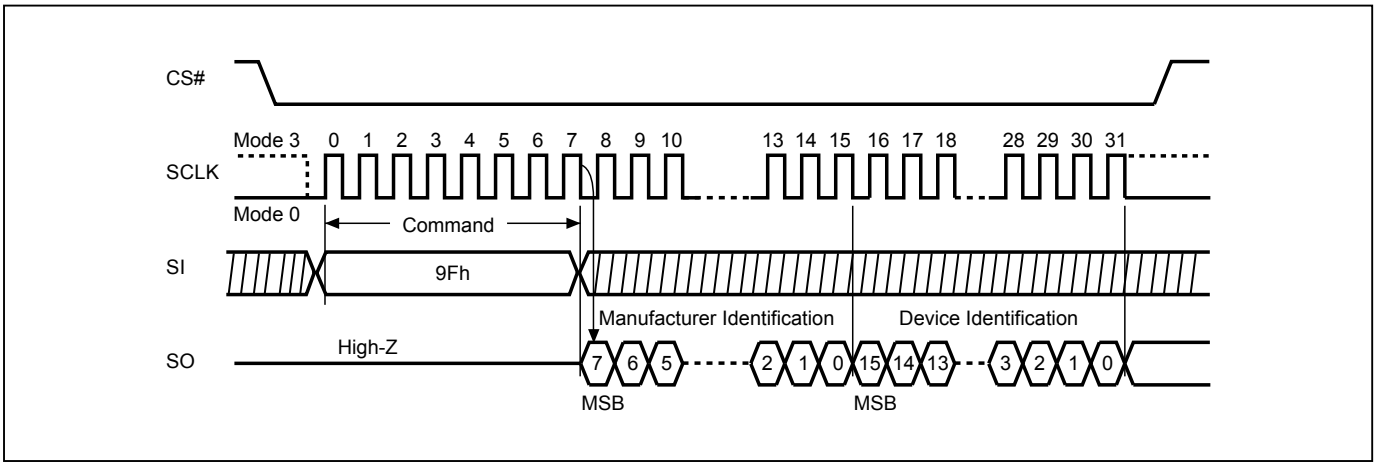

### 9-3. Read Identification (RDID)

The RDID instruction is for reading the manufacturer ID of 1-byte and followed by Device ID of 2-byte. The Macronix Manufacturer ID and Device ID are listed as *"Table 6. ID Definitions"*.

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

While Program/Erase operation is in progress, it will not decode the RDID instruction, therefore 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 10. Read Identification (RDID) Sequence (SPI mode only)**



### 9-4. 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 Stand-by Power mode. If the device was not previously in the Deep Power-down mode, the transition to the Stand-by Power mode is immediate. If the device was previously in the Deep Power-down mode, though, the transition to the Stand-by Power mode is delayed by tRES2, and Chip Select (CS#) must remain High for at least tRES2(max), as specified in *"Table 18. AC CHARACTERISTICS"*. Once in the Stand-by Power mode, the device waits to be selected, so that it can receive, decode and execute instructions. The RDP instruction is only for releasing from Deep Power Down Mode. Reset# pin goes low will release the Flash from deep power down mode.

RES instruction is for reading out the old style of 8-bit Electronic Signature, whose values are shown as *"Table 6. 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.

Even in Deep power-down mode, the RDP and RES are also allowed to be executed, only except the device is in progress of program/erase/write cycle; there's no effect on the current program/erase/write cycle in progress.

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

The RES instruction is ended by 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 be receive, decode, and execute instruction.

**Figure 11. Read Electronic Signature (RES) Sequence (SPI Mode)**

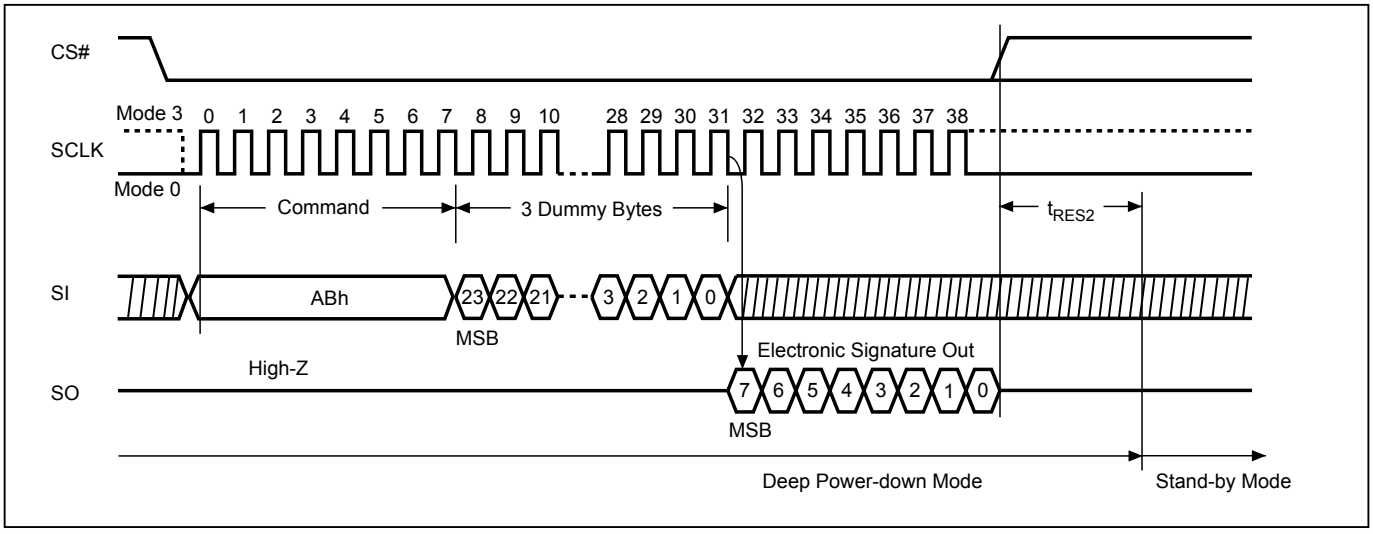


**Figure 12. Read Electronic Signature (RES) Sequence (QPI Mode)**

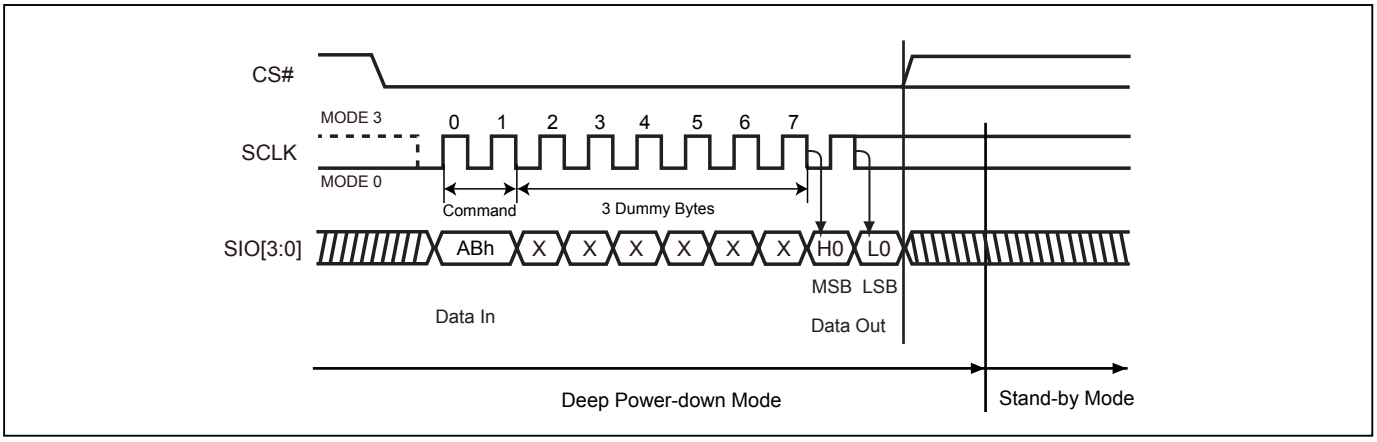



**Figure 13. Release from Deep Power-down (RDP) Sequence (SPI Mode)**

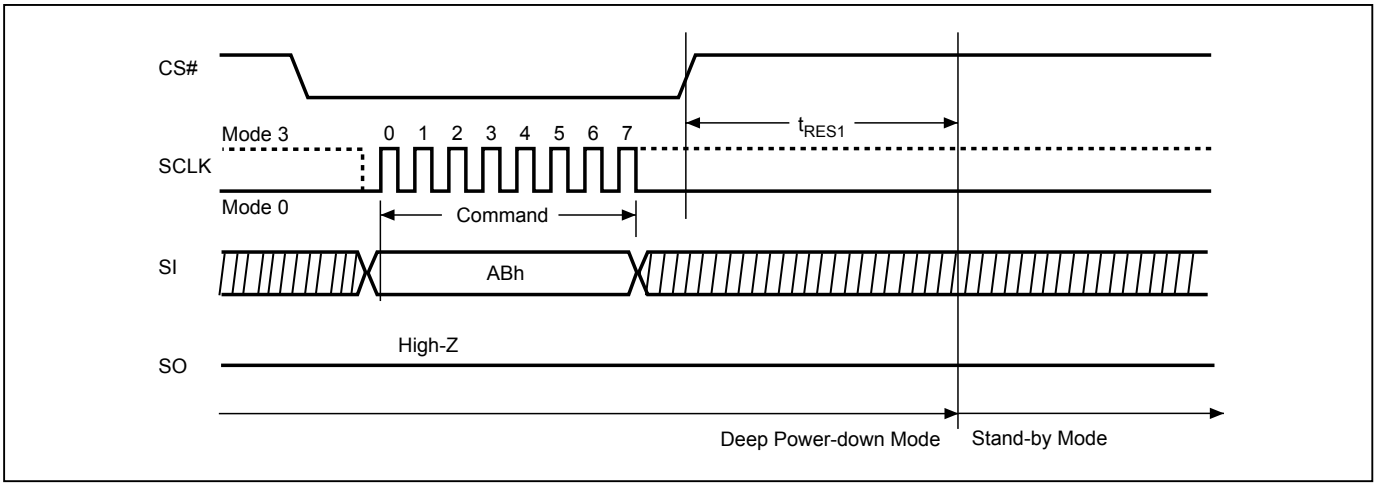
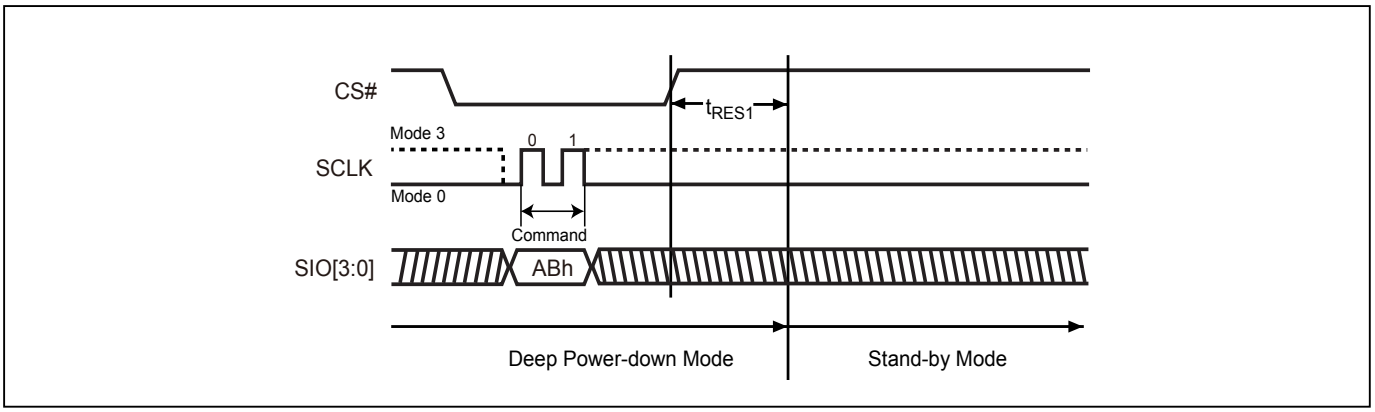



**Figure 14. Release from Deep Power-down (RDP) Sequence (QPI Mode)**





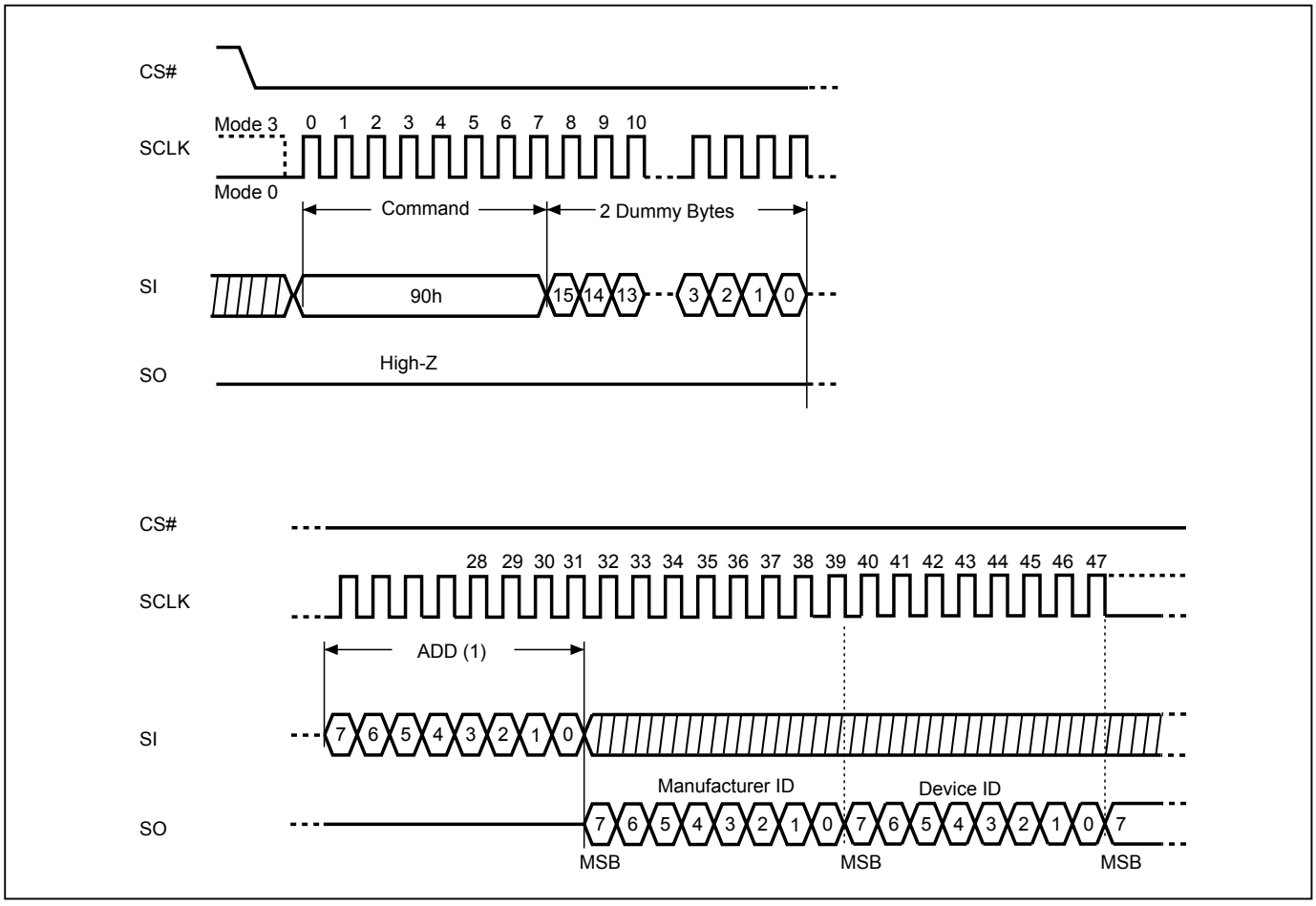
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### 9-5. Read Electronic Manufacturer ID & Device ID (REMS)

The REMS instruction is an alternative to the Release from Power-down/Device ID instruction that provides both the JEDEC assigned manufacturer ID and the specific device ID.

The REMS instruction is very similar to the Release from Power-down/Device ID instruction. The instruction is initiated by driving the CS# pin low and shift the instruction code "90h" followed by two dummy bytes and one bytes address (A7~A0). After which, the Manufacturer ID for Macronix (C2h) and the Device ID are shifted out on the falling edge of SCLK with most significant bit (MSB) first. The Device ID values are listed in *"Table 6. ID Definitions"*. If the one-byte address is initially set to 01h, then the device ID will be read first and then followed by the Manufacturer ID. The Manufacturer and Device IDs can be read continuously, alternating from one to the other. The instruction is completed by driving CS# high.

**Figure 15. Read Electronic Manufacturer & Device ID (REMS) Sequence (SPI Mode only)**




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

### 9-6. QPI ID Read (QPIID)

User can execute this QPIID Read instruction to identify the Device ID and Manufacturer ID. The sequence of issue QPIID instruction is CS# goes low→sending 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 device ID data byte will be output continuously, until the CS# goes high.

**Table 6. ID Definitions**

| Command Type | | MX25L12873F | | |
|---|---|---|---|---|
| RDID | 9Fh | Manufactory ID | Memory type | Memory density |
| | | C2 | 20 | 18 |
| RES | ABh | Electronic ID | | |
| | | 17 | | |
| REMS | 90h | Manufactory ID | Device ID | |
| | | C2 | 17 | |
| QPIID | AFh | Manufactory ID | Memory type | Memory density |
| | | C2 | 20 | 18 |

### 9-7. Read Status Register (RDSR)

The RDSR instruction is for reading Status Register Bits. The Read Status Register can be read at any time (even in program/erase/write status register condition). 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→ sending RDSR instruction code→ Status Register data out on SO.

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

**Figure 16. Read Status Register (RDSR) Sequence (SPI Mode)**

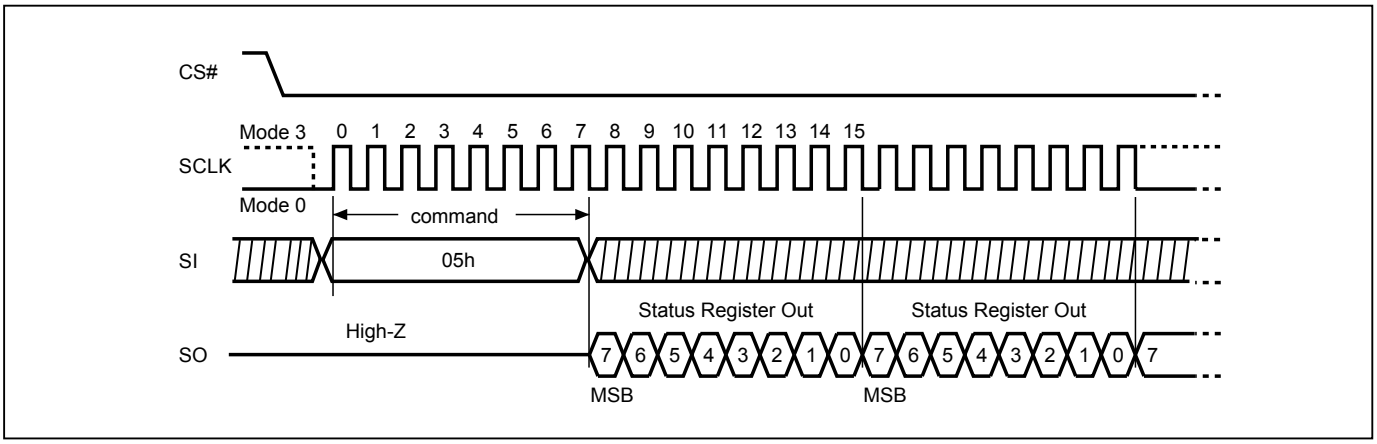
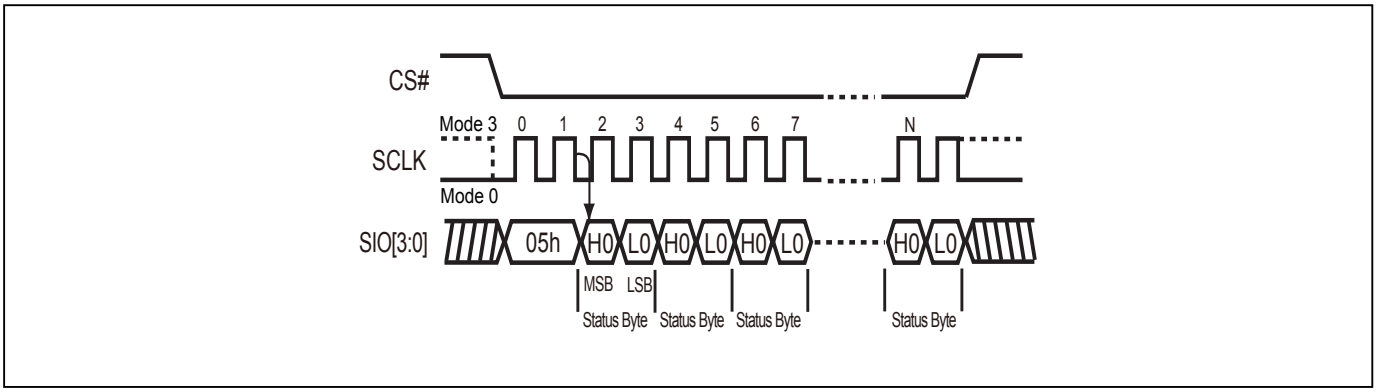



**Figure 17. Read Status Register (RDSR) Sequence (QPI Mode)**



### 9-8. 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→ sending RDCR instruction code→ Configuration Register data out on SO.

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

**Figure 18. Read Configuration Register (RDCR) Sequence (SPI Mode)**

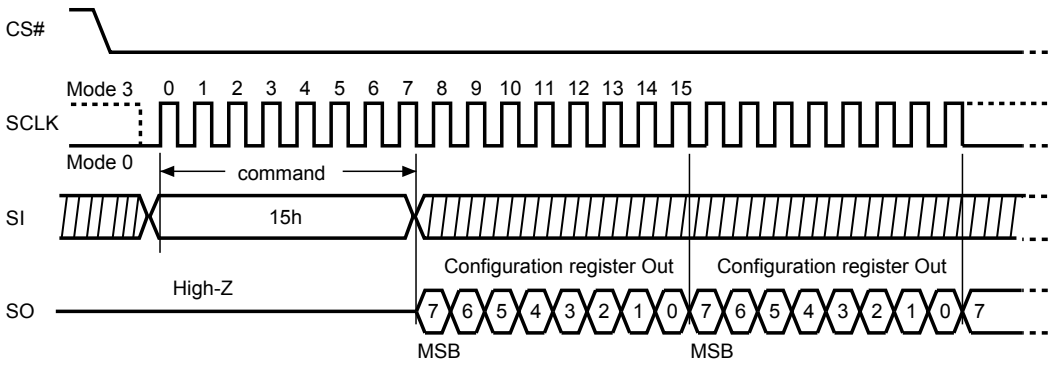
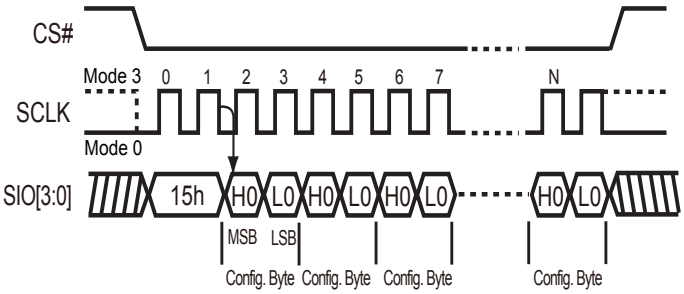



**Figure 19. Read Configuration Register (RDCR) Sequence (QPI Mode)**



For user to check if Program/Erase operation is finished or not, RDSR instruction flow are shown as follows:

**Figure 20. Program/Erase flow with read array data**

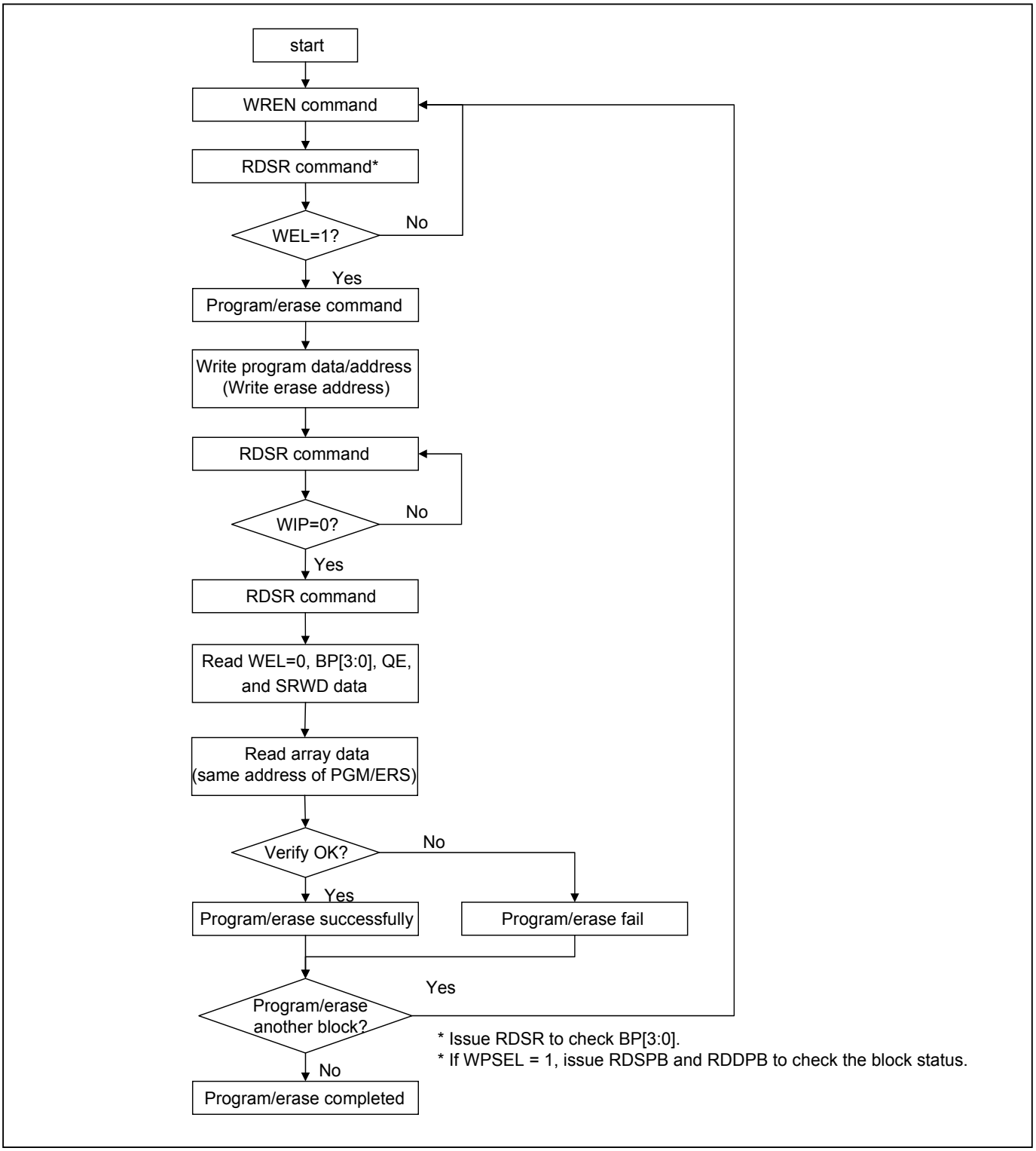
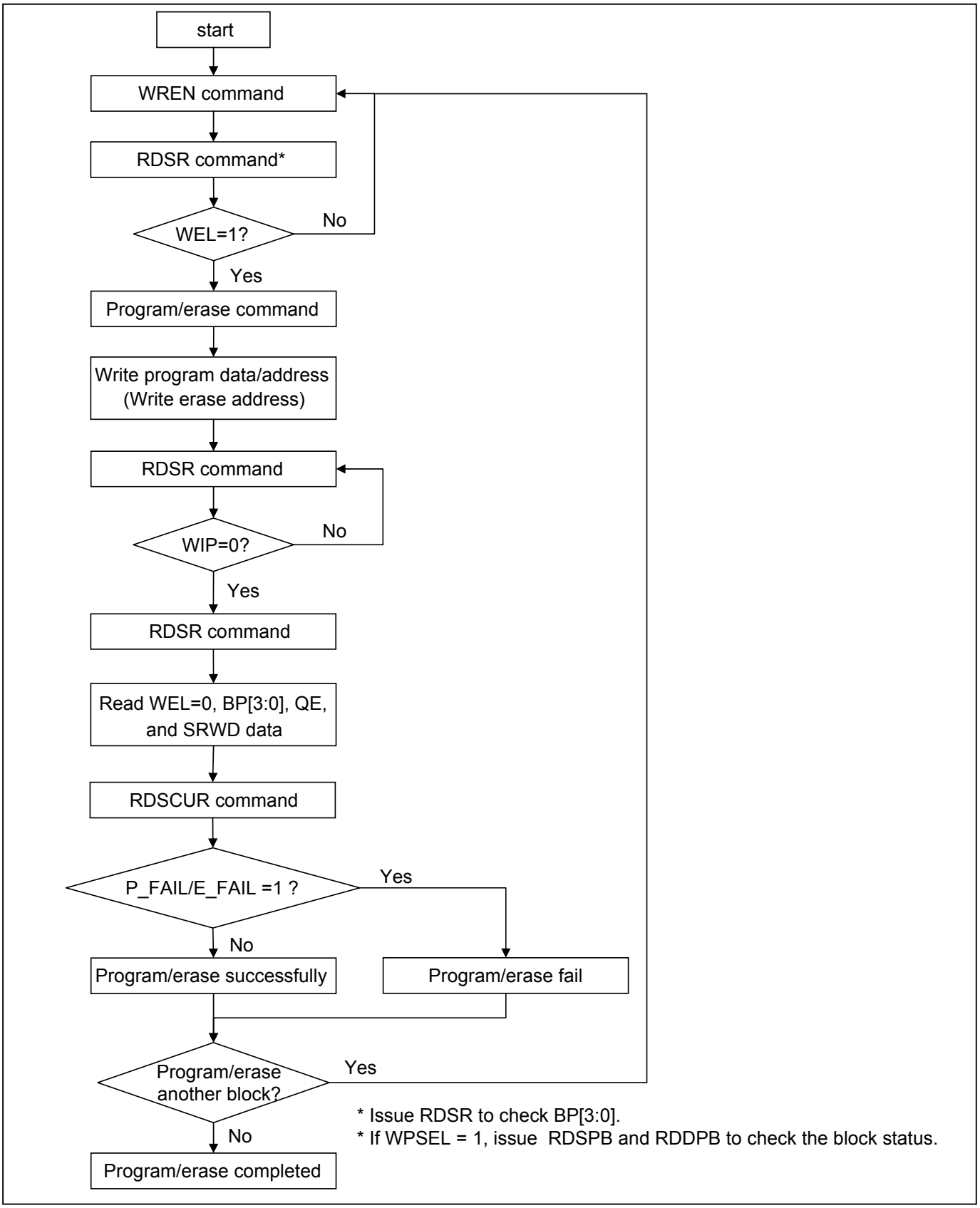


**Figure 21. Program/Erase flow without read array data (read P_FAIL/E_FAIL flag)**





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### 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, a volatile bit, indicates whether the device is set to internal write enable latch. When WEL bit sets to 1, which means the internal write enable latch is set, the device can accept program/erase/write status register instruction. When WEL bit sets to 0, which means no internal write enable latch; the device will not accept program/erase/write status register instruction. The program/erase command will be ignored if it is applied to a protected memory area. To ensure both WIP bit & WEL bit are both set to 0 and available for next program/erase/operations, WIP bit needs to be confirm to be 0 before polling WEL bit. After WIP bit confirmed, WEL bit needs to be confirm to be 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 2. 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 32KB (BE32K), Block Erase (BE) and Chip Erase (CE) instructions (only if Block Protect bits (BP3:BP0) set to 0, the CE instruction can be executed). The BP3, BP2, BP1, BP0 bits are "0" as default. Which is unprotected.

