DS25M4AE

1.8V 128M-bit

Serial Flash Memory with 4KB Sectors, Dual and Quad I/O SPI & QPI

Documents title

1.8V 128M bit Serial Flash Memory with 4KB Sectors, Dual and Quad I/O SPI &QPI

Revision History

Revision No.	History	Draft date	Release date	Remark
0.0	Initial Draft	Jun.21.2024	Aug.05.2024	
0.1	Update dummy configurations, few AC/DC parameters and some typo modification	Aug.07.2024	Aug.09.2024	
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0.6	Update BBh/EBh dummy description in SPI mode	Sep.10.2025	Sep.11.2025	
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0.8	Add BGA24 package info	Aug.21.2026	Aug.24.2026	

Datasheet can be modified without any notice!

Table of Contents

1. GENERAL DESCRIPTIONS 6

2. FEATURES 6

3. PACKAGE TYPES AND PIN CONFIGURATIONS 7
3.1. Pin Configuration SOP 208-mil 7
3.2. Pin Configuration SOP16 300-mil 7
3.3. Pad Configuration WSON 6x5-mm/USON 4X4-mm 7
3.4. Pin Configuration FBGA24(5x5 Array) 8
3.5. Pin Configuration WLCSP 8
3.6. Pin Description SOP 208-mil/300-mil, WSON 6x5-mm, USON 4x4-mm, FBGA24, WLCSP 9

4. PIN DESCRIPTIONS 11
4.1. Chip Select (/CS) 11
4.2. Serial Data Input, Output and IOs (DI, DO and IO0, IO1, IO2, IO3) 11
4.3. Write Protect (/WP) 11
4.4. HOLD (/HOLD) or Reset(/RESET) 11
4.5. Serial Clock (CLK) 11

5. BLOCK DIAGRAM 12

6. FUNCTIONAL DESCRIPTIONS 13
6.1. SPI / QPI Operations 13
6.1.1. Standard SPI Instructions 13
6.1.2. Dual SPI Instructions 13
6.1.3. Quad SPI Instructions 14
6.1.4. QPI Instructions 14
6.1.5. Single, Dual Quad / QPI DTR Read Instructions 14
6.1.6. Hold Function 14
6.1.7. Software Reset & Hardware /RESET pin 15
6.2. DATA PROTECTION 16

7. STATUS REGISTERS 17
7.1. Status Registers 17
7.1.1. Erase/Write In Progress (BUSY) – *Status Only* 17
7.1.2. Write Enable Latch (WEL) – *Status Only* 17
7.1.3. Block Protect Bits (BP2, BP1, BP0) – *Volatile/Non-Volatile Writable* 17
7.1.4. Top/Bottom Block Protect (TB) – *Volatile/Non-Volatile Writable* 17
7.1.5. Sector/Block Protect Bit (SEC) – *Volatile/Non-Volatile Writable* 18
7.1.6. Complement Protect (CMP) – Volatile/Non-Volatile Writable 18
7.1.7. Status Register Protect (SRP1, SRP0) – *Volatile/Non-Volatile Writable* 18
7.1.8. Erase/Program Suspend Status (SUS) –SUS1, SUS2 bits- *Status Only* 19
7.1.9. Security Register Lock Bits (LB3, LB2, LB1) – *Non-Volatile OTP Writable* 19
7.1.10. Quad Enable (QE) – Volatile/Non-Volatile Writable 19
7.1.11. Output Driver Strength (DRV1 & DRV0) – *Volatile/Non-Volatile Writable* 20
7.1.12. /HOLD or /RESET Pin Function (HOLD/RST) – *Volatile/Non-Volatile Writable* 20
7.1.13. Reserved Bits – *Non Functional* 20
7.1.14. DS25M4AE Status Register Memory Protection (CMP = 0) 21
7.1.15. DS25M4AE Status Register Memory Protection (CMP = 1) 22

8. INSTRUCTIONS 23
8.1. Device ID and Instruction Set Tables 23
8.1.1. Manufacturer and Device Identification 23
8.1.2. Instruction Set Table (Standard/Dual/Quad SPI Instructions) 24

8.1.3. Instruction Set Table (QPI Instructions) 26
8.2. Instruction Descriptions 29
8.2.1. Write Enable (06h) 29
8.2.2. Write Enable for Volatile Status Register (50h) 29
8.2.3. Write Disable (04h) 30
8.2.4. Read Status Register-1 (05h), Status Register-2 (35h) & Status Register-3 (15h) 30
8.2.5. Write Status Register-1 (01h), Status Register-2 (31h) & Status Register-3 (11h) 31
8.2.6. Read Data (03h) 34
8.2.7. Fast Read (0Bh) 35
8.2.8. Fast Read (0Bh) in QPI Mode 36
8.2.9. Fast Read Dual Output (3Bh) 37
8.2.10. Fast Read Quad Output (6Bh) 38
8.2.11. Fast Read Dual I/O (BBh) 39
8.2.12. Fast Read Dual I/O with “Continuous Read Mode” 39
8.2.13. Fast Read Quad I/O (EBh) 41
8.2.14. Fast Read Quad I/O with “Continuous Read Mode” 41
8.2.15. Fast Read Quad I/O with “8/16/32/64-Byte Wrap Around” in Standard SPI mode 42
8.2.16. Fast Read Quad I/O (EBh) in QPI Mode 43
8.2.17. Word Read Quad I/O (E7h) 44
8.2.18. Word Read Quad I/O with “Continuous Read Mode” 44
8.2.19. Word Read Quad I/O with “8/16/32/64-Byte Wrap Around” in Standard SPI mode 45
8.2.20. Set Burst with Wrap (77h) 46
8.2.21. DTR Read (0Dh) 47
8.2.22. DTR Read in QPI (0Dh) 47
8.2.23. DTR Read Dual I/O (BDh) with “Continuous Read Mode” 48
8.2.24. DTR wrap read (0Eh) 49
8.2.25. DTR Read Quad I/O (EDh) 49
8.2.26. DTR Read Quad I/O with “Continuous Read Mode” 50
8.2.27. DTR Read Quad I/O (EDh) in QPI Mode 51
8.2.28. Page Program (02h) 52
8.2.29. Quad Input Page Program (32h) 53
8.2.30. Sector Erase (20h) 54
8.2.31. 32KB Block Erase (52h) 55
8.2.32. 64KB Block Erase (D8h) 56
8.2.33. Chip Erase (C7h / 60h) 57
8.2.34. Erase / Program Suspend (75h) 58
8.2.35. Erase / Program Resume (7Ah) 60
8.2.36. Deep Power-down (B9h) 61
8.2.37. Release Power-down / Device ID (ABh) 62
8.2.38. Read Manufacturer / Device ID (90h) 64
8.2.39. Read Manufacturer / Device ID Dual I/O (92h) 65
8.2.40. Read Manufacturer / Device ID Quad I/O (94h) 66
8.2.41. Read Unique ID Number (4Bh) 67
8.2.42. Read JEDEC ID (9Fh) 68
8.2.43. Read SFDP Register (5Ah) 69
8.2.44. Erase Security Registers (44h) 70
8.2.45. Program Security Registers (42h) 71
8.2.46. Read Security Registers (48h) 72
8.2.47. Set Read Parameters (C0h) 73
8.2.48. Burst Read with Wrap (0Ch) 74
8.2.49. Enter QPI Mode (38h) 75
8.2.50. Exit QPI Mode (FFh) 76
8.2.51. Enable Reset (66h) and Reset Device (99h) 77
9. ELECTRICAL CHARACTERISTICS 78

9.1. Absolute Maximum Ratings 78
9.2. Initial Delivery State 78
9.3. Capacitance Measurement Conditions 78
9.4. Power-Up Timing and Requirements 79
9.5. DC Electrical Characteristics 80
9.6. AC Electrical Characteristics 81

10. PACKAGE SPECIFICATIONS 84
10.1. 8-Pin SOP 208-mil 84
10.2. 16-pin SOP 300-mil 85
10.3. 8-contact 6x5 WSON 86
10.4. 8-contact 4x4 USON 87
10.5. 24-ball FBGA 88
10.6. WLCSP 89

11. ORDERING INFORMATION 90

1. GENERAL DESCRIPTIONS

The DS25M4AE (128M-bit) Serial Flash memory provides a storage solution for systems with limited space, pins and power. The 25 series offers flexibility and performance well beyond ordinary Serial Flash devices. They are ideal for code shadowing to RAM, executing code directly from Dual/Quad SPI (XIP) and storing voice, text and data. The device operates on a single 1.65V to 2.0V power supply with current consumption as low as 9uA standby current and 0.5µA for power-down. All devices are offered in space- saving packages.

The DS25M4AE array is organized into 65536 programmable pages of 256-bytes each. Up to 256 bytes can be programmed at a time. Pages can be erased in groups of 16 (4KB sector erase), groups of 128 (32KB block erase), groups of 256 (64KB block erase) or the entire chip (chip erase). The DS25M4AE has 4096 erasable sectors and 256 erasable blocks respectively. The small 4KB sectors allow for greater flexibility in applications that require data and parameter storage. (See Figure 2.)

The DS25M4AE support the standard Serial Peripheral Interface (SPI), Dual/Quad I/O SPI as well as 2-clocks instruction cycle Quad Peripheral Interface (QPI) as well as Double Transfer Rate(DTR) : Serial Clock, Chip Select, Serial Data I/O0 (DI), I/O1 (DO), I/O2 (/WP), and I/O3 (/HOLD). SPI clock frequencies of up to 133MHz are supported allowing equivalent data rates of 266Mbits/s for Dual I/O and 532Mbits/s for Quad I/O when using the Fast Read Dual/Quad I/O and QPI instructions. These transfer rates can outperform standard Asynchronous 8 and 16-bit Parallel Flash memories. The Continuous Read Mode allows for efficient memory access with as few as 8-clocks of instruction-overhead to read a 24-bit address, allowing true XIP (execute in place) operation.

A Hold pin, Write Protect pin and programmable write protection, with top or bottom array control, provide further control flexibility. Additionally, the device supports JEDEC standard manufacturer and device ID and SFDP Register, a 128-bit Unique Serial Number and 3x1024bytes Security Registers.

2. FEATURES

- **New Family of SPI Flash Memories**
  - DS25M4AE: 128M-bit /16M-byte
  - Standard SPI: CLK, /CS, DI, DO, /WP, /Hold
  - Dual SPI: CLK, /CS, IO_0, IO_1, /WP, /Hold
  - Quad SPI: CLK, /CS, IO_0, IO_1, IO_2, IO_3
  - QPI: CLK, /CS, IO_0, IO_1, IO_2, IO_3
  - DTR(Double Transfer Rate) Read
- **Highest Performance Serial Flash**
  - 133MHz Single, Dual/Quad SPI clocks
  - More than 100,000 erase/program cycles
  - More than 20-year data retention
  - Burst Read with 8/16/32/64 Byte Wrap
- **Efficient "Continuous Read" and QPI Mode**
  - Continuous Read with 8/16/32/64-Byte Wrap
  - Quad Peripheral Interface (QPI) reduces instruction overhead
  - Allows true XIP (execute in place) operation
- **High performance program/erase speed**
  - Page program time: 0.5ms typical
  - Sector erase time: 30ms typical / Industrial
    60ms typical / Automotive
  - Block Erase time: 0.1s/0.15s typical
  - Chip erase time: 25 seconds typical
- **Low Power Consumption**
  - Full voltage range: 1.65-2.0V
  - 9µA typical standby current
  - 0.5µA typical deep power down current
- **Temperature Range**
  - -40°C to 85°C/105°C/125°C operating range
- **Flexible Architecture with 4KB sectors**
  - Uniform Sector of 4K-Byte
  - Uniform Block of 32/64K-Byte
- **Advanced Security Features**
  - Write protect all/portion of memory via software
  - Enable/Disable protection with WP# Pin
  - Top/Bottom Block protection
  - 128-Bit Unique ID for each device
  - Support Serial Flash Discoverable Parameters (SFDP) signature
  - 3 sets of OTP lockable 1024 byte security pages
  - Volatile & Non-volatile Status Register Bits
- **Space Efficient Packaging**
  - 8-pin SOP 208-mil
  - 16-pin SOP 300-mil
  - 8-pad WSON 6x5-mm
  - 8-pad USON 4x4-mm
  - 24-ball FBGA
  - WLCSP
  - Contact Dosilicon for KGD and other options

3. PACKAGE TYPES AND PIN CONFIGURATIONS

3.1. Pin Configuration SOP 208-mil

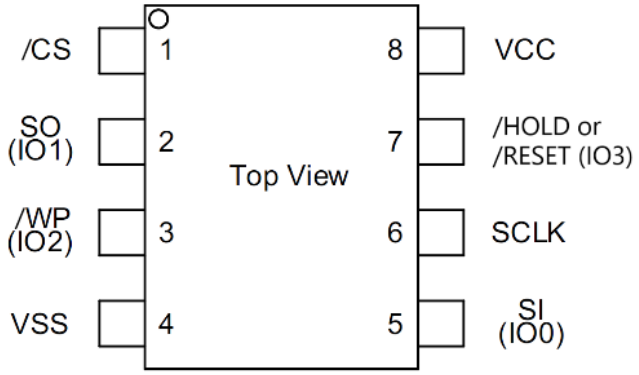


Figure 1a. 8-pin SOP 208-mil

3.2. Pin Configuration SOP16 300-mil

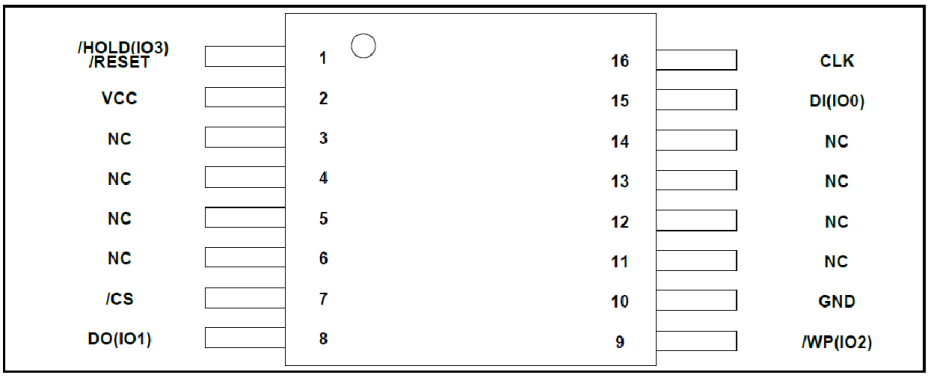


Figure 1b. 16-pin SOP 300-mil

3.3. Pad Configuration WSON 6x5-mm/USON 4X4-mm

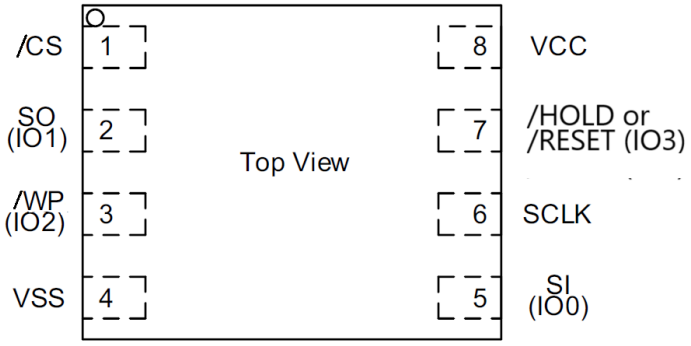


Figure 1c. 8-pad WSON 6x5-mm

3.4. Pin Configuration FBGA24(5x5 Array)

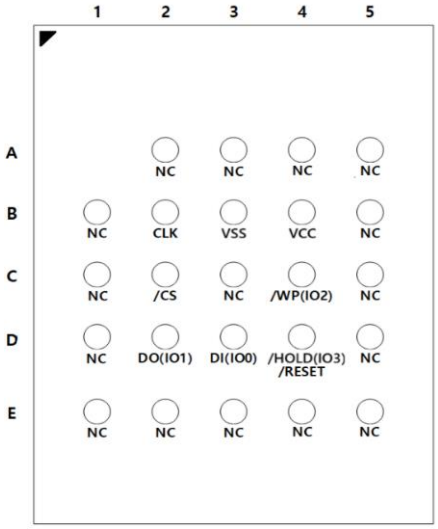


Figure 1c. 24-ball FBGA(Top View)

3.5. Pin Configuration WLCSP

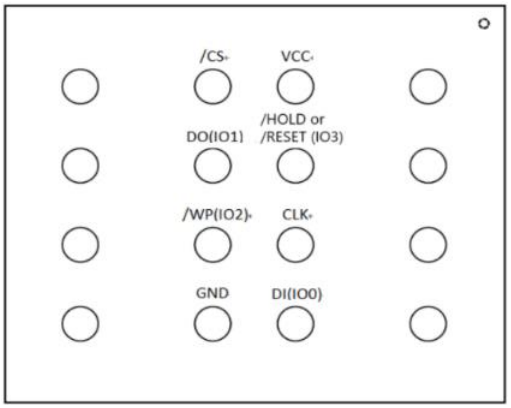


Figure 1d. DS25M4AE Pad Assignments, 16Ball WLCSP(Bottom View)

3.6. Pin Description SOP 208-mil/300-mil, WSON 6x5-mm, USON 4x4-mm, FBGA24, WLCSP

Table1 Pin Description for SOP8/WSON8/USON8/WLCSP Package

PIN NO.	PIN NAME	I/O	FUNCTION
1	/CS	I	Chip Select Input
2	DO (IO1)	I/O	Data Output (Data Input Output 1)(1)
3	/WP (IO2)	I/O	Write Protect Input (Data Input Output 2)(2)
4	VSS/GND		Ground
5	DI (IO0)	I/O	Data Input (Data Input Output 0)(1)
6	CLK	I	Serial Clock Input
7	/HOLD or /RESET(IO3)	I/O	Hold or Reset Input (Data Input Output 3)(2)
8	VCC		Power Supply

Table 2. Pin Description for SOP16

PIN NO.	PIN NAME	I/O	FUNCTION
1	/HOLD or /RESET(IO3)	I/O	Data Input Output 3
2	VCC		Power Supply
3	N/C		Reset Input
4	N/C		No Connect
5	N/C		No Connect
6	N/C		No Connect
7	/CS	I	Chip Select Input
8	DO(IO1)	I/O	Data output (Data Input Output 1)
9	/WP(IO2)	I/O	Write Protection Input (Data Input Output 2)
10	GND		Ground
11	N/C		No Connect
12	N/C		No Connect
13	N/C		No Connect
14	N/C		No Connect
15	DI(IO0)	I/O	Data Input (Data Input Output 0)
16	CLK	I	Serial Clock Input

Table 3. Pin Description for FBGA24 Package

PIN NO.	PIN NAME	I/O	FUNCTION
B2	CLK	I	Serial Clock Input
B3	VSS		Ground
B4	VCC		Power Supply
C2	/CS	I	Chip Select Input
C4	/WP(IO2)	I/O	Write Protection Input (Data Input Output 2)
D2	DO(IO1)	I/O	Data output (Data Input Output 1)

D3	DI(IO0)	I/O	Data Input (Data Input Output 0)
D4	/HOLD or /RESET (IO3)	I/O	Hold or Reset Input (Data Input Output 3)
Others	N/C		No Connect

Notes:

1. IO0 and IO1 are used for Standard and Dual SPI instructions
2. IO0 – IO3 are used for Quad SPI instructions, /WP & /HOLD (or /RESET) functions are only available for Standard/Dual SPI.
3. If /WP or /HOLD (or /RESET) pin is not used, it must be driven high by host, or an external pull-up resistor must be placed on the PCB in order to avoid floating.
4. CS# must be driven high if chip is not selected. Please don't leave CS# floating any time after power is on.

4. PIN DESCRIPTIONS

4.1. Chip Select (/CS)

The SPI Chip Select (/CS) pin enables and disables device operation. When /CS is high the device is deselected and the Serial Data Output (DO, or IO0, IO1, IO2, IO3) pins are at high impedance. When deselected, the devices power consumption will be at standby levels unless an internal erase, program or write status register cycle is in progress. When /CS is brought low the device will be selected, power consumption will increase to active levels and instructions can be written to and data read from the device. After power-up, /CS must transition from high to low before a new instruction will be accepted.

4.2. Serial Data Input, Output and IOs (DI, DO and IO0, IO1, IO2, IO3)

The DS25M4AE supports standard SPI, Dual SPI and Quad SPI operation. Standard SPI instructions use the unidirectional DI (input) pin to serially write instructions, addresses or data to the device on the rising edge of the Serial Clock (CLK) input pin. Standard SPI also uses the unidirectional DO (output) to read data or status from the device on the falling edge ofCLK.

Dual and Quad SPI instructions use the bidirectional IO pins to serially write instructions, addresses or data to the device on the rising edge of CLK and read data or status from the device on the falling edge of CLK. Quad SPI instructions require the non-volatile Quad Enable bit (QE) in Status Register-2 to be set. When QE=1, the /WP pin becomes IO2 and /HOLD pin becomes IO3.

4.3. Write Protect (/WP)

The Write Protect (/WP) pin can be used to prevent the Status Register from being written. Used in conjunction with the Status Register's Block Protect (CMP, SEC, TB, BP2, BP1 and BP0) bits and Status Register Protect (SRP) bits, a portion as small as a 4KB sector or the entire memory array can be hardware protected. The /WP pin is active low. When the QE bit of Status Register-2 is set for Quad I/O, the /WP pin function is not available since this pin is used for IO2. See Figure 1a-b for the pin configuration of Quad I/O operation.

4.4. HOLD (/HOLD) or Reset(/RESET)

The /HOLD pin allows the device to be paused while it is actively selected. When /HOLD is broughtlow, while /CS is low, the DO pin will be at high impedance and signals on the DI and CLK pins will be ignored (don't care). When /HOLD is brought high, device operation can resume. The /HOLD function can be useful when multiple devices are sharing the same SPI signals. The /HOLD pin is active low. When the QE bit of Status Register-2 is set for Quad I/O, the /HOLD pin function is not available since this pin is used for IO3. See Figure 1a-b for the pin configuration of Quad I/O operation.

The /RESET pin allows the device to be reset by the controller.When QE=0, the IO3 pin can be configured either as a /HOLD pin or as a /RESET pin depending on Status Register setting. When QE=1, the /HOLD or /RESET function is not available.

4.5. Serial Clock (CLK)

The SPI Serial Clock Input (CLK) pin provides the timing for serial input and output operations. ("See SPI Operations")

5. BLOCK DIAGRAM

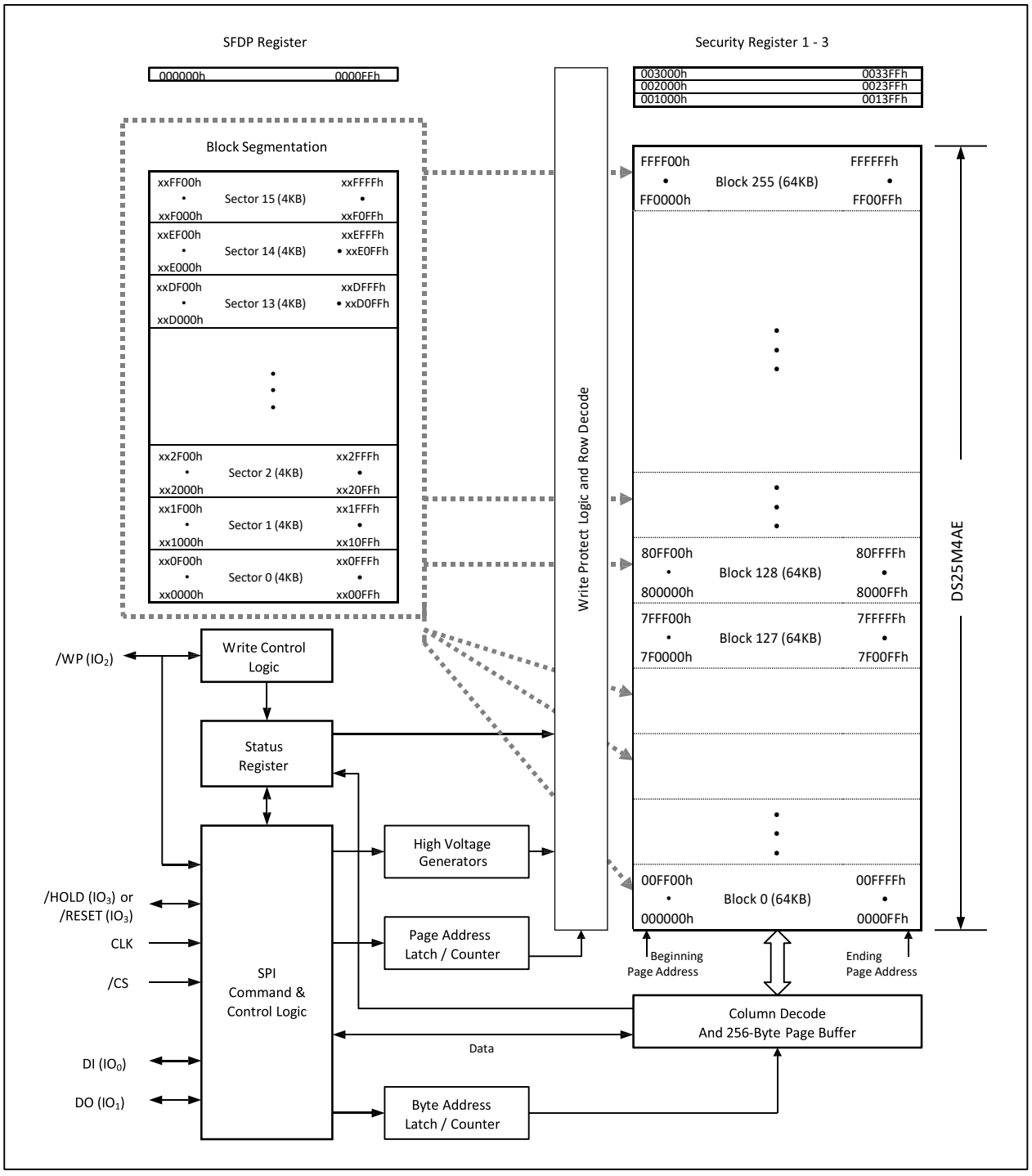


Figure 2. DS25M4AE Serial Flash Memory Block Diagram

6. FUNCTIONAL DESCRIPTIONS

6.1. SPI / QPI Operations

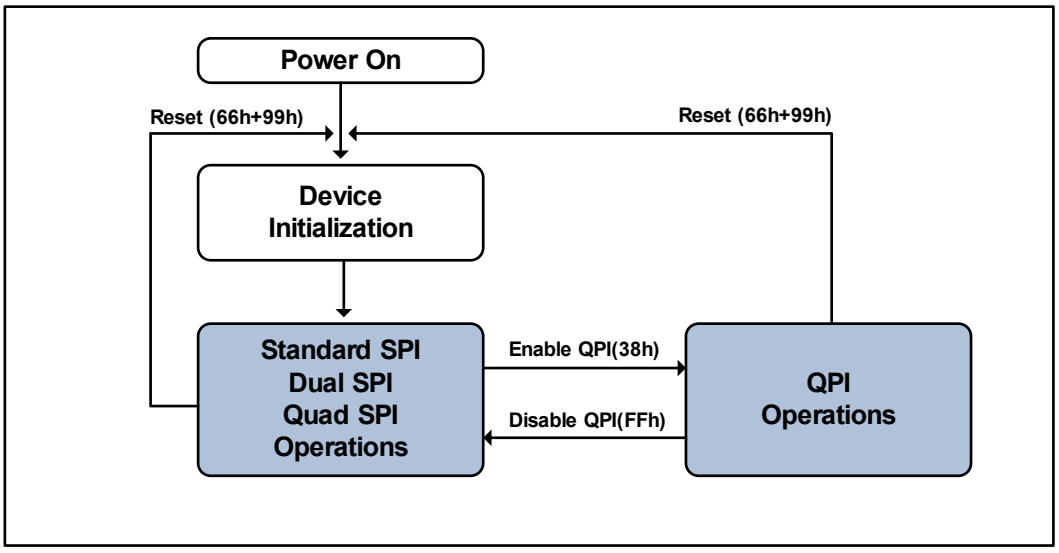


Figure 3. DS25M4AE Serial Flash Memory Operation Diagram

6.1.1. Standard SPI Instructions

The DS25M4AE is accessed through an SPI compatible bus consisting of four signals: Serial Clock (CLK), Chip Select (/CS), Serial Data Input (DI) and Serial Data Output (DO). Standard SPI instructions use the DI input pin to serially write instructions, addresses or data to the device on the rising edge of CLK. The DO output pin is used to read data or status from the device on the falling edge of CLK.

SPI bus operation Mode 0 (0,0) and 3 (1,1) are supported. The primary difference between Mode 0 and Mode 3 concerns the normal state of the CLK signal when the SPI bus master is in standby and data is not being transferred to the Serial Flash. For Mode 0, the CLK signal is normally low on the falling and rising edges of /CS. For Mode 3, the CLK signal is normally high on the falling and rising edges of /CS.

6.1.2. Dual SPI Instructions

The DS25M4AE supports Dual SPI operation when using instructions such as “Fast Read Dual Output (3Bh)” and “Fast Read Dual I/O (BBh)”. These instructions allow data to be transferred to or from the device at two to three times the rate of ordinary Serial Flash devices. The Dual SPI Read instructions are ideal for quickly downloading code to RAM upon power-up (code-shadowing) or for executing non- speed-critical code directly from the SPI bus (XIP). When using Dual SPI instructions, the DI and DO pins become bidirectional I/O pins: IO0 and IO1.

6.1.3. Quad SPI Instructions

The DS25M4AE supports Quad SPI operation when using instructions such as “Fast Read Quad Output (6Bh)”, “Fast Read Quad I/O (EBh)”, and “Word Read Quad I/O (E7h)”. These instructions allow data to be transferred to or from the device four to six times the rate of ordinary Serial Flash. The Quad Read instructions offer a significant improvement in continuous and random access transfer rates allowing fast code-shadowing to RAM or execution directly from the SPI bus (XIP). When using Quad SPI instructions the DI and DO pins become bidirectional IO0 and IO1, and the /WP and /HOLD pins become IO2 and IO3 respectively. Quad SPI instructions require the non-volatile Quad Enable bit (QE) in Status Register-2 to be set.

6.1.4. QPI Instructions

The DS25M4AE supports Quad Peripheral Interface (QPI) operations only when the device is switched from Standard/Dual/Quad SPI mode to QPI mode using the “Enter QPI (38h)” instruction. The typical SPI protocol requires that the byte-long instruction code being shifted into the device only via DI pin in eight serial clocks. The QPI mode utilizes all four IO pins to input the instruction code, thus only two serial clocks are required. This can significantly reduce the SPI instruction overhead and improve system performance in an XIP environment. Standard/Dual/Quad SPI mode and QPI mode are exclusive. Only one mode can be active at any given time. “Enter QPI (38h)” and “Exit QPI (FFh)” instructions are used to switch between these two modes. Upon power-up or after a software reset using “Reset (99h)” instruction, the default state of the device is Standard/Dual/Quad SPI mode. To enable QPI mode, the non-volatile Quad Enable bit (QE) in Status Register-2 is required to be set. When using QPI instructions, the DI and DO pins become bidirectional IO0 and IO1, and the /WP and
/HOLD pins become IO2 and IO3 respectively. See Figure 3 for the device operation modes.

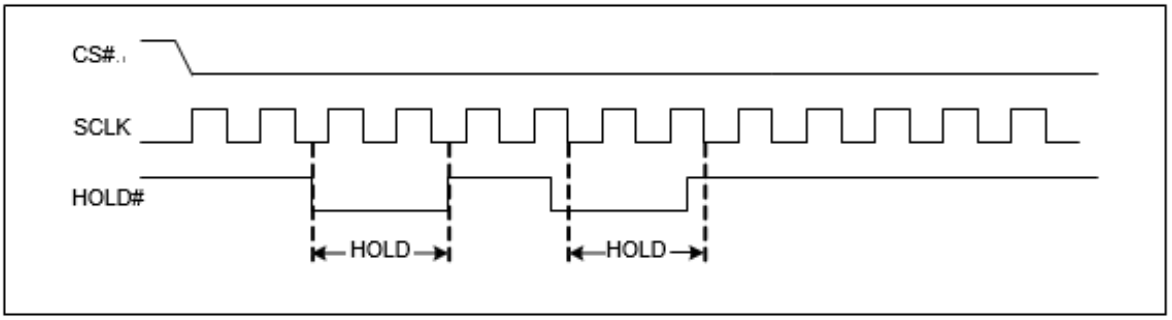
6.1.5. Single, Dual Quad / QPI DTR Read Instructions

To effectively improve the read operation throughput without increasing the serial clock frequency, DS25M4AE introduces multiple DTR (Double Transfer Rate) Read instructions that support Single, Dual Quad SPI and QPI modes. The byte-long instruction code is still latched into the device on the rising edge of the serial clock. Once a DTR instruction code is accepted by the device, the address input and data output will be latched on both rising and falling edges of the serial clock.

6.1.6. Hold Function

For Standard SPI and Dual SPI operations, the /HOLD signal allows the DS25M4AE operation to be paused while it is actively selected (when /CS is low). The /HOLD function may be useful in cases where the SPI data and clock signals are shared with other devices. For example, consider if the page buffer was only partially written when a priority interrupt requires use of the SPI bus. In this case the /HOLD function can save the state of the instruction and the data in the buffer so programming can resume where it left off once the bus is available again. The /HOLD function is only available for standard SPI and Dual SPI operation, not during Quad SPI or QPI. The Quad Enable Bit QE in Status Register-2 is used to determine if the pin is used as /HOLD pin or data I/O pin. When QE=0 (factory default), the pin is /HOLD, when QE=1, the pin will become an I/O pin, /HOLD function is no longer available.

To initiate a /HOLD condition, the device must be selected with /CS low, and then driving /HOLD low/high, /HOLD condition will activate/terminate at the next rising edge of CLK. During a /HOLD condition, the Serial Data Output (DO) is high impedance, and Serial Data Input (DI) and Serial Clock (CLK) are ignored. The Chip Select (/CS) signal should be kept active (low) for the full duration of the /HOLD operation to avoid resetting the internal logic state of the device.



6.1.7. Software Reset & Hardware /RESET pin

The DS25M4AE can be reset to the initial power-on state by a software Reset sequence, either in SPI mode or QPI mode. This sequence must include two consecutive commands: Enable Reset (66h) & Reset (99h). If the command sequence is successfully accepted, the device will take approximately 30us (t_{RST}) to reset. No command will be accepted during the resetperiod.

DS25M4AE can also be configured to utilize a hardware /RESET pin. The HOLD/RST bit in the Status Register-3 is the configuration bit for /HOLD pin function or RESET pin function. When HOLD/RST=0 (factory default), the pin acts as a /HOLD pin as described above; when HOLD/RST=1, the pin acts as a /RESET pin. Drive the /RESET pin low for a minimum period of ~1us (t_{RESET}*) will reset the device to its initial power-on state. Any on-going Program/Erase operation will be interrupted and data corruption may happen. While /RESET is low, the device will not accept any command input.(Figure 50)

If QE bit is set to 1, the /HOLD or /RESET function will be disabled, the pin will become one of the four data I/O pins.

Hardware /RESET pin has the highest priority among all the input signals. Drive /RESET low for a minimum period of ~1us (t_{RESET}*) will interrupt any on-going external/internal operations, regardless the status of other SPI signals (/CS, CLK, IOs, /WP and/or /HOLD).

Note:

1. While a faster /RESET pulse (as short as a few hundred nanoseconds) will often reset the device, a 1us minimum is recommended to ensure reliable operation.

6.2. DATA PROTECTION

The DS25M4AE provide the following data protection methods:

1，Write Enable (WREN) command: The WREN command is set the Write Enable Latch bit (WEL). The WEL bit will return to reset by the following situation:

-Power-Up / Software Reset (66H+99H)

-Write Disable (WRDI)

-Write Status Register (WRSR)

-Page Program (PP) / Quad Page Program (QPP) / Program SecurityRegister (PER)

-Sector Erase (SE) / Block Erase (BE) / Chip Erase (CE) / Erase Security Register (ESR)

2，Software Protection Mode: The Block Protect bits (CMP, SEC, TB, BP2, BP1, and BP0) define the section of the memory array that can be read but not changed.

3，Hardware Protection Mode: WP# goes low to protect the Block Protect bits (CMP, SEC, TB, BP2, BP1, and BP0) and the SRP bits (SRP1 and SRP0).

4，Deep Power-Down Mode: In Deep Power-Down Mode, all commands are ignored except the Release from Deep Power-Down Mode command and Software Reset (66H+99H).

After power-up the device is automatically placed in a write-disabled state with the Status Register Write Enable Latch (WEL) set to a 0. A Write Enable instruction must be issued before a Page Program, Sector Erase, Block Erase, Chip Erase or Write Status Register instruction will be accepted. After completing a program, erase or write instruction the Write Enable Latch (WEL) is automatically cleared to a write-disabled state of 0.

Software controlled write protection is facilitated using the Write Status Register instruction and setting the Status Register Protect (SRP0, SRP1) and Block Protect (CMP, SEC, TB, BP[2:0]) bits. These settings allow a portion or the entire memory array to be configured as read only. Used in conjunction with the Write Protect (/WP) pin, changes to the Status Register can be enabled or disabled under hardware control. See Status Register section for further information. Additionally, the Deep Power-down instruction offers an extra level of write protection as all instructions are ignored except for the Release Power-down and software reset instruction.

