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1.2V 64M-BIT SERIAL FLASH MEMORY WITH DUAL/QUAD SPI & QPI



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1. GENERAL DESCRIPTIONS

The W25Q64NE (64M-bit) Serial Flash memory provides a storage solution for systems with limited space, pins and power. The 25Q 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 1.14V to 1.26V power supply with current consumption as low as 0.5µA for power-down. All devices are offered in space-saving packages.

The W25Q64NE array is organized into 32,768 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 W25Q64NE has 2,048 erasable sectors and 128 erasable blocks respectively. The small 4KB sectors allow for greater flexibility in applications that require data and parameter storage. (See Figure 2.)

The W25Q64NE supports the standard Serial Peripheral Interface (SPI), and a high performance Dual/Quad output as well as Dual/Quad I/O SPI: Serial Clock, Chip Select, Serial Data I/O0 (DI), I/O1 (DO), I/O2, and I/O3. SPI clock frequencies of up to 84MHz are supported allowing equivalent clock rates of 336MHz (84MHz x 4) for Quad I/O when using the SPI Fast Read Quad I/O instructions. These transfer rates can outperform standard Asynchronous 8 and 16-bit Parallel Flash memories

A Hold pin, Write Protect pin and programmable write protection, with top, bottom or complement array control, provide further control flexibility. Additionally, the device supports JEDEC standard manufacturer and device identification with a 64-bit Unique Serial Number.

2. FEATURES

• Family of SpiFlash Memories

- W25Q64NE: 64M-bit / 8M-byte
- 256-byte per programmable page
- Standard SPI: CLK, /CS, DI, DO, /WP, /Hold
- Dual SPI: CLK, /CS, IO₀, IO₁, /WP, /Hold
- Quad SPI: CLK, /CS, IO₀, IO₁, IO₂, IO₃
- QPI: CLK, /CS, IO₀, IO₁, IO₂, IO₃

Highest Performance Serial Flash

- 84MHz Quad I/O SPI clocks
- 40MB/S continuous data transfer rate
- Up to 6X that of ordinary Serial Flash
- Min 100K Program-Erase cycles
- More than 20-year data retention

• Low Power, Wide Temperature Range

- -1.14 V to 1.26V supply
- -<0.5µA Power-down current
- --40°C to +85°C operating range

• Flexible Architecture with 4KB sectors

- Uniform Sector Erase (4K-bytes)
- Uniform Block Erase (32K and 64K-bytes)
- Program one to 256 bytes
- Erase/Program Suspend & Resume

• Advanced Security Features

- Software and Hardware Write-Protect
- Top/Bottom, 4KB complement array protection
- Lock-Down and Special OTP array protection
- 64-Bit Unique Serial Number for each device
- Discoverable Parameters (SFDP) Register
- 3X256-Byte Security Registers with OTP locks
- Volatile & Non-volatile Status Register Bits

Space Efficient Packaging¹

- 8-pin SOIC 208-mil
- 8-pad USON 4x3-mm
- 8-pad XSON 4x4-mm
- 8-pad WSON 6x5-mm
- 12-ball WLCSP

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- Contact Winbond for KGD and other options



3. PACKAGE TYPES AND PIN CONFIGURATIONS

3.1 Pin Configuration SOIC 208-mil

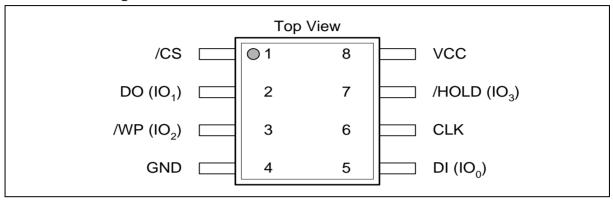


Figure 1a. W25Q64NE Pin Assignments, 8-pin 208-mil (Package Code SS)

3.2 Pad Configuration WSON 6x5-mm, XSON 4x4-mm, USON4x3-mm

	Тор	View	
/CS	1	8 (VCC
DO (IO ₁)	2	7	/HOLD (IO ₃)
/WP (IO ₂)	3	6 (CLK
GND	4	5 (DI (IO ₀)