**QE bit.** The Quad Enable (QE) bit, a non-volatile bit which is permanently set to "1". The flash always performs Quad I/O mode.

**SRWD bit.** The Status Register Write Disable (SRWD) bit, non-volatile bit, default value is "0".

**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 disable 0=status register write enable | 1=Quad Enable | (note 1) | (note 1) | (note 1) | (note 1) | 1=write enable 0=not write enable | 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: See the *"Table 2. Protected Area Sizes"*.


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**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 *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 non-volatile 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 bits requires the Write Status Register (WRSR) instruction to be executed.

**Table 7. Configuration Register Table**

| bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|
| DC1 (Dummy cycle 1) | DC0 (Dummy cycle 0) | Reserved | Reserved | TB (top/bottom selected) | ODS 2 (output driver strength) | ODS 1 (output driver strength) | ODS 0 (output driver strength) |
| *(note 2)* | *(note 2)* | x | x | 0=Top area protect 1=Bottom area protect (Default=0) | *(note 1)* | *(note 1)* | *(note 1)* |
| volatile bit | volatile bit | x | x | OTP | volatile bit | volatile bit | volatile bit |

Note 1: see *"Output Driver Strength Table"*
Note 2: see *"Dummy Cycle and Frequency Table (MHz)"*

**Output Driver Strength Table**

| ODS2 | ODS1 | ODS0 | Description | Note |
|---|---|---|---|---|
| 0 | 0 | 0 | Reserved | Impedance at VCC/2 |
| 0 | 0 | 1 | 90 Ohms | |
| 0 | 1 | 0 | 60 Ohms | |
| 0 | 1 | 1 | 45 Ohms | |
| 1 | 0 | 0 | Reserved | |
| 1 | 0 | 1 | 20 Ohms | |
| 1 | 1 | 0 | 15 Ohms | |
| 1 | 1 | 1 | 30 Ohms (Default) | |

**Dummy Cycle and Frequency Table (MHz)**

| DC[1:0] | Numbers of Dummy clock cycles | Fast Read | Dual Output Fast Read | Quad Output Fast Read |
|---|---|---|---|---|
| **00 (default)** | 8 | 104 | 104 | 104 |
| **01** | 6 | 104 | 104 | 84 |
| **10** | 8 | 104 | 104 | 104 |
| **11** | 10 | 133 | 133 | 133 |

| DC[1:0] | Numbers of Dummy clock cycles | Dual IO Fast Read |
|---|---|---|
| **00 (default)** | 4 | 84 |
| **01** | 6 | 104 |
| **10** | 8 | 104 |
| **11** | 10 | 133 |

| DC[1:0] | Numbers of Dummy clock cycles | Quad IO Fast Read |
|---|---|---|
| **00 (default)** | 6 | 84 |
| **01** | 4 | 70 |
| **10** | 8 | 104 |
| **11** | 10 | 133 |

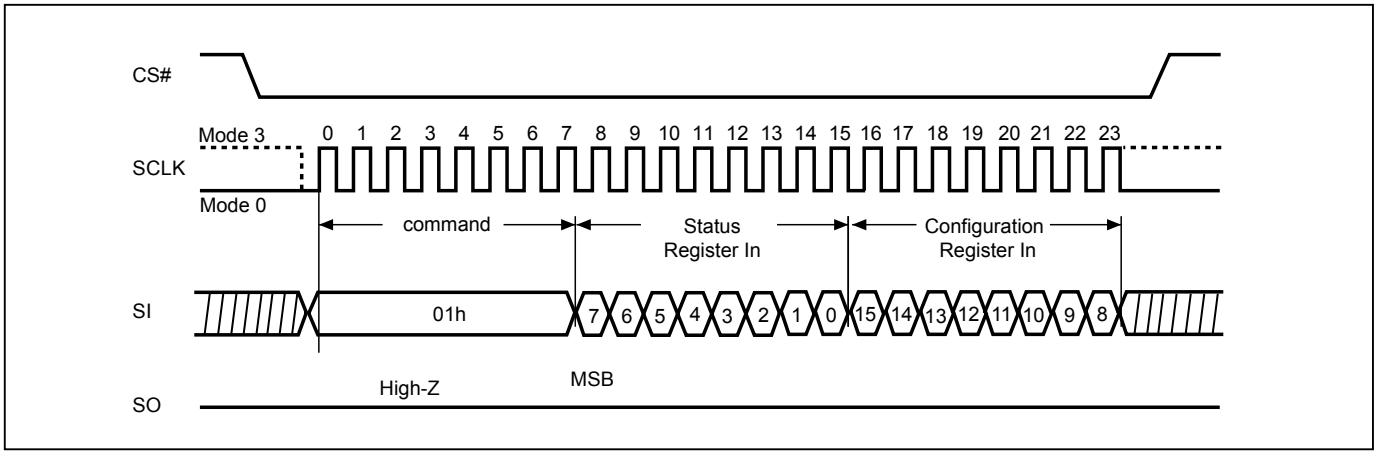
### 9-9. Write Status Register (WRSR)

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 2. Protected Area Sizes"*), 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→ sending WRSR instruction code→ Status Register data on SI→CS# goes high.

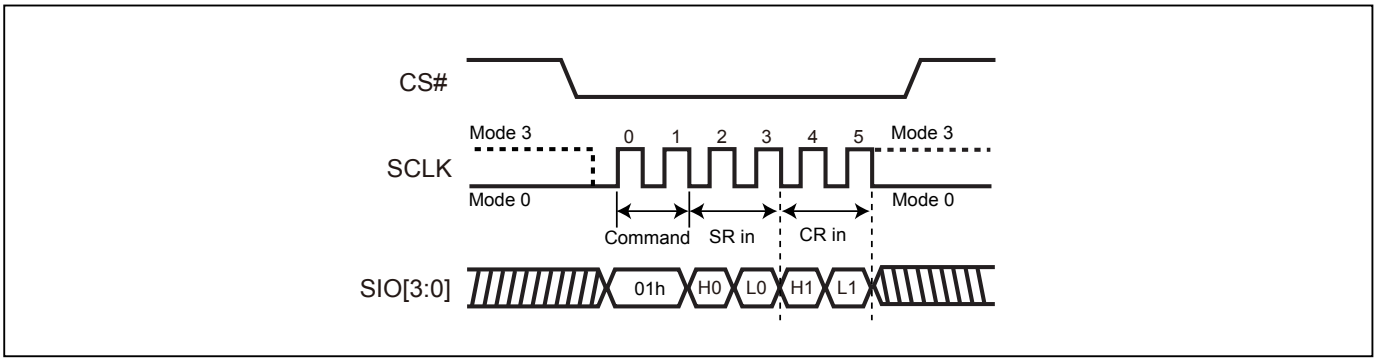
The CS# must go high exactly at the 8 bits or 16 bits data boundary; otherwise, the instruction will be rejected and not executed. The self-timed Write Status Register cycle time (tW) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be check out during the 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.

**Figure 22. Write Status Register (WRSR) Sequence (SPI Mode)**




Note : The CS# must go high exactly at 8 bits or 16 bits data boundary to completed the write register command.

**Figure 23. Write Status Register (WRSR) Sequence (QPI Mode)**





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**Software Protected Mode (SPM):**

- When SRWD bit=0, 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 and T/B bit, is at software protected mode (SPM).

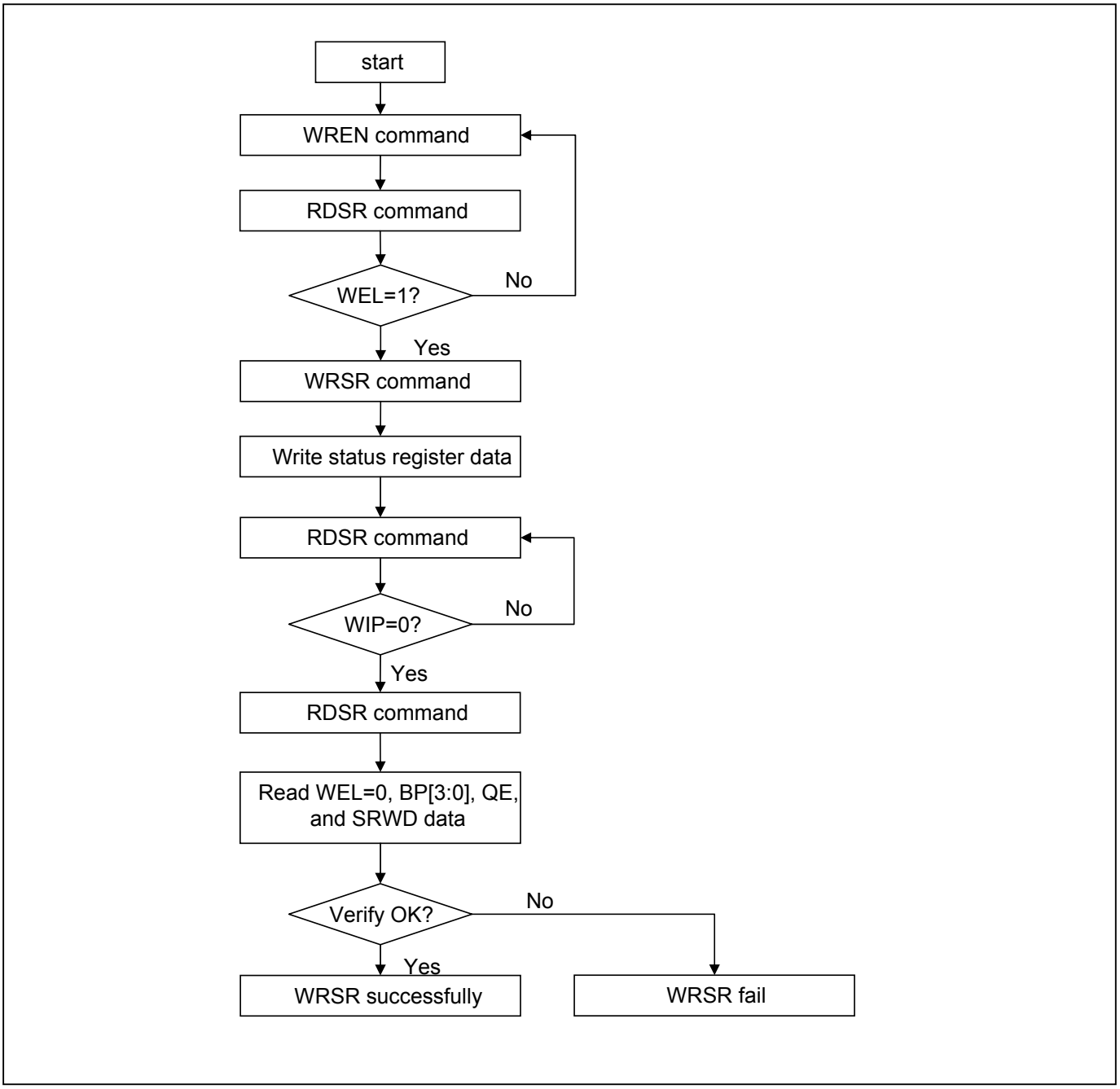
**Table 8. Protection Modes**

| Mode | Status register condition | 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 | SRWD bit=0 | The protected area cannot be program or erase. |

Note:

1. As defined by the values in the Block Protect (BP3, BP2, BP1, BP0) bits of the Status Register, as shown in *"Table 2. Protected Area Sizes"*.

**Figure 24. WRSR flow**

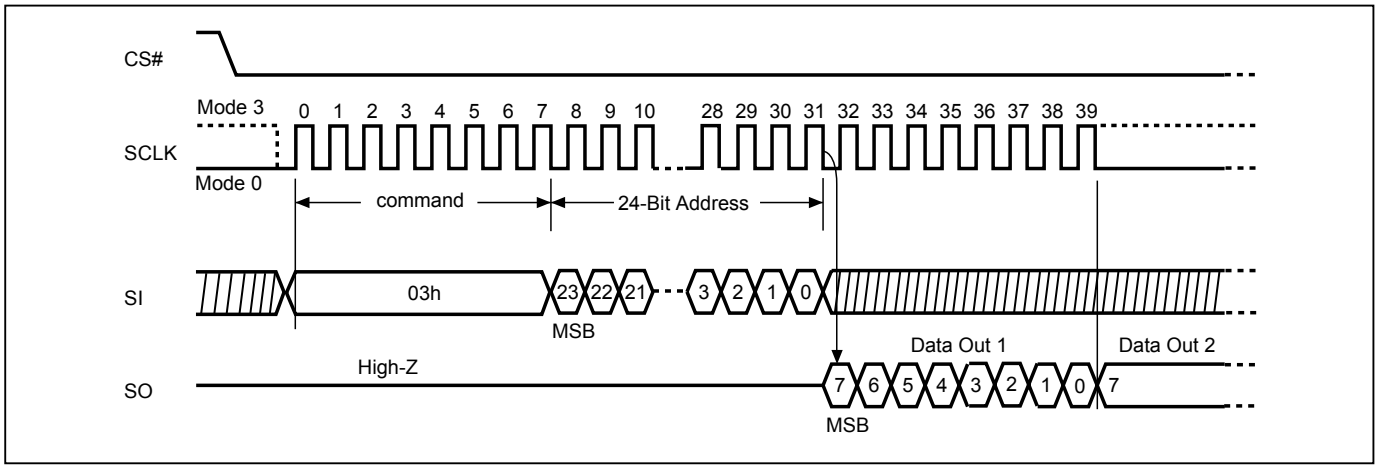


### 9-10. Read Data Bytes (READ)

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→sending READ instruction code→ 3-byte address on SI→ data out on SO→to end READ operation can use CS# to high at any time during data out.

**Figure 25. Read Data Bytes (READ) Sequence (SPI Mode only)**



### 9-11. Read Data Bytes at Higher Speed (FAST_READ)

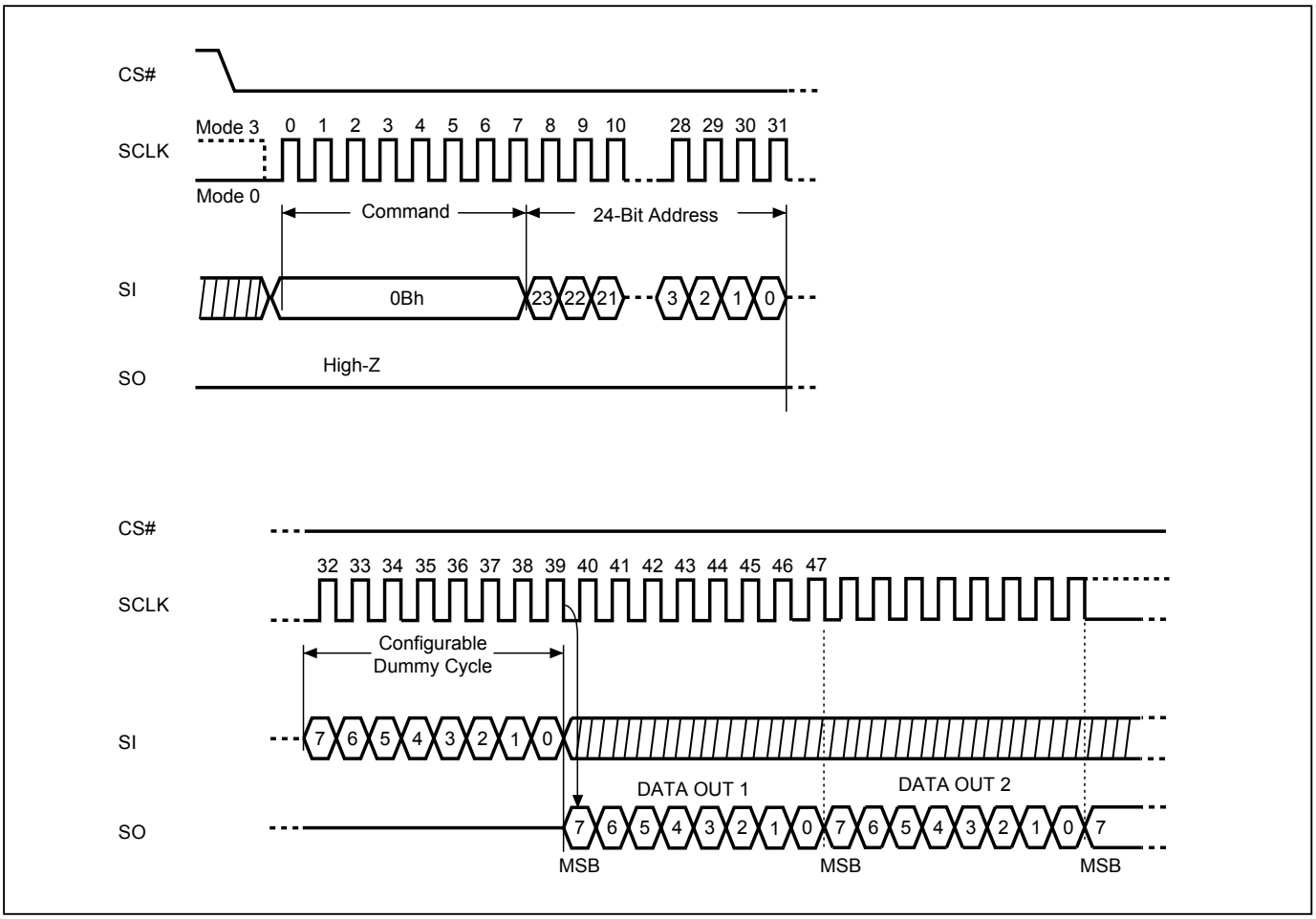
The FAST_READ instruction is for quickly reading data out. The address is latched on rising edge of SCLK, and data of each bit shifts out on the falling edge of SCLK at a maximum frequency fC. The first address byte can be at any location. The address is automatically increased to the next higher address 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→ sending FAST_READ instruction code→ 3-byte address on SI→ 8 dummy cycles (default)→ data out on SO→ to end FAST_READ operation can use CS# to high at any time during data out.

In the performance-enhancing 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 and afterwards CS# is raised and then lowered, the system then will escape from performance enhance mode and return to normal operation.

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 26. Read at Higher Speed (FAST_READ) Sequence (SPI Mode)**





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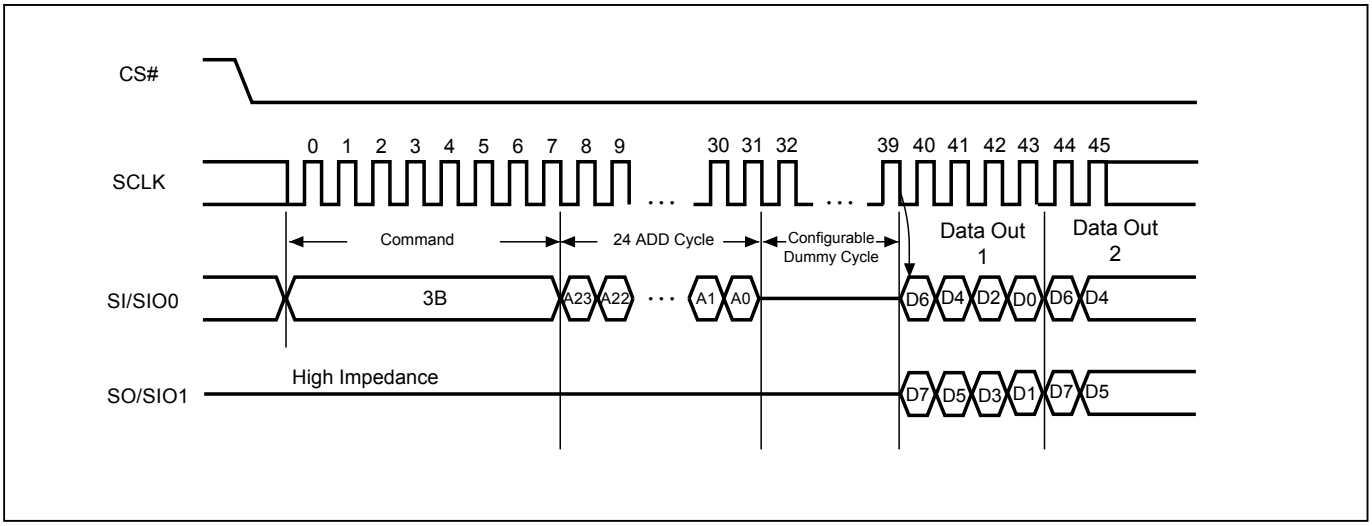
### 9-12. Dual Output Read Mode (DREAD)

The DREAD instruction enable double throughput of Serial 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→ sending DREAD instruction→3-byte address on SIO0→ 8 dummy cycles (default) on SIO0→ data out interleave on SIO1 & SIO0→ to end DREAD operation can use CS# to 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 27. Dual Read Mode Sequence**



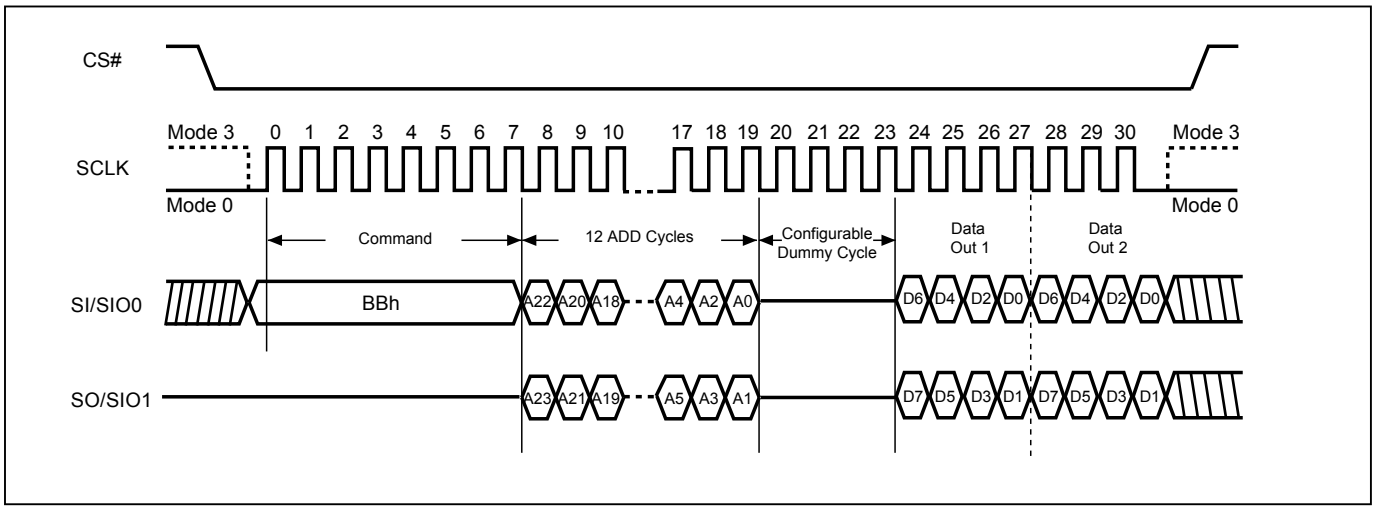
### 9-13. 2 x I/O Read Mode (2READ)

The 2READ instruction enable double throughput of Serial 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→ sending 2READ instruction→ 3-byte address interleave on SIO1 & SIO0→ 4 dummy cycles (default) on SIO1 & SIO0→ data out interleave on SIO1 & SIO0→ to end 2READ operation can use CS# to 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 28. 2 x I/O Read Mode Sequence (SPI Mode only)**



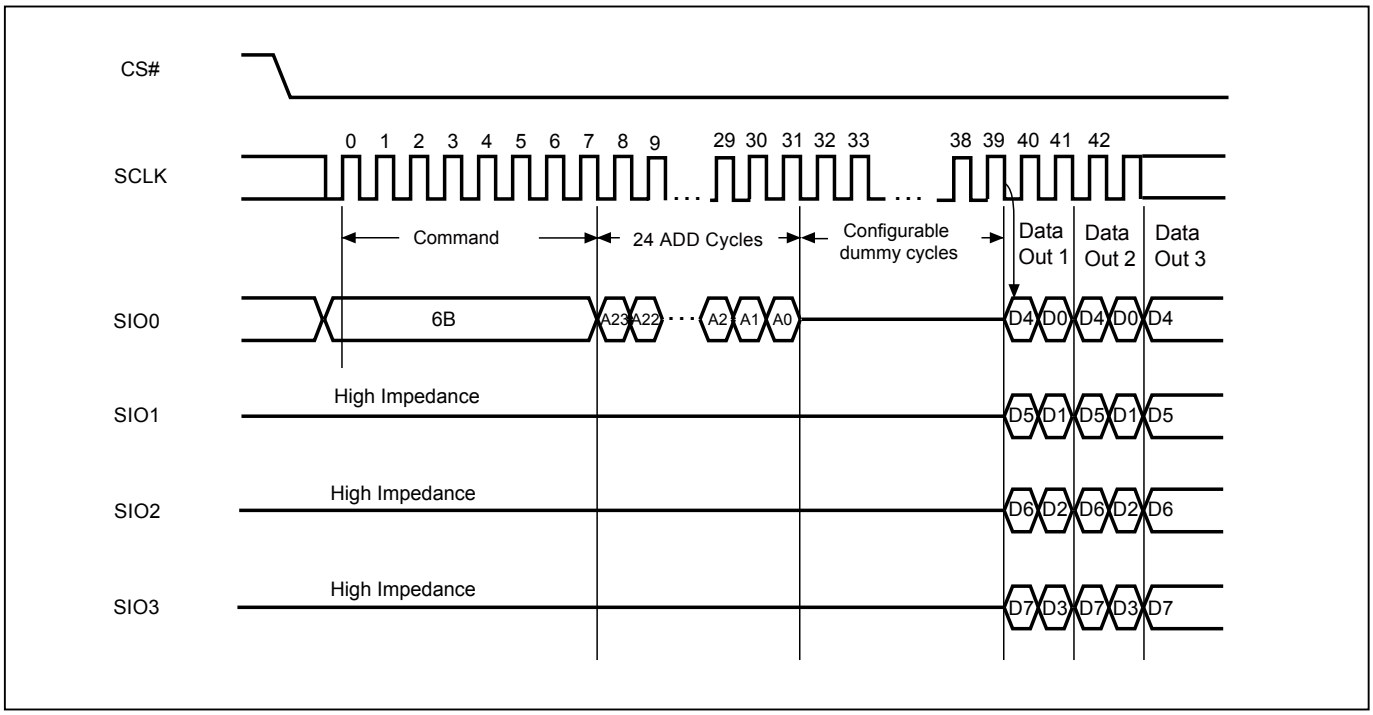
### 9-14. Quad Read Mode (QREAD)