7. STATUS REGISTERS

Three Status and Configuration Registers are provided for DS25M4AE. The Read Status Register- 1/2/3 instructions can be used to provide status on the availability of the flash memory array, whether the device is write enabled or disabled, the state of write protection, Quad SPI setting, Security Register lock status, Erase/Program Suspend status and output driver strength. The Write Status Register instruction can be used to configure the device write protection features, Quad SPI setting, Security Register OTP locks, Hold/Reset functions, output driver strength and power- up Address Mode. Write access to the Status Register is controlled by the state of the non-volatile Status Register Protect bits (SRP0, SRP1), the Write Enable instruction, and during Standard/Dual SPI operations, the /WP pin.

7.1. Status Registers

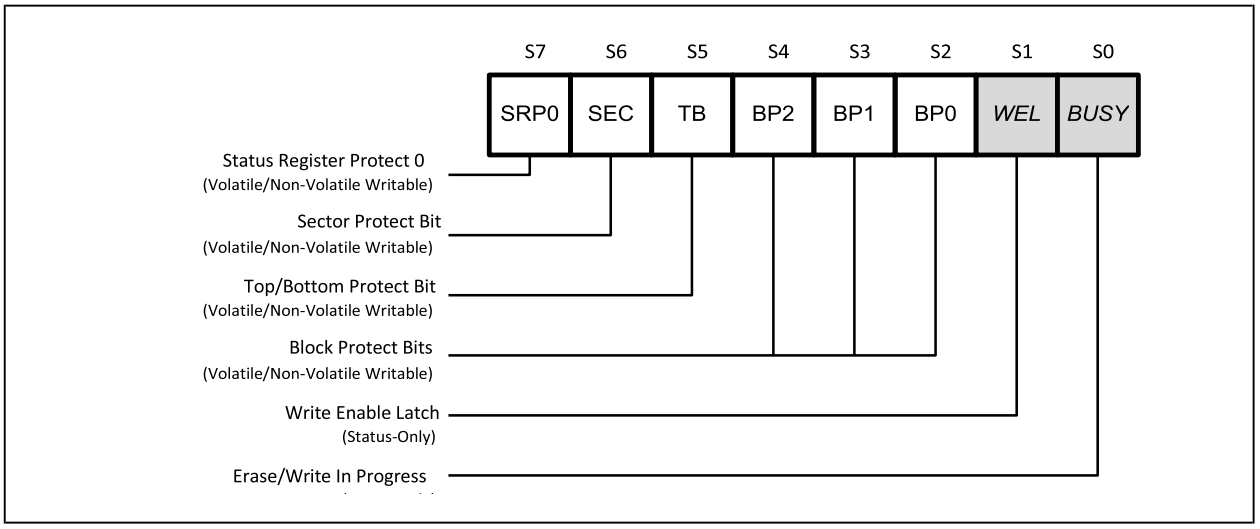


Figure 4a. Status Register-1

7.1.1. Erase/Write In Progress (BUSY) – *Status Only*

BUSY is a read only bit in the status register (S0) that is set to a 1 state when the device is executing a Page Program, Quad Page Program, Sector Erase, Block Erase, Chip Erase, Write Status Register or Erase/Program Security Register instruction. During this time the device will ignore further instructions except for the Read Status Register and Erase/Program Suspend instruction (see t_W, t_{PP}, t_{SE}, t_{BE}, and t_{CE} in AC Characteristics). When the program, erase or write status/security register instruction has completed, the BUSY bit will be cleared to a 0 state indicating the device is ready for further instructions.

7.1.2. Write Enable Latch (WEL) – *Status Only*

Write Enable Latch (WEL) is a read only bit in the status register (S1) that is set to 1 after executing a Write Enable Instruction. The WEL status bit is cleared to 0 when the device is write disabled. A write disable state occurs upon power-up or after any of the following instructions: Write Disable, Page Program, Quad Page Program, Sector Erase, Block Erase, Chip Erase, Write Status Register, Erase Security Register and Program Security Register.

7.1.3. Block Protect Bits (BP2, BP1, BP0) – *Volatile/Non-Volatile Writable*

The Block Protect Bits (BP2, BP1, BP0) are non-volatile read/write bits in the status register (S4, S3, and S2) that provide Write Protection control and status. Block Protect bits can be set using the Write Status Register Instruction (see t_W in AC characteristics). All, none or a portion of the memory array can be protected from Program and Erase instructions (see Status Register Memory Protection table). The factory default setting for the Block Protection Bits is 0, none of the array protected.

7.1.4. Top/Bottom Block Protect (TB) – *Volatile/Non-Volatile Writable*

The non-volatile Top/Bottom bit (TB) controls if the Block Protect Bits (BP2, BP1, BP0) protect from the Top (TB=0) or the Bottom (TB=1) of the array as shown in the Status Register Memory Protection table. The factory default setting is TB=0. The TB bit can be set with the Write Status Register Instruction depending on the state of the SRP0, SRP1 and WEL bits.

7.1.5. Sector/Block Protect Bit (SEC) – *Volatile/Non-Volatile Writable*

The non-volatile Sector/Block Protect bit (SEC) controls if the Block Protect Bits (BP2, BP1, BP0) protect either 4KB Sectors (SEC=1) or 64KB Blocks (SEC=0) in the Top (TB=0) or the Bottom (TB=1) of the array as shown in the Status Register Memory Protection table. The default setting is SEC=0.

7.1.6. Complement Protect (CMP) – Volatile/Non-Volatile Writable

The Complement Protect bit (CMP) is a non-volatile read/write bit in the status register (S14). It is used in conjunction with SEC, TB, BP2, BP1 and BP0 bits to provide more flexibility for the array protection. Once CMP is set to 1, previous array protection set by SEC, TB, BP2, BP1 and BP0 will be reversed. For instance, when CMP=0, a top 64KB block can be protected while the rest of the array is not; when CMP=1, the top 64KB block will become unprotected while the rest of the array become read-only. Please refer to the Status Register Memory Protection table for details. The default setting is CMP=0.

7.1.7. Status Register Protect (SRP1, SRP0) – *Volatile/Non-Volatile Writable*

The Status Register Protect bits (SRP1 and SRP0) are non-volatile read/write bits in the status register (S8 and S7). The SRP bits control the method of write protection: software protection, hardware protection, power supply lock-down or one time programmable (OTP) protection.

SRP1	SRP0	/WP	Status Register	Description
0	0	X	Software Protection	/WP pin has no control. The Status register can be written to after a Write Enable instruction, WEL=1. [Factory Default]
0	1	0	Hardware Protected	When /WP pin is low the Status Register locked and cannot be written to.
0	1	1	Hardware Unprotected	When /WP pin is high the Status register is unlocked and can be written to after a Write Enable instruction, WEL=1.
1	0	X	Power Supply Lock-Down	Status Register is protected and cannot be written to again until the next power-down, power-up cycle.(1)
1	1	X	One Time Program(2)	Status Register is permanently protected and cannot be written.

Notes:

1. When Non-Volatile SRP1, SRP0 = (1, 0), a power-down, power-up cycle will change Volatile SRP1, SRP0 to (0, 0) state.
2. This feature is available upon special order. Please contact Dosilicon for details.

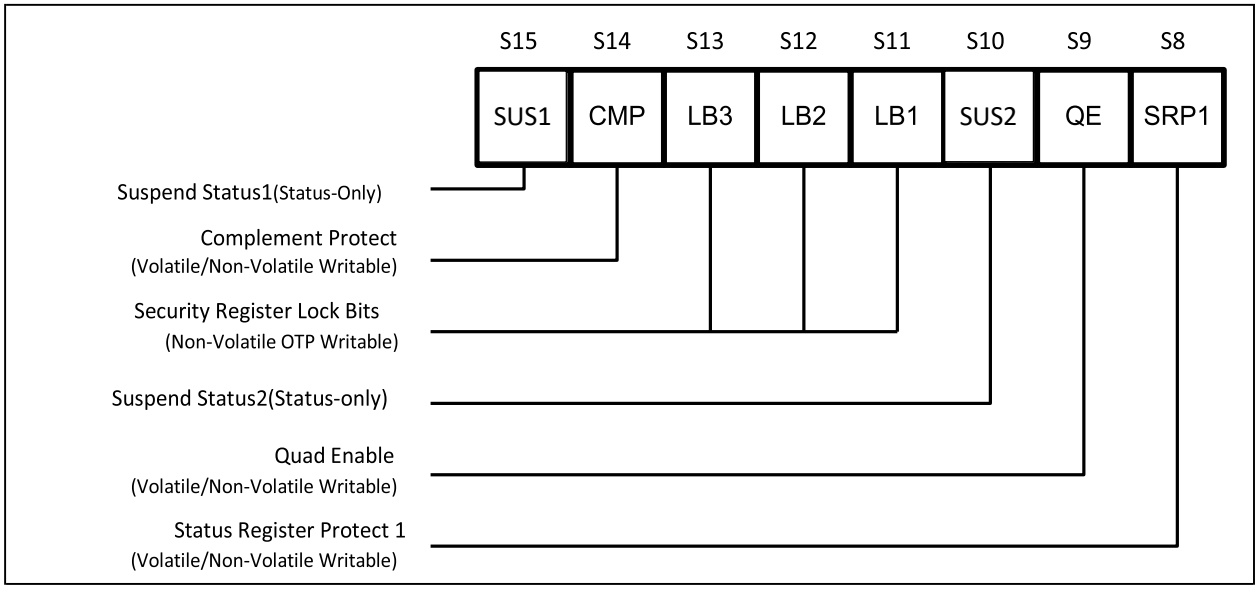


Figure 4b. Status Register-2

7.1.8. Erase/Program Suspend Status (SUS) –SUS1, SUS2 bits- *Status Only*

The SUS1 and SUS2 bits are read only bits in the status register (S15 and S10) that are set to 1 after executing an Erase/ Program Suspend (75H) command (The Erase Suspend will set the SUS1 bit to 1, and the Program Suspend will set the SUS2 bit to 1). The SUS1 and SUS2 bits are cleared to 0 by Erase/Program Resume (7AH) command, software reset (66H+99H) command, as well as a power-down, power-up cycle.

7.1.9. Security Register Lock Bits (LB3, LB2, LB1) – *Non-Volatile OTP Writable*

The Security Register Lock Bits (LB3, LB2, LB1) are non-volatile One Time Program (OTP) bits in Status Register (S13, S12, S11) that provide the write protect control and status to the Security Registers. The default state of LB3-1 is 0, Security Registers are unlocked. LB3-1 can be set to 1 individually using the Write Status Register instruction. LB3-1 are One Time Programmable (OTP), once it's set to 1, the corresponding 1024-Byte Security Register will become read-only permanently. LB[3:1] cannot be changed from "1" to "0" because of the OTP protection for these bits.

7.1.10. Quad Enable (QE) – Volatile/Non-Volatile Writable

The Quad Enable (QE) bit is a non-volatile read/write bit in the status register (S9) that allows Quad SPI and QPI operation. When the QE bit is set to a 0 state, the /WP pin and /HOLD are enabled. When the QE bit is set to a 1, the Quad IO2 and IO3 pins are enabled, and /WP and /HOLD functions are disabled.

QE bit is required to be set to a 1 before issuing an "Enter QPI (38h)" to switch the device from Standard/Dual/Quad SPI to QPI, otherwise the command will be ignored.

WARNING: If the /WP or /HOLD pins are tied directly to the power supply or ground during standard SPI or Dual SPI operation, the QE bit should never be set to a 1.

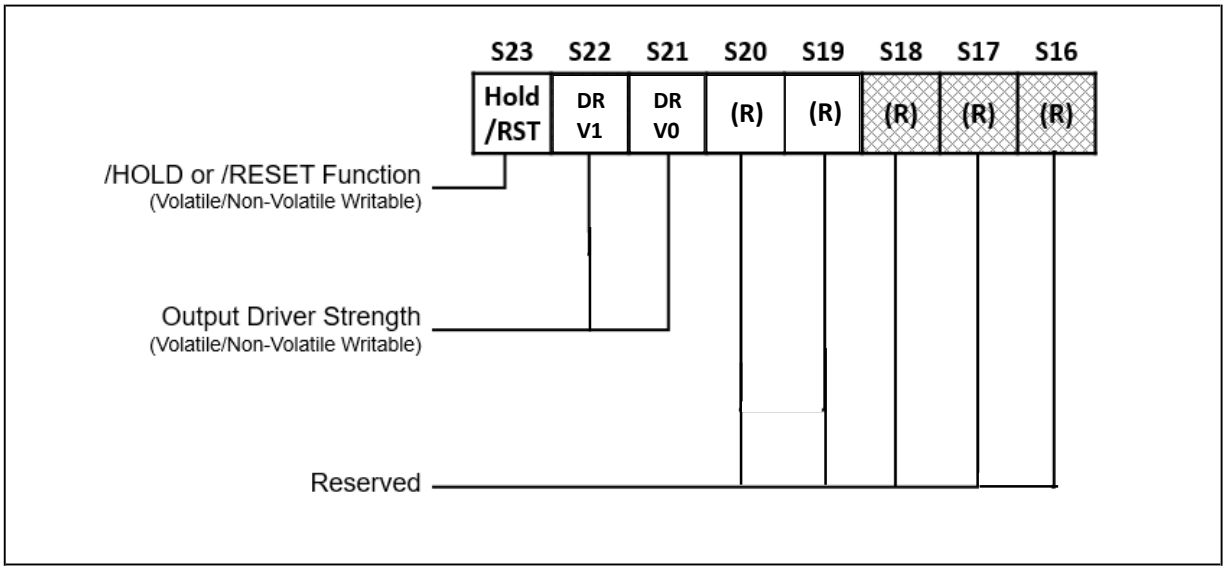


Figure 4c. Status Register-3

7.1.11. Output Driver Strength (DRV1 & DRV0) – *Volatile/Non-Volatile Writable*

The Oupput Driver Strength (DRV1 & DRV0) bits are used to determine the output driver strength for the Read operations.

DRV1	DRV0	Driver Strength
0	0	25%
0	1	50%
1	0	75%(default)
1	1	100%

7.1.12. /HOLD or /RESET Pin Function (HOLD/RST) – *Volatile/Non-Volatile Writable*

The HOLD/RST bit is used to determine whether /HOLD or /RESET function should be implemented on the hardware pin for 8-pin packages. When HOLD/RST=0 (factory default), the pin acts as /HOLD; when HOLD/RST=1, the pin acts as /RESET. However, /HOLD or /RESET functions are only available when QE=0. If QE is set to 1, the /HOLD and /RESET functions are disabled, the pin acts as a dedicated data I/O pin.

7.1.13. Reserved Bits – *Non Functional*

There are a few reserved Status Register bits that may be read out as a "0" or "1". It is recommended to ignore the values of those bits. During a "Write Status Register" instruction, the Reserved Bits can be written as "0", but there will not be any effects.

7.1.14. DS25M4AE Status Register Memory Protection (CMP = 0)

Status Register Content					Memory Content			
SEC	TB	BP2	BP1	BP0	Blocks	Addresses	Density	Portion
X	X	0	0	0	NONE	NONE	NONE	NONE
0	0	0	0	1	252 to 255	FC0000H-FFFFFFH	256KB	Upper 1/64
0	0	0	1	0	248 to 255	F80000H-FFFFFFH	512KB	Upper 1/32
0	0	0	1	1	240 to 255	F00000H-FFFFFFH	1MB	Upper 1/16
0	0	1	0	0	224 to 255	E00000H-FFFFFFH	2MB	Upper 1/8
0	0	1	0	1	192 to 255	C00000H-FFFFFFH	4MB	Upper 1/4
0	0	1	1	0	128 to 255	800000H-FFFFFFH	8MB	Upper 1/2
0	1	0	0	1	0 to 3	000000H-03FFFFH	256KB	Lower 1/64
0	1	0	1	0	0 to 7	000000H-07FFFFH	512KB	Lower 1/32
0	1	0	1	1	0 to 15	000000H-0FFFFFH	1MB	Lower 1/16
0	1	1	0	0	0 to 31	000000H-1FFFFFH	2MB	Lower 1/8
0	1	1	0	1	0 to 63	000000H-3FFFFFH	4MB	Lower 1/4
0	1	1	1	0	0 to 127	000000H-7FFFFFH	8MB	Lower 1/2
X	X	1	1	1	0 to 255	000000H-FFFFFFH	16MB	ALL
1	0	0	0	1	255	FFF000H-FFFFFFH	4KB	Top Block
1	0	0	1	0	255	FFE000H-FFFFFFH	8KB	Top Block
1	0	0	1	1	255	FFC000H-FFFFFFH	16KB	Top Block
1	0	1	0	X	255	FF8000H-FFFFFFH	32KB	Top Block
1	0	1	1	0	255	FF8000H-FFFFFFH	32KB	Top Block
1	1	0	0	1	0	000000H-000FFFH	4KB	Bottom Block
1	1	0	1	0	0	000000H-001FFFH	8KB	Bottom Block
1	1	0	1	1	0	000000H-003FFFH	16KB	Bottom Block
1	1	1	0	X	0	000000H-007FFFH	32KB	Bottom Block
1	1	1	1	0	0	000000H-007FFFH	32KB	Bottom Block

Notes:

1. X = don't care
2. L = Lower; U = Upper
3. If any Erase or Program command specifies a memory region that contains protected data portion, this command will be ignored

7.1.15. DS25M4AE Status Register Memory Protection (CMP = 1)

Status Register Content					Memory Content			
SEC	TB	BP2	BP1	BP0	Blocks	Addresses	Density	Portion
X	X	0	0	0	0 to 255	000000H-FFFFFFH	ALL	ALL
0	0	0	0	1	0 to 251	000000H-FBFFFFH	16128KB	Lower 63/64
0	0	0	1	0	0 to 247	000000H-F7FFFFH	15872KB	Lower 31/32
0	0	0	1	1	0 to 239	000000H-EFFFFFH	15MB	Lower 15/16
0	0	1	0	0	0 to 223	000000H-DFFFFFH	14MB	Lower 7/8
0	0	1	0	1	0 to 191	000000H-BFFFFFH	12MB	Lower 3/4
0	0	1	1	0	0 to 127	000000H-7FFFFFH	8MB	Lower 1/2
0	1	0	0	1	4 to 255	040000H-FFFFFFH	16128KB	Upper 63/64
0	1	0	1	0	8 to 255	080000H-FFFFFFH	15872KB	Upper 31/32
0	1	0	1	1	16 to 255	100000H-FFFFFFH	15MB	Upper 15/16
0	1	1	0	0	32 to 255	200000H-FFFFFFH	14MB	Upper 7/8
0	1	1	0	1	64 to 255	400000H-FFFFFFH	12MB	Upper 3/4
0	1	1	1	0	128 to 255	800000H-FFFFFFH	8MB	Upper 1/2
X	X	1	1	1	NONE	NONE	NONE	NONE
1	0	0	0	1	0 to 255	000000H-FFEFFFH	16380KB	L-4095/4096
1	0	0	1	0	0 to 255	000000H-FFDFFFH	16376KB	L-2047/2048
1	0	0	1	1	0 to 255	000000H-FFBFFFH	16368KB	L-1023/1024
1	0	1	0	X	0 to 255	000000H-FF7FFFH	16352KB	L-511/512
1	0	1	1	0	0 to 255	000000H-FF7FFFH	16352KB	L-511/512
1	1	0	0	1	0 to 255	001000H-FFFFFFH	16380KB	U-4095/4096
1	1	0	1	0	0 to 255	002000H-FFFFFFH	16376KB	U-2047/2048
1	1	0	1	1	0 to 255	004000H-FFFFFFH	16368KB	U-1023/1024
1	1	1	0	X	0 to 255	008000H-FFFFFFH	16352KB	U-511/512
1	1	1	1	0	0 to 255	008000H-FFFFFFH	16352KB	U-511/512

Notes:

1. X = don't care
2. L = Lower; U = Upper
3. If any Erase or Program command specifies a memory region that contains protected data portion, this command will be ignored

8. INSTRUCTIONS

The Standard/Dual/Quad SPI instruction set of the DS25M4AE consists of 43 basic instructions that are fully controlled through the SPI bus (see Instruction Set Table1-2). Instructions are initiated with the falling edge of Chip Select (/CS). The first byte of data clocked into the DI input provides the instruction code. Data on the DI input is sampled on the rising edge of clock with most significant bit (MSB) first.

The QPI instruction set of the DS25M4AE consists of 36 basic instructions that are fully controlled through the SPI bus (see Instruction Set Table). Instructions are initiated with the falling edge of Chip Select (/CS). The first byte of data clocked through IO[3:0] pins provides the instruction code. Data on all four IO pins are sampled on the rising edge of clock with most significant bit (MSB) first. All QPI instructions, addresses, data and dummy bytes are using all four IO pins to transfer every byte of data with every two serial clocks(CLK).

Instructions vary in length from a single byte to several bytes and may be followed by address bytes, data bytes, dummy bytes (don't care), and in some cases, a combination. Instructions are completed with the rising edge of edge /CS. Clock relative timing diagrams for each instruction are included in Figures in 8.2. All read instructions can be completed after any clocked bit. However, all instructions that Write, Program or Erase must complete on a byte boundary (/CS driven high after a full 8-bits have been clocked) otherwise the instruction will be ignored. This feature further protects the device from inadvertent writes. Additionally, while the memory is being programmed or erased, or when the Status Register is being written, all instructions except for Read Status Register will be ignored until the program or erase cycle has completed.

8.1. Device ID and Instruction Set Tables

8.1.1. Manufacturer and Device Identification

DS25M4AE

Operation Code	MID7-MID0	ID15-ID8	ID7-ID0
9FH	E5	41	18
90H	E5		17
ABH			17

8.1.2. Instruction Set Table (Standard/Dual/Quad SPI Instructions)

Command Name	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
Write Enable	06H								
Write Disable	04H								
Read Status Register-1	05H	(S7-S0)	(cont.)						
Read Status Register-2	35H	(S15-S8)	(cont.)						
Read Status Register-3	15H	(S23-S15)	(cont.)						
Write Status Register-1&2	01H	S7-S0	S15-S8						
Write Status Register-2	31H	S15-S8							
Write Status Register-3	11H	S23-S15							
Volatile SR write Enable	50H								
Read Data	03H	A23-A16	A15-A8	A7-A0	(D7-D0)	(cont.)			
Fast Read	0BH	A23-A16	A15-A8	A7-A0	dummy (8 clk)	(D7-D0)	(cont.)		
Dual Output Fast Read	3BH	A23-A16	A15-A8	A7-A0	dummy (8 clk)	(D7-D0)[1]	(cont.)		
Quad Output Fast Read	6BH	A23-A16	A15-A8	A7-A0	dummy (8 clk)	(D7-D0)[2]	(cont.)		
Dual I/O Fast Read	BBH	A23-A16[3]	A15-A8[3]	A7-A0[3]	M7-M0[4] (4 clk)	dummy[12] (0/4 clk)	(D7-D0)[1]	(cont.)	
Quad I/O Fast Read	EBH	A23-A16[5]	A15-A8[5]	A7-A0[5]	M7-M0[6] (2 clk)	dummy[12] (4/6 clk)	(D7-D0)[2]	(cont.)	
Quad I/O WORD Fast Read	E7H	A23-A16[5]	A15-A8[5]	A7-A0[5]	M7-M0[6] (2 clk)	dummy (4 clk)	(D7-D0)[2]	(cont.)	
Set Burst with Wrap	77H	dummy[7]	dummy[7]	dummy[7]	W7-W0[7]				
Page Program	02H	A23-A16	A15-A8	A7-A0	D7-D0	Next Byte			
Quad Input Page Program	32H	A23-A16	A15-A8	A7-A0	D7-D0[8]	Next Byte			
Sector Erase	20H	A23-A16	A15-A8	A7-A0					
Block Erase (32K)	52H	A23-A16	A15-A8	A7-A0					
Block Erase (64K)	D8H	A23-A16	A15-A8	A7-A0					
Chip Erase	C7/60H								
Read Manufacturer/ Device ID	90H	00H	00H	00H	(MID7-MID0)	(ID7-ID0)	(cont.)		
Read Manufacturer/Device ID Dual IO	92H	00H	00H	00H	M7-M0[6] (4 clk)	dummy (4 clk)	(MID7-MID0)	(ID7-ID0)	(cont.)

Read Manufacturer/Device ID Quad IO	94H	00H	00H	00H	M7-M0[6] (2 clk)	dummy (6 clk)	(MID7-MID0)	(ID7-ID0)	(cont.)
Read Identification	9FH	(MID7-MID0)	(ID15-ID8)	(ID7-ID0)	(cont.)				
Read Unique ID	4BH	00H	00H	00H	dummy (8 clk)	(UID7-UID0)	(cont.)		
Erase Security Registers[9]	44H	A23-A16	A15-A8	A7-A0					
Program Security Registers[9]	42H	A23-A16	A15-A8	A7-A0	D7-D0	Next Byte			
Read Security Registers[9]	48H	A23-A16	A15-A8	A7-A0	dummy (8 clk)	(D7-D0)	(cont.)		
Enable Reset	66H								
Reset	99H								
Program/Erase Suspend	75H								
Program/Erase Resume	7AH								
Deep Power-Down	B9H								
Release From Deep Power-Down	ABH								
Release From Deep Power-Down and Read Device ID	ABH	dummy	dummy	dummy	(ID7-ID0)	(cont.)			
Enable QPI	38H								
Read Serial Flash Discoverable Parameter	5AH	A23-A16	A15-A8	A7-A0	dummy (8 clk)	(D7-D0)	(cont.)		
DTR read	0DH	A23-A0, 1 dtr input 12 cycles			dummy (6 clk)				
DTR Dual IO read	BDH	A23-A0, 2 dtr input 6 cycles			M7-M0+dummy (2+6 clks)				
DTR Quad IO read	EDH	A23-A0, 4 dtr input 3 cycles			M7-M0+dummy (1+9 clks)				

8.1.3. Instruction Set Table (QPI Instructions)

Command Name	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
Clock Number	(0,1)	(2,3)	(4,5)	(6,7)	(8,9)	(10,11)	(12,13)	(14,15)
Write Enable	06H							
Write Disable	04H							
Read Status Register-1	05H	(S7-S0)						
Read Status Register-2	35H	(S15-S8)						
Read Status Register-3	15H	(S23-S15)						
Write Status Register-1&2	01H	S7-S0	S15-S8					
Write Status Register-2	31H	S15-S8						
Write Status Register-3	11H	S23-S15						
Volatile SR Write Enable	50H							
Fast Read	0BH	A23-A16	A15-A8	A7-A0	dummy	dummy	(D7-D0)	(cont.)
Quad I/O Fast Read	EBH	A23-A16	A15-A8	A7-A0	M7-M0	dummy	(D7-D0)	(cont.)
Page Program	02H	A23-A16	A15-A8	A7-A0	D7-D0	Next Byte		
Sector Erase	20H	A23-A16	A15-A8	A7-A0				
Block Erase (32K)	52H	A23-A16	A15-A8	A7-A0				
Block Erase (64K)	D8H	A23-A16	A15-A8	A7-A0				
Chip Erase	C7/60H							
Set Read Parameters	C0H	P7-P0						
Burst Read with Wrap	0CH	A23-A16	A15-A8	A7-A0	dummy	dummy	(D7-D0)	(cont.)
Manufacturer/Device ID	90H	00H	00H	00H	(MID7-MID0)	(ID7-ID0)	(cont.)	
Read Identification	9FH	(MID7-MID0)	(ID15-ID8)	(ID7-ID0)	(cont.)			
Read Unique ID	4BH	00H	00H	00H	dummy (8 clk)	(UID7-UID0)	(cont.)	
Erase Security Registers[9]	44H	A23-A16	A15-A8	A7-A0				
Program Security Registers[9]	42H	A23-A16	A15-A8	A7-A0	D7-D0	Next Byte		
Read Security Registers[9]	48H	A23-A16	A15-A8	A7-A0	dummy	dummy	(D7-D0)	(cont.)
Enable Reset	66H							
Reset	99H							
Program/Erase Suspend	75H							
Program/Erase Resume	7AH							
Deep Power-Down	B9H							

Release From Deep Power-Down	ABH							
Release From Deep Power-Down, And Read Device ID	ABH	dummy	dummy	dummy	(ID7-ID0)	(cont.)		
Disable QPI	FFH							
Read Serial Flash Discoverable Parameter	5AH	A23-A16	A15-A8	A7-A0	dummy	dummy	(D7-D0)	(cont.)
DTR read	0DH	A23-A0, 4 dtr input 3 cycles			dummy	dummy		
DTR wrap read	0EH	A23-A0, 4 dtr input 3 cycles			dummy	dummy		
DTR Quad IO read	EDH	A23-A0, 4 dtr input 3 cycles			dummy	dummy		

Note:

1. Dual Output data

IO0 = (D6, D4, D2, D0)

IO1 = (D7, D5, D3, D1)

2. Quad Output Data

IO0 = (D4, D0, …)

IO1 = (D5, D1, …)

IO2 = (D6, D2, …)

IO3 = (D7, D3, …)

3. Dual Input Address

IO0 = A22, A20, A18, A16, A14, A12, A10, A8 A6, A4, A2, A0

IO1 = A23, A21, A19, A17, A15, A13, A11, A9 A7, A5, A3, A1

4. Dual Input Mode bit

IO0 = M6, M4, M2, M0

IO1 = M7, M5, M3, M1

5. Quad Input Address

IO0 = A20, A16, A12, A8, A4, A0

IO1 = A21, A17, A13, A9, A5, A1

IO2 = A22, A18, A14, A10, A6, A2

IO3 = A23, A19, A15, A11, A7, A3

6. Quad Input Mode bit

IO0 = M4, M0

IO1 = M5, M1

IO2 = M6, M2

IO3 = M7, M3

7. Dummy bits and Wrap Bits

IO0 = (x, x, x, x, x, x, W4, x)

IO1 = (x, x, x, x, x, x, W5, x)

IO2 = (x, x, x, x, x, x, W6, x)

IO3 = (x, x, x, x, x, x, x, x)

8. Quad Output Data

IO0 = D4, D0, …

IO1 = D5, D1, …

IO2 = D6, D2, …

IO3 = D7, D3, …

9. Security Registers Address

Security Register1: A23-A16=00H, A15-A12=1H, A11-A10 = 00b, A9-A0= Byte Address;

Security Register2: A23-A16=00H, A15-A12=2H, A11-A10 = 00b, A9-A0= Byte Address;

Security Register3: A23-A16=00H, A15-A12=3H, A11-A10 = 00b, A9-A0= Byte Address;

10. QPI Command, Address, Data input/output format:

CLK # 0 1 2 3 4 5 6 7 8 9 10 11

IO0= C4, C0, A20, A16, A12, A8, A4, A0, D4, D0, D4, D0,

IO1= C5, C1, A21, A17, A13, A9, A5, A1, D5, D1, D5, D1

IO2= C6, C2, A22, A18, A14, A10, A6, A2, D6, D2, D6, D2

IO3= C7, C3, A23, A19, A15, A11, A7, A3, D7, D3, D7, D3

11. All dummy that not specific mark how many dummy clocks can be configured(if there is “Continuous Read Mode” bits M7-0, also considered as dummy clock), please refer 8.2.47.

12. The number of dummy clock of BBh/EBh in SPI instruction table can be set 0/4 or 4/6 (which do not include the M7-0) before delivery, if need specify which one exactly, please contact with us in advance.

8.2. Instruction Descriptions

8.2.1. Write Enable (06h)

The Write Enable instruction (Figure 5) sets the Write Enable Latch (WEL) bit in the Status Register to a 1. The WEL bit must be set prior to every Page Program, Quad Page Program, Sector Erase, Block Erase, Chip Erase, Write Status Register and Erase/Program Security Registers instruction. The Write Enable instruction is entered by driving /CS low, shifting the instruction code "06h" into the Data Input (DI) pin on the rising edge of CLK, and then driving /CS high.

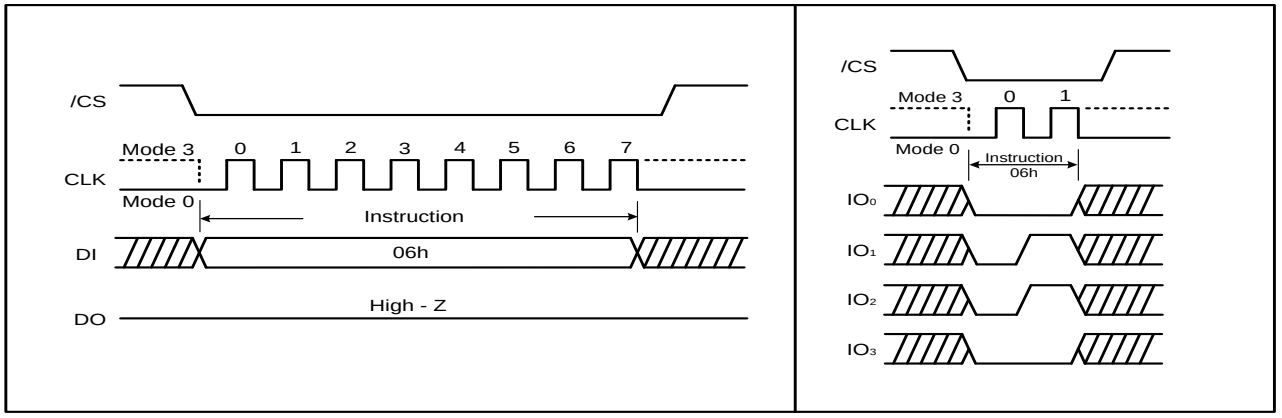


Figure 5. Write Enable Instruction for SPI Mode (left) or QPI Mode (right)

8.2.2. Write Enable for Volatile Status Register (50h)

The non-volatile Status Register bits described in section 7.1 can also be written to as volatile bits. This gives more flexibility to change the system configuration and memory protection schemes quickly without waiting for the typical non-volatile bit write cycles or affecting the endurance of the Status Register non-volatile bits. To write the volatile values into the Status Register bits, the Write Enable for Volatile Status Register (50h) instruction must be issued prior to a Write Status Register (01h) instruction. Write Enable for Volatile Status Register instruction (Figure 6) will not set the Write Enable Latch (WEL) bit, it is only valid for the Write Status Register instruction to change the volatile Status Register bit values.

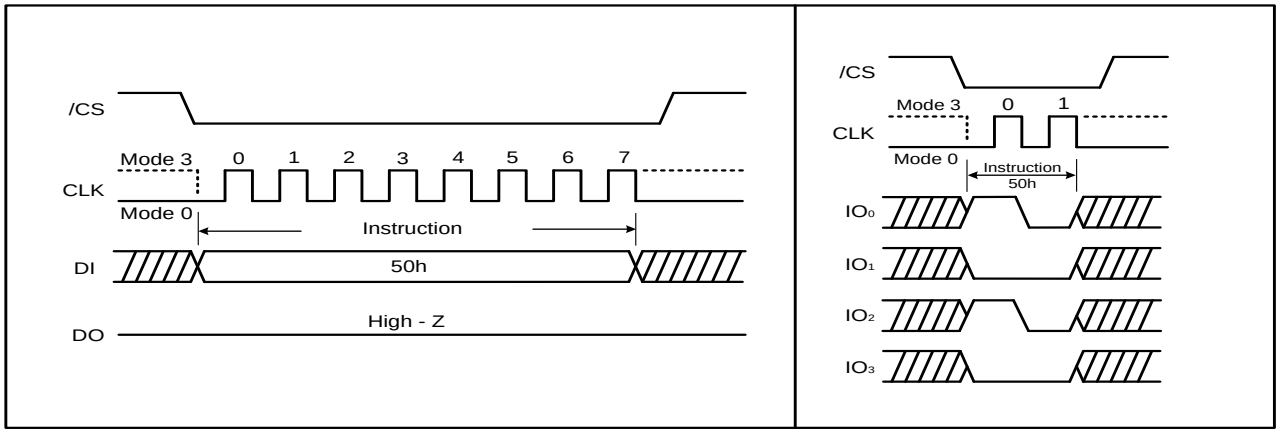


Figure 6. Write Enable for Volatile Status Register Instruction for SPI Mode (left) or QPI Mode (right)

8.2.3. Write Disable (04h)

The Write Disable instruction (Figure 7) resets the Write Enable Latch (WEL) bit in the Status Register to a 0. The Write Disable instruction is entered by driving /CS low, shifting the instruction code "04h" into the DI pin and then driving /CS high. Note that the WEL bit is automatically reset after Power-up and upon completion of the Write Status Register, Erase/Program Security Registers, Page Program, Quad Page Program, Sector Erase, Block Erase, Chip Erase and Reset instructions.