Figure 1b. W25Q64NE Pad Assignments, 8-pad WSON 6x5-mm & XSON 4x4 (Package Code ZP, XG, UU)

3.3 Pin Description SOIC 208-mil, WSON 6x5-mm, XSON 4x4-mm, USON4x3-mm

PAD NO.	PAD 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	GND		Ground	
5	DI (IO0)	I/O	Data Input (Data Input Output 0)(1)	
6	CLK	I	Serial Clock Input	
7	/HOLD (IO3)	I/O	Hold Input (Data Input Output 3)(2)	
8	VCC		Power Supply	

Notes:

- 1. IO0 and IO1 are used for Standard and Dual SPI instructions
- 2. IO0 IO3 are used for Quad SPI instructions, /HOLD function is only available for Standard/Dual SPI.



Ball Configuration WLCSP

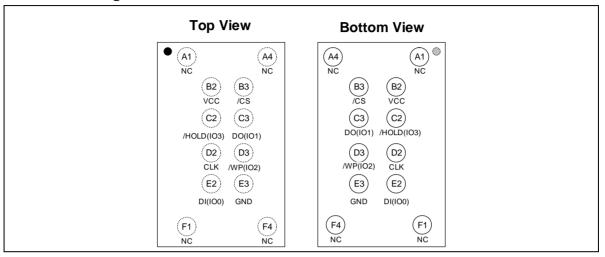


Figure 1d. W25Q64NEJW Ball Assignments, 12-ball WLCSP (Package Code BY)

Ball Description WLCSP12

BALL NO.	PIN NAME	I/O	FUNCTION	
B2	VCC		Power Supply	
C2	/HOLD (IO3)	I/O	I/O Hold Input (Data Input Output 3) ⁽²⁾	
D2	CLK	I	Serial Clock Input	
E2	DI (IO0)	I/O	Data Input (Data Input Output 0)(1)	
В3	/CS	I	Chip Select Input	
C3	DO (IO1)	I/O	Data Output (Data Input Output 1) ⁽¹⁾	
D3	/WP (IO2)	I/O	Write Protect Input (Data Input Output 2)(2)	
E3	GND		Ground	
Multiple	NC		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 functions are only available for Standard/Dual SPI.



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. The /CS input must track the VCC supply level at power-up (see "Write Protection" and figure 37). If needed a pull-up resister on /CS can be used to accomplish this.

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

The W25Q64NE 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 of CLK.

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)

The /HOLD pin allows the device to be paused while it is actively selected. When /HOLD is brought low, 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-c for the pin configuration of Quad I/O operation.

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. FUNCTIONAL DESCRIPTION

5.1 SPI OPERATIONS

5.1.1 Standard SPI Instructions

The W25Q64NE 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 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.

5.1.2 Dual SPI Instructions

The W25Q64NE supports Dual SPI operation when using the "Fast Read Dual Output (3Bh)" and "Fast Read Dual I/O (BBh)" instructions. 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.

5.1.3 Quad SPI Instructions

The W25Q64NE supports Quad SPI operation when using "Fast Read Quad I/O (EBh)" instructions. These instructions allow data to be transferred to or from the device six to eight 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.

5.2 QPI Instructions

The W25Q64NE 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.

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5.2.1 Hold Function

For Standard SPI and Dual SPI operations, the /HOLD signal allows the W25Q64NE 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. A /HOLD condition will activate on the falling edge of the /HOLD signal if the CLK signal is already low. If the CLK is not already low the /HOLD condition will activate after the next falling edge of CLK. The /HOLD condition will terminate on the rising edge of the /HOLD signal if the CLK signal is already low. If the CLK is not already low the /HOLD condition will terminate after the next falling 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.



5.3 WRITE PROTECTION

Applications that use non-volatile memory must take into consideration the possibility of noise and other adverse system conditions that may compromise data integrity. To address this concern, the W25Q64NE provides several means to protect the data from inadvertent writes.

