# MX66U51235F

# DATASHEET

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# Contents

**1. FEATURES ..... 4**
**2. GENERAL DESCRIPTION ..... 6**
Table 1. Read performance Comparison ..... 6
**3. PIN CONFIGURATIONS ..... 7**
**4. PIN DESCRIPTION ..... 7**
**5. BLOCK DIAGRAM ..... 8**
**6. DATA PROTECTION ..... 9**
Table 2. Protected Area Sizes ..... 10
Table 3. 4K-bit Secured OTP Definition ..... 11
**7. Memory Organization ..... 12**
Table 4. Memory Organization ..... 12
**8. DEVICE OPERATION ..... 13**
8-1. Address Protocol ..... 15
8-2. Quad Peripheral Interface (QPI) Read Mode ..... 17
**9. COMMAND DESCRIPTION ..... 18**
Table 5. Command Set ..... 18
9-1. Write Enable (WREN) ..... 23
9-2. Write Disable (WRDI) ..... 24
9-3. Read Identification (RDID) ..... 25
9-4. Release from Deep Power-down (RDP), Read Electronic Signature (RES) ..... 26
9-5. Read Electronic Manufacturer ID & Device ID (REMS) ..... 28
9-6. QPI ID Read (QPIID) ..... 29
Table 6. ID Definitions ..... 29
9-7. Read Status Register (RDSR) ..... 30
9-8. Read Configuration Register (RDCR) ..... 31
9-9. Write Status Register (WRSR) ..... 37
Table 7. Protection Modes ..... 38
9-10. Enter 4-byte mode (EN4B) ..... 41
9-11. Exit 4-byte mode (EX4B) ..... 41
9-12. Read Data Bytes (READ) ..... 42
9-13. Read Data Bytes at Higher Speed (FAST_READ) ..... 43
9-14. Dual Output Read Mode (DREAD) ..... 45
9-15. 2 x I/O Read Mode (2READ) ..... 46
9-16. Quad Read Mode (QREAD) ..... 47
9-17. 4 x I/O Read Mode (4READ) ..... 48
9-18. 4 Byte Address Command Set ..... 50
9-19. Burst Read ..... 52
9-20. Performance Enhance Mode ..... 53
9-21. Performance Enhance Mode Reset ..... 56
9-22. Fast Boot ..... 58
9-23. Sector Erase (SE) ..... 61
9-24. Block Erase (BE32K) ..... 62


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9-25. Block Erase (BE) ..... 63
9-26. Chip Erase (CE) ..... 64
9-27. Page Program (PP) ..... 65
9-28. 4 x I/O Page Program (4PP) ..... 67
9-29. Deep Power-down (DP) ..... 68
9-30. Enter Secured OTP (ENSO) ..... 69
9-31. Exit Secured OTP (EXSO) ..... 69
9-32. Read Security Register (RDSCUR) ..... 69
9-33. Write Security Register (WRSCUR) ..... 69
Table 8. Security Register Definition ..... 70
9-34. Block Lock (BP) Protection ..... 70
9-35. Program/Erase Suspend/Resume ..... 71
9-36. Erase Suspend ..... 71
9-37. Program Suspend ..... 71
9-38. Write-Resume ..... 73
9-39. No Operation (NOP) ..... 73
9-40. Software Reset (Reset-Enable (RSTEN) and Reset (RST)) ..... 73
9-41. Read SFDP Mode (RDSFDP) ..... 75
Table 9. Signature and Parameter Identification Data Values ..... 76
Table 10. Parameter Table (0): JEDEC Flash Parameter Tables ..... 77
Table 11. Parameter Table (1): Macronix Flash Parameter Tables ..... 79
**10. RESET ..... 81**
Table 12. Reset Timing-(Power On) ..... 81
Table 13. Reset Timing-(Other Operation) ..... 81
**11. POWER-ON STATE ..... 82**
**12. ELECTRICAL SPECIFICATIONS ..... 83**
Table 14. ABSOLUTE MAXIMUM RATINGS ..... 83
Table 15. CAPACITANCE TA = 25°C, f = 1.0 MHz ..... 83
Table 16. DC CHARACTERISTICS ..... 85
Table 17. AC CHARACTERISTICS ..... 86
**13. OPERATING CONDITIONS ..... 87**
Table 18. Power-Up/Down Voltage and Timing ..... 89
13-1. INITIAL DELIVERY STATE ..... 89
**14. ERASE AND PROGRAMMING PERFORMANCE ..... 90**
**15. DATA RETENTION ..... 90**
**16. LATCH-UP CHARACTERISTICS ..... 90**
**17. ORDERING INFORMATION ..... 91**
**18. PART NAME DESCRIPTION ..... 92**
**19. PACKAGE INFORMATION ..... 93**
**20. REVISION HISTORY ..... 96**

**1.8V 512M-BIT [x 1/x 2/x 4] CMOS MXSMIO® (SERIAL MULTI I/O) FLASH MEMORY**

## 1. FEATURES

### GENERAL

- Serial Peripheral Interface compatible -- Mode 0 and Mode 3
- Single Power Supply Operation
  - 1.65 to 2.0 volt for read, erase, and program operations
- 512Mb: 536,870,912 x 1 bit structure or 268,435,456 x 2 bits (two I/O mode) structure or 134,217,728 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
- Low Vcc write inhibit is from 1.0V to 1.4V
- Fast read for SPI mode
  - Support clock frequency up to 108MHz for all protocols
  - Support Fast Read, 2READ, DREAD, 4READ, QREAD instructions.
  - Configurable dummy cycle number for fast read operation
- 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 bits define the size of the area to be protected against program and erase instructions
- 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
- 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
- WP#/SIO2
  - Hardware write protection or serial data Input/Output for 4 x I/O read mode
- RESET#/SIO3
  - Hardware Reset pin or Serial input & Output for 4 x I/O read mode
- PACKAGE
  -16-pin SOP (300mil)
  -8-land WSON (8x6mm 3.4x4.3 EP)
  -24-Ball BGA (5x5 ball array)
  -**All devices are RoHS Compliant and Halogen Free.**

## 2. GENERAL DESCRIPTION

MX66U51235F is 512Mb bits serial Flash memory, which is configured as 67,108,864 x 8 internally. When it is in two or four I/O mode, the structure becomes 268,435,456 bits x 2 or 134,217,728 bits x 4. MX66U51235F 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, WP# and RESET# pin become SIO0 pin, SIO1 pin, SIO2 pin and SIO3 pin for address/dummy bits input and data output.

The MX66U51235F 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.

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

The MX66U51235F utilizes Macronix's proprietary memory cell, which reliably stores memory contents even after 100,000 program and erase cycles.

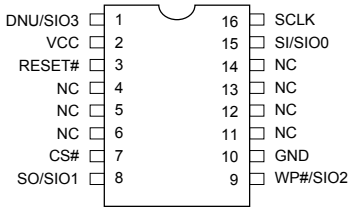
**Table 1. Read performance Comparison**

| 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 | 108 | 108 | 84 | 108 | 84* |
| 8 | 108* | 108* | 108* | 108 | 108 |

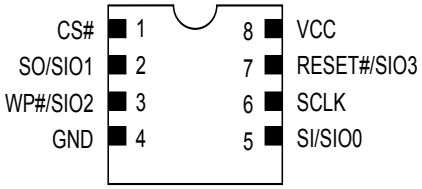
**Note:** * mean default status

## 3. PIN CONFIGURATIONS

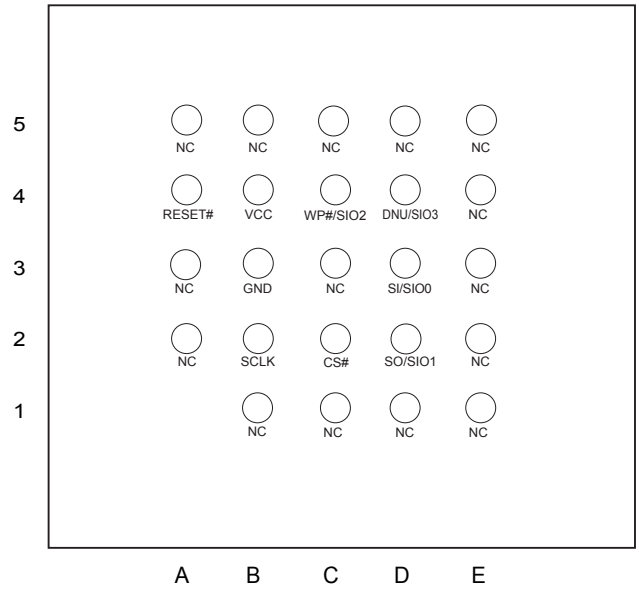
### 16-PIN SOP (300mil)




### 8-WSON (8x6mm 3.4x4.3 EP)




### 24-BALL BGA (5x5 ball array)

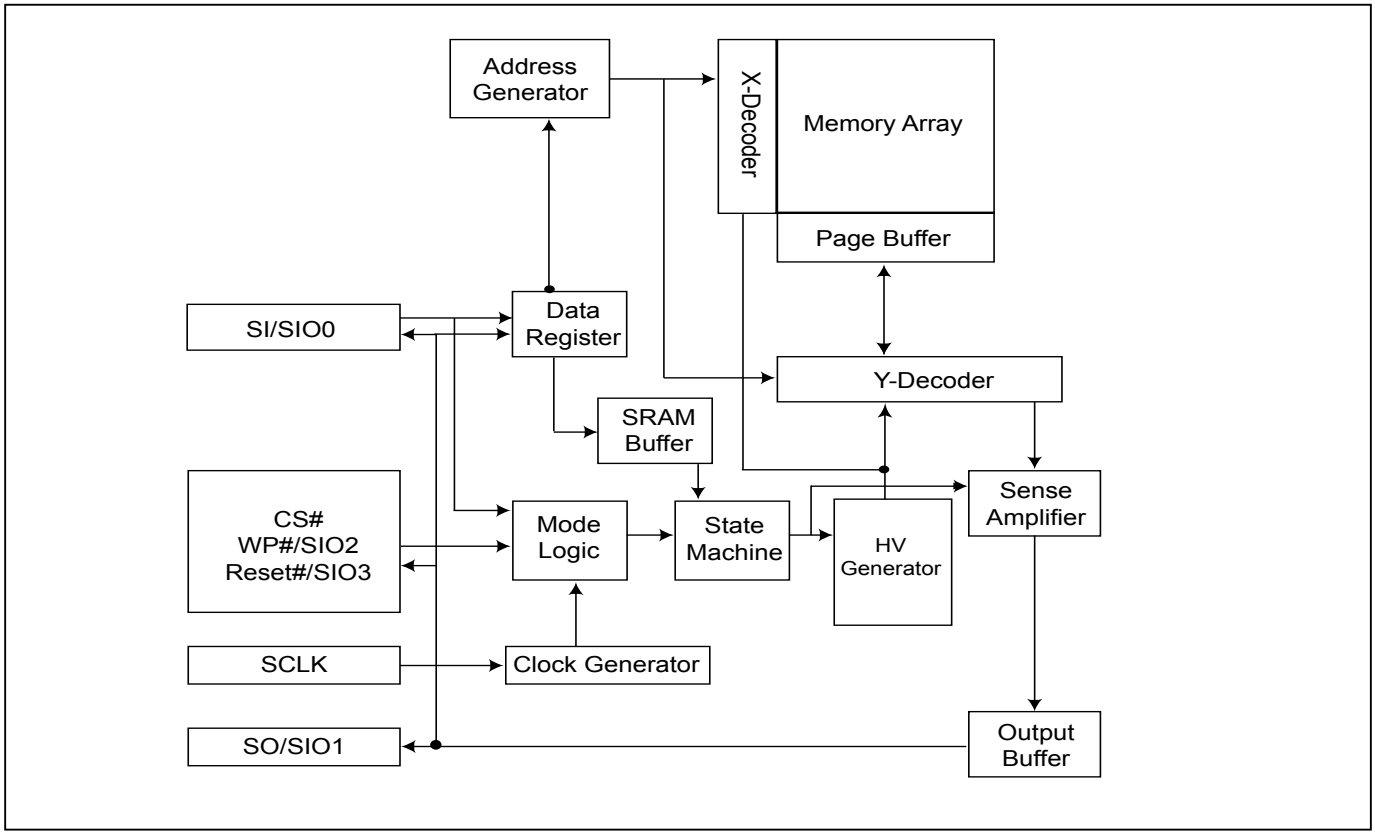



## 4. PIN DESCRIPTION

| 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 |
| WP#/SIO2 | Write protection: connect to GND or Serial Data Input & Output (for 4xI/O read mode) |
| RESET#/SIO3 (8WSON) | Hardware Reset Pin Active low or Serial Data Input & Output (for 4xI/O read mode)Note 1 |
| DNU/SIO3 Note 2 (16SOP, 24BGA) | Do Not Use or Serial Data Input & Output (for 4xI/O read mode) |
| VCC | + 1.8V Power Supply |
| GND | Ground |
| DNU | Do not use |
| NC | No Connection |

Notes:
1. RESET# pin has internal pull up.
2. When using 1 I/O or 2 I/O (QE bit not enabled), the DNU/SIO3 pin of 16SOP & 24BGA can not connect to GND. We suggest user to connect this pin to VCC or floating.

## 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.

**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.
- The Hardware Proteced Mode (HPM) use WP#/SIO2 to protect the (BP3, BP2, BP1, BP0) bits and Status Register Write Protect bit.
- 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 | 512Mb |
| 0 | 0 | 0 | 0 | 0 (none) |
| 0 | 0 | 0 | 1 | 1 (1 block, protected block 1023rd) |
| 0 | 0 | 1 | 0 | 2 (2 blocks, protected block 1022nd~1023rd) |
| 0 | 0 | 1 | 1 | 3 (4 blocks, protected block 1020th~1023rd) |
| 0 | 1 | 0 | 0 | 4 (8 blocks, protected block 1016th~1023rd) |
| 0 | 1 | 0 | 1 | 5 (16 blocks, protected block 1008th~1023rd) |
| 0 | 1 | 1 | 0 | 6 (32 blocks, protected block 992nd~1023rd) |
| 0 | 1 | 1 | 1 | 7 (64 blocks, protected block 960th~1023rd) |
| 1 | 0 | 0 | 0 | 8 (128 blocks, protected block 896th~1023rd) |
| 1 | 0 | 0 | 1 | 9 (256 blocks, protected block 768th~1023rd) |
| 1 | 0 | 1 | 0 | 10 (512 blocks, protected block 512nd~1023rd) |
| 1 | 0 | 1 | 1 | 11 (1024 blocks, protected all) |
| 1 | 1 | 0 | 0 | 12 (1024 blocks, protected all) |
| 1 | 1 | 0 | 1 | 13 (1024 blocks, protected all) |
| 1 | 1 | 1 | 0 | 14 (1024 blocks, protected all) |
| 1 | 1 | 1 | 1 | 15 (1024 blocks, protected all) |

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

| Status bit | | | | Protect Level |
|---|---|---|---|---|
| BP3 | BP2 | BP1 | BP0 | 512Mb |
| 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~1th) |
| 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 block 0th~255th) |
| 1 | 0 | 1 | 0 | 10 (512 blocks, protected block 0th~511st) |
| 1 | 0 | 1 | 1 | 11 (1024 blocks, protected all) |
| 1 | 1 | 0 | 0 | 12 (1024 blocks, protected all) |
| 1 | 1 | 0 | 1 | 13 (1024 blocks, protected all) |
| 1 | 1 | 1 | 0 | 14 (1024 blocks, protected all) |
| 1 | 1 | 1 | 1 | 15 (1024 blocks, protected all) |

**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 8. 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 | |
|---|---|---|---|---|
| 1023 | 2047 | 16383 | 3FFF000h | 3FFFFFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 16376 | 3FF8000h | 3FF8FFFh |
| | 2046 | 16375 | 3FF7000h | 3FF7FFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 16368 | 3FF0000h | 3FF0FFFh |
| 1022 | 2045 | 16367 | 3FEF000h | 3FEFFFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 16360 | 3FE8000h | 3FE8FFFh |
| | 2044 | 16359 | 3FE7000h | 3FE7FFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 16352 | 3FE0000h | 3FE0FFFh |
| 1021 | 2043 | 16351 | 3FDF000h | 3FDFFFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 16344 | 3FD8000h | 3FD8FFFh |
| | 2042 | 16343 | 3FD7000h | 3FD7FFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 16336 | 3FD0000h | 3FD0FFFh |



| | | | | |
|---|---|---|---|---|
| 2 | 5 | 47 | 002F000h | 002FFFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 40 | 0028000h | 0028FFFh |
| | 4 | 39 | 027000h | 0027FFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 32 | 0020000h | 0020FFFh |
| 1 | 3 | 31 | 001F000h | 001FFFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 24 | 0018000h | 0018FFFh |
| | 2 | 23 | 0017000h | 0017FFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 16 | 0010000h | 0010FFFh |
| 0 | 1 | 15 | 000F000h | 000FFFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 8 | 0008000h | 0008FFFh |
| | 0 | 7 | 0007000h | 0007FFFh |
| | | ⋮ | ⋮ | ⋮ |
| | | 0 | 0000000h | 0000FFFh |

## 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.

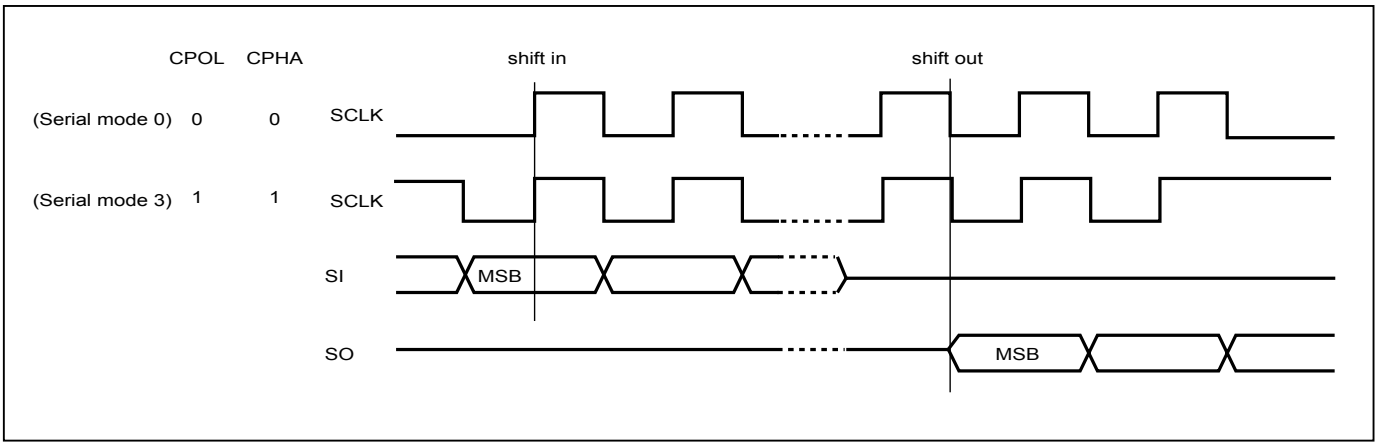
3. When correct command is inputted to this device, this device becomes active mode and keeps the active mode until next CS# rising edge.

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/READ4B, FAST_READ/FAST_READ4B, 2READ/2READ4B, DREAD/DREAD4B, 4READ/4READ4B, QREAD/QREAD4B, RDSFDP, RES, REMS, QPIID, RDEAR, RDFBR, 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/SE4B, BE32K/BE32K4B, BE/BE4B, CE, PP/PP4B, 4PP/4PP4B, DP, ENSO, EXSO, WRSCUR, EN4B, EX4B, 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. While a Write Status Register, Program or Erase operation is in progress, access to 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**

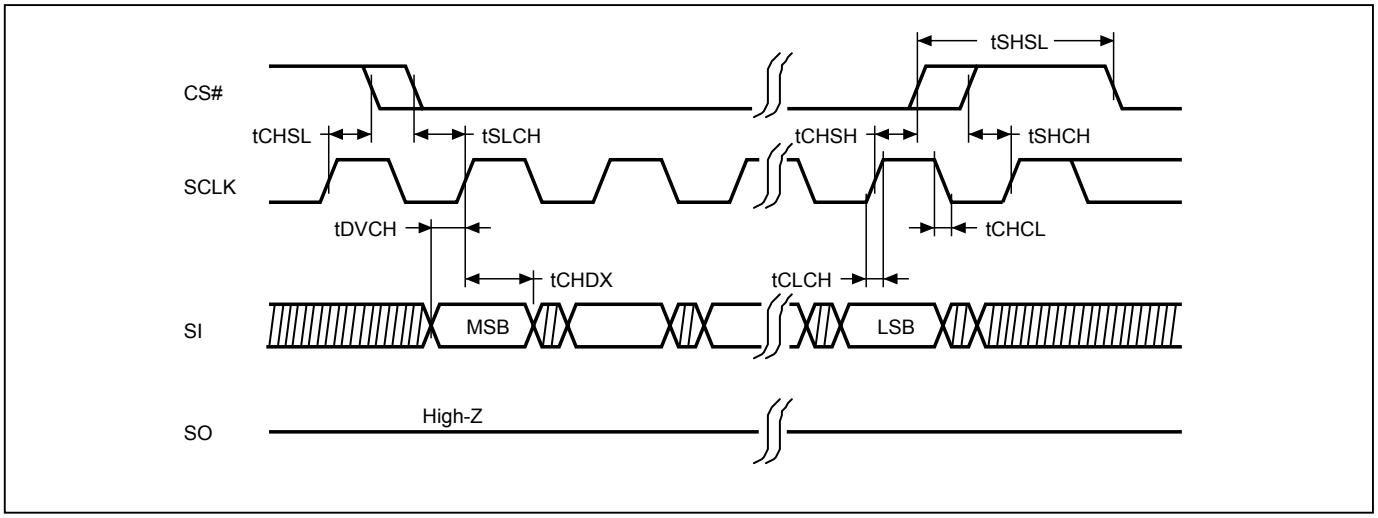
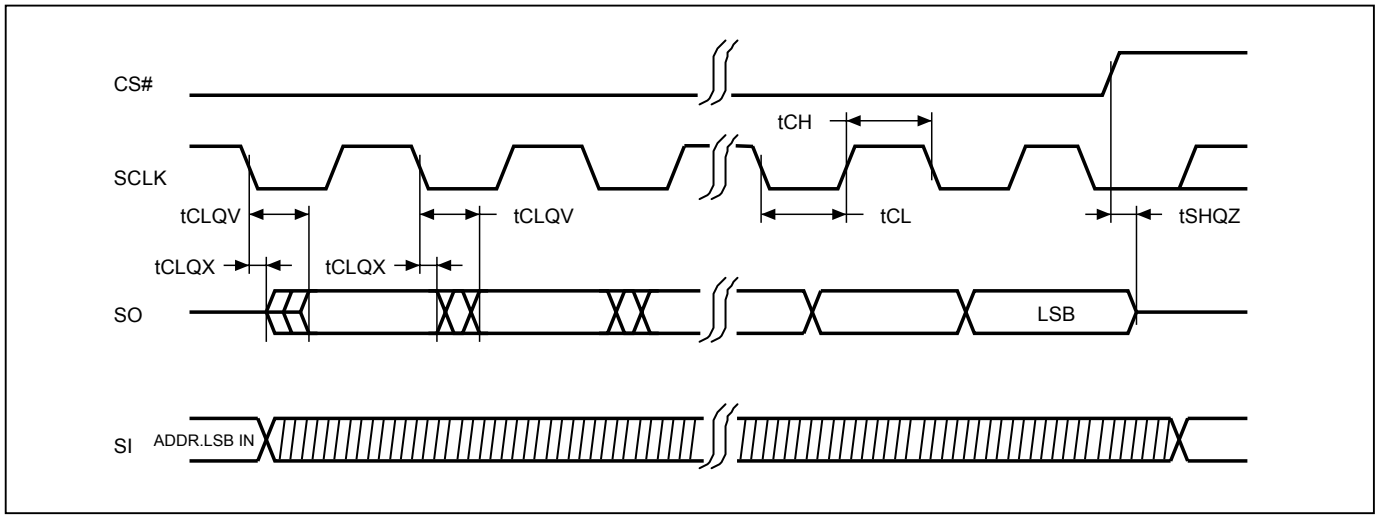



**Figure 3. Output Timing**



## 8-1. Address Protocol

The original 24 bit address protocol of serial Flash can only access density size below 128Mb. For the memory device of 256Mb and above, the 32bit address is requested for access higher memory size. The MX66U51235F provides three different methods to access the whole 512Mb density:

**(1)Command entry 4-byte address mode**: Issue Enter 4-Byte mode command to set up the 4BYTE bit in Configuration Register bit. After 4BYTE bit has been set, the number of address cycle become 32-bit.

**(2)Extended Address Register (EAR)**: configure the memory device into four 128Mb segments to select which one is active through the EAR bit "0" and EAR bit "1".

**(3)4-byte Address Command Set**: When issuing 4-byte address command set, 4-byte address (A31-A0) is requested after the instruction code. Please note that it is not necessary to issue EN4B command before issuing any of 4-byte command set.

### Enter 4-Byte Address Mode

In 4-byte Address mode, all instructions are 32-bits address clock cycles. By using EN4B and EX4B to enable and disable the 4-byte address mode.

When 4-byte address mode is enabled, the EAR<0> becomes "don't care" for all instructions requiring 4-byte address. The EAR function will be disabled when 4-byte mode is enabled.

### Extended Address Register (Configurable)

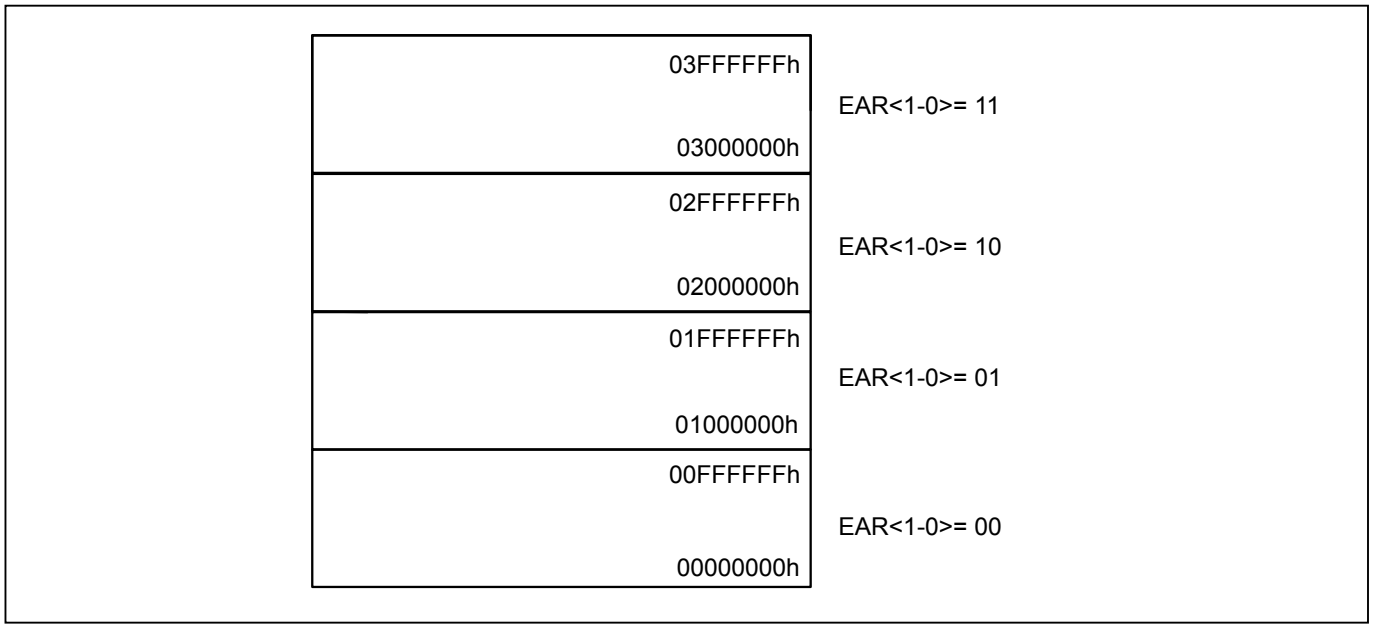
The device provides an 8-bit volatile register for extended Address Register: it indentifies the extended address (A31~A24) above 128Mb density by using original 3-byte address.

### Extended Address Register (EAR)

| Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---|---|---|---|---|---|---|---|
| A31 | A30 | A29 | A28 | A27 | A26 | A25 | A24 |

For the MX66U51235F the A31 to A26 are Don’t Care. During EAR, reading these bits will read as 0. The bit <1-0> is default as "0".

**Figure 4. EAR Operation Segments**




When under EAR mode, Read, Program, Erase operates in the selected segment by using 3-byte address mode.

For the read operation, the whole array data can be continually read out with one command. Data output starts from the selected 128Mb, but it can cross the boundary. When the last byte of the segment is reached, the next byte (in a continuous reading) is the first byte of the next segment. However, the EAR (Extended Address Register) value does not change. The random access reading can only be operated in the selected segment.

The Chip erase command will erase the whole chip and is not limited by EAR selected segment.


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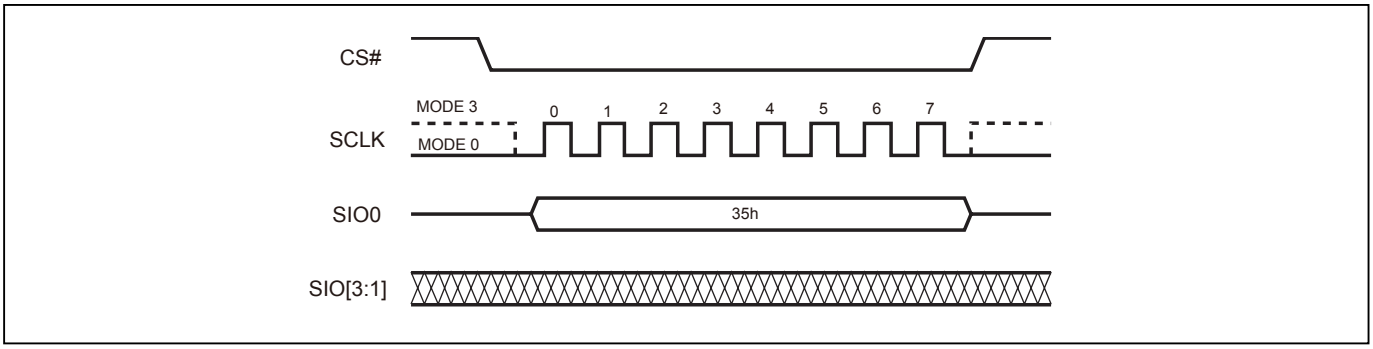
## 8-2. Quad Peripheral Interface (QPI) Read Mode

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.