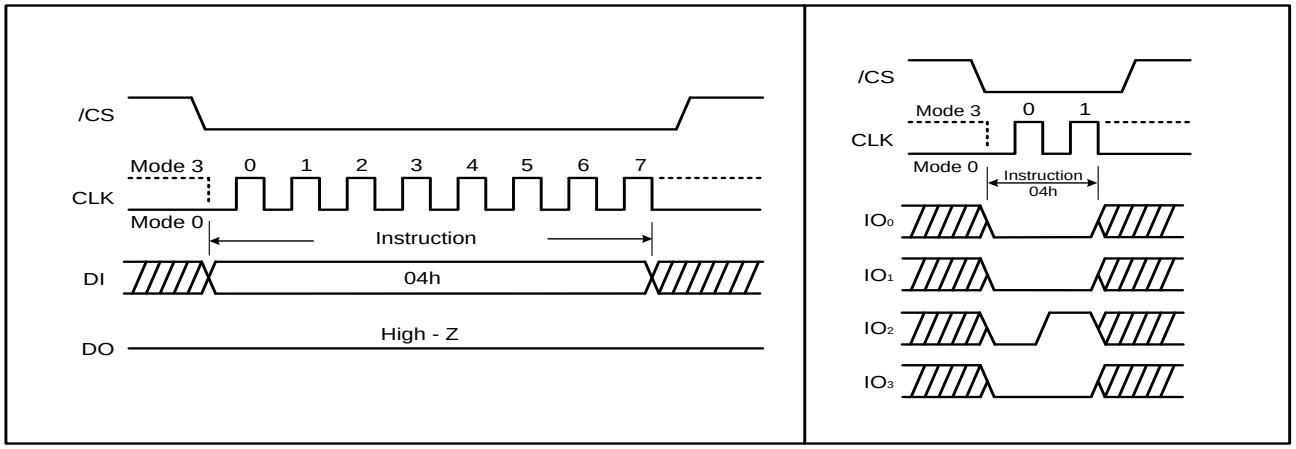


Figure 7. Write Disable Instruction for SPI Mode (left) or QPI Mode (right)

8.2.4. Read Status Register-1 (05h), Status Register-2 (35h) & Status Register-3 (15h)

The Read Status Register instructions allow the 8-bit Status Registers to be read. The instruction is entered by driving /CS low and shifting the instruction code "05h" for Status Register-1, "35h" for Status Register-2 or "15h" for Status Register-3 into the DI pin on the rising edge of CLK. The status register bits are then shifted out on the DO pin at the falling edge of CLK with most significant bit (MSB) first as shown in Figure 8. Refer to section 7.1 for Status Register descriptions.

The Read Status Register instruction may be used at any time, even while a Program, Erase or Write Status Register cycle is in progress. This allows the BUSY status bit to be checked to determine when the cycle is complete and if the device can accept another instruction. The Status Register can be read continuously, as shown in Figure 8. The instruction is completed by driving /CS high.

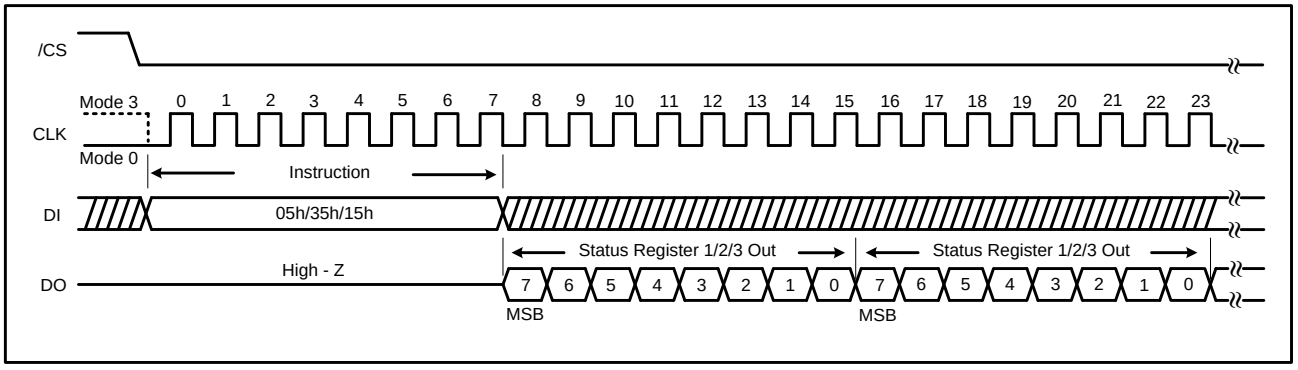


Figure 8a. Read Status Register Instruction (SPI Mode)

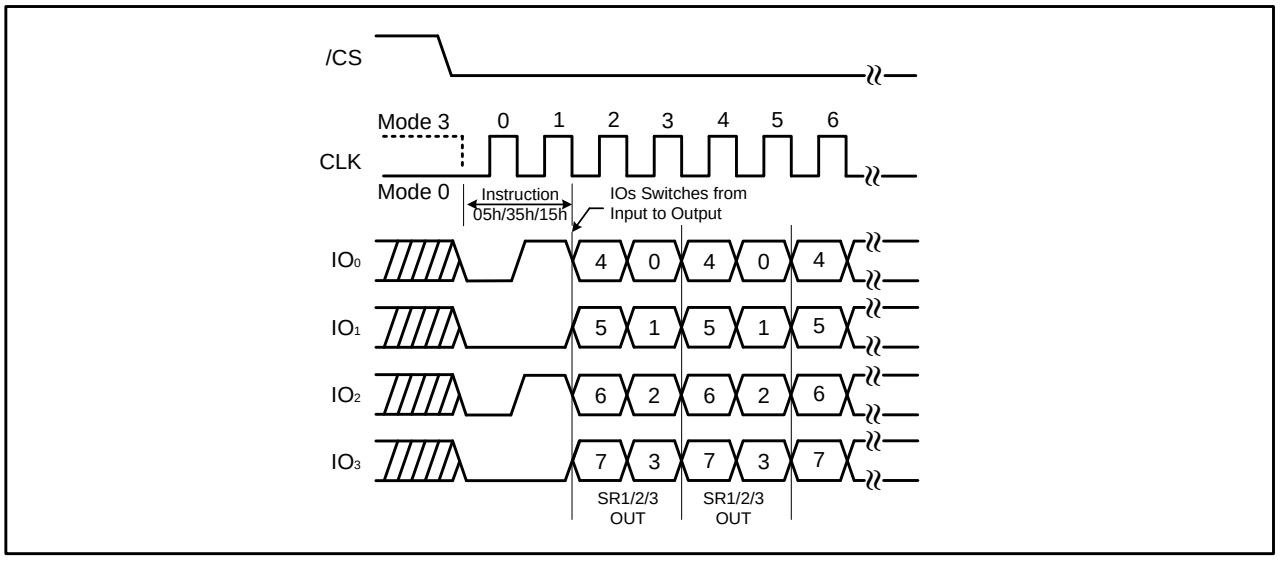


Figure 8b. Read Status Register Instruction (QPI Mode)

8.2.5. Write Status Register-1 (01h), Status Register-2 (31h) & Status Register-3 (11h)

The Write Status Register instruction allows the Status Registers to be written. The writable Status Register bits include: SRP0, SEC, TB, BP[2:0] in Status Register-1; CMP, LB[3:1], QE, SRP1 in Status Register-2; HOLD/RST, DRV in Status Register-3. All other Status Register bit locations are read-only and will not be affected by the Write Status Register instruction. LB[3:1] are non- volatile OTP bits, once it is set to 1, it cannot be cleared to 0.

To write non-volatile Status Register bits, a standard Write Enable (06h) instruction must previously have been executed for the device to accept the Write Status Register instruction (Status Register bit WEL must equal 1). Once write enabled, the instruction is entered by driving /CS low, sending the instruction code "01h/31h/11h", and then writing the status register data byte as illustrated in Figure 9a & 9b.

To write volatile Status Register bits, a Write Enable for Volatile Status Register (50h) instruction must have been executed prior to the Write Status Register instruction (Status Register bit WEL remains 0). Upon power off or the execution of a Software/Hardware Reset, the volatile Status Register bit values will be lost, and the non-volatile Status Register bit values will be restored.

During non-volatile Status Register write operation (06h combined with 01h/31h/11h), after /CS isdriven high, the self-timed Write Status Register cycle will commence for a time duration of tw (See AC Characteristics). While the Write Status Register cycle is in progress, the Read Status Register instruction may still be accessed to check the status of the BUSY bit. The BUSY bit is a 1 during the Write Status Register cycle and a 0 when the cycle is finished and ready to accept other instructions again. After the Write Status Register cycle has finished, the Write Enable Latch (WEL) bit in the Status Register will be cleared to 0.

During volatile Status Register write operation (50h combined with 01h/31h/11h), after /CS is driven high, the Status Register bits will be refreshed to the new values within the time period of t_{SHSL} (See AC Characteristics). BUSY bit will remain 0 during the Status Register bit refresh period.

The Write Status Register instruction can be used in both SPI mode and QPI mode. However, the QE bit cannot be written to when the device is in the QPI mode, because QE=1 is required for the device to enter and operate in the QPI mode.

Refer to section 7.1 for Status Register descriptions.

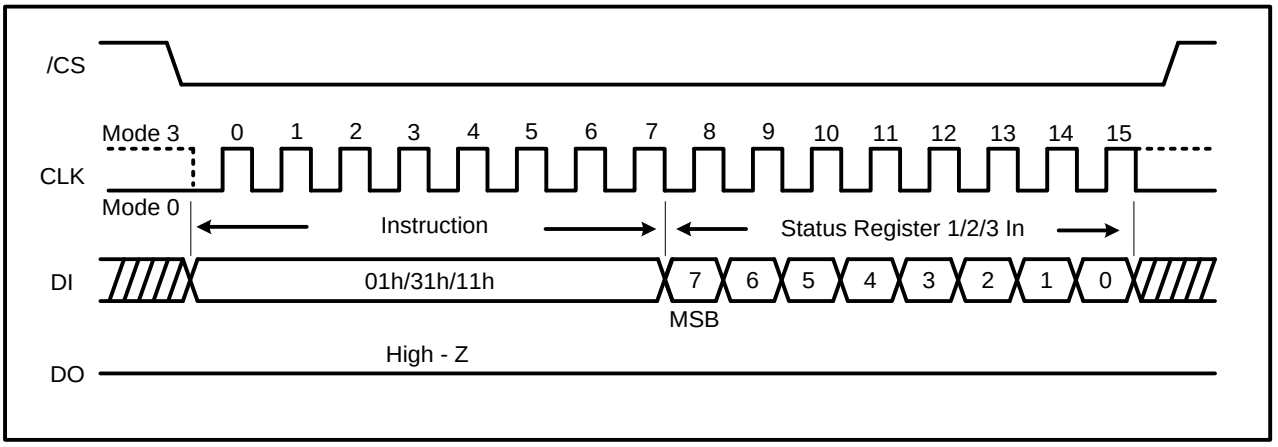


Figure 9a. Write Status Register-1/2/3 Instruction (SPI Mode)

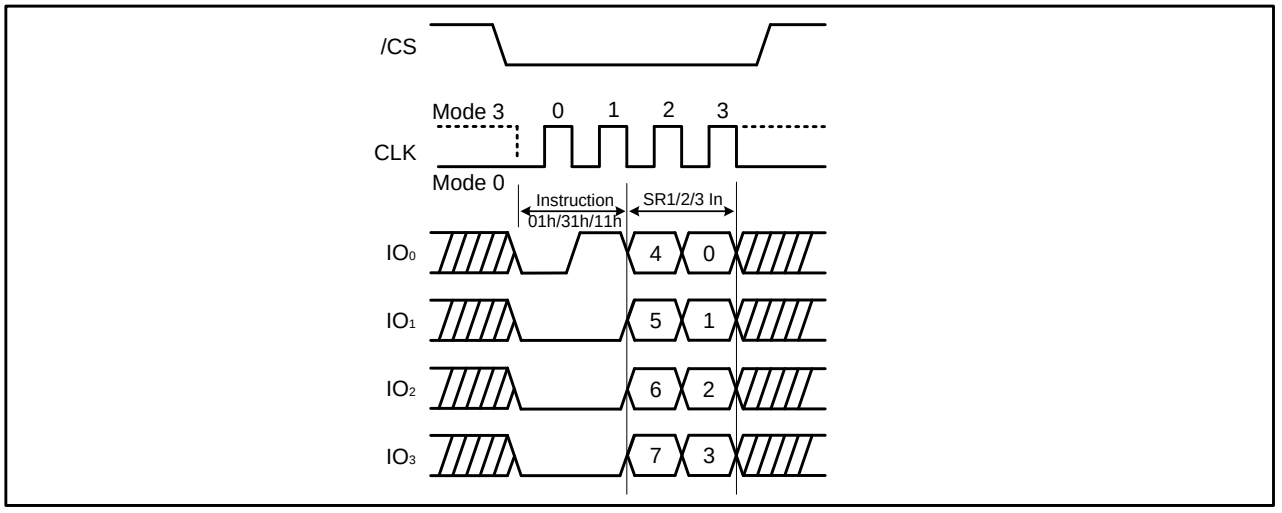


Figure 9b. Write Status Register-1/2/3 Instruction (QPI Mode)

The DS25M4AE is also backward compatible to Dosilicon's previous generations of serial flash memories, in which the Status Register-1&2 can be written using a single "Write Status Register-1 (01h)" command. To complete the Write Status Register-1&2 instruction, the /CS pin must be driven high after the sixteenth bit of data that is clocked in as shown in Figure 9c & 9d. If /CS is driven high after the eighth clock, the Write Status Register-1 (01h) instruction will only program the Status Register-1, the Status Register-2 will not be affected.

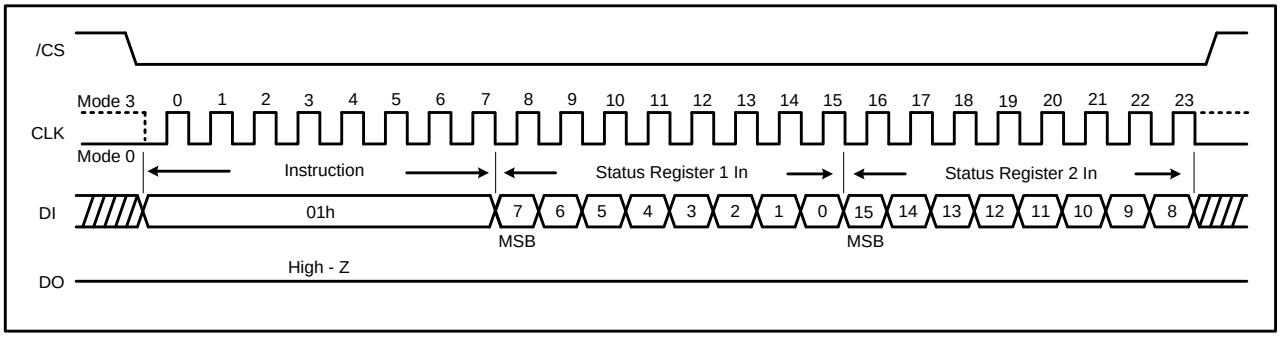


Figure 9c. Write Status Register-1/2 Instruction (SPI Mode)

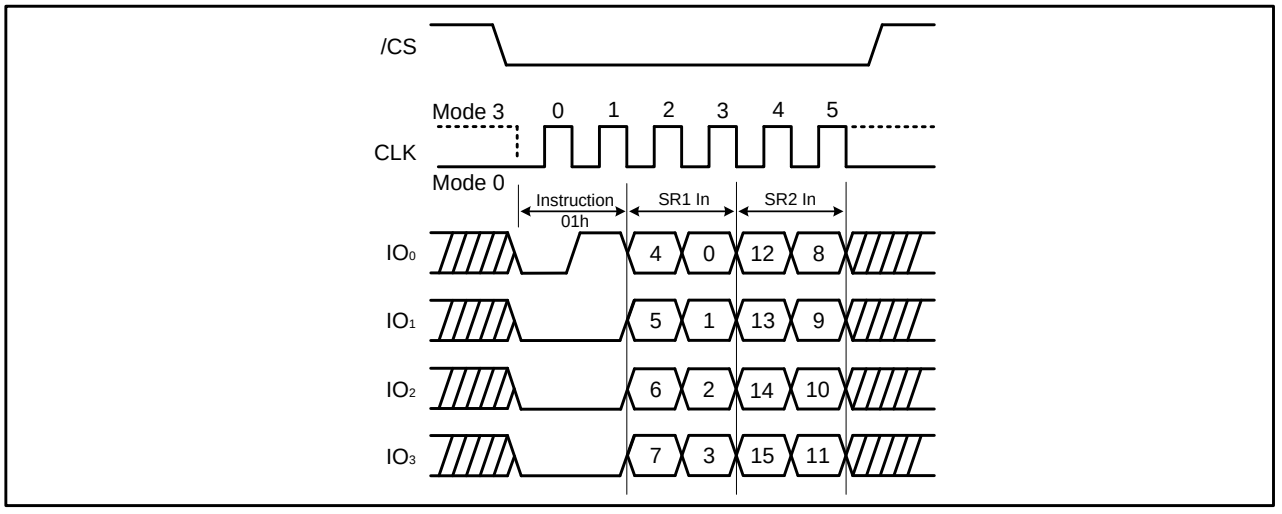


Figure 9d. Write Status Register-1/2 Instruction (QPI Mode)

8.2.6. Read Data (03h)

The Read Data instruction allows one or more data bytes to be sequentially read from the memory. The instruction is initiated by driving the /CS pin low and then shifting the instruction code “03h” followed by a 24-bit address (A23-A0) into the DI pin. The code and address bits are latched on the rising edge of the CLK pin. After the address is received, the data byte of the addressed memory location will be shifted out on the DO pin at the falling edge of CLK with most significant bit (MSB) first. The address is automatically incremented to the next higher address after each byte of data is shifted out allowing for a continuous stream of data. This means that the entire memory can be accessed with a single instruction as long as the clock continues. The instruction is completed by driving /CS high.

The Read Data instruction sequence is shown in Figure 10. If a Read Data instruction is issued while an Erase, Program or Write cycle is in process (BUSY=1) the instruction is ignored and will not have any effects on the current cycle. The Read Data instruction allows clock rates from D.C. to a maximum of f_R (see AC Electrical Characteristics).

The Read Data (03h) instruction is only supported in Standard SPI mode.

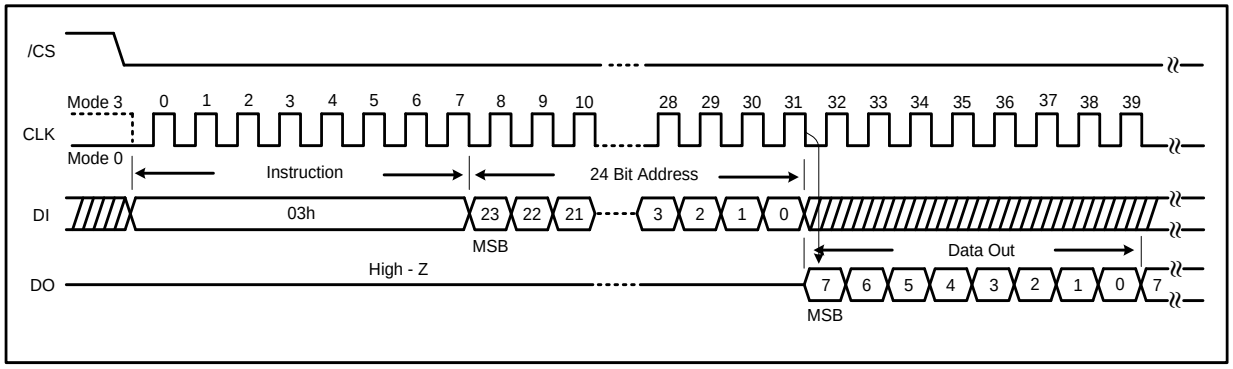


Figure 10. Read Data Instruction (SPI Mode only)

8.2.7. **Fast Read (0Bh)**

The Fast Read instruction is similar to the Read Data instruction except that it can operate at the highest possible frequency of F_R (see AC Electrical Characteristics). This is accomplished by adding eight "dummy" clocks after the 24-bit address as shown in Figure 11. The dummy clocks allow the devices internal circuits additional time for setting up the initial address. During the dummy clocks the data value on the DO pin is a "don't care".

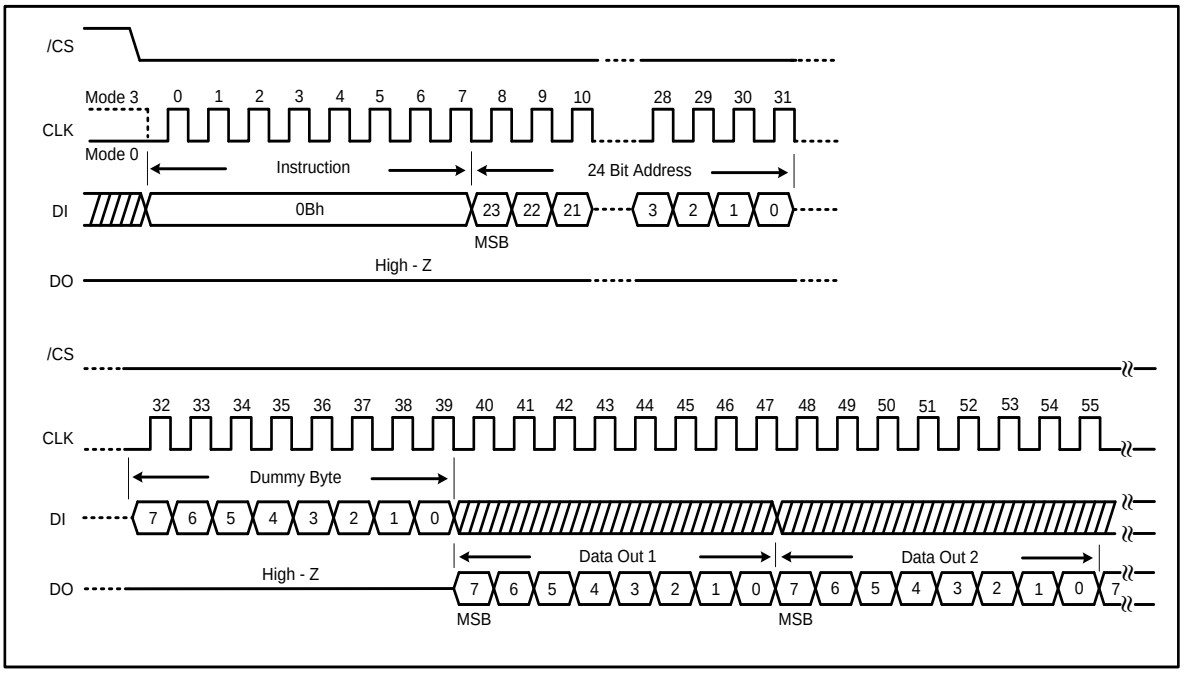


Figure 11a. Fast Read Instruction (SPI Mode)

8.2.8. Fast Read (0Bh) in QPI Mode

The Fast Read instruction is also supported in QPI mode. When QPI mode is enabled, the number of dummy clocks is configured by the "Set Read Parameters (C0h)" instruction to accommodate a wide range of applications with different needs for either maximum Fast Read frequency or minimum data access latency. Depending on the Read Parameter Bits P[5:4] setting, the number of dummy clocks can be configured as either 6 or 8. The default number of dummy clocks upon power up or after a Reset instruction is 8.

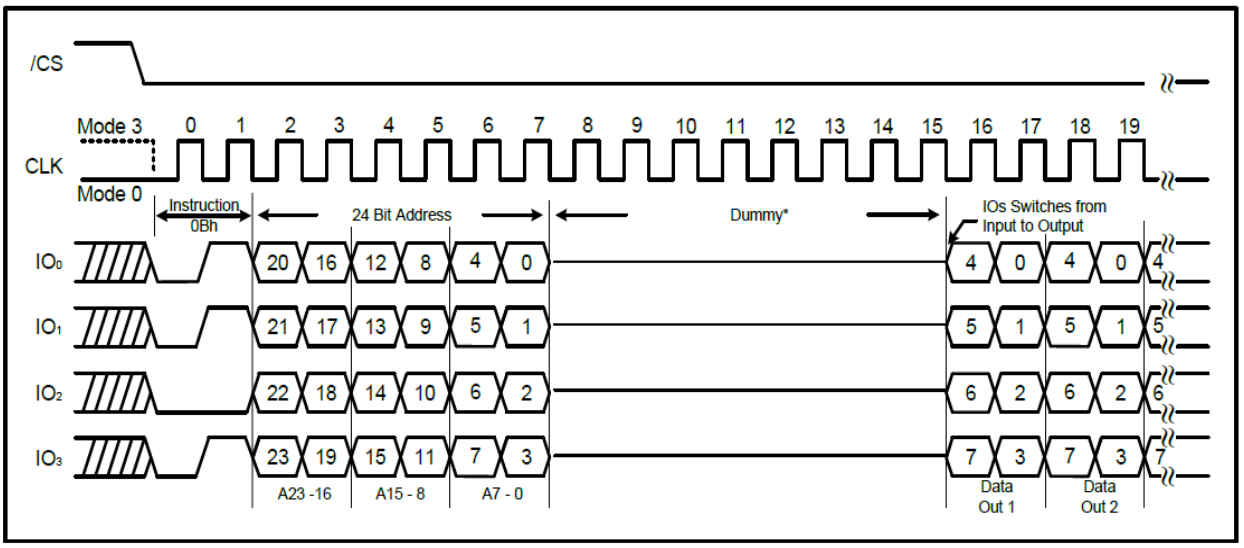


Figure 11b. Fast Read Instruction (QPI Mode)

8.2.9. Fast Read Dual Output (3Bh)

The Fast Read Dual Output (3Bh) instruction is similar to the standard Fast Read (0Bh) instruction except that data is output on two pins; IO_0 and IO_1. This allows data to be transferred at twice the rate of standard SPI devices. The Fast Read Dual Output instruction is ideal for quickly downloading code from Flash to RAM upon power-up or for applications that cache code-segments to RAM for execution.

Similar to the Fast Read instruction, the Fast Read Dual Output instruction can operate at the highest possible frequency of F_R (see AC Electrical Characteristics). This is accomplished by adding eight “dummy” clocks after the 24-bit address as shown in Figure 12. The dummy clocks allow the device's internal circuits additional time for setting up the initial address. The input data during the dummy clocks is “don’t care”. However, the IO_0 pin should be high-impedance prior to the falling edge of the first data out clock.

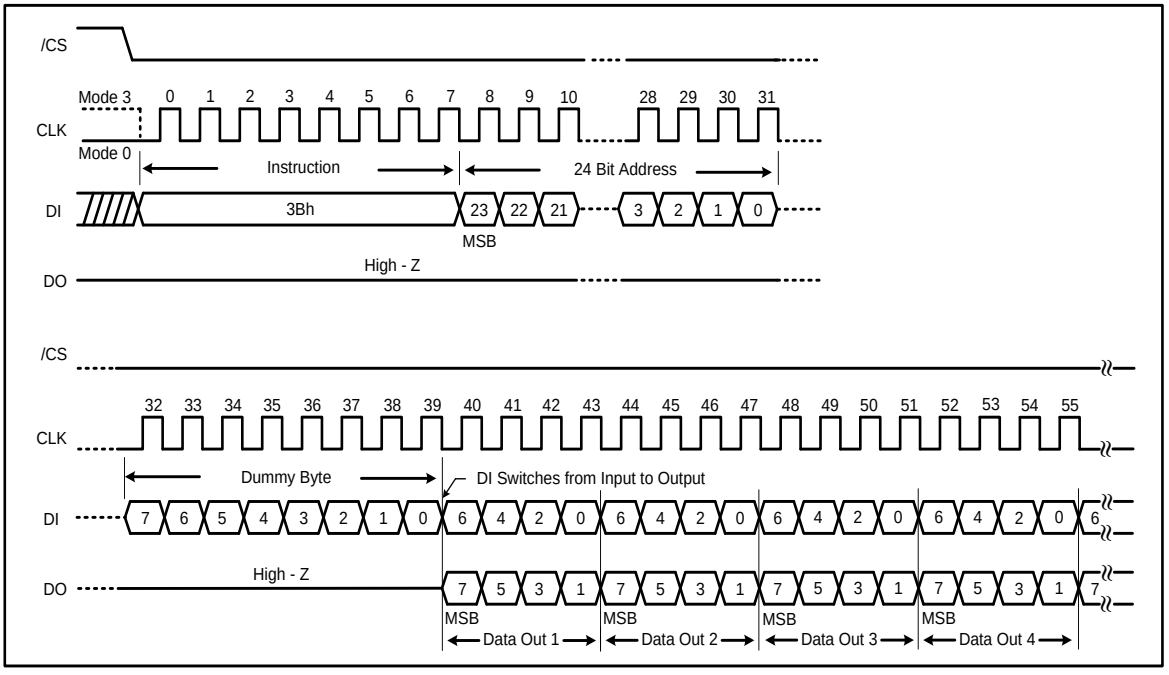


Figure 12. Fast Read Dual Output Instruction (SPI Mode only)

8.2.10. **Fast Read Quad Output (6Bh)**

The Fast Read Quad Output (6Bh) instruction is similar to the Fast Read Dual Output (3Bh) instruction except that data is output on four pins, IO_0, IO_1, IO_2, and IO_3. The Quad Enable (QE) bit in Status Register-2 must be set to 1 before the device will accept the Fast Read Quad Output Instruction. The Fast Read Quad Output Instruction allows data to be transferred at four times the rate of standard SPI devices.

The Fast Read Quad Output instruction can operate at the highest possible frequency of F_R (see AC Electrical Characteristics). This is accomplished by adding eight "dummy" clocks after the 24-bit address as shown in Figure 13. The dummy clocks allow the device's internal circuits additional time for setting up the initial address. The input data during the dummy clocks is "don't care". However, the IO pins should be high-impedance prior to the falling edge of the first data out clock.

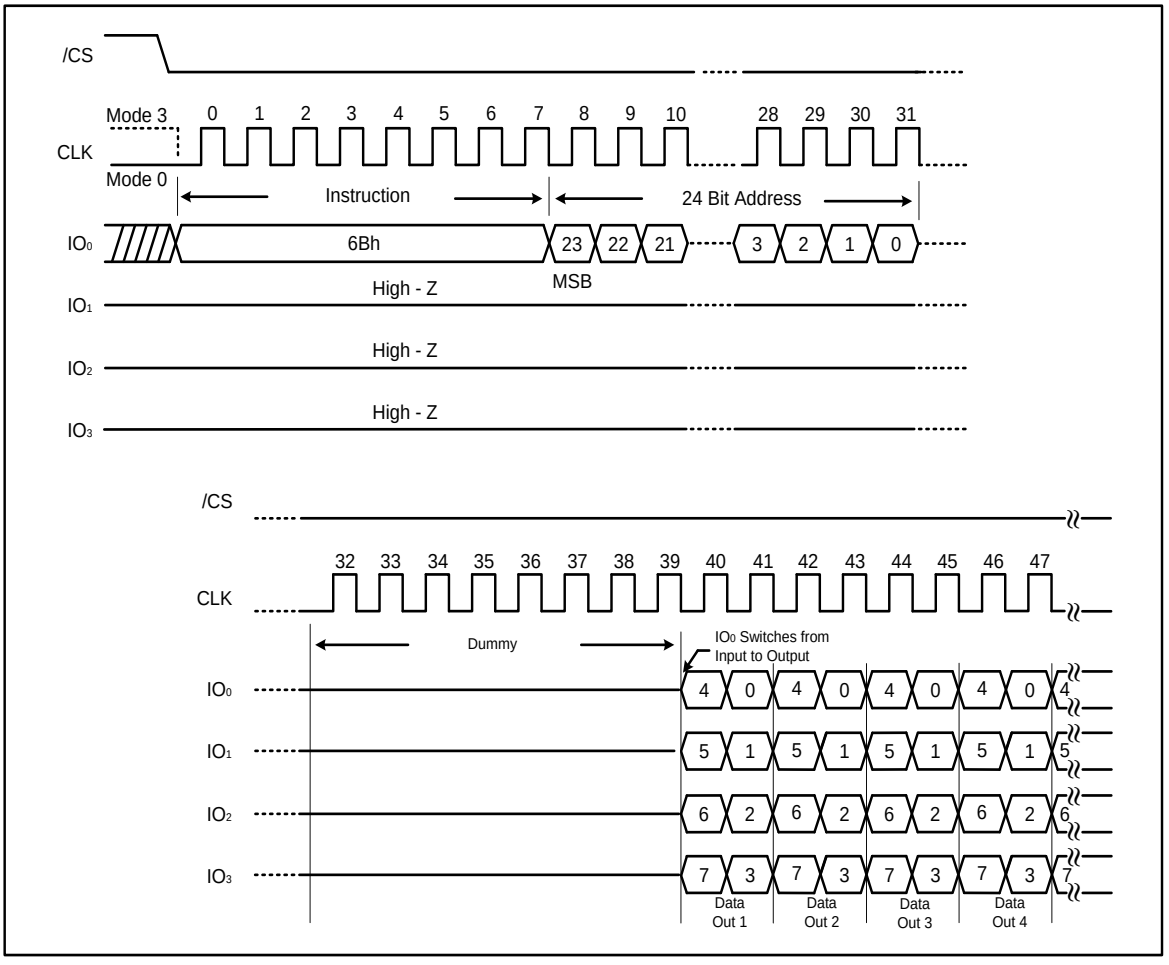


Figure 13. Fast Read Quad Output Instruction (SPI Mode only)

8.2.11. Fast Read Dual I/O (BBh)

The Fast Read Dual I/O (BBh) instruction allows for improved random access while maintaining two IO pins, IO_0 and IO_1. It is similar to the Fast Read Dual Output (3Bh) instruction but with the capability to input the Address bits (A23-0) two bits per clock. This reduced instruction overhead may allow for code execution (XIP) directly from the Dual SPI in some applications. The Fast Read Quad I/O (BBh) instruction address and data bits are input and output through two pins IO_0, IO_1, and dummy clocks are required in SPI mode prior to the data output.

8.2.12. Fast Read Dual I/O with "Continuous Read Mode"

The Fast Read Dual I/O instruction can further reduce instruction overhead through setting the "Continuous Read Mode" bits (M7-0) after the input Address bits (A23-0), as shown in Figure 14a. The upper nibble of the (M7-4) controls the length of the next Fast Read Dual I/O instruction through the inclusion or exclusion of the first byte instruction code. The lower nibble bits of the (M3-0) are don't care ("x"). However, the IO pins should be high-impedance prior to the falling edge of the first data out clock.

If the "Continuous Read Mode" bits M5-4 = (1,0), then the next Fast Read Dual I/O instruction (after /CS is raised and then lowered) does not require the BBh instruction code, as shown in Figure 14b. This reduces the instruction sequence by eight clocks and allows the Read address to be immediately entered after /CS is asserted low. If the "Continuous Read Mode" bits M5-4 do not equal to (1,0), the next instruction (after /CS is raised and then lowered) requires the first byte instruction code, thus returning to normal operation. It is recommended to input FFh on IO0 for the next instruction (16 clocks), to ensure M4 = 1 and return the device to normal operation. The "Continuous Read Mode" bits M7-0 are also considered as dummy clocks.
4 or 8 dummy clock can be set before delivery, if need specify which one exactly, please contact with us in advance.