The QREAD instruction enable quad throughput of Serial Flash in read mode. 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→ sending QREAD instruction → 3-byte address on SI → 8 dummy cycle (Default) → data out interleave on SO3, SO2, SO1 & SO0→ to end QREAD operation can use CS# to 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 29. Quad Read Mode Sequence**



### 9-15. 4 x I/O Read Mode (4READ)

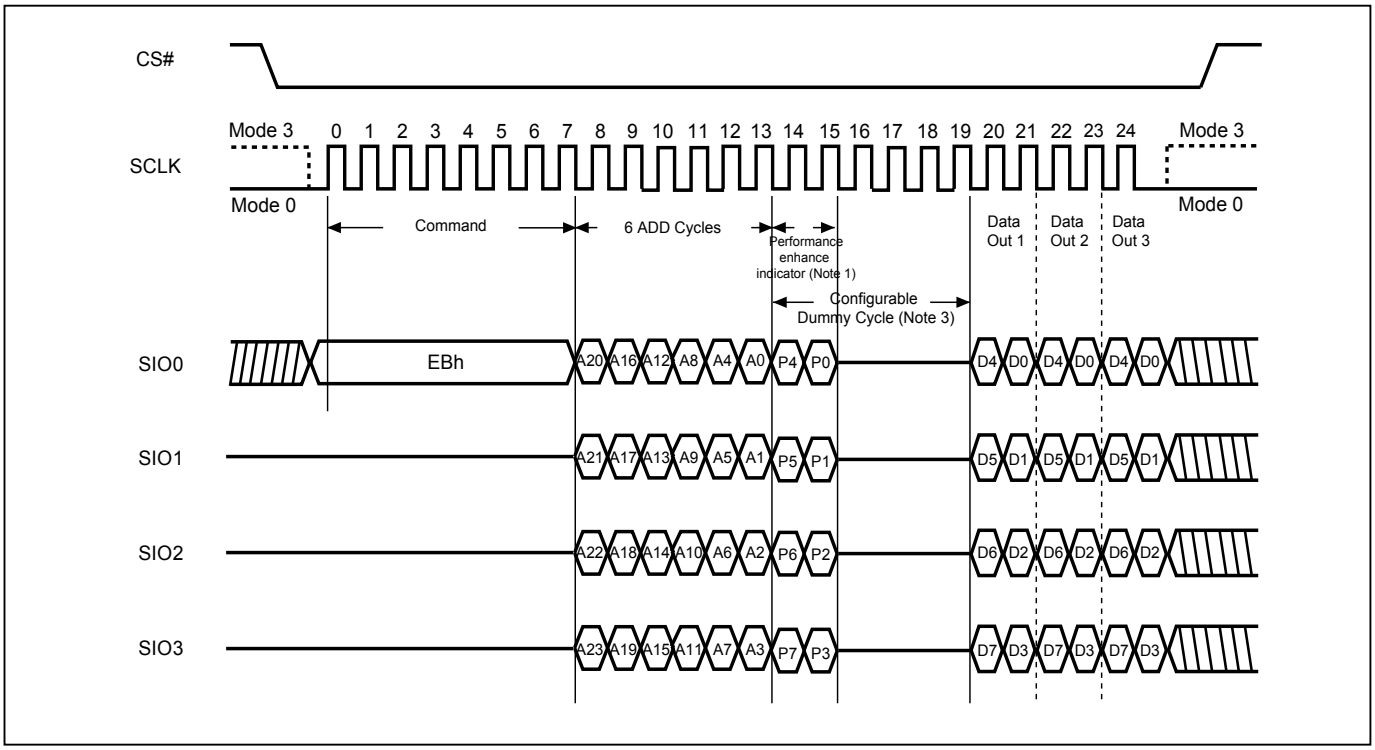
The 4READ instruction enable quad throughput of Serial Flash in read mode. A Quad Enable (QE) bit of status Register must be set to "1" before sending the 4READ instruction. The address is latched on rising edge of SCLK, and data of every four bits (interleave on 4 I/O pins) shift out on the falling 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→ sending 4READ instruction→ 3-byte address interleave on SIO3, SIO2, SIO1 & SIO0→ 6 dummy cycles (Default) →data out interleave on SIO3, SIO2, SIO1 & SIO0→ to end 4READ operation can use CS# to 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→ sending 4READ instruction→ 3-byte address interleave on SIO3, SIO2, SIO1 & SIO0→ 6 dummy cycles (Default) →data out interleave on SIO3, SIO2, SIO1 & SIO0→ to end 4READ operation can use CS# to high at any time during data out.

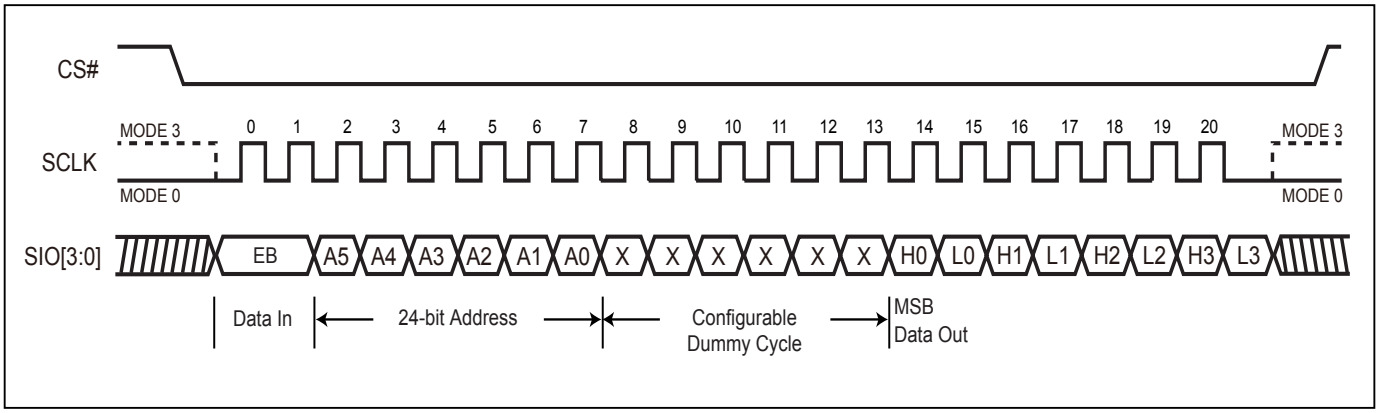
While Program/Erase/Write Status Register cycle is in progress, 4READ instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

**Figure 30. 4 x I/O Read Mode Sequence (SPI Mode)**




Notes:
1. Hi-impedance is inhibited for the two clock cycles.
2. P7≠P3, P6≠P2, P5≠P1 & P4≠P0 (Toggling) is inhibited.
3. Configuration Dummy cycle numbers will be different depending on the bit6 & bit 7 (DC0 & DC1) setting in configuration register.

**Figure 31. 4 x I/O Read Mode Sequence (QPI Mode)**



### 9-16. Burst Read

This device supports Burst Read in both SPI and QPI mode.
To set the Burst length, following command operation is required to issue command: “C0h” in the first Byte (8-clocks), following 4 clocks defining wrap around enable with “0h” and disable with“1h”.

The next 4 clocks are to define wrap around depth. Their definitions are as the following table:

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

The wrap around unit is defined within the 256Byte page, with random initial address. It is defined as “wrap-around mode disable” for the default state of the device. To exit wrap around, it is required to issue another “C0” command in which data=‘1xh”. Otherwise, wrap around status will be retained until power down or reset command. To change wrap around depth, it is requried to issue another “C0” command in which data=“0xh”. QPI “EBh” and SPI “EBh” support wrap around feature after wrap around is enabled. Burst read is supported in both SPI and QPI mode. The device is default without Burst read.

**Figure 32. SPI Mode**

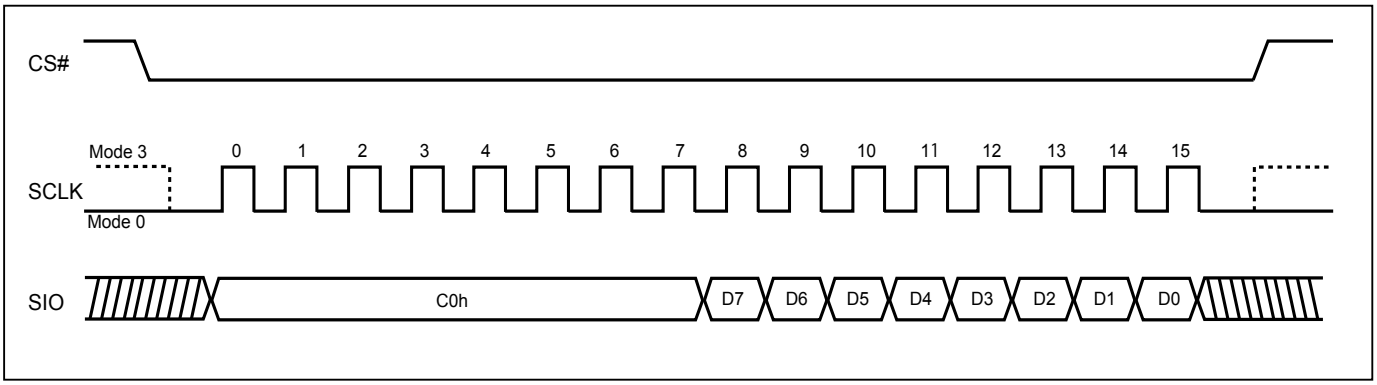
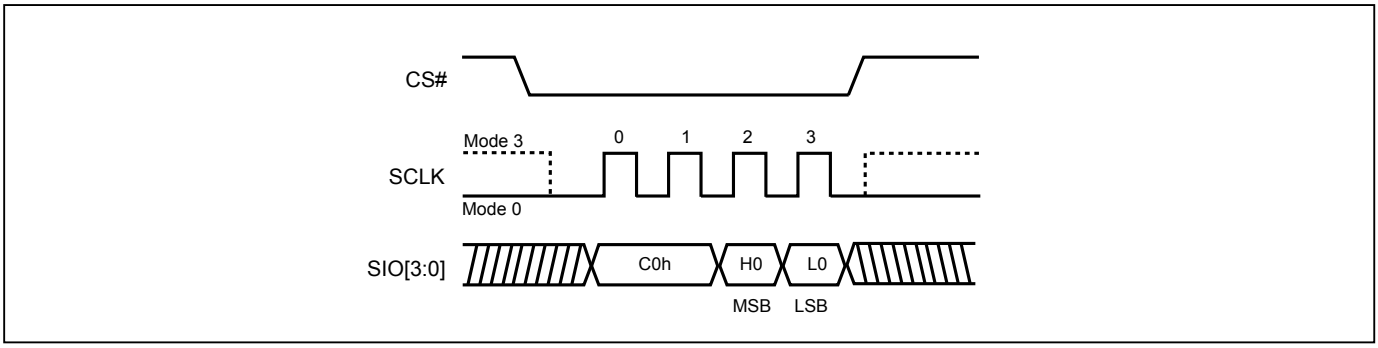



**Figure 33. QPI Mode**




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


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### 9-17. Performance Enhance Mode

The device could waive the command cycle bits if the two cycle bits after address cycle toggles.

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

In QPI mode, “EBh” and SPI “EBh” commands support enhance mode. The performance enhance mode is not supported in dual I/O mode.

To enter performance-enhancing 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 skip the next 4READ instruction. To leave enhance mode, P[7:4] is no longer toggling with P[3:0]; likewise P[7:0]=FFh, 00h, AAh or 55h along with CS# is afterwards raised and then lowered. Issuing ”FFh” data cycle can also exit enhance mode. The system then will leave performance enhance mode and return to normal operation.

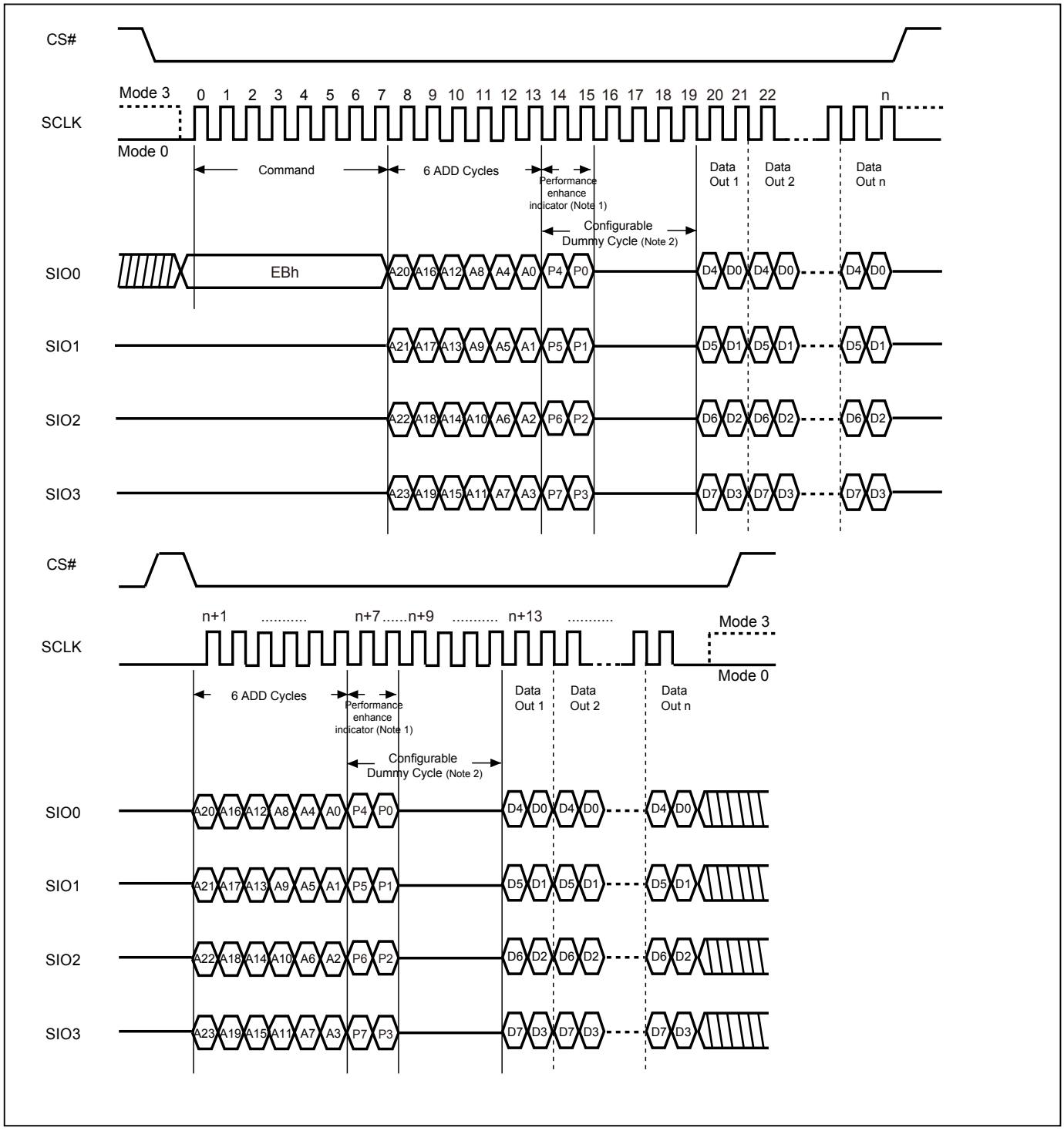
After entering enhance mode, following CS# go high, the device will stay in the read mode and treat CS# go low of the first clock as address instead of command cycle.

This sequence of issuing 4READ instruction is especially useful in random access: 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 (Default) →data out until CS# goes high → CS# goes low (the following 4READ instruction is ignored) → 3-bytes random access address.

To conduct the Performance Enhance Mode Reset operation in SPI mode, FFh data cycle, 8 clocks, should be issued in 1I/O sequence. In QPI Mode, FFFFFFFFh data cycle, 8 clocks, in 4I/O should be issued.

If the system controller is being Reset during operation, the flash device will return to the standard SPI operation.

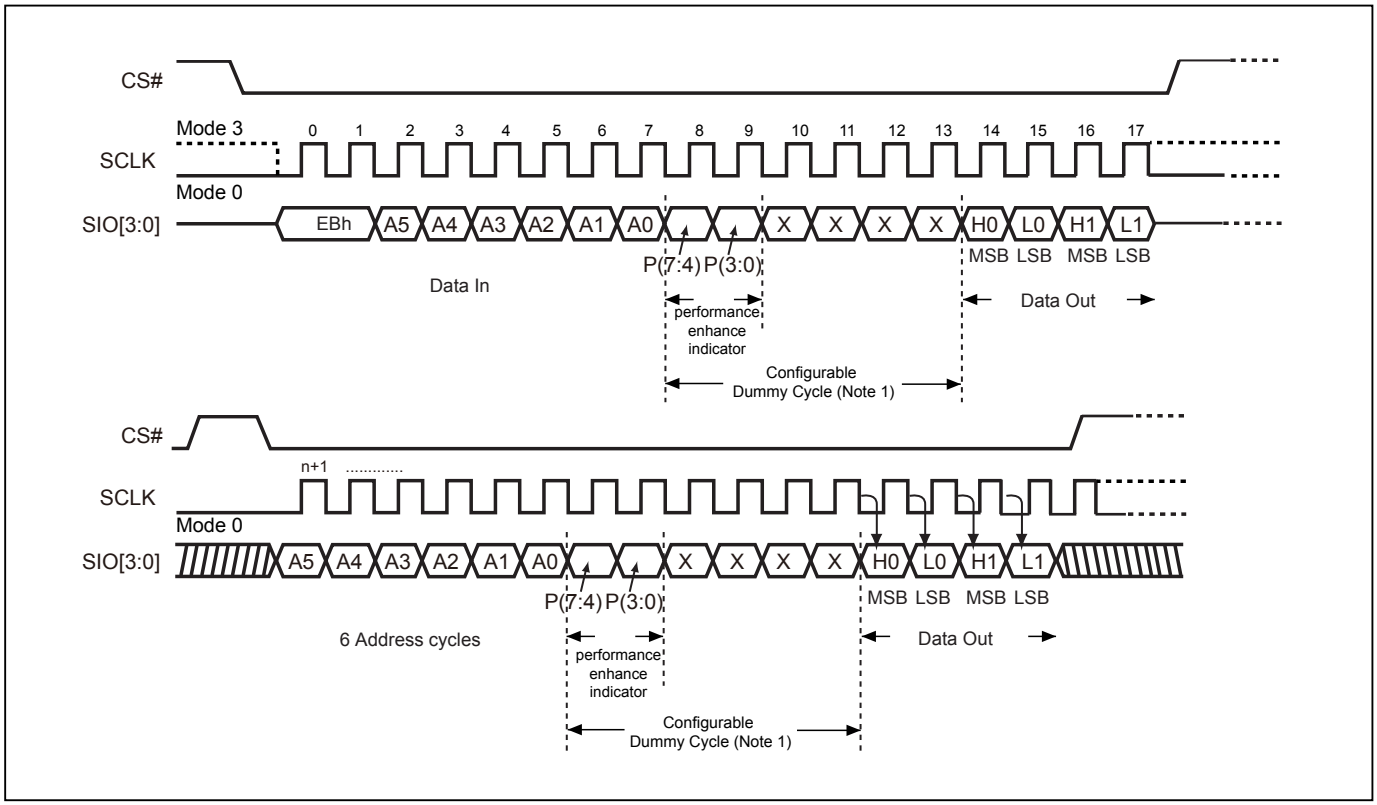
**Figure 34. 4 x I/O Read Performance Enhance Mode Sequence (SPI Mode)**




Notes:

1. 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. Configuration Dummy cycle numbers will be different depending on the bit6 & bit 7 (DC0 & DC1) setting in configuration register.

**Figure 35. 4 x I/O Read Performance Enhance Mode Sequence (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.

### 9-18. Fast Boot

The Fast Boot Feature provides the ability to automatically execute read operation after power on cycle or reset without any read instruction.

A Fast Boot Register is provided on this device. It can enable the Fast Boot function and also define the number of delay cycles and start address (where boot code being transferred). Instruction WRFBR (write fast boot register) and ESFBR (erase fast boot register) can be used for the status configuration or alternation of the Fast Boot Register bit. RDFBR (read fast boot register) can be used to verify the program state of the Fast Boot Register. The default number of delay cycles is 13 cycles, and there is a 16bytes boundary address for the start of boot code access.

When CS# starts to go low, data begins to output from default address after the delay cycles (default as 13 cycles). After CS# returns to go high, the device will go back to standard SPI mode. In the fast boot data out process from CS# goes low to CS# goes high, a minimum of one byte must be output.

Once Fast Boot feature has been enabled, the device will automatically start a read operation after power on cycle, reset command, or hardware reset operation.

The fast Boot feature support Quad I/O interface, the data is output by Quad I/O interface.

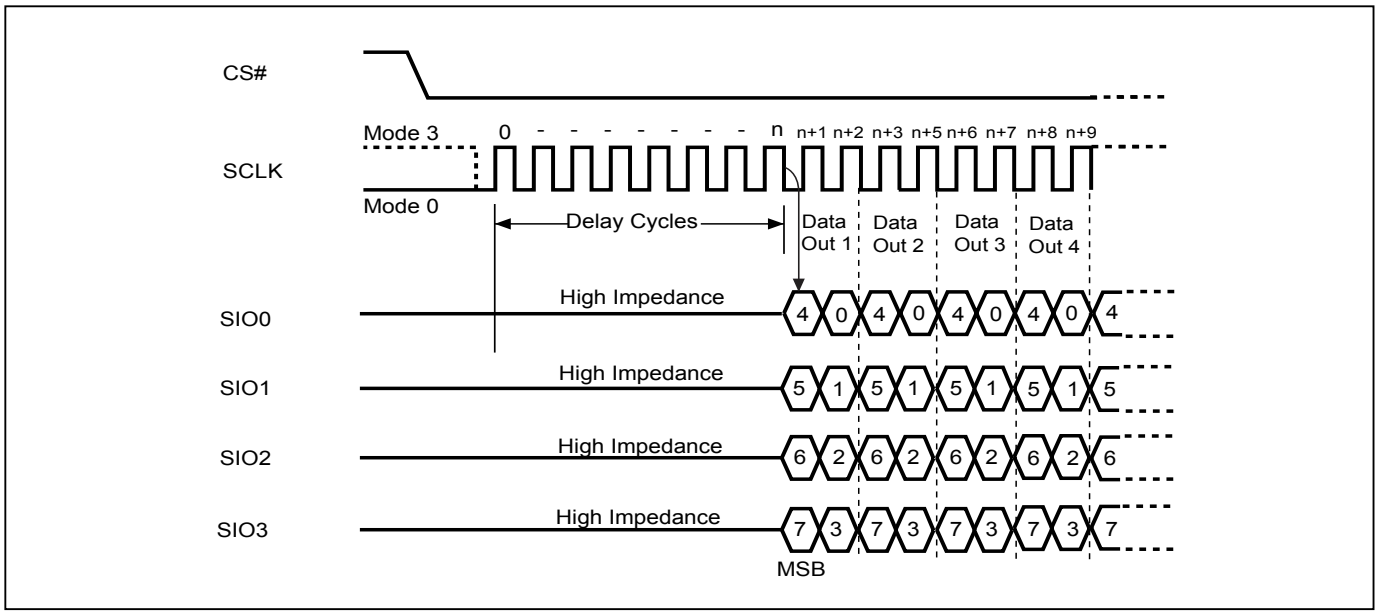
**Fast Boot Register (FBR)**

| Bits | Description | Bit Status | Default State | Type |
|---|---|---|---|---|
| 31 to 4 | FBSA (FastBoot Start Address) | 16 bytes boundary address for the start of boot code access. | FFFFFFF | Non-Volatile |
| 3 | x | | 1 | Non-Volatile |
| 2 to 1 | FBSD (FastBoot Start Delay Cycle) | 00: 7 delay cycles<br>01: 9 delay cycles<br>10: 11 delay cycles<br>11: 13 delay cycles | 11 | Non-Volatile |
| 0 | FBE (FastBoot Enable) | 0=FastBoot is enabled.<br>1=FastBoot is not enabled. | 1 | Non-Volatile |

Note: If FBSD = 11, the maximum clock frequency is 133 MHz
If FBSD = 10, the maximum clock frequency is 104 MHz
If FBSD = 01, the maximum clock frequency is 84 MHz
If FBSD = 00, the maximum clock frequency is 70 MHz


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**Figure 36. Fast Boot Sequence (QE bit =1)**




Note: If FBSD = 11, delay cycles is 13 and n is 12.
If FBSD = 10, delay cycles is 11 and n is 10.
If FBSD = 01, delay cycles is 9 and n is 8.
If FBSD = 00, delay cycles is 7 and n is 6.

**Figure 37. Read Fast Boot Register (RDFBR) Sequence**

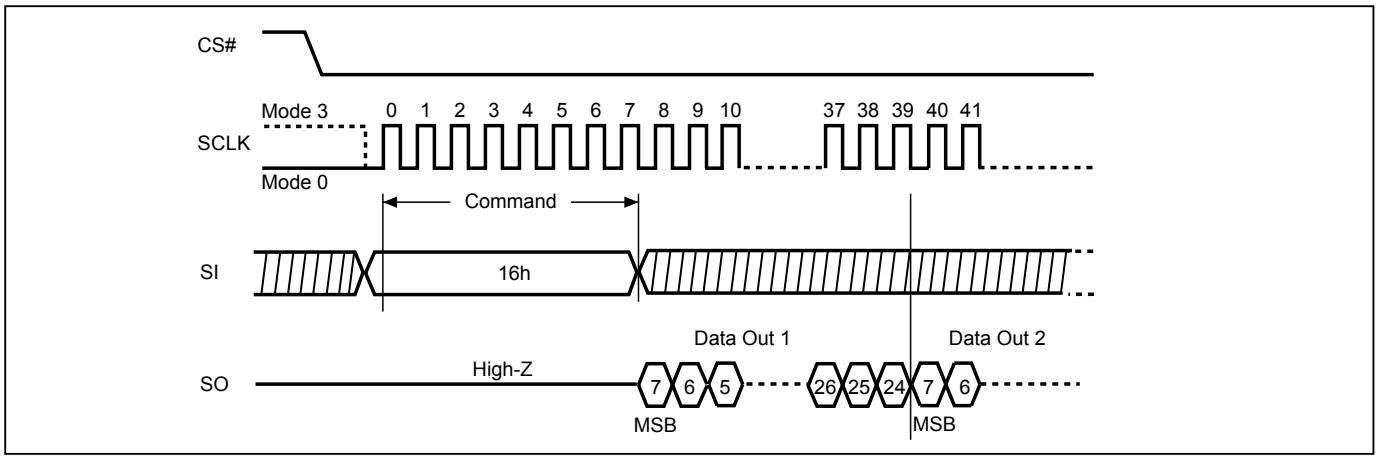



**Figure 38. Write Fast Boot Register (WRFBR) Sequence**

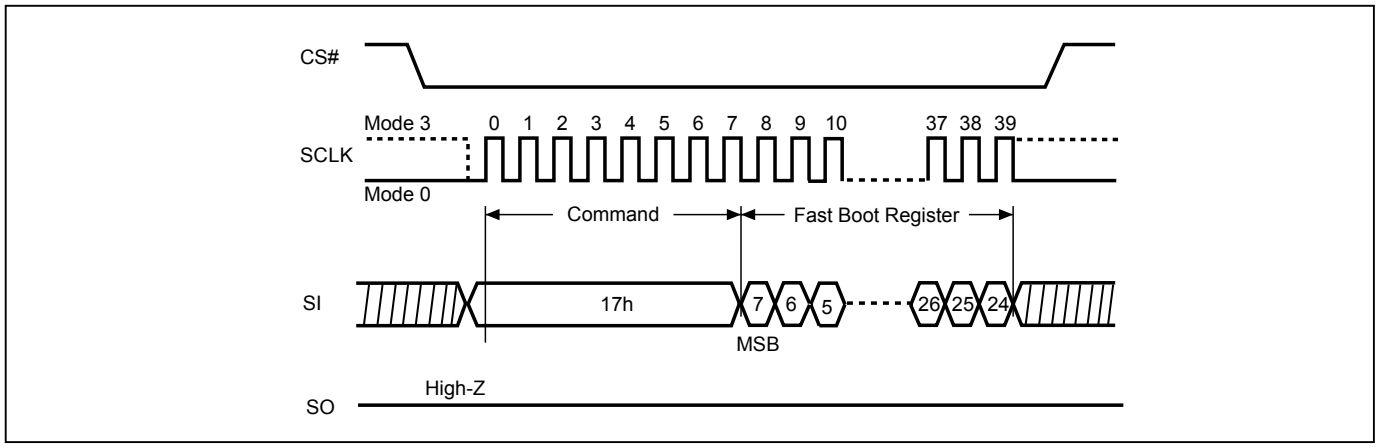
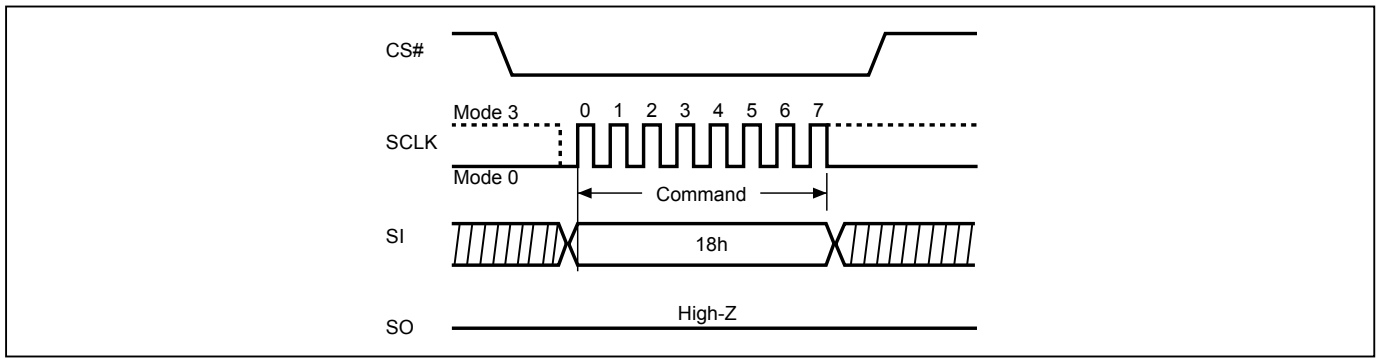



**Figure 39. Erase Fast Boot Register (ESFBR) Sequence**



### 9-19. 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 execute to set the Write Enable Latch (WEL) bit before sending the Sector Erase (SE). Any address of the sector (see *"Table 4. 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 byte been latched-in); otherwise, the instruction will be rejected and not executed.