**Figure 5. Enable QPI Sequence**

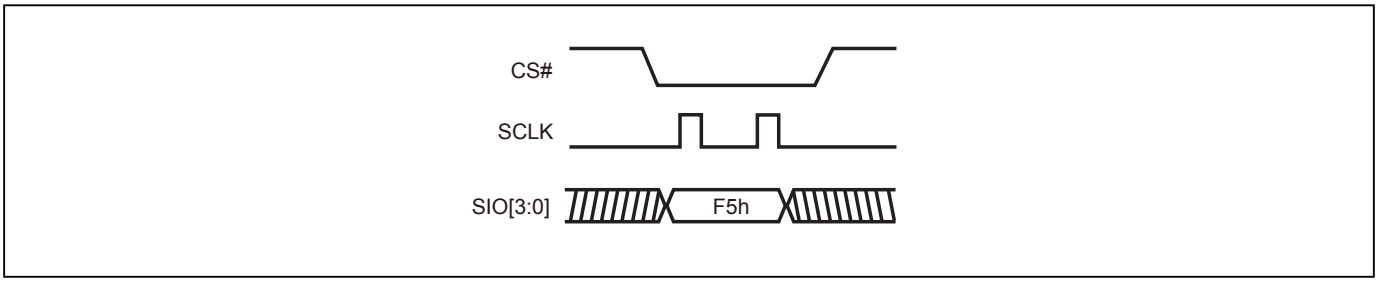



### Reset QPI (RSTQIO)

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 6. 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 | QREAD (1I 4O read) |
|---|---|---|---|---|---|---|
| Mode | SPI | SPI | SPI | SPI | SPI/QPI | SPI |
| Address Bytes | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 |
| 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 | Quad I/O read with 6 dummy cycles | 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 |
| Address Bytes | 3/4 | 3/4 | 3/4 | 3/4 | 3/4 | 0 |
| 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.

### Read/Write Array Commands (4 Byte Address Command Set)

| Command (byte) | READ4B | FAST READ4B | 2READ4B | DREAD4B | 4READ4B | QREAD4B |
|---|---|---|---|---|---|---|
| Mode | SPI | SPI | SPI | SPI | SPI/QPI | SPI |
| Address Bytes | 4 | 4 | 4 | 4 | 4 | 4 |
| 1st byte | 13 (hex) | 0C (hex) | BC (hex) | 3C (hex) | EC (hex) | 6C (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 | ADD4 | ADD4 | ADD4 | ADD4 | ADD4 | ADD4 |
| 6th byte | | Dummy | Dummy | Dummy | Dummy | Dummy |
| Data Cycles | | | | | | |
| Action | read data byte by 4 byte address | read data byte by 4 byte address | read data byte by 2 x I/O with 4 byte address | Read data byte by Dual Output with 4 byte address | read data byte by 4 x I/O with 4 byte address | Read data byte by Quad Output with 4 byte address |

| Command (byte) | PP4B | 4PP4B | BE4B (block erase 64KB) | BE32K4B (block erase 32KB) | SE4B (Sector erase 4KB) |
|---|---|---|---|---|---|
| Mode | SPI/QPI | SPI | SPI/QPI | SPI/QPI | SPI/QPI |
| Address Bytes | 4 | 4 | 4 | 4 | 4 |
| 1st byte | 12 (hex) | 3E (hex) | DC (hex) | 5C (hex) | 21 (hex) |
| 2nd byte | ADD1 | ADD1 | ADD1 | ADD1 | ADD1 |
| 3rd byte | ADD2 | ADD2 | ADD2 | ADD2 | ADD2 |
| 4th byte | ADD3 | ADD3 | ADD3 | ADD3 | ADD3 |
| 5th byte | ADD4 | ADD4 | ADD4 | ADD4 | ADD4 |
| 6th byte | | | | | |
| Data Cycles | 1-256 | 1-256 | | | |
| Action | to program the selected page with 4byte address | Quad input to program the selected page with 4byte address | to erase the selected (64KB) block with 4byte address | to erase the selected (32KB) block with 4byte address | to erase the selected (4KB) sector with 4byte address |

## Register/Setting Commands

| Command (byte) | WREN (write enable) | WRDI (write disable) | RDSR (read status register) | RDCR (read configuration register) | WRSR (write status/ configuration register) | RDEAR (read extended address register) | WREAR (write extended address register) |
|---|---|---|---|---|---|---|---|
| Mode | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI |
| 1st byte | 06 (hex) | 04 (hex) | 05 (hex) | 15 (hex) | 01 (hex) | C8 (hex) | C5 (hex) |
| 2nd byte | | | | | Values | | |
| 3rd byte | | | | | Values | | |
| 4th byte | | | | | | | |
| 5th byte | | | | | | | |
| Data Cycles | | | | | 1-2 | | 1 |
| 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 | read extended address register | write extended address register |

| Command (byte) | EQIO (Enable QPI) | RSTQIO (Reset QPI) | EN4B (enter 4-byte mode) | EX4B (exit 4-byte mode) | PGM/ERS Suspend (Suspends Program/ Erase) | PGM/ERS Resume (Resumes Program/ Erase) | DP (Deep power down) |
|---|---|---|---|---|---|---|---|
| Mode | SPI | QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI | SPI/QPI |
| 1st byte | 35 (hex) | F5 (hex) | B7 (hex) | E9 (hex) | B0 (hex) | 30 (hex) | B9 (hex) |
| 2nd byte | | | | | | | |
| 3rd byte | | | | | | | |
| 4th byte | | | | | | | |
| 5th byte | | | | | | | |
| Data Cycles | | | | | | | |
| Action | Entering the QPI mode | Exiting the QPI mode | to enter 4-byte mode and set 4BYTE bit as "1" | to exit 4-byte mode and clear 4BYTE bit to be "0" | | | enters deep power down mode |

| Command (byte) | RDP (Release from deep power down) | SBL (Set Burst Length) | RDFBR (read fast boot register) | WRFBR (write fast boot register) | ESFBR (erase fast boot register) |
|---|---|---|---|---|---|
| Mode | SPI/QPI | SPI/QPI | SPI | SPI | SPI |
| 1st byte | AB (hex) | C0 (hex) | 16(hex) | 17(hex) | 18(hex) |
| 2nd byte | | | | | |
| 3rd byte | | | | | |
| 4th byte | | | | | |
| 5th byte | | | | | |
| Data Cycles | | | 1-4 | 4 | |
| Action | release from deep power down mode | to set Burst length | | | |

## 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 | | | ADD1 (Note 1) | | ADD3 | | |
| 5th byte | | | | | Dummy (8)(Note 4) | | |
| 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) |
|---|---|---|
| Mode | SPI/QPI | SPI/QPI |
| Address Bytes | 0 | 0 |
| 1st byte | 2B (hex) | 2F (hex) |
| 2nd byte | | |
| 3rd byte | | |
| 4th byte | | |
| 5th byte | | |
| Data Cycles | | |
| Action | to read value of security register | to set the lock-down bit as "1" (once lock-down, cannot be updated) |

### 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)(Note 3) | 99 (hex)(Note 3) |
| 2nd byte | | | |
| 3rd byte | | | |
| 4th byte | | | |
| 5th byte | | | |
| Action | | | |

Note 1: ADD=00H will output the manufacturer ID first and ADD=01H will output device ID first.
Note 2: It is not recommended to adopt any other code not in the command definition table, which will potentially enter the hidden mode.
Note 3: Before executing RST command, RSTEN command must be executed. If there is any other command to interfere, the reset operation will be disabled.
Note 4: 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. Please note the number after "ADD" are based on 3-byte address mode, for 4-byte address mode, which will be increased.

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

The Write Enable (WREN) instruction is for setting Write Enable Latch (WEL) bit. For those instructions like PP/PP4B, 4PP/4PP4B, SE/SE4B, BE32K/BE32K4B, BE/BE4B, CE, WRSR, WRFBR, ESFBR, and WRSCUR, 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 7. Write Enable (WREN) Sequence (SPI Mode)**

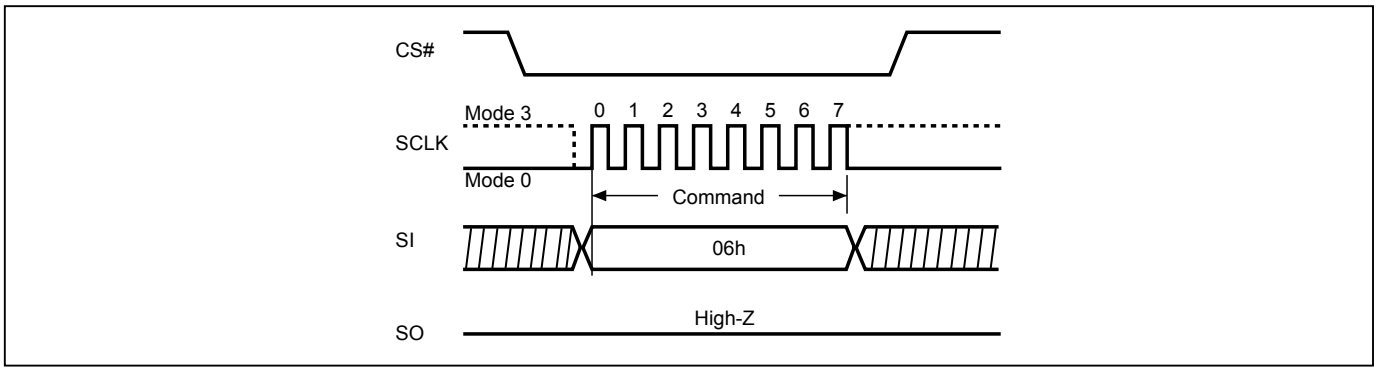
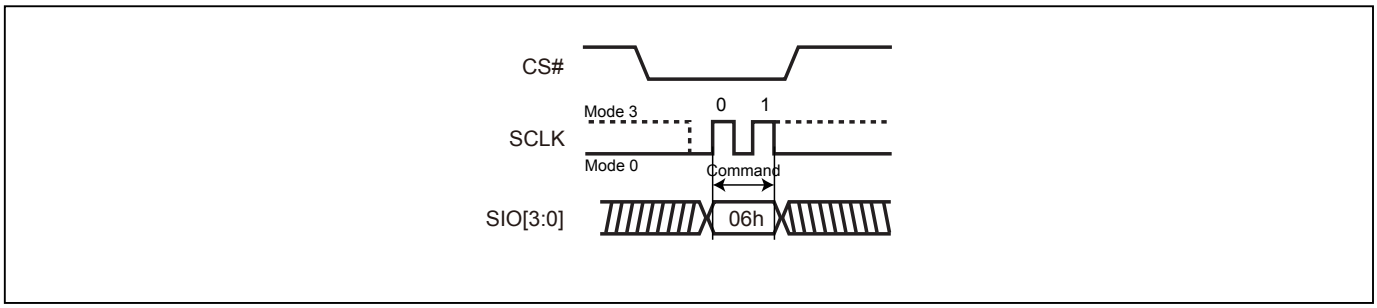



**Figure 8. Write Enable (WREN) Sequence (QPI Mode)**



### 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/PP4B command completion
- 4PP/4PP4B command completion
- SE/SE4B command completion
- BE32K/BE32K4B command completion
- BE/BE4B command completion
- CE command completion
- PGM/ERS Suspend command completion
- Softreset command completion
- WRSCUR command completion
- WREAR command completion
- WRFBR command completion
- ESFBR command completion

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

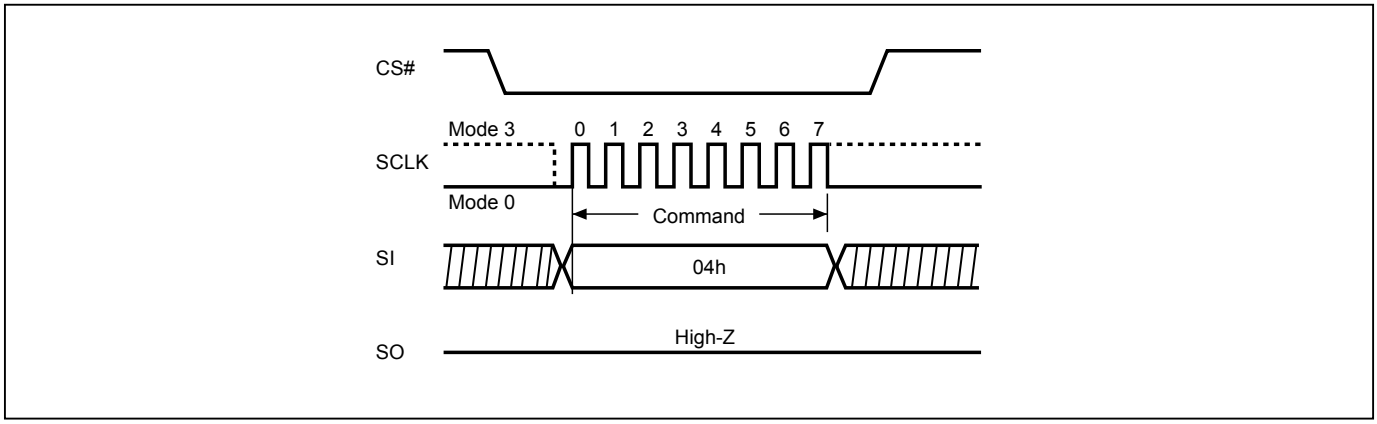
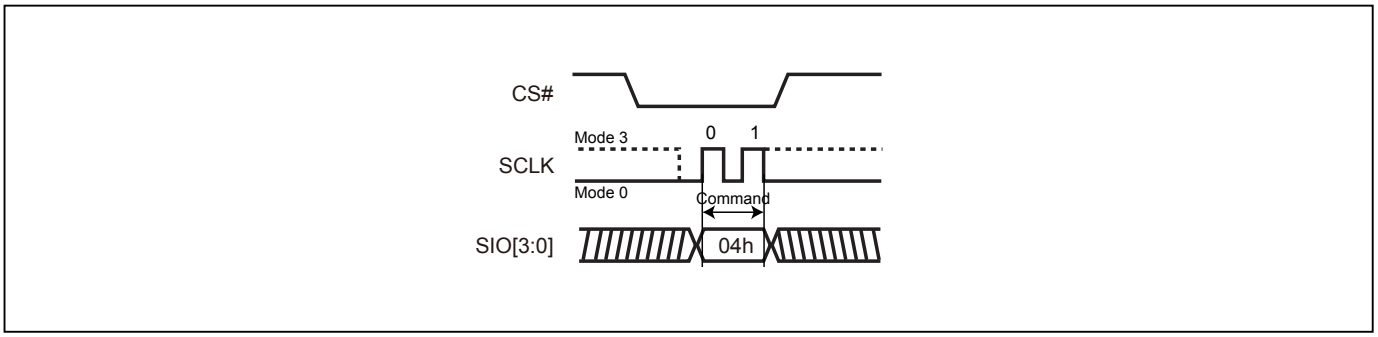


**Figure 10. Write Disable (WRDI) Sequence (QPI Mode)**



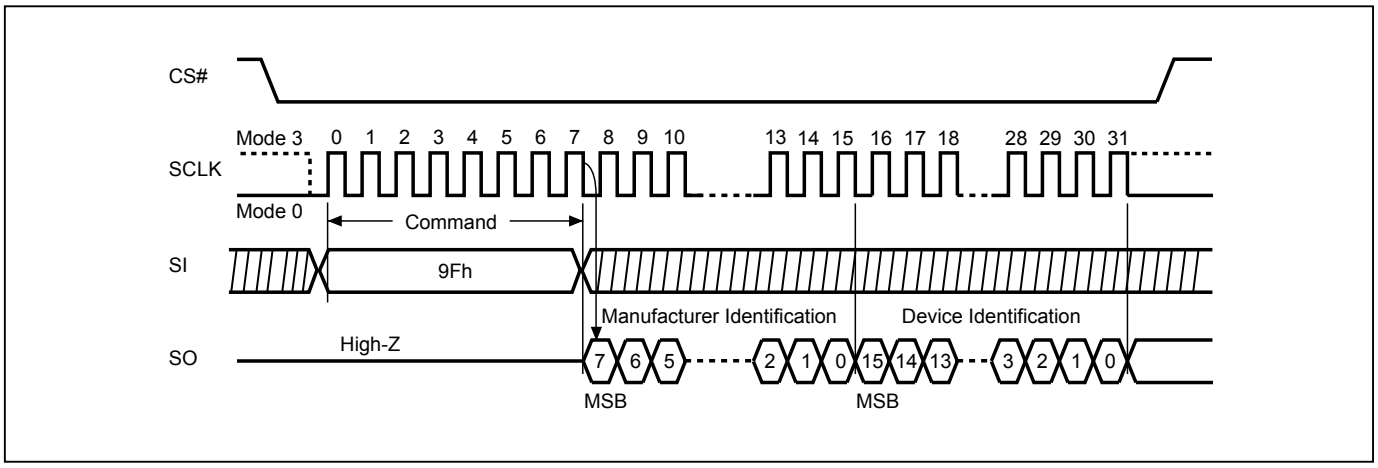

## 9-3. Read Identification (RDID)

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 11. 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 17* 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 12. Read Electronic Signature (RES) Sequence (SPI Mode)**

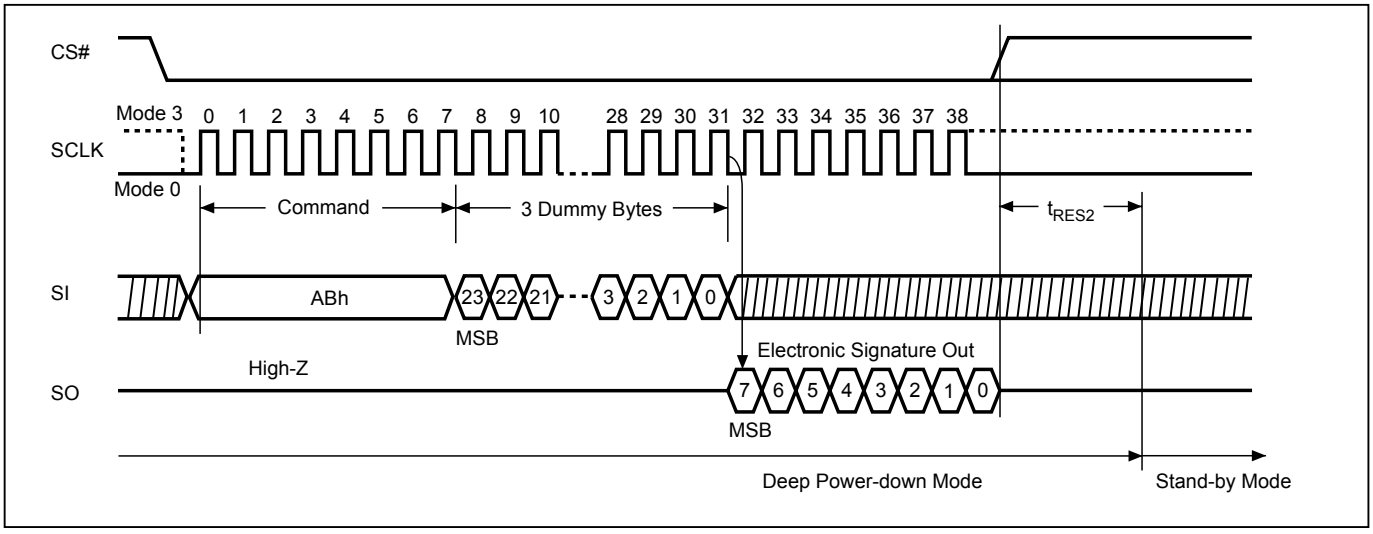


**Figure 13. Read Electronic Signature (RES) Sequence (QPI Mode)**

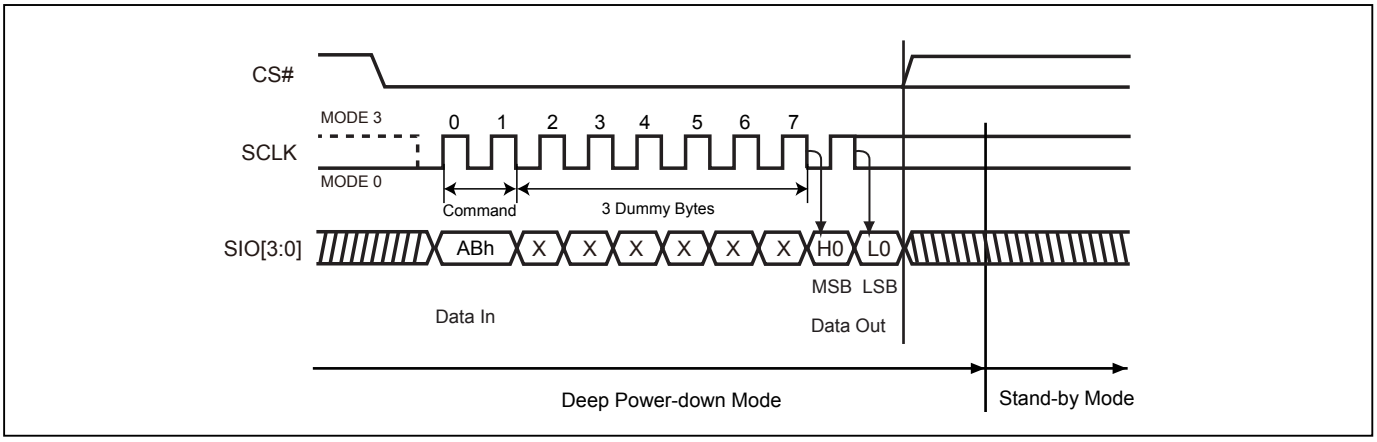



**Figure 14. Release from Deep Power-down (RDP) Sequence (SPI Mode)**

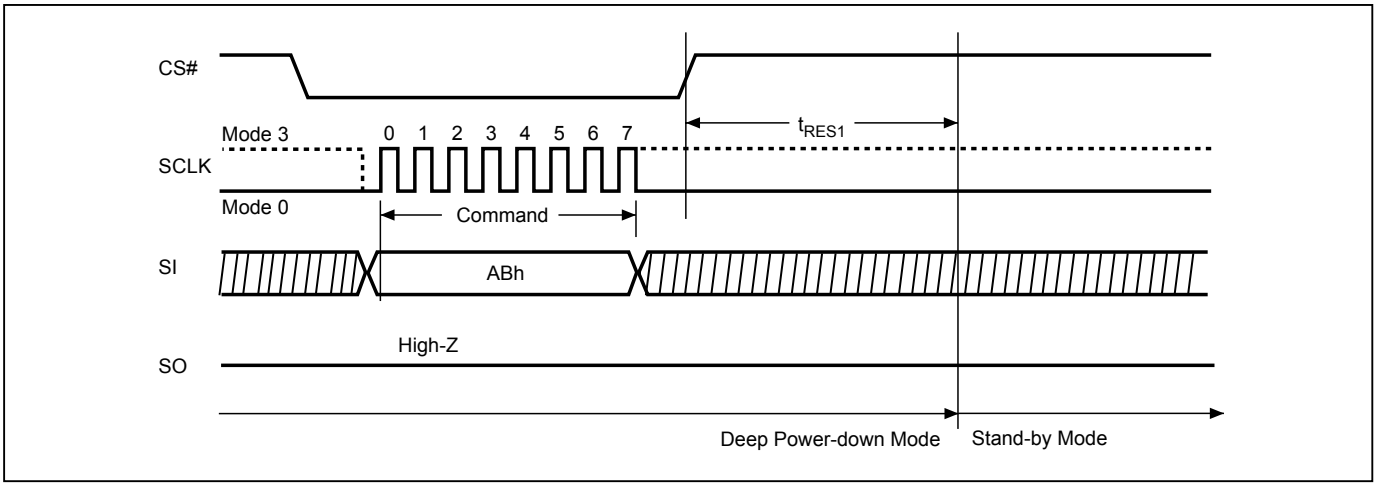
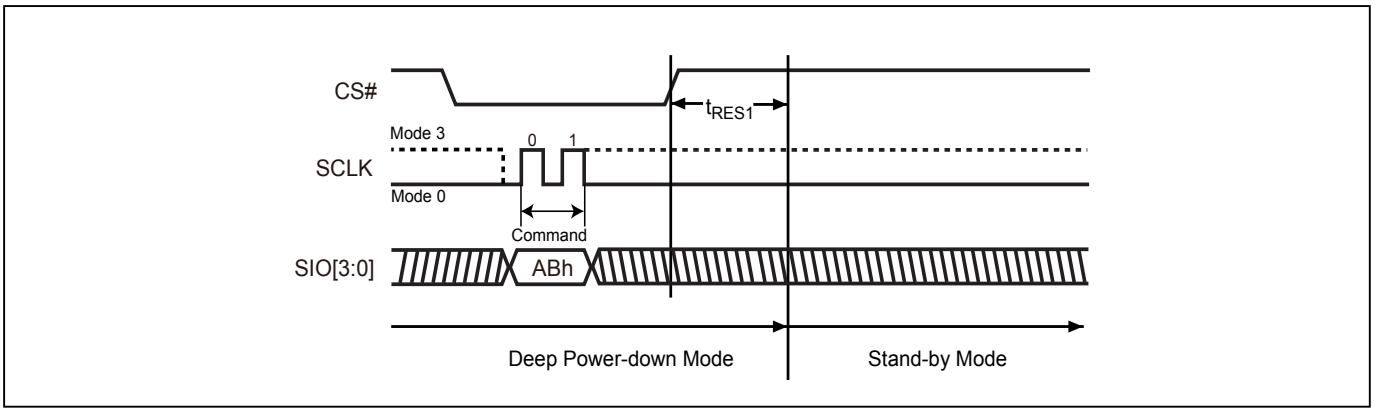



**Figure 15. Release from Deep Power-down (RDP) Sequence (QPI Mode)**

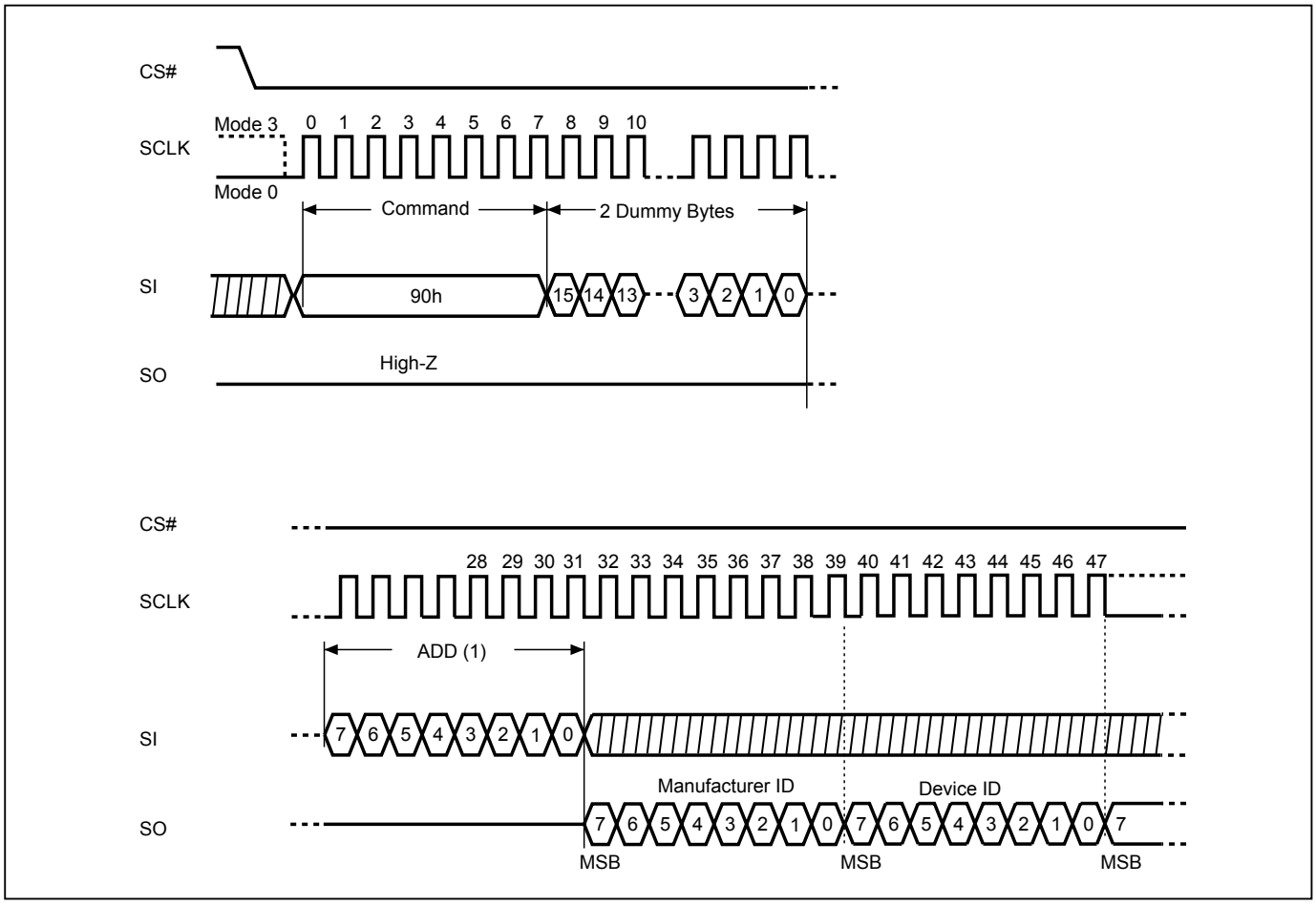


### 9-5. Read Electronic Manufacturer ID & Device ID (REMS)

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* of 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 16. 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 | | MX66U51235F | | |
|---|---|---|---|---|
| RDID | 9Fh | Manufactory ID | Memory type | Memory density |
| | | C2 | 25 | 3A |
| RES | ABh | Electronic ID | | |
| | | 3A | | |
| REMS | 90h | Manufactory ID | Device ID | |
| | | C2 | 3A | |
| QPIID | AFh | Manufactory ID | Memory type | Memory density |
| | | C2 | 25 | 3A |