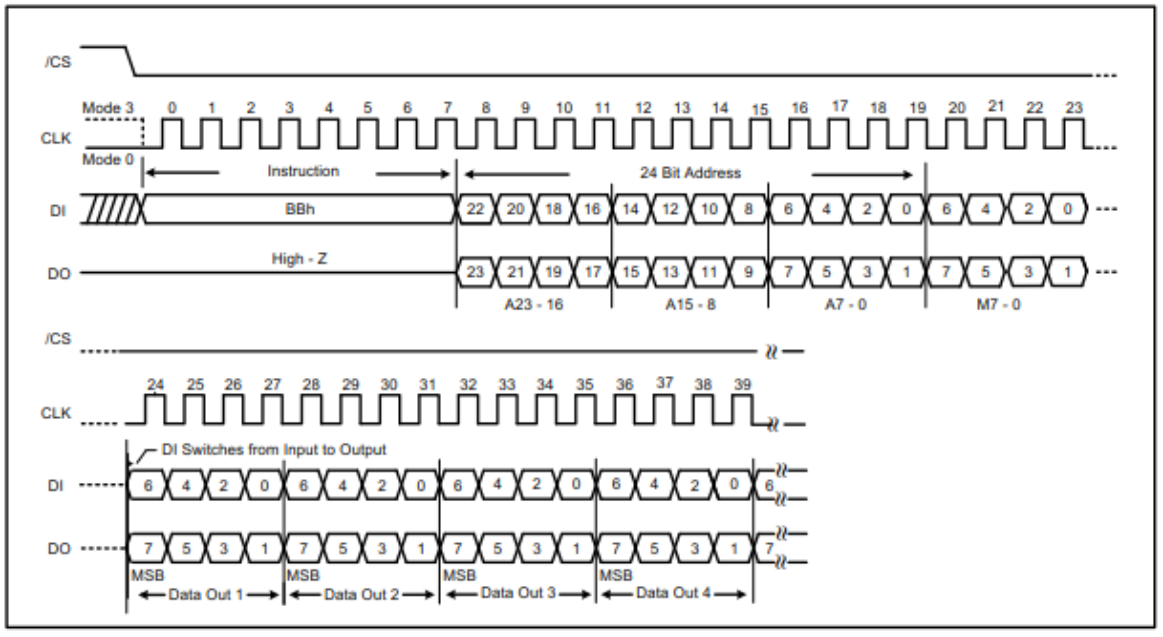


Figure 14a. Fast Read Dual I/O Instruction (Initial instruction or previous M5-4 ≠ 10, SPI Mode only, 4 Dummy)

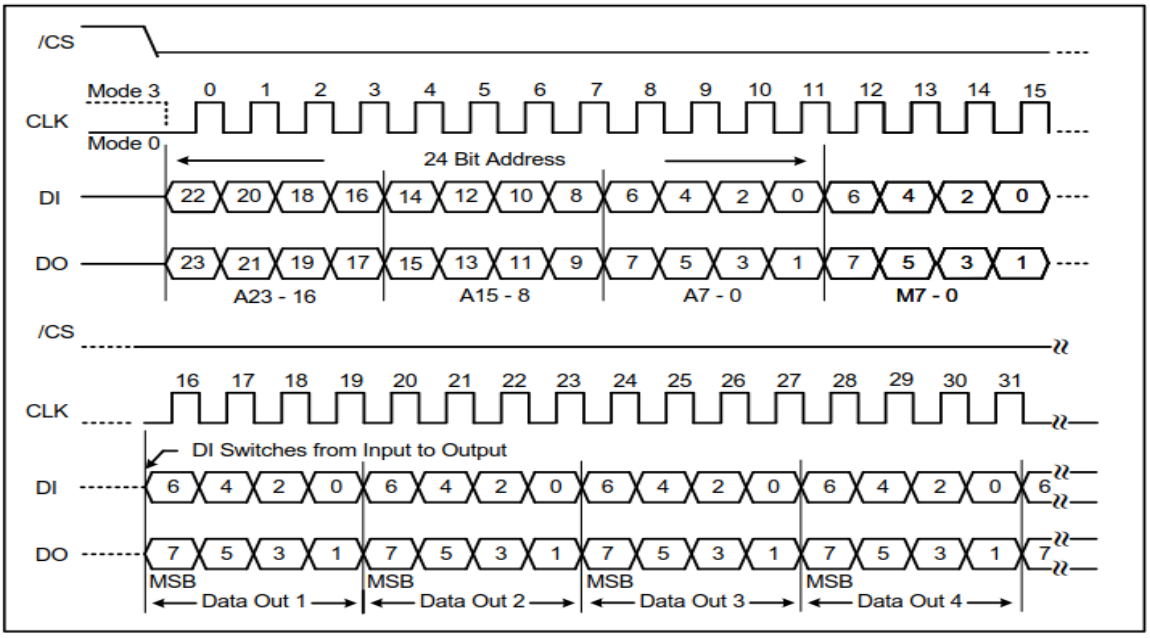


Figure 14b. Fast Read Dual I/O Instruction (Previous instruction set M5-4 = 10, SPI Mode only, 4 Dummy)

8.2.13. Fast Read Quad I/O (EBh)

The Fast Read Quad I/O (EBh) instruction is similar to the Fast Read Dual I/O (BBh) instruction except that address and data bits are input and output through four pins IO_0, IO_1, IO_2 and IO_3 and dummy clocks are required in SPI mode prior to the data output, if. The Quad I/O dramatically reduces instruction overhead allowing faster random access for code execution (XIP) directly from the Quad SPI. The Quad Enable bit (QE) of Status Register-2 must be set to enable the Fast Read Quad I/O Instruction.

8.2.14. Fast Read Quad I/O with "Continuous Read Mode"

The Fast Read Quad I/O instruction can further reduce instruction overhead through setting the "Continuous Read Mode" bits (M7-0) after the input Address bits (A23-0), as shown in Figure 15a. The upper nibble of the (M7-4) controls the length of the next Fast Read Quad I/O instruction through the inclusion or exclusion of the first byte instruction code. The lower nibble bits of the (M3-0) are don't care ("x"). However, the IO pins should be high-impedance prior to the falling edge of the first data out clock.

If the "Continuous Read Mode" bits M5-4 = (1,0), then the next Fast Read Quad I/O instruction (after /CS is raised and then lowered) does not require the EBh instruction code, as shown in Figure 15b. This reduces the instruction sequence by eight clocks and allows the Read address to be immediately entered after /CS is asserted low. If the "Continuous Read Mode" bits M5-4 do not equal to (1,0), the next instruction (after /CS is raised and then lowered) requires the first byte instruction code, thus returning to normal operation. It is recommended to input FFh on IO0 for the next instruction (8 clocks), to ensure M4 = 1 and return the device to normal operation. The "Continuous Read Mode" bits M7-0 are also considered as dummy clocks. 6 or 8 dummy clock can be set before delivery, if need specify which one exactly, please contact with us in advance.

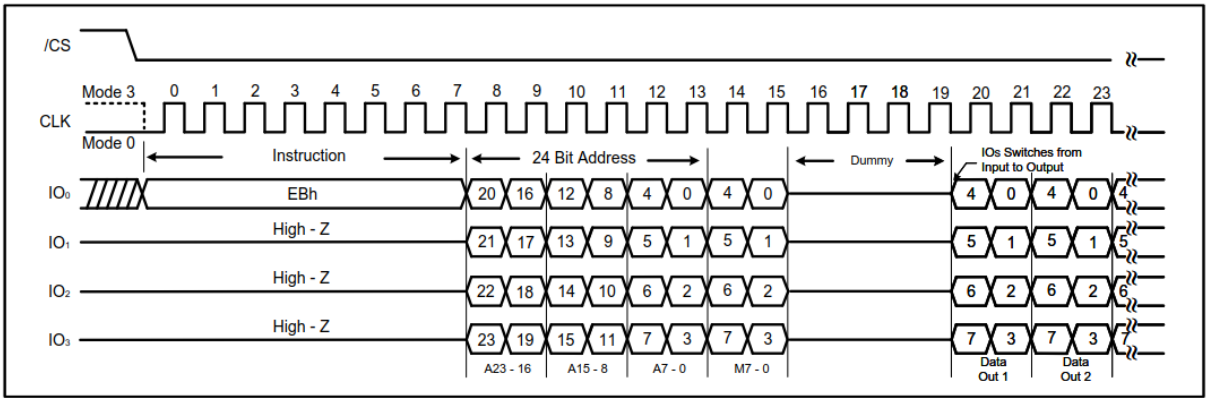


Figure 15a. Fast Read Quad I/O Instruction (Initial instruction or previous M5-4 ≠ 10, SPI Mode, 6 Dummy)

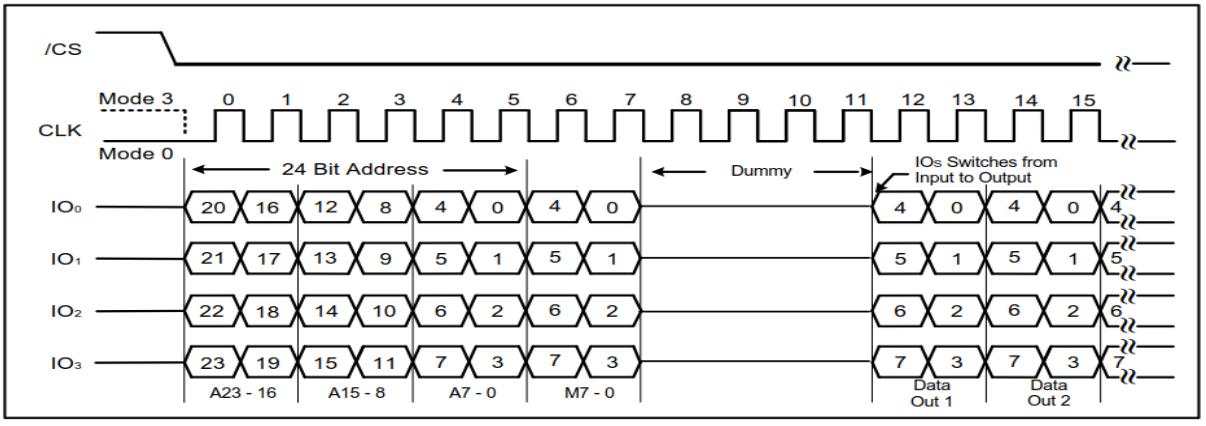


Figure 15b. Fast Read Quad I/O Instruction (Previous instruction set M5-4 = 10, SPI Mode, 6 Dummy

8.2.15. Fast Read Quad I/O with "8/16/32/64-Byte Wrap Around" in Standard SPI mode

The Fast Read Quad I/O instruction can also be used to access a specific portion within a page by issuing a "Set Burst with Wrap" (77h) command prior to EBh. The "Set Burst with Wrap" (77h) command can either enable or disable the "Wrap Around" feature for the following EBh commands. When "Wrap Around" is enabled, the data being accessed can be limited to either an 8, 16, 32 or 64- byte section of a 256-byte page. The output data starts at the initial address specified in the instruction, once it reaches the ending boundary of the 8/16/32/64-byte section, the output will wrap around to the beginning boundary automatically until /CS is pulled high to terminate the command.

The Burst with Wrap feature allows applications that use cache to quickly fetch a critical address and then fill the cache afterwards within a fixed length (8/16/32/64-byte) of data without issuing multiple read commands.

The "Set Burst with Wrap" instruction allows three "Wrap Bits", W6-4 to be set. The W4 bit is used to enable or disable the "Wrap Around" operation while W6-5 are used to specify the length of the wrap around section within a page. Refer to section "Set Burst with Wrap" for detail descriptions.

8.2.16. **Fast Read Quad I/O (EBh) in QPI Mode**

The Fast Read Quad I/O instruction is also supported in QPI mode, as shown in Figure 15c. When QPI mode is enabled, the number of dummy clocks is configured by the "Set Read Parameters (C0h)" instruction to accommodate a wide range of applications with different needs for either maximum Fast Read frequency or minimum data access latency. Depending on the Read Parameter Bits P[5:4] setting, the number of dummy clocks can be configured as either 6 or 8. The default number of dummy clocks upon power up or after a Reset instruction is 8. In QPI mode, the "Continuous Read Mode" bits M7-0 are also considered as dummy clocks. In the default setting, the data output will follow the Continuous Read Mode bits immediately.

"Continuous Read Mode" feature is also available in QPI mode for Fast Read Quad I/O instruction. Please refer to the description on previous pages.

"Wrap Around" feature is not available in QPI mode for Fast Read Quad I/O instruction. To perform a read operation with fixed data length wrap around in QPI mode, a dedicated "Burst Read with Wrap" (0Ch) instruction must be used. Please refer to section "Burst Read with Wrap" for details.

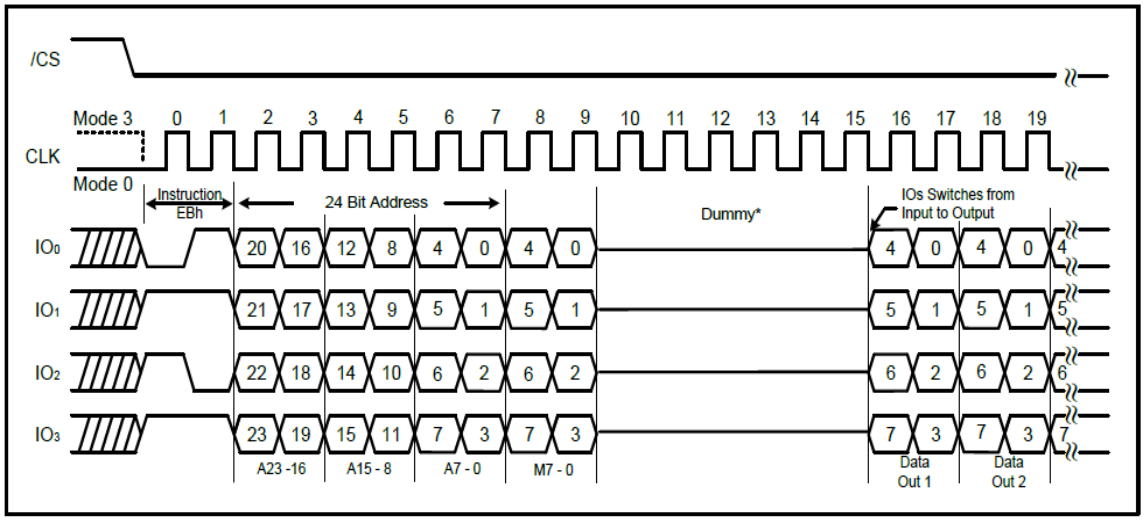


Figure 15c. Fast Read Quad I/O Instruction (Initial instruction or previous M5-4 ≠ 10, QPI Mode)

8.2.17. **Word Read Quad I/O (E7h)**

The Word Read Quad I/O (E7h) instruction is similar to the Fast Read Quad I/O (EBh) instruction except that the lowest Address bit (A0) must equal 0 and six Dummy clocks are required prior to the data output. The Quad I/O dramatically reduces instruction overhead allowing faster random access for code execution (XIP) directly from the Quad SPI. The Quad Enable bit (QE) of Status Register-2 must be set to enable the Word Read Quad I/O Instruction.

8.2.18. **Word Read Quad I/O with "Continuous Read Mode"**

The Word Read Quad I/O instruction can further reduce instruction overhead through setting the "Continuous Read Mode" bits (M7-0) after the input Address bits (A23-0), as shown in Figure 16a. The upper nibble of the (M7-4) controls the length of the next Fast Read Quad I/O instruction through the inclusion or exclusion of the first byte instruction code. The lower nibble bits of the (M3-0) are don't care ("x"). However, the IO pins should be high-impedance prior to the falling edge of the first data out clock.

If the "Continuous Read Mode" bits M5-4 = (1,0), then the next Fast Read Quad I/O instruction (after /CS is raised and then lowered) does not require the E7h instruction code, as shown in Figure 16b. This reduces the instruction sequence by eight clocks and allows the Read address to be immediately entered after /CS is asserted low. If the "Continuous Read Mode" bits M5-4 do not equal to (1,0), the next instruction (after /CS is raised and then lowered) requires the first byte instruction code, thus returning to normal operation. It is recommended to input FFh on IO0 for the next instruction (8 clocks), to ensure M4 = 1 and return the device to normal operation. The "Continuous Read Mode" bits M7-0 are also considered as dummy clocks.

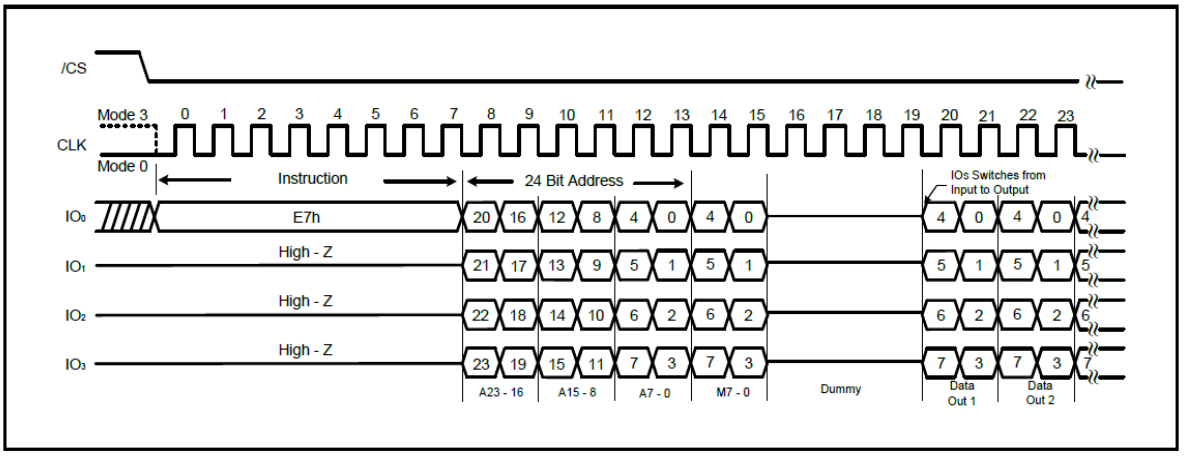


Figure 16a. Word Read Quad I/O Instruction (Initial instruction or previous M5-4 ≠ 10, SPI Mode only)

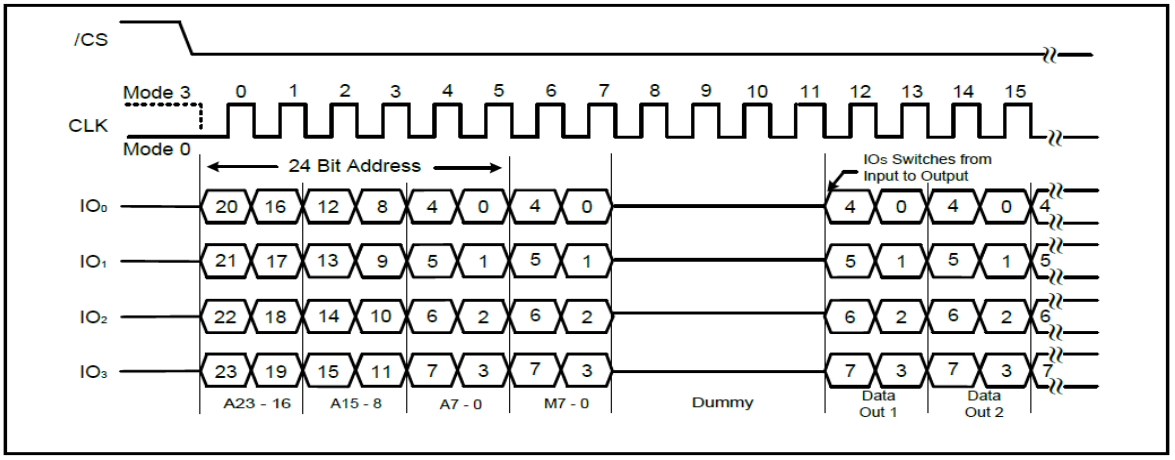


Figure16b. Word Read Quad I/O Instruction (Previous instruction set M5-4 = 10, SPI Mode only)

8.2.19. Word Read Quad I/O with "8/16/32/64-Byte Wrap Around" in Standard SPI mode

The Word Read Quad I/O instruction can also be used to access a specific portion within a page by issuing a "Set Burst with Wrap" (77h) command prior to E7h. The "Set Burst with Wrap" (77h) command can either enable or disable the "Wrap Around" feature for the following E7h commands. When "Wrap Around" is enabled, the data being accessed can be limited to either an 8, 16, 32 or 64- byte section of a 256-byte page. The output data starts at the initial address specified in the instruction, once it reaches the ending boundary of the 8/16/32/64-byte section, the output will wrap around to the beginning boundary automatically until /CS is pulled high to terminate the command.

The Burst with Wrap feature allows applications that use cache to quickly fetch a critical address and then fill the cache afterwards within a fixed length (8/16/32/64-byte) of data without issuing multiple read commands.

The "Set Burst with Wrap" instruction allows three "Wrap Bits", W6-4 to be set. The W4 bit is used to enable or disable the "Wrap Around" operation while W6-5 are used to specify the length of the wrap around section within a page. See section "Set Burst with Wrap" for detail descriptions.

8.2.20. **Set Burst with Wrap (77h)**

In Standard SPI mode, the Set Burst with Wrap (77h) instruction is used in conjunction with "Fast Read Quad I/O" and "Word Read Quad I/O" and "DTR Read Quad I/O" instructions to access a fixed length of 8/16/32/64-byte section within a 256-byte page. Certain applications can benefit from this feature and improve the overall system code execution performance.

Similar to a Quad I/O instruction, the Set Burst with Wrap instruction is initiated by driving the /CS pin low and then shifting the instruction code "77h" followed by 24 dummy bits and 8 "Wrap Bits", W7-0. The instruction sequence is shown in Figure 17. Wrap bit W7 and the lower nibble W3-0 are not used.

W6, W5	W4 = 0		W4 =1 (DEFAULT)	
	Wrap Around	Wrap Length	Wrap Around	Wrap Length
0 0	Yes	8-byte	No	N/A
0 1	Yes	16-byte	No	N/A
1 0	Yes	32-byte	No	N/A
1 1	Yes	64-byte	No	N/A

Once W6-4 is set by a Set Burst with Wrap instruction, all the following "Fast Read Quad I/O" and "Word Read Quad I/O" instructions will use the W6-4 setting to access the 8/16/32/64-byte section within any page. To exit the "Wrap Around" function and return to normal read operation, another Set Burst with Wrap instruction should be issued to set W4 = 1. The default value of W4 upon power on or after a software/hardware reset is 1.

In QPI mode, the "Burst Read with Wrap (0Ch)" instruction should be used to perform the Read operation with "Wrap Around" feature. The Wrap Length set by W5-4 in Standard SPI mode is still valid in QPI mode and can also be re-configured by "Set Read Parameters (C0h)" instruction. Refer to section "Set Read Parameters" and "Burst Read with Wrap" for details.

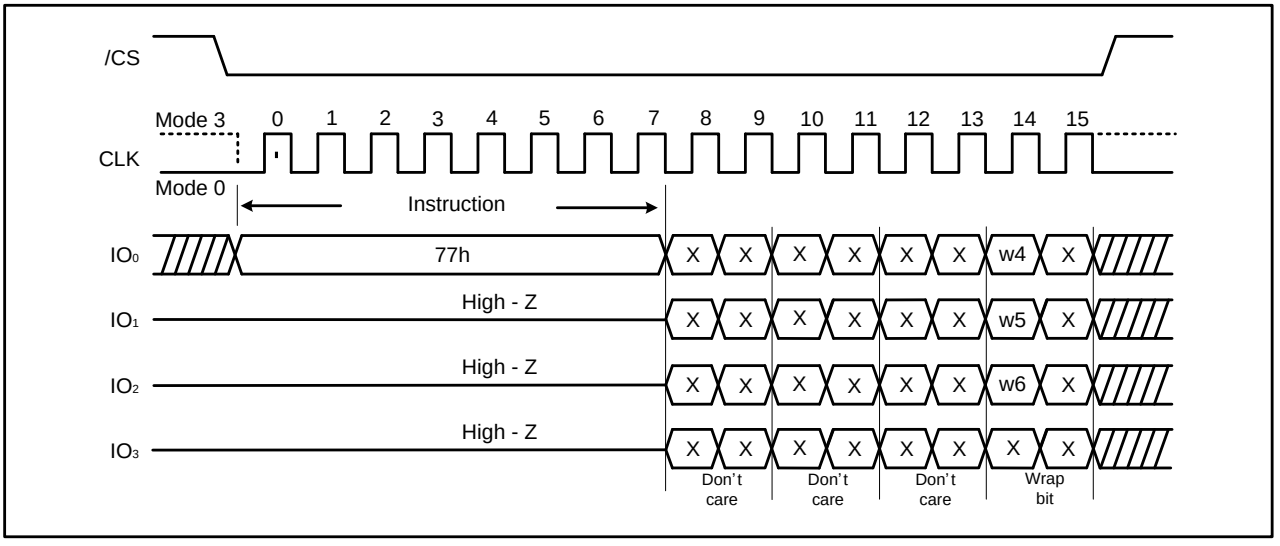


Figure 17. Set Burst with Wrap Instruction (SPI Mode only)

8.2.21. DTR Read (0Dh)

The DTR Read I/O instruction enables Double Transfer Rate throughput on I/O of Serial Flash in read mode. The address on I/O pin is latched on both rising and falling edge of CLK. The 2-bit address can be latched-in at one clock, and 2-bit data can be read out at one clock, which means one bits at rising edge of clock, another one bits at falling edge of clock. The first address Byte can be at any location. The address is automatically increased to the next higher address after each Byte data is shifted out, so the whole memory can be read out at a single DTR Read I/O instruction.As shown in Figure18a.

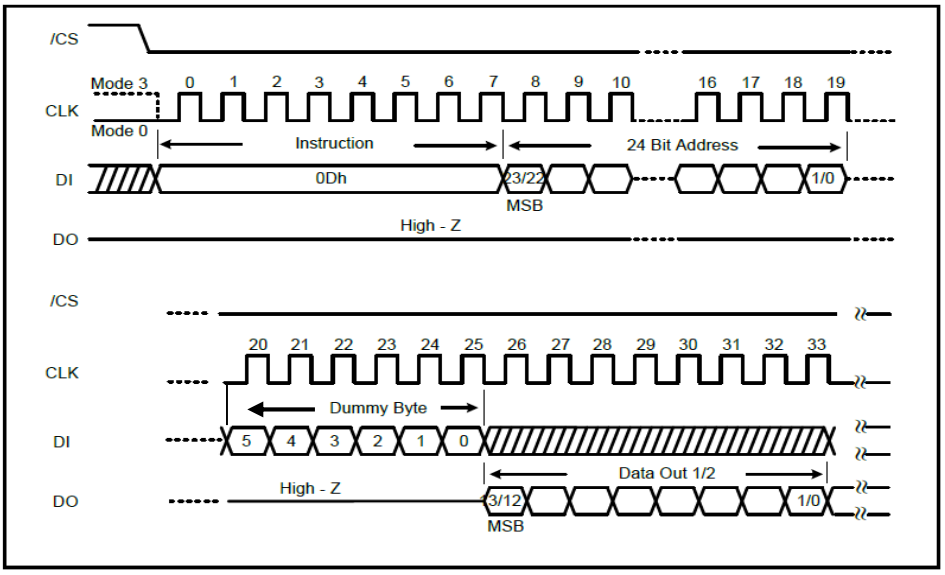


Figure 18a. DTR Read Instruction (SPI Mode)

While Program/Erase/Write Status Register cycle is in progress, DTR Read Quad I/O instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

8.2.22. DTR Read in QPI (0Dh)

The DTR Read instruction is also supported in QPI mode, as shown in Figure18b. It enables Double Transfer Rate throughput on quad I/O of Serial Flash in read mode.

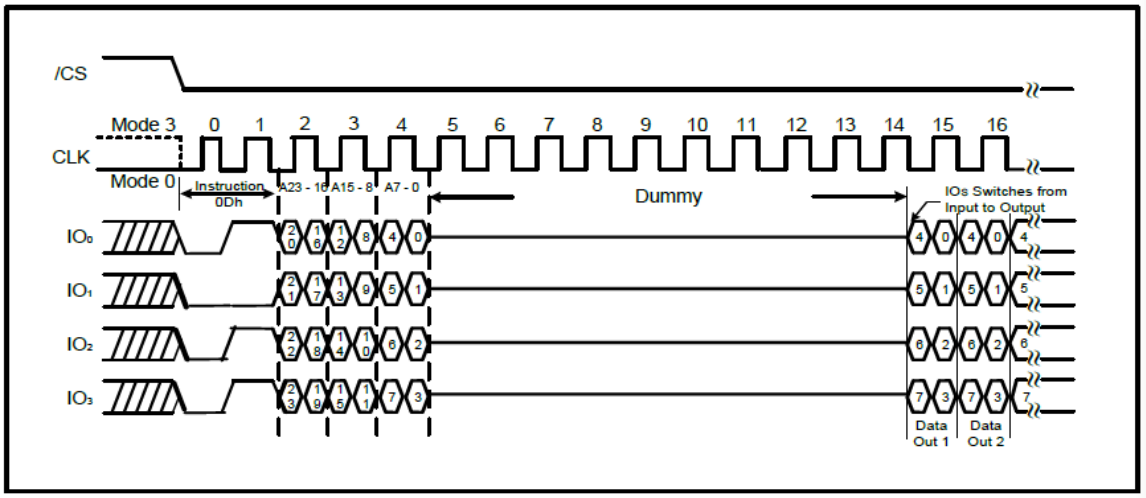


Figure18b. DTR Read Instruction (QPI Mode)

8.2.23. DTR Read Dual I/O (BDh) with "Continuous Read Mode"

The DTR Read Dual I/O instruction enables Double Transfer Rate throughput on dual I/O of Serial Flash in read mode. The address (interleave on 2 I/O pins) is latched on both rising and falling edge of CLK. The 4-bit address can be latched-in at one clock, and 4-bit data can be read out at one clock, which means one bits at rising edge of clock, another one bits at falling edge of clock. The first address Byte can be at any location. The address is automatically increased to the next higher address after each Byte data is shifted out, so the whole memory can be read out at a single DTR Read I/O instruction.

While Program/Erase/Write Status Register cycle is in progress, DTR Read Quad I/O instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

The DTR Read Quad I/O instruction can further reduce instruction overhead through setting the "Continuous Read Mode" bits (M7-0) after the input Address bits (A23-0), as shown in Figure 18c. The upper nibble of the (M7-4) controls the length of the next DTR Read Quad I/O instruction through the inclusion or exclusion of the first byte instruction code. The lower nibble bits of the (M3-0) are don't care ("x"). However, the IO pins should be high-impedance prior to the falling edge of the first data out clock.

If the "Continuous Read Mode" bits M5-4 = (1,0), then the next DTR Read Quad I/O instruction (after /CS is raised and then lowered) does not require the BDh instruction code, as shown in Figure 18d. This reduces the instruction sequence by eight clocks and allows the Read address to be immediately entered after /CS is asserted low. If the "Continuous Read Mode" bits M5-4 do not equal to (1,0), the next instruction (after /CS is raised and then lowered) requires the first byte instruction code, thus returning to normal operation. It is recommended to input FFh on IO0 for the next instruction (8 clocks), to ensure M4 = 1 and return the device to normal operation.

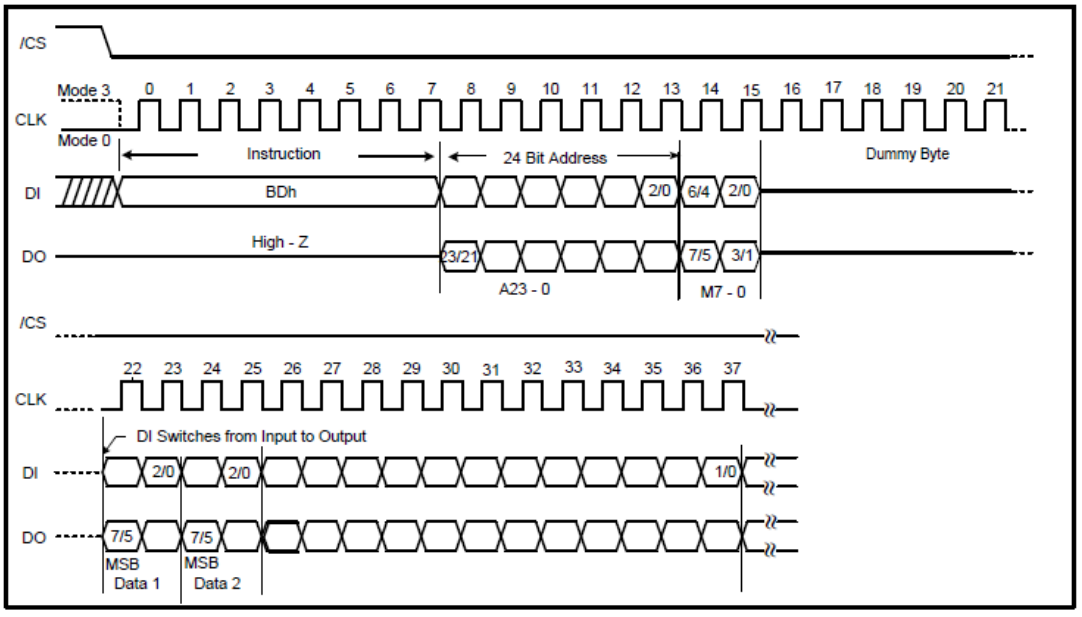


Figure18c. DTR Read Dual I/O Instruction (Previous instruction set M5-4 ≠ 10, SPI Mode)

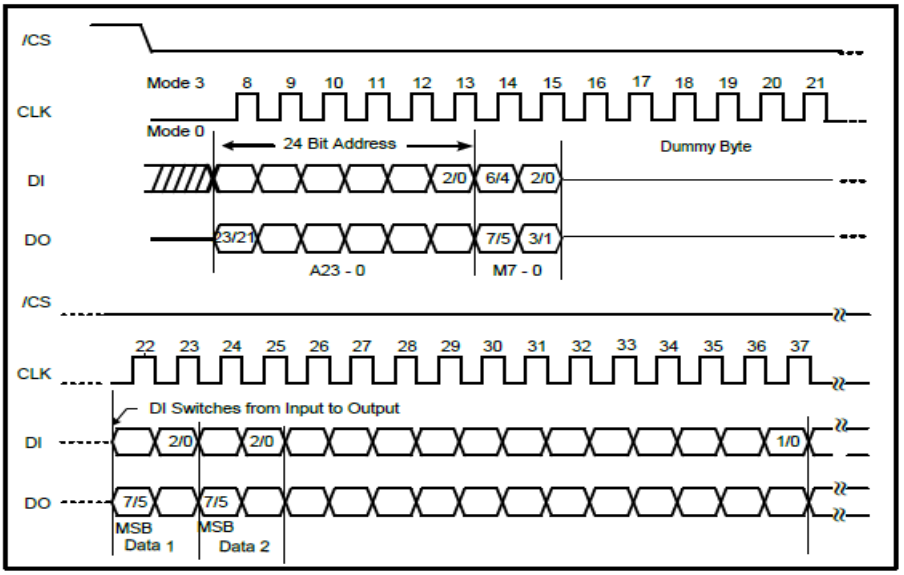


Figure18d. DTR Read Dual I/O Instruction (Previous instruction set M5-4 = 10, SPI Mode)

8.2.24. **DTR wrap read (0Eh)**

The “DTR Burst Read with Wrap (0Eh)” instruction provides an alternative way to perform the read operation with “Wrap Around” in QPI mode. The instruction is similar to the “Fast Read (0Bh)” instruction in QPI mode, except the addressing of the read operation will “Wrap Around” to the beginning boundary of the “Wrap Length” once the ending boundary is reached.The “Wrap Length” can be configured by the “Set Read Parameters (C0h)” instruction.

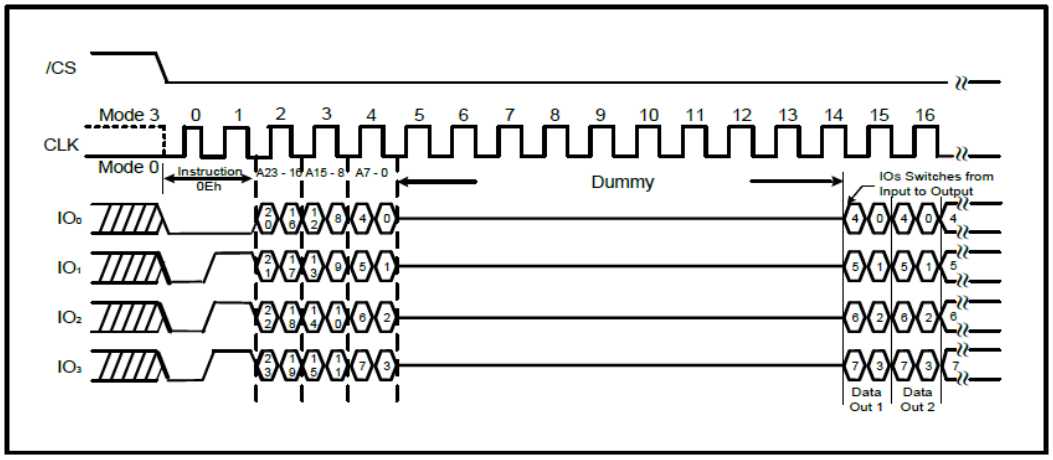


Figure18e. DTR wrap read (QPI Mode)

8.2.25. **DTR Read Quad I/O (EDh)**

The DTR Read Quad I/O instruction enables Double Transfer Rate throughput on quad I/O of Serial Flash in read mode. A Quad Enable (QE) bit of Status Register must be set to “1” before sending the DTR Read Quad I/O instruction. The address (interleave on 4 I/O pins) is latched on both rising and falling edge of CLK. The 8-bit address can be latched-in at one clock, and 8-bit data can be read out at one clock, which means four bits at rising edge of clock, the other four bits at falling edge of clock. The first address Byte can be at any location. The address is automatically increased to the next higher address after each Byte data is shifted out, so the whole memory can be read out at a single DTR Read Quad I/O instruction, the following address/dummy/data out will perform as 8-bit instead of previous 1-bit.

While Program/Erase/Write Status Register cycle is in progress, DTR Read Quad I/O instruction is rejected without any impact on the Program/Erase/Write Status Register current cycle.

8.2.26. DTR Read Quad I/O with "Continuous Read Mode"

The DTR Read Quad I/O instruction can further reduce instruction overhead through setting the "Continuous Read Mode" bits (M7-0) after the input Address bits (A23-0), as shown in Figure 18f. The upper nibble of the (M7-4) controls the length of the next DTR Read Quad I/O instruction through the inclusion or exclusion of the first byte instruction code. The lower nibble bits of the (M3-0) are don't care ("x"). However, the IO pins should be high-impedance prior to the falling edge of the first data out clock.

If the "Continuous Read Mode" bits M5-4 = (1,0), then the next DTR Read Quad I/O instruction (after /CS is raised and then lowered) does not require the EDh instruction code, as shown in Figure 18g. This reduces the instruction sequence by eight clocks and allows the Read address to be immediately entered after /CS is asserted low. If the "Continuous Read Mode" bits M5-4 do not equal to (1,0), the next instruction (after /CS is raised and then lowered) requires the first byte instruction code, thus returning to normal operation. It is recommended to input FFh on IO0 for the next instruction (8 clocks), to ensure M4 = 1 and return the device to normal operation.