Address bits [Am-A12] (Am is the most significant address) select the sector address.

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

Both SPI (8 clocks) and QPI (2 clocks) command cycle can accept by this instruction. The SIO[3:1] are don't care when 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 1 during the tSE timing, and clears when Sector Erase Cycle is completed, and the Write Enable Latch (WEL) bit is cleared. If the Block is protected by BP bits (WPSEL=0; Block Protect Mode) or SPB/DPB (WPSEL=1; Advanced Sector Protect Mode), the Sector Erase (SE) instruction will not be executed on the block.

**Figure 40. Sector Erase (SE) Sequence (SPI Mode)**

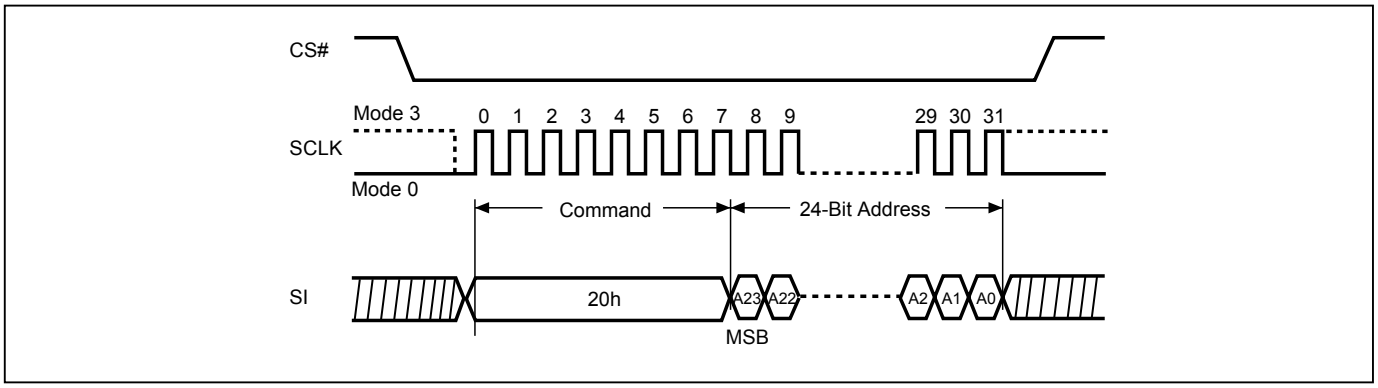
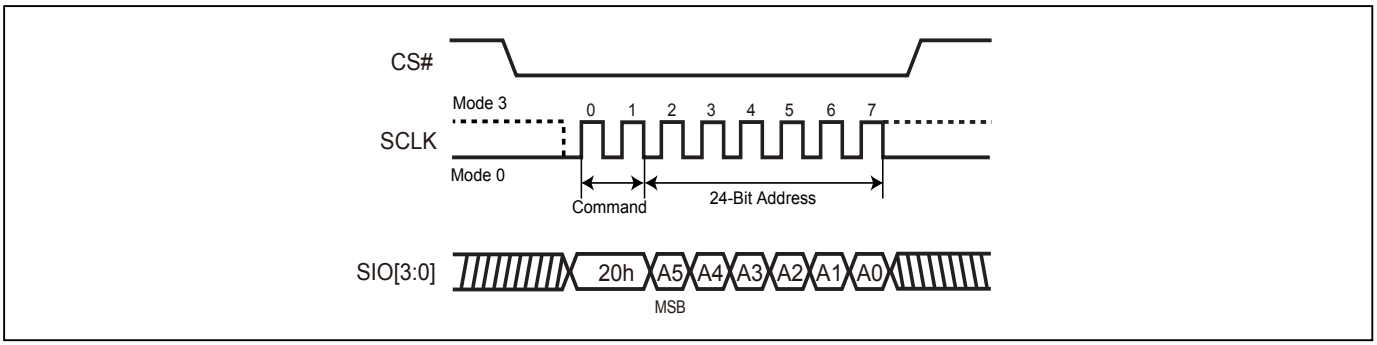



**Figure 41. Sector Erase (SE) Sequence (QPI Mode)**



### 9-20. 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 be executed to set the Write Enable Latch (WEL) bit before sending the Block Erase (BE32K). Any address of the block (see *"Table 4. 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 been latched-in); otherwise, the instruction will be rejected and not executed.

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

Both SPI (8 clocks) and QPI (2 clocks) command cycle can accept by this instruction. The SIO[3:1] are don't care when 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 during 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 BP bits (WPSEL=0; Block Protect Mode) or SPB/DPB (WPSEL=1; Advanced Sector Protect Mode), the Block Erase (BE32K) instruction will not be executed on the block.

**Figure 42. Block Erase 32KB (BE32K) Sequence (SPI Mode)**

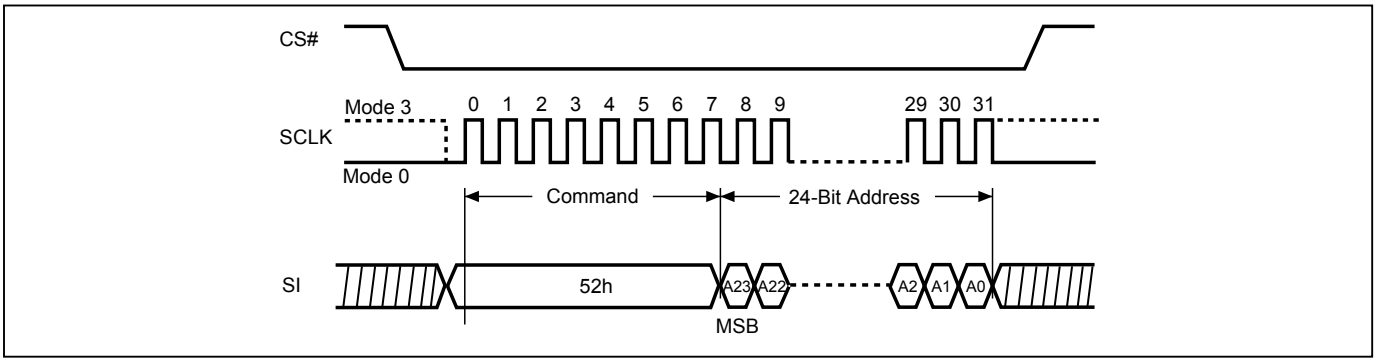
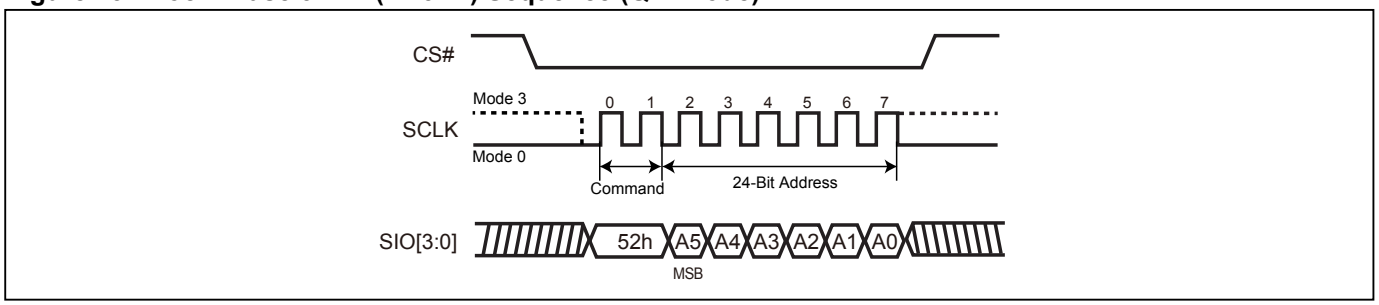



**Figure 43. Block Erase 32KB (BE32K) Sequence (QPI Mode)**



### 9-21. 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 4. 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 been latched-in); otherwise, the instruction will be rejected and not executed.

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

Both SPI (8 clocks) and QPI (2 clocks) command cycle can accept by this instruction. The SIO[3:1] are don't care when 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 reset. If the Block is protected by BP bits (WPSEL=0; Block Protect Mode) or SPB/DPB (WPSEL=1; Advanced Sector Protect Mode), the Block Erase (BE) instruction will not be executed on the block.

**Figure 44. Block Erase (BE) Sequence (SPI Mode)**

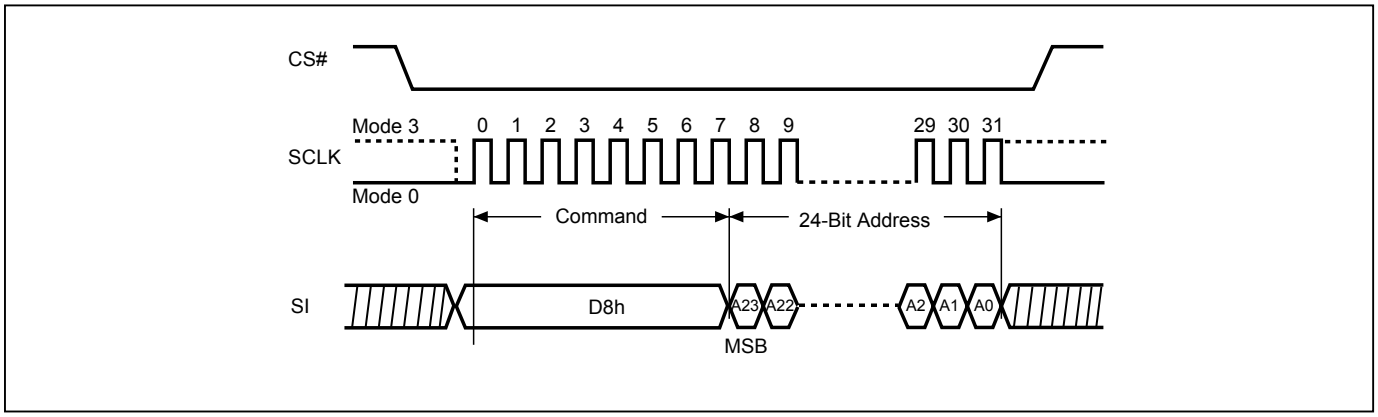
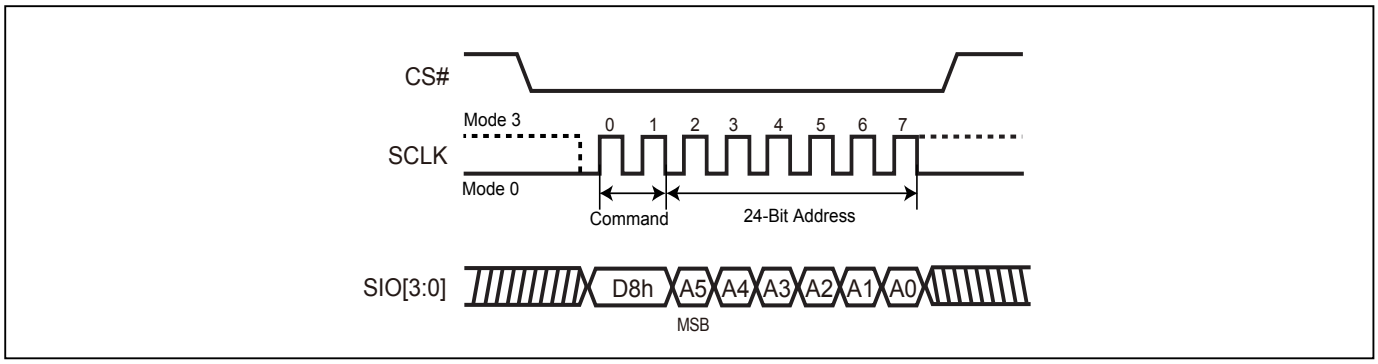



**Figure 45. Block Erase (BE) Sequence (QPI Mode)**



### 9-22. 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→sending CE instruction code→CS# goes high.

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

When the chip is under "Block protect (BP) 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 "Advances Sector Protect 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 46. Chip Erase (CE) Sequence (SPI Mode)**

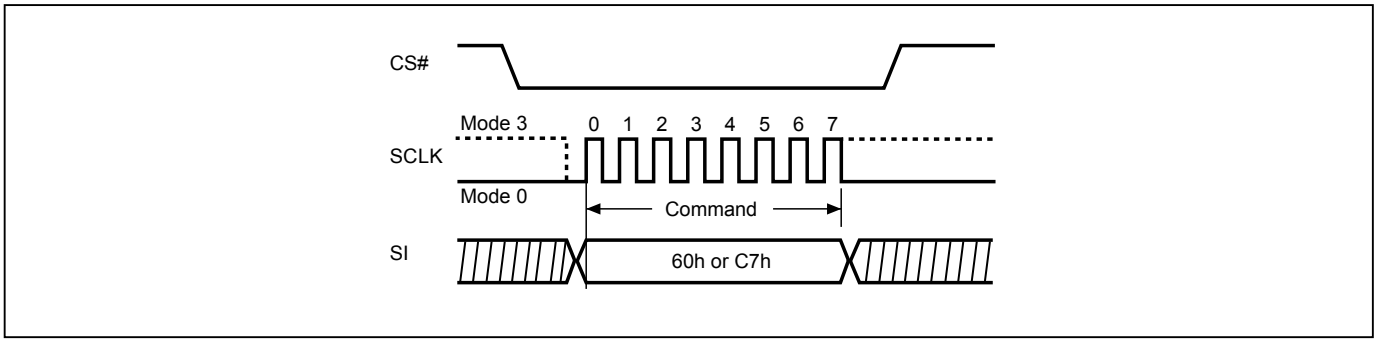
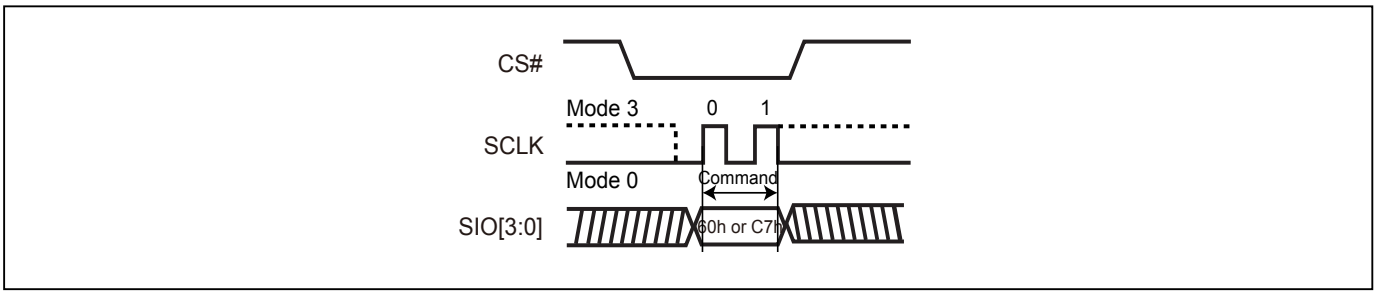



**Figure 47. Chip Erase (CE) Sequence (QPI Mode)**



### 9-23. 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→ sending 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 Protect Mode) or SPB/DPB (WPSEL=1; Advanced Sector Protect Mode) the Page Program (PP) instruction will not be executed.

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

**Figure 48. Page Program (PP) Sequence (SPI Mode)**

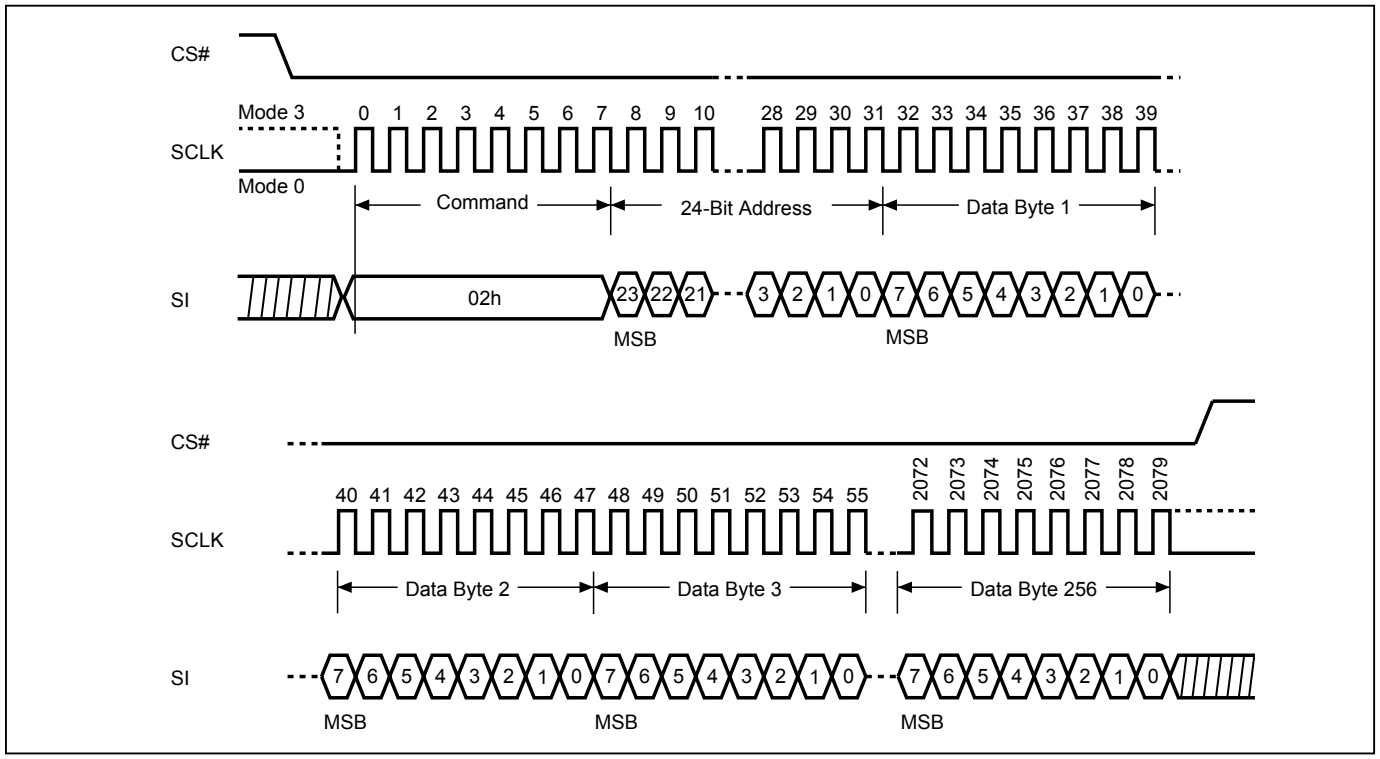
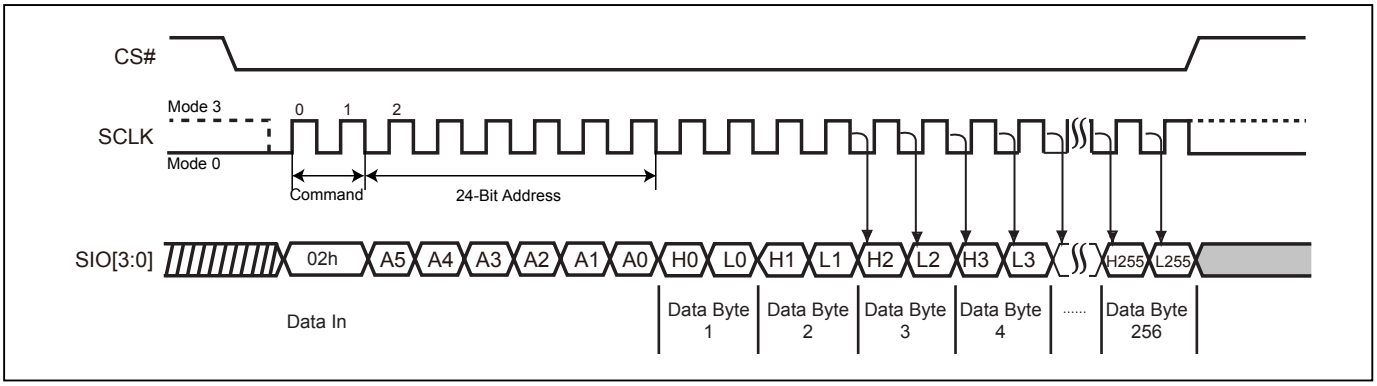



**Figure 49. Page Program (PP) Sequence (QPI Mode)**



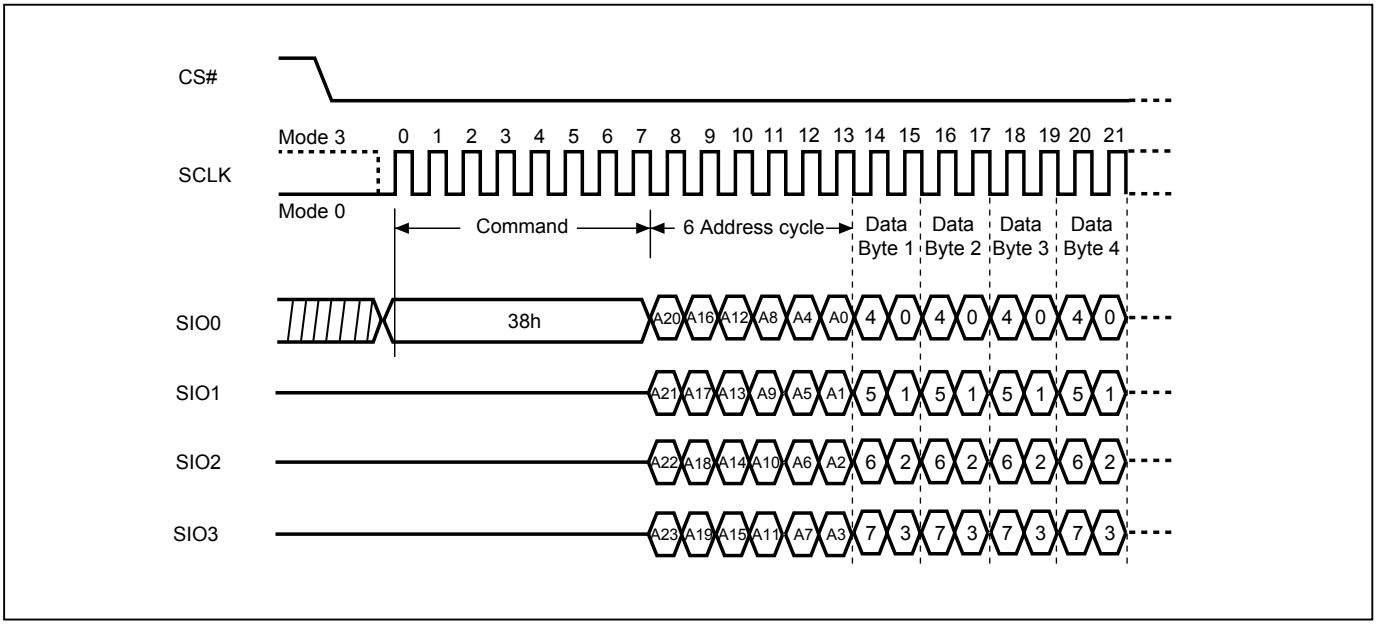
### 9-24. 4 x I/O Page Program (4PP)

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 as address and data input, which can improve programmer performance and the effectiveness of application. The other function descriptions are as same as standard page program.

The sequence of issuing 4PP instruction is: CS# goes low→ sending 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 Protect Mode) or SPB/DPB (WPSEL=1; Advanced Sector Protect Mode), the Quad Page Program (4PP) instruction will not be executed.

**Figure 50. 4 x I/O Page Program (4PP) Sequence (SPI Mode only)**



### 9-25. Deep Power-down (DP)

The Deep Power-down (DP) instruction is for setting the device to minimum power consumption (the standby current is reduced from ISB1 to ISB2). The Deep Power-down mode requires the Deep Power-down (DP) instruction to enter, during the Deep Power-down mode, the device is not active and all Write/Program/Erase instruction are ignored. When CS# goes high, it's only in deep power-down mode not standby mode. It's different from Standby mode.

The sequence of issuing DP instruction is: CS# goes low→sending DP instruction code→CS# goes high.

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

Once the DP instruction is set, all instruction will be ignored except the Release from Deep Power-down mode (RDP) and Read Electronic Signature (RES) instruction and softreset command. (those instructions allow the ID being reading out). When Power-down, or software reset command the deep power-down mode automatically stops, and when power-up, the device automatically is in standby mode. For DP instruction the CS# must go high exactly at the byte boundary (the latest eighth bit of instruction code been latched-in); otherwise, the instruction will not executed. As soon as Chip Select (CS#) goes high, a delay of tDP is required before entering the Deep Power-down mode.

**Figure 51. Deep Power-down (DP) Sequence (SPI Mode)**

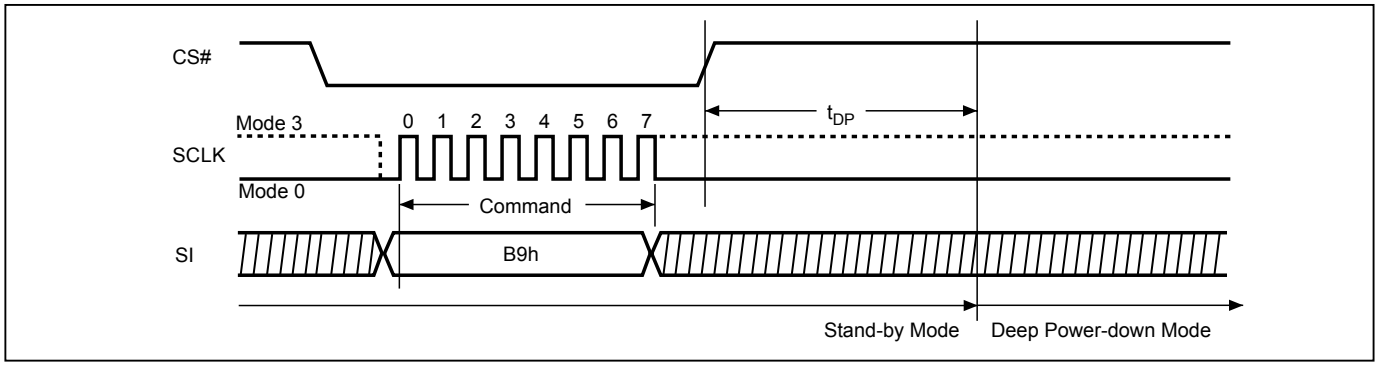
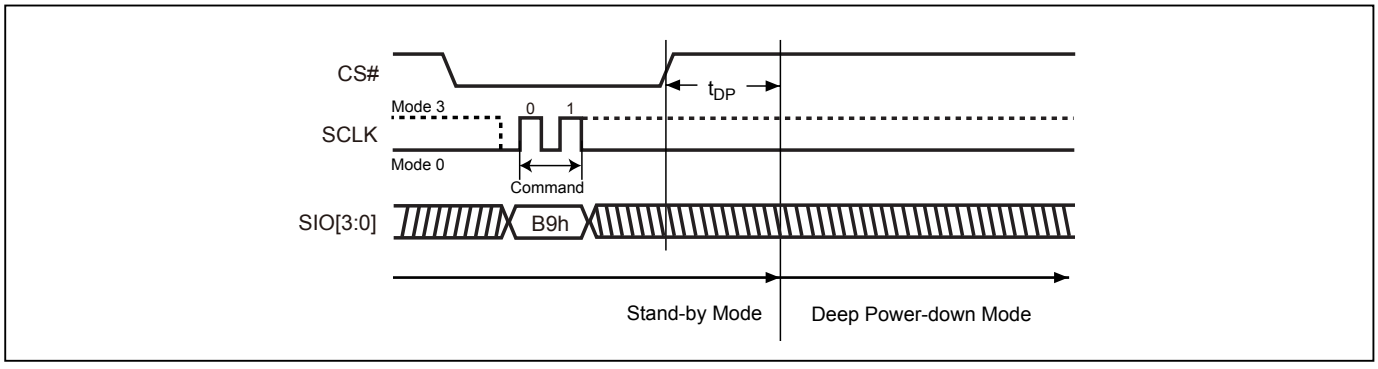



**Figure 52. Deep Power-down (DP) Sequence (QPI Mode)**



### 9-26. Enter Secured OTP (ENSO)

The ENSO instruction is for entering the additional 4K-bit secured OTP mode. While device is in 4K-bit secured OTPmode, main array access is not available. The additional 4K-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→ sending ENSO instruction to enter Secured OTP mode→ CS# goes high.