### 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 17. Read Status Register (RDSR) Sequence (SPI Mode)**

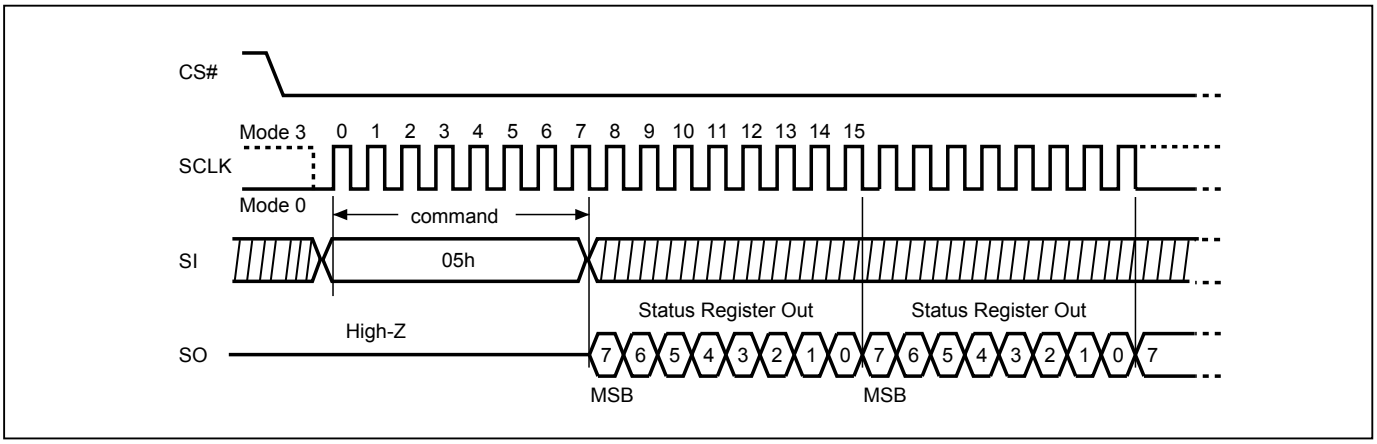
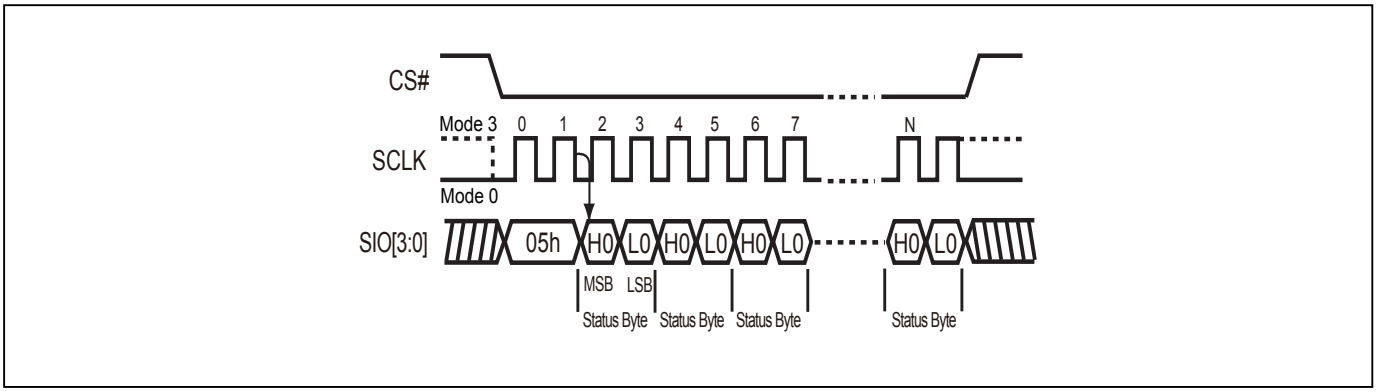



**Figure 18. Read Status Register (RDSR) Sequence (QPI Mode)**



### 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).

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 19. Read Configuration Register (RDCR) Sequence (SPI Mode)**

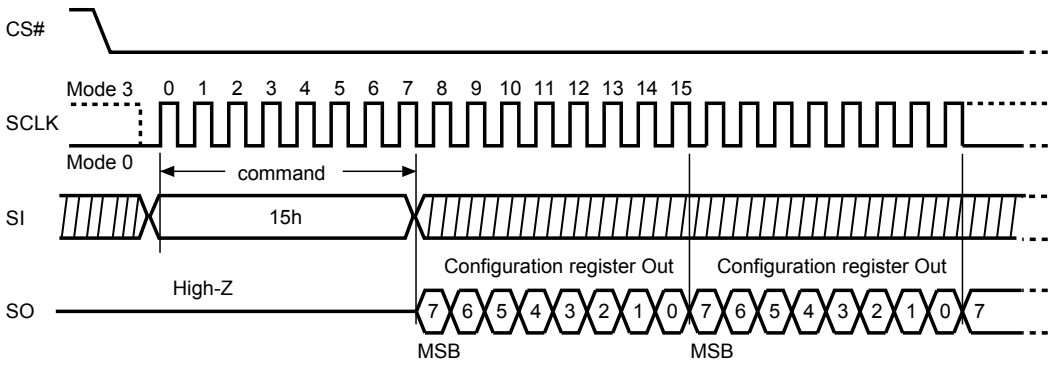
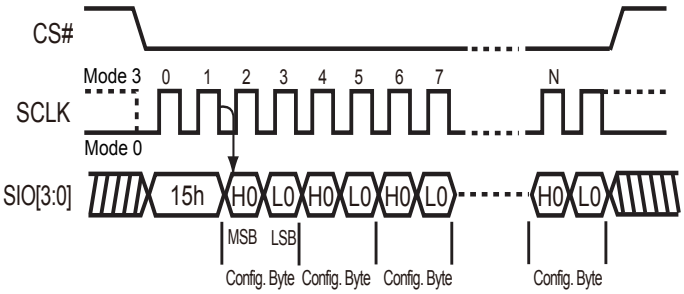



**Figure 20. Read Configuration Register (RDCR) Sequence (QPI Mode)**



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

**Figure 21. Program/Erase flow with read array data**

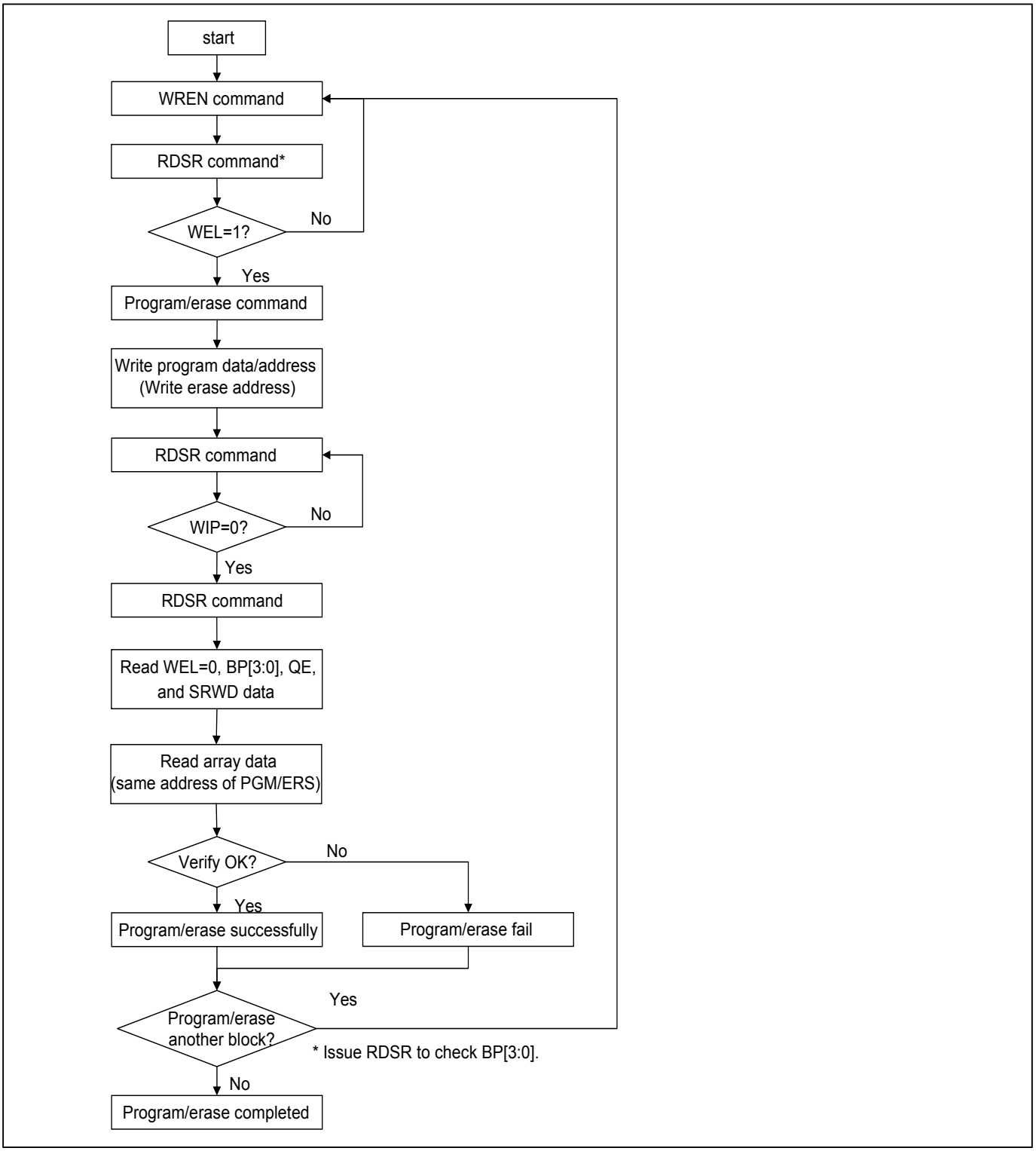
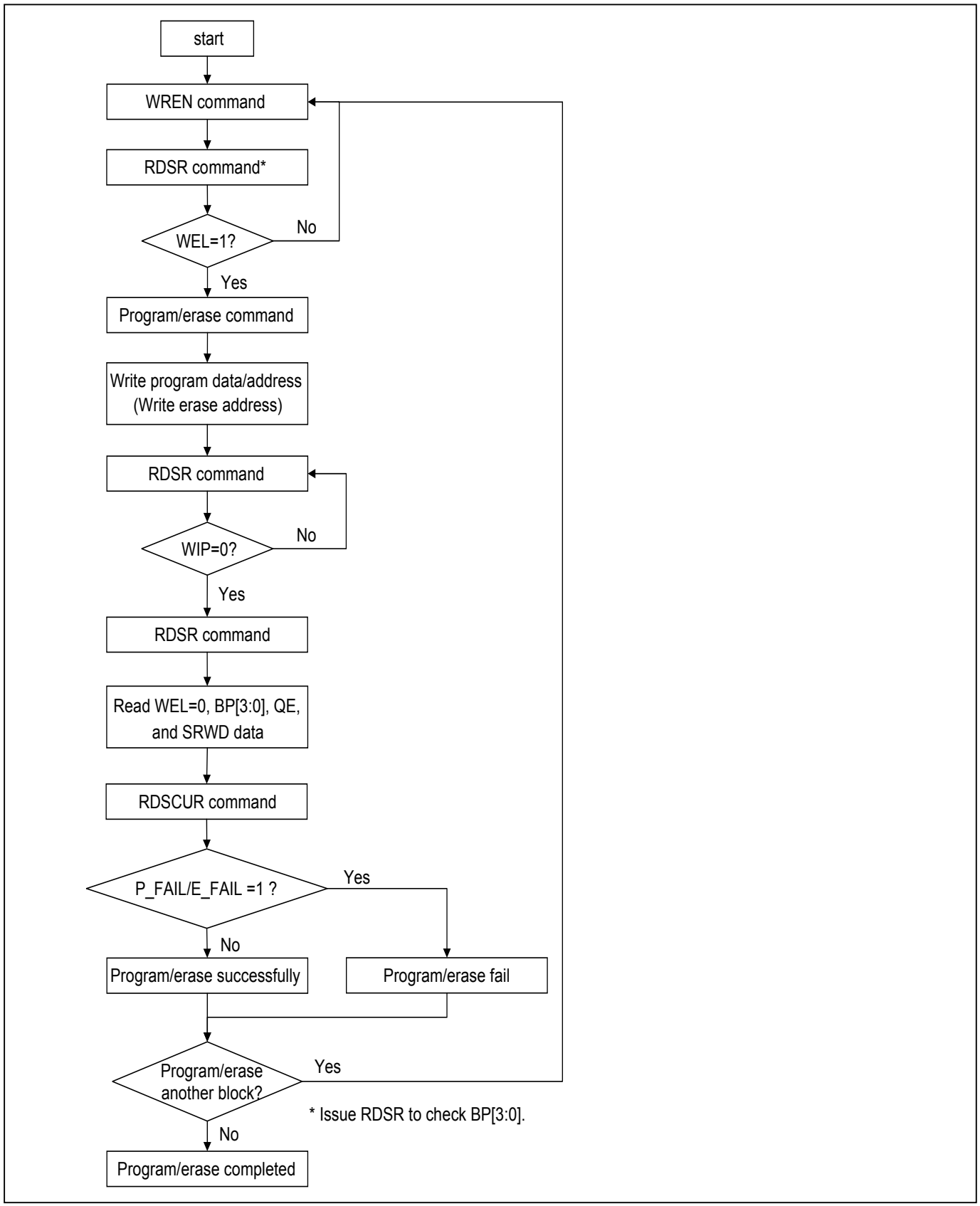


**Figure 22. Program/Erase flow without read array data (read P_FAIL/E_FAIL flag)**



### 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*) 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 un-protected.

**QE bit.** The Quad Enable (QE) bit, non-volatile bit, while it is "0" (factory default), it performs non-Quad and WP#, RESET# are enable. While QE is "1", it performs Quad I/O mode and WP#, RESET# are disabled. In the other word, if the system goes into four I/O mode (QE=1), the feature of HPM and RESET will be disabled.

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

**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 | 1=Quad Enable 0=not 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 Size".

### 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.

**DC bits**
The dummy cycle (DC1, DC2) bits are volatile bits, which indicate the number of dummy cycles (as defined in *"Dummy Cycle and Frequency Table (MHz)"*) of the device. The default Dummy Cycle bits are DC[1:0]=00. To write the Dummy cycle bits requires the Write Status Register (WRSR) instruction to be executed.

**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.

**4BYTE Indicator bit**
By writing EN4B instruction, the 4BYTE bit may be set as "1" to access the address length of 32-bit for memory area of higher density (large than 128Mb). The default state is "0" as the 24-bit address mode. The 4BYTE bit may be cleared by power-off or writing EX4B instruction to reset the state to be "0".

**Configuration Register**

| bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|
| DC1 (Dummy cycle 1) | DC0 (Dummy cycle 0) | 4 BYTE | Reserved | TB (top/bottom selected) | ODS 2 (output driver strength) | ODS 1 (output driver strength) | ODS 0 (output driver strength) |
| *(note 2)* | *(note 2)* | 0=3-byte address mode 1=4-byte address mode (Default=0) | x | 0=Top area protect 1=Bottom area protect (Default=0) | *(note 1)* | *(note 1)* | *(note 1)* |
| volatile bit | volatile bit | volatile bit | 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 | 108 | 108 | 108 |
| **01** | 6 | 108 | 108 | 84 |
| **10** | 8 | 108 | 108 | 108 |

| DC[1:0] | Numbers of Dummy clock cycles | Dual IO Fast Read |
|---|---|---|
| **00 (default)** | 4 | 84 |
| **01** | 6 | 108 |
| **10** | 8 | 108 |

| DC[1:0] | Numbers of Dummy clock cycles | Quad IO Fast Read |
|---|---|---|
| **00 (default)** | 6 | 84 |
| **01** | 4 | 70 |
| **10** | 8 | 108 |

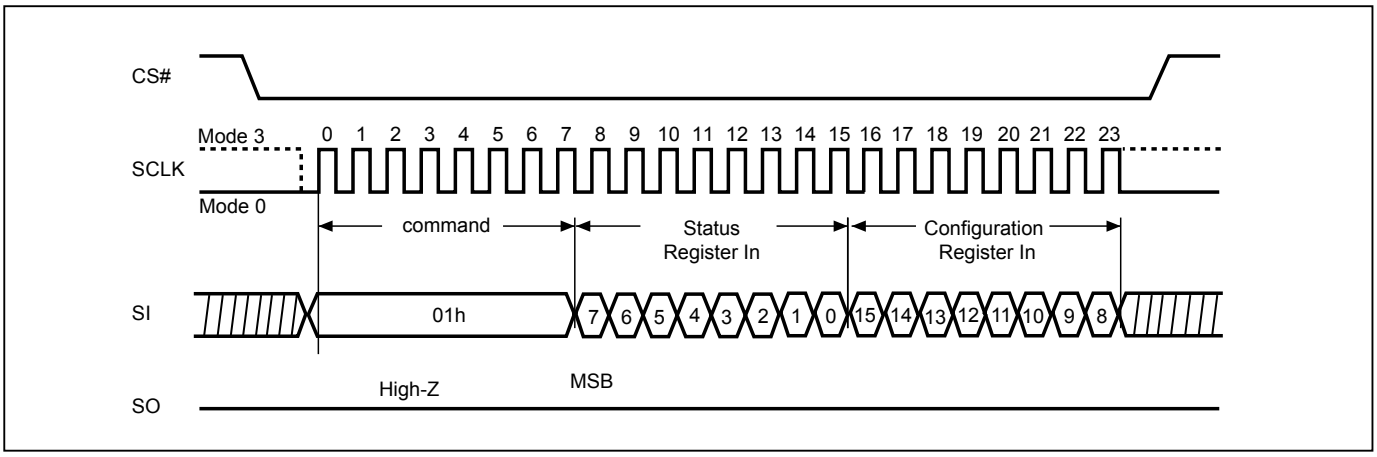
### 9-9. Write Status Register (WRSR)

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"*). The WRSR also can set or reset the Quad enable (QE) bit and set or reset the Status Register Write Disable (SRWD) bit in accordance with Write Protection (WP#/SIO2) pin signal, but has no effect on bit1(WEL) and bit0 (WIP) of the status register. The WRSR instruction cannot be executed once the Hardware Protected Mode (HPM) is entered.

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

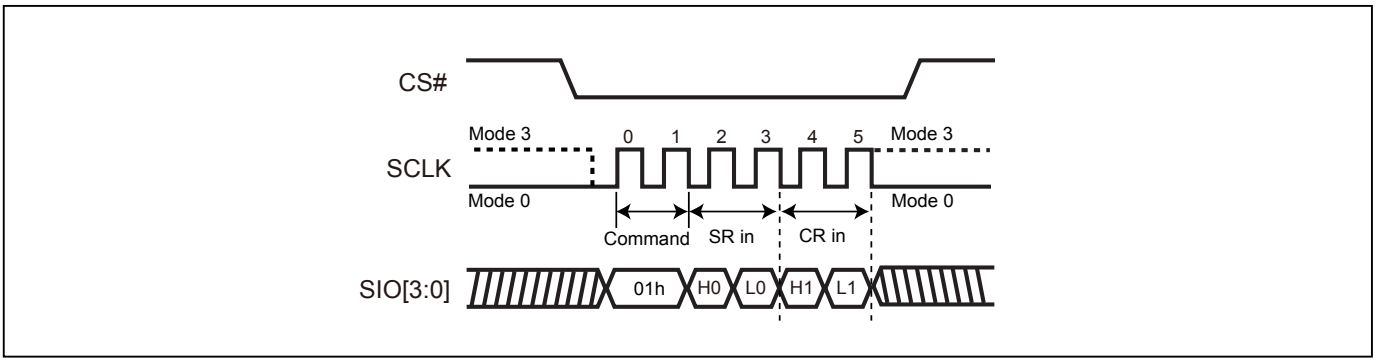
The CS# must go high exactly at the 8 bits or 16 bits data boundary; otherwise, the instruction will be rejected and not executed. The self-timed Write Status Register cycle time (tW) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be check out during the 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 23. 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 24. Write Status Register (WRSR) Sequence (QPI Mode)**





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**Software Protected Mode (SPM):**

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

***Note:***

If SRWD bit=1 but WP#/SIO2 is low, it is impossible to write the Status Register even if the WEL bit has previously been set. It is rejected to write the Status Register and not be executed.

**Hardware Protected Mode (HPM):**

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

***Note:***

To exit the hardware protected mode requires WP#/SIO2 driving high once the hardware protected mode is entered. If the WP#/SIO2 pin is permanently connected to high, the hardware protected mode can never be entered; only can use software protected mode via BP3, BP2, BP1, BP0 and T/B bit.
If the system enter QPI or set QE=1, the feature of HPM will be disabled.

**Table 7. Protection Modes**

| Mode | Status register condition | WP# and SRWD bit status | Memory |
|---|---|---|---|
| Software protection mode (SPM) | Status register can be written in (WEL bit is set to "1") and the SRWD, BP0-BP3 bits can be changed | WP#=1 and SRWD bit=0, or WP#=0 and SRWD bit=0, or WP#=1 and SRWD=1 | The protected area cannot be program or erase. |
| Hardware protection mode (HPM) | The SRWD, BP0-BP3 of status register bits cannot be changed | WP#=0, SRWD bit=1 | 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 25. WRSR flow**

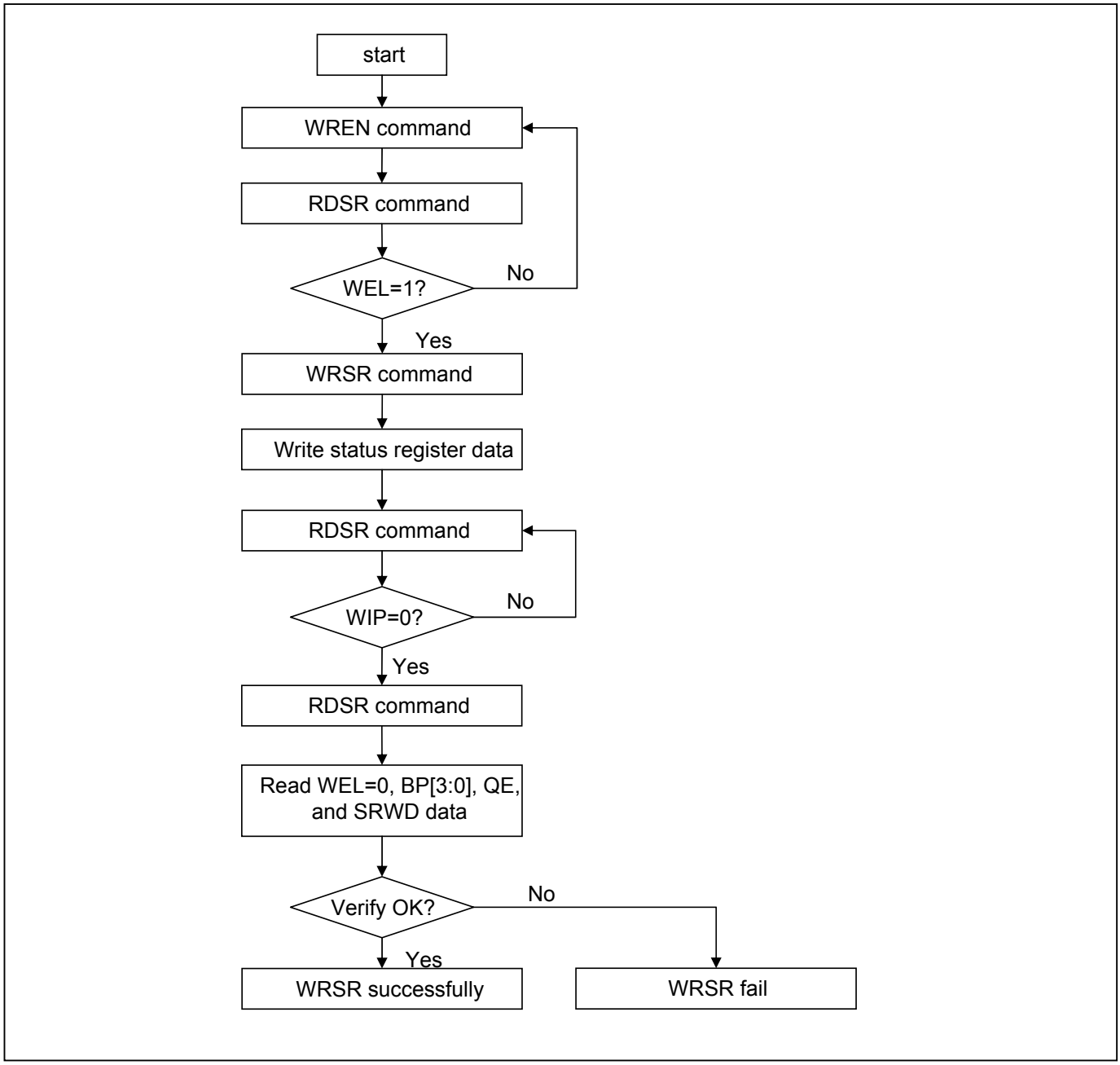
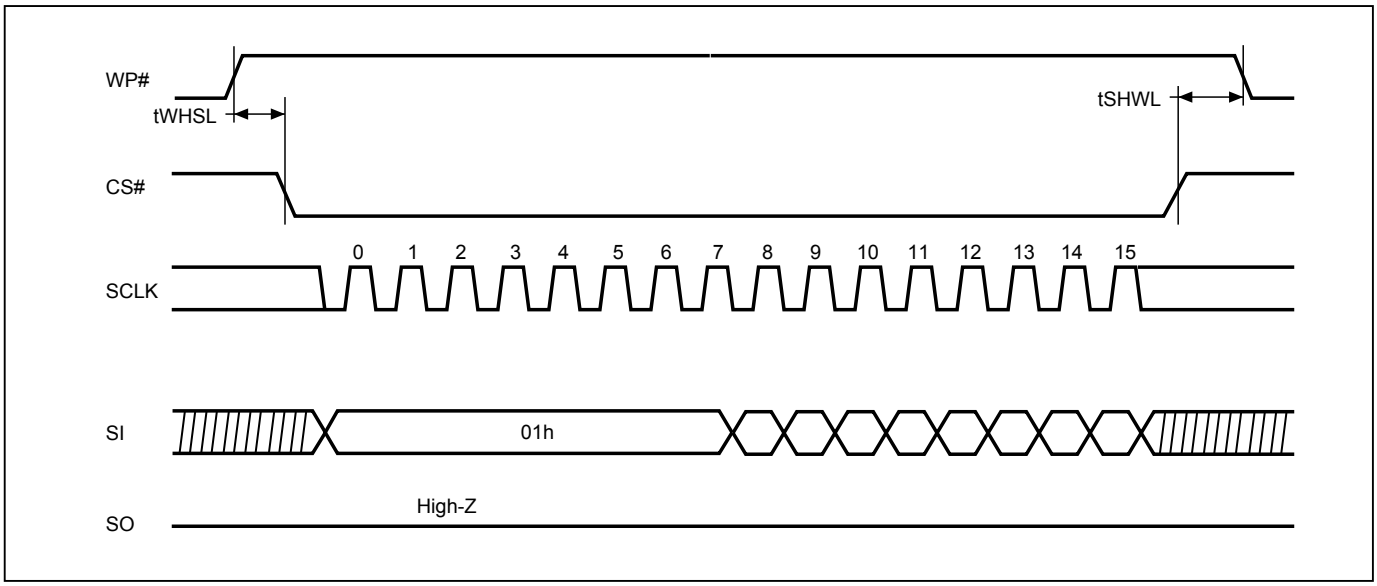


**Figure 26. WP# Setup Timing and Hold Timing during WRSR when SRWD=1**




Note: WP# must be kept high until the embedded operation finish.

### 9-10. Enter 4-byte mode (EN4B)

The EN4B instruction enables accessing the address length of 32-bit for the memory area of higher density (larger than 128Mb). The device default is in 24-bit address mode; after sending out the EN4B instruction, the bit5 (4BYTE bit) of security register will be automatically set to "1" to indicate the 4-byte address mode has been enabled. Once the 4-byte address mode is enabled, the address length becomes 32-bit instead of the default 24-bit. There are three methods to exit the 4-byte mode: writing exit 4-byte mode (EX4B) instruction, Reset or power-off.

All instructions are accepted normally, and just the address bit is changed from 24-bit to 32-bit.

The following command don't support 4bye address: RDSFDP, RES and REMS.

The sequence of issuing EN4B instruction is: CS# goes low → sending EN4B instruction to enter 4-byte mode( automatically set 4BYTE bit as "1") → CS# goes high.

### 9-11. Exit 4-byte mode (EX4B)

The EX4B instruction is executed to exit the 4-byte address mode and return to the default 3-bytes address mode. After sending out the EX4B instruction, the bit5 (4BYTE bit) of Configuration register will be cleared to be "0" to indicate the exit of the 4-byte address mode. Once exiting the 4-byte address mode, the address length will return to 24-bit.

The sequence of issuing EX4B instruction is: CS# goes low → sending EX4B instruction to exit 4-byte mode (automatically clear the 4BYTE bit to be "0") → CS# goes high.

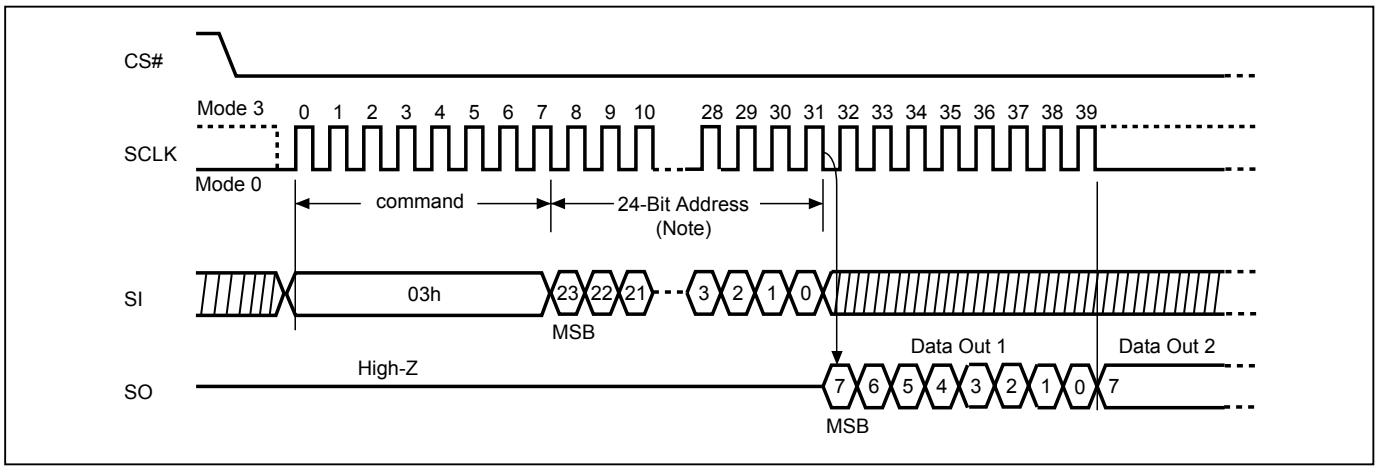
### 9-12. Read Data Bytes (READ)

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 can't be any location if the device is still in 3-Byte mode. 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 default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte mode, please refer to the enter 4-byte mode (EN4B) Mode section.