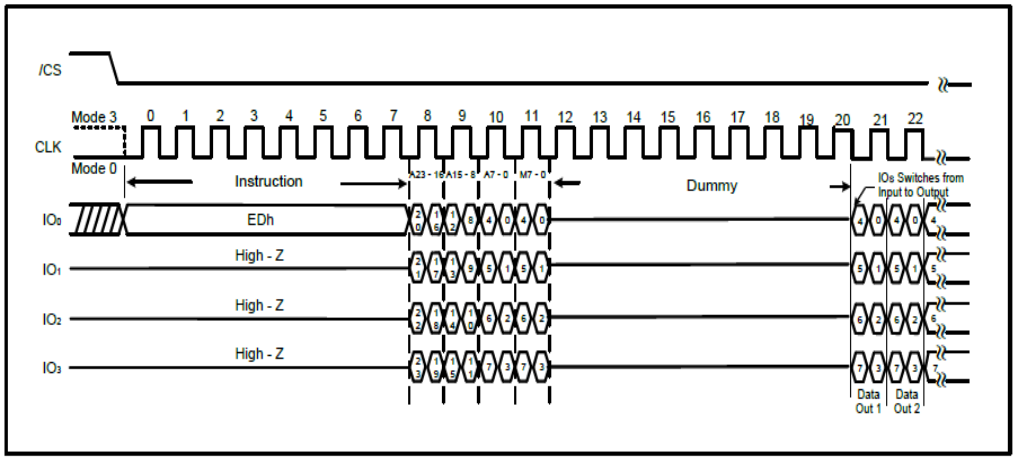


Figure18f. DTR Read Quad I/O Instruction (Previous instruction set M5-4 ≠ 10, SPI Mode)

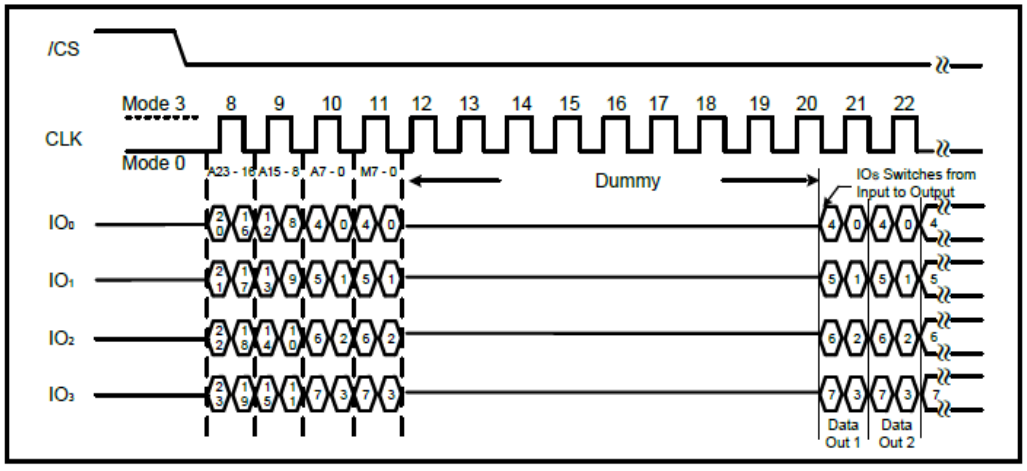


Figure18g. DTR Read Quad I/O Instruction (Previous instruction set M5-4 = 10, SPI Mode)

8.2.27. DTR Read Quad I/O (EDh) in QPI Mode

The DTR Read Quad I/O instruction is also supported in QPI mode, as shown in Figure 18h. In QPI mode, the "Continuous Read Mode" bits M7-0 are also considered as dummy clocks. In the default setting, the data output will follow the Continuous Read Mode bits immediately.

"Continuous Read Mode" feature is also available in QPI mode for DTR Read Quad I/O instruction. Please refer to the description on previous pages.

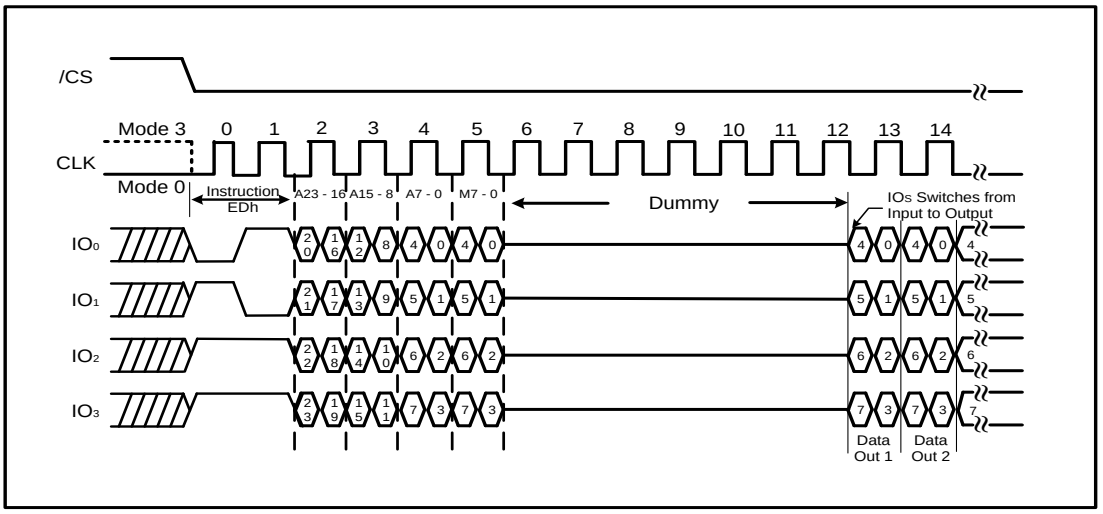


Figure18h. DTR Read Quad I/O Instruction (Previous instruction set M5-4 ≠ 10, QPI Mode)

8.2.28. **Page Program (02h)**

The Page Program instruction allows from one byte to 256 bytes (a page) of data to be programmed at previously erased (FFh) memory locations. A Write Enable instruction must be executed before the device will accept the Page Program Instruction (Status Register bit WEL= 1). The instruction is initiated by driving the /CS pin low then shifting the instruction code "02h" followed by a 24-bit address (A23-A0) and at least one data byte, into the DI pin. The /CS pin must be held low for the entire length of the instruction while data is being sent to the device. The Page Program instruction sequence is shown in Figure 19 & 20

If an entire 256 byte page is to be programmed, the last address byte (the 8 least significant address bits) should be set to 0. If the last address byte is not zero, and the number of clocks exceeds the remaining page length, the addressing will wrap to the beginning of the page. In some cases, less than 256 bytes (a partial page) can be programmed without having any effect on other bytes within the same page. One condition to perform a partial page program is that the number of clocks cannot exceed the remaining page length. If more than 256 bytes are sent to the device the addressing will wrap to the beginning of the page and overwrite previously sent data.

As with the write and erase instructions, the /CS pin must be driven high after the eighth bit of the last byte has been latched. If this is not done the Page Program instruction will not be executed. After /CS is driven high, the self-timed Page Program instruction will commence for a time duration of tpp (See AC Characteristics). While the Page Program cycle is in progress, the Read Status Register instruction may still be accessed for checking the status of the BUSY bit. The BUSY bit is a 1 during the Page Program cycle and becomes a 0 when the cycle is finished and the device is ready to accept other instructions again. After the Page Program cycle has finished the Write Enable Latch (WEL) bit in the Status Register is cleared to 0. The Page Program instruction will not be executed if the addressed page is protected by the Block Protect (CMP, SEC, TB, BP2, BP1, and BP0) bits.

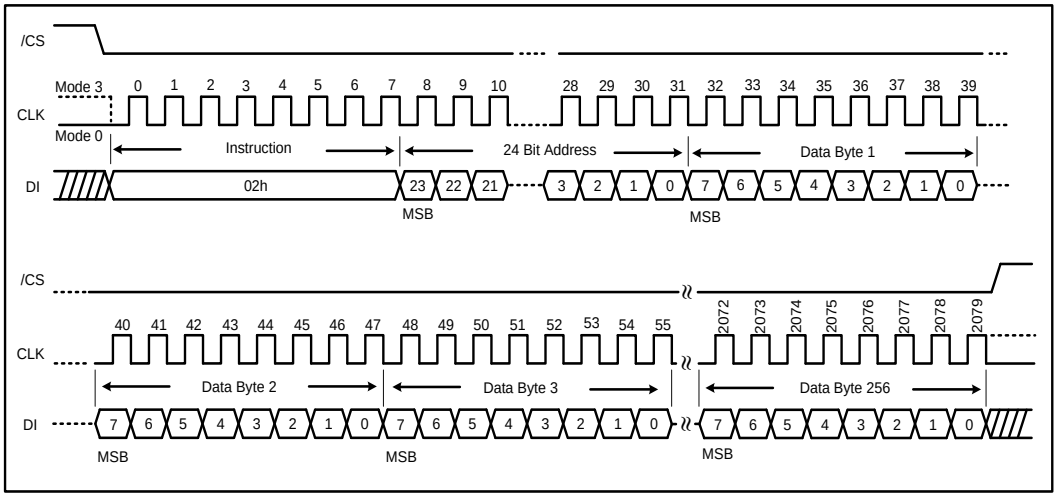


Figure 19. Page Program Instruction (SPI Mode)

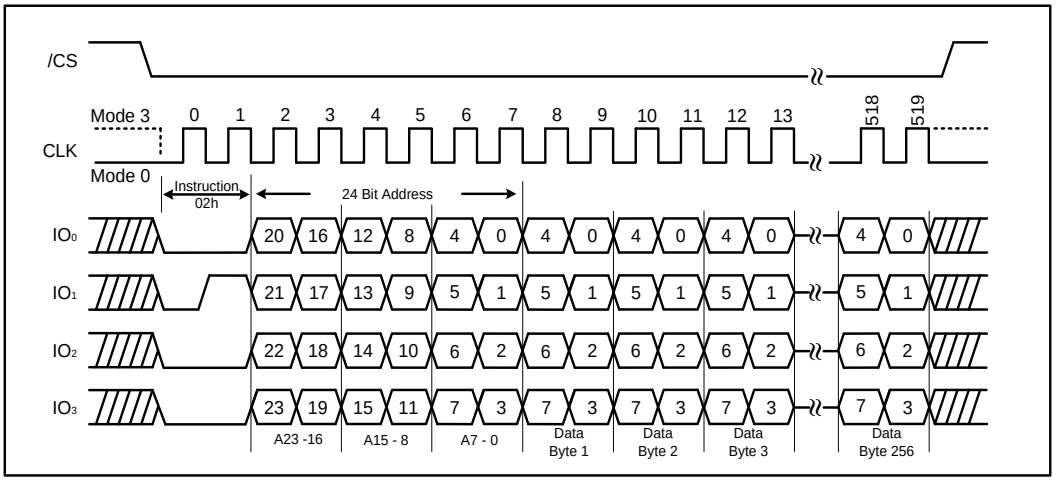


Figure 20. Page Program Instruction (QPI Mode)

8.2.29. Quad Input Page Program (32h)

The Quad Input Page Program instruction allows up to 256 bytes of data to be programmed at previously erased (FFh) memory locations using four pins: IO_0, IO_1, IO_2, and IO_3. The Quad Input Page Program can improve performance for PROM Programmer and applications that have slow clock speeds <5MHz. Systems with faster clock speed will not realize much benefit for the Quad Input Page Program instruction since the inherent page program time is much greater than the time it take to clock-in the data.

To use Quad Input Page Program the Quad Enable (QE) bit in Status Register-2 must be set to 1. A Write Enable instruction must be executed before the device will accept the Quad Input Page Program instruction (Status Register-1, WEL=1). The instruction is initiated by driving the /CS pin low then shifting the instruction code "32h" followed by a 24-bit address (A23-A0) and at least one data byte, into the IO pins. The /CS pin must be held low for the entire length of the instruction while data is being sent to the device. All other functions of Quad Input Page Program are identical to standard Page Program. The Quad Input Page Program instruction sequence is shown in Figure 21.

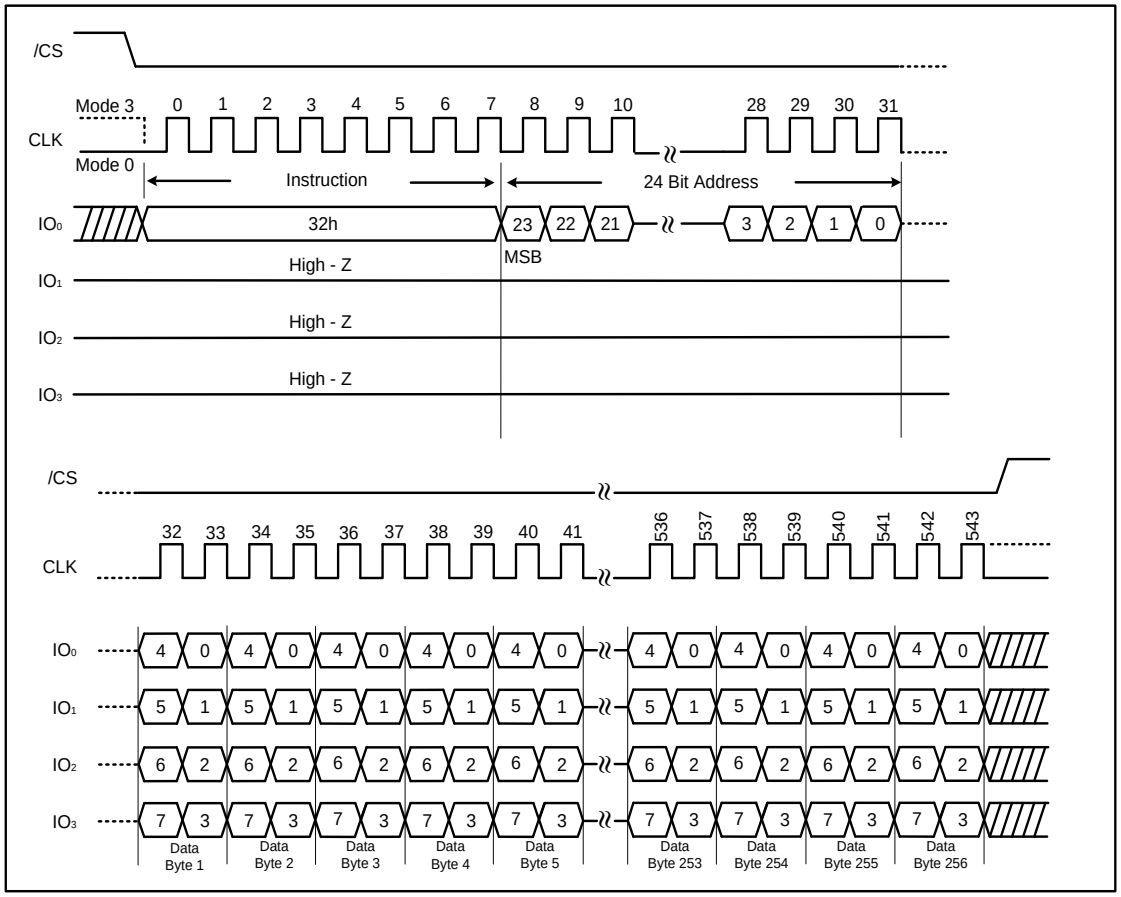


Figure 21. Quad Input Page Program Instruction (SPI Mode only)

8.2.30. **Sector Erase (20h)**

The Sector Erase instruction sets all memory within a specified sector (4K-bytes) to the erased state of all 1s (FFh). A Write Enable instruction must be executed before the device will accept the Sector Erase Instruction (Status Register bit WEL must equal 1). The instruction is initiated by driving the /CS pin low and shifting the instruction code "20h" followed a 24-bit sector address (A23-A0). The Sector Erase instruction sequence is shown in Figure 22a & 22b.

The /CS pin must be driven high after the eighth bit of the last byte has been latched. If this is not done the Sector Erase instruction will not be executed. After /CS is driven high, the self-timed Sector Erase instruction will commence for a time duration of t_{SE} (See AC Characteristics). While the Sector Erase cycle is in progress, the Read Status Register instruction may still be accessed for checking the status of the BUSY bit. The BUSY bit is a 1 during the Sector Erase cycle and becomes a 0 when the cycle is finished and the device is ready to accept other instructions again. After the Sector Erase cycle has finished the Write Enable Latch (WEL) bit in the Status Register is cleared to 0. The Sector Erase instruction will not be executed if the addressed page is protected by the Block Protect (CMP, SEC, TB, BP2, BP1, and BP0) bits.

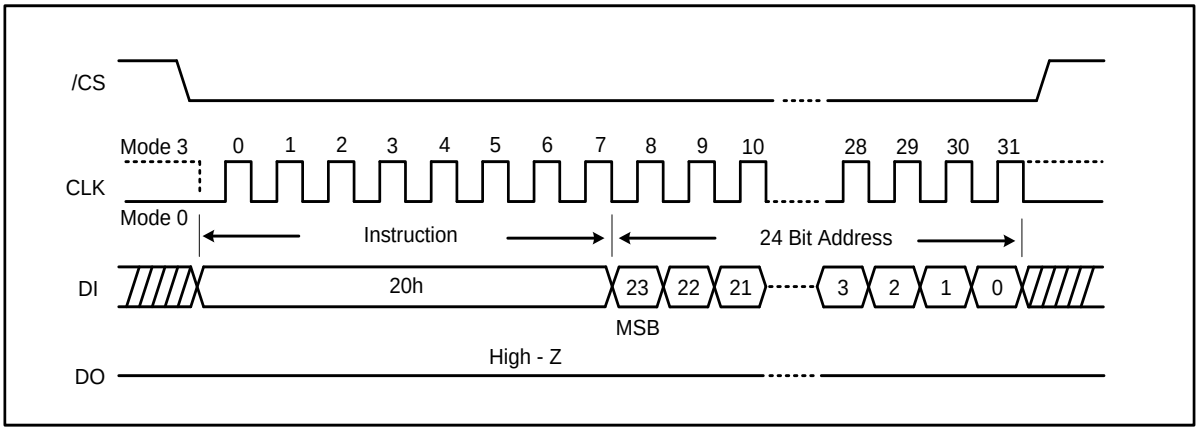


Figure 22a. Sector Erase Instruction (SPI Mode)

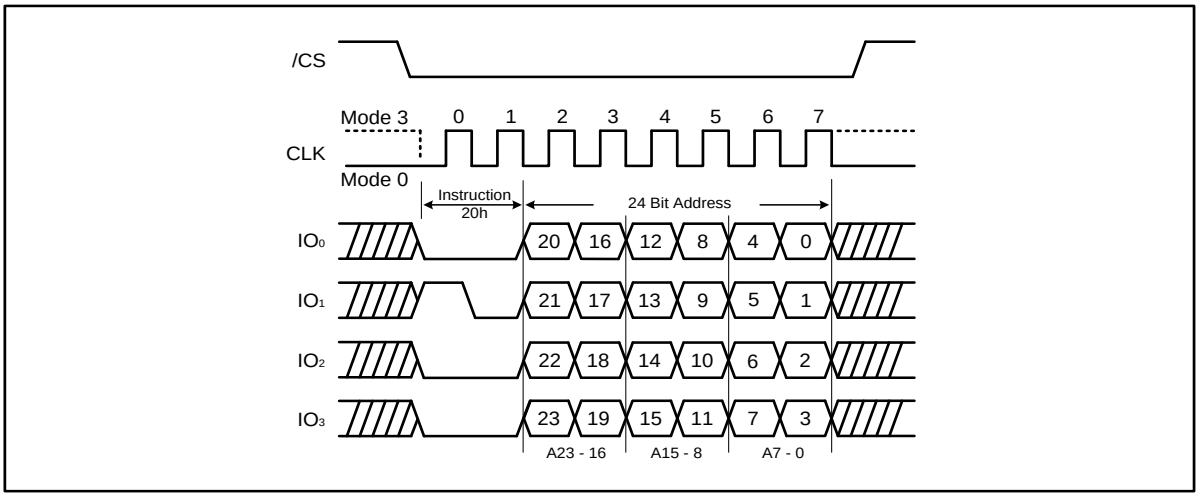


Figure 22b. Sector Erase Instruction (QPI Mode)

8.2.31. 32KB Block Erase (52h)

The Block Erase instruction sets all memory within a specified block (32K-bytes) to the erased state of all 1s (FFh). A Write Enable instruction must be executed before the device will accept the Block Erase Instruction (Status Register bit WEL must equal 1). The instruction is initiated by driving the /CS pin low and shifting the instruction code "52h" followed a 24-bit block address (A23-A0). The Block Erase instruction sequence is shown in Figure 23a &23b.

The /CS pin must be driven high after the eighth bit of the last byte has been latched. If this is not done the Block Erase instruction will not be executed. After /CS is driven high, the self-timed Block Erase instruction will commence for a time duration of t_{BE1} (See AC Characteristics). While the Block Erase cycle is in progress, the Read Status Register instruction may still be accessed for checking the status of the BUSY bit. The BUSY bit is a 1 during the Block Erase cycle and becomes a 0 when the cycle is finished and the device is ready to accept other instructions again. After the Block Erase cycle has finished the Write Enable Latch (WEL) bit in the Status Register is cleared to 0. The Block Erase instruction will not be executed if the addressed page is protected by the Block Protect (CMP, SEC, TB, BP2, BP1, and BP0) bits.

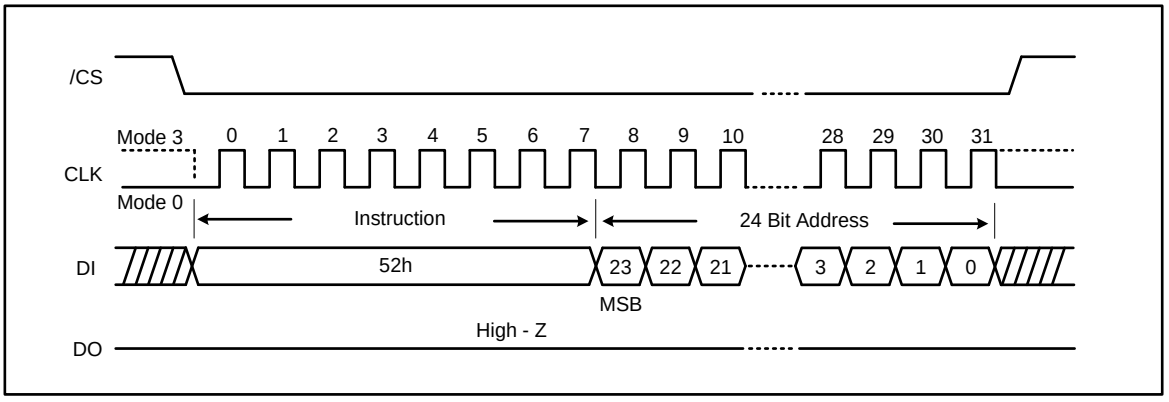


Figure 23a. 32KB Block Erase Instruction (SPI Mode)

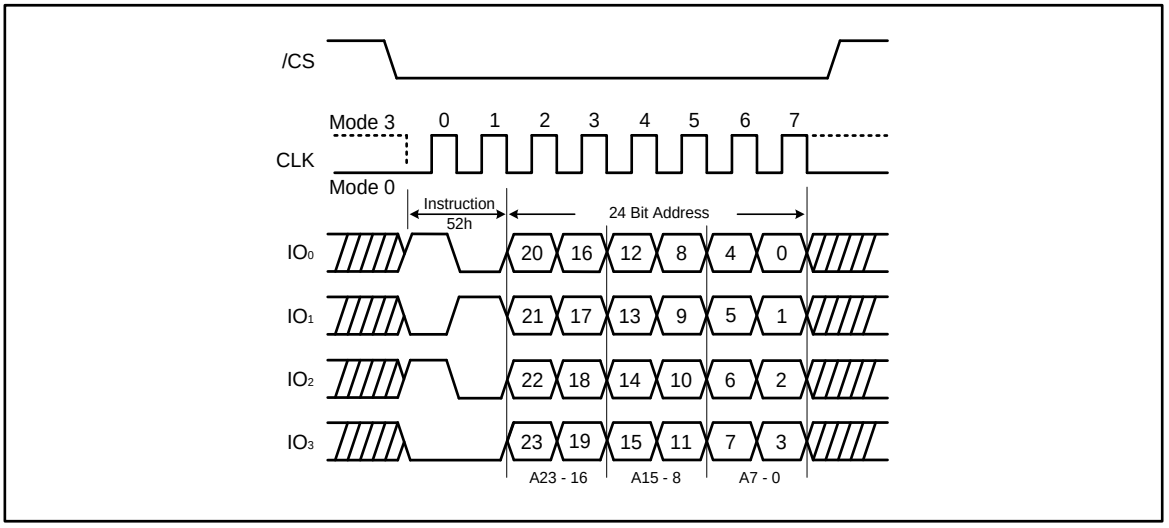


Figure 23b. 32KB Block Erase Instruction (QPI Mode)

8.2.32. 64KB Block Erase (D8h)

The Block Erase instruction sets all memory within a specified block (64K-bytes) to the erased state of all 1s (FFh). A Write Enable instruction must be executed before the device will accept the Block Erase Instruction (Status Register bit WEL must equal 1). The instruction is initiated by driving the /CS pin low and shifting the instruction code "D8h" followed a 24-bit block address (A23-A0). The Block Erase instruction sequence is shown in Figure 24a & 24b.

The /CS pin must be driven high after the eighth bit of the last byte has been latched. If this is not done the Block Erase instruction will not be executed. After /CS is driven high, the self-timed Block Erase instruction will commence for a time duration of t_{BE} (See AC Characteristics). While the Block Erase cycle is in progress, the Read Status Register instruction may still be accessed for checking the status of the BUSY bit. The BUSY bit is a 1 during the Block Erase cycle and becomes a 0 when the cycle is finished and the device is ready to accept other instructions again. After the Block Erase cycle has finished the Write Enable Latch (WEL) bit in the Status Register is cleared to 0. The Block Erase instruction will not be executed if the addressed page is protected by the Block Protect (CMP, SEC, TB, BP2, BP1, and BP0) bits.

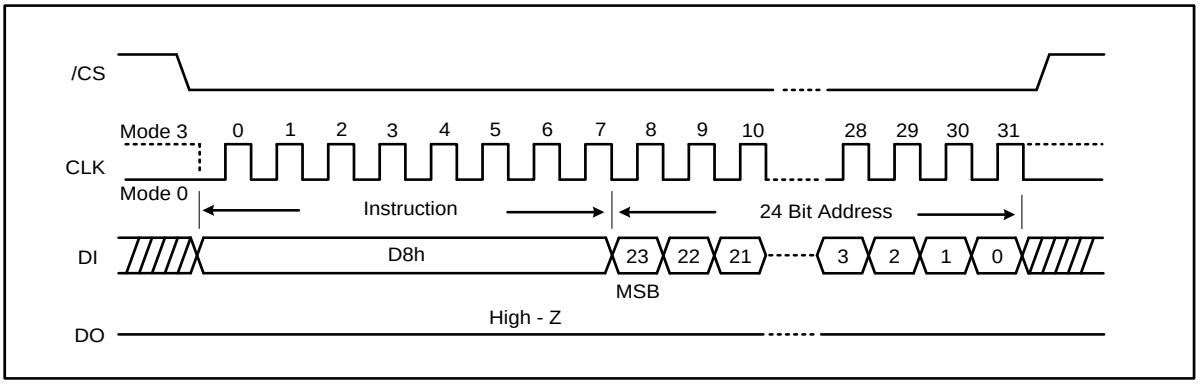


Figure 24a. 64KB Block Erase Instruction (SPI Mode)

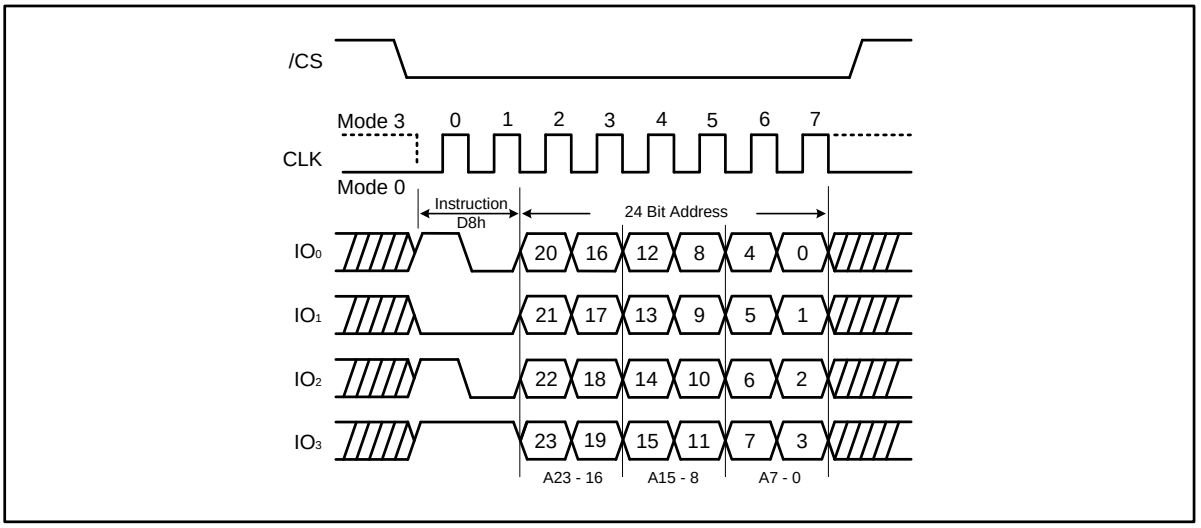


Figure 24b. 64KB Block Erase Instruction (QPI Mode)

8.2.33. **Chip Erase (C7h / 60h)**

The Chip Erase instruction sets all memory within the device to the erased state of all 1s (FFh). A Write Enable instruction must be executed before the device will accept the Chip Erase Instruction (Status Register bit WEL must equal 1). The instruction is initiated by driving the /CS pin low and shifting the instruction code "C7h" or "60h". The Chip Erase instruction sequence is shown in Figure 25.

The /CS pin must be driven high after the eighth bit has been latched. If this is not done the Chip Erase instruction will not be executed. After /CS is driven high, the self-timed Chip Erase instruction will commence for a time duration of t_{CE} (See AC Characteristics). While the Chip Erase cycle is in progress, the Read Status Register instruction may still be accessed to check the status of the BUSY bit. The BUSY bit is a 1 during the Chip Erase cycle and becomes a 0 when finished and the device is ready to accept other instructions again. After the Chip Erase cycle has finished the Write Enable Latch (WEL) bit in the Status Register is cleared to 0. The Chip Erase instruction will not be executed if any memory region is protected by the Block Protect (CMP, SEC, TB, BP2, BP1, and BP0) bits.

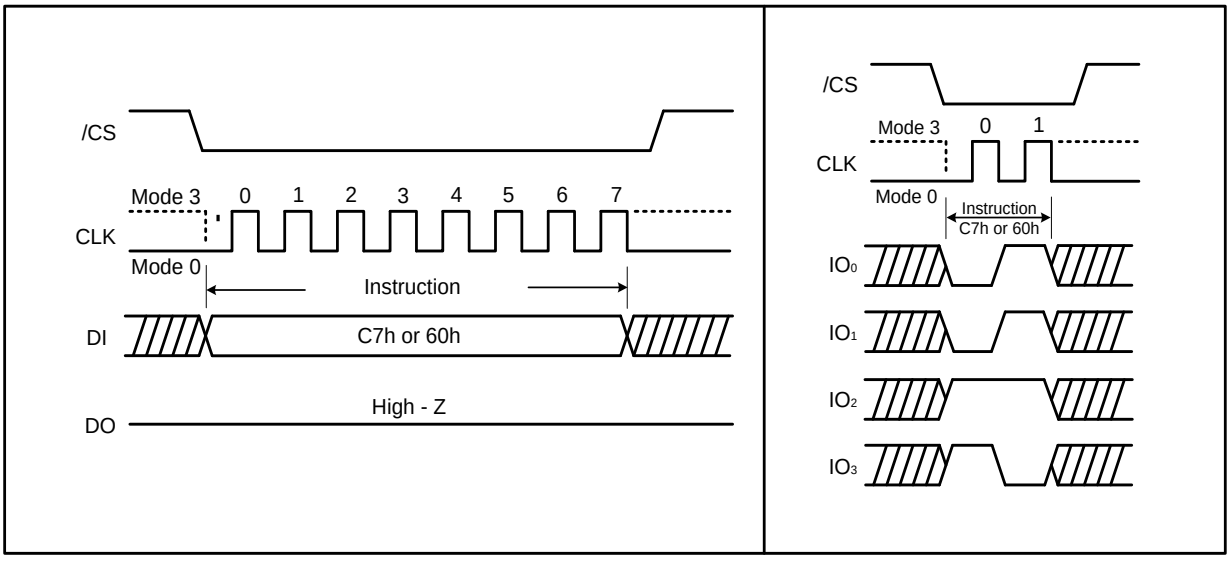


Figure 25. Chip Erase Instruction for SPI Mode (left) or QPI Mode (right)

8.2.34. Erase / Program Suspend (75h)

The Erase/Program Suspend instruction “75h”, allows the system to interrupt a Sector or Block Erase operation or a Page Program operation and then read from or program/erase data to, any other sectors or blocks. The Erase/Program Suspend instruction sequence is shown in Figure 26a & 26b.

The Write Status Register instruction (01h, 31h, 11h) and Erase instructions (20h, 52h, D8h, C7h, 60h, 44h) are not allowed during Erase Suspend. Erase Suspend is valid only during the Sector or Block erase operation. If written during the Chip Erase operation, the Erase Suspend instruction is ignored. The Write Status Register instructions (01h, 31h, 11h), Erase instructions (20h, 52h, D8h, C7h, 60h, 44h) and Program instructions (02h, 32h, 42h) are not allowed during Program Suspend. Program Suspend is valid only during the Page Program or Quad Page Program operation.

The Erase/Program Suspend instruction “75h” will be accepted by the device only if the both SUS1 and SUS2 bits in the Status Register equal to 0 and the BUSY bit equals to 1 while a Sector or Block Erase or a Page Program operation is on-going. If at least one of SUS1/SUS2 bit equals to 1 or the BUSY bit equals to 0, the Suspend instruction will be ignored by the device. A maximum of time of “t_{SUS}” (See AC Characteristics) is required to suspend the erase or program operation. The BUSY bit in the Status Register will be cleared from 1 to 0 within “t_{SUS}” and the SUS bit in the Status Register will be set from 0 to 1 immediately after Erase/Program Suspend. For a previously resumed Erase/Program operation, it is also required that the Suspend instruction “75h” is not issued earlier than a minimum of time of “t_{SUS}” following the preceding Resume instruction “7Ah”.

Unexpected power off during the Erase/Program suspend state will reset the device and release the suspend state. SUS bit in the Status Register will also reset to 0. The data within the page, sector or block that was being suspended may become corrupted. It is recommended for the user to implement system design techniques against the accidental power interruption and preserve data integrity during erase/program suspend state.