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

Please note that after issuing ENSO command user can only access secure OTP region with standard read or program procedure. Furthermore, once security OTP is lock down, only read related commands are valid.

### 9-27. Exit Secured OTP (EXSO)

The EXSO instruction is for exiting the additional 4K-bit secured OTP mode.

The sequence of issuing EXSO instruction is: CS# goes low→ sending EXSO instruction to exit Secured OTP mode→ CS# goes high.

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

### 9-28. Read Security Register (RDSCUR)

The RDSCUR instruction is for reading the value of Security Register bits. 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→sending RDSCUR instruction→Security Register data out on SO→ CS# goes high.

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

### 9-29. Write Security Register (WRSCUR)

The WRSCUR instruction is for changing the values of Security Register Bits. The WREN (Write Enable) instruction is required before issuing WRSCUR instruction. The WRSCUR instruction may change the values of bit1 (LDSO bit) for customer to lock-down the 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→ sending WRSCUR instruction → CS# goes high.

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

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

**Security Register**

The definition of the Security Register bits is as below:

**Write Protection Selection bit**. Please reference to *"Write Protection Selection"*

**Erase Fail bit.** The Erase Fail bit is a status flag, which shows the status of last Erase operation. It will be set to "1", if the erase operation fails. It will be set to "0", if the last operation is success. Please note that it will not interrupt or stop any operation in the flash memory.

**Program Fail bit.** The Program Fail bit is a status flag, which shows the status of last Program operation. It will be set to "1", if the program operation fails or the program region is protected. It will be set to "0", if the last operation is success. Please note that it will not interrupt or stop any operation in the flash memory.

**Erase Suspend 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 Suspend 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.

**Secured OTP Indicator bit.** The Secured OTP indicator bit shows the chip 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. While it is in 4K-bit secured OTP mode, main array access is not allowed.

**Table 9. Security Register Definition**

| bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|
| WPSEL | E_FAIL | P_FAIL | Reserved | ESB (Erase Suspend bit) | PSB (Program Suspend bit) | LDSO (indicate if lock-down) | Secured OTP indicator bit |
| 0=normal WP mode 1=individual mode (default=0) | 0=normal Erase succeed 1=indicate Erase failed (default=0) | 0=normal Program succeed 1=indicate Program failed (default=0) | - | 0=Erase is not suspended 1= Erase suspended (default=0) | 0=Program is not suspended 1= Program suspended (default=0) | 0 = not lock-down 1 = lock-down (cannot program/ erase OTP) | 0 = non-factory lock 1 = factory lock |
| Non-volatile bit (OTP) | Volatile bit | Volatile bit | Volatile bit | Volatile bit | Volatile bit | Non-volatile bit (OTP) | Non-volatile bit (OTP) |

### 9-30. Write Protection Selection (WPSEL)

There are two write protection methods provided on this device, (1) Block Lock (BP) protection mode (2) Advance Sector protection mode. If WPSEL=0, flash is under BP protection mode . If WPSEL=1, flash is under Advance Sector protection mode. The default value of WPSEL is "0". WPSEL command can be used to set WPSEL=1. **Please note that WPSEL is an OTP bit. Once WPSEL is set to 1, there is no chance to recovery WPSEL back to "0".** If the flash is put on BP mode, the Advance Sector protection mode is disabled. Contrarily, if flash is on the Advance Sector protection mode, the BP mode is disabled.

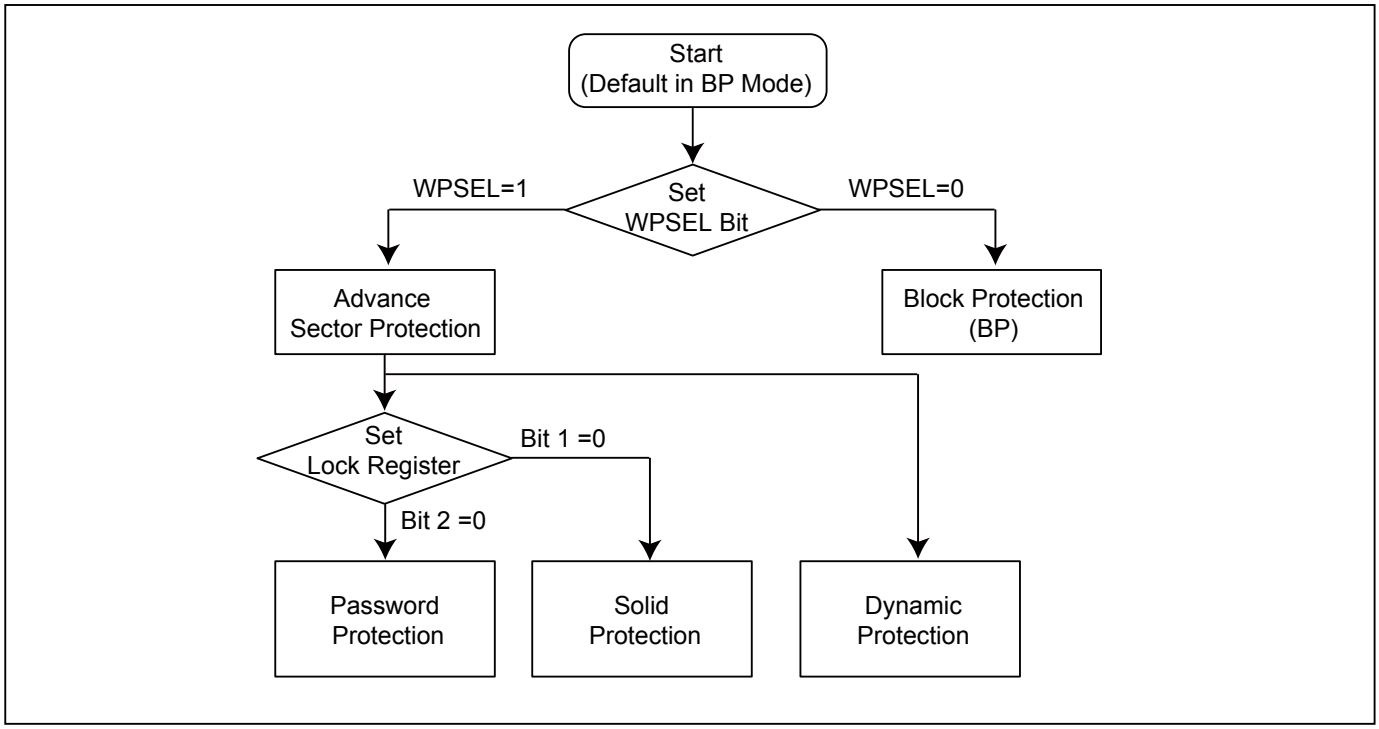
**Every time after the system is powered-on, and the Security Register bit 7 is checked to be WPSEL=1, all the blocks or sectors will be write protected by Dynamic Protected Bit (DPB) in default.** User may only unlock the blocks or sectors via GBULK instruction. Program or erase functions can only be operated after the Unlock instruction is conducted.

When WPSEL = 0: Block Lock (BP) protection mode,
Array is protected by BP3~BP0, where SRWD is bit 7 of status register that can be set by WRSR command.

When WPSEL =1: Advance Sector protection mode,
Blocks are individually protected by their own SPB or DPB lock bits which are set to "1" after power up. When the system accepts and executes WPSEL instruction, the bit 7 in security register will be set. It will activate WRLR, RDLR, WRPASS, RDPASS, PASSULK, WRSPB, ESSPB, SPBLK, RDSPBLK, WRDPB, RDDPB, GBLK, GBULK etc instructions to conduct block lock protection and replace the original Software Protect Mode (SPM) use (BP3~BP0) indicated block methods.

The sequence of issuing WPSEL instruction is: CS# goes low → sending WPSEL instruction to enter the individual block protect mode → CS# goes high.

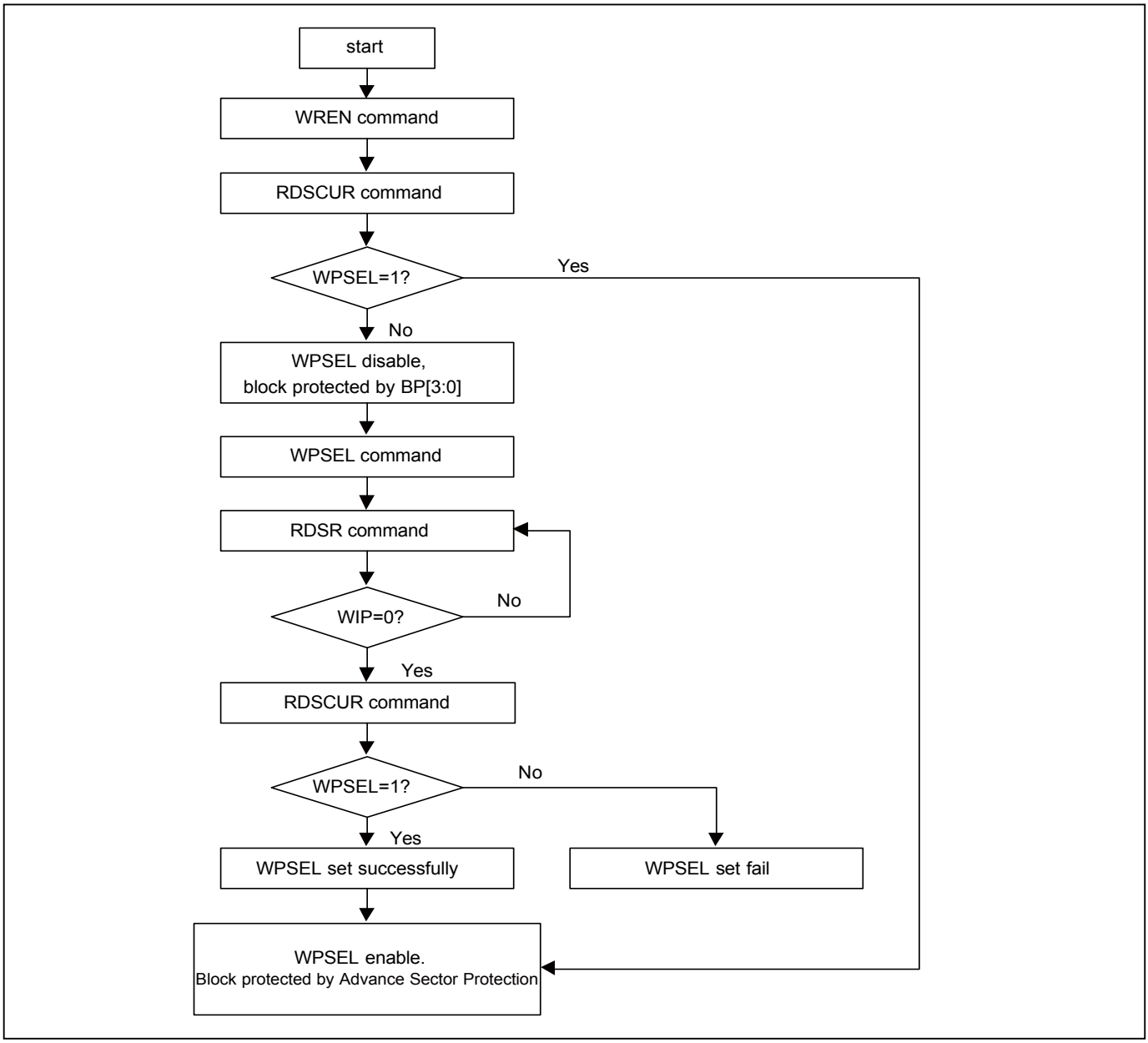
**Write Protection Selection**





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**Figure 53. WPSEL Flow**



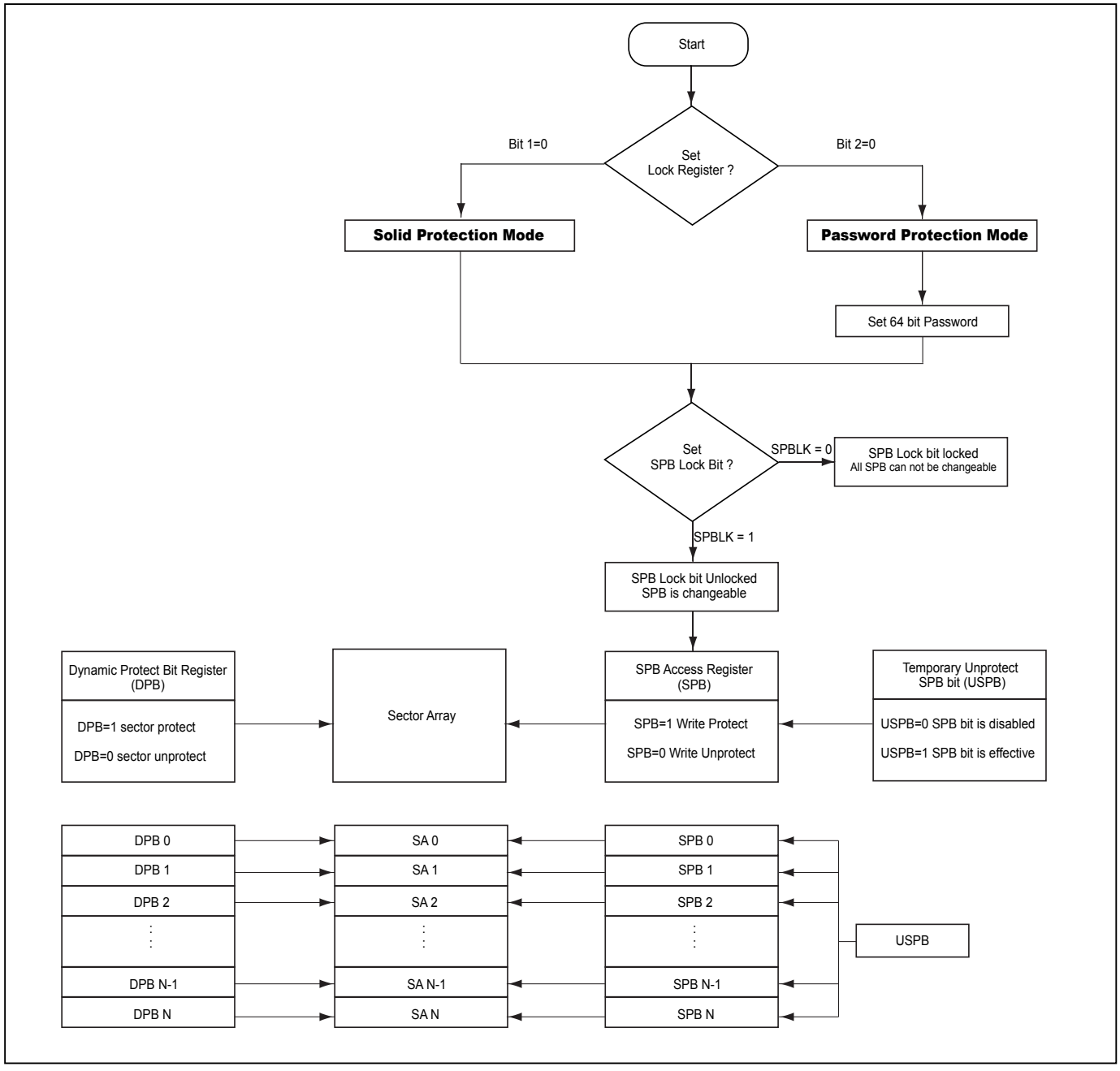
## 9-31. Advanced Sector Protection

There are two ways to implement software Advanced Sector Protection on this device: Password method or Solid method. Through these two protection methods, user can disable or enable the programming or erasing operation to any individual sector or all sectors.

There is a non-volatile (SPB) and volatile (DPB) protection bit related to the single sector in main flash array. Each of the sectors is protected from programming or erasing operation when the bit is set. The temporary unprotect solid write protect bit (USPB) can temporarily unprotect the sectors protected by SPB.

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:

**Figure 54. Advanced Sector Protection Overview**



### 9-31-1. Lock Register

User can choose favorite sector protecting method via setting Lock Register bits 1 and 2. Lock Register is a 16-bit one-time programmable register. Once bit 1 or bit 2 has been programmed (cleared to "0"), they will be locked in that mode and the others will be disabled permanently. Bit 1 and bit 2 can not be programmed at the same time, otherwise the device will abort the operation.

If user selects Password Protection mode, the password setting is required. User can set password by issuing WRPASS command.

**Lock Register**

| Bit 15-3 | Bit 2 | Bit 1 | Bit0 |
|---|---|---|---|
| Reserved | Password Protection Mode Lock Bit | Solid Protection Mode Lock Bit | Reserved |
| x | 0=Password Protection Mode Enable<br>1= Password Protection Mode not enable (Default =1) | 0=Solid Protection Mode Enable<br>1= Solid Protection Mode not enable (Default =1) | x |
| OTP | OTP | OTP | OTP |

***Notes:***
1. While bit 2 or bit 1 has been "0" status, other bits can't be changed any more. If set lock register program mode, program fail will be set to "1".
2. While bit 2 and bit 1 is "1" status,other bits can be programmed, program fail will be set to "1".

**Figure 55. Read Lock Register (RDLR) Sequence**

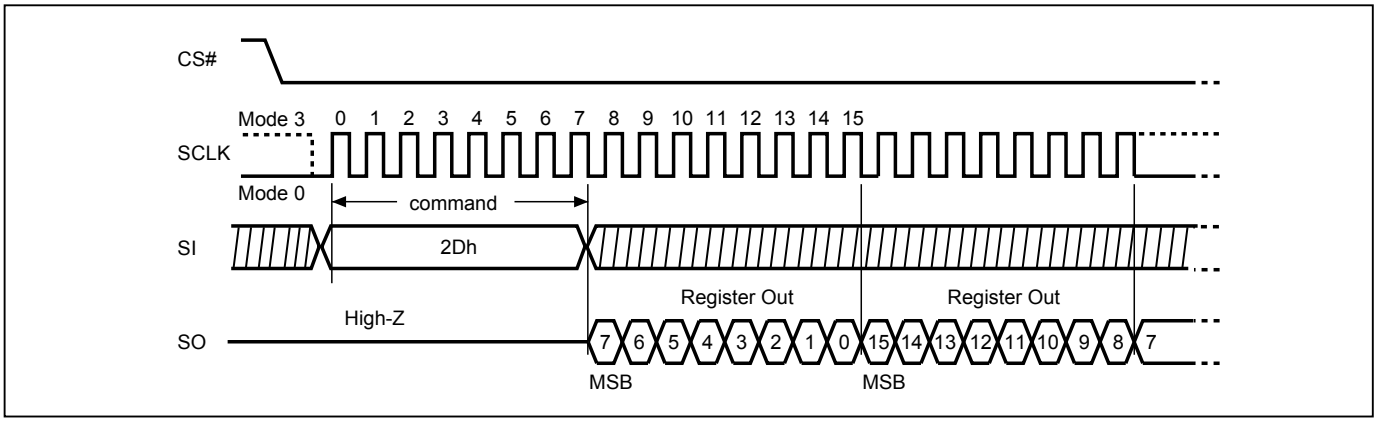
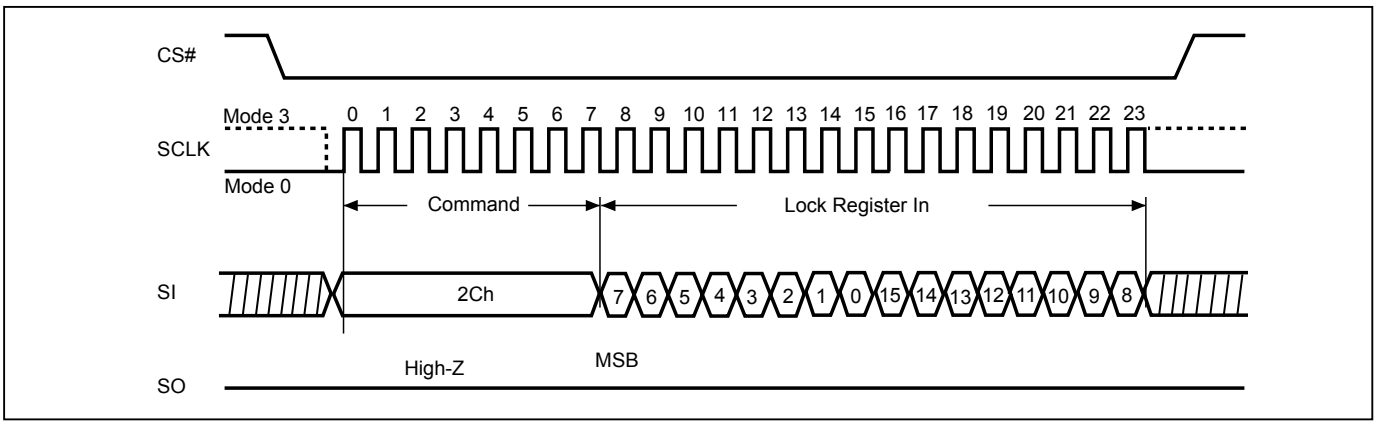



**Figure 56. Write Lock Register (WRLR) Sequence (SPI Mode)**





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### 9-31-2. SPB Lock Bit (SPBLB)

The Solid Protection Bit Lock Bit (SPBLB) is assigned to control all SPB status. It is unique and volatile.

The default status of this register is determined by Lock Register bit 1 and bit 2 status. Refer to *"SPB Lock Register"* for more SPB Lock information.

When under Solid Protect Mode, there is no software command sequence requested to unlock this bit. To clear the SPB lock bit, just take the device through a reset or a power-up cycle. When under Password Protection Mode, in order to prevent modification, the SPB Lock Bit must be set after all SPBs are setting the desired status.

**SPB Lock Register**

| Bit | Description | Bit Status | Default | Type |
|---|---|---|---|---|
| 7-1 | Reserved | X | 0000000 | Volatile |
| 0 | SPBLK (Lock SPB Bit) | 0= SPB bit protected<br>1= SPB bit unprotected | Solid protected Mode=1<br>Password Protected Mode=0 | Volatile |

**Figure 57. SPB Lock Bit Set (SPBLK) Sequence**

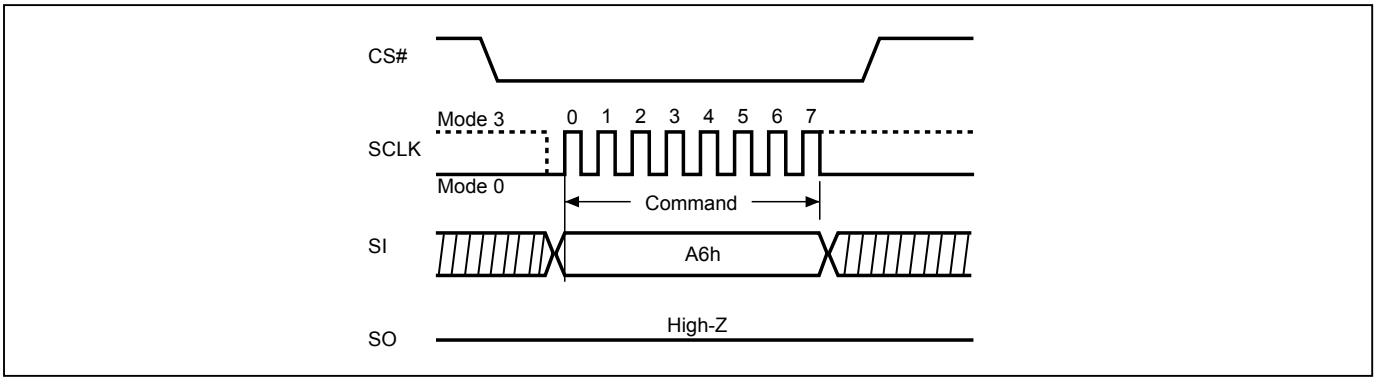
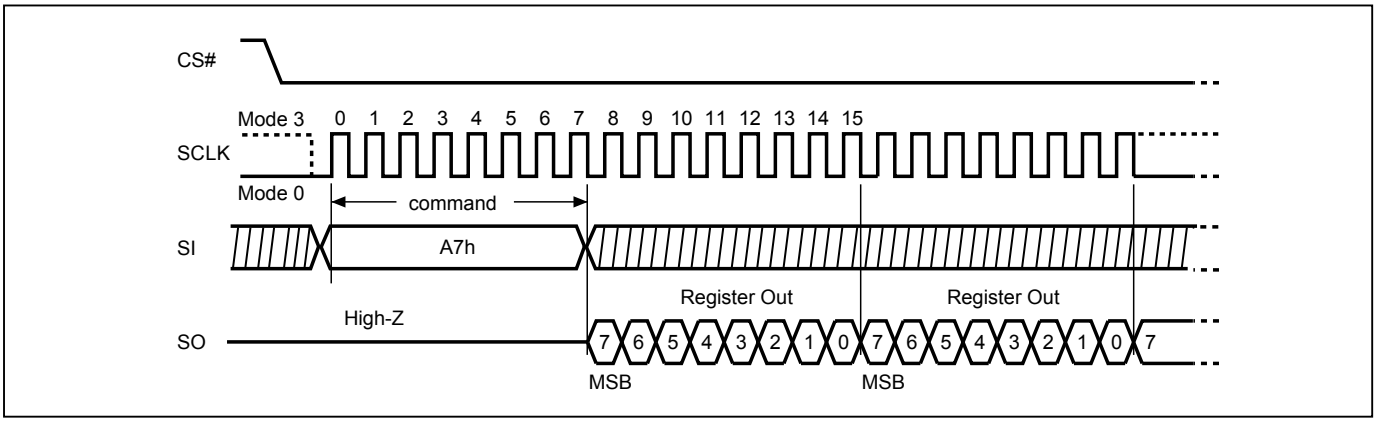



**Figure 58. Read SPB Lock Register (RDSPBLK) Sequence**



### 9-31-3. Solid Protection Bits

The Solid write Protection bit (SPB) is a nonvolatile bit with the same endurances as the Flash memory. It is assigned to each sector individually.

When a SPB is set to “1”, the associated sector may be protected, preventing any program or erase operation on this sector. The SPB bits are set individually by WRSPB command. However, it cannot be cleared individually. Issuing the ESSPB command will erase all SPB in the same time.

To unprotect a protected sector (corresponding SPB cleared to “0”), the SPB lock bit must be unlocked first. Under password protection mode (lock register bit 2 set as "0"), a PASSULK command is requested before unlocking SPB lock bit. However, while the device is under Solid Protection mode (lock register bit 1 set as "0"), just a reset or a power-up cycle can unlock the SPB lock bit.

After the SPB lock bit unlocked, the SPB status can be changed for desired settings. To lock the Solid Protection Bits after the modification has finished, the SPB Lock Bit must be set once again.

To verify the programming state of the SPB for a given sector, issuing a RDSPB Command to the device is required.

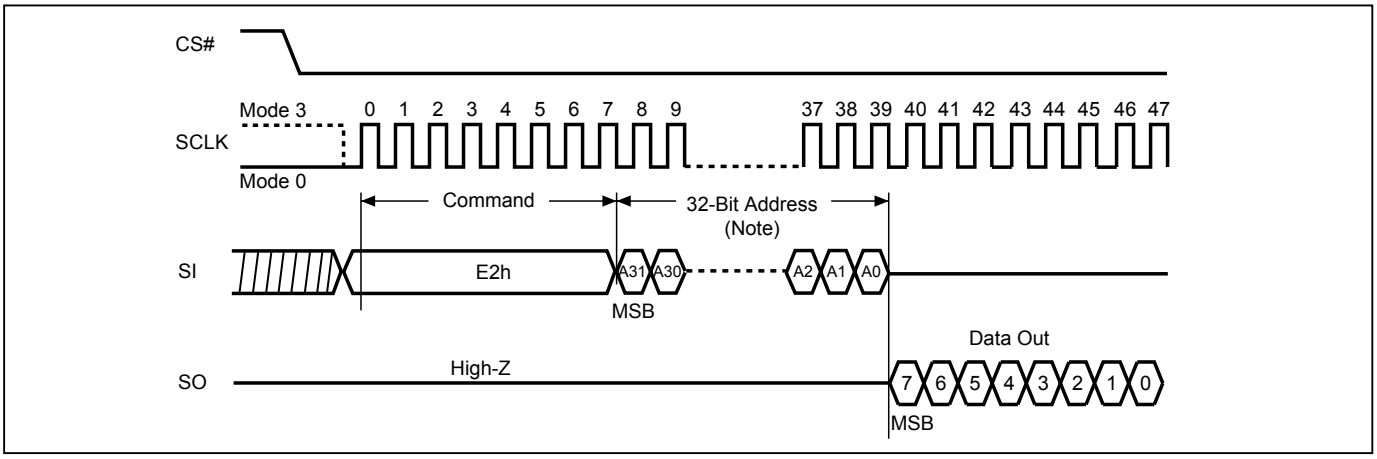
***Note:***

1. Once SPB Lock Bit is set, its program or erase command will not be executed and time-out without programming or erasing the SPB.