The sequence of issuing READ instruction is: CS# goes low→sending READ instruction code→ 3-byte or 4-byte address on SI→ data out on SO→to end READ operation can use CS# to high at any time during data out.

**Figure 27. Read Data Bytes (READ) Sequence (SPI Mode only)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

### 9-13. Read Data Bytes at Higher Speed (FAST_READ)

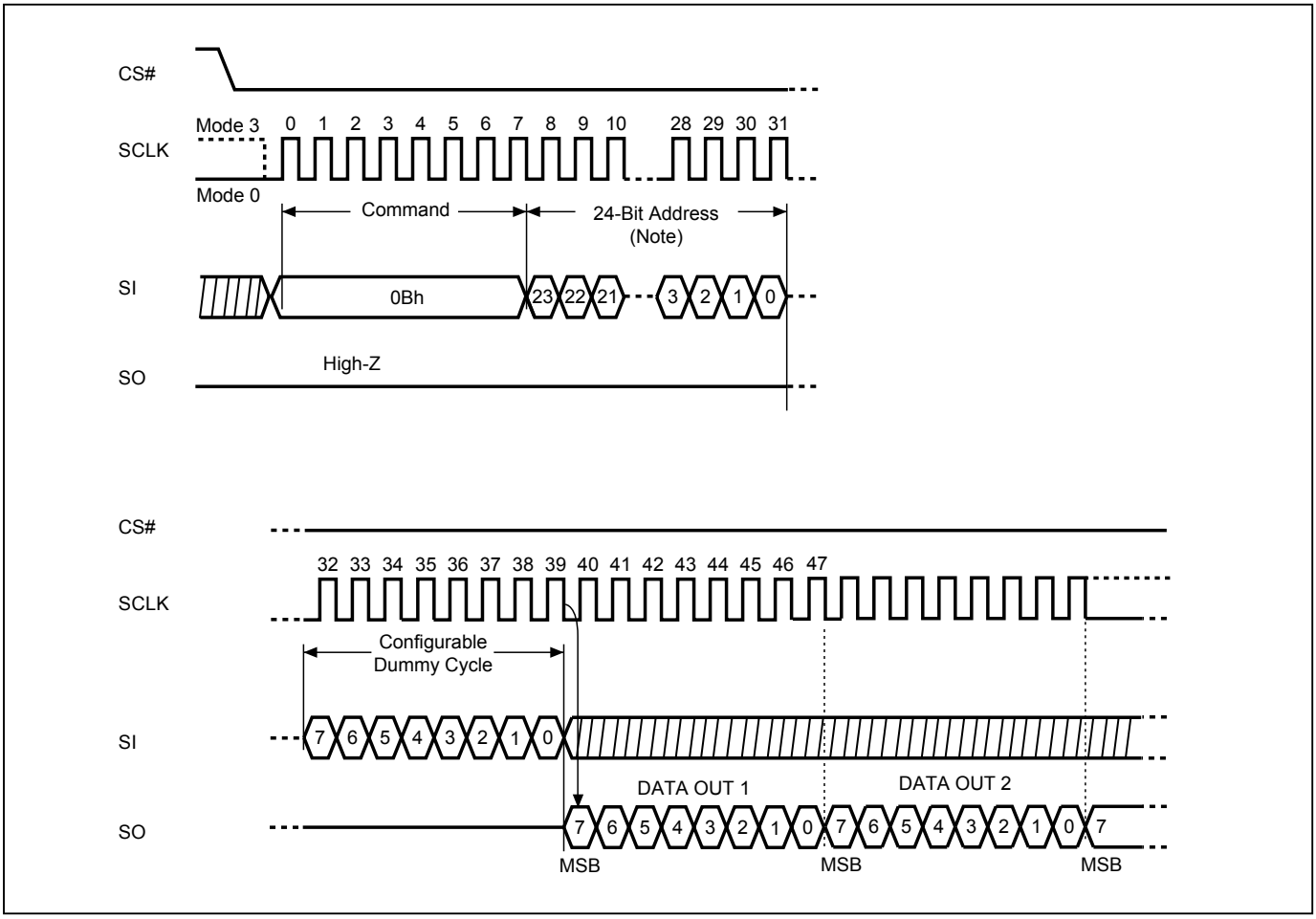
The FAST_READ instruction is for quickly reading data out. The address is latched on rising edge of SCLK, and data of each bit shifts out on the falling edge of SCLK at a maximum frequency fC. The first address can't be any location if the device is still in 3-Byte mode. The address is automatically 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.

The default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte mode, please refer to the enter 4-byte mode (EN4B) Mode section.

**Read on SPI Mode** The sequence of issuing FAST_READ instruction is: CS# goes low→ sending FAST_READ instruction code→ 3-byte or 4-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.

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




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

### 9-14. Dual Output Read Mode (DREAD)

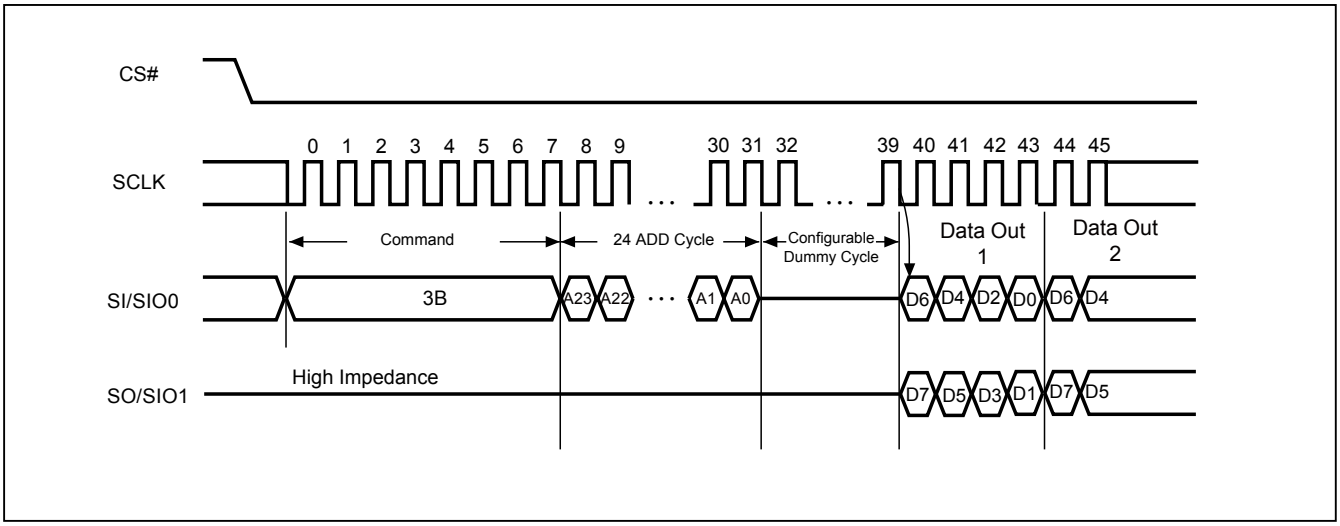
The DREAD instruction enable double throughput of Serial Flash in read mode. The address is latched on rising edge of SCLK, and data of every two bits (interleave on 2 I/O pins) shift out on the falling edge of SCLK at a maximum frequency fT. The first address can't be any location if the device is still in 3-Byte mode. 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 default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte mode, please refer to the enter 4-byte mode (EN4B) Mode section.

The sequence of issuing DREAD instruction is: CS# goes low→ sending DREAD instruction→3-byte or 4-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 29. Dual Read Mode Sequence**




Notes:
1. Please note the above address cycles are base on 3-byte address mode, for 4-byte address mode, the address cycles will be increased.

### 9-15. 2 x I/O Read Mode (2READ)

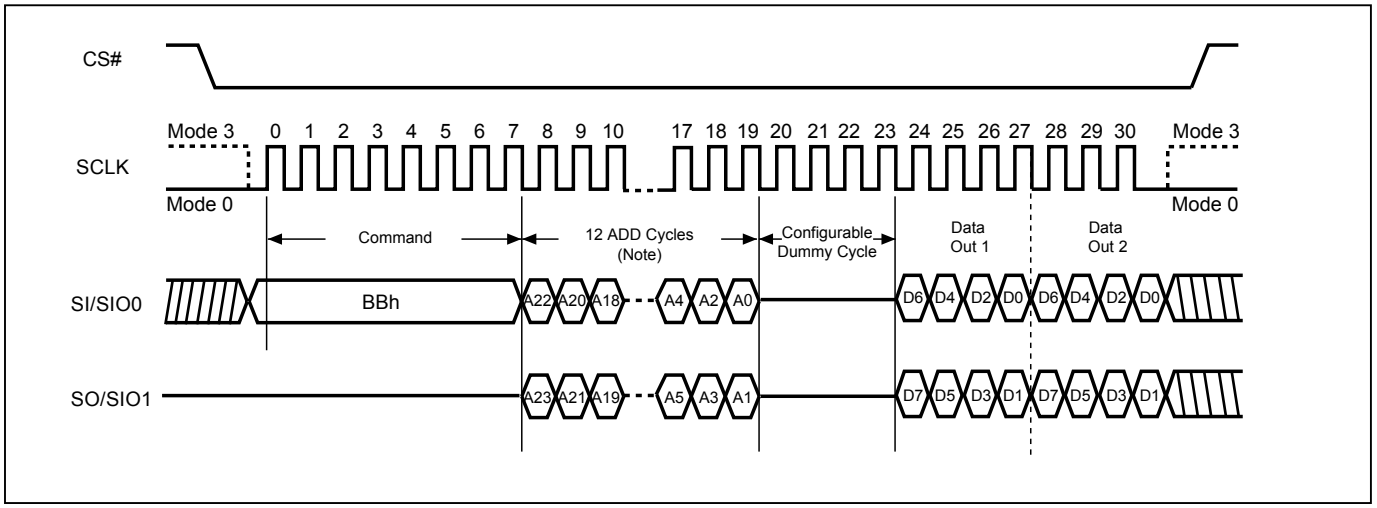
The 2READ instruction enable double throughput of Serial Flash in read mode. The address is latched on rising edge of SCLK, and data of every two bits (interleave on 2 I/O pins) shift out on the falling edge of SCLK at a maximum frequency fT. The first address can't be any location if the device is still in 3-Byte mode. 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 default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte mode, please refer to the enter 4-byte mode (EN4B) Mode section.

The sequence of issuing 2READ instruction is: CS# goes low→ sending 2READ instruction→ 3-byte or 4-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 30. 2 x I/O Read Mode Sequence (SPI Mode only)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

### 9-16. Quad Read Mode (QREAD)

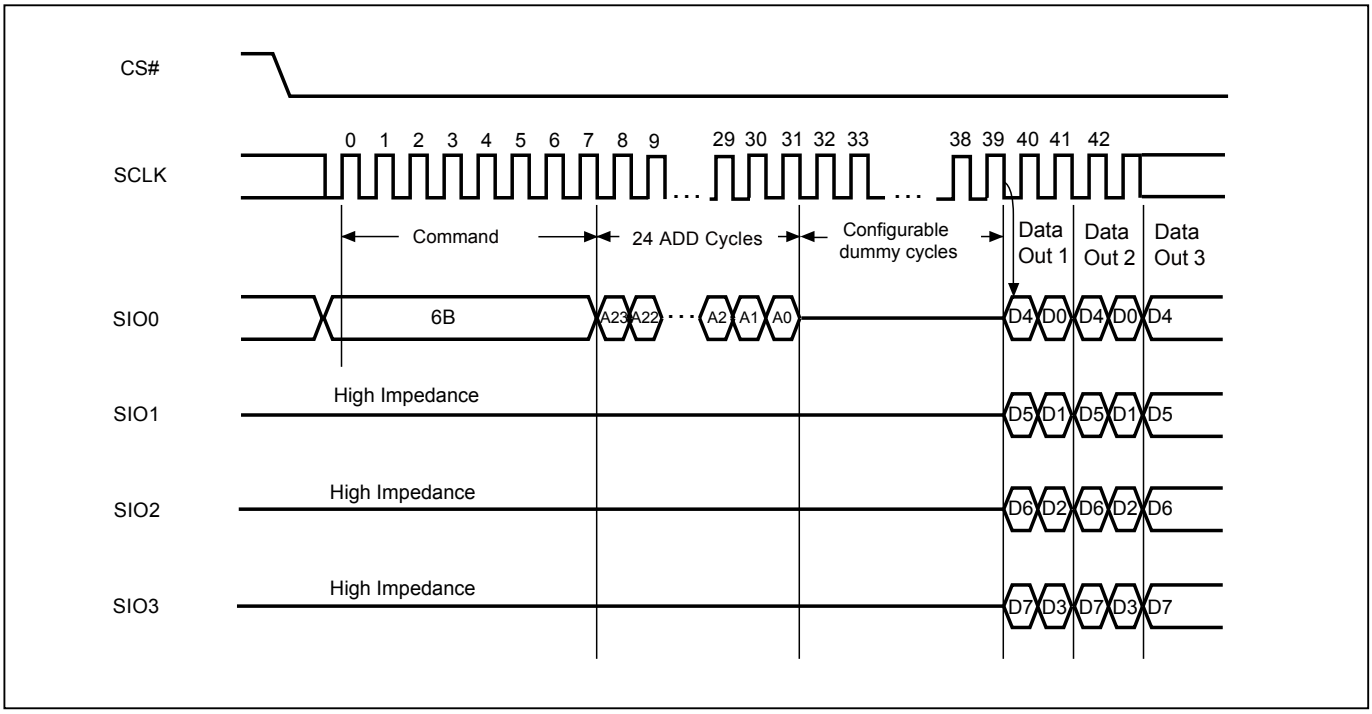
The QREAD instruction enable quad throughput of Serial Flash in read mode. A Quad Enable (QE) bit of status Register must be set to "1" before sending the QREAD instruction. The address is latched on rising edge of SCLK, and data of every four bits (interleave on 4 I/O pins) shift out on the falling edge of SCLK at a maximum frequency fQ. The first address can't be any location if the device is still in 3-Byte mode. 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 default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte mode, please refer to the enter 4-byte mode (EN4B) Mode section.

The sequence of issuing QREAD instruction is: CS# goes low→ sending QREAD instruction → 3-byte or 4-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 31. Quad Read Mode Sequence**




Notes:
1. Please note the above address cycles are base on 3-byte address mode, for 4-byte address mode, the address cycles will be increased.
2. The MSB is on SIO3, which is different from 1 x I/O condition.

### 9-17. 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 can't be any location if the device is still in 3-Byte mode. 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.

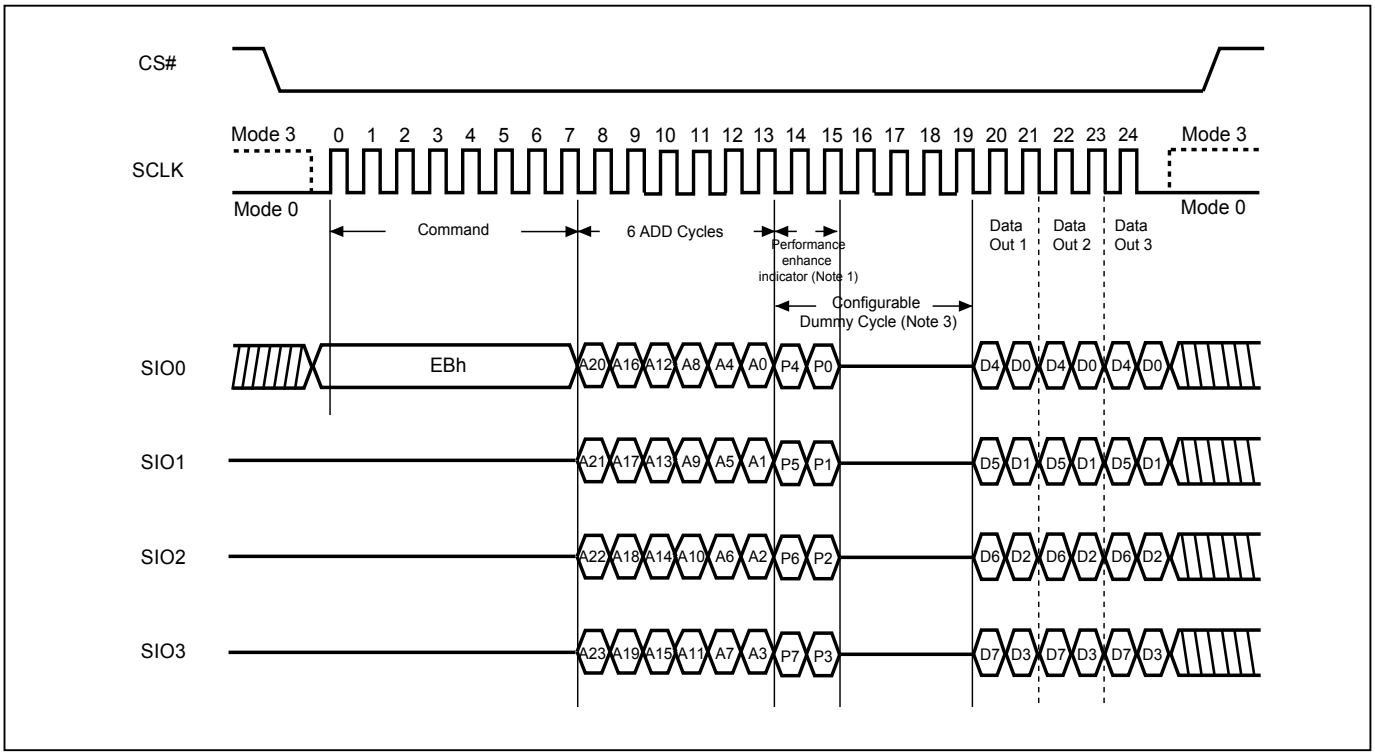
The default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte mode, please refer to the enter 4-byte mode (EN4B) Mode section.

**4 x I/O Read on SPI Mode (4READ)** The sequence of issuing 4READ instruction is: CS# goes low→ sending 4READ instruction→ 3-byte or 4-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 or 4-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.

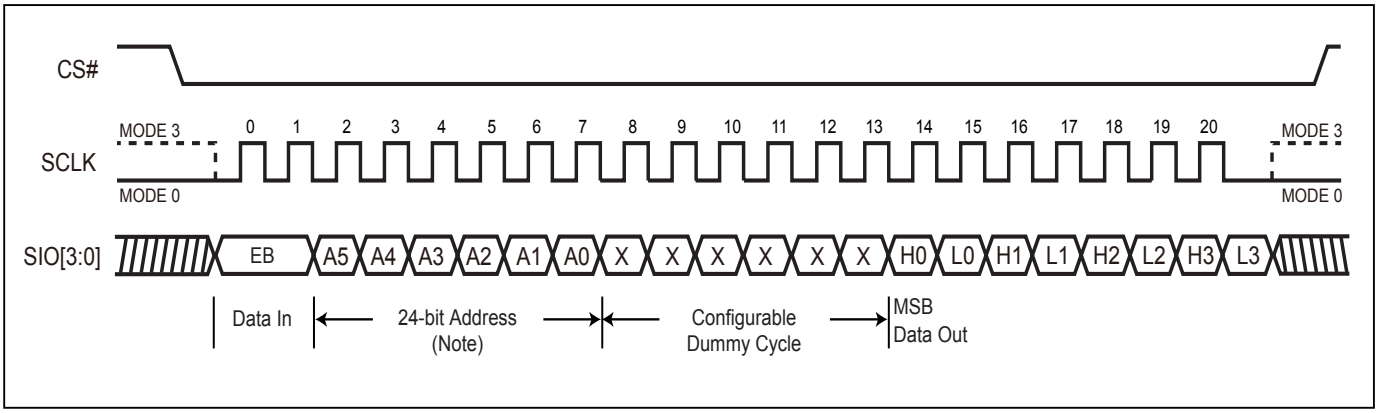
While Program/Erase/Write Status Register cycle is in progress, 4READ instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

**Figure 32. 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.
4. Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.
5. The MSB is on SIO3, which is different from 1 x I/O condition

**Figure 33. 4 x I/O Read Mode Sequence (QPI Mode)**




Note: 1. Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.
2. The MSB is on SIO3 which is different from 1 x I/O condition.

### 9-18. 4 Byte Address Command Set

The operation of 4-byte address command set was very similar to original 3-byte address command set. The only different is all the 4-byte command set request 4-byte address (A31-A0) followed by instruction code. The command set support 4-byte address including: READ4B, Fast_Read4B, DREAD4B, 2READ4B, QREAD4B, 4READ4B, PP4B, 4PP4B, SE4B, BE32K4B, BE4B. Please note that it is not necessary to issue EN4B command before issuing any of 4-byte command set.

**Figure 34. Read Data Bytes using 4 Byte Address Sequence (READ4B)**

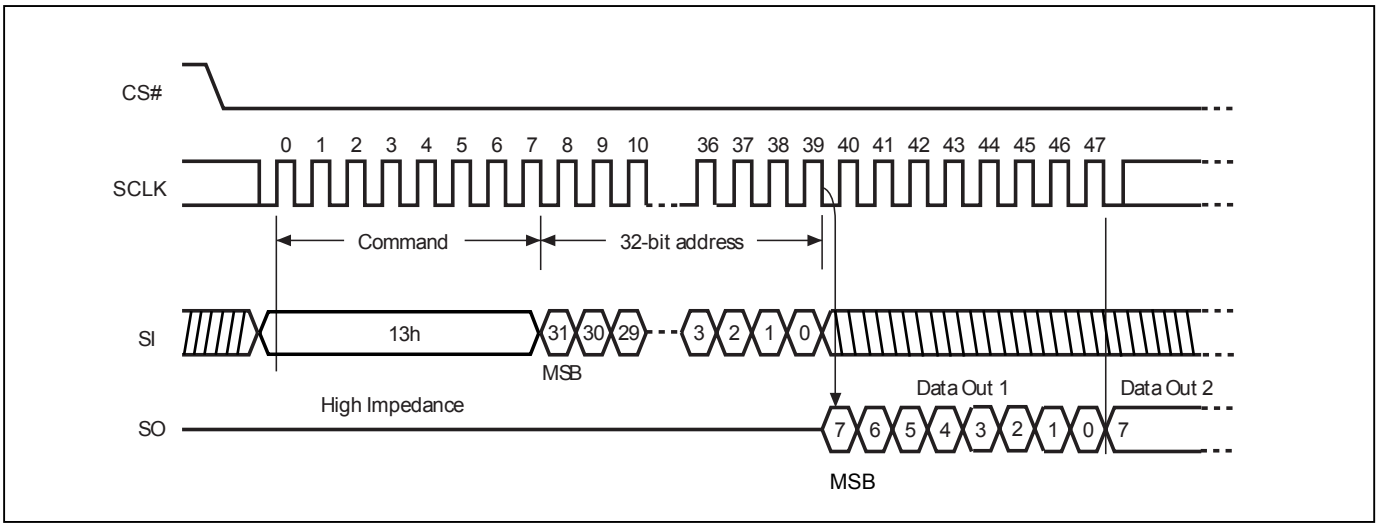



**Figure 35. Read Data Bytes at Higher Speed using 4 Byte Address Sequence (FASTREAD4B)**

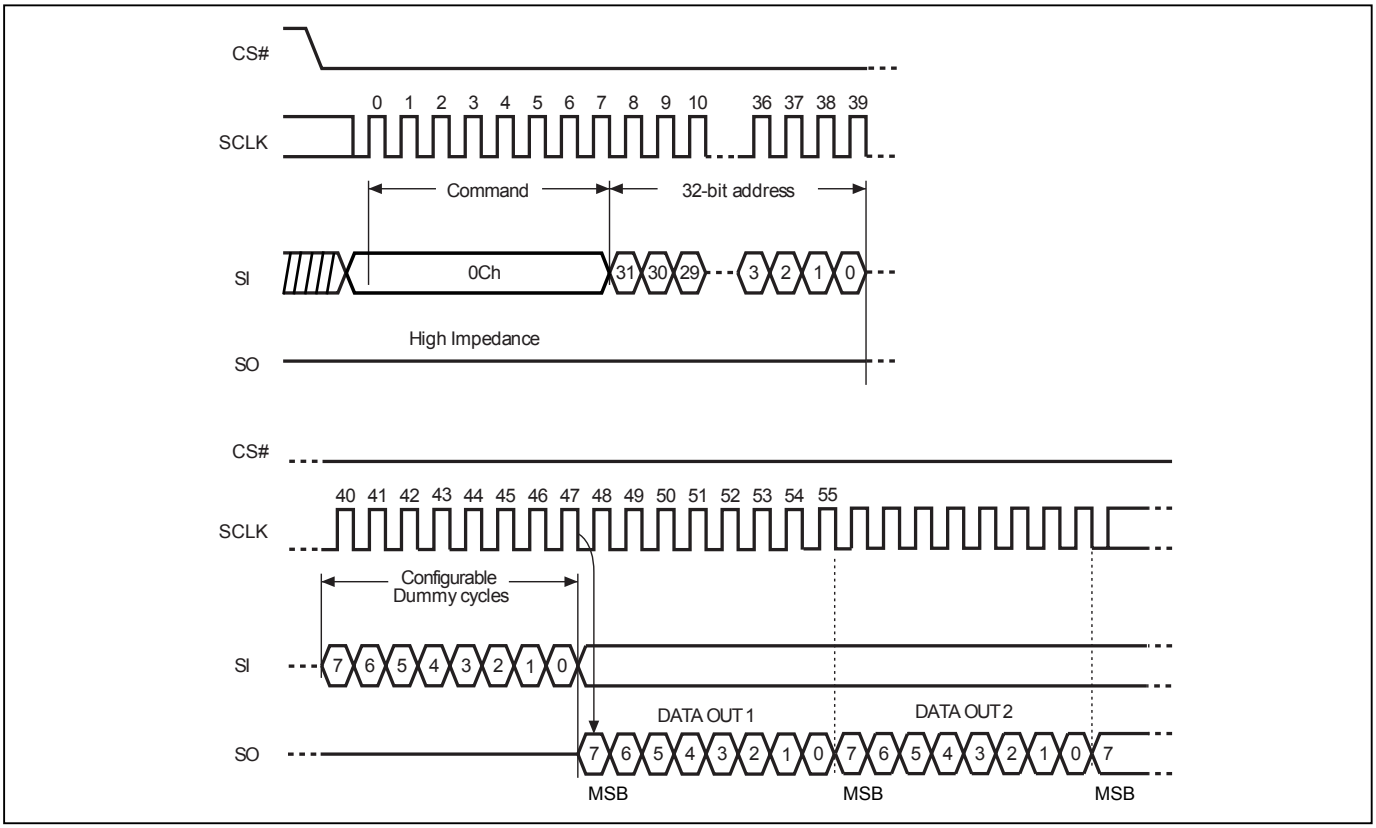
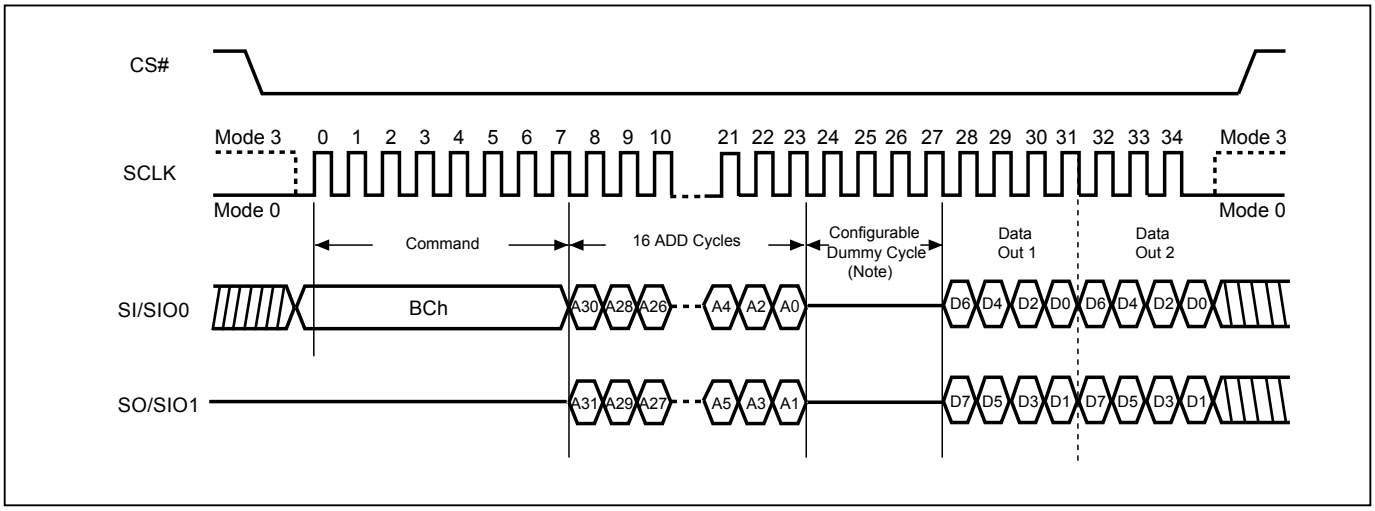
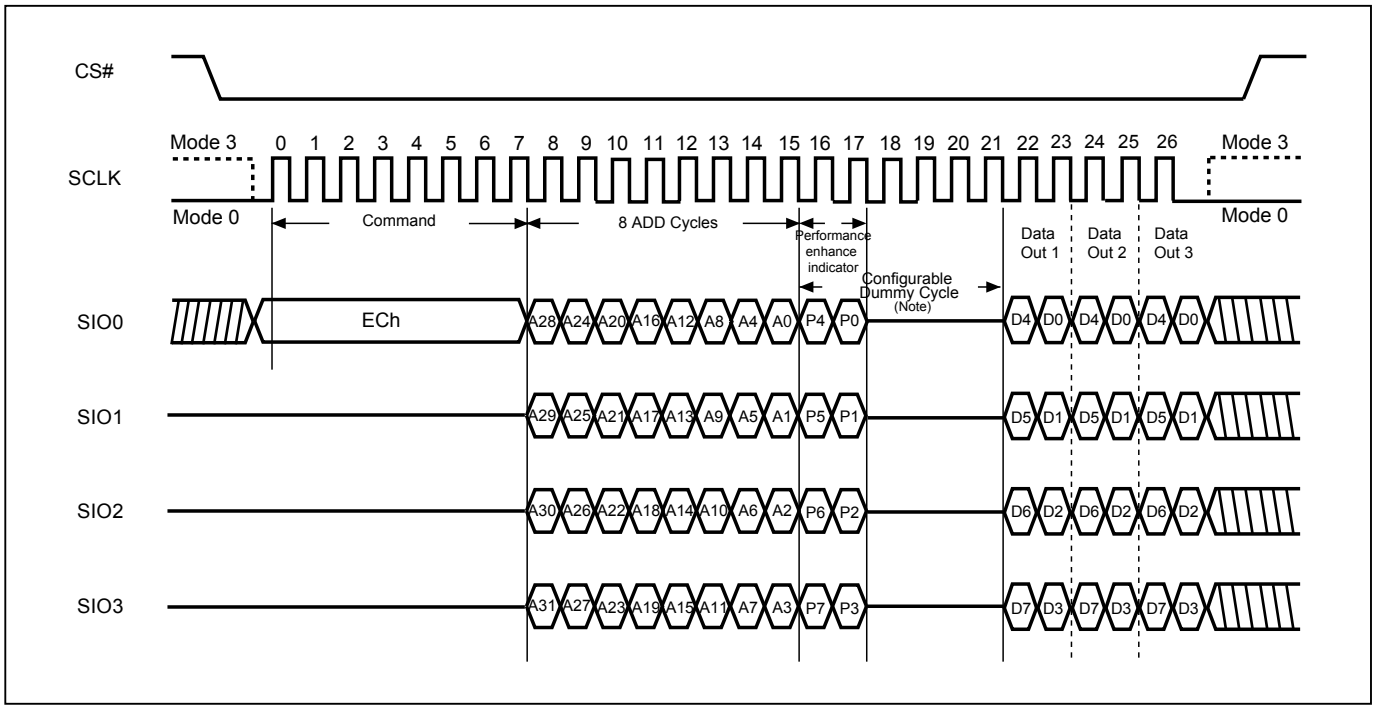


**Figure 36. 2 x I/O Fast Read using 4 Byte Address Sequence (2READ4B)**




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

**Figure 37. 4 I/O Fast Read using 4 Byte Address sequence (4READ4B)**




Note: 1. Configuration Dummy cycle numbers will be different depending on the bit6 & bit 7 (DC0 & DC1) setting in configuration register.
2. The MSB is on SIO3, which is different from 1 x I/O condition.