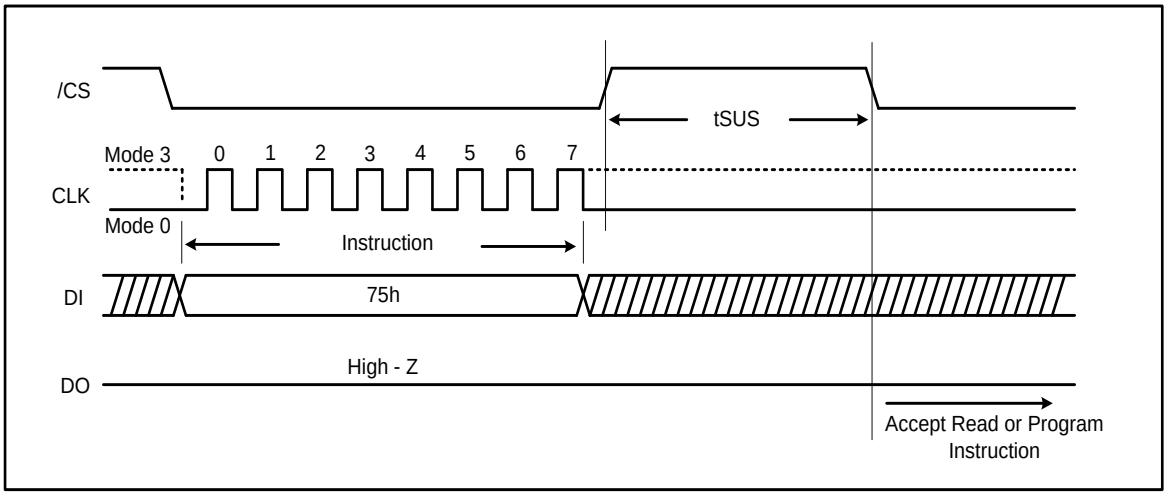


Figure 26a. Erase/Program Suspend Instruction (SPI Mode)

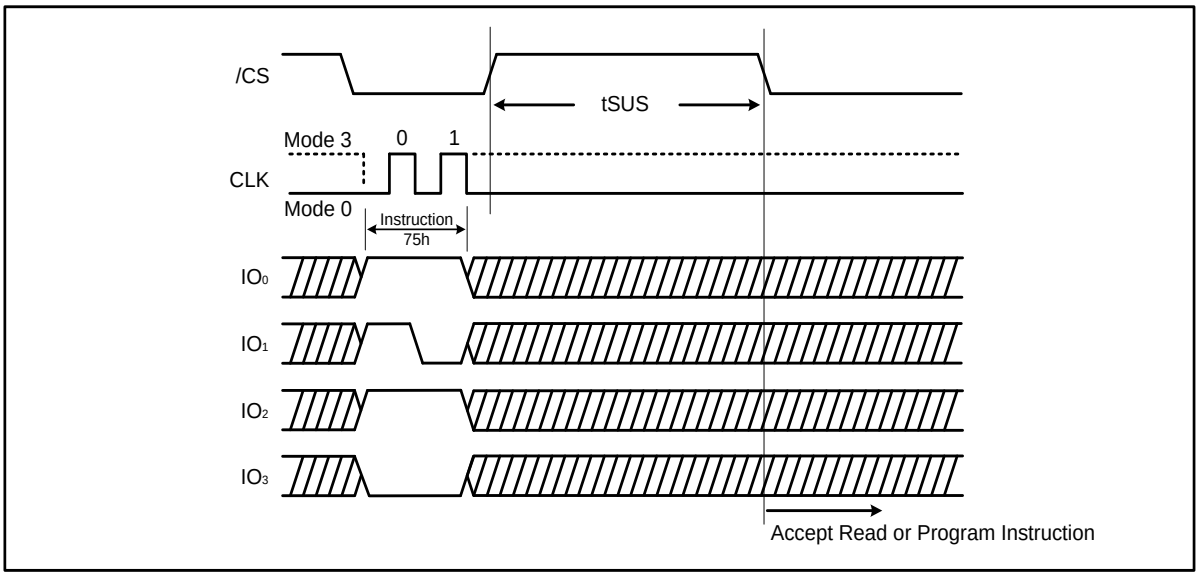


Figure 26b. Erase/Program Suspend Instruction (QPI Mode)

8.2.35. Erase / Program Resume (7Ah)

The Erase/Program Resume instruction "7Ah" must be written to resume the Sector or Block Erase operation or the Page Program operation after an Erase/Program Suspend. The Resume instruction "7Ah" will be accepted by the device only if the SUS bit in the Status Register equals to 1 and the BUSY bit equals to 0. After issued the SUS bit will be cleared from 1 to 0 immediately, the BUSY bit will be set from 0 to 1 within 200ns and the Sector or Block will complete the erase operation or the page will complete the program operation. If the SUS bit equals to 0 or the BUSY bit equals to 1, the Resume instruction "7Ah" will be ignored by the device. The Erase/Program Resume instruction sequence is shown in Figure 27a & 27b.

Resume instruction is ignored if the previous Erase/Program Suspend operation was interrupted by unexpected power off. It is also required that a subsequent Erase/Program Suspend instruction not to be issued within a minimum of time of "t_{SUS}" following a previous Resume instruction.

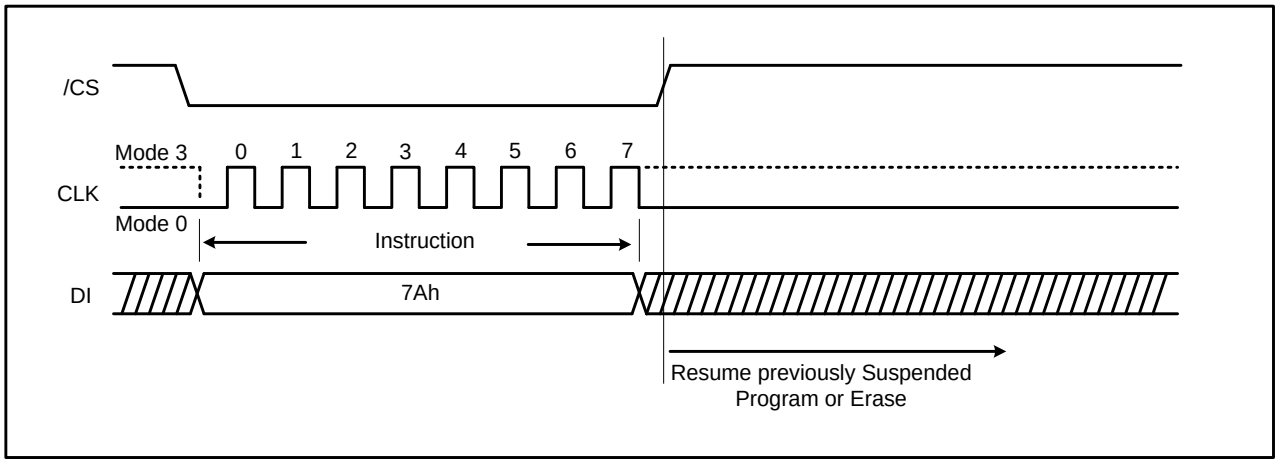


Figure 27a. Erase/Program Resume Instruction (SPI Mode)

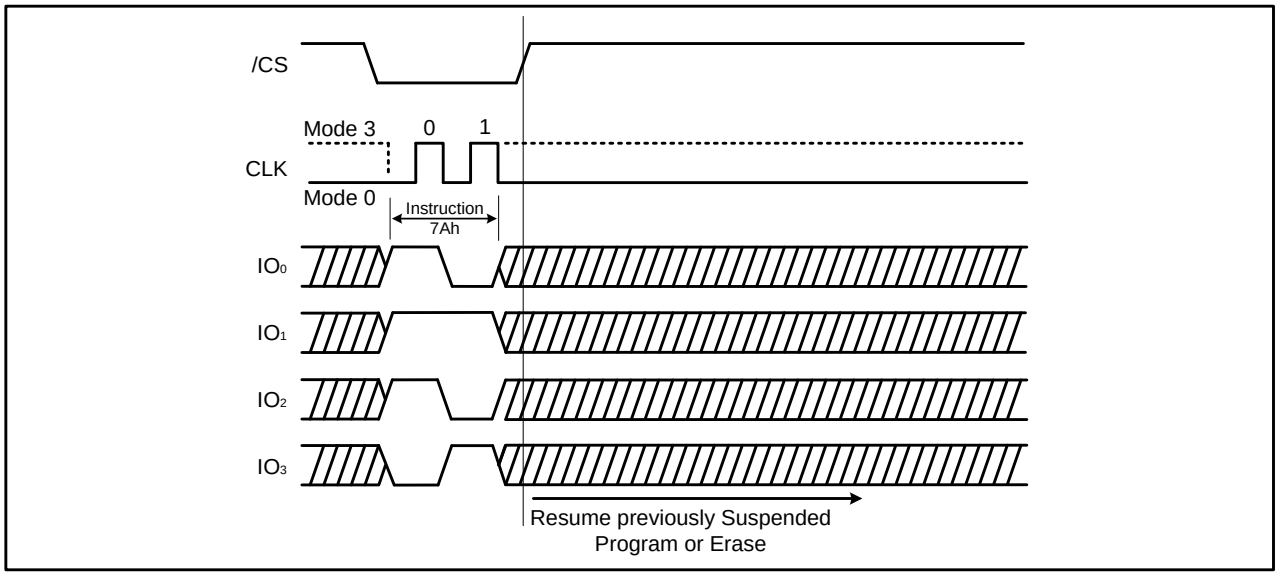


Figure 27b. Erase/Program Resume Instruction (QPI Mode)

8.2.36. **Deep Power-down (B9h)**

Although the standby current during normal operation is relatively low, standby current can be further reduced with the Deep Power-down instruction. The lower power consumption makes the Deep Power-down instruction especially useful for battery powered applications (See ICC1 and ICC2 in AC Characteristics). The instruction is initiated by driving the /CS pin low and shifting the instruction code "B9h" as shown in Figure 28a & 28b.

The /CS pin must be driven high after the eighth bit has been latched. If this is not done the Deep Power-down instruction will not be executed. After /CS is driven high, the power-down state will entered within the time duration of t_{DP} (See AC Characteristics). While in the power-down state only the Release Power- down / Device ID (ABh) instruction, which restores the device to normal operation, and software reset(66H+99H) will be recognized. All other instructions are ignored. This includes the Read Status Register instruction, which is always available during normal operation. Ignoring all but one instruction makes the Deep Power Down state a useful condition for securing maximum write protection. The device always powers-up in the normal operation with the standby current of ICC1.

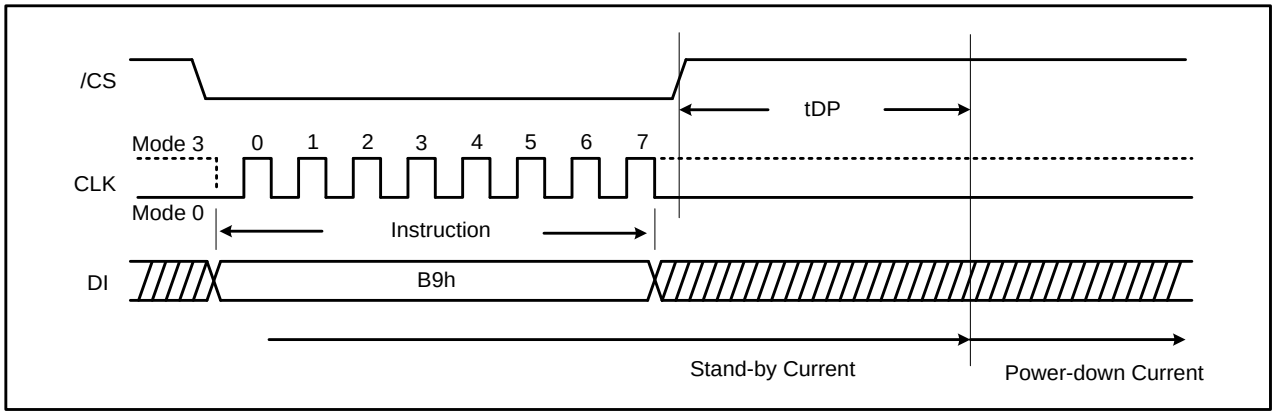


Figure 28a. Deep Power-down Instruction (SPI Mode)

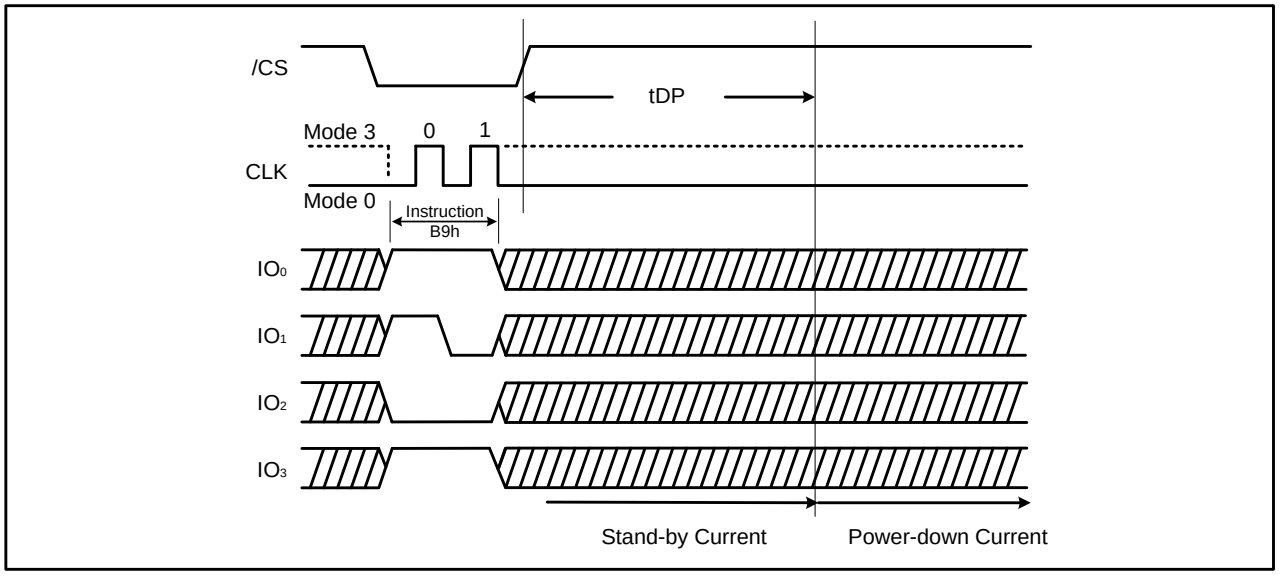


Figure 28b. Deep Power-down Instruction (QPI Mode)

8.2.37. Release Power-down / Device ID (ABh)

The Release from Power-down / Device ID instruction is a multi-purpose instruction. It can be used to release the device from the power-down state, or obtain the devices electronic identification (ID) number.

To release the device from the power-down state, the instruction is issued by driving the /CS pin low, shifting the instruction code "ABh" and driving /CS high as shown in Figure 29a & 29b. Release from power-down will take the time duration of t_{RES1} (See AC Characteristics) before the device will resume normal operation and other instructions are accepted. The /CS pin must remain high during the t_{RES1} time duration.

When used only to obtain the Device ID while not in the power-down state, the instruction is initiated by driving the /CS pin low and shifting the instruction code "ABh" followed by 3-dummy bytes. The Device ID bits are then shifted out on the falling edge of CLK with most significant bit (MSB) first. The Device ID value for the DS25M4AE is listed in Manufacturer and Device Identification table. The Device ID can be read continuously. The instruction is completed by driving /CS high.

When used to release the device from the power-down state and obtain the Device ID, the instruction is the same as previously described, and shown in Figure 29c & 29d, except that after /CS is driven high it must remain high for a time duration of t_{RES2} (See AC Characteristics). After this time duration the device will resume normal operation and other instructions will be accepted. If the Release from Power- down / Device ID instruction is issued while an Erase, Program or Write cycle is in process (when BUSY equals 1) the instruction is ignored and will not have any effects on the current cycle.

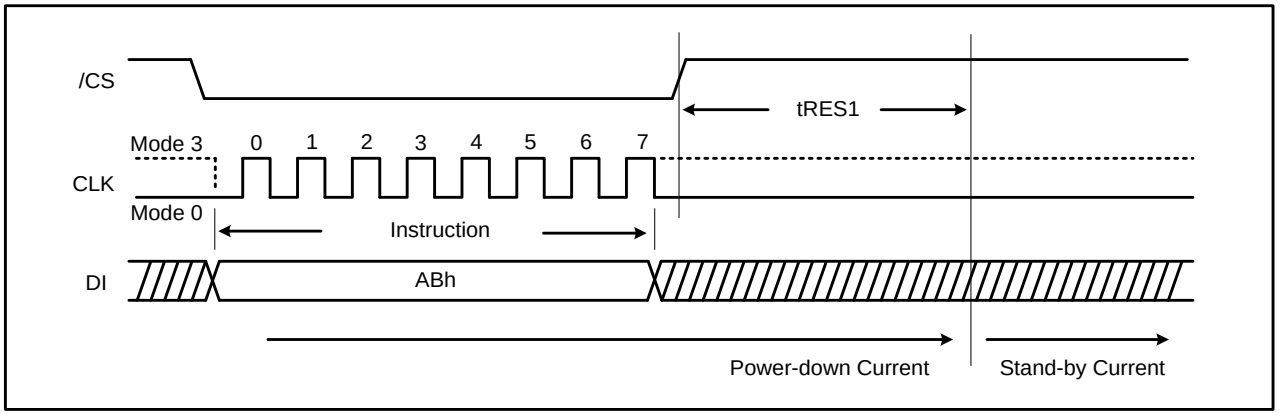


Figure 29a. Release Power-down Instruction (SPI Mode)

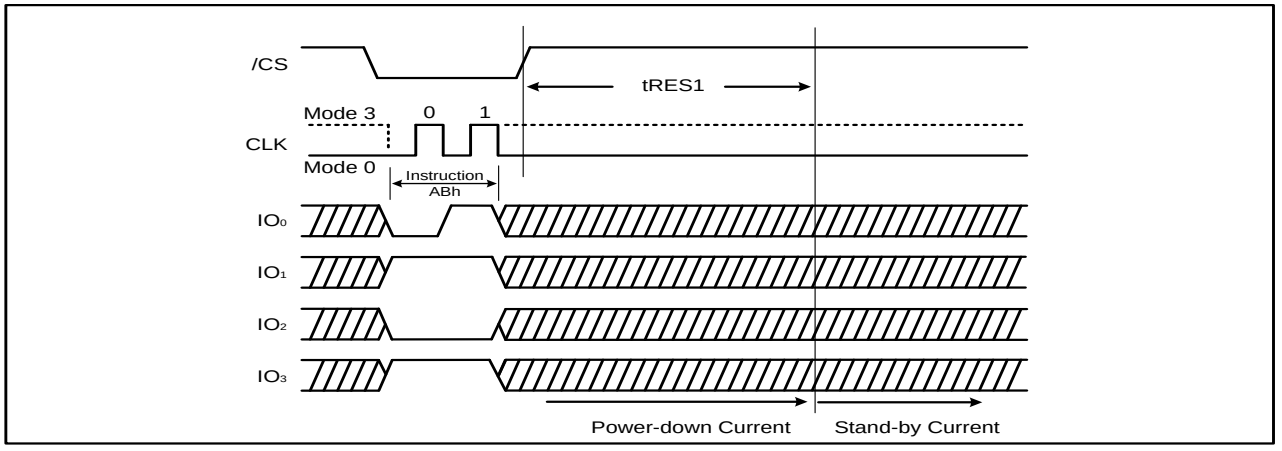


Figure 29b. Release Power-down Instruction (QPI Mode)

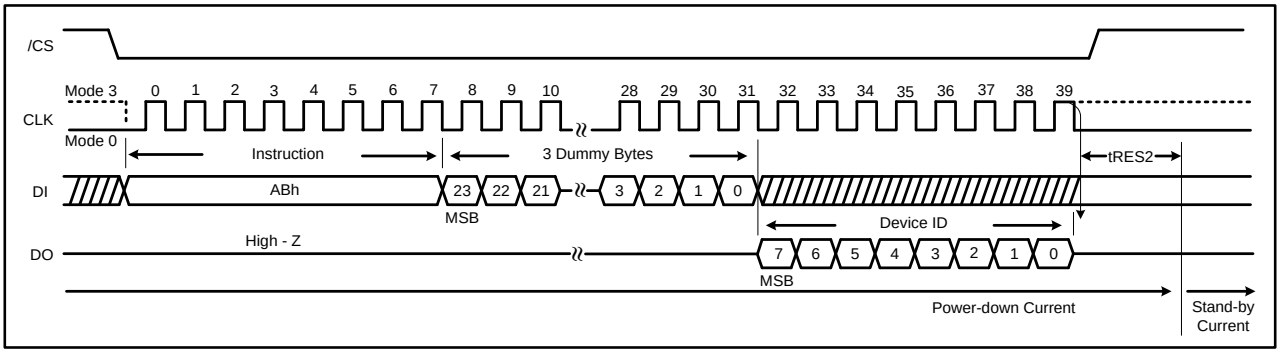


Figure 29c. Release Power-down / Device ID Instruction (SPI Mode)

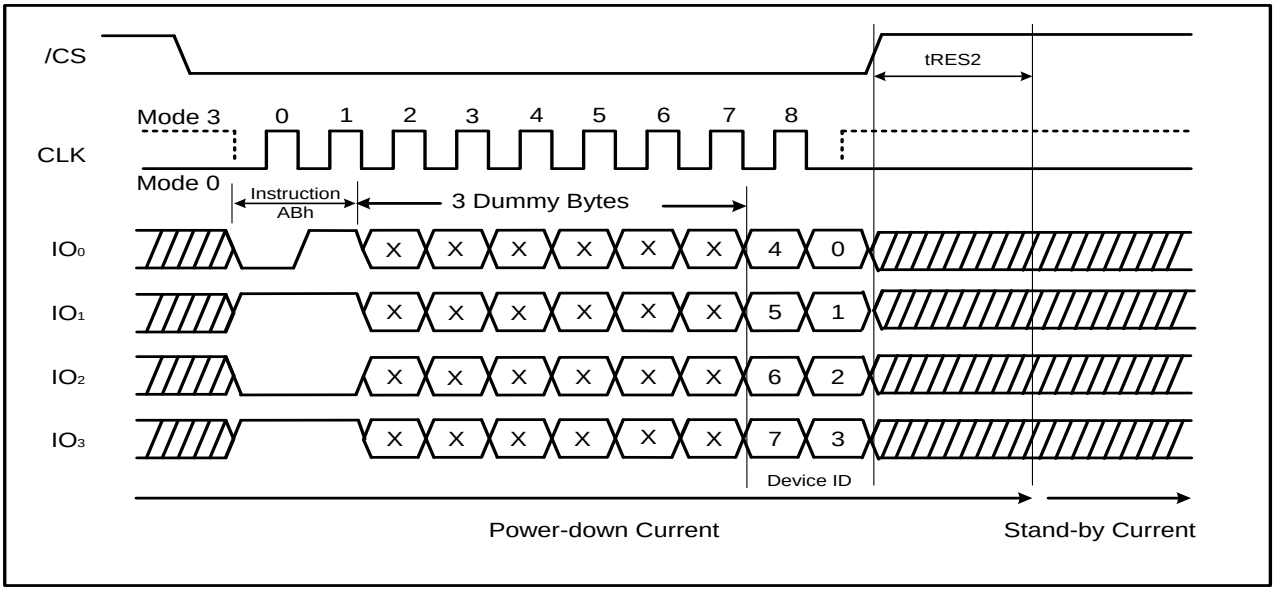


Figure 29d. Release Power-down / Device ID Instruction (QPI Mode)

8.2.38. **Read Manufacturer / Device ID (90h)**

The Read Manufacturer/Device ID 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 Read Manufacturer/Device ID instruction is very similar to the Release from Power-down / Device ID instruction. The instruction is initiated by driving the /CS pin low and shifting the instruction code "90h" followed by a 24-bit address (A23-A0) of 000000h. After which, the Manufacturer ID for Dosilicon (E5h) and the Device ID are shifted out on the falling edge of CLK with most significant bit (MSB) first as shown in Figure 30a & 30b. The Device ID values for the DS25M4AE are listed in Manufacturer and Device Identification table. The instruction is completed by driving /CS high.

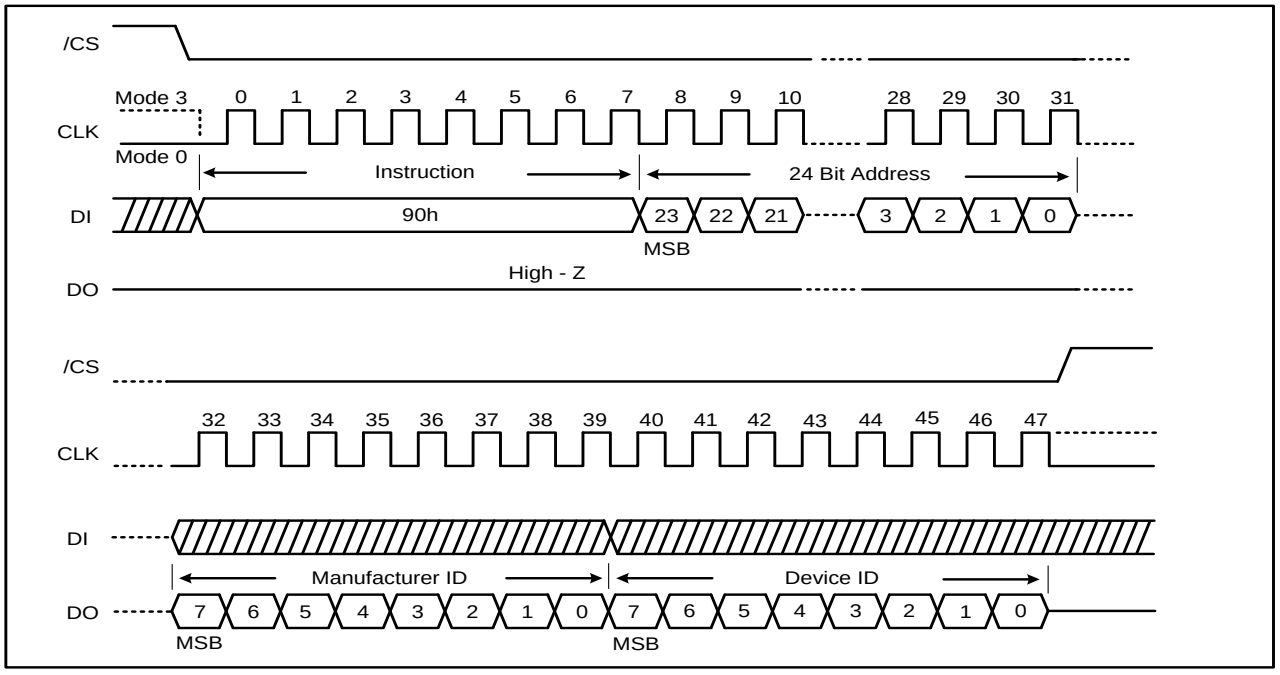


Figure 30a. Read Manufacturer / Device ID Instruction (SPI Mode)

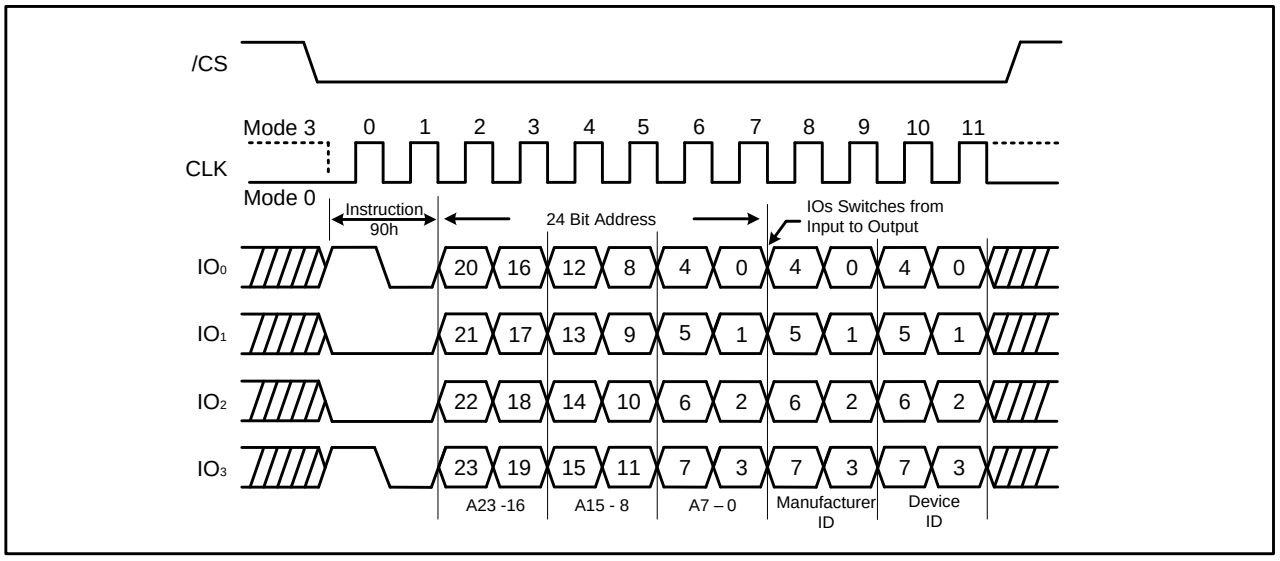


Figure 30b. Read Manufacturer / Device ID Instruction (QPI Mode)

8.2.39. Read Manufacturer / Device ID Dual I/O (92h)

The Read Manufacturer / Device ID Dual I/O instruction is an alternative to the Read Manufacturer / Device ID instruction that provides both the JEDEC assigned manufacturer ID and the specific device ID at 2x speed.

The Read Manufacturer / Device ID Dual I/O instruction is similar to the Fast Read Dual I/O instruction. The instruction is initiated by driving the /CS pin low and shifting the instruction code "92h" followed by a 24-bit address (A23-A0) of 000000h and then a 8 clock dummy cycles, but with the capability to input the Address bits two bits per clock. After which, the Manufacturer ID for Dosilicon (E5h) and the Device ID are shifted out 2 bits per clock on the falling edge of CLK with most significant bits (MSB) first as shown in Figure 31. The Device ID values for the DS25M4AE are listed in Manufacturer and Device Identification table. The Manufacturer and Device IDs can be read continuously, alternating from one to the other. The instruction is completed by driving /CS high. The "Continuous Read Mode" bits M7-0 are also considered as dummy clocks.

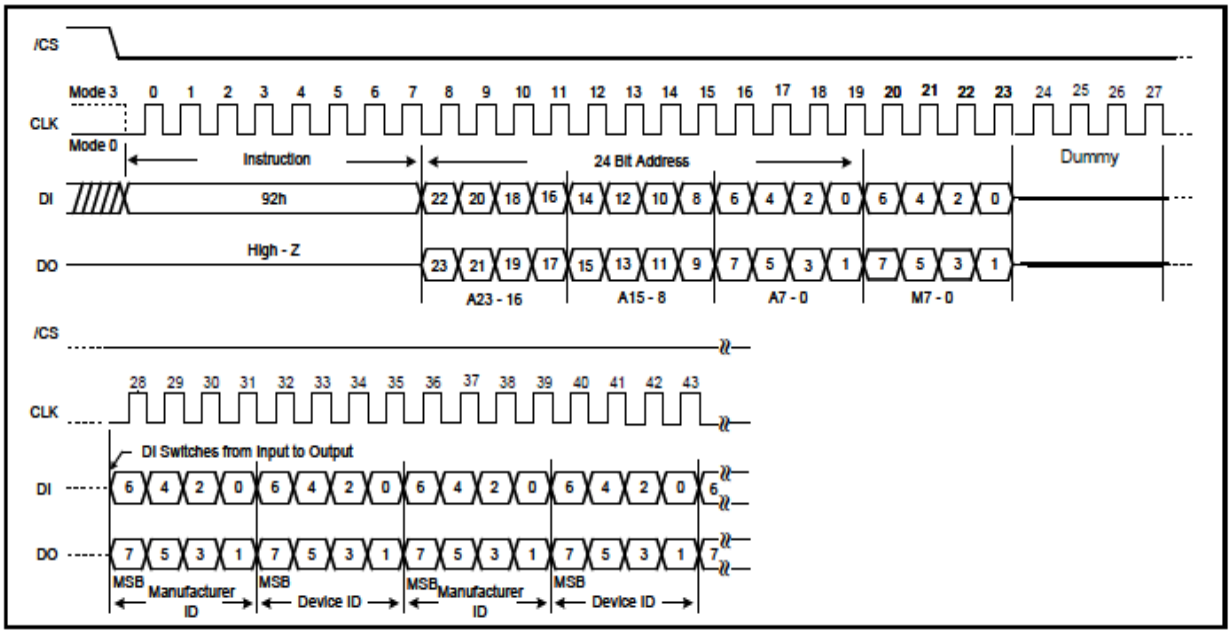


Figure 31. Read Manufacturer / Device ID Dual I/O Instruction (SPI Mode only)

8.2.40. **Read Manufacturer / Device ID Quad I/O (94h)**

The Read Manufacturer / Device ID Quad I/O instruction is an alternative to the Read Manufacturer / Device ID instruction that provides both the JEDEC assigned manufacturer ID and the specific device ID at 4x speed.

The Read Manufacturer / Device ID Quad I/O instruction is similar to the Fast Read Quad I/O instruction. The instruction is initiated by driving the /CS pin low and shifting the instruction code "94h" followed by a 24-bit address (A23-A0) of 000000h and then a 8 clock dummy cycles, but with the capability to input the Address bits four bits per clock. After which, the Manufacturer ID for Dosilicon (E5h) and the Device ID are shifted out four bits per clock on the falling edge of CLK with most significant bit (MSB) first as shown in Figure 32. The Device ID values for the DS25M4AE are listed in Manufacturer and Device Identification table. The Manufacturer and Device IDs can be read continuously, alternating from one to the other. The instruction is completed by driving /CS high. The "Continuous Read Mode" bits M7-0 are also considered as dummy clocks.

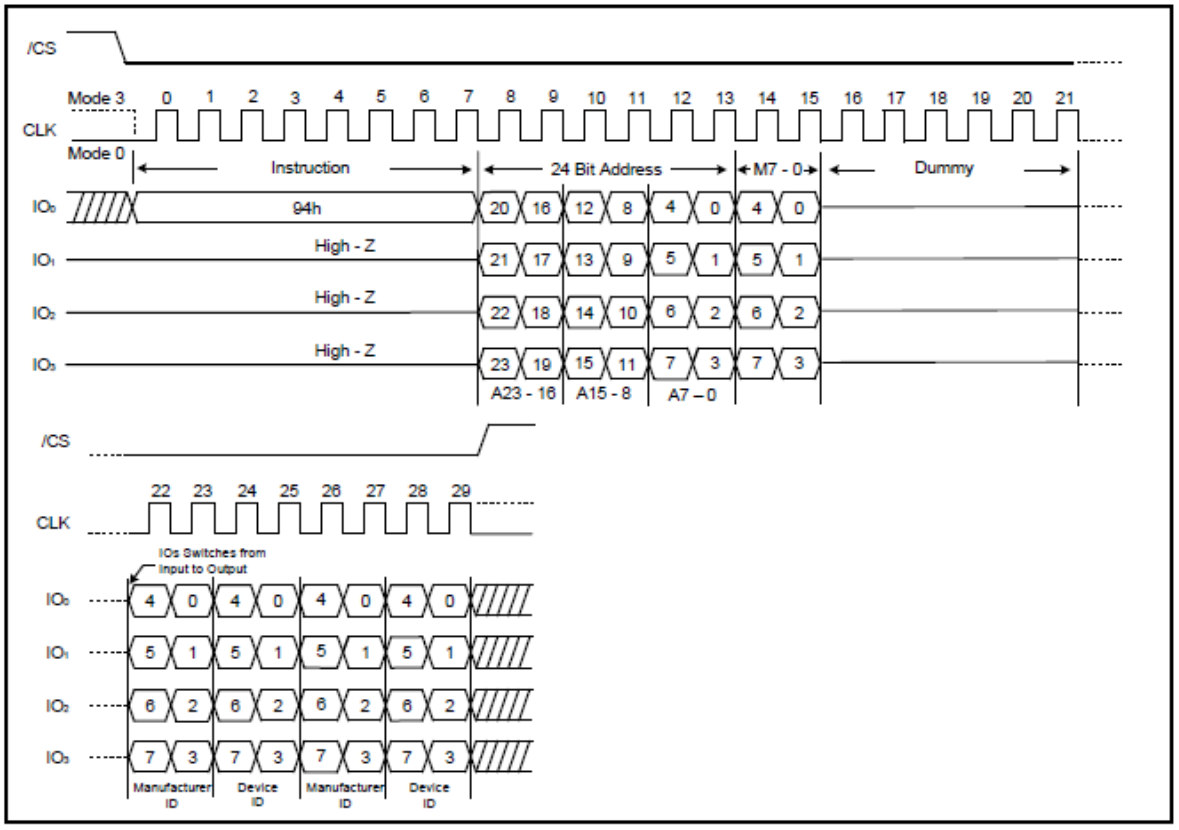


Figure 32. Read Manufacturer / Device ID Quad I/O Instruction (SPI Mode only)

8.2.41. **Read Unique ID Number (4Bh)**

The Read Unique ID Number instruction accesses a factory-set read-only 128-bit number that is unique to each DS25M4AE device. The ID number can be used in conjunction with user software methods to help prevent copying or cloning of a system. The Read Unique ID instruction is initiated by driving the /CS pin low and shifting the instruction code "4Bh" followed by 24 bits of '0' and one dummy byte. After which, the 128-bit ID is shifted out on the falling edge of CLK as shown in Figure 33a & 33b.