**SPB Register**

| Bit | Description | Bit Status | Default | Type |
|---|---|---|---|---|
| 7 to 0 | SPB (Solid protected Bit) | 00h= SPB for the sector address unprotected<br>FFh= SPB for the sector address protected | 00h | Non-volatile |

**Figure 59. Read SPB Status (RDSPB) Sequence**




Note: One dummy byte follow 3-byte address.

**Figure 60. SPB Erase (ESSPB) Sequence**

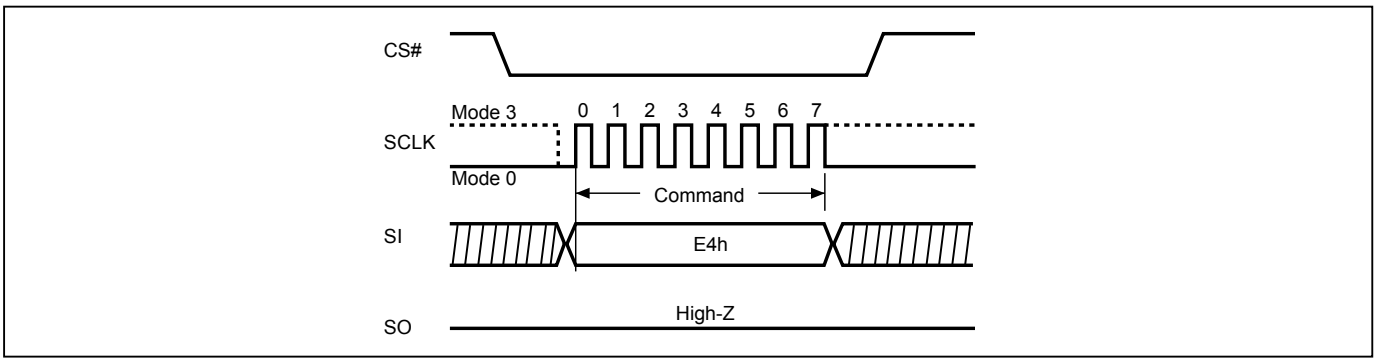
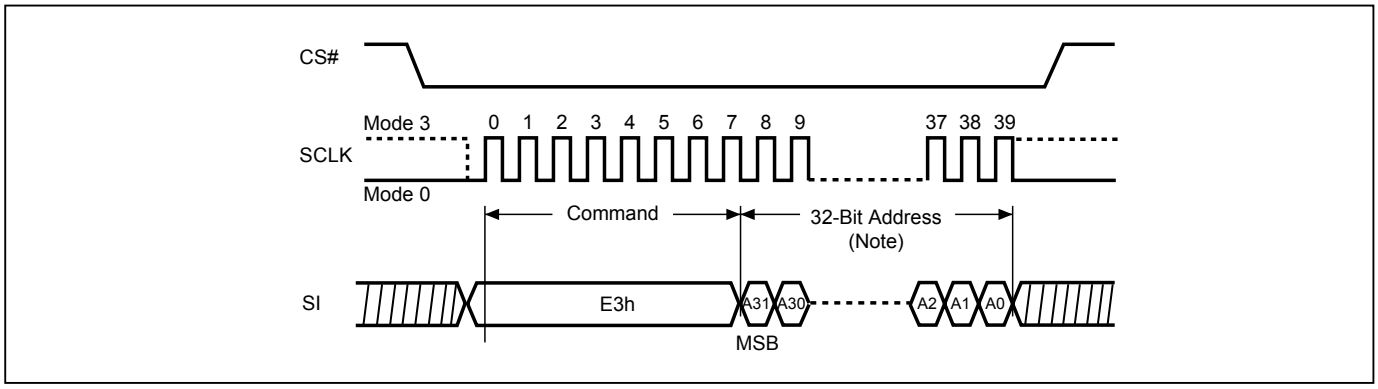



**Figure 61. SPB Program (WRSPB) Sequence**




Note: One dummy byte follow 3-byte address.

### 9-31-4. Dynamic Write Protection Bits

The Dynamic Protection features a volatile type protection to each individual sector. It can protect sectors from unintentional change, and is easy to disable when there are necessary changes.

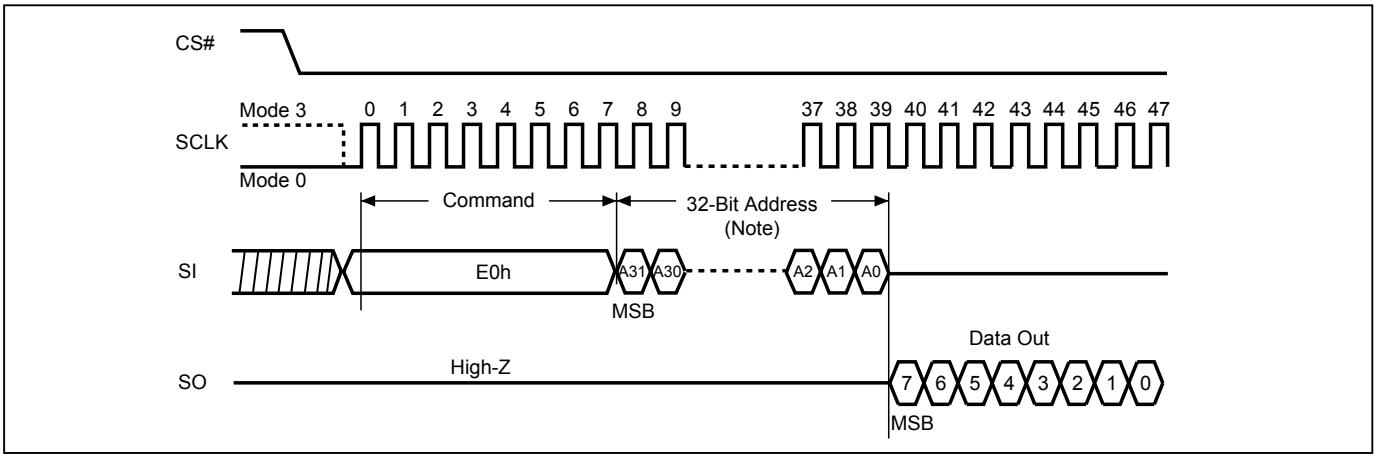
All DPBs are default as protected (FFh) after reset or upon power up cycle. Via setting up Dynamic Protection bit (DPB) by write DPB command (WRDPB), user can cancel the Dynamic Protection of associated sector.

The Dynamic Protection only works on those unprotected sectors whose SPBs are cleared. After the DPB state is cleared to “0”, the sector can be modified if the SPB state is unprotected state.

**DPB Register**

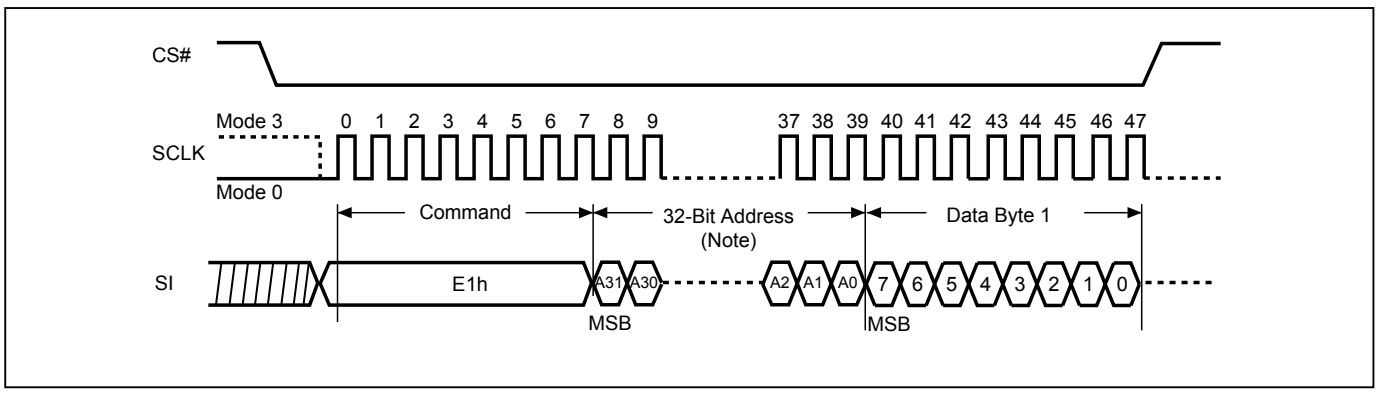
| Bit | Description | Bit Status | Default | Type |
|---|---|---|---|---|
| 7 to 0 | DPB (Dynamic protected Bit) | 00h= DPB for the sector address unprotected<br>FFh= DPB for the sector address protected | FFh | Volatile |

**Figure 62. Read DPB Register (RDDPB) Sequence**




Note: One dummy byte follow 3-byte address.

**Figure 63. Write DPB Register (WRDPB) Sequence**




Note: One dummy byte follow 3-byte address.

### 9-31-5. Temporary Un-protect Solid write protect bit (USPB)

Temporary Un-protect Solid write Protect Bit is volatile bit. Software can temporarily unprotect write protect sectors despite of SPBs' property when DPBs are cleared. While the USPB=1, all the SPBs' property is masked.

Notes:
1. Upon power up, the USPB status is default protected. The USPB can be unprotected (to "0") or protected (to "1") as often as needed. The hardware reset will reset USPB/DPB to their default values.
2. Please refer to *"9-31-7. Sector Protection States Summary Table"* for the sector state with the protection status of DPB/SPB/USPB bits.

### 9-31-6. Gang Block Lock/Unlock (GBLK/GBULK)

These instructions are only effective after WPSEL was executed. The GBLK/GBULK instruction is a chip-based protected or unprotected operation. It can enable or disable all DPB.

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

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

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

### 9-31-7. Sector Protection States Summary Table

| Protection Status | | | Sector State |
|---|---|---|---|
| DPB bit | SPB bit | USPB bit | |
| 0 | 0 | 0 | Unprotect |
| 0 | 0 | 1 | Unprotect |
| 0 | 1 | 0 | Unprotect |
| 0 | 1 | 1 | Protect |
| 1 | 0 | 0 | Protect |
| 1 | 0 | 1 | Protect |
| 1 | 1 | 0 | Protect |
| 1 | 1 | 1 | Protect |

### 9-32. Password Protection Mode

The security level of Password Protection Method is higher than the Solid protection mode. The 64 bit password is requested before modify SPB lock bit status. When device is under password protection mode, the SPB lock bit is cleared to “0”, after a power-up cycle or Reset Command.

A correct password is required for password Unlock command, to unlock the SPB lock bit. Await 2us is necessary to unlocked the device after valid password is given. After that, the SPB bits are allows to be changed. The Password Unlock command are issued slower than 2us every time, to prevent hacker from trying all the 64-bit password combinations.

To place the device in password protection mode, a few more steps are required. First, prior to entering the password protection mode, it is necessary to set a 64-bit password to verify it. Password verification is only allowed during the password programming operation. Second, the password protection mode is then activated by programming the Password Protection Mode Lock Bit to”0”. This operation is not reversible. Once the bit is programmed, it cannot be erased, and the device remains permanently in password protection mode, and the 64-bit password can neither be retrieved nor reprogrammed. Moreover, all commands to the address where the password is stored are disabled.

The password is all “1”s when shipped from the factory, it is only capable of programming "0"s under password program command. All 64-bit password combinations are valid as a password. No special address is required for programming the password. The password is no longer readable after the Password Protection mode is selected by programming Lock register bit 2 to "0".

Once sector under protected status, device will ignores the program/erase command, enable status polling and returns to read mode without contents change. The DPB, SPB and SPB lock bit status of each sector can be verified by issuing DPB, SPB and SPB Lock bit read commands.

- The unlock operation may fail if the password provided by password unlock command does not match the previously entered password. It causes the same result when a programming operation is performed on a protected sector. The P_FAIL bit is set to 1 and the WIP Bit remains set.

- It is not allowed to execute the Password Unlock command faster than every 100us ± 20us. The reason behind it is to make it impossible to hack into the system by running through all the combinations of a set of 64-bit password (58 million years). To verify if the device has completed the password unlock command and is available to process a new password command, the Read Status Register command is needed to read the WIP bit. When a valid password is provided the password unlock command does not insert the 100us delay before returning the WIP bit to zero.

- It is not feasible to set the SPB Lock bit if the password is missing after the Password Mode is selected.

**Password Register (PASS)**

| Bits | Field Name | Function | Type | Default State | Description |
|---|---|---|---|---|---|
| 63 to 0 | PWD | Hidden Password | OTP | FFFFFFFFFFFFFFFFh | Non-volatile OTP storage of 64 bit password. The password is no longer readable after the password protection mode is selected by programming Lock register bit 2 to zero. |

**Figure 64. Read Password Register (RDPASS) Sequence**

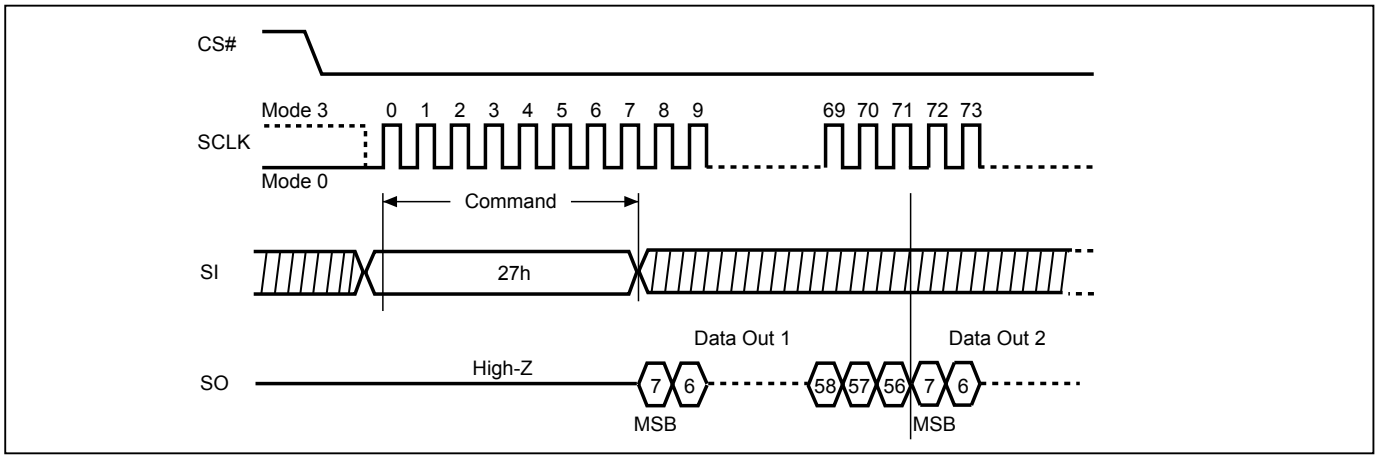



**Figure 65. Write Password Register (WRPASS) Sequence**

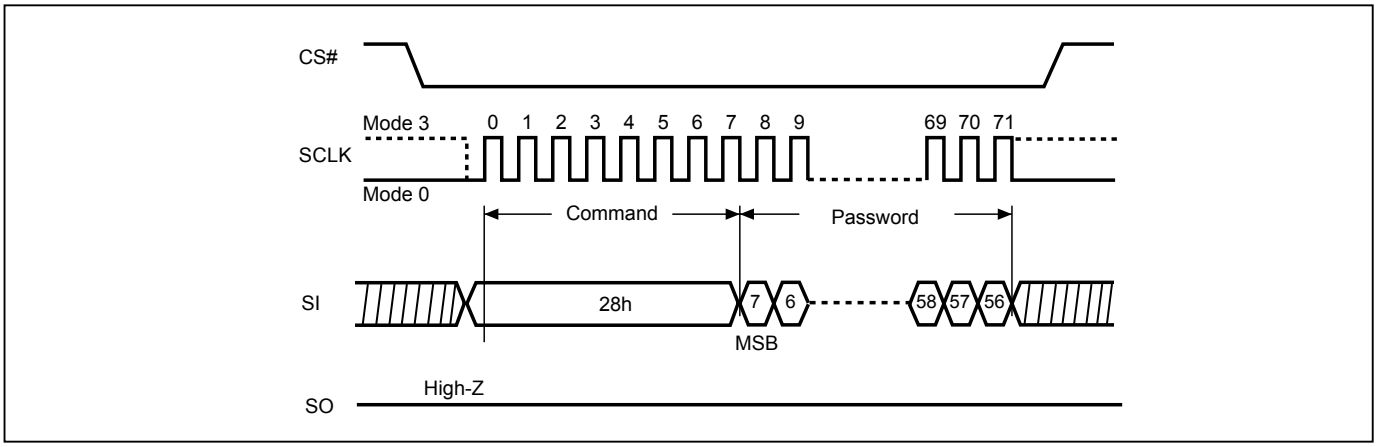
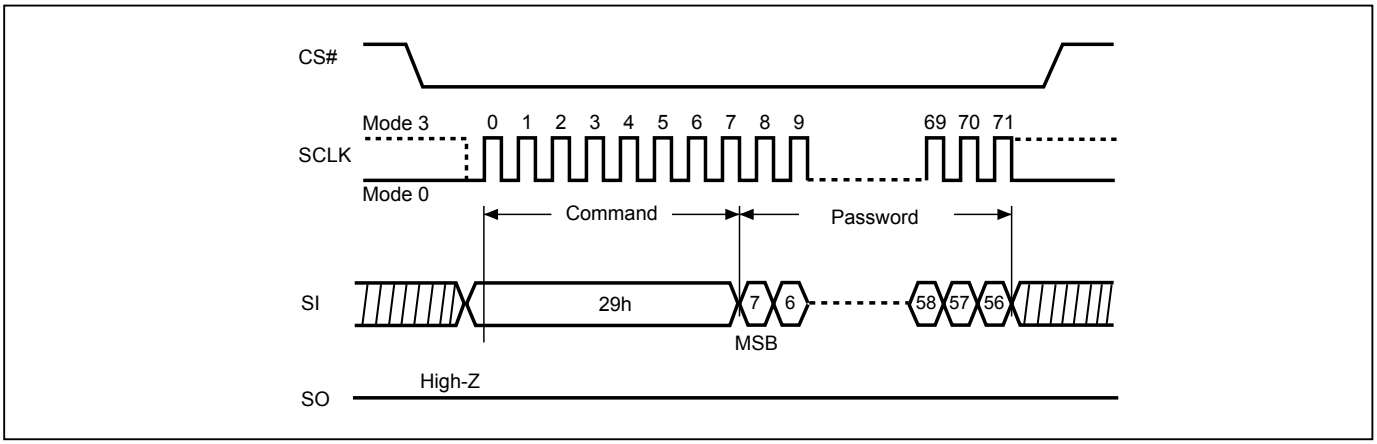



**Figure 66. Password Unlock (PASSULK) Sequence**



### 9-33. Program/Erase Suspend/Resume

The device allow the interruption of Sector-Erase, Block-Erase or Page-Program operations and conduct other operations.

After issue suspend command, the system can determine if the device has entered the Erase-Suspended mode through Bit2 (PSB) and Bit3 (ESB) of security register. (please refer to *"Table 9. Security Register Definition"*)

The latency time of erase operation :
Suspend to suspend ready timing: 20us.
Resume to another suspend timing: 1ms.

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

### 9-34. Erase Suspend

Erase suspend allow the interruption of all erase operations. After the device has entered Erase-Suspended mode, the system can read any sector(s) or Block(s) except those being erased by the suspended erase operation. Reading the sector or Block being erase suspended is invalid.

After erase suspend, WEL bit will be clear, only read related, resume and reset command can be accepted. (including: 03h, 0Bh, 3Bh, 6Bh, BBh, EBh, 5Ah, C0h, 06h, 04h, 2Bh, 9Fh, AFh, 05h, ABh, 90h, B1h, C1h, B0h, 30h, 66h, 99h, 00h, 35h, F5h, 15h, 2Dh, 27h, A7h, E2h, E0h, 16h)

If the system issues an Erase Suspend command after the sector erase operation has already begun, the device will not enter Erase-Suspended mode until 20us time has elapsed.

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.

### 9-35. Program Suspend

Program suspend allows the interruption of all program operations. After the device has entered Program-Suspended mode, the system can read any sector(s) or Block(s) except those being programmed by the suspended program operation. Reading the sector or Block being program suspended is invalid.

After program suspend, WEL bit will be cleared, only read related, resume and reset command can be accepted. (including: 03h, 0Bh, 3Bh, 6Bh, BBh, EBh, 5Ah, C0h, 06h, 04h, 2Bh, 9Fh, AFh, 05h, ABh, 90h, B1h, C1h, B0h, 30h, 66h, 99h, 00h, 35h, F5h, 15h, 2Dh, 27h, A7h, E2h, E0h, 16h)

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.

**Figure 67. Suspend to Read Latency**

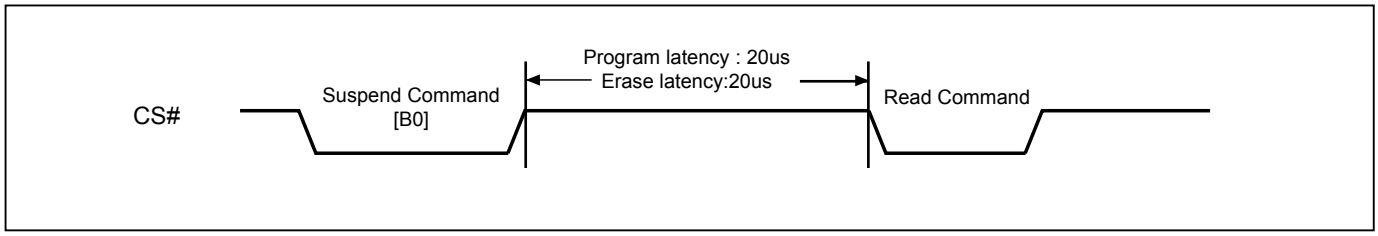



**Figure 68. Resume to Read Latency**

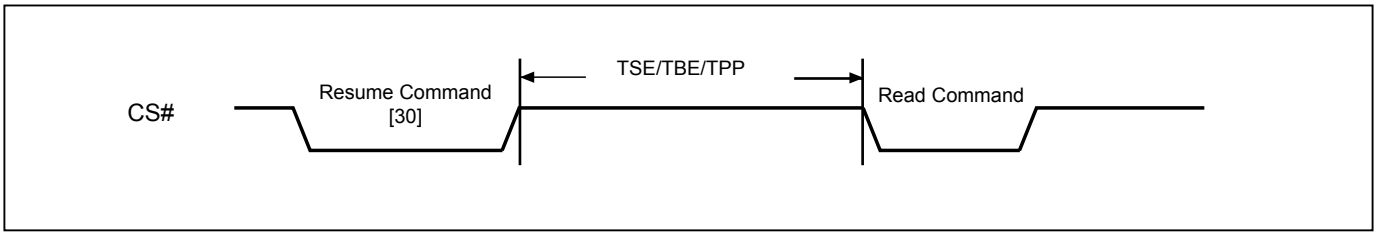
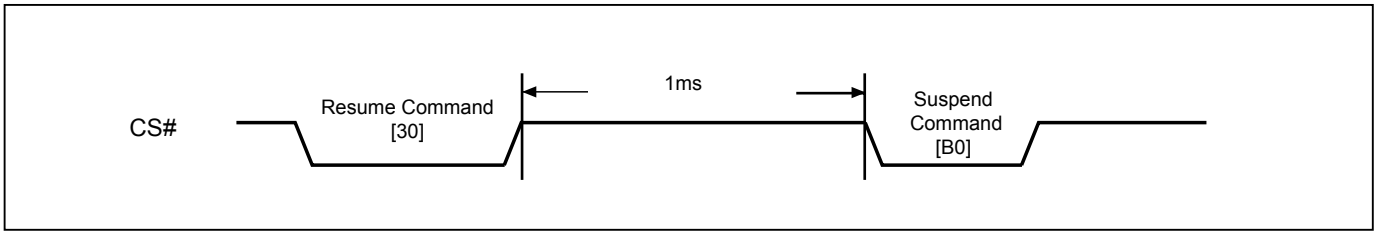



**Figure 69. Resume to Suspend Latency**



### 9-36. Write-Resume

The Write operation is being resumed when Write-Resume instruction issued. ESB or PSB (suspend status bit) in Status register will be changed back to “0”.

The operation of Write-Resume is as follows: CS# drives low → send write resume command cycle (30H) → drive CS# high. By polling Busy Bit in status register, the internal write operation status could be checked to be completed or not. The user may also wait the time lag of TSE, TBE, TPP for Sector-erase, Block-erase or Page-programming. WREN (command "06") is not required to issue before resume. Resume to another suspend operation requires latency time of 1ms.

Please note that, if "performance enhance mode" is executed during suspend operation, the device can not be resumed. To restart the write command, disable the "performance enhance mode" is required. After the "performance enhance mode" is disabled, the write-resume command is effective.

### 9-37. No Operation (NOP)

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

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

### 9-38. Software Reset (Reset-Enable (RSTEN) and Reset (RST))

The Software Reset operation combines two instructions: Reset-Enable (RSTEN) command following a 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.

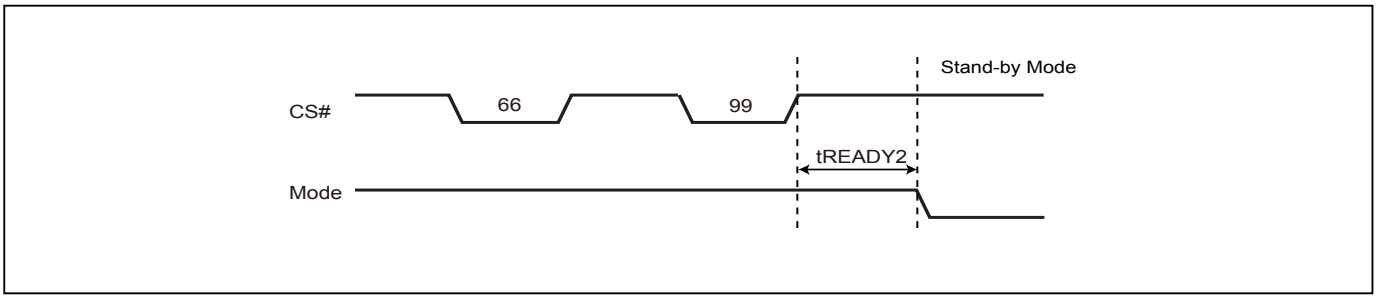
To execute Reset command (RST), the Reset-Enable (RSTEN) command must be executed first to perform the Reset operation. If there is any other command to interrupt after the Reset-Enable command, the Reset-Enable will be invalid.

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

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. For details, please refer to *"Table 14. Reset Timing-(Other Operation)"* for tREADY2.

**Figure 70. Software Reset Recovery**




Note: Refer to *"Table 14. Reset Timing-(Other Operation)"* for tREADY2.