### 9-19. 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 38. SPI Mode**

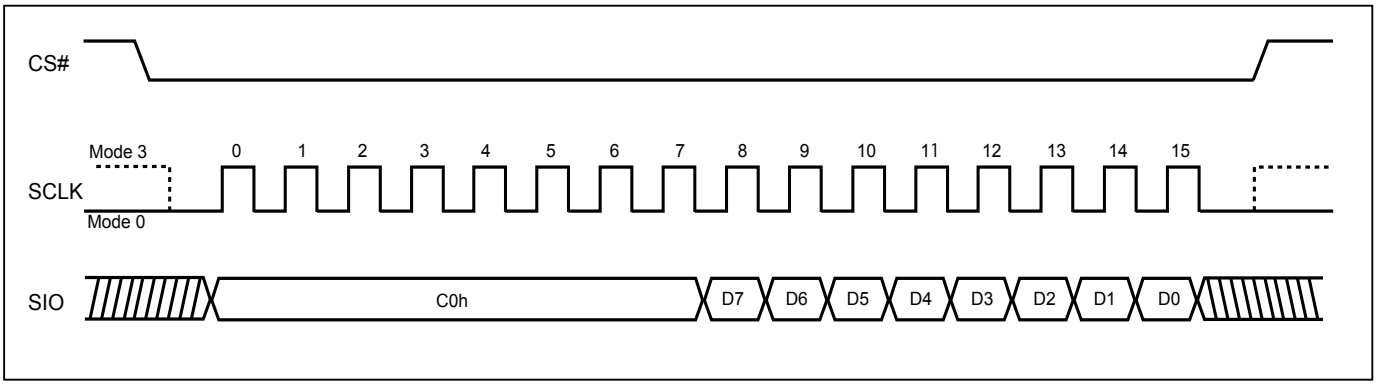
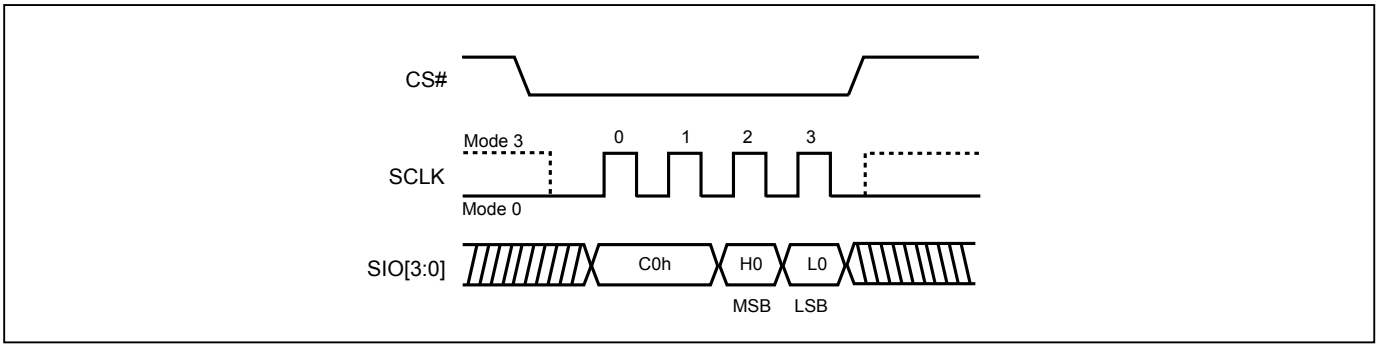



**Figure 39. QPI Mode**




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


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### 9-20. 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.

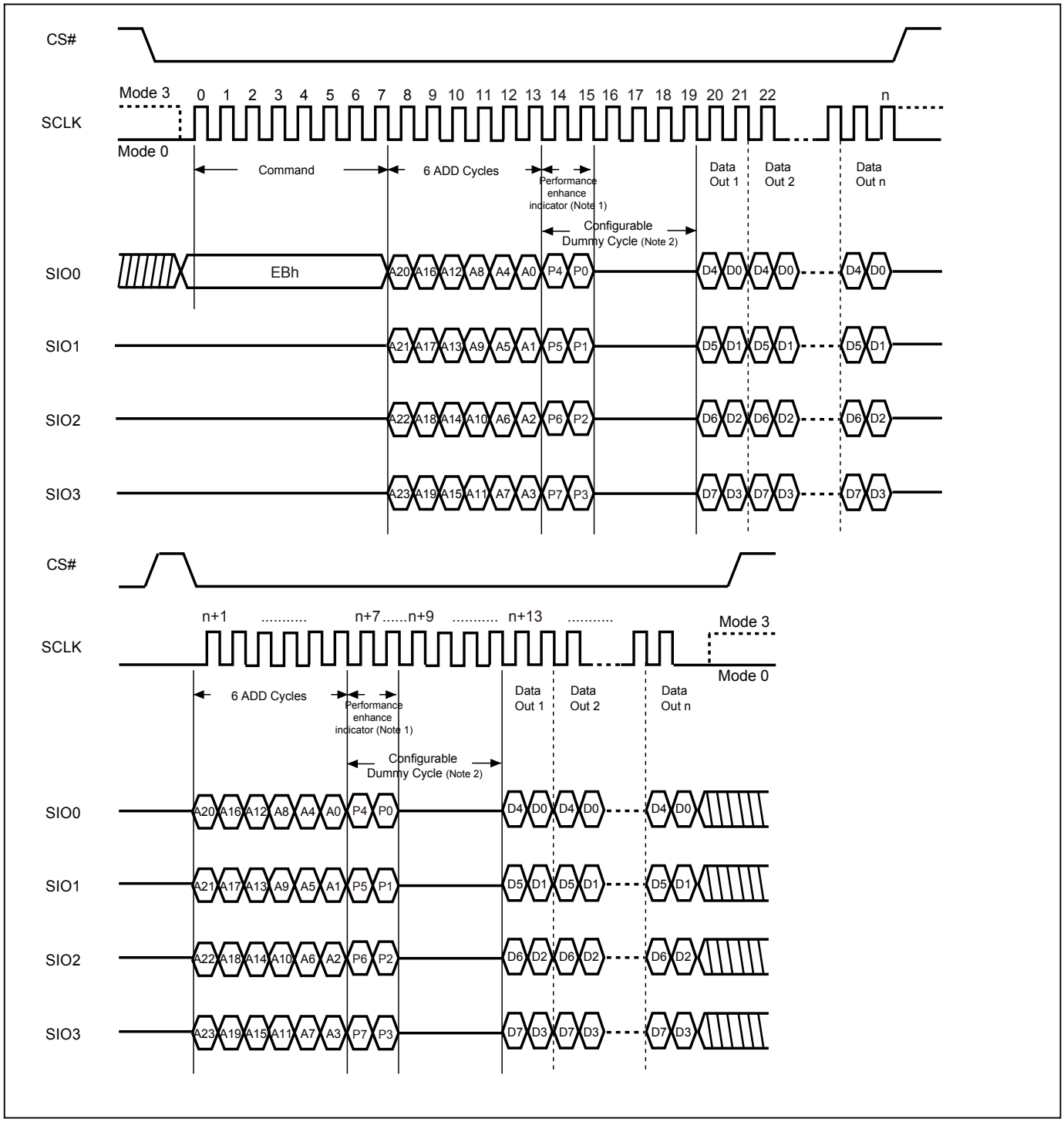
In QPI mode, “EBh” "ECh" and SPI “EBh” "ECh" commands support enhance mode. The performance enhance mode is not supported in dual I/O mode.

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.

Another sequence of issuing 4READ instruction especially useful in random access is : CS# goes low→sending 4 READ instruction→3-bytes or 4-bytes address interleave on SIO3, SIO2, SIO1 & SIO0 →performance enhance toggling bit P[7:0]→ 4 dummy cycles (Default) →data out still CS# goes high → CS# goes low (reduce 4 Read instruction) → 3-bytes or 4-bytes random access address.

**Figure 40. 4 x I/O Read enhance performance Mode Sequence (SPI Mode)**

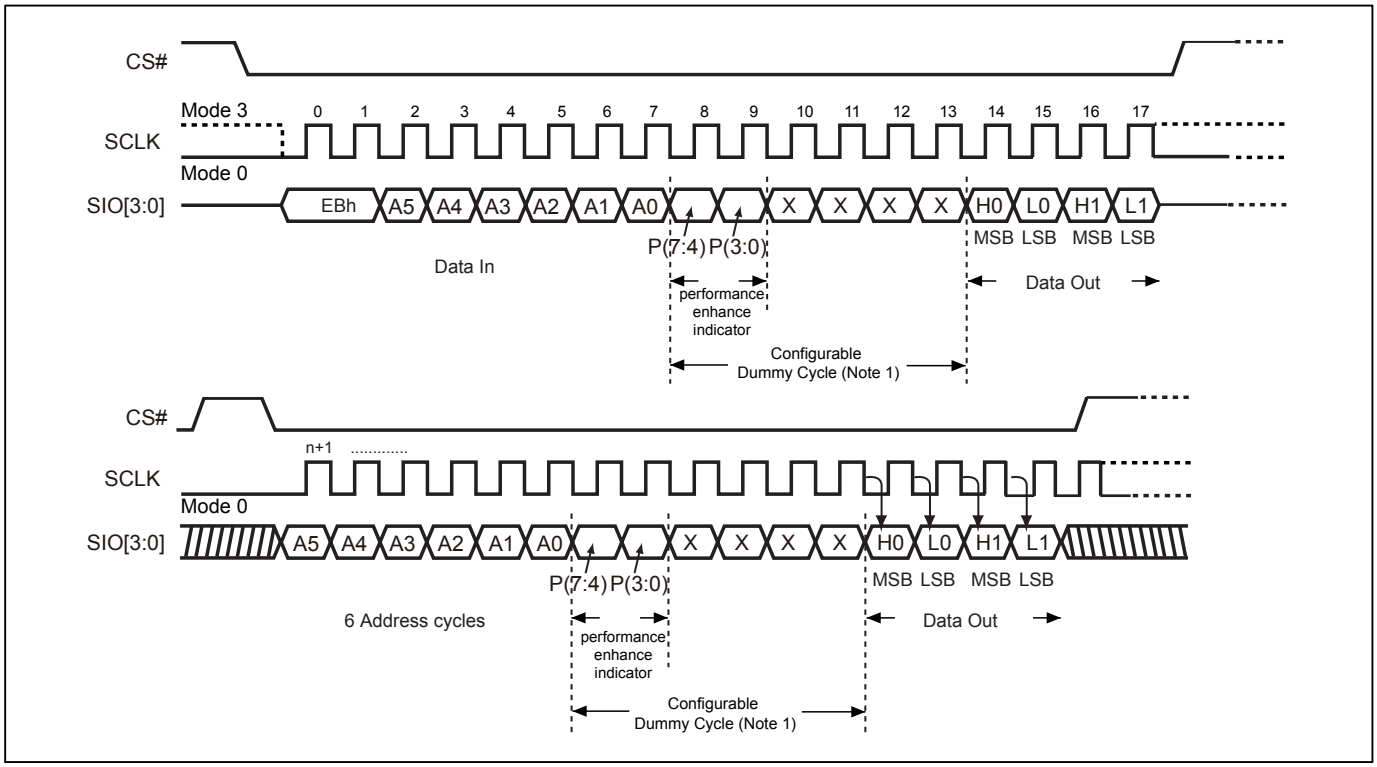



Notes:

1. If not using performance enhance recommend to keep 1 or 0 in performance enhance indicator.
2. Configuration Dummy cycle numbers will be different depending on the bit6 & bit 7 (DC0 & DC1) setting in configuration register.
3. The MSB is on SIO3, which is different from 1 x I/O condition.


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**Figure 41. 4 x I/O Read enhance performance 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. Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

### 9-21. Performance Enhance Mode Reset

To conduct the Performance Enhance Mode Reset operation in SPI mode, FFh data cycle(8 clocks in 3-byte address mode)/3FFh data cycle(10 clocks in 4-byte address mode), should be issued in 1I/O sequence. In QPI Mode, FFFFFFFFh data cycle(8 clocks in 3-byte address mode)/FFFFFFFFFFh data cycle (10 clocks in 4-byte address mode), 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.

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 42. Performance Enhance Mode Reset for Fast Read Quad I/O (SPI Mode)**

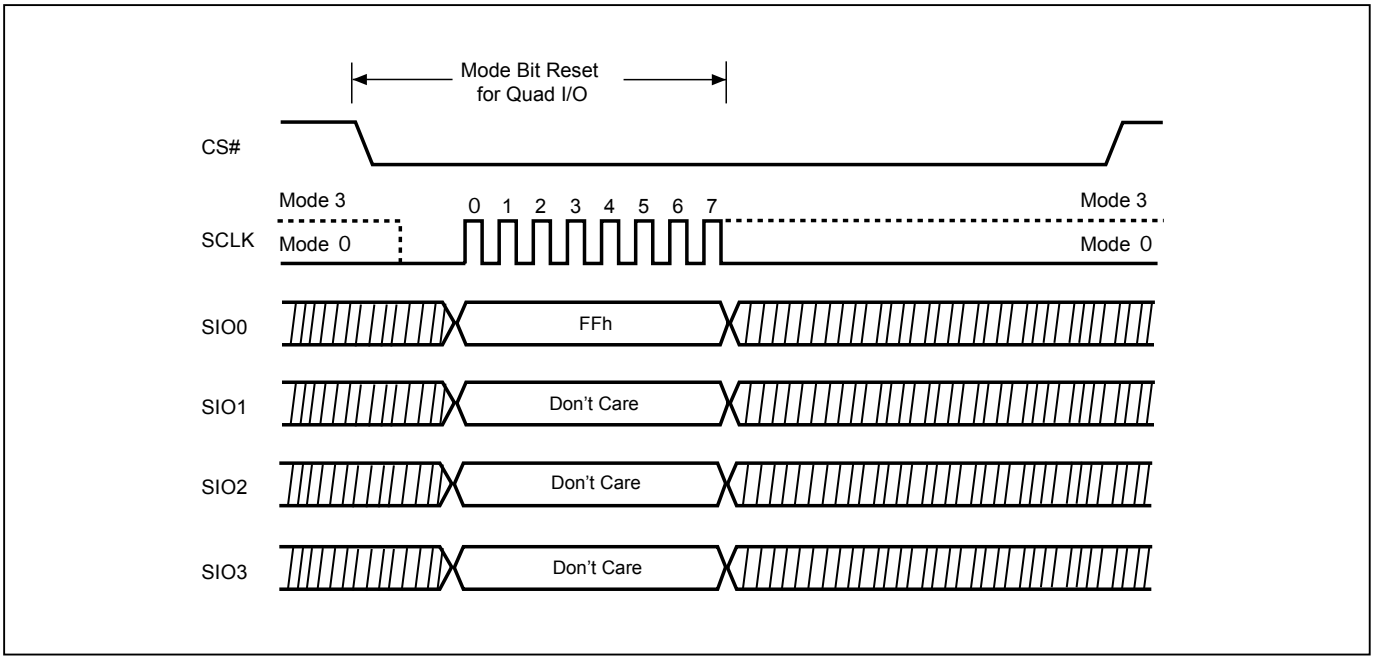



**Figure 43. Performance Enhance Mode Reset for Fast Read Quad I/O (QPI Mode)**

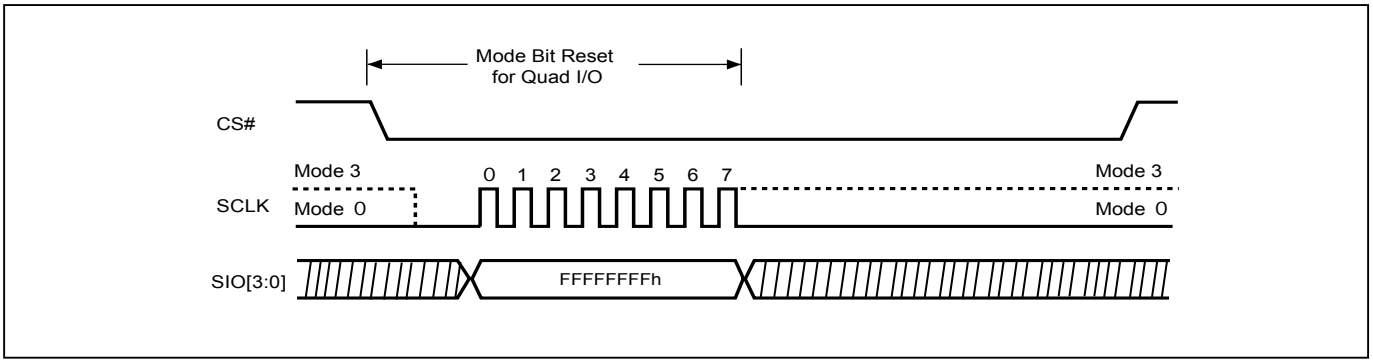


**Figure 44. Performance Enhance Mode Reset for Fast Read Quad I/O using 4Byte Address Sequence (SPI Mode)**

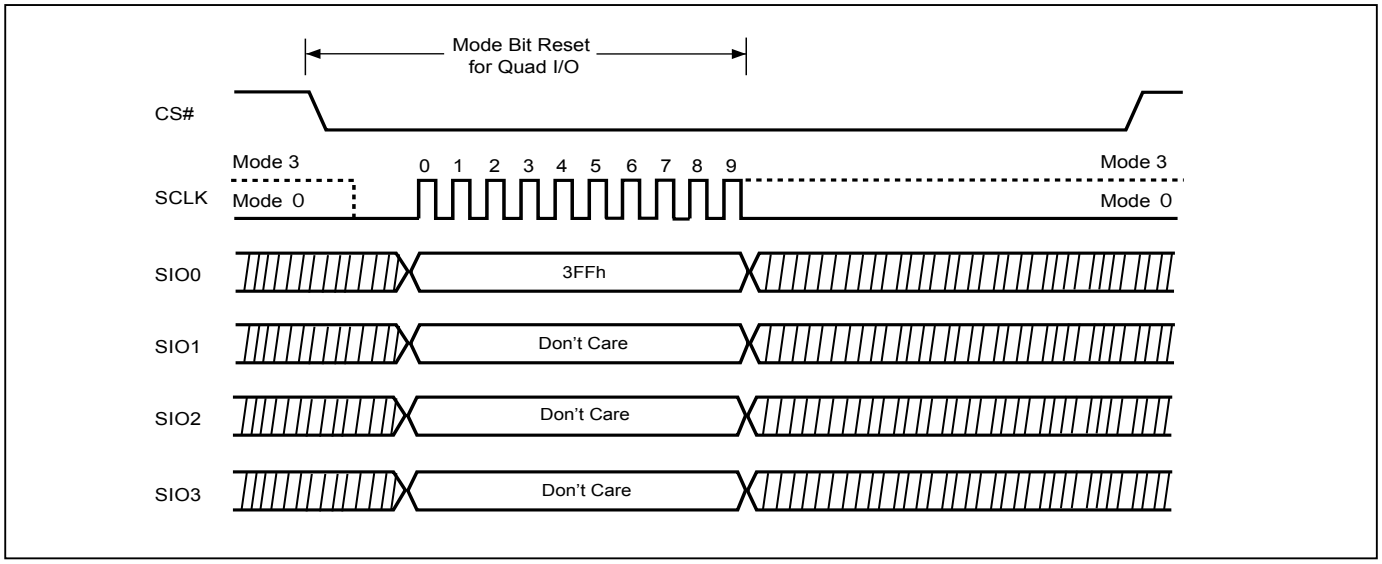
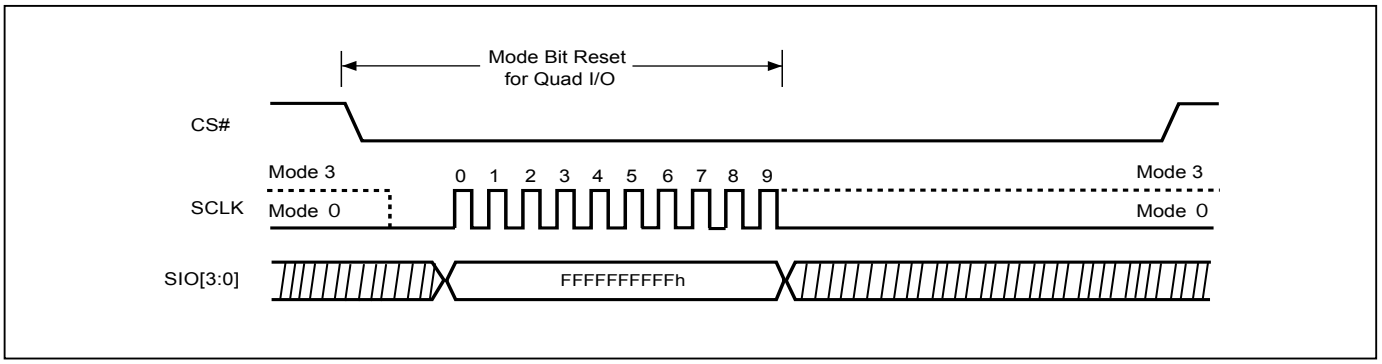



**Figure 45. Performance Enhance Mode Reset for Fast Read Quad I/O using 4Byte Address Sequence (QPI Mode)**





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### 9-22. 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 and user can start to input command. 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 can support Single I/O and Quad I/O interface. If the QE bit of Status Register is “0”, the data is output by Single I/O interface. If the QE bit of Status Register is set to “1”, the data is output by Quad I/O interface.

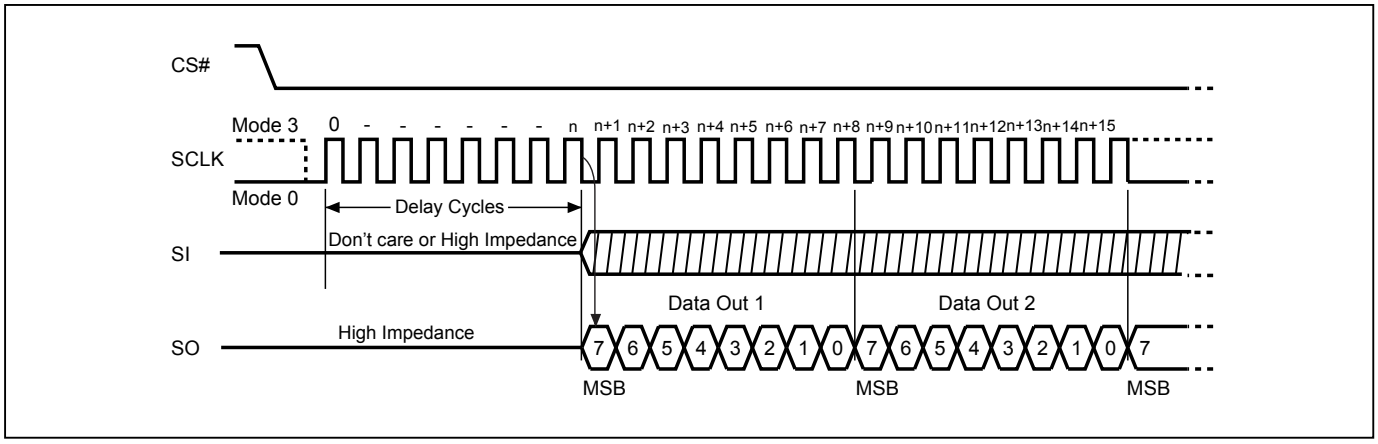
**Fast Boot Register (FBR)**

| 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 108 MHz
If FBSD = 10, the maximum clock frequency is 108 MHz
If FBSD = 01, the maximum clock frequency is 84 MHz
If FBSD = 00, the maximum clock frequency is 70 MHz

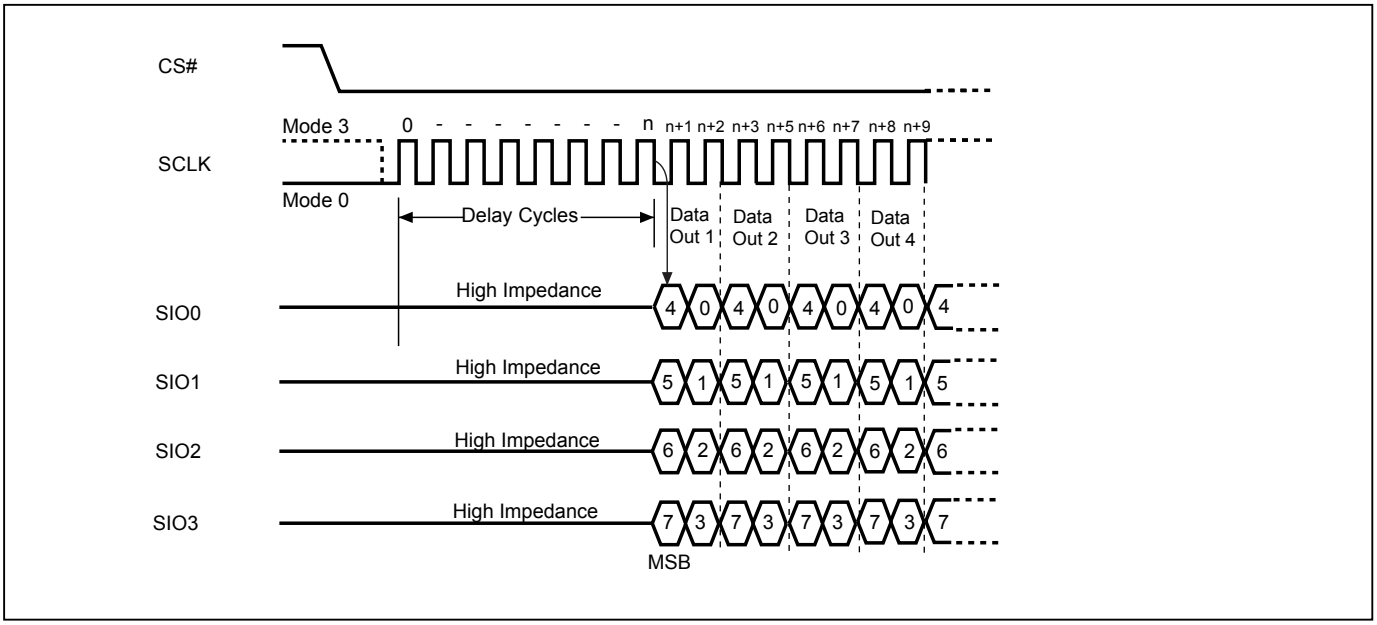

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**Figure 46. Fast Boot Sequence (QE=0)**




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 47. Fast Boot Sequence (QE=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 48. Read Fast Boot Register (RDFBR) Sequence**