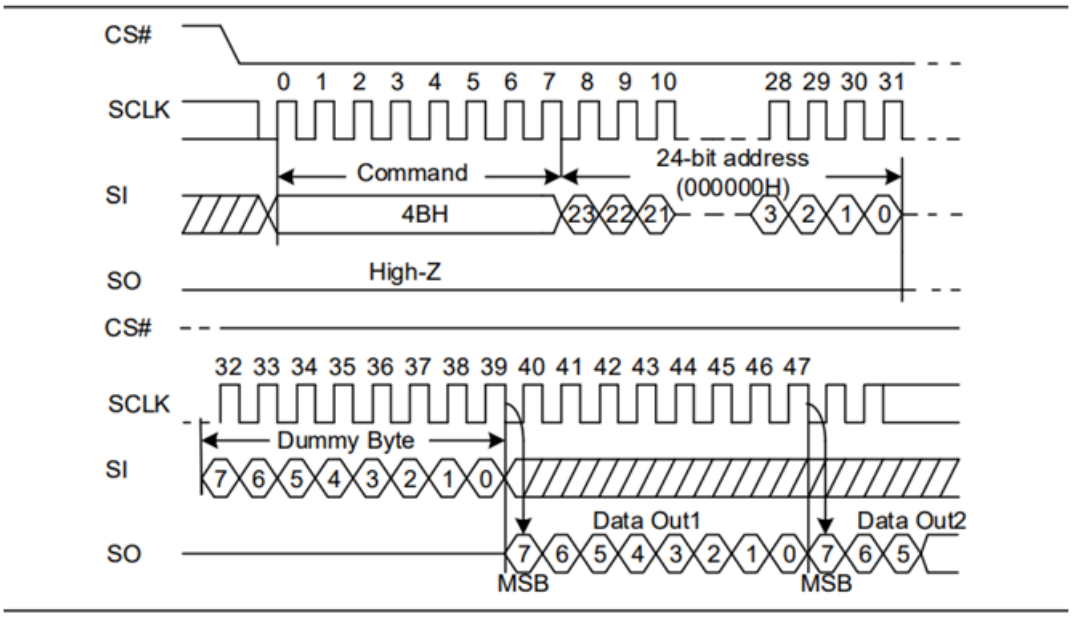


Figure 33a. Read Unique ID Number Instruction(SPI mode)

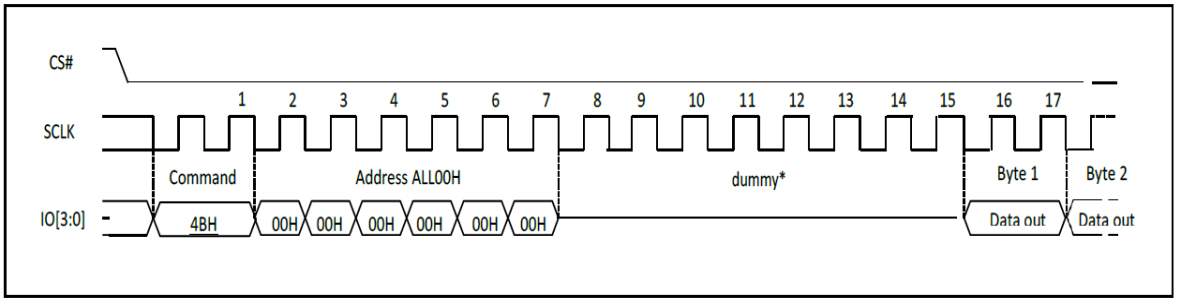


Figure 33b. Read Unique ID Number Instruction(QPI mode)

8.2.42. **Read JEDEC ID (9Fh)**

For compatibility reasons, the DS25M4AE provides several instructions to electronically determine the identity of the device. The Read JEDEC ID instruction is compatible with the JEDEC standard for SPI compatible serial memories that was adopted in 2003. The instruction is initiated by driving the /CS pin low and shifting the instruction code "9Fh". The JEDEC assigned Manufacturer ID byte for Dosilicon (E5h) and two Device ID bytes, Memory Type (ID15-ID8) and Capacity (ID7-ID0) are then shifted out on the falling edge of CLK with most significant bit (MSB) first as shown in Figure 34a & 34b. For memory type and capacity values refer to Manufacturer and Device Identification table.

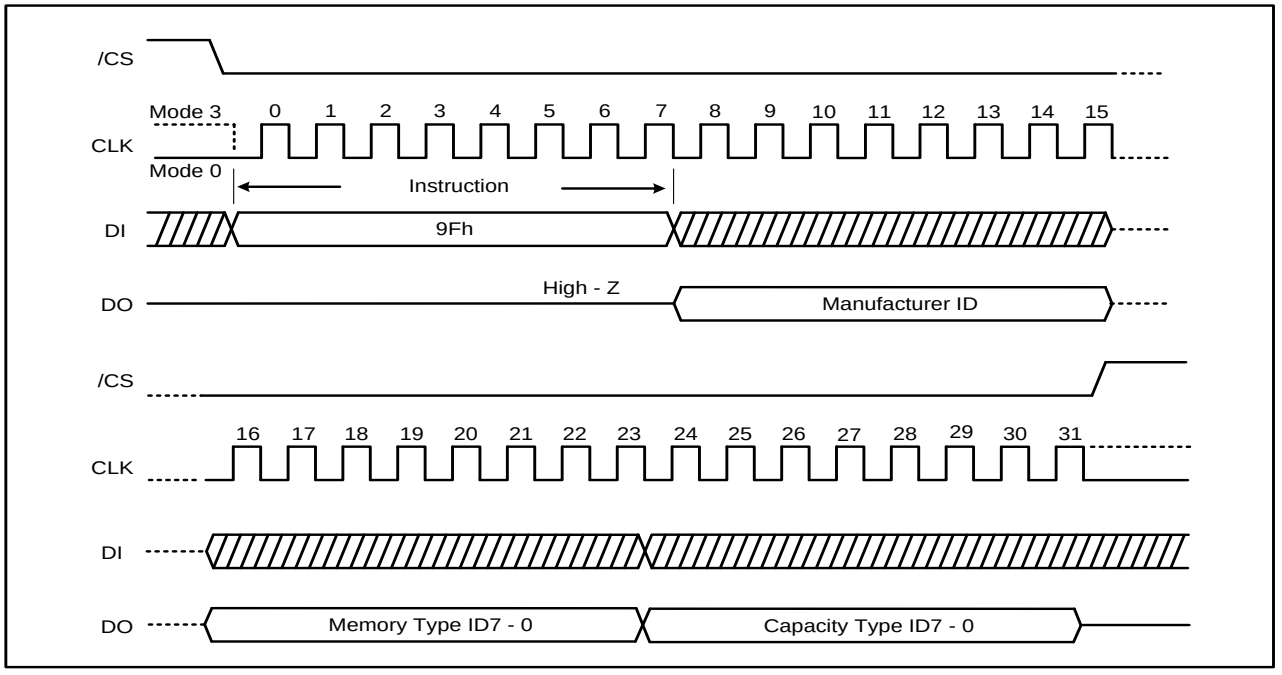


Figure 34a. Read JEDEC ID Instruction (SPI Mode)

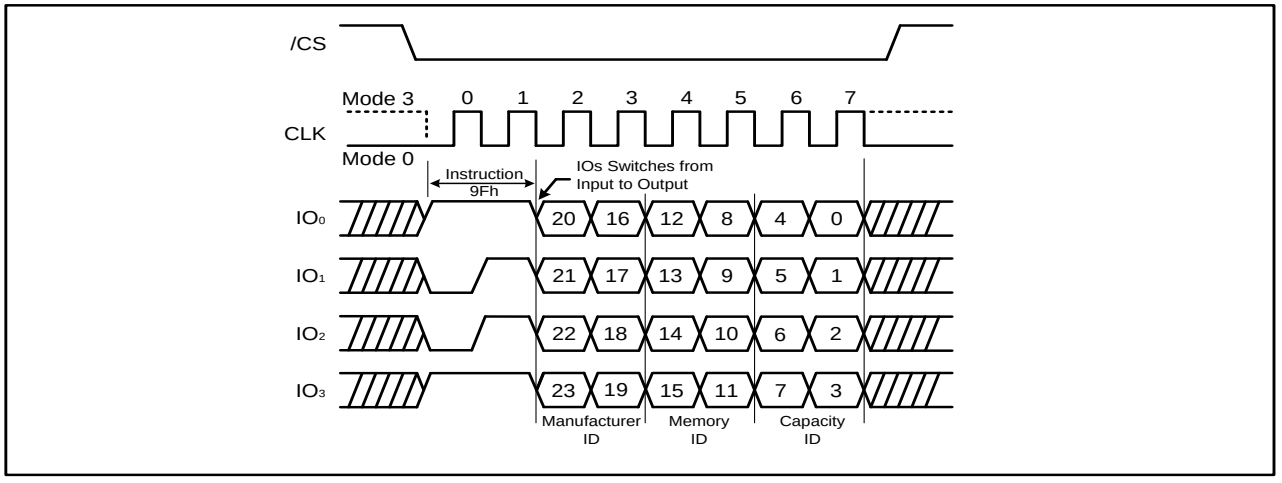


Figure 34b. Read JEDEC ID Instruction (QPI Mode)

8.2.43. **Read SFDP Register (5Ah)**

The DS25M4AE features a 256-Byte Serial Flash Discoverable Parameter (SFDP) register that contains information about device configurations, available instructions and other features. The SFDP parameters are stored in one or more Parameter Identification (PID) tables. Currently only one PID table is specified, but more may be added in the future. The Read SFDP Register instruction is compatible with the SFDP standard initially established in 2010 for PC and other applications, as well as the JEDEC standard JESD216 that is published in 2011.

The Read SFDP instruction is initiated by driving the /CS pin low and shifting the instruction code "5Ah" followed by a 24-bit address (A23-A0)(1) into the DI pin. Eight "dummy" clocks are also required before the SFDP register contents are shifted out on the falling edge of the 40th CLK with most significant bit (MSB) first as shown in Figure 35a, 36b. For SFDP register values and descriptions, please refer to the Dosilicon Application Note for SFDP Definition Table.

Note 1: A23-A8 = 0; A7-A0 are used to define the starting byte address for the 256-Byte SFDP Register.

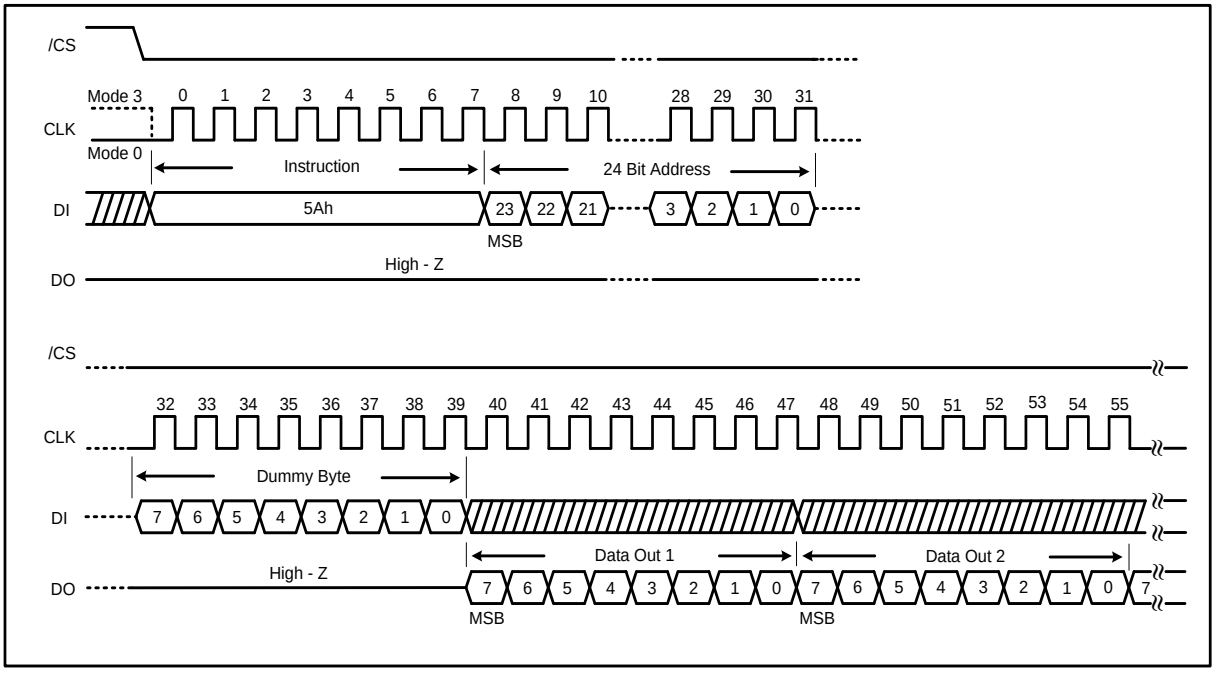


Figure 35a. Read SFDP Register Instruction Sequence Diagram

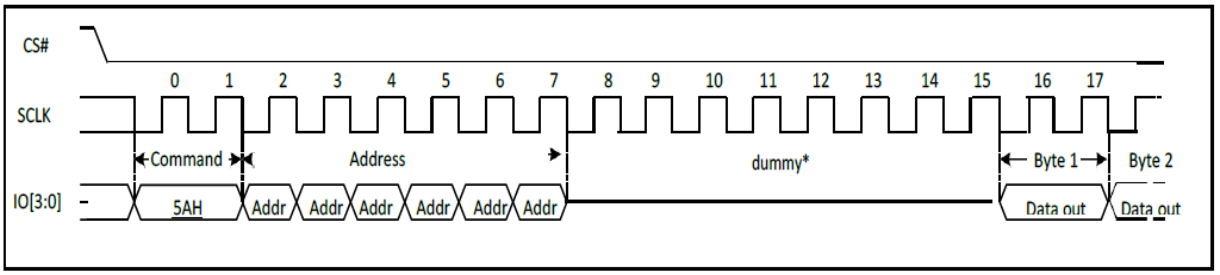


Figure 35b. Read SFDP Register Instruction Sequence Diagram (QPI Mode)

8.2.44. Erase Security Registers (44h)

The DS25M4AE offers 3x1024-byte Security Registers which can be erased and programmed individually. These registers may be used by the system manufacturers to store security and other important information separately from the main memory array.

The Erase Security Register instruction is similar to the Sector Erase instruction. A Write Enable instruction must be executed before the device will accept the Erase Security Register Instruction (Status Register bit WEL must equal 1). The instruction is initiated by driving the /CS pin low and shifting the instruction code "44h" followed by a 24-bit address (A23-A0) to erase one of the three security registers.

ADDRESS	A23-16	A15-12	A11-A10	A9-0
Security Register #1	00h	0 0 0 1b	0 0b	Don't Care
Security Register #2	00h	0 0 1 0b	0 0b	Don't Care
Security Register #3	00h	0 0 1 1b	0 0b	Don't Care

The Erase Security Register instruction sequence is shown in Figure 36a, 36b. The /CS pin must be driven high after the eighth bit of the last byte has been latched. If this is not done the instruction will not be executed. After /CS is driven high, the self-timed Erase Security Register operation will commence for a time duration of t_{SE} (See AC Characteristics). While the Erase Security Register cycle is in progress, the Read Status Register instruction may still be accessed for checking the status of the BUSY bit. The BUSY bit is a 1 during the erase cycle and becomes a 0 when the cycle is finished and the device is ready to accept other instructions again. After the Erase Security Register cycle has finished the Write Enable Latch (WEL) bit in the Status Register is cleared to 0. The Security Register Lock Bits (LB3-1) in the Status Register-2 can be used to OTP protect the security registers. Once a lock bit is set to 1, the corresponding security register will be permanently locked, Erase Security Register instruction to that register will be ignored (Refer to section 7.1.8 for detail descriptions).

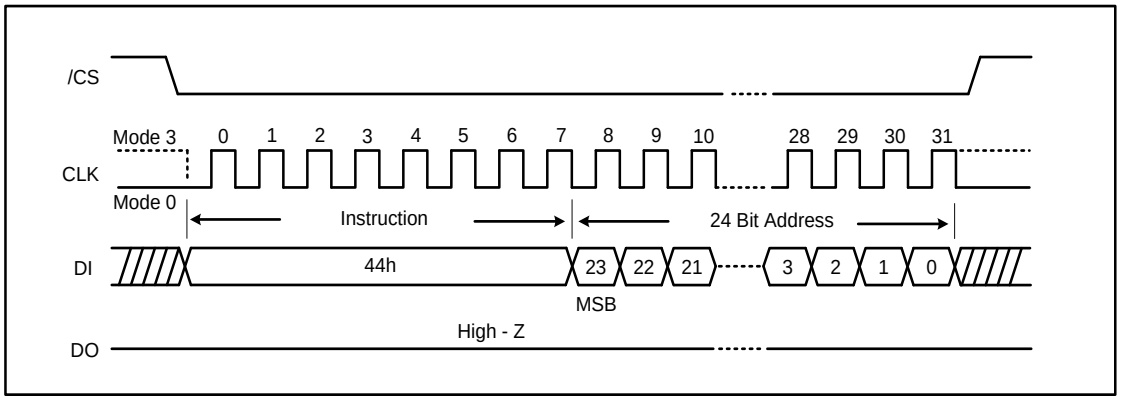


Figure 36a. Erase Security Registers Instruction (SPI Mode)

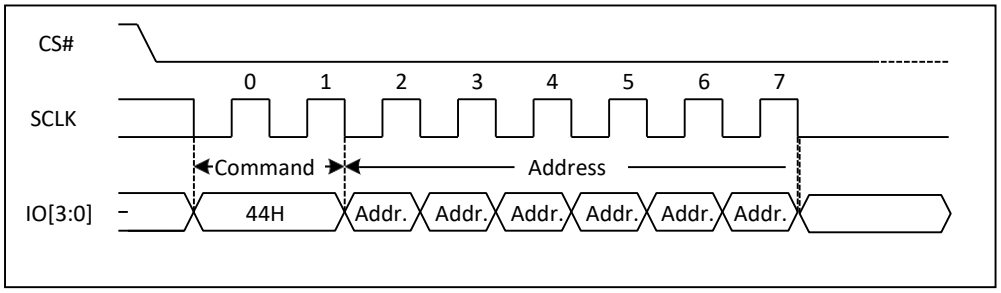


Figure 36b. Erase Security Registers Instruction (QPI Mode)

8.2.45. **Program Security Registers (42h)**

The Program Security Register instruction is similar to the Page Program instruction. It allows from one byte to 1024 bytes of security register data to be programmed at previously erased (FFh) memory locations. A Write Enable instruction must be executed before the device will accept the Program Security Register Instruction (Status Register bit WEL= 1). The instruction is initiated by driving the /CS pin low then shifting the instruction code "42h" followed by a 24-bit address (A23-A0) and at least one data byte, into the DI pin. The /CS pin must be held low for the entire length of the instruction while data is being sent to the device.

ADDRESS	A23-16	A15-12	A11-A10	A9-0
Security Register #1	00h	0 0 0 1b	0 0b	Byte Address
Security Register #2	00h	0 0 1 0b	0 0b	Byte Address
Security Register #3	00h	0 0 1 1b	0 0b	Byte Address

The Program Security Register instruction sequence is shown in Figure 37a, 37b. The Security Register Lock Bits (LB3-1) in the Status Register-2 can be used to OTP protect the security registers. Once a lock bit is set to 1, the corresponding security register will be permanently locked, Program Security Register instruction to that register will be ignored (See Section "Security Register Lock Bits(LB3, B2, LB1) for detail descriptions).

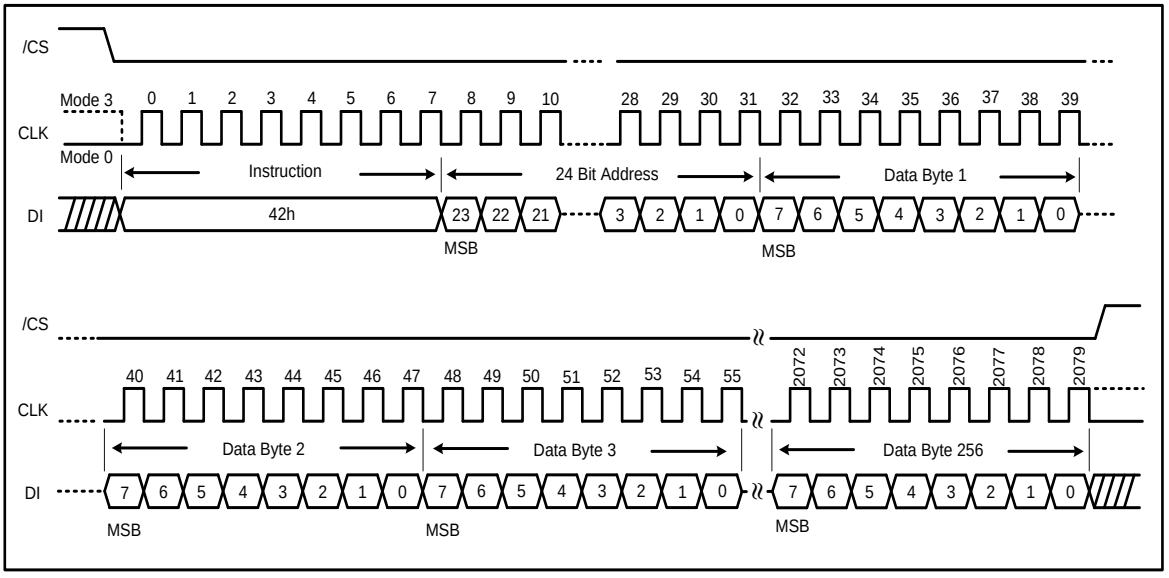


Figure 37a. Program Security Registers Instruction (SPI Mode)

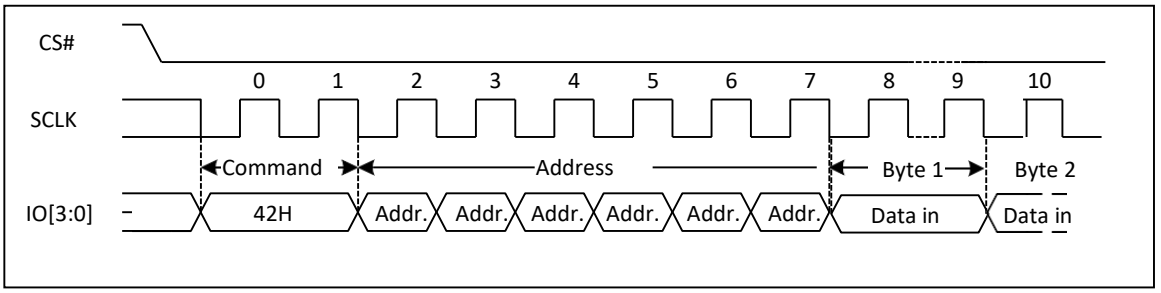


Figure 37b. Program Security Registers Instruction (QPI Mode)

8.2.46. **Read Security Registers (48h)**

The Read Security Register instruction is similar to the Fast Read instruction and allows one or more data bytes to be sequentially read from one of the 3 security registers. The instruction is initiated by driving the /CS pin low and then shifting the instruction code "48h" followed by a 24-bit address (A23-A0) and eight "dummy" clocks into the DI pin. The code and address bits are latched on the rising edge of the CLK pin. After the address is received, the data byte of the addressed memory location will be shifted out on the DO pin at the falling edge of CLK with most significant bit (MSB) first. The byte address is automatically incremented to the next byte address after each byte of data is shifted out. Once the byte address reaches the last byte of the register (byte address 3FFh), it will reset to address 000h, the first byte of the register, and continue to increment. The instruction is completed by driving /CS high. The Read Security Register instruction sequence is shown in Figure 38a, 38b. If a Read Security Register instruction is issued while an Erase, Program or Write cycle is in process (BUSY=1) the instruction is ignored and will not have any effects on the current cycle. The Read Security Register instruction allows clock rates from D.C. to a maximum of F_R (see AC Electrical Characteristics).

ADDRESS	A23-16	A15-12	A11-A10	A9-0
Security Register #1	00h	0 0 0 1	0 0b	Byte Address
Security Register #2	00h	0 0 1 0	0 0b	Byte Address
Security Register #3	00h	0 0 1 1	0 0b	Byte Address

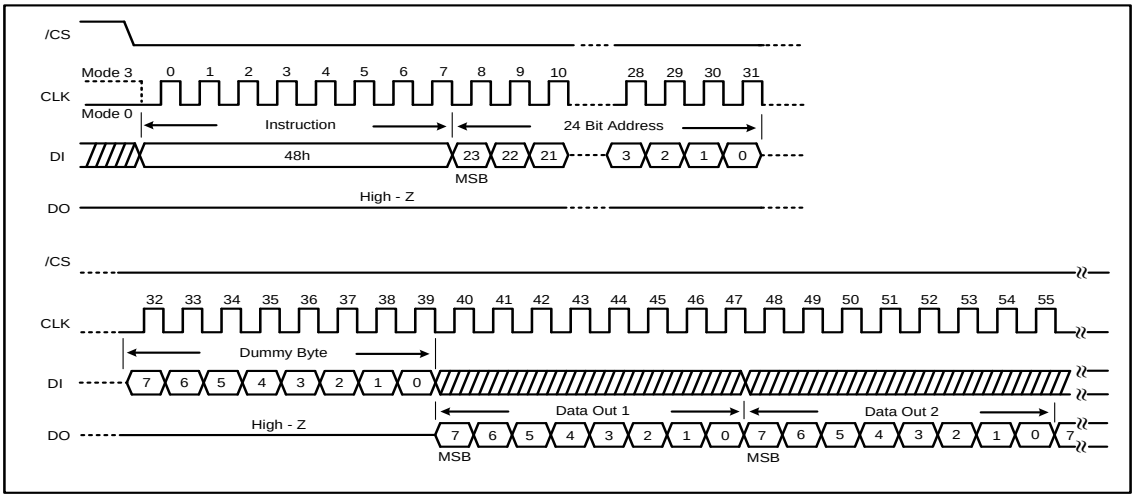


Figure 38a. Read Security Registers Instruction (SPI Mode)

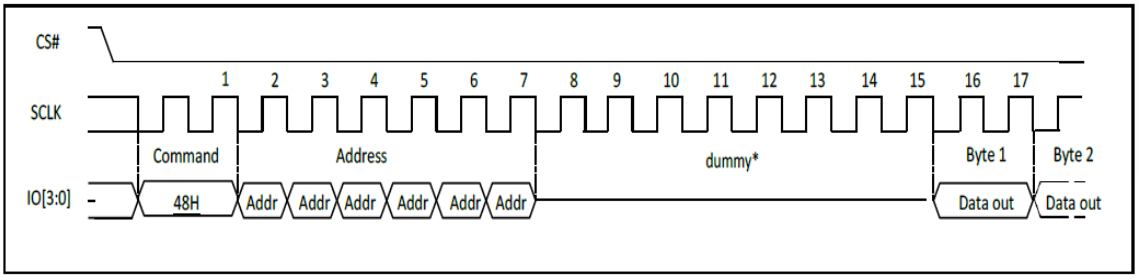


Figure 38b. Read Security Registers Instruction (QPI Mode)

8.2.47. Set Read Parameters (C0h)

In QPI mode, to accommodate a wide range of applications with different needs for either maximum read frequency or minimum data access latency, “Set Read Parameters (C0h)” instruction can be used to configure the number of dummy clocks for “Fast Read (0Bh)”, “Fast Read Quad I/O (EBh)”, “Burst Read with Wrap (0Ch)”, “Read Security Registers (48h)”, “Read SFDP Register (5Ah)” and 0Dh/0Eh/EDh instructions, and to configure the number of bytes of “Wrap Length” for the “Burst Read with Wrap (0Ch)” and “DTR wrap read(0Eh)” instruction.

In Standard SPI mode, the “Set Read Parameters (C0h)” instruction is not accepted. The dummy clocks for various Fast Read instructions in Standard/Dual/Quad SPI mode are fixed, please refer to the Instruction Table for details. The “Wrap Length” is set by W5-4 bit in the “Set Burst with Wrap (77h)” instruction. This setting will remain unchanged when the device is switched from Standard SPI mode to QPI mode.

The default “Wrap Length” after a power up or a Reset instruction is 8 bytes, the default number of dummy clocks is 8 for 0Bh/EBh/0Ch/48h/5Ah and 10 for 0Dh/0Eh/EDh CMD. The number of dummy clocks is only programmable for “Fast Read (0Bh)”, “Fast Read Quad I/O (EBh)”, “Burst Read with Wrap (0Ch)”, “Read Security Registers (48h)”, “Read SFDP Register (5Ah)” and 0Dh/0Eh/EDh” instructions in the QPI mode. Whenever the device is switched from SPI mode to QPI mode, the number of dummy clocks should be set again.

P5 – P4		DUMMY CLOCKS	MAXIMUM READ FREQ (0Bh/EBh/0Ch/48h /5Ah)	DUMMY CLOCKS	MAXIMUM READ FREQ (0Dh/0Eh/EDh)	P1 – P0	WRAP LENGTH
0	0	6	100MHz	8	80MHz	0 0	8-byte
0	1	6	100MHz	8	80MHz	0 1	16-byte
1	0	8	133MHz	8	80MHz	1 0	32-byte
1	1	8	133MHz	10	80MHz (100MHz)	1 1	64-byte

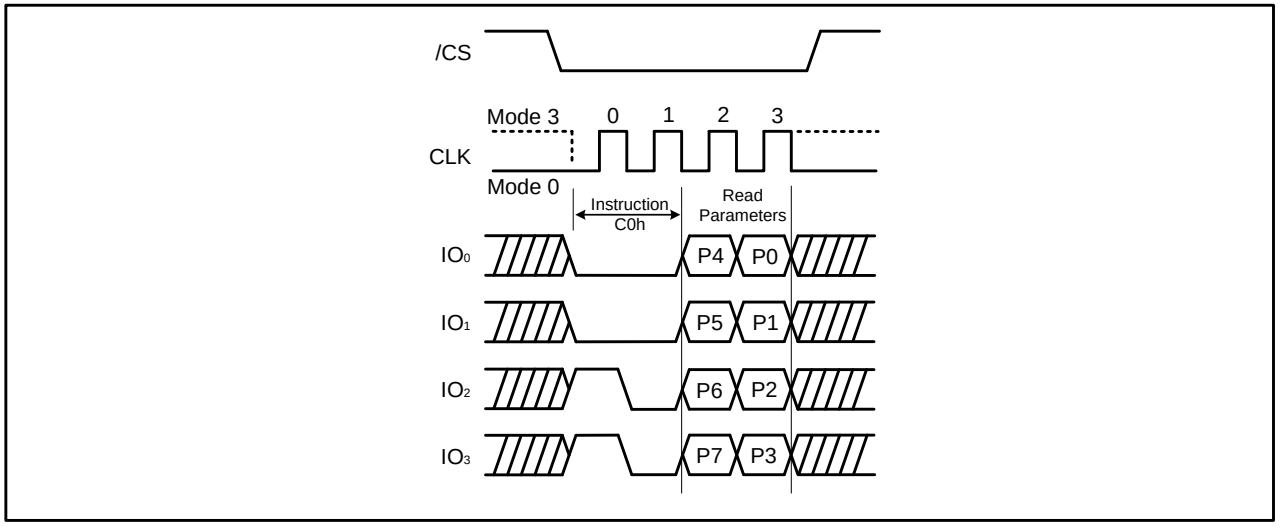


Figure 39. Set Read Parameters Instruction (QPI Mode only)

8.2.48. Burst Read with Wrap (0Ch)

The “Burst Read with Wrap (0Ch)” instruction provides an alternative way to perform the read operation with “Wrap Around” in QPI mode. The instruction is similar to the “Fast Read (0Bh)” instruction in QPI mode, except the addressing of the read operation will “Wrap Around” to the beginning boundary of the “Wrap Length” once the ending boundary is reached.

The “Wrap Length” and the number of dummy clocks can be configured by the “Set Read Parameters (C0h)” instruction.

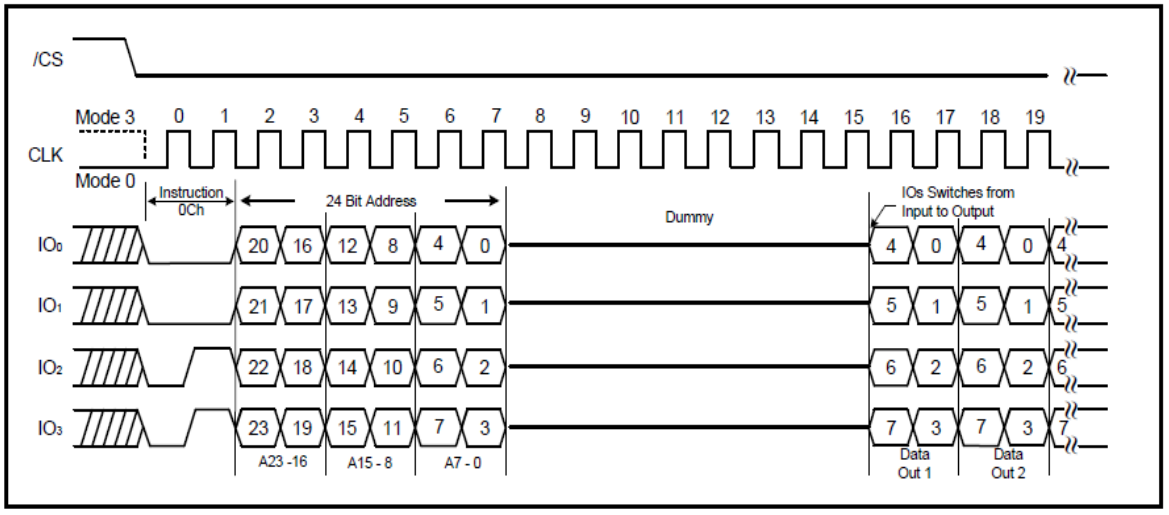


Figure 40. Burst Read with Wrap Instruction (QPI Mode only)

8.2.49. **Enter QPI Mode (38h)**

The DS25M4AE support both Standard/Dual/Quad Serial Peripheral Interface (SPI) and Quad Peripheral Interface (QPI). However, SPI mode and QPI mode cannot be used at the same time. “Enter QPI (38h)” instruction is the only way to switch the device from SPI mode to QPI mode.

Upon power-up, the default state of the device upon is Standard/Dual/Quad SPI mode. This provides full backward compatibility with earlier generations of Dosilicon serial flash memories. See Instruction Set Table for all supported SPI commands. In order to switch the device to QPI mode, the Quad Enable (QE) bit in Status Register-2 must be set to 1 first, and an “Enter QPI (38h)” instruction must be issued. If the Quad Enable (QE) bit is 0, the “Enter QPI (38h)” instruction will be ignored and the device will remain in SPI mode.

See Instruction Set Table for all the commands supported in QPI mode.

When the device is switched from SPI mode to QPI mode, the existing Write Enable and Program/Erase Suspend status, and the Wrap Length setting will remain unchanged.

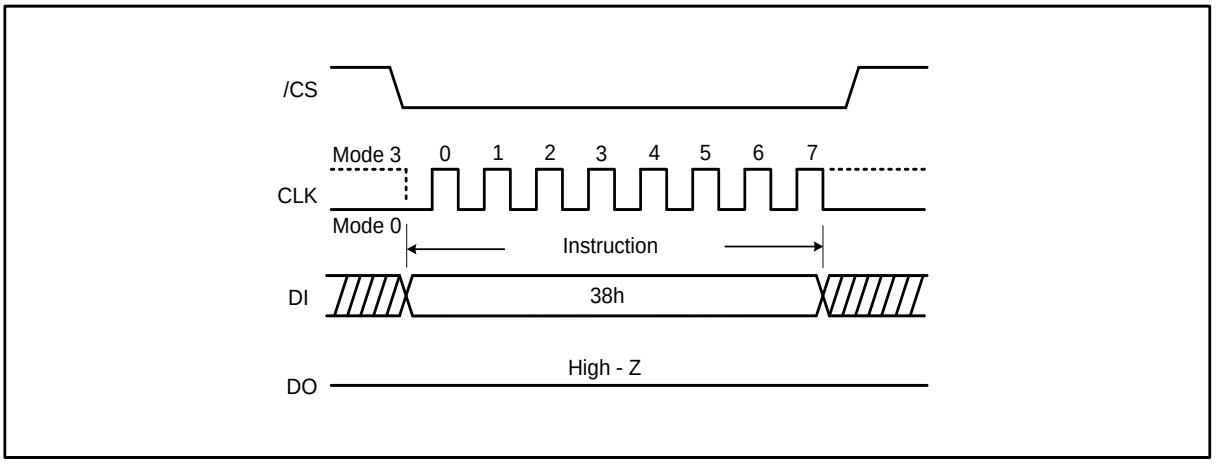


Figure 41. Enter QPI Instruction (SPI Mode only)

8.2.50. **Exit QPI Mode (FFh)**

In order to exit the QPI mode and return to the Standard/Dual/Quad SPI mode, an “Exit QPI (FFh)” instruction must be issued.

When the device is switched from QPI mode to SPI mode, the existing Write Enable Latch (WEL) and Program/Erase Suspend status, and the Wrap Length setting will remain unchanged.

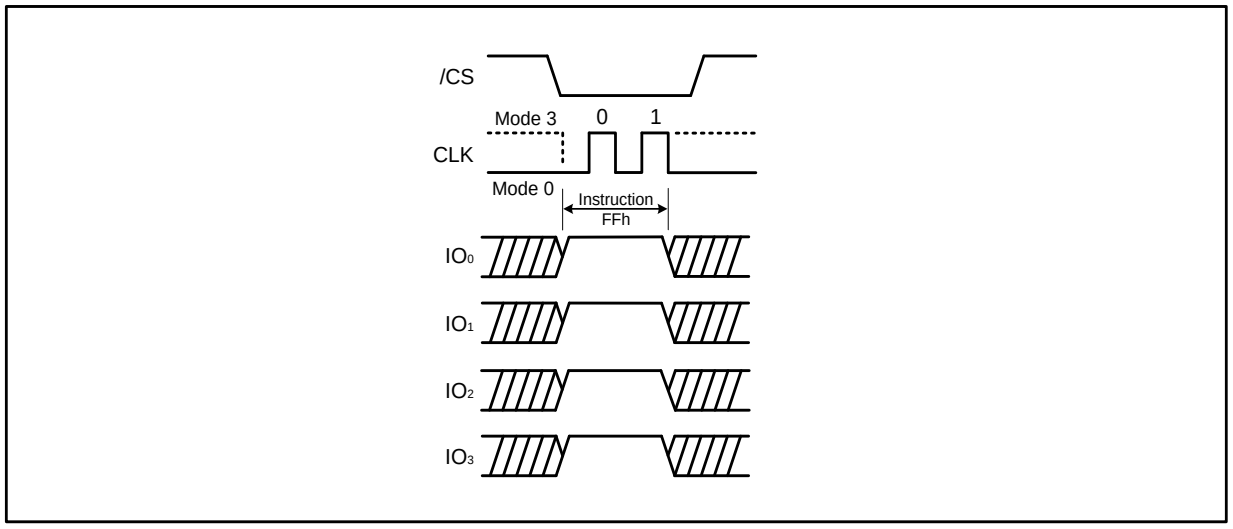


Figure 42. Exit QPI Instruction (QPI Mode only)

8.2.51. Enable Reset (66h) and Reset Device (99h)

Because of the small package and the limitation on the number of pins, the DS25M4AE provide a software Reset instruction instead of a dedicated RESET pin. Once the Reset instruction is accepted, any on-going internal operations will be terminated and the device will return to its default power-on state and lose all the current volatile settings, such as Volatile Status Register bits, Write Enable Latch (WEL) status, Program/Erase Suspend status, Read parameter setting (P7-P0), Continuous Read Mode bit setting (M7-M0) and Wrap Bit setting (W6-W4).