**Figure 71. Reset Sequence (SPI mode)**

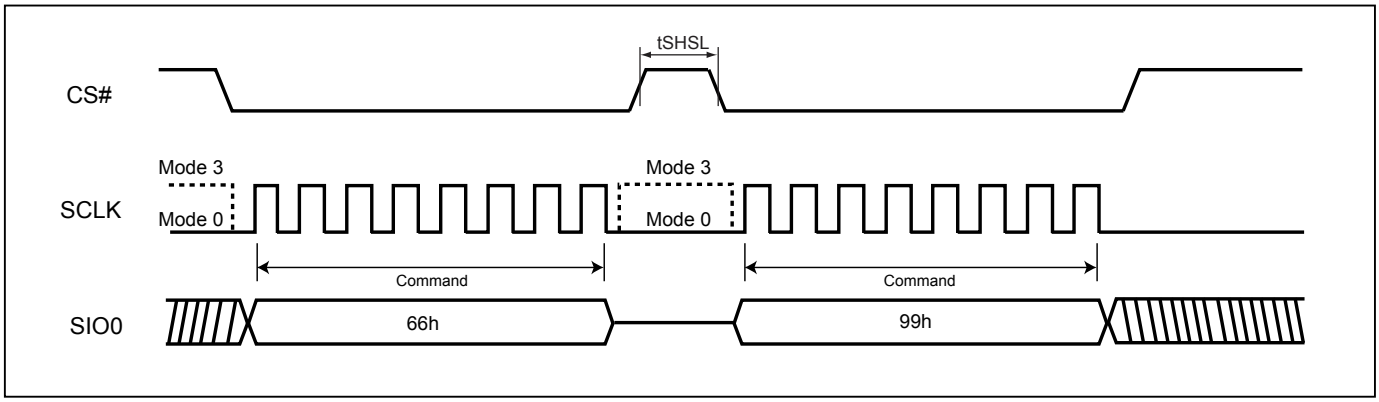
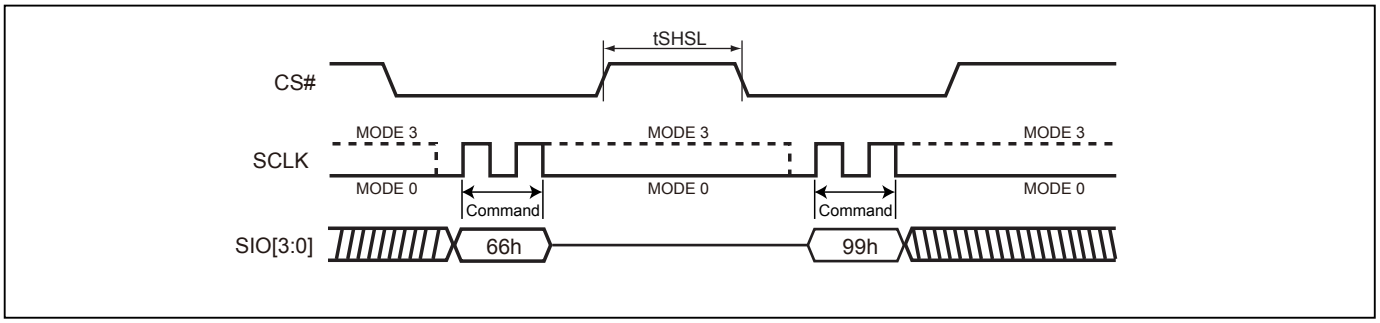



**Figure 72. Reset Sequence (QPI mode)**



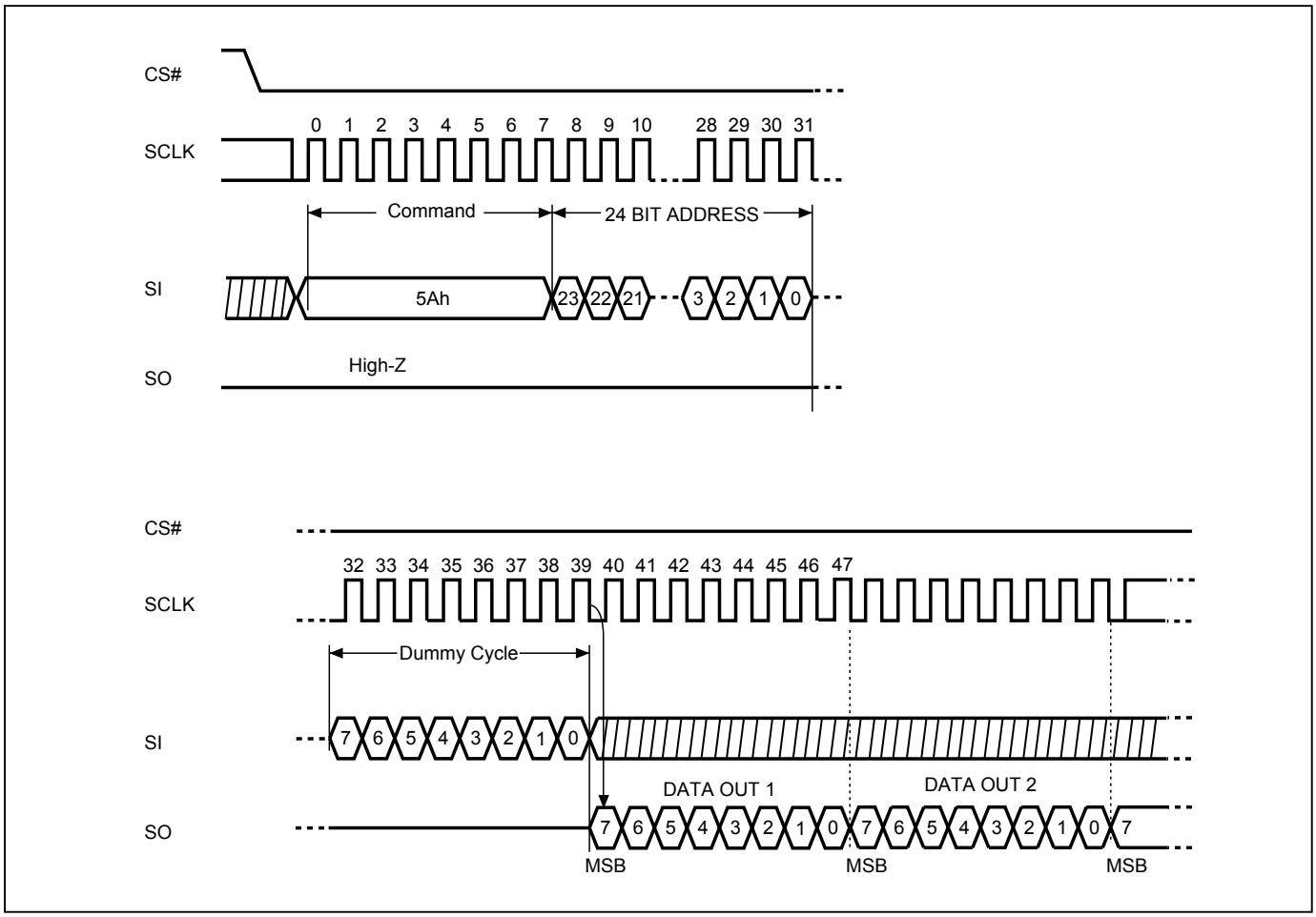
### 9-39. Read SFDP Mode (RDSFDP)

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.

**Figure 73. Read Serial Flash Discoverable Parameter (RDSFDP) Sequence**





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**Table 10. Signature and Parameter Identification Data Values**

| Description | Comment | Add (h) (Byte) | DW Add (Bit) | Data (h/b) note1 | Data (h) |
|---|---|---|---|---|---|
| SFDP Signature | Fixed: 50444653h | 00h | 07:00 | 53h | 53h |
| | | 01h | 15:08 | 46h | 46h |
| | | 02h | 23:16 | 44h | 44h |
| | | 03h | 31:24 | 50h | 50h |
| SFDP Minor Revision Number | Start from 00h | 04h | 07:00 | 00h | 00h |
| SFDP Major Revision Number | Start from 01h | 05h | 15:08 | 01h | 01h |
| Number of Parameter Headers | This number is 0-based. Therefore, 0 indicates 1 parameter header. | 06h | 23:16 | 01h | 01h |
| Unused | | 07h | 31:24 | FFh | FFh |
| ID number (JEDEC) | 00h: it indicates a JEDEC specified header. | 08h | 07:00 | 00h | 00h |
| Parameter Table Minor Revision Number | Start from 00h | 09h | 15:08 | 00h | 00h |
| Parameter Table Major Revision Number | Start from 01h | 0Ah | 23:16 | 01h | 01h |
| Parameter Table Length (in double word) | How many DWORDs in the Parameter table | 0Bh | 31:24 | 09h | 09h |
| Parameter Table Pointer (PTP) | First address of JEDEC Flash Parameter table | 0Ch | 07:00 | 30h | 30h |
| | | 0Dh | 15:08 | 00h | 00h |
| | | 0Eh | 23:16 | 00h | 00h |
| Unused | | 0Fh | 31:24 | FFh | FFh |
| ID number (Macronix manufacturer ID) | it indicates Macronix manufacturer ID | 10h | 07:00 | C2h | C2h |
| Parameter Table Minor Revision Number | Start from 00h | 11h | 15:08 | 00h | 00h |
| Parameter Table Major Revision Number | Start from 01h | 12h | 23:16 | 01h | 01h |
| Parameter Table Length (in double word) | How many DWORDs in the Parameter table | 13h | 31:24 | 04h | 04h |
| Parameter Table Pointer (PTP) | First address of Macronix Flash Parameter table | 14h | 07:00 | 60h | 60h |
| | | 15h | 15:08 | 00h | 00h |
| | | 16h | 23:16 | 00h | 00h |
| Unused | | 17h | 31:24 | FFh | FFh |


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**Table 11. Parameter Table (0): JEDEC Flash Parameter Tables**

| Description | Comment | Add (h) (Byte) | DW Add (Bit) | Data (h/b) note1 | Data (h) |
|---|---|---|---|---|---|
| Block/Sector Erase sizes | 00: Reserved, 01: 4KB erase,<br>10: Reserved,<br>11: not support 4KB erase | 30h | 01:00 | 01b | E5h |
| Write Granularity | 0: 1Byte, 1: 64Byte or larger | | 02 | 1b | |
| Write Enable Instruction Required for Writing to Volatile Status Registers | 0: not required<br>1: required 00h to be written to the status register | | 03 | 0b | |
| Write Enable Opcode Select for Writing to Volatile Status Registers | 0: use 50h opcode,<br>1: use 06h opcode<br>Note: If target flash status register is nonvolatile, then bits 3 and 4 must be set to 00b. | | 04 | 0b | |
| Unused | Contains 111b and can never be changed | | 07:05 | 111b | |
| 4KB Erase Opcode | | 31h | 15:08 | 20h | 20h |
| (1-1-2) Fast Read (Note2) | 0=not support 1=support | 32h | 16 | 1b | F1h |
| Address Bytes Number used in addressing flash array | 00: 3Byte only, 01: 3 or 4Byte,<br>10: 4Byte only, 11: Reserved | | 18:17 | 00b | |
| Double Transfer Rate (DTR) Clocking | 0=not support 1=support | | 19 | 0b | |
| (1-2-2) Fast Read | 0=not support 1=support | | 20 | 1b | |
| (1-4-4) Fast Read | 0=not support 1=support | | 21 | 1b | |
| (1-1-4) Fast Read | 0=not support 1=support | | 22 | 1b | |
| Unused | | | 23 | 1b | |
| Unused | | 33h | 31:24 | FFh | FFh |
| Flash Memory Density | | 37h:34h | 31:00 | 07FF FFFFh | |
| (1-4-4) Fast Read Number of Wait states (Note3) | 0 0000b: Wait states (Dummy Clocks) not support | 38h | 04:00 | 0 0100b | 44h |
| (1-4-4) Fast Read Number of Mode Bits (Note4) | 000b: Mode Bits not support | | 07:05 | 010b | |
| (1-4-4) Fast Read Opcode | | 39h | 15:08 | EBh | EBh |
| (1-1-4) Fast Read Number of Wait states | 0 0000b: Wait states (Dummy Clocks) not support | 3Ah | 20:16 | 0 1000b | 08h |
| (1-1-4) Fast Read Number of Mode Bits | 000b: Mode Bits not support | | 23:21 | 000b | |
| (1-1-4) Fast Read Opcode | | 3Bh | 31:24 | 6Bh | 6Bh |


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| Description | Comment | Add (h) (Byte) | DW Add (Bit) | Data (h/b) note1 | Data (h) |
|---|---|---|---|---|---|
| (1-1-2) Fast Read Number of Wait states | 0 0000b: Wait states (Dummy Clocks) not supported | 3Ch | 04:00 | 0 1000b | 08h |
| (1-1-2) Fast Read Number of Mode Bits | 000b: Mode Bits not supported | | 07:05 | 000b | |
| (1-1-2) Fast Read Opcode | | 3Dh | 15:08 | 3Bh | 3Bh |
| (1-2-2) Fast Read Number of Wait states | 0 0000b: Wait states (Dummy Clocks) not supported | 3Eh | 20:16 | 0 0100b | 04h |
| (1-2-2) Fast Read Number of Mode Bits | 000b: Mode Bits not supported | | 23:21 | 000b | |
| (1-2-2) Fast Read Opcode | | 3Fh | 31:24 | BBh | BBh |
| (2-2-2) Fast Read | 0=not support 1=support | 40h | 00 | 0b | FEh |
| Unused | | | 03:01 | 111b | |
| (4-4-4) Fast Read | 0=not support 1=support | | 04 | 1b | |
| Unused | | | 07:05 | 111b | |
| Unused | | 43h:41h | 31:08 | FFh | FFh |
| Unused | | 45h:44h | 15:00 | FFh | FFh |
| (2-2-2) Fast Read Number of Wait states | 0 0000b: Wait states (Dummy Clocks) not supported | 46h | 20:16 | 0 0000b | 00h |
| (2-2-2) Fast Read Number of Mode Bits | 000b: Mode Bits not supported | | 23:21 | 000b | |
| (2-2-2) Fast Read Opcode | | 47h | 31:24 | FFh | FFh |
| Unused | | 49h:48h | 15:00 | FFh | FFh |
| (4-4-4) Fast Read Number of Wait states | 0 0000b: Wait states (Dummy Clocks) not supported | 4Ah | 20:16 | 0 0100b | 44h |
| (4-4-4) Fast Read Number of Mode Bits | 000b: Mode Bits not supported | | 23:21 | 010b | |
| (4-4-4) Fast Read Opcode | | 4Bh | 31:24 | EBh | EBh |
| Sector Type 1 Size | Sector/block size = 2^N bytes (Note5)<br>0x00b: this sector type doesn't exist | 4Ch | 07:00 | 0Ch | 0Ch |
| Sector Type 1 erase Opcode | | 4Dh | 15:08 | 20h | 20h |
| Sector Type 2 Size | Sector/block size = 2^N bytes<br>0x00b: this sector type doesn't exist | 4Eh | 23:16 | 0Fh | 0Fh |
| Sector Type 2 erase Opcode | | 4Fh | 31:24 | 52h | 52h |
| Sector Type 3 Size | Sector/block size = 2^N bytes<br>0x00b: this sector type doesn't exist | 50h | 07:00 | 10h | 10h |
| Sector Type 3 erase Opcode | | 51h | 15:08 | D8h | D8h |
| Sector Type 4 Size | Sector/block size = 2^N bytes<br>0x00b: this sector type doesn't exist | 52h | 23:16 | 00h | 00h |
| Sector Type 4 erase Opcode | | 53h | 31:24 | FFh | FFh |

**Table 12. Parameter Table (1): Macronix Flash Parameter Tables**

| Description | Comment | Add (h) (Byte) | DW Add (Bit) | Data (h/b) note1 | Data (h) |
|---|---|---|---|---|---|
| Vcc Supply Maximum Voltage | 2000h=2.000V<br>2700h=2.700V<br>3600h=3.600V | 61h:60h | 07:00<br>15:08 | 00h<br>36h | 00h<br>36h |
| Vcc Supply Minimum Voltage | 1650h=1.650V<br>2250h=2.250V<br>2350h=2.350V<br>2700h=2.700V | 63h:62h | 23:16<br>31:24 | 00h<br>27h | 00h<br>27h |
| H/W Reset# pin | 0=not support 1=support | 65h:64h | 00 | 0b | F99Ch |
| H/W Hold# pin | 0=not support 1=support | | 01 | 0b | |
| Deep Power Down Mode | 0=not support 1=support | | 02 | 1b | |
| S/W Reset | 0=not support 1=support | | 03 | 1b | |
| S/W Reset Opcode | Reset Enable (66h) should be issued before Reset Opcode | | 11:04 | 1001 1001b (99h) | |
| Program Suspend/Resume | 0=not support 1=support | | 12 | 1b | |
| Erase Suspend/Resume | 0=not support 1=support | | 13 | 1b | |
| Unused | | | 14 | 1b | |
| Wrap-Around Read mode | 0=not support 1=support | | 15 | 1b | |
| Wrap-Around Read mode Opcode | | 66h | 23:16 | C0h | C0h |
| Wrap-Around Read data length | 08h:support 8B wrap-around read<br>16h:8B&16B<br>32h:8B&16B&32B<br>64h:8B&16B&32B&64B | 67h | 31:24 | 64h | 64h |
| Individual block lock | 0=not support 1=support | 6Bh:68h | 00 | 1b | CB85h |
| Individual block lock bit (Volatile/Nonvolatile) | 0=Volatile 1=Nonvolatile | | 01 | 0b | |
| Individual block lock Opcode | | | 09:02 | 1110 0001b (E1h) | |
| Individual block lock Volatile protect bit default protect status | 0=protect 1=unprotect | | 10 | 0b | |
| Secured OTP | 0=not support 1=support | | 11 | 1b | |
| Read Lock | 0=not support 1=support | | 12 | 0b | |
| Permanent Lock | 0=not support 1=support | | 13 | 0b | |
| Unused | | | 15:14 | 11b | |
| Unused | | | 31:16 | FFh | FFh |
| Unused | | 6Fh:6Ch | [31:00] | FFh | FFh |

Note 1: h/b is hexadecimal or binary.

Note 2: **(x-y-z)** means I/O mode nomenclature used to indicate the number of active pins used for the opcode (x), address (y), and data (z). At the present time, the only valid Read SFDP instruction modes are: (1-1-1), (2-2-2), and (4-4-4)

Note 3: **Wait States** is required dummy clock cycles after the address bits or optional mode bits.

Note 4: **Mode Bits** is optional control bits that follow the address bits. These bits are driven by the system controller if they are specified. (eg,read performance enhance toggling bits)

Note 5: 4KB=2^0Ch,32KB=2^0Fh,64KB=2^10h

Note 6: All unused and undefined area data is  blank FFh.

## 10. RESET

Driving the RESET# pin low for a period of tRLRH or longer will reset the device. After reset cycle, the device is at the following states:
- Standby mode
- All the volatile bits such as WEL/WIP/SRAM lock bit will return to the default status as power on.
- 3-byte address mode

If the device is under programming or erasing, driving the RESET# pin low will also terminate the operation and data could be lost. During the resetting cycle, the SO data becomes high impedance and the current will be reduced to minimum.

**Figure 74. RESET Timing**

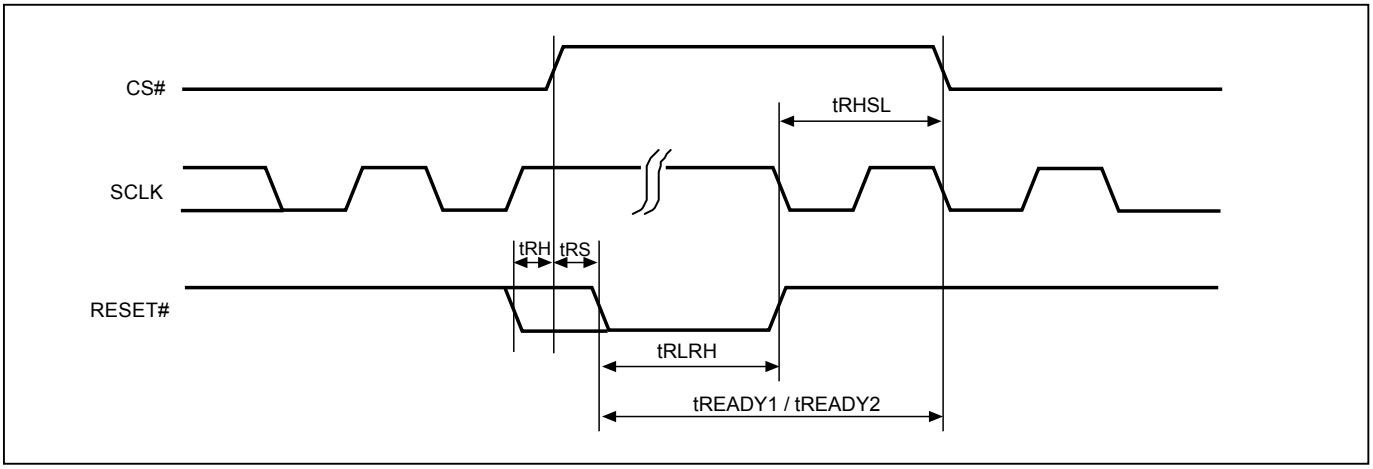



**Table 13. Reset Timing-(Power On)**

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| tRHSL | Reset# high before CS# low | 10 | | | us |
| tRS | Reset# setup time | 15 | | | ns |
| tRH | Reset# hold time | 15 | | | ns |
| tRLRH | Reset# low pulse width | 10 | | | us |
| tREADY1 | Reset Recovery time | 35 | | | us |

**Table 14. Reset Timing-(Other Operation)**

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| tRHSL | Reset# high before CS# low | 10 | | | us |
| tRS | Reset# setup time | 15 | | | ns |
| tRH | Reset# hold time | 15 | | | ns |
| tRLRH | Reset# low pulse width | 10 | | | us |
| tREADY2 | Reset Recovery time (During instruction decoding) | 40 | | | us |
| | Reset Recovery time (for read operation) | 35 | | | us |
| | Reset Recovery time (for program operation) | 310 | | | us |
| | Reset Recovery time(for SE4KB operation) | 12 | | | ms |
| | Reset Recovery time (for BE64K/BE32KB operation) | 25 | | | ms |
| | Reset Recovery time (for Chip Erase operation) | 100 | | | ms |
| | Reset Recovery time (for WRSR operation) | 40 | | | ms |

## 11. POWER-ON STATE

The device is at below states when power-up:
- Standby mode (please note it is not deep power-down mode)
- Write Enable Latch (WEL) bit is reset

The device must not be selected during power-up and power-down stage unless the VCC achieves below correct level:
- 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. When VCC is lower than VWI (POR threshold voltage value), the internal logic is reset and the flash device has no response to any command.

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 below time delay:
- tVSL after VCC reached VCC minimum level

Please refer to the *"Figure 81. Power-up Timing"*.

Note:
- To stabilize the VCC level, the VCC rail decoupled by a suitable capacitor close to package pins is recommended. (generally around 0.1uF)
- At power-down stage, the VCC drops below VWI level, all operations are disable and device has no response to any command. The data corruption might occur during the stage while a write, program, erase cycle is in progress.


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## 12. ELECTRICAL SPECIFICATIONS

### Table 15. 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 *Figure 75* and *Figure 76.*

**Figure 75. Maximum Negative Overshoot Waveform**

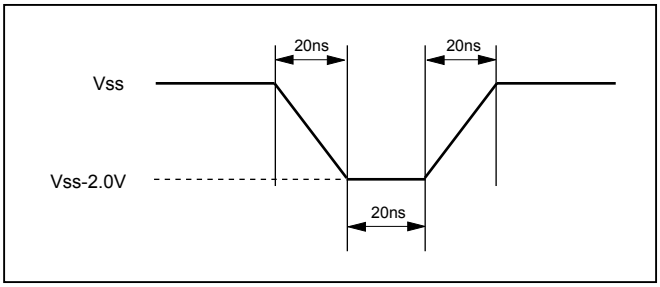
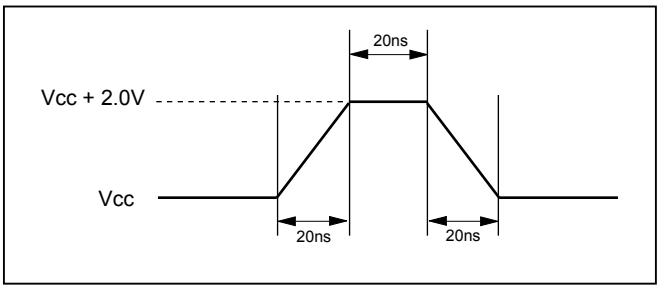



**Figure 76. Maximum Positive Overshoot Waveform**

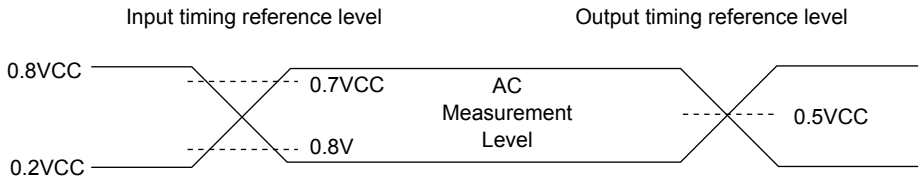



### Table 16. CAPACITANCE TA = 25°C, f = 1.0 MHz

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

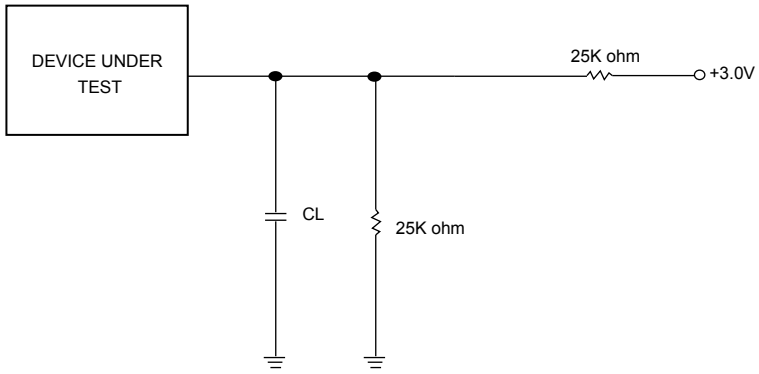

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**Figure 77. INPUT TEST WAVEFORMS AND MEASUREMENT LEVEL**




Note: Input pulse rise and fall time are <5ns

**Figure 78. OUTPUT LOADING**




CL=30pF Including jig capacitance


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**Table 17. DC CHARACTERISTICS**

**(Temperature = -40°C to 85°C, VCC = 2.7V ~ 3.6V)**

| 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 | | | 2 | 20 | uA | VIN = VCC or GND, CS# = VCC |
| ICC1 | VCC Read | 1 | | 14 | 25 | mA | f=133MHz, (4 x I/O read) SCLK=0.1VCC/0.9VCC, SO=Open |
| | | | | | 20 | mA | f=104MHz, (4 x I/O read) SCLK=0.1VCC/0.9VCC, SO=Open |
| | | | | | 15 | mA | f=84MHz, SCLK=0.1VCC/0.9VCC, SO=Open |
| ICC2 | VCC Program Current (PP) | 1 | | 14 | 20 | mA | Program in Progress, CS# = VCC |
| ICC3 | VCC Write Status Register (WRSR) Current | | | 10 | 12 | mA | Program status register in progress, CS#=VCC |
| ICC4 | VCC Sector/Block (32K, 64K) Erase Current (SE/BE/BE32K) | 1 | | 14 | 25 | mA | Erase in Progress, CS#=VCC |
| ICC5 | VCC Chip Erase Current (CE) | 1 | | 14 | 25 | 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 | | | | 0.2 | V | IOL = 100uA |
| 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.