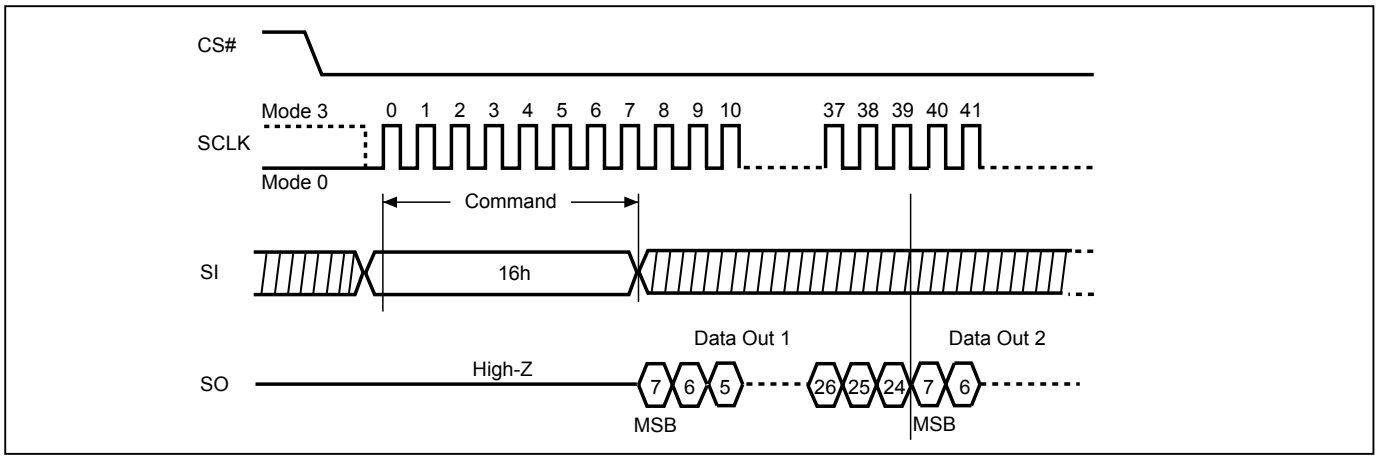



**Figure 49. Write Fast Boot Register (WRFBR) Sequence**

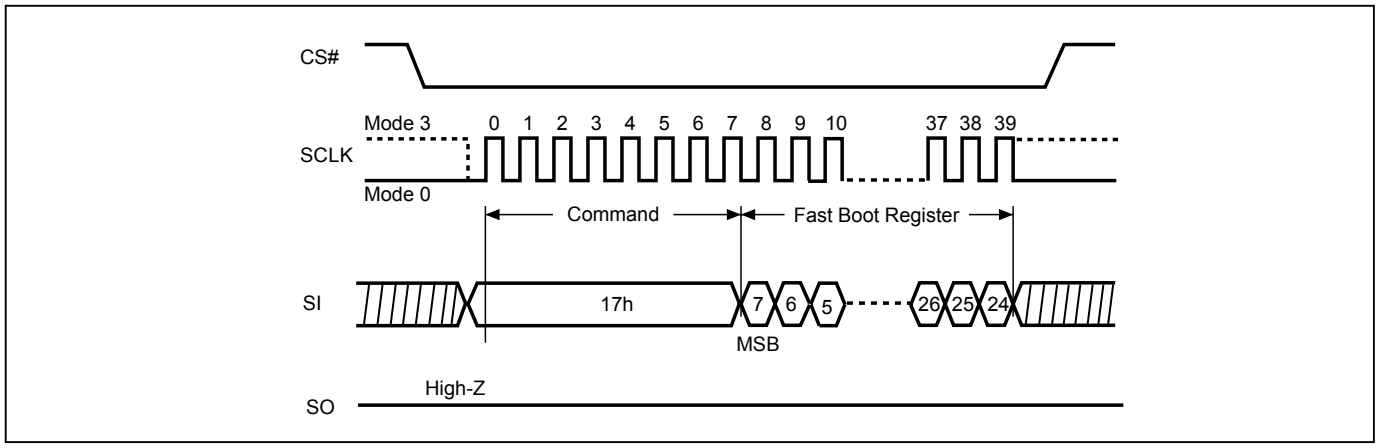
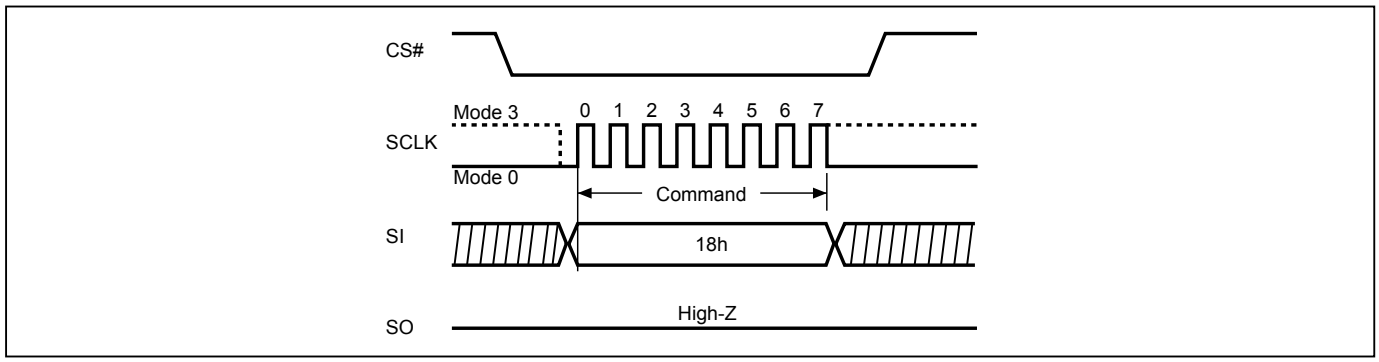



**Figure 50. Erase Fast Boot Register (ESFBR) Sequence**



### 9-23. 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.

The default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. Address bits [Am-A12] (Am is the most significant address) select the sector address.

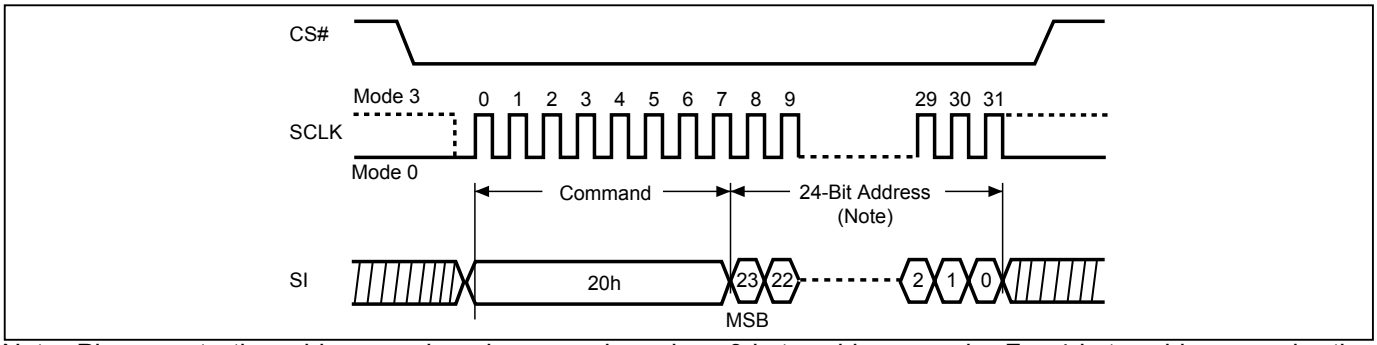
To enter the 4-byte address mode, please refer to the enter 4-byte mode (EN4B) Mode section.

The sequence of issuing SE instruction is: CS# goes low→ sending SE instruction code→ 3-byte or 4-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.

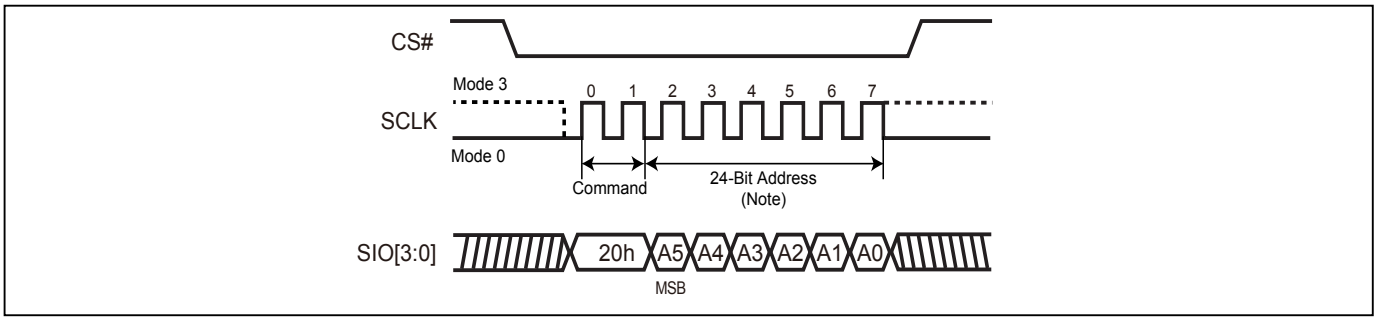
The self-timed Sector Erase Cycle time (tSE) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked while the Sector Erase cycle is in progress. The WIP sets 1 during the tSE timing, and clears when Sector Erase Cycle is completed, and the Write Enable Latch (WEL) bit is cleared. If the Block is protected by BP bits (Block Protect Mode), the Sector Erase (SE) instruction will not be executed on the block.

**Figure 51. Sector Erase (SE) Sequence (SPI Mode)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

**Figure 52. Sector Erase (SE) Sequence (QPI Mode)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

### 9-24. 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.

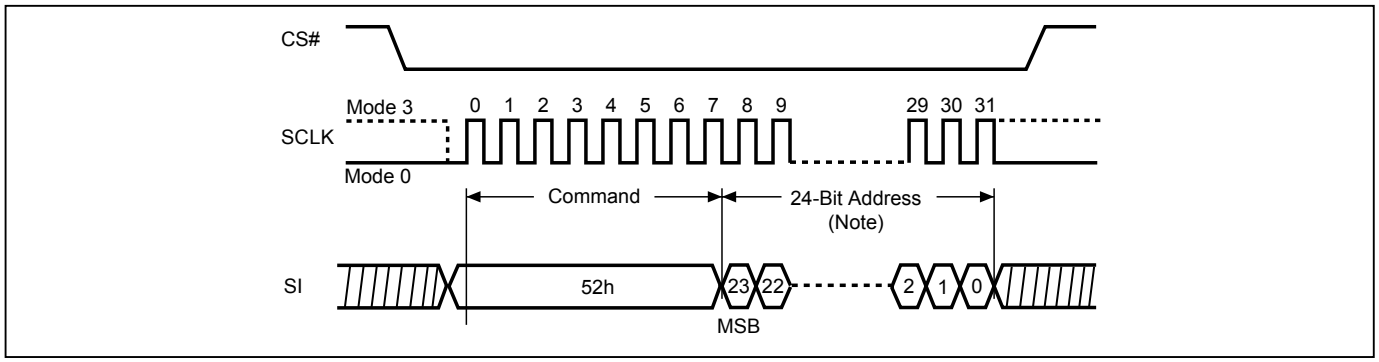
Address bits [Am-A15] (Am is the most significant address) select the 32KB block address. The default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte address mode, please refer to the enter 4-byte mode (EN4B) Mode section.

The sequence of issuing BE32K instruction is: CS# goes low→ sending BE32K instruction code→ 3-byte or 4-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.

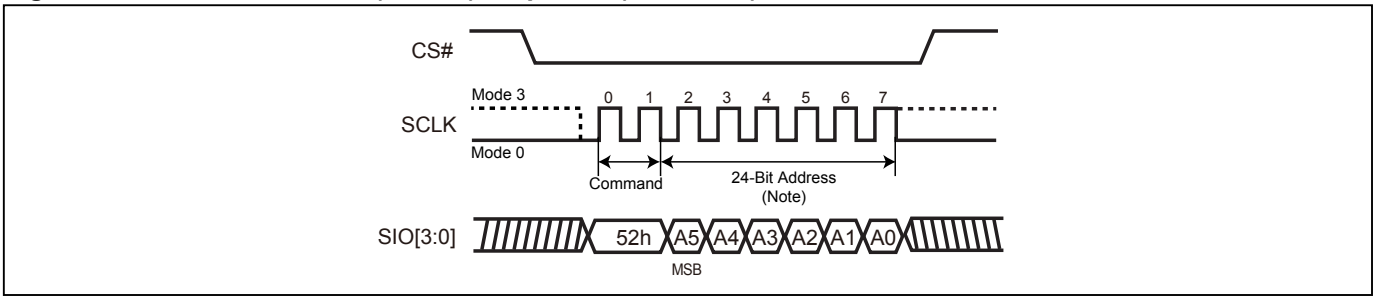
The self-timed Block Erase Cycle time (tBE32K) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked while during the Block Erase cycle is in progress. The WIP sets during the tBE32K timing, and clears when Block Erase Cycle is completed, and the Write Enable Latch (WEL) bit is cleared. If the Block is protected by BP bits (Block Protect Mode), the Block Erase (BE32K) instruction will not be executed on the block.

**Figure 53. Block Erase 32KB (BE32K) Sequence (SPI Mode)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

**Figure 54. Block Erase 32KB (BE32K) Sequence (QPI Mode)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

### 9-25. 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.

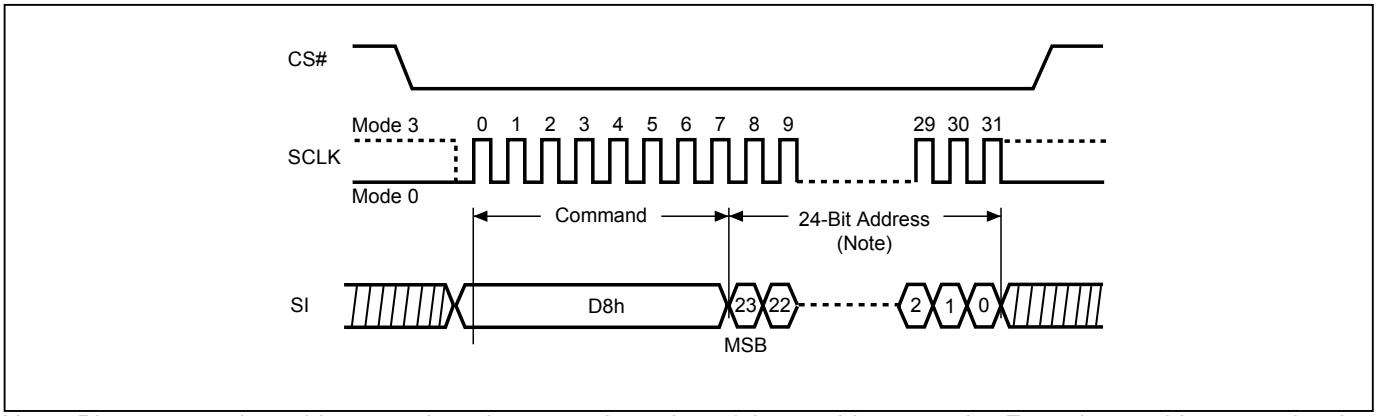
The default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte address mode, please refer to the enter 4-byte mode (EN4B) Mode section.

The sequence of issuing BE instruction is: CS# goes low→ sending BE instruction code→ 3-byte or 4-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.

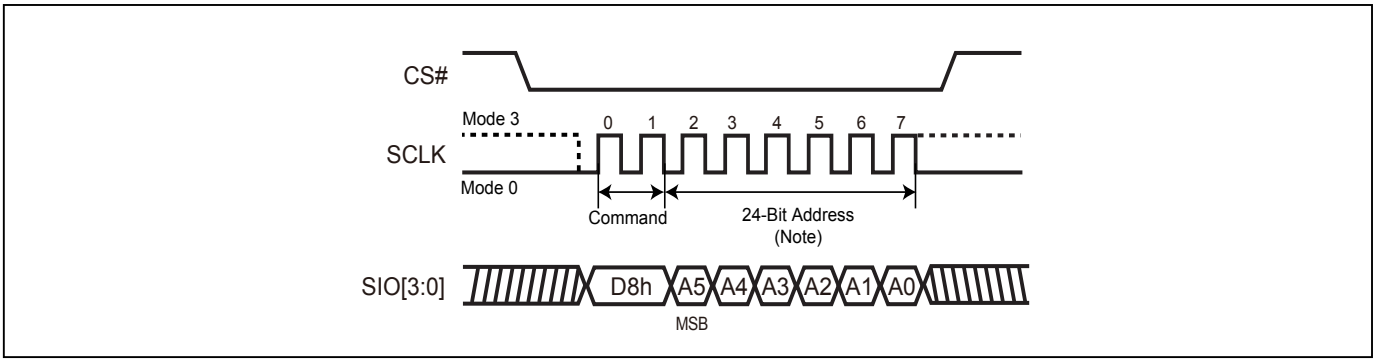
The self-timed Block Erase Cycle time (tBE) is initiated as soon as Chip Select (CS#) goes high. The Write in Progress (WIP) bit still can be checked while the Block Erase cycle is in progress. The WIP sets during the tBE timing, and clears when Block Erase Cycle is completed, and the Write Enable Latch (WEL) bit is reset. If the Block is protected by BP bits (Block Protect Mode), the Block Erase (BE) instruction will not be executed on the block.

**Figure 55. Block Erase (BE) Sequence (SPI Mode)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

**Figure 56. Block Erase (BE) Sequence (QPI Mode)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

### 9-26. 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". 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".

**Figure 57. Chip Erase (CE) Sequence (SPI Mode)**

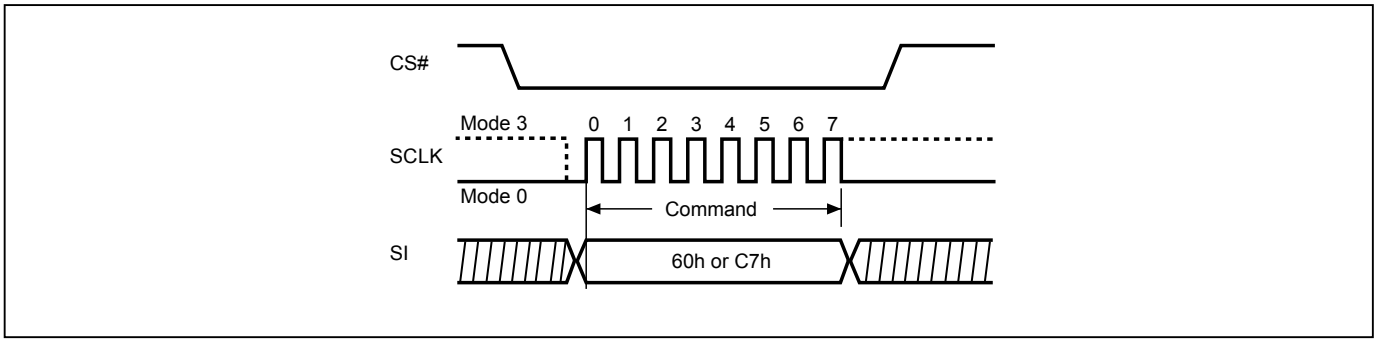
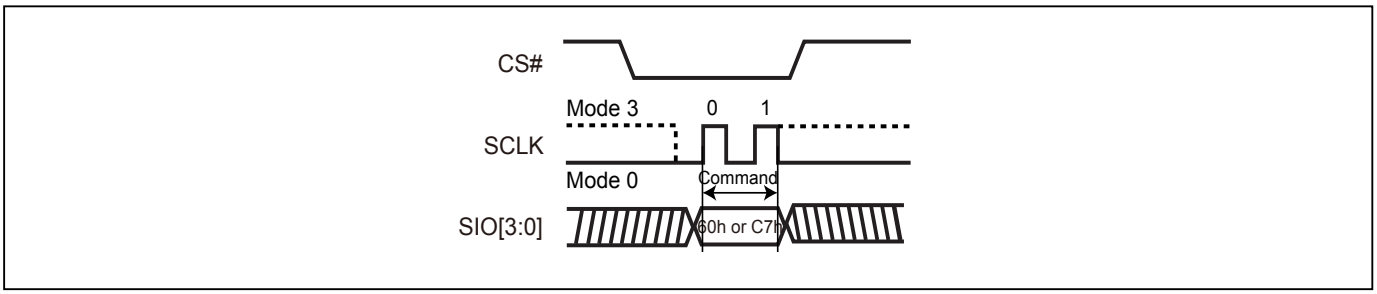



**Figure 58. Chip Erase (CE) Sequence (QPI Mode)**



### 9-27. Page Program (PP)

The Page Program (PP) 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 before sending the Page Program (PP). The device programs only the last 256 data bytes sent to the device. The last address byte (the 8 least significant address bits, A7-A0) should be set to 0 for 256 bytes page program. If A7-A0 are not all zero, transmitted data that exceed page length are programmed from the starting address (24-bit address that last 8 bit are all 0) of currently selected page. If the data bytes sent to the device exceeds 256, the last 256 data byte is programmed at the request page and previous data will be disregarded. If the data bytes sent to the device has not exceeded 256, the data will be programmed at the request address of the page. There will be no effort on the other data bytes of the same page.

The default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte address mode, please refer to the enter 4-byte mode (EN4B) Mode section.

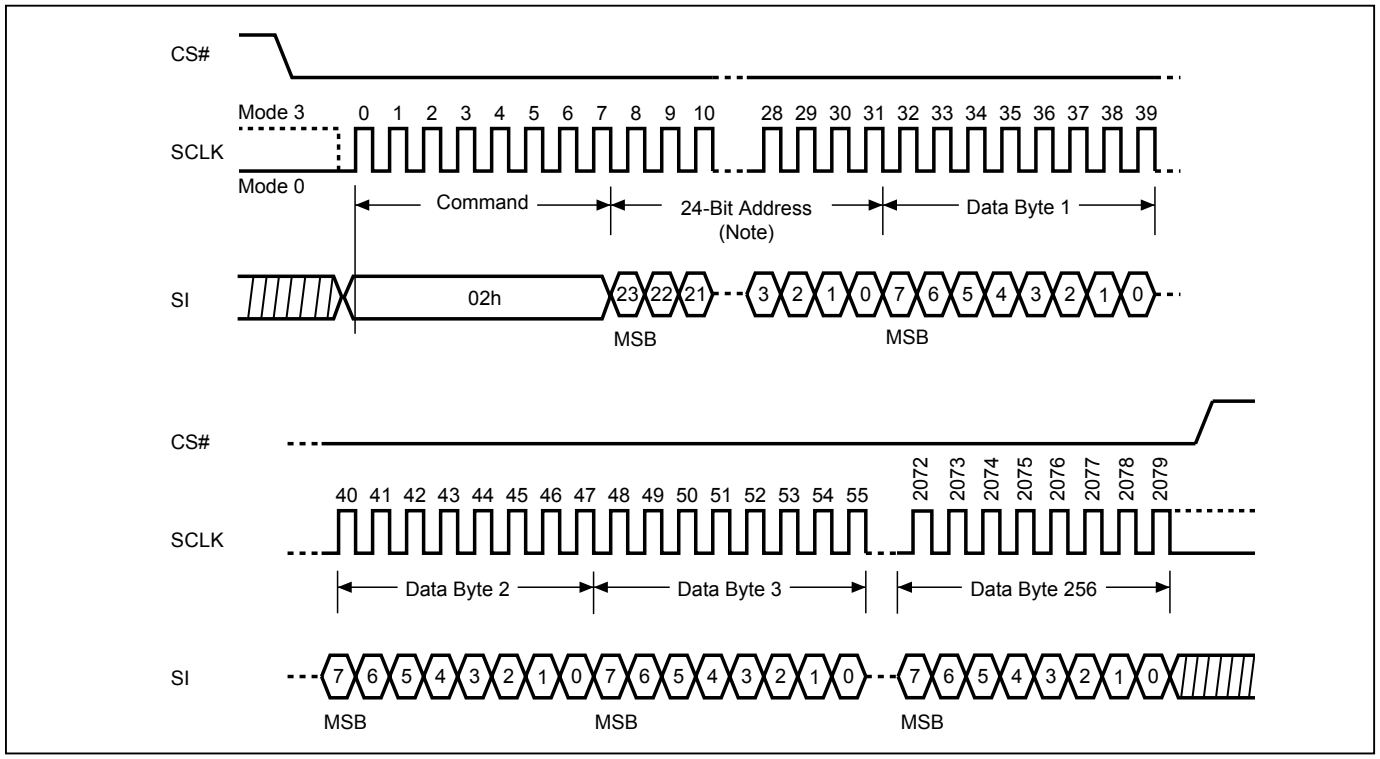
The sequence of issuing PP instruction is: CS# goes low→ sending PP instruction code→ 3-byte or 4-byte address on SI→ at least 1-byte on data on SI→ CS# goes high.

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 page is protected by BP bits (Block Protect Mode), the Page Program (PP) instruction will not be executed.

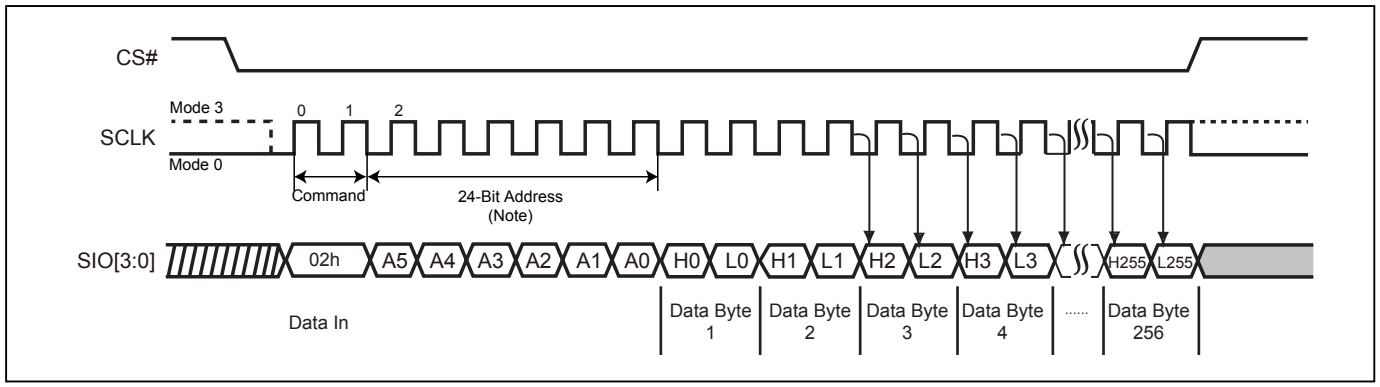
Both SPI (8 clocks) and QPI (2 clocks) command cycle can accept by this instruction. The SIO[3:1] are don't care when during SPI mode.

**Figure 59. Page Program (PP) Sequence (SPI Mode)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

**Figure 60. Page Program (PP) Sequence (QPI Mode)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

### 9-28. 4 x I/O Page Program (4PP)

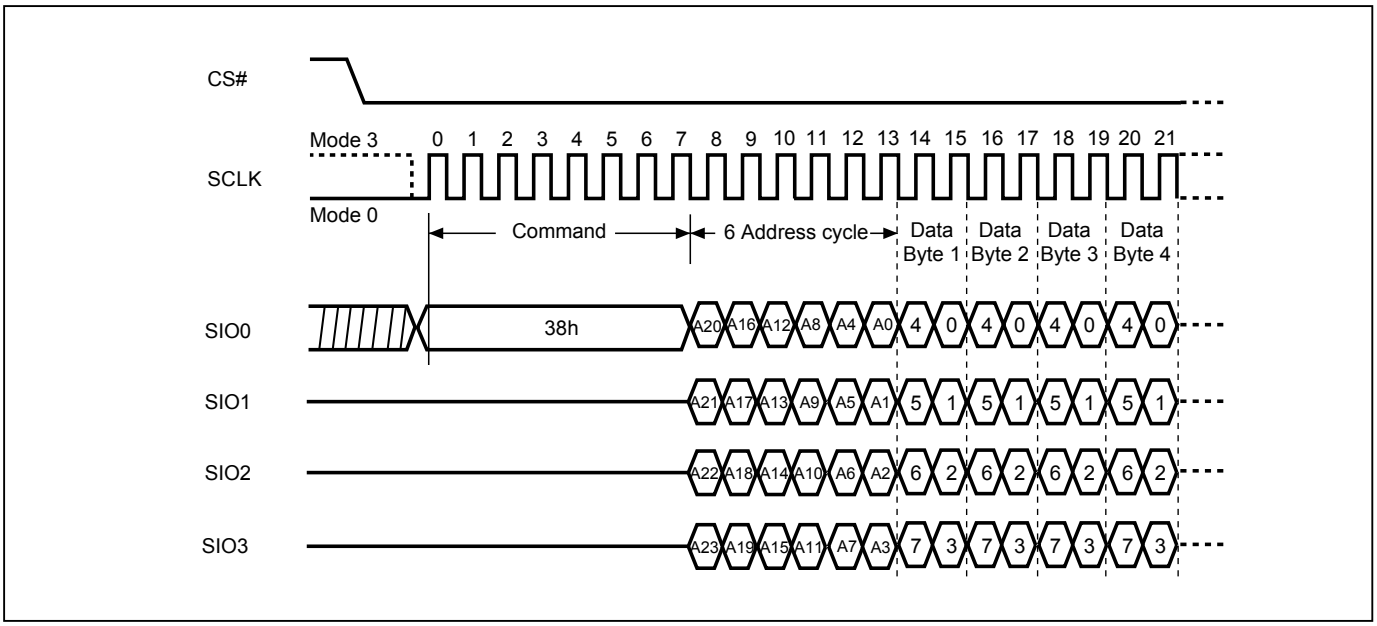
The Quad Page Program (4PP) instruction is for programming the memory to be "0". A Write Enable (WREN) instruction must be executed to set the Write Enable Latch (WEL) bit and Quad Enable (QE) bit must be set to "1" before sending the Quad Page Program (4PP). The Quad Page Programming takes four pins: 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 default read mode is 3-byte address, to access higher address (4-byte address) which requires to enter the 4-byte address read mode or to define EAR bit. To enter the 4-byte address mode, please refer to the enter 4-byte mode (EN4B) Mode section.

The sequence of issuing 4PP instruction is: CS# goes low→ sending 4PP instruction code→ 3-byte or 4-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 (Block Protect Mode), the Quad Page Program (4PP) instruction will not be executed.

**Figure 61. 4 x I/O Page Program (4PP) Sequence (SPI Mode only)**




Note: Please note the address cycles above are based on 3-byte address mode. For 4-byte address mode, the address cycles will be increased.