"Enable Reset (66h)" and "Reset (99h)" instructions can be issued in either SPI mode or QPI mode. To avoid accidental reset, both instructions must be issued in sequence. Any other commands other than "Reset (99h)" after the "Enable Reset (66h)" command will disable the "Reset Enable" state. A new sequence of "Enable Reset (66h)" and "Reset (99h)" is needed to reset the device. Once the Reset command is accepted by the device, the device will take approximately tRST=30us to reset. During this period, no command will be accepted.

Data corruption may happen if there is an on-going or suspended internal Erase or Program operation when Reset command sequence is accepted by the device. It is recommended to check the BUSY bit and the SUS bit in Status Register before issuing the Reset command sequence.

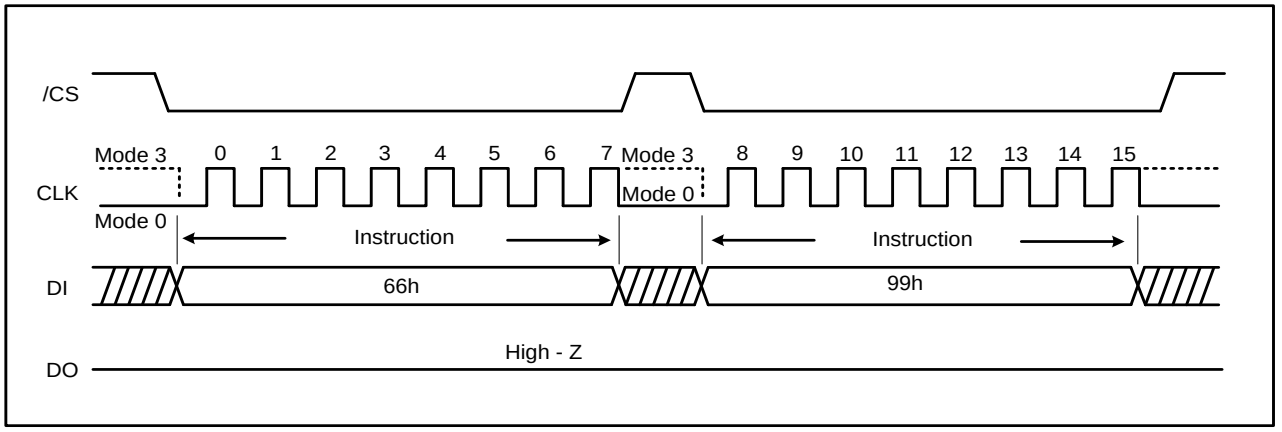


Figure 43a. Enable Reset and Reset Instruction Sequence (SPI Mode)

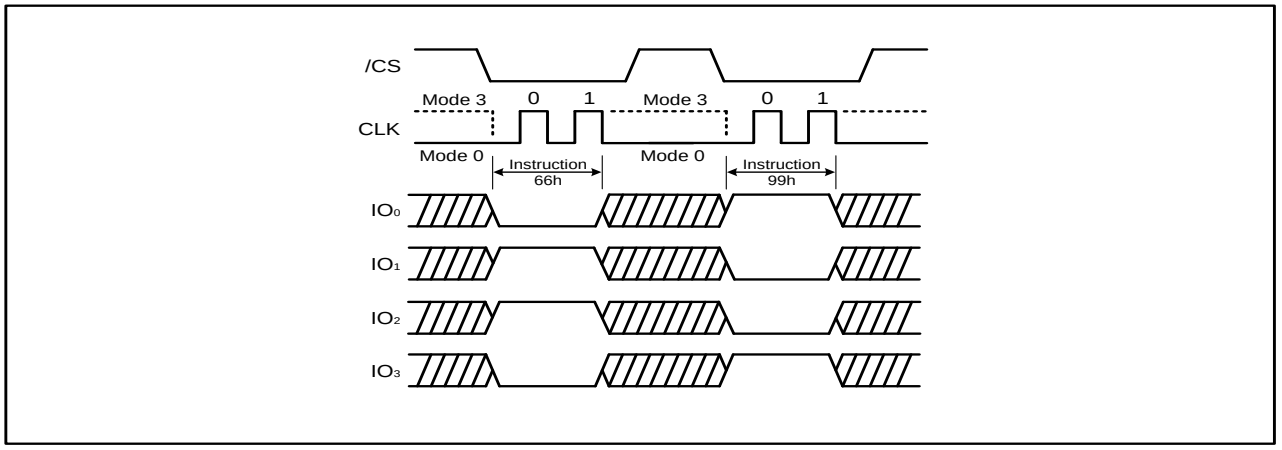


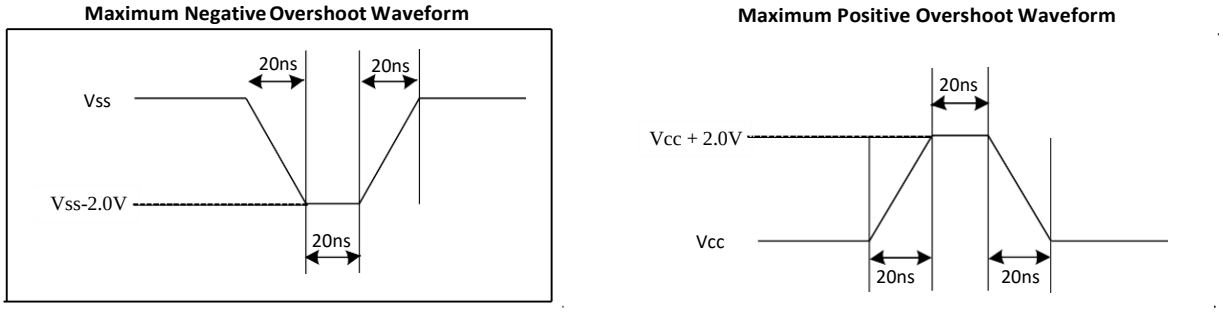
Figure 43b. Enable Reset and Reset Instruction Sequence (QPI Mode)

9. ELECTRICAL CHARACTERISTICS

9.1. Absolute Maximum Ratings

Parameter	Value	Unit
Ambient Operating Temperature (T_A)	-40 to 85/105/125	℃
Storage Temperature	-65 to 150	℃
Transient Input/Output Voltage (note: overshoot)	-2.0 to VCC+2.0	V
Applied Input/Output Voltage	-0.6 to VCC+0.5	V
VCC	-0.6 to 2.5	V

Figure 44. Input Test Waveform and Measurement Level



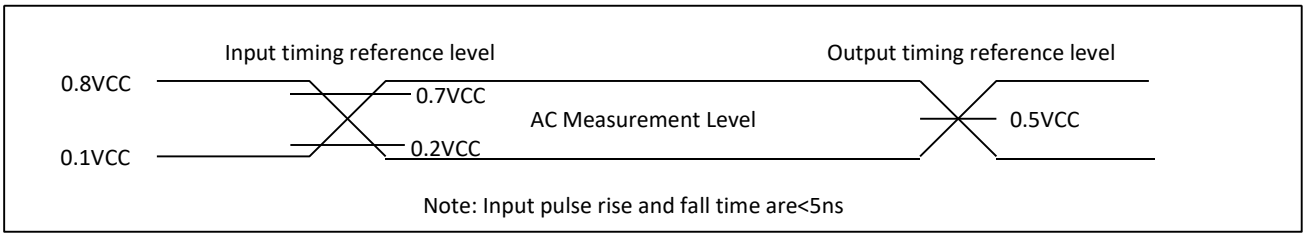
9.2. Initial Delivery State

The device is delivered with the memory array erased: all bits are set to 1 (each Byte contains FFH). All Status Register bits are set to 0 except DRV1(DRV1 equals to 1).

9.3. Capacitance Measurement Conditions

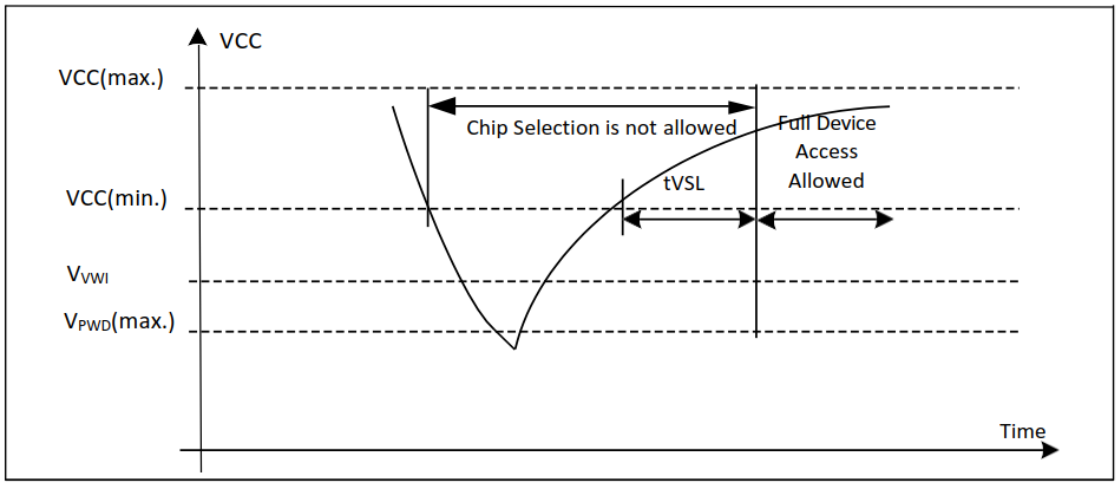
Symbol	Parameter	Min.	Typ.	Max.	Unit	Conditions
CIN	Input Capacitance			6	pF	VIN=0V
COUT	Output Capacitance			8	pF	VOUT=0V
C_L	Load Capacitance		30		pF	
	Input Rise And Fall time			5	ns	
	Input Pause Voltage		0.1VCC to 0.8VCC		V	
	Input Timing Reference Voltage		0.2VCC to 0.7VCC		V	
	Output Timing Reference Voltage		0.5VCC		V	

Figure 45. Absolute Maximum Ratings Diagram



9.4. Power-Up Timing and Requirements

Figure 46. Power-On Timing Sequence Diagram



Power-Up Timing and Write Inhibit Threshold

Symbol	Parameter	Min.	Max.	Unit
tVSL	VCC (min.) to device operation	200		μs
VWI	Write Inhibit Voltage	1	1.4	V
VPWD	VCC voltage needed to below VPWD for ensuring initialization will occur		0.4	V

9.5. DC Electrical Characteristics

(T_A = -40℃~85℃/105℃/125℃, VCC=1.65~2.0V)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit.
I_{LI}	Input Leakage Current				±2	μA
I_{LO}	Output Leakage Current				±2	μA
I_{CC1}	Standby Current	CS#=VCC, VIN=VCC or VSS		9	25/40/80	μA
I_{CC2}	Deep Power-Down Current	CS#=VCC, VIN=VCC or VSS		0.5	7/16/36	μA
I_{CC3}	Operating Current (Read)	f = 133MHz, Q=Open (x4 I/O)		4.5	5.5	mA
		f = 104MHz, Q=Open (x4 I/O)		4	5	mA
		f = 80MHz, Q=Open (x4 I/O)		3	5	mA
		f = 80MHz, Q=Open (x1 I/O)		1.8	2.5	mA
		f = 80MHz, DTR Q=Open (x4 I/O)		4	4.5	mA
I_{CC4}	Operating Current (PP)	CS#=VCC		7	10/13/15	mA
I_{CC5}	Operating Current (WRSR)	CS#=VCC		7	10/13/15	mA
I_{CC6}	Operating Current (SE)	CS#=VCC		7	10/13/15	mA
I_{CC7}	Operating Current (BE)	CS#=VCC		7	10/13/15	mA
I_{CC8}	Operating Current (CE)	CS#=VCC		7	10/13/15	mA
V_{IL}	Input Low Voltage		-0.5		0.3VCC	V
V_{IH}	Input High Voltage		0.7VCC		VCC+0.4	V
V_{OL}	Output Low Voltage	I_{OL} = 100μA			0.2	V
V_{OH}	Output High Voltage	I_{OH} = -100μA	VCC-0.2			V

Note:

1. Typical value at T_A = 25℃, VCC = 1.8V. X/X/X means values of 85℃/105℃/125℃ product
2. Value guaranteed by design and/or characterization, not 100% tested in production

9.6. AC Electrical Characteristics

(T=-40℃~85℃/105℃/125℃, VCC=1.65~2.0V, C_L=30pf)

Symbol	Parameter	Min.	Typ.	Max.	Unit.
F_{C1}	Serial Clock Frequency for: all commands except normal Read and DTR read (normal read: 03H,DTR read: 0DH,BDH,EDH)			133	MHz
f_{C2}	Serial Clock Frequency for DTR Read (DTR read: 0DH,BDH,EDH)			80	MHz
f_R	Serial Clock Frequency For: Read (03H)			80	MHz
t_{CLH}	Serial Clock High Time	45% (1/Fc)			ns
t_{CLL}	Serial Clock Low Time	45% (1/Fc)			ns
t_{CLCH}	Serial Clock Rise Time (Slew Rate)	0.2			V/ns
t_{CHCL}	Serial Clock Fall Time (Slew Rate)	0.2			V/ns
t_{SLCH}	CS# Active Setup Time	5			ns
t_{CHSH}	CS# Active Hold Time	5			ns
t_{SHCH}	CS# Not Active Setup Time	5			ns
t_{CHSL}	CS# Not Active Hold Time	5			ns
t_{SHSL}	CS# High Time (Read/Write)	20			ns
t_{SHQZ}	Output Disable Time			6	ns
t_{CLQX}	Output Hold Time	1.2			ns
t_{DVCH}	Data In Setup Time	2			ns
t_{CHDX}	Data In Hold Time	2			ns
t_{HLCH}	HOLD# Low Setup Time (Relative To Clock)	5			ns
t_{HHCH}	HOLD# High Setup Time (Relative To Clock)	5			ns
t_{CHHH}	HOLD# Low Hold Time (Relative To Clock)	5			ns
t_{CHHL}	HOLD# High Hold Time (Relative To Clock)	5			ns
t_{HLQZ}	HOLD# Low To High-Z Output			6	ns
t_{HHQX}	HOLD# High To Low-Z Output			6	ns
t_{CLQV}	Clock Low To Output Valid			7	ns
t_{WHSL}	Write Protect Setup Time Before CS# Low	20			ns
t_{SHWL}	Write Protect Hold Time After CS# High	100			ns
t_{DP}	CS# High To Deep Power-Down Mode			3	µs
t_{RES1}	CS# High To Standby Mode Without Electronic Signature Read			20	µs
t_{RES2}	CS# High To Standby Mode With Electronic Signature Read			20	µs
t_{SUS}	CS# High To Next Command After Suspend			20	µs
t_{RS}	Latency Between Resume And Next Suspend	100			µs

t_{RST}	CS# High To Next Command After Reset (Except From Erase)			30	μs
t_{RST_E}	CS# High To Next Command After Reset (From Erase)			12	ms
t_W	Write Status Register Cycle Time		2	25	ms
t_{BP1}	Byte Program Time (First Byte)		30	60	μs
t_{PP}	Page Programming Time		0.5	2	ms
t_{SE}	Sector Erase Time		30	300	ms
	Sector Erase Time(Automotive)		60	300	ms
t_{BE1}	Block Erase Time (32K Bytes)		0.1	0.8	s
t_{BE2}	Block Erase Time (64K Bytes)		0.15	1.2	s
t_{CE}	Chip Erase Time		25	100	s

Note:

1. Typical value at T = 25℃.
2. Value guaranteed by design and/or characterization, not 100% tested in production.

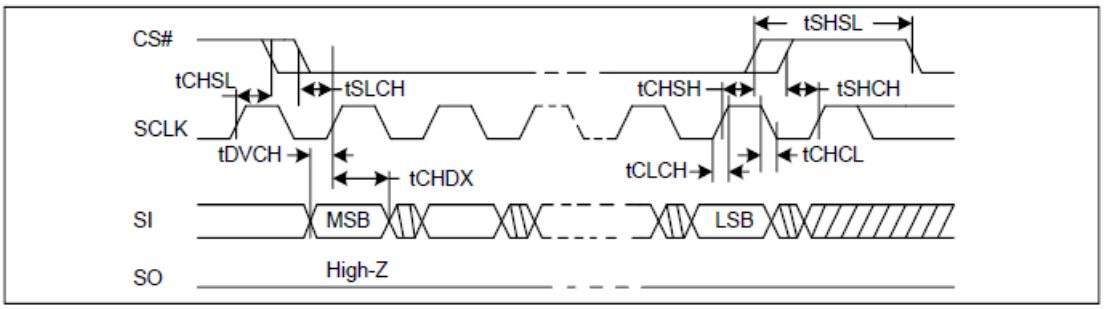


Figure 47. Input Timing

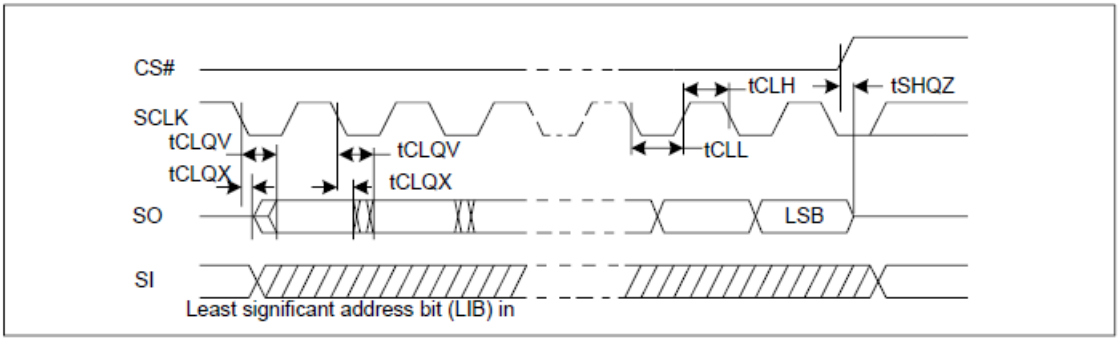


Figure 48. Output Timing

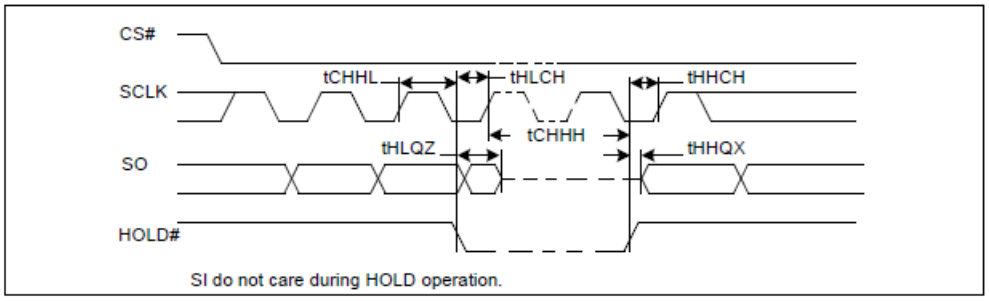


Figure 49. Hold Timing

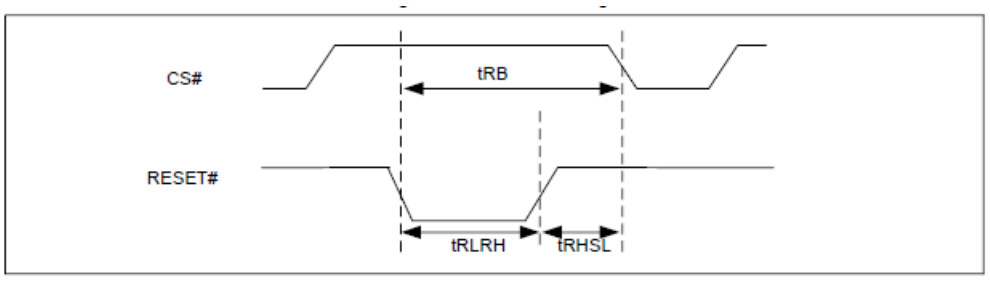
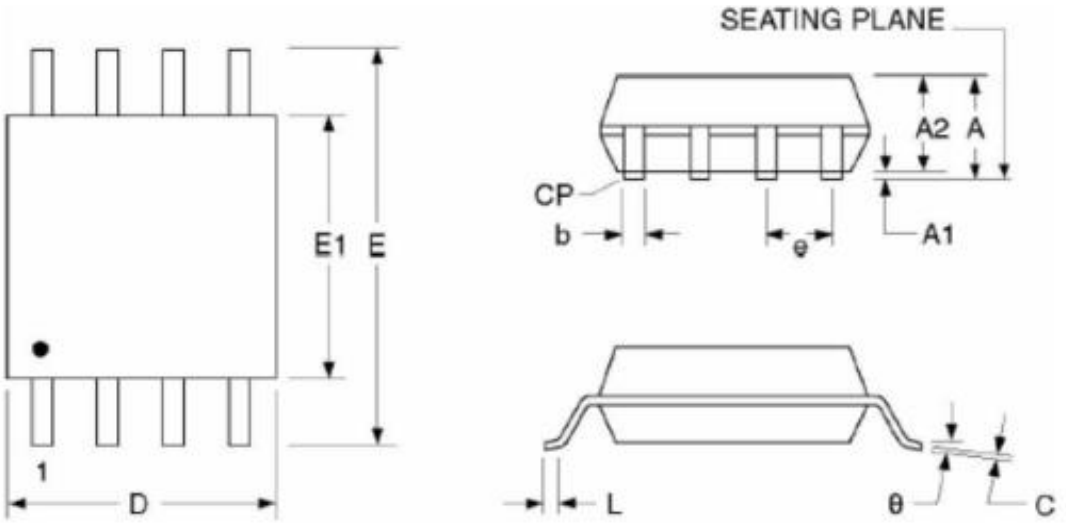


Figure 50. Reset Timing

Symbol	Parameter	Min.	Typ.	Max.	Unit.
t_{RLRH}(t_{RESET})	Reset Pulse Width	1			μs
t_{RHSL}	Reset Hold time before next Operation	40			ns
t_{RB}	Reset Recovery Time (From Read or Program)			30	μs
	Reset Recovery Time (From Erase)			12	ms

10. PACKAGE SPECIFICATIONS

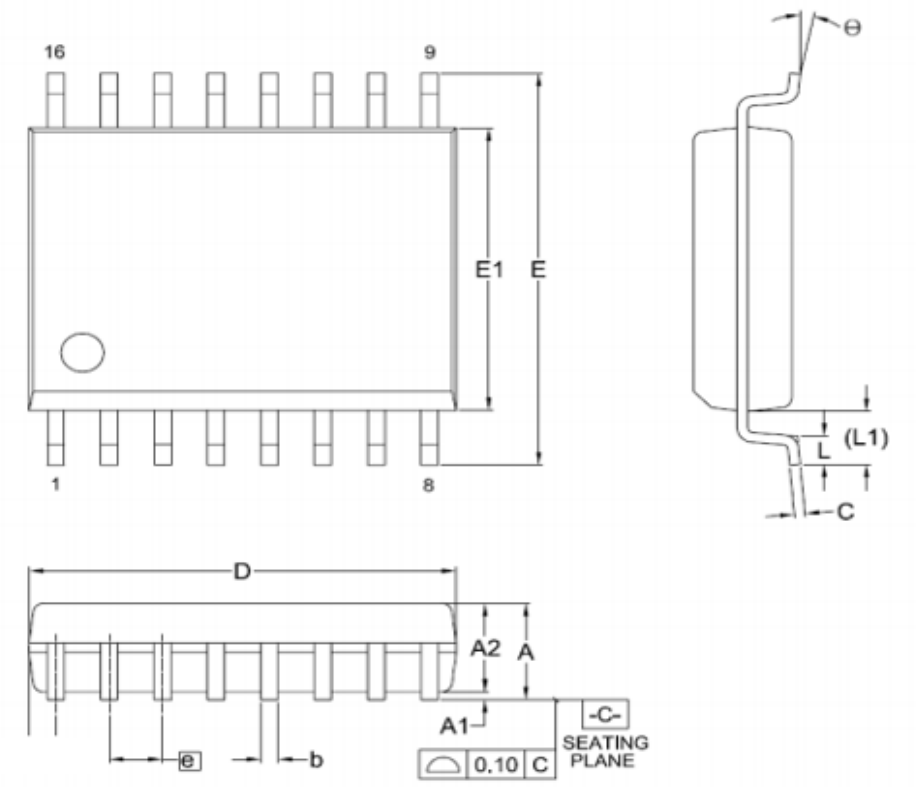
10.1. 8-Pin SOP 208-mil



Symbol	Dimension (mm)		
	MIN	NOM	MAX
A	1.75	1.95	2.16
A1	0.05	0.15	0.25
A2	1.70	1.80	1.91
b	0.35	0.42	0.5
c	0.19	0.20	0.25
D	5.13	5.28	5.38
E	7.7	7.9	8.1
E1	5.18	5.28	5.39
e	1.27 BSC		
L	0.5	0.65	0.8
θ	0°	-	8°

The shape may be of little difference according to different package lead frames/substrates. These shapes are compatible with each other.

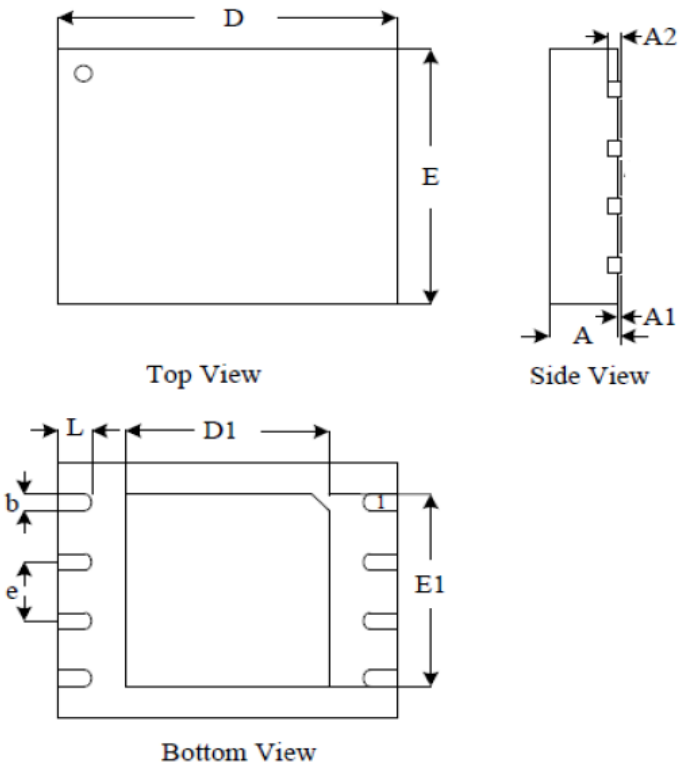
10.2. **16-pin SOP 300-mil**



Symbol	Dimension (mm)		
	MIN	NOM	MAX
A	-	-	2.65
A1	0.1	0.2	0.3
A2	2.25	2.30	2.35
b	0.35	-	0.43
c	0.25	-	0.31
D	10.2	10.3	10.4
E	10.2	10.3	10.4
E1	7.4	7.5	7.6
e	1.27 BSC		
L	0.55	0.7	0.85
L1	1.40REF		
θ	0°	-	8°

The shape may be of little difference according to different package lead frames/substrates. These shapes are compatible with each other.

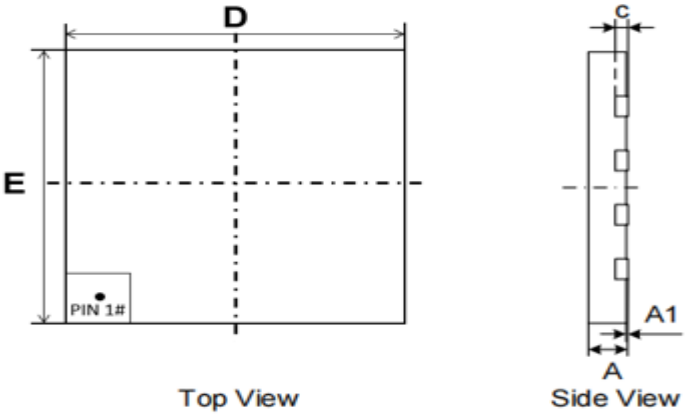
10.3. 8-contact 6x5 WSON

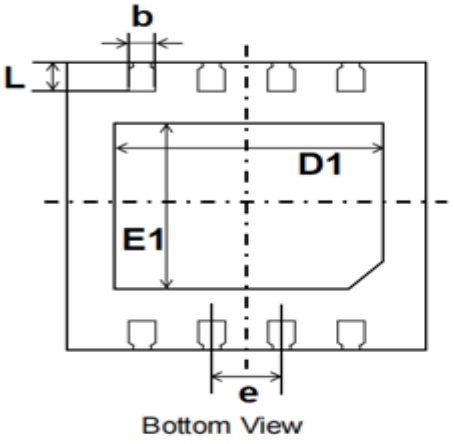


Symbol	Dimension (mm)		
	MIN	NOM	MAX
A	0.7	0.75	0.80
A1	0.00	0.02	0.05
A2	0.20REF		
D	5.90	6.00	6.10
E	4.90	5.00	5.10
D1	3.25	3.40	3.50
E1	3.85	-	4.40
b	0.35	0.40	0.45
L	0.50	0.60	0.70
e	-	1.27BSC	-

The shape may be of little difference according to different package lead frames/substrates. These shapes are compatible with each other.

10.4. **8-contact 4x4 USON**

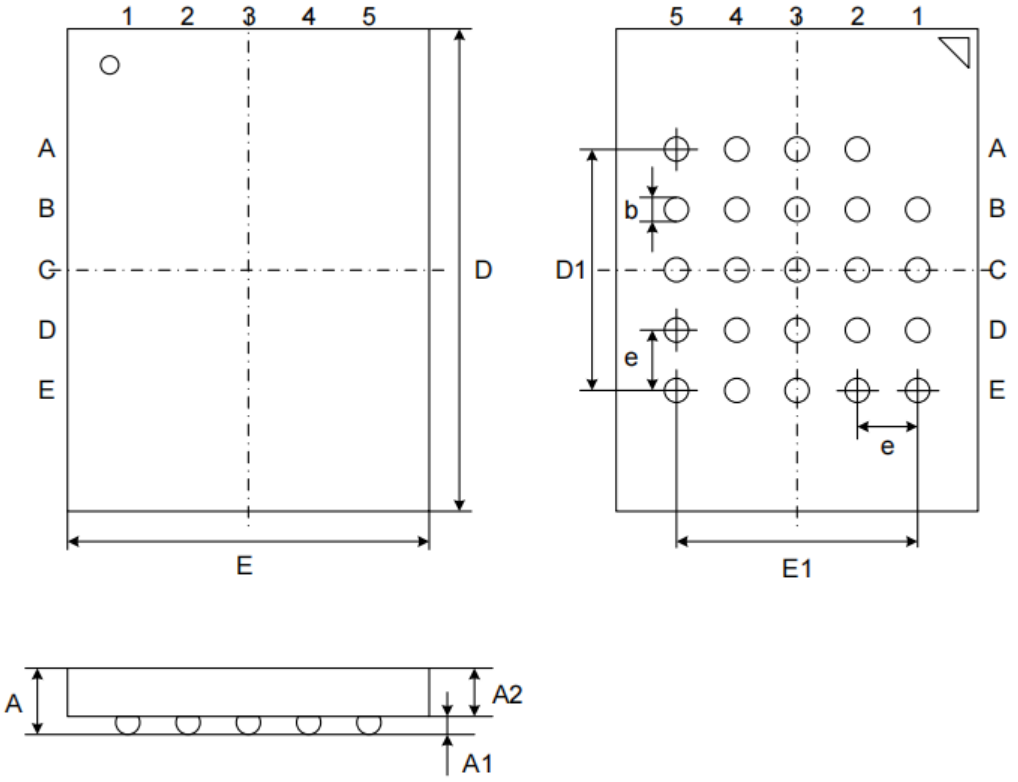




Symbol	Dimension (mm)		
	MIN	NOM	MAX
A	0.4	0.45	0.5
A1	0	0.02	0.05
c	0.10	0.15	0.20
b	0.25	0.30	0.35
D	3.9	4.0	4.1
D1	2.9	3.0	3.1
E	3.9	4.0	4.1
E1	2.2	2.3	2.4
e	0.80 BSC		
L	0.35	0.40	0.45

The shape may be of little difference according to different package lead frames/substrates. These shapes are compatible with each other.

10.5. **24-ball FBGA**



Symbol	Dimension (mm)		
	MIN	NOM	MAX
A	-	-	1.20
A1	0.25	0.3	0.35
A2	-	0.79	-
b	0.35	0.40	0.45
D	7.9	8.0	8.1
D1	4.0 BSC		
E	5.9	6.0	6.1
E1	4.0 BSC		
e	1.0 BSC		

The shape may be of little difference according to different package lead frames/substrates. These shapes are compatible with each other.

10.6. **WLCSP**

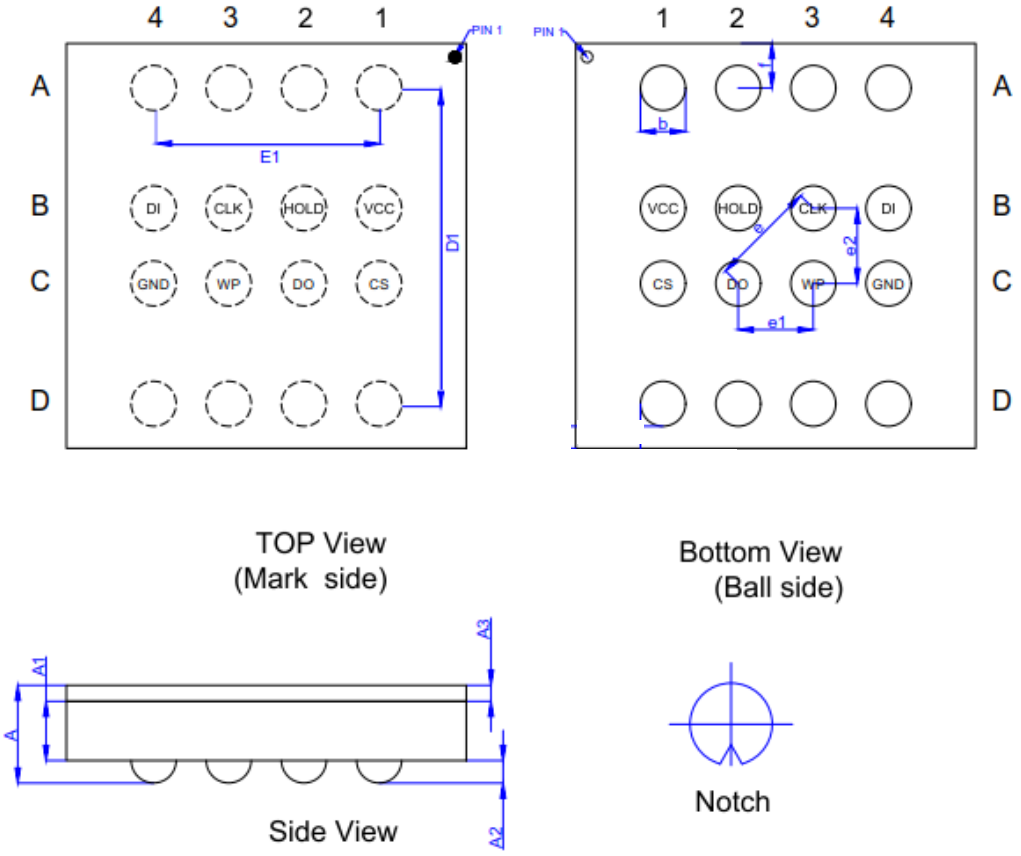


Table: Package Dimension				
Parameter	Symbol	Nominal(um)	Min(um)	Max(um)
Package Height	A	485	450	520
Package Body Thickness	A1	295	265	325
Ball Height	A2	165	148	182
BSC	A3	25		
Dimension x	E1	1500		
Dimension y	D1	2100		
Ball pitch	e	707.11 REF		
Ball pitch	e1	500		
Ball pitch	e2	500		
Ball Center to Edge Distance	f	296.5		
Ball Diameter	b	300	270	330
Ball Count		16 ea		

Note:
Please contact Dosilicon for full dimension information

The shape may be of little difference according to different package lead frames/substrates. These shapes are compatible with each other.

11. ORDERING INFORMATION