**Table 18. AC CHARACTERISTICS**

**(Temperature = -40°C to 85°C, VCC = 2.7V ~ 3.6V)**

| Symbol | Alt. | Parameter | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| fSCLK | fC | Clock Frequency for all commands (except Read) | | D.C. | | 133 | MHz |
| fRSCLK | fR | Clock Frequency for READ instructions | | | | 50 | MHz |
| fTSCLK | fT | Clock Frequency for 2READ instructions | | | | 84(7) | MHz |
| | fQ | Clock Frequency for 4READ instructions | | | | 84(7) | MHz |
| tCH(1) | tCLH | Clock High Time | Others (fSCLK) | 45% fTSCLK | | | ns |
| | | | Normal Read (fRSCLK) | 7 | | | ns |
| tCL(1) | tCLL | Clock Low Time | Others (fSCLK) | 45% fTSCLK | | | ns |
| | | | Normal Read (fRSCLK) | 7 | | | 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) | | 3 | | | ns |
| tCHSL | | CS# Not Active Hold Time (relative to SCLK) | | 3 | | | ns |
| tDVCH | tDSU | Data In Setup Time | | 2 | | | ns |
| tCHDX | tDH | Data In Hold Time | | 2 | | | ns |
| tCHSH | | CS# Active Hold Time (relative to SCLK) | | 3 | | | ns |
| tSHCH | | CS# Not Active Setup Time (relative to SCLK) | | 3 | | | ns |
| tSHSL | tCSH | CS# Deselect Time | Read | 7 | | | ns |
| | | | Write/Erase/Program | 30 | | | ns |
| tSHQZ(2) | tDIS | Output Disable Time | | | | 8 | ns |
| tCLQV | tV | Clock Low to Output Valid Loading: 30pF/15pF | Loading: 30pF | | | 8 | ns |
| | | | Loading: 15pF | | | 6 | ns |
| tCLQX | tHO | Output Hold Time | | 1 | | | ns |
| tWHSL(3) | | Write Protect Setup Time | | 20 | | | ns |
| tSHWL(3) | | Write Protect Hold Time | | 100 | | | ns |
| tDP(2) | | CS# High to Deep Power-down Mode | | | | 10 | us |
| tRES1(2) | | CS# High to Standby Mode without Electronic Signature Read | | | | 30 | us |
| tRES2(2) | | CS# High to Standby Mode with Electronic Signature Read | | | | 30 | us |
| tW | | Write Status/Configuration Register Cycle Time | | | | 40 | ms |
| tBP | | Byte-Program | | | 16 | 30 | us |
| tPP | | Page Program Cycle Time | | | 0.5 | 1.5 | ms |
| tPP(5) | | Page Program Cycle Time (n bytes) | | | 0.008+ (nx0.004) (6) | 1.5 | ms |
| tSE | | Sector Erase Cycle Time | | | 30 | 120 | ms |
| tBE32 | | Block Erase (32KB) Cycle Time | | | 150 | 650 | ms |
| tBE | | Block Erase (64KB) Cycle Time | | | 280 | 650 | ms |
| tCE | | Chip Erase Cycle Time | | | 50 | 80 | s |

**Notes:**
1. tCH + tCL must be greater than or equal to 1/ Frequency.
2. Typical values given for TA=25°C. Not 100% tested.
3. Only applicable as a constraint for a WRSR instruction when SRWD is set at 1.
4. Test condition is shown as *Figure 77* and *Figure 78*.
5. While programming consecutive bytes, Page Program instruction provides optimized timings by selecting to program the whole 256 bytes or only a few bytes between 1~256 bytes.
6. "n"=how many bytes to program. In the formula, while n=1, byte program time=12us.
7. By default dummy cycle value. Please refer to the *"Table 1. Read performance Comparison".*

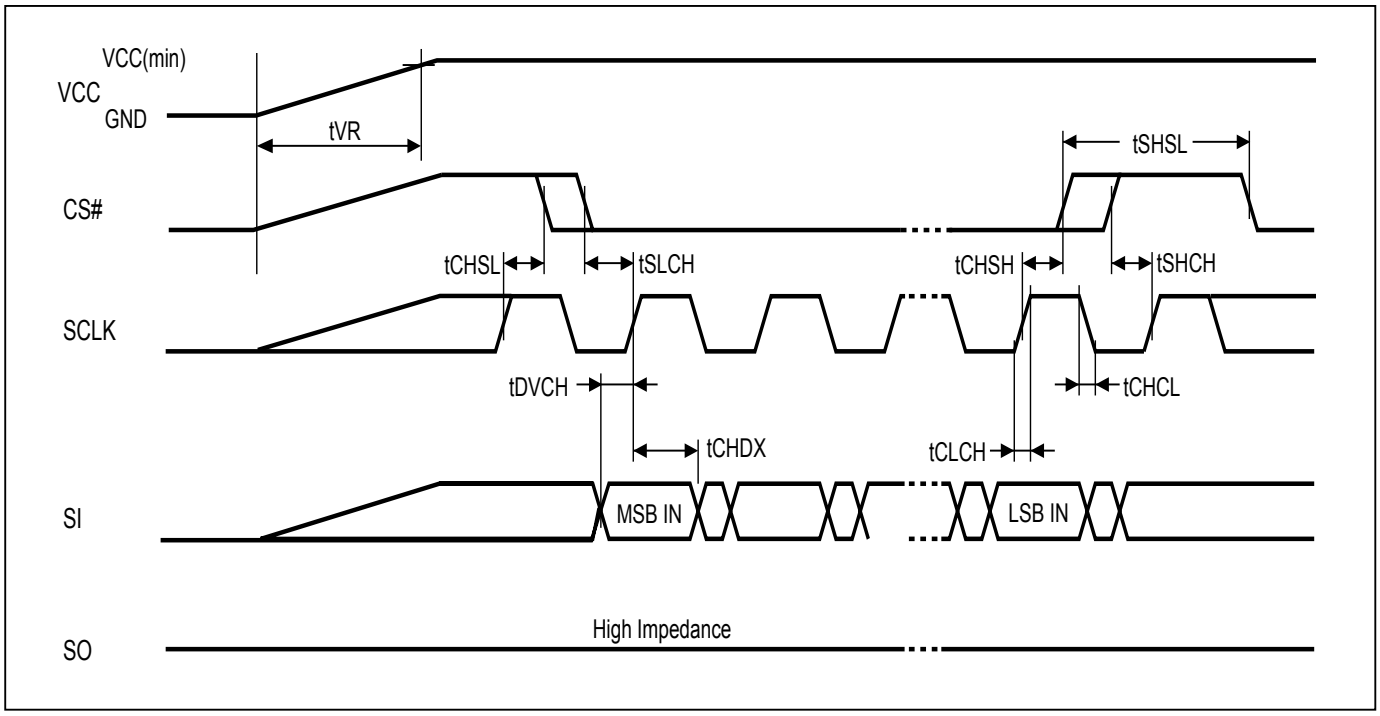
## 13. OPERATING CONDITIONS

### At Device Power-Up and Power-Down

AC timing illustrated in *"Figure 79. AC Timing at Device Power-Up"* and *"Figure 80. 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 79. 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 17.* AC CHARACTERISTICS.


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**Figure 80. Power-Down Sequence**

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

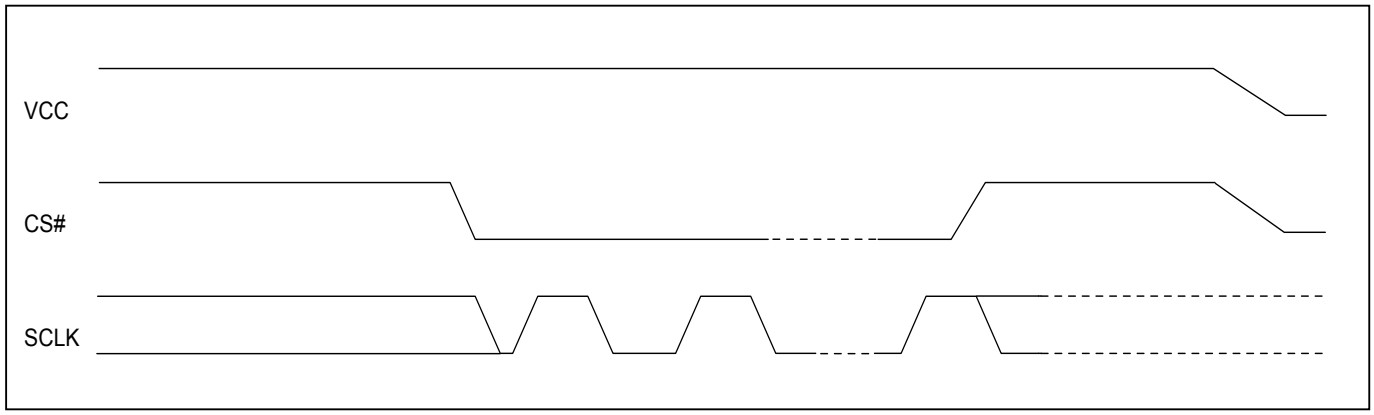
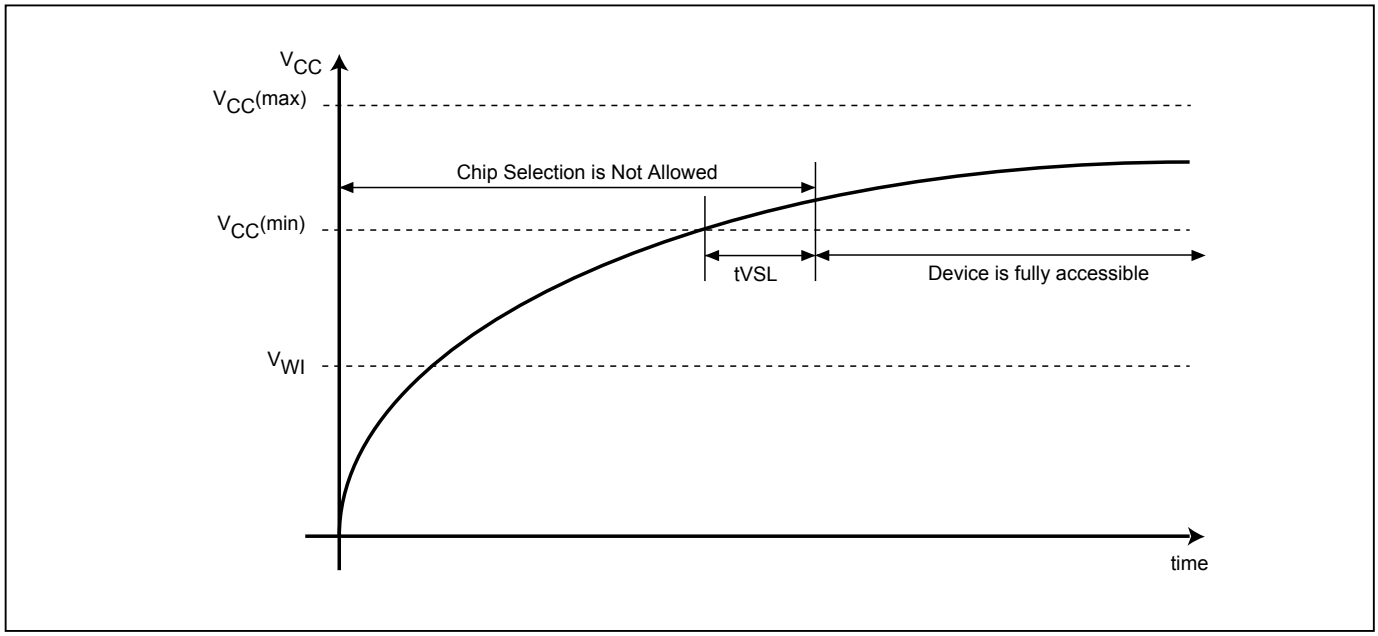



**Figure 81. Power-up Timing**





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**Figure 82. Power Up/Down and Voltage Drop**

For Power-down to Power-up operation, the VCC of flash device must below $V_{PWD}$ for at least tPWD timing. Please check the table below for more detail.

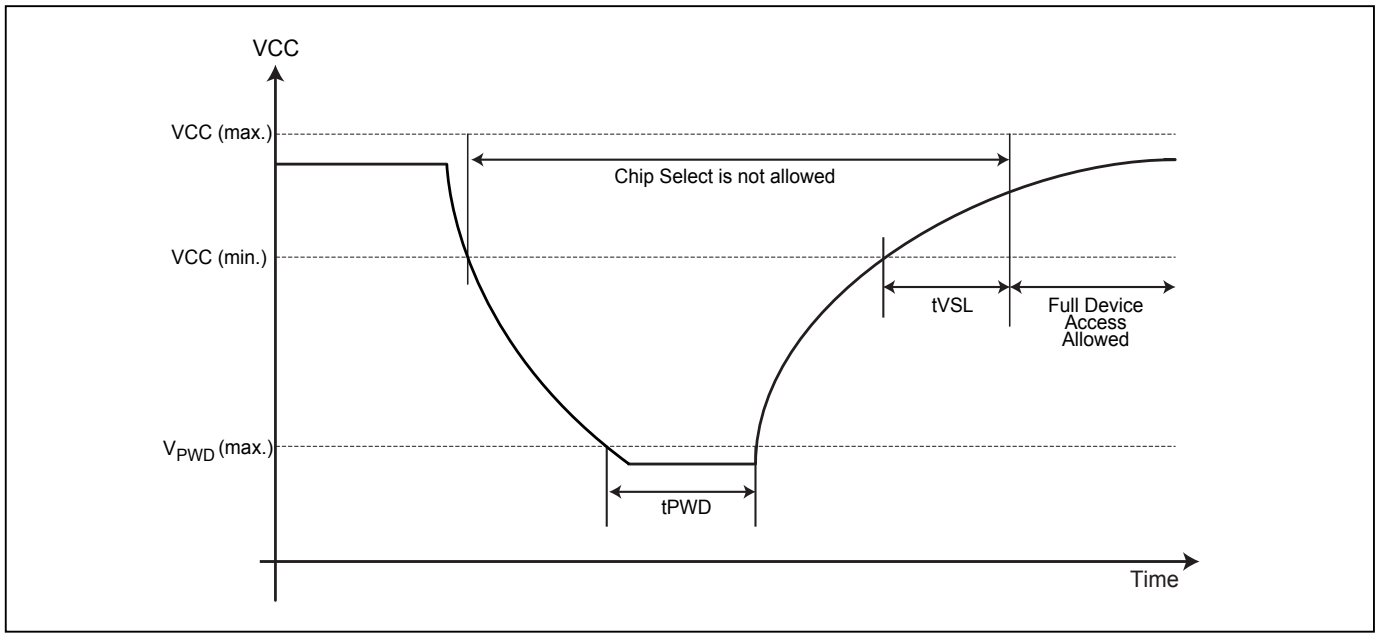



**Table 19. Power-Up/Down Voltage and Timing**

| 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 | 2.7 | 3.6 | V |

Note: These parameters are characterized only.

## 13-1. 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).

## 14. ERASE AND PROGRAMMING PERFORMANCE

| Parameter | Min. | Typ. (1) | Max. (2) | Unit |
|---|---|---|---|---|
| Write Status Register Cycle Time | | | 40 | ms |
| Sector Erase Cycle Time (4KB) | | 30 | 120 | ms |
| Block Erase Cycle Time (32KB) | | 0.15 | 0.65 | s |
| Block Erase Cycle Time (64KB) | | 0.28 | 0.65 | s |
| Chip Erase Cycle Time | | 50 | 80 | s |
| Byte Program Time (via page program command) | | 16 | 30 | us |
| Page Program Time | | 0.5 | 1.5 | ms |
| Erase/Program Cycle | | 100,000 | | cycles |

Note:
1. Typical program and erase time assumes the following conditions: 25°C, 3.3V, and all zero pattern.
2. Under worst conditions of 85°C and 2.7V.
3. System-level overhead is the time required to execute the first-bus-cycle sequence for the programming command.
4. The maximum chip programming time is evaluated under the worst conditions of 0°C, VCC=3.3V, and 100K cycle with 90% confidence level.

## 15. DATA RETENTION

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

## 16. LATCH-UP CHARACTERISTICS

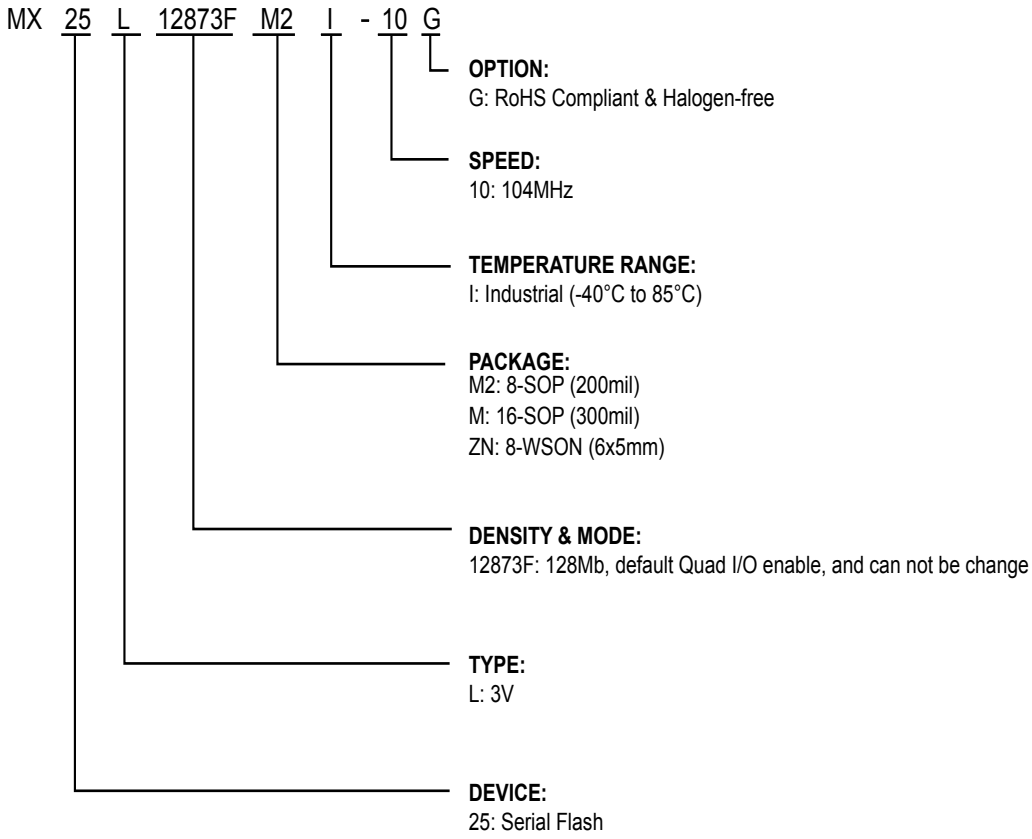
| | Min. | Max. |
|---|---|---|
| Input Voltage with respect to GND on all power pins, SI, CS# | -1.0V | 2 VCCmax |
| Input Voltage with respect to GND on SO | -1.0V | VCC + 1.0V |
| Current | -100mA | +100mA |
| Includes all pins except VCC. Test conditions: VCC = 3.0V, one pin at a time. | | |


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## 17. ORDERING INFORMATION

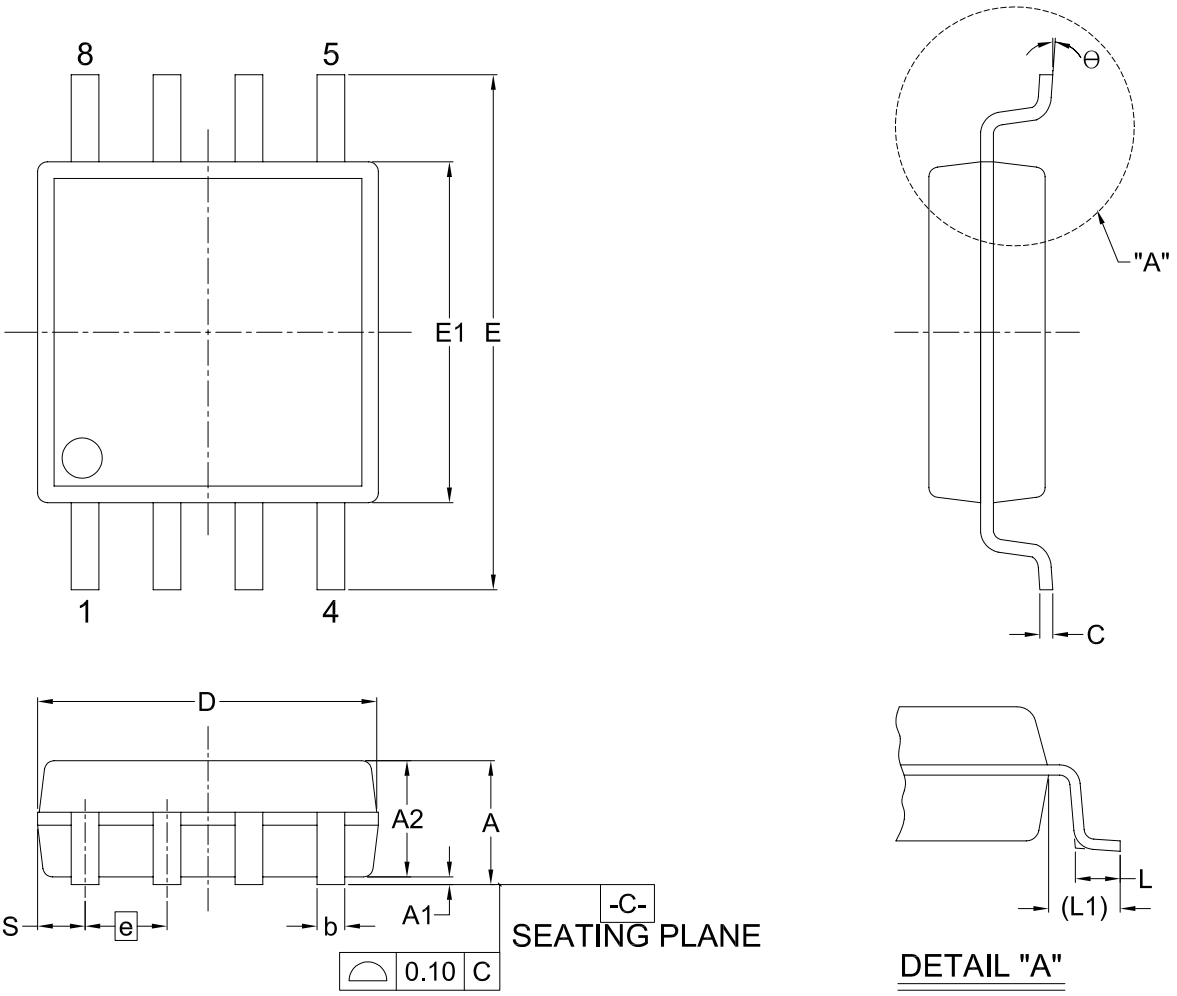
| PART NO. | CLOCK (MHz) | TEMPERATURE | PACKAGE | Remark |
|---|---|---|---|---|
| MX25L12873FM2I-10G | 104 | -40°C to 85°C | 8-SOP (200mil) | |
| MX25L12873FMI-10G | 104 | -40°C to 85°C | 16-SOP (300mil) | |
| MX25L12873FZNI-10G | 104 | -40°C to 85°C | 8-WSON (6x5mm) | |

## 18. PART NAME DESCRIPTION



## 19. PACKAGE INFORMATION

Doc. Title: Package Outline for SOP 8L 200MIL (official name - 209MIL)

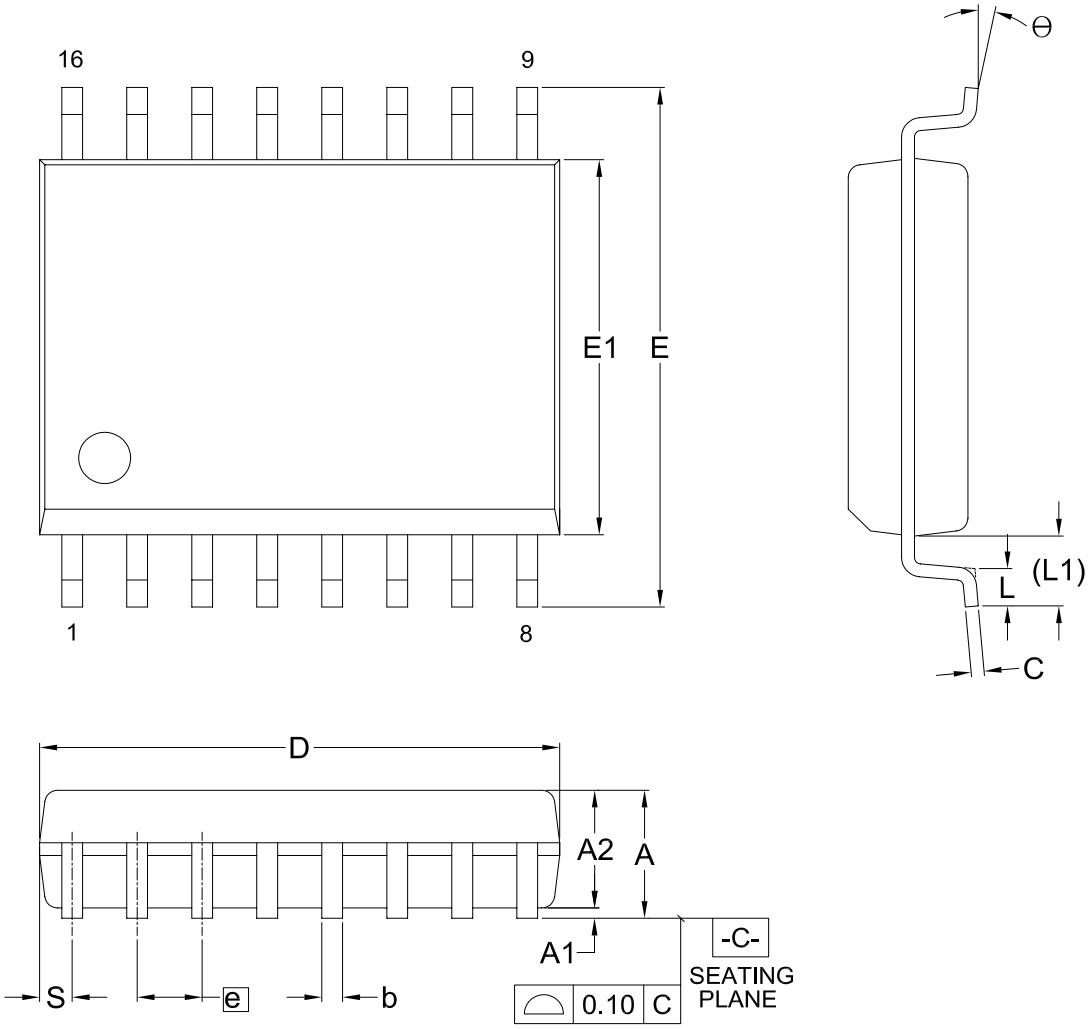



Dimensions (inch dimensions are derived from the original mm dimensions)

| 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° |

| Dwg. No. | Revision | Reference | | | |
|---|---|---|---|---|---|
| | | JEDEC | EIAJ | | |
| 6110-1406 | 5 | | | | |

Doc. Title: Package Outline for SOP 16L (300MIL)

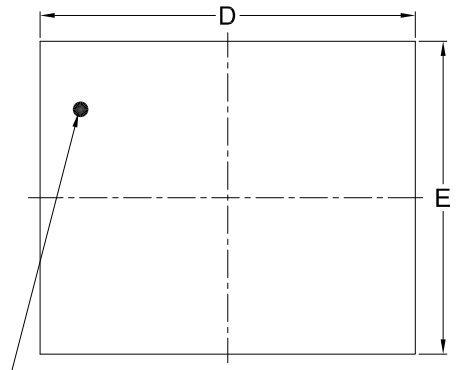



Dimensions (inch dimensions are derived from the original mm dimensions)

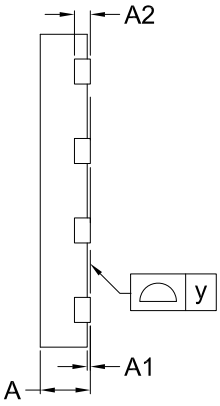
| SYMBOL / UNIT | | A | A1 | A2 | b | C | D | E | E1 | e | L | L1 | S | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | Min. | --- | 0.10 | 2.25 | 0.31 | 0.20 | 10.10 | 10.10 | 7.42 | --- | 0.40 | 1.31 | 0.51 | 0° |
| | Nom. | --- | 0.20 | 2.35 | 0.41 | 0.25 | 10.30 | 10.30 | 7.52 | 1.27 | 0.84 | 1.44 | 0.64 | 5° |
| | Max. | 2.65 | 0.30 | 2.45 | 0.51 | 0.30 | 10.50 | 10.50 | 7.60 | --- | 1.27 | 1.57 | 0.77 | 8° |
| Inch | Min. | --- | 0.004 | 0.089 | 0.012 | 0.008 | 0.397 | 0.397 | 0.292 | --- | 0.016 | 0.052 | 0.020 | 0° |
| | Nom. | --- | 0.008 | 0.093 | 0.016 | 0.010 | 0.405 | 0.405 | 0.296 | 0.050 | 0.033 | 0.057 | 0.025 | 5° |
| | Max. | 0.104 | 0.012 | 0.096 | 0.020 | 0.012 | 0.413 | 0.413 | 0.299 | --- | 0.050 | 0.062 | 0.030 | 8° |

| Dwg. No. | Revision | Reference | | | |
|---|---|---|---|---|---|
| | | JEDEC | EIAJ | | |
| 6110-1402 | 13 | MS-013 | | | |

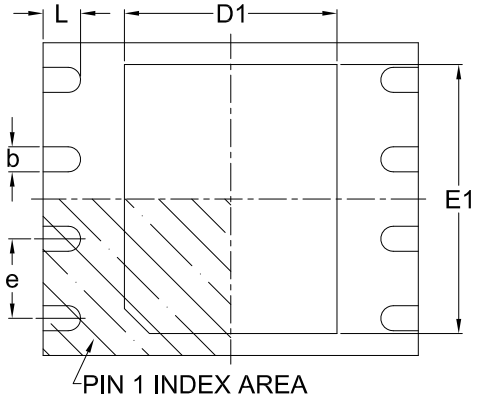
**Doc. Title: Package Outline for WSON 8L (6x5x0.8MM, LEAD PITCH 1.27MM)**




TOP VIEW




SIDE VIEW




BOTTOM VIEW

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 | 3.30 | 4.90 | 3.90 | 0.50 | --- | 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 | 3.50 | 5.10 | 4.10 | 0.75 | --- | 0.05 |
| Inch | Min. | 0.028 | --- | --- | 0.014 | 0.232 | 0.129 | 0.193 | 0.154 | 0.020 | --- | 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 | 0.138 | 0.201 | 0.161 | 0.030 | --- | 0.002 |

| Dwg. No. | Revision | Reference | | | |
|---|---|---|---|---|---|
| | | JEDEC | EIAJ | | |
| 6110-3401 | 8 | MO-220 | | | |

## 20. REVISION HISTORY

| Revision No. | Description | Page | Date |
|---|---|---|---|
| 1.0 | 1. Removed "Advanced Information" | P4 | MAR/22/2013 |
| | 2. Added RESET# information | All | |
| | 3. Added USPB information | P64,70 | |
| | 4. Added Power Up/Down and Voltage Drop information | P91 | |
| | 5. Corrected content error | P9,49,67,69, P76,85,88 | |
| 1.1 | 1. Updated parameters for DC/AC Characteristics | P87,88 | OCT/31/2013 |
| | 2. Updated Erase and Programming Performance | P92 | |
| | 3. Content correction | P64~70 | |
| | 4. Modified VCC to Ground Potential parameter | P85 | |
| 1.2 | 1. Updated tVR values | P88,90 | JUL/22/2016 |
| | 2. Updated package outline | P94-96 | |
| | 3. Updated BLOCK DIAGRAM | P8 | |
| | 4. Updated Write Inhibit Voltage | P90 | |
| | 5. Description modification | P4,45-47,55,70 | |

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