### 9-29. 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 62. Deep Power-down (DP) Sequence (SPI Mode)**

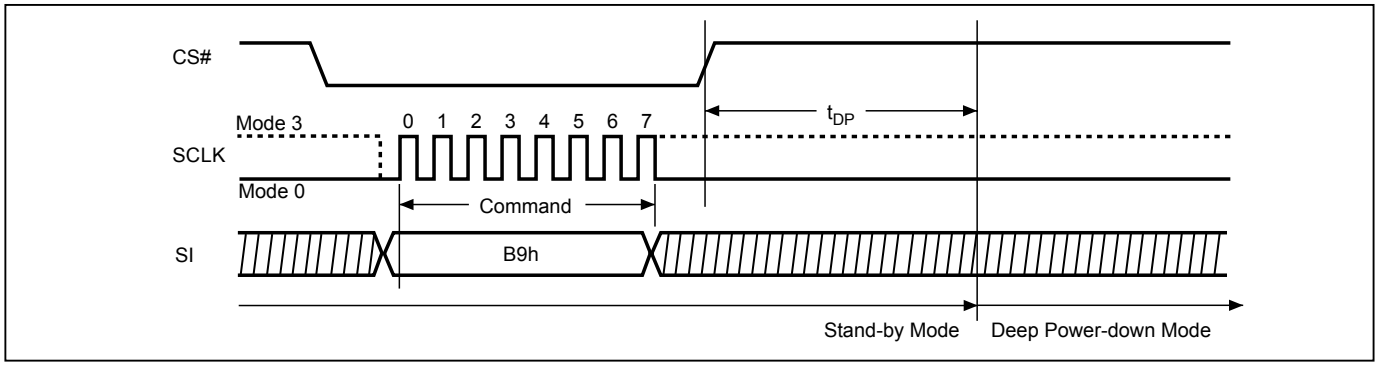
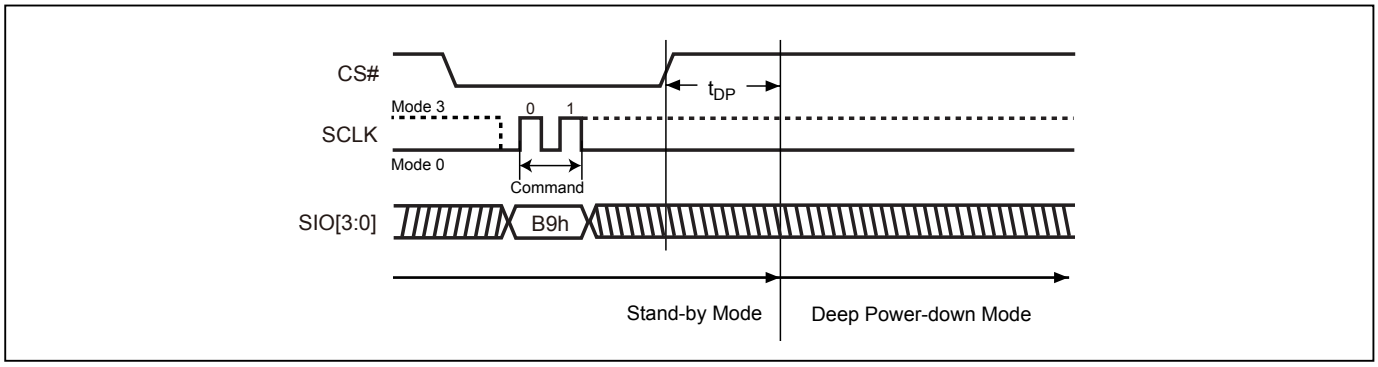



**Figure 63. Deep Power-down (DP) Sequence (QPI Mode)**



### 9-30. 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.

### 9-31. 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.

### 9-32. 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.

### 9-33. Write Security Register (WRSCUR)

The WRSCUR instruction sets the LDSO bit of the Security Register. 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:

**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 or the erase region is protected. It will be set to "0", if the last operation is successful. 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 successful. 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 8. Security Register Definition**

| bit7 | bit6 | bit5 | bit4 | bit3 | bit2 | bit1 | bit0 |
|---|---|---|---|---|---|---|---|
| Reserved | E_FAIL | P_FAIL | Reserved | ESB (Erase Suspend bit) | PSB (Program Suspend bit) | LDSO (indicate if lock-down) | Secured OTP indicator bit |
| - | 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 |
| - | Volatile bit | Volatile bit | - | Volatile bit | Volatile bit | Non-volatile bit (OTP) | Non-volatile bit (OTP) |

**9-34. Block Lock (BP) Protection**

In Block Lock (BP) protection mode,
Array is protected by BP3~BP0 and BP bits are protected by “SRWD=1 and WP#=0”, where SRWD is bit 7 of status register that can be set by WRSR command. 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.

### 9-35. 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 8. Security Register Definition"*)

| | MX66U51235F |
|---|---|
| Suspend to suspend ready timing | 20us |
| The minimum timing of Suspend Resume to another suspend | 0.85us *(Note 1)* |
| The typical timing of Program Suspend Resume to another suspend | 100us |
| The typical timing of Erase Suspend Resume to another suspend | 200us |

***Note 1:*** the flash memory can accept another suspend command just after 0.85us from suspend resume. However, if the timing is less than 100us from Program Suspend Resume or 200us from Erase Suspend Resume, the content of flash memory might not be changed before the suspend command has been issued.

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.

### 9-36. 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, following commands can be accepted. (including: 03h, 0Bh, 3Bh, 6Bh, BBh, EBh, 5Ah, C0h, 06h, 04h, 2Bh, 9Fh, AFh, 05h, ABh, 90h, 02h, 38h, B1h, C1h, B0h, 30h, 66h, 99h, 00h, 35h, F5h, 15h, 16h, 13h, 0Ch, BCh, 3Ch, ECh, 6Ch, 12h, 3Eh)

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.

### 9-37. 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, 16h, 13h, 0Ch, BCh, 3Ch, ECh, 6Ch)

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.


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**Figure 64. Suspend to Read/Program Latency**

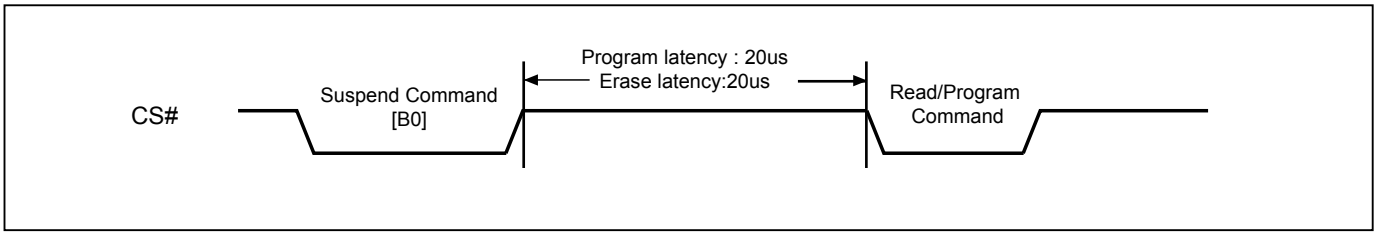



**Figure 65. Resume to Read Latency**

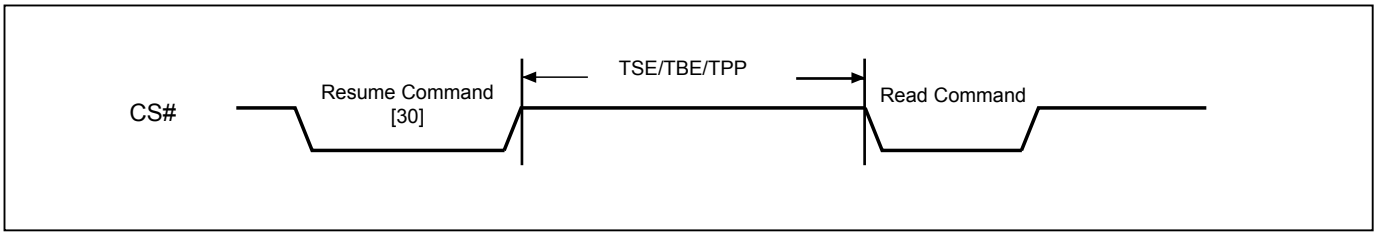
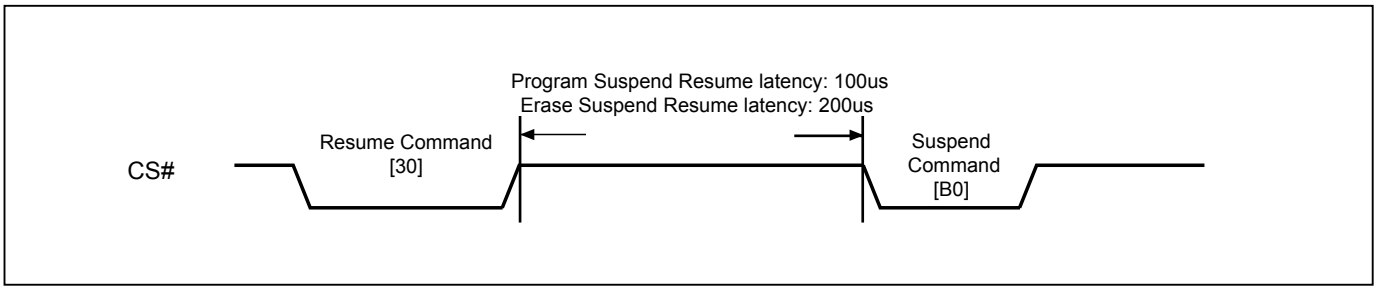



**Figure 66. Resume to Suspend Latency**



### 9-38. 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 100us (from Program Suspend Resume)/200us (from Erase Suspend Resume).

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

### 9-39. 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 when during SPI mode.

### 9-40. 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.

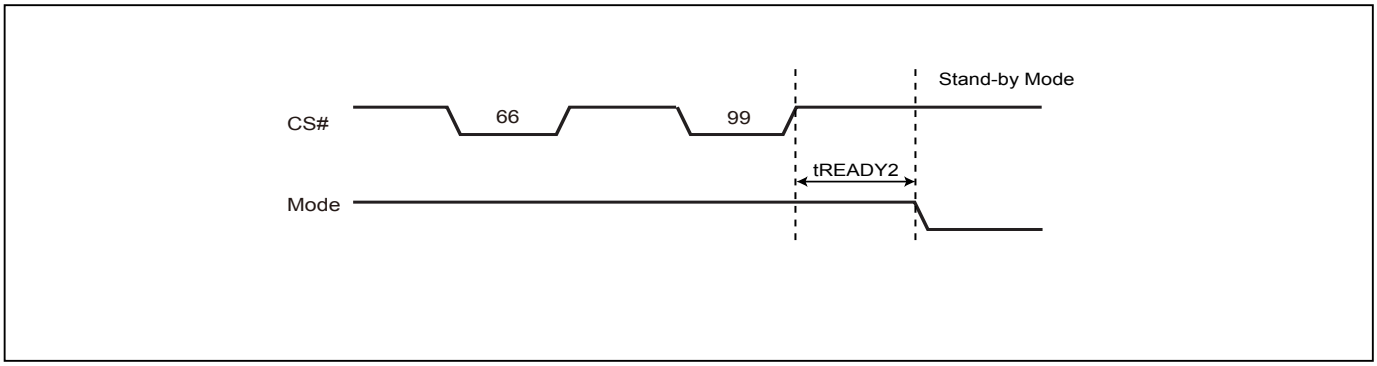
To execute Reset command (RST), the Reset-Enable (RSTEN) command must be executed first to perform the Reset operation. If there is any other command to interrupt after the Reset-Enable command, the Reset-Enable will be invalid.

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 13. Reset Timing-(Other Operation)"* for tREADY2.

**Figure 67. Software Reset Recovery**




Note: Refer to *"Table 13. Reset Timing-(Other Operation)"* for tREADY2.

**Figure 68. Reset Sequence (SPI mode)**

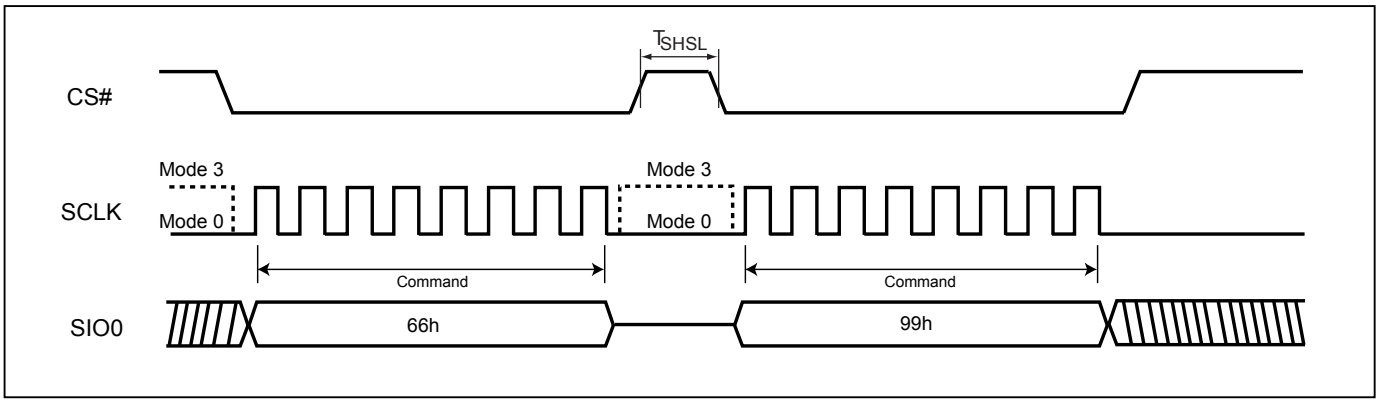
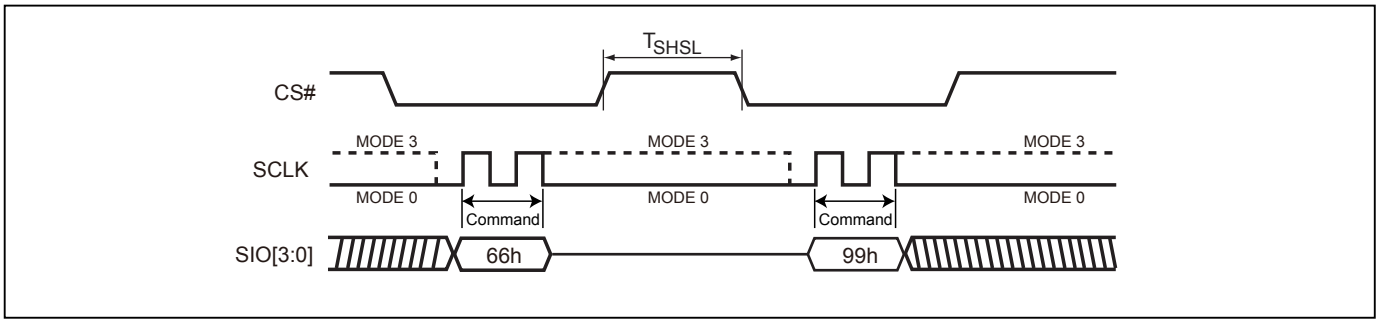



**Figure 69. Reset Sequence (QPI mode)**



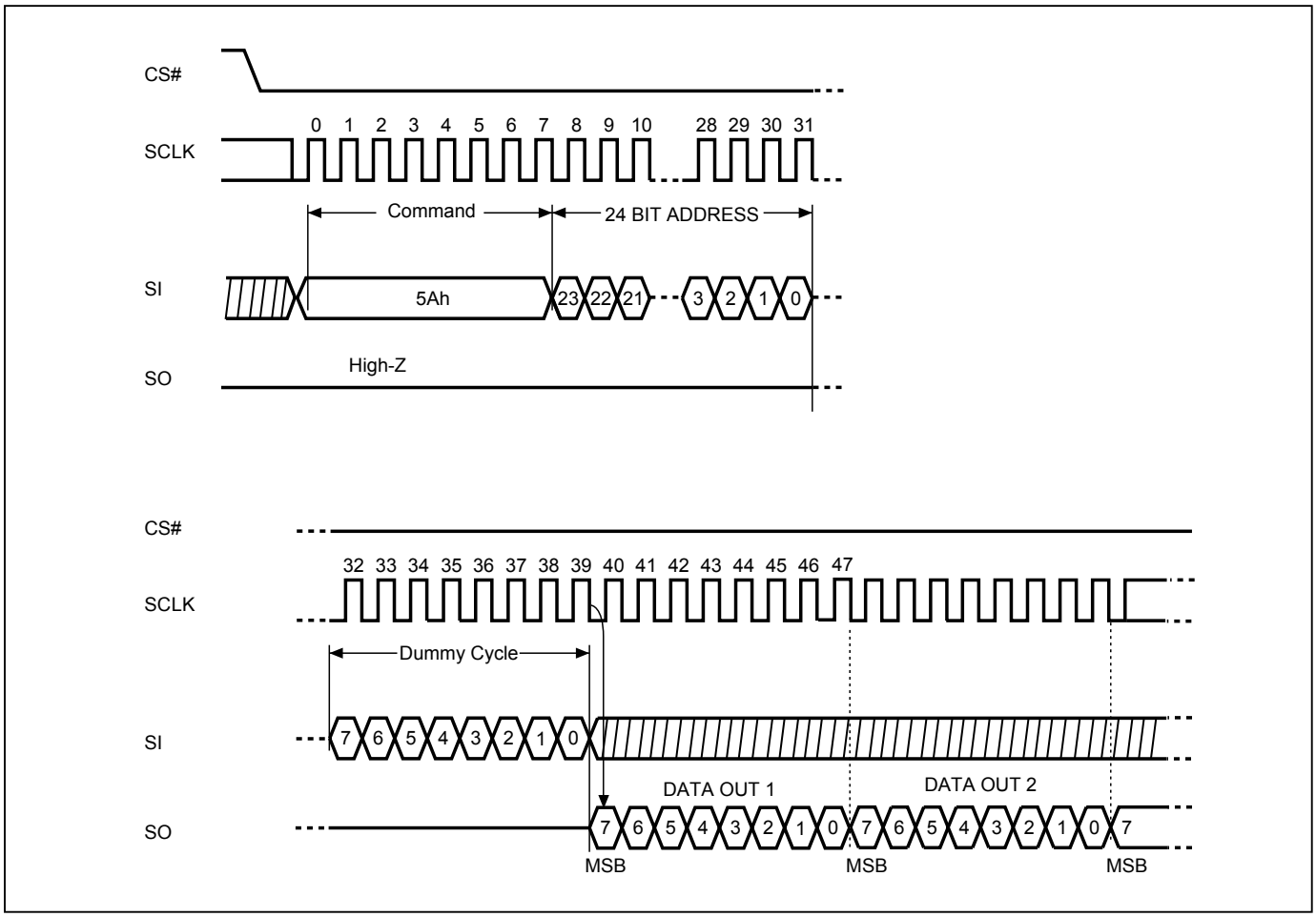
### 9-41. Read SFDP Mode (RDSFDP)

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 70. Read Serial Flash Discoverable Parameter (RDSFDP) Sequence**





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**Table 9. Signature and Parameter Identification Data Values**

SFDP Table below is for MX66U51235FMI-10G, MX66U51235FXDI-10G and MX66U51235FZ4I-10G

| 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 10. Parameter Table (0): JEDEC Flash Parameter Tables**

SFDP Table below is for MX66U51235FMI-10G, MX66U51235FXDI-10G and MX66U51235FZ4I-10G

| 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 | F3h |
| Address Bytes Number used in addressing flash array | 00: 3Byte only, 01: 3 or 4Byte,<br>10: 4Byte only, 11: Reserved | | 18:17 | 01b | |
| 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 | 1FFF 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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SFDP Table below is for MX66U51235FMI-10G, MX66U51235FXDI-10G and MX66U51235FZ4I-10G

| 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 support | 3Ch | 04:00 | 0 1000b | 08h |
| (1-1-2) Fast Read Number of Mode Bits | 000b: Mode Bits not support | | 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 support | 3Eh | 20:16 | 0 0100b | 04h |
| (1-2-2) Fast Read Number of Mode Bits | 000b: Mode Bits not support | | 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 support | 46h | 20:16 | 0 0000b | 00h |
| (2-2-2) Fast Read Number of Mode Bits | 000b: Mode Bits not support | | 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 support | 4Ah | 20:16 | 0 0100b | 44h |
| (4-4-4) Fast Read Number of Mode Bits | 000b: Mode Bits not support | | 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 |


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**Table 11. Parameter Table (1): Macronix Flash Parameter Tables**

SFDP Table below is for MX66U51235FMI-10G, MX66U51235FXDI-10G and MX66U51235FZ4I-10G

| 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>20h | 00h<br>20h |
| 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 | 50h<br>16h | 50h<br>16h |
| H/W Reset# pin | 0=not support 1=support | 65h:64h | 00 | 1b | F99Dh |
| 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 | 0b | CFFEh |
| Individual block lock bit (Volatile/Nonvolatile) | 0=Volatile 1=Nonvolatile | | 01 | 1b | |
| Individual block lock Opcode | | | 09:02 | 1111 1111b (FFh) | |
| Individual block lock Volatile protect bit default protect status | 0=protect 1=unprotect | | 10 | 1b | |
| 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 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 71. RESET Timing**

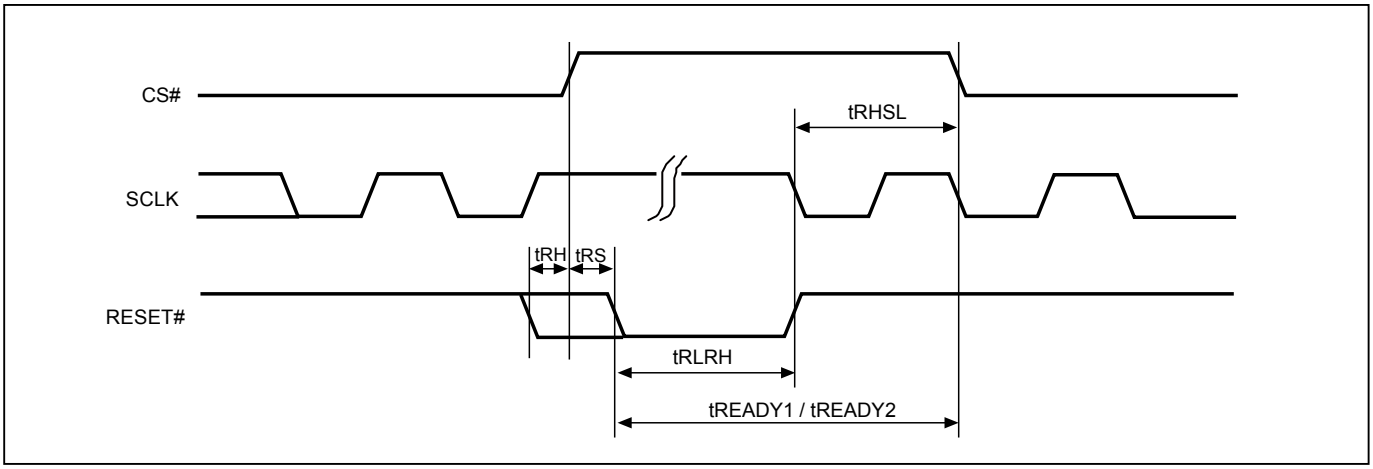



**Table 12. Reset Timing-(Power On)**

| 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 13. 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) | 40 | | | 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 write, erase, and program command should be sent after the below time delay:
- tVSL after VCC reached VCC minimum level

The device can accept read command after VCC reached VCC minimum and a time delay of tVSL.
Please refer to the "*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 14. 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 2.5V |

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 to VCC+1.0V or -1.0V for period up to 20ns.

**Figure 72. Maximum Negative Overshoot Waveform**

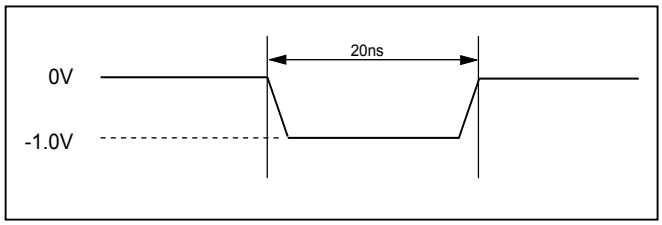
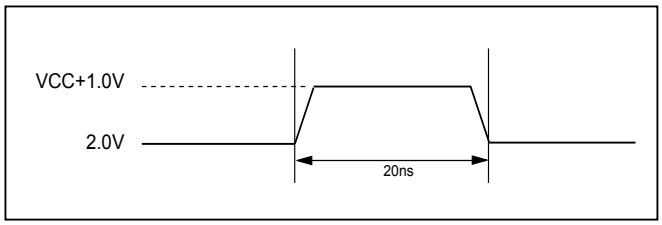



**Figure 73. Maximum Positive Overshoot Waveform**

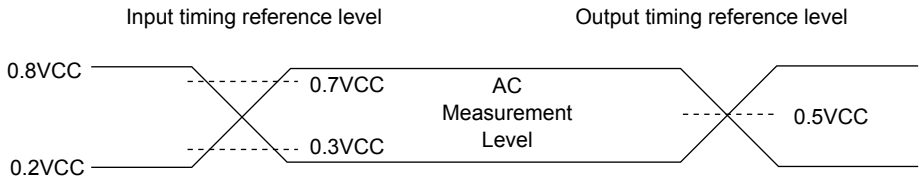



### Table 15. CAPACITANCE TA = 25°C, f = 1.0 MHz

| Symbol | Parameter | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| CIN | Input Capacitance | | | 16 | pF | VIN = 0V |
| COUT | Output Capacitance | | | 16 | pF | VOUT = 0V |

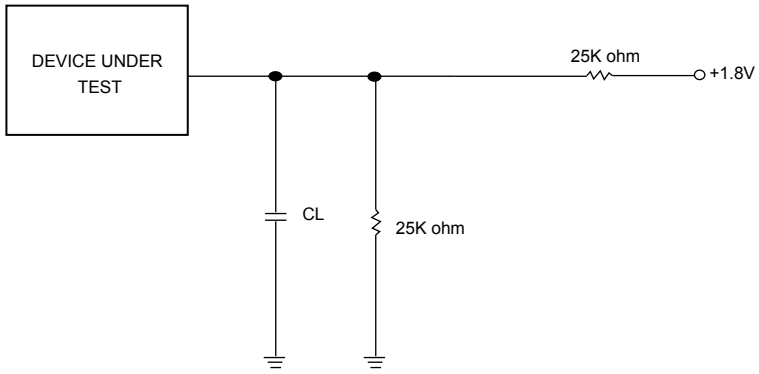

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**Figure 74. INPUT TEST WAVEFORMS AND MEASUREMENT LEVEL**




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

**Figure 75. OUTPUT LOADING**




CL=30pF Including jig capacitance


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**Table 16. DC CHARACTERISTICS**

Temperature = -40°C to 85°C, VCC = 1.65V ~ 2.0V

| Symbol | Parameter | Notes | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|---|
| ILI | Input Load Current | 1 | | | ±4 | uA | VCC = VCC Max, VIN = VCC or GND |
| ILO | Output Leakage Current | 1 | | | ±4 | uA | VCC = VCC Max, VOUT = VCC or GND |
| ISB1 | VCC Standby Current | 1 | | 40 | 200 | uA | VIN = VCC or GND, CS# = VCC |
| ISB2 | Deep Power-down Current | | | 3 | 40 | uA | VIN = VCC or GND, CS# = VCC |
| ICC1 | VCC Read | 1 | | | 40 | mA | f=108MHz, (4 x I/O read) SCLK=0.1VCC/0.9VCC, SO=Open |
| | | | | | 30 | mA | f=84MHz, SCLK=0.1VCC/0.9VCC, SO=Open |
| ICC2 | VCC Program Current (PP) | 1 | | 20 | 25 | mA | Program in Progress, CS# = VCC |
| ICC3 | VCC Write Status Register (WRSR) Current | | | 20 | 40 | mA | Program status register in progress, CS#=VCC |
| ICC4 | VCC Sector/Block (32K, 64K) Erase Current (SE/BE/BE32K) | 1 | | 20 | 25 | mA | Erase in Progress, CS#=VCC |
| ICC5 | VCC Chip Erase Current (CE) | 1 | | 40 | 50 | mA | Erase in Progress, CS#=VCC |
| VIL | Input Low Voltage | | -0.5 | | 0.3VCC | 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 = 1.8V, T = 25°C. These currents are valid for all product versions (package and speeds).
2. Typical value is calculated by simulation.

**Table 17. AC CHARACTERISTICS**

Temperature = -40°C to 85°C, VCC = 1.65V ~ 2.0V

| Symbol | Alt. | Parameter | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| fSCLK | fC | Clock Frequency for all commands (except Read) | | D.C. | | 108 | MHz |
| fRSCLK | fR | Clock Frequency for READ instructions | | | | 55 | MHz |
| fTSCLK | fT | Clock Frequency for 2READ instructions | | | | 84(6) | MHz |
| | fQ | Clock Frequency for 4READ instructions | | | | 84(6) | MHz |
| tCH(1) | tCLH | Clock High Time | Others (fSCLK) | 4.5 | | | ns |
| | | | Normal Read (fRSCLK) | 7 | | | ns |
| tCL(1) | tCL | Clock Low Time | Others (fSCLK) | 4.5 | | | 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) | | 5 | | | ns |
| tCHSL | | CS# Not Active Hold Time (relative to SCLK) | | 7 | | | ns |
| tDVCH | tDSU | Data In Setup Time | | 2.5 | | | ns |
| tCHDX | tDH | Data In Hold Time | | 3.5 | | | ns |
| tCHSH | | CS# Active Hold Time (relative to SCLK) | | 5 | | | ns |
| tSHCH | | CS# Not Active Setup Time (relative to SCLK) | | 5 | | | 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 | | | 12 | ns |
| | | | Loading: 15pF | | | 9 | 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 |
| tWREAR | | Write Extended Address Register | | | 40 | | ns |
| tBP | | Byte-Program | | | 12 | 30 | us |
| tPP(5) | | Page Program Cycle Time | | | 1 | 3 | ms |
| tSE | | Sector Erase Cycle Time | | | 45 | 200 | ms |
| tBE32 | | Block Erase (32KB) Cycle Time | | | 200 | 1000 | ms |
| tBE | | Block Erase (64KB) Cycle Time | | | 400 | 2000 | ms |
| tCE | | Chip Erase Cycle Time | | | 200 | 320 | 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 74* and *Figure 75*.
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. By default dummy cycle value. Please refer to the *"Table 1. Read performance Comparison"*.

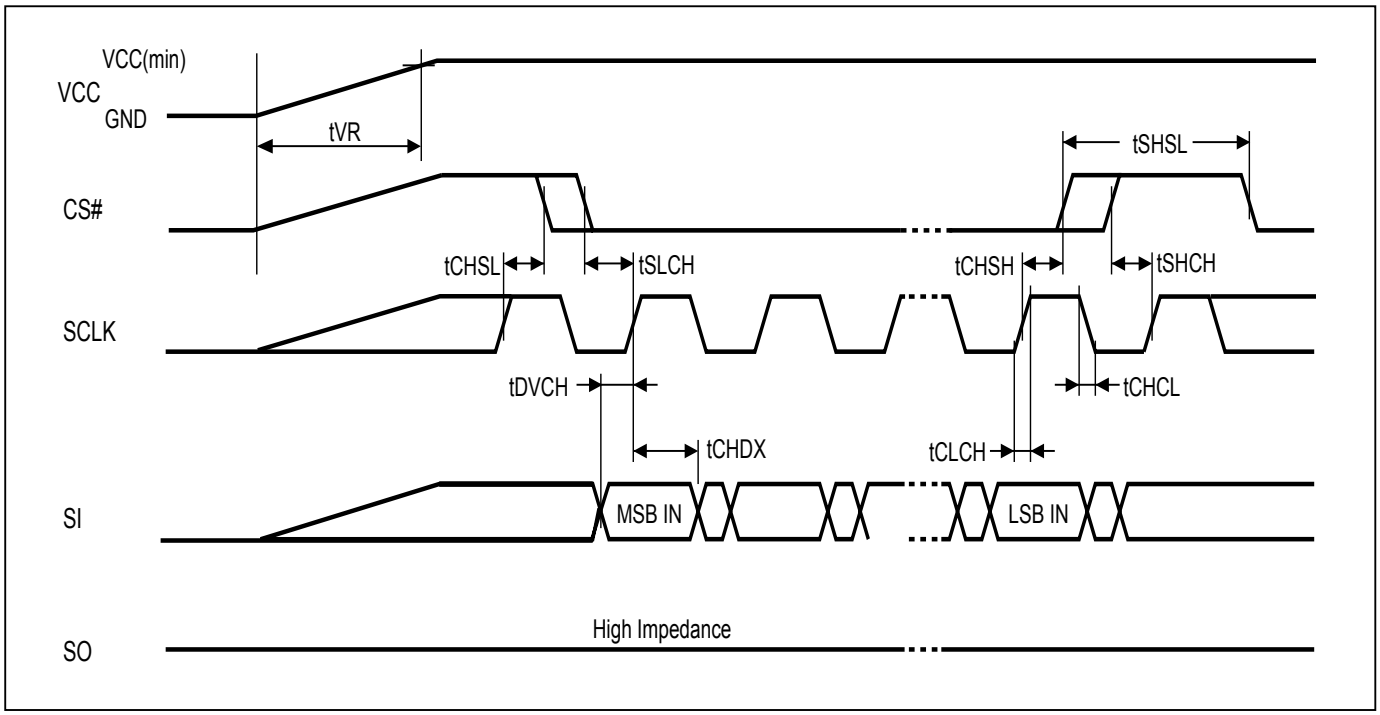
## 13. OPERATING CONDITIONS

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

AC timing illustrated in *Figure 76* and *Figure 77* 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 76. AC Timing at Device Power-Up**




| Symbol | Parameter | Notes | Min. | Max. | Unit |
|---|---|---|---|---|---|
| tVR | VCC Rise Time | 1 | 20 | 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 77. Power-Down Sequence**

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

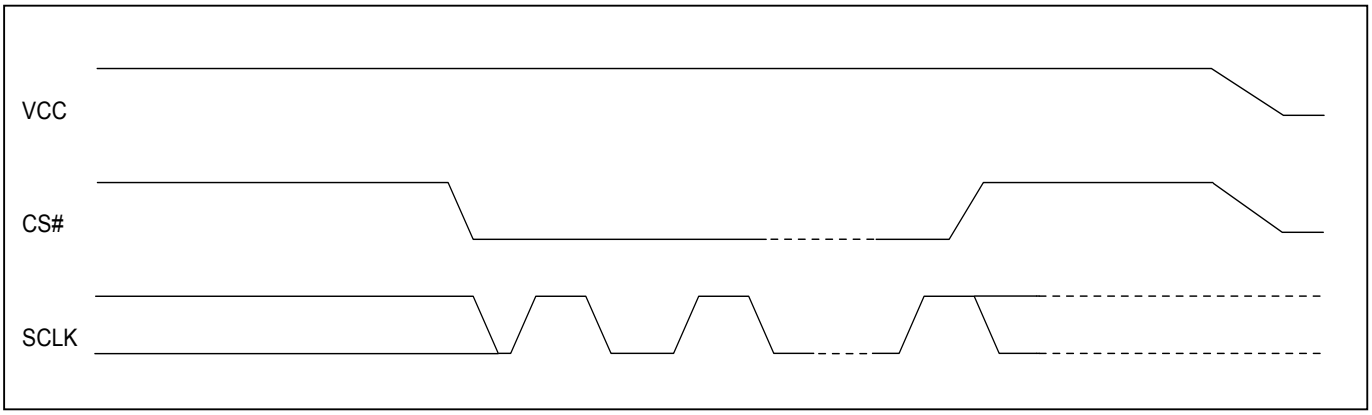
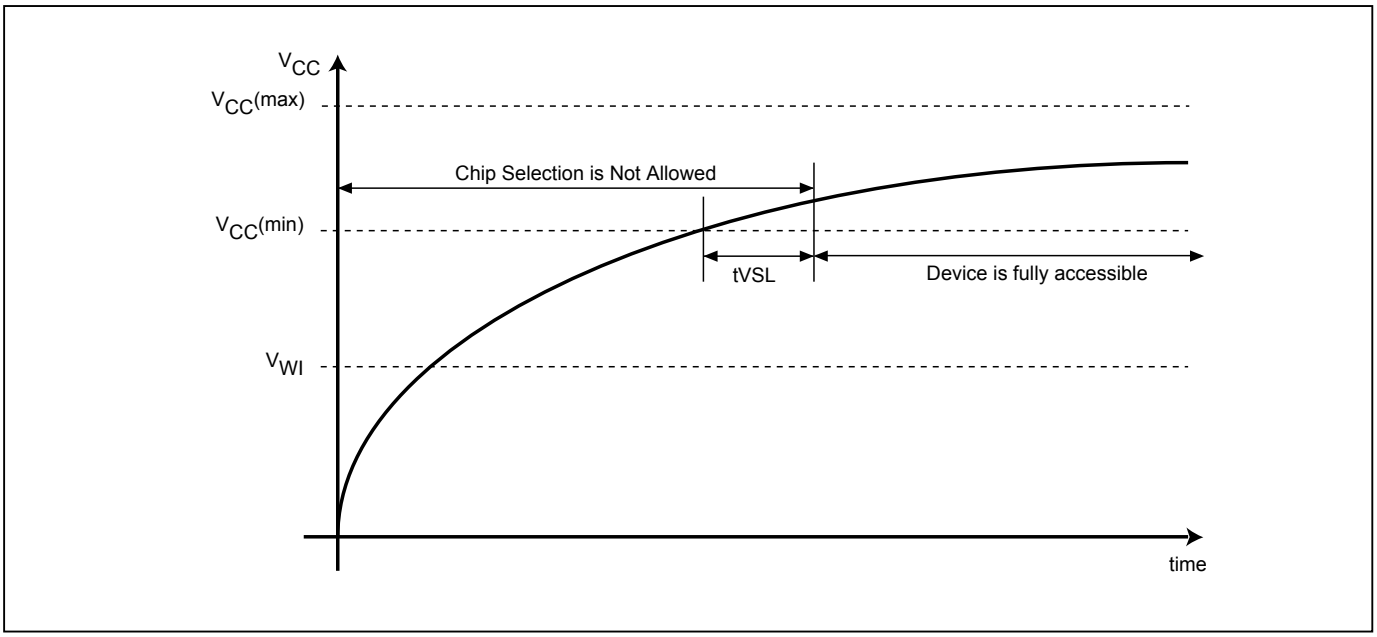



**Figure 78. Power-up Timing**





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**Figure 79. 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.

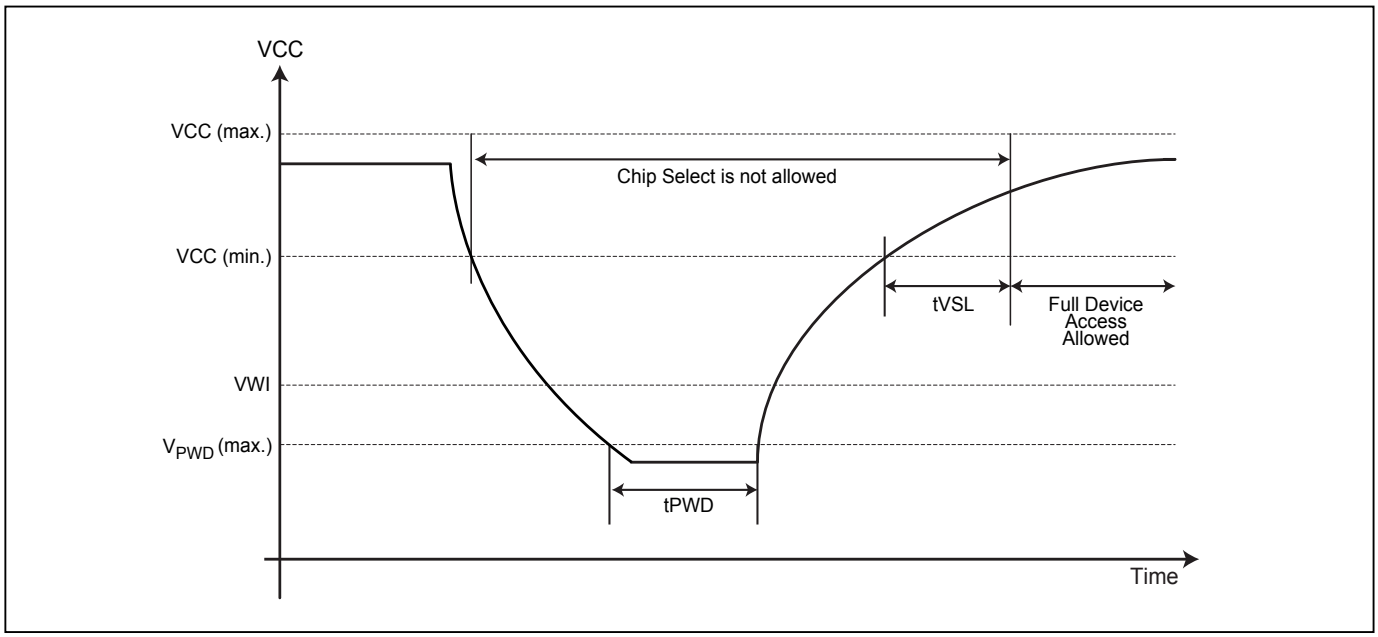



**Table 18. Power-Up/Down Voltage and Timing**

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{PWD}$ | VCC voltage needed to below $V_{PWD}$ for ensuring initialization will occur | | 0.8 | V |
| tPWD | The minimum duration for ensuring initialization will occur | 300 | | us |
| tVSL | VCC(min.) to device operation | 1.5 | | ms |
| tVR | VCC Rise Time | 20 | 500000 | us/V |
| VCC | VCC Power Supply | 1.65 | 2.0 | V |
| VWI | Command Inhibit Voltage | 1.0 | 1.4 | V |

## 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) | | 45 | 200 | ms |
| Block Erase Cycle Time (32KB) | | 0.2 | 1 | s |
| Block Erase Cycle Time (64KB) | | 0.4 | 2 | s |
| Chip Erase Cycle Time | | 200 | 320 | s |
| Byte Program Time (via page program command) | | 12 | 30 | us |
| Page Program Time | | 1 | 3 | ms |
| Erase/Program Cycle | | 100,000 | | cycles |

Note:
1. Typical program and erase time assumes the following conditions: 25°C, 1.8V, and all zero pattern.
2. Under worst conditions of 85°C and 1.65V.
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=1.8V, 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

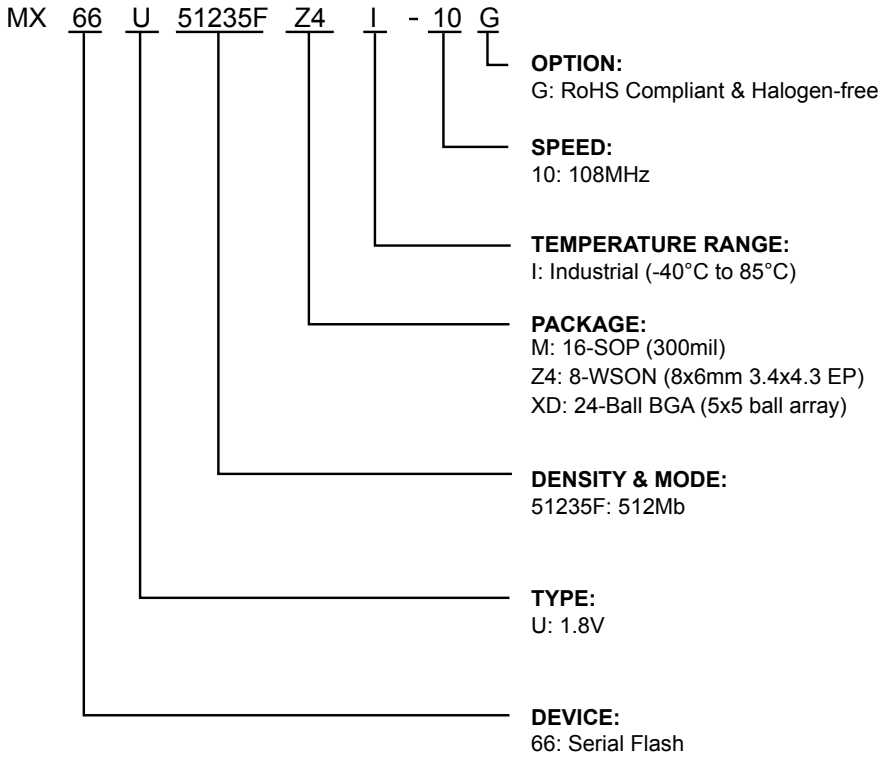
| | Min. | Max. |
|---|---|---|
| Input Voltage with respect to GND on all power pins, SI, CS# | -1.0V | 2 VCCmax |
| Input Voltage with respect to GND on SO | -1.0V | VCC + 1.0V |
| Current | -100mA | +100mA |
| Includes all pins except VCC. Test conditions: VCC = 3.0V, one pin at a time. | | |


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## 17. ORDERING INFORMATION

| PART NO. | CLOCK (MHz) | TEMPERATURE | PACKAGE | Remark |
|---|---|---|---|---|
| MX66U51235FMI-10G | 108 | -40°C~85°C | 16-SOP (300mil) | |
| MX66U51235FZ4I-10G | 108 | -40°C~85°C | 8-WSON (8x6mm 3.4x4.3 EP) | |
| MX66U51235FXDI-10G | 108 | -40°C~85°C | 24-Ball BGA (5x5 ball array) | |

## 18. PART NAME DESCRIPTION

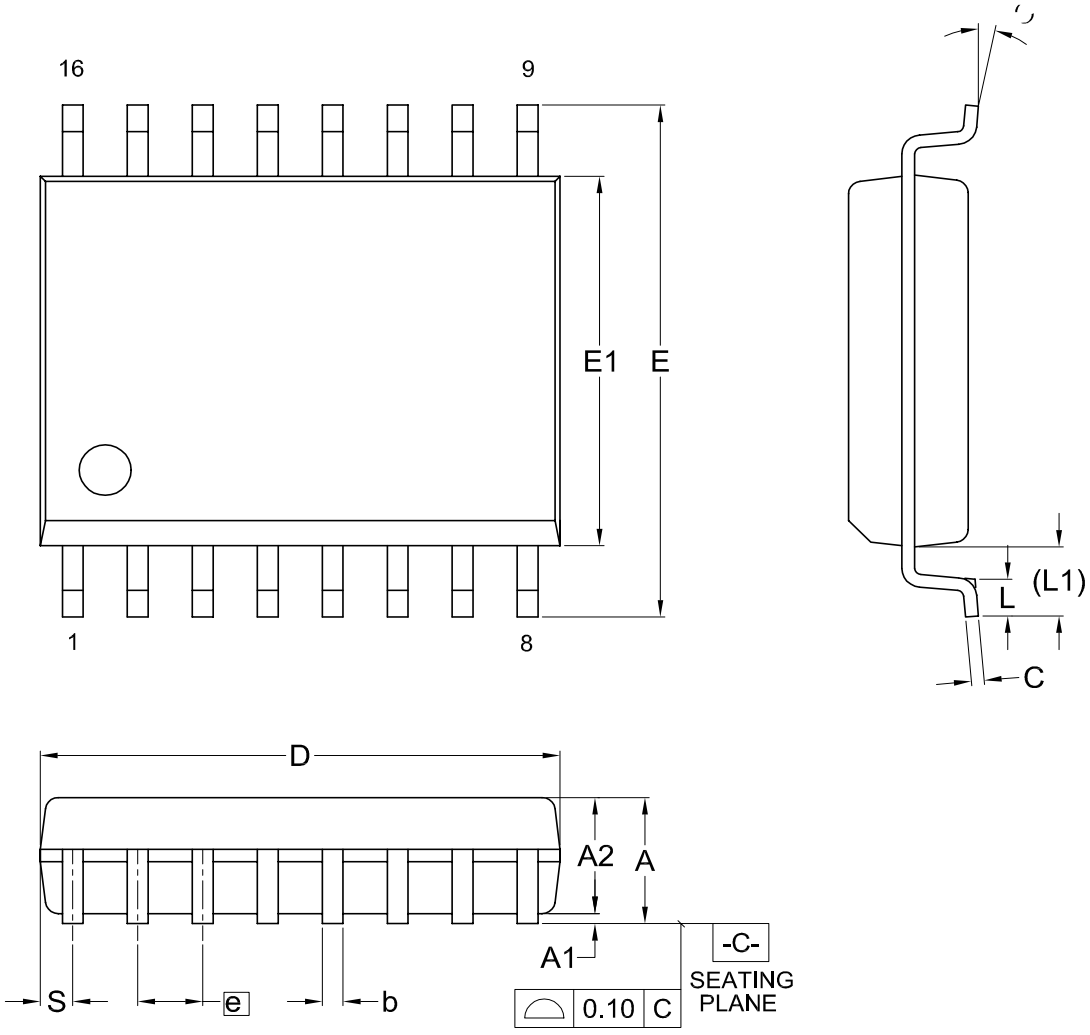




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## 19. PACKAGE INFORMATION

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

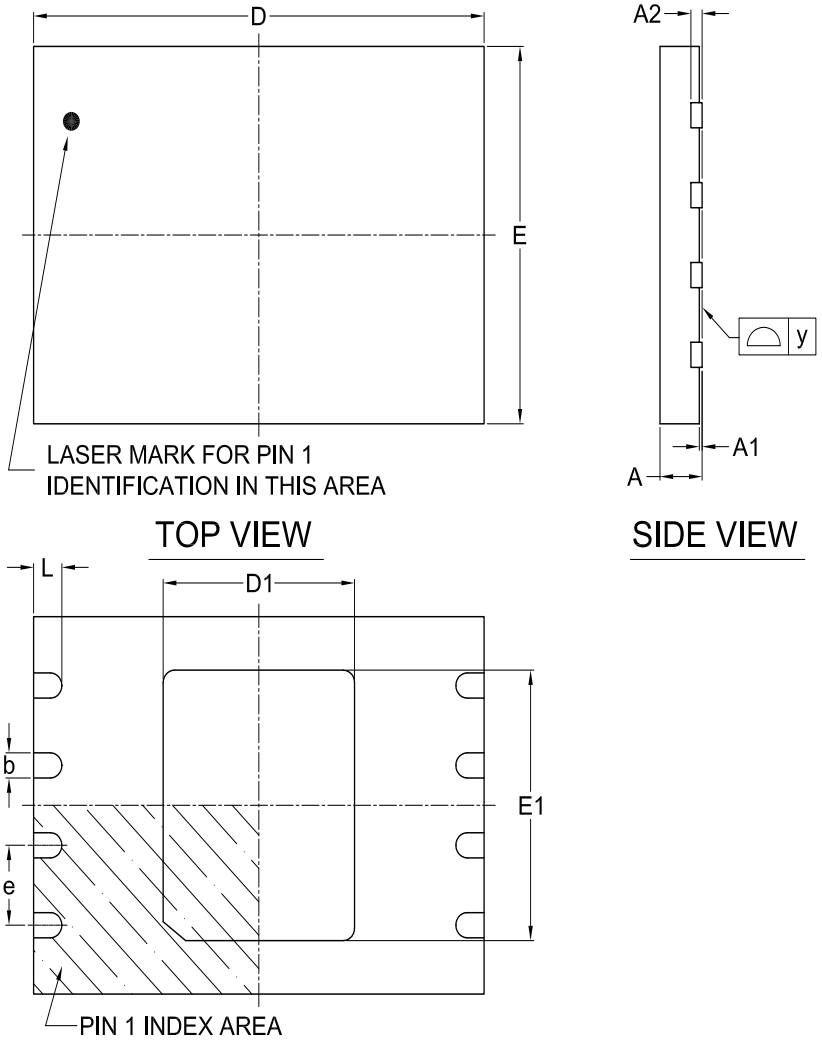



Dimensions (inch dimensions are derived from the original mm dimensions)

| SYMBOL / UNIT | | A | A1 | A2 | b | C | D | E | E1 | e | L | L1 | S | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | Min. | --- | 0.10 | 2.34 | 0.36 | 0.20 | 10.10 | 10.10 | 7.42 | --- | 0.40 | 1.31 | 0.51 | 0 |
| | Nom. | --- | 0.20 | 2.39 | 0.41 | 0.25 | 10.30 | 10.30 | 7.52 | 1.27 | 0.84 | 1.44 | 0.64 | 5 |
| | Max. | 2.65 | 0.30 | 2.44 | 0.51 | 0.30 | 10.50 | 10.50 | 7.60 | --- | 1.27 | 1.57 | 0.77 | 8 |
| Inch | Min. | --- | 0.004 | 0.092 | 0.014 | 0.008 | 0.397 | 0.397 | 0.292 | --- | 0.016 | 0.052 | 0.020 | 0 |
| | Nom. | --- | 0.008 | 0.094 | 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 | 10 | MS-013 | | | |

**Doc. Title: Package Outline for WSON 8L (8x6x0.8MM, LEAD PITCH 1.27MM, E.P. 3.4x4.3MM)**




Note:

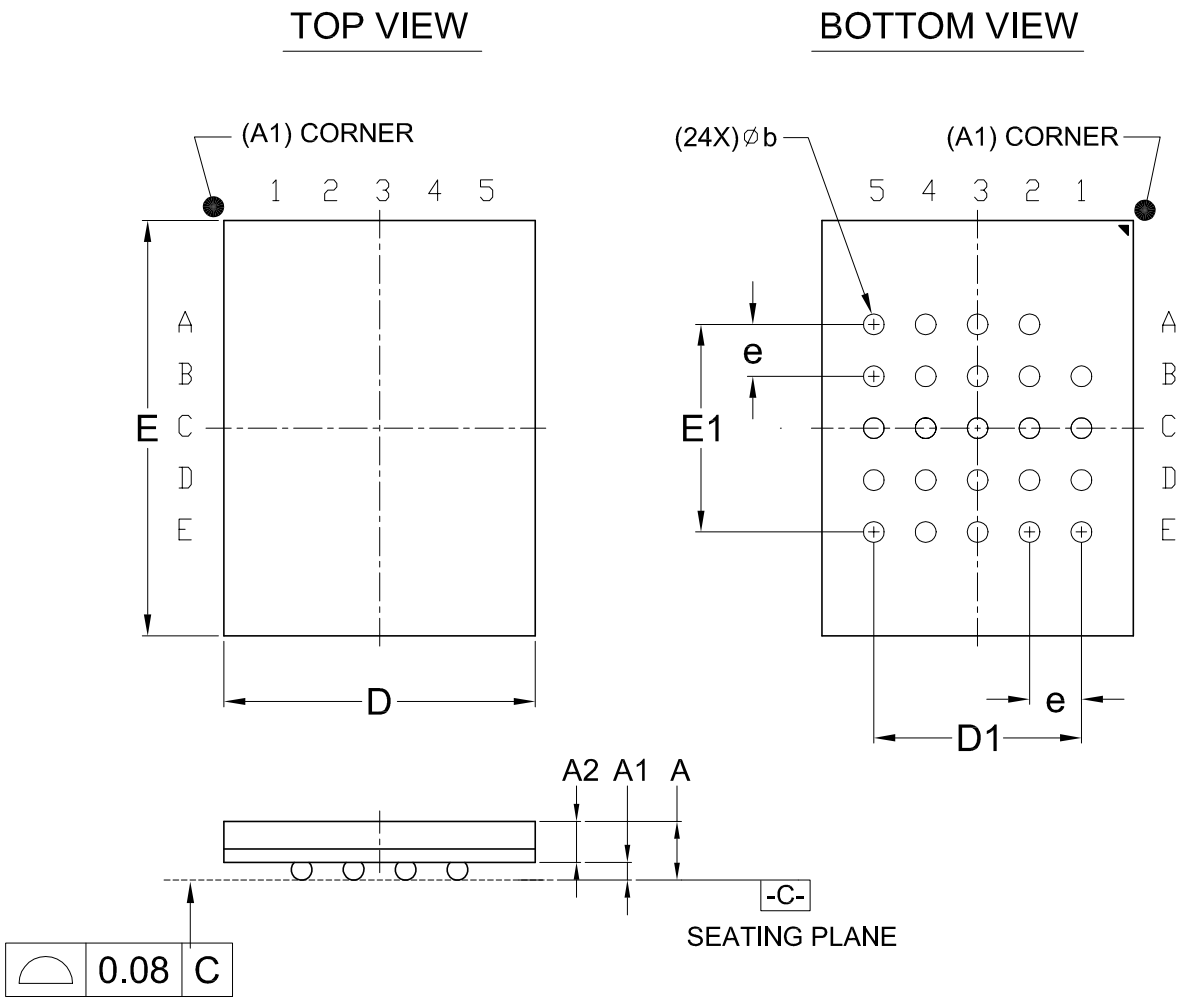
This package has an exposed metal pad underneath the package. It is recommended to leave the metal pad floating or to connect it to the same ground as the GND pin of the package. Do not connect the metal pad to any other voltage or signal line on the PCB. Avoid placing vias or traces underneath the metal 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 | 7.90 | 3.30 | 5.90 | 4.20 | 0.40 | --- | 0.00 |
| | Nom. | --- | — | 0.20 | 0.40 | 8.00 | 3.40 | 6.00 | 4.30 | 0.50 | 1.27 | --- |
| | Max. | 0.80 | 0.05 | — | 0.48 | 8.10 | 3.50 | 6.10 | 4.40 | 0.60 | — | 0.08 |
| Inch | Min. | 0.028 | — | — | 0.014 | 0.311 | 0.130 | 0.232 | 0.165 | 0.016 | --- | 0.00 |
| | Nom. | --- | — | 0.008 | 0.016 | 0.315 | 0.134 | 0.236 | 0.169 | 0.020 | 0.05 | --- |
| | Max. | 0.032 | 0.002 | — | 0.019 | 0.319 | 0.138 | 0.240 | 0.173 | 0.024 | --- | 0.003 |

| Dwg. No. | Revision | Reference | | | |
|---|---|---|---|---|---|
| | | JEDEC | EIAJ | | |
| 6110-3402.1 | 2 | MO-220 | | | |

Doc. Title: Package Outline for CSP 24BALL (6x8x1.2MM, BALL PITCH 1.0MM, BALL DIAMETER 0.4MM)




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

| SYMBOL / UNIT | | A | A1 | A2 | b | D | D1 | E | E1 | e |
|---|---|---|---|---|---|---|---|---|---|---|
| mm | Min. | --- | 0.25 | 0.65 | 0.35 | 5.90 | --- | 7.90 | --- | --- |
| | Nom. | --- | 0.30 | --- | 0.40 | 6.00 | 4.00 | 8.00 | 4.00 | 1.00 |
| | Max. | 1.20 | 0.35 | --- | 0.45 | 6.10 | --- | 8.10 | --- | --- |
| Inch | Min. | --- | 0.010 | 0.026 | 0.014 | 0.232 | --- | 0.311 | --- | --- |
| | Nom. | --- | 0.012 | --- | 0.016 | 0.236 | 0.157 | 0.315 | 0.157 | 0.039 |
| | Max. | 0.047 | 0.014 | --- | 0.018 | 0.240 | --- | 0.319 | --- | --- |

| Dwg. No. | Revision | Reference | | | |
|---|---|---|---|---|---|
| | | JEDEC | EIAJ | | |
| 6110-4257.1 | 0 | | | | |

## 20. REVISION HISTORY

| Revision No. | Description | Page | Date |
|---|---|---|---|
| 0.01 | 1. Deleted 8x6mm 8-WSON packages. | P5,7,91,92,94 | SEP/25/2013 |
| | 2. Revised *"Figure 72. Maximum Negative Overshoot Waveform"* | P83 | |
| | 3. Changed status from "Advanced Information" to "Preliminary" | All | |
| | 4. Modified *"Table 1. Read performance Comparison"* | P6 | |
| | 5. Modified *"Dummy Cycle and Frequency Table (MHz)"* | P36 | |
| | 6. Modified *"Figure 64. Suspend to Read/Program Latency"* | P72 | |
| | 7. Modified *"Table 14. ABSOLUTE MAXIMUM RATINGS"* | P83 | |
| 1.0 | 1. Updated parameters for DC/AC Characteristics | P4,85,86 | NOV/28/2013 |
| | 2. Updated Erase and Programming Performance | P4,90 | |
| | 3. Modified "Enter 4-Byte Address Mode" section | P15 | |
| | 4. Removed PRELIMINARY status | All | |
| 1.1 | 1. Modified Reset Timing figure | P81 | FEB/26/2014 |
| | 2. Modified Power Up/Down and Voltage figure & timing | P89 | |
| | 3. Added 24-Ball BGA package and Part No. | P5,7,91,92,95 | |

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