5.3.1 Write Protect Features

- Device resets when VCC is below threshold
- Time delay write disable after Power-up
- Write enable/disable instructions and automatic write disable after erase or program
- Software and Hardware (/WP pin) write protection using Status Register
- Write Protection using Power-down instruction
- Lock Down write protection until next power-up
- One Time Program (OTP) write protection*

Upon power-up or at power-down, the W25Q64NE will maintain a reset condition while VCC is below the threshold value of VWI, (See Power-up Timing and Voltage Levels and Figure 37). While reset, all operations are disabled and no instructions are recognized. During power-up and after the VCC voltage exceeds VWI, all program and erase related instructions are further disabled for a time delay of tpuW. This includes the Write Enable, Page Program, Sector Erase, Block Erase, Chip Erase and the Write Status Register instructions. Note that the chip select pin (/CS) must track the VCC supply level at power-up until the VCC-min level and tVSL time delay is reached. If needed a pull-up resister on /CS can be used to accomplish this.

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 (SRP, SRL) and Block Protect (CMP, SEC,TB, BP2, BP1 and BP0) bits. These settings allow a portion as small as 4KB sector 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 Power-down instruction offers an extra level of write protection as all instructions are ignored except for the Release Power-down instruction.

^{*} Note: This feature is available upon special flow. Please contact Winbond for details.



6. BLOCK DIAGRAM

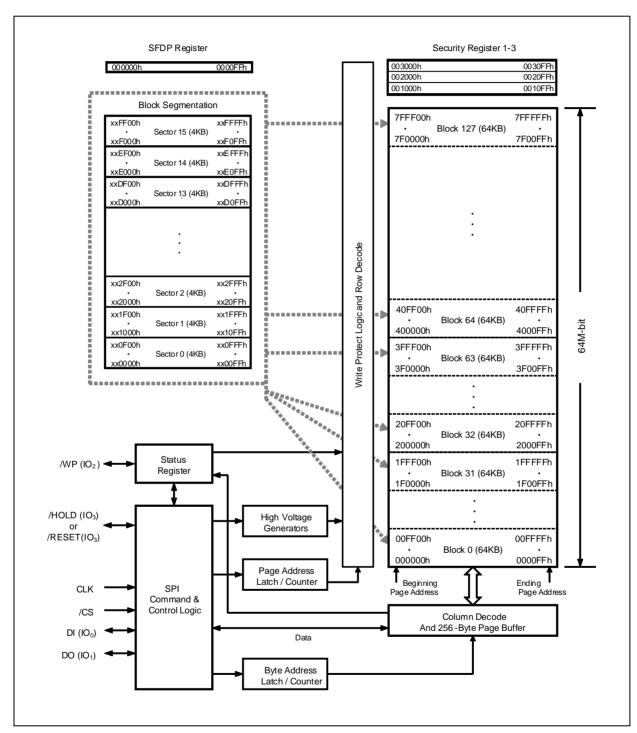


Figure 2. W25Q64NE Serial Flash Memory Block Diagram



7. STATUS REGISTERS AND INSTRUCTIONS

The Read Status Register-1 and Status Register-2 instructions can be used to provide status on the availability of the Flash memory array, if the device is write enabled or disabled, the state of write protection, Quad SPI setting, Security Register lock status and Erase/Program Suspend status. The Write Status Register instruction can be used to configure the device write protection features, Quad SPI setting and Security Register OTP lock. Write access to the Status Register is controlled by the state of the non-volatile Status Register Protect bits (SRP, SRL), the Write Enable instruction, and during Standard/Dual SPI operations, the /WP pin.

7.1 STATUS REGISTER

7.1.1 BUSY Status (BUSY)

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 tw, tpp, tse, tbe, and tce 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 Status (WEL)

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)

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 tw 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)

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 SRP and WEL bits.

7.1.5 Sector/Block Protect (SEC)

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)

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 4KB sector can be protected while the rest of the array is not; when CMP=1, the top 4KB sector 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 (SRP, SRL)

The Status Register Protect bits (SRP) are non-volatile read/write bits in the status register (S7). The SRP bits control the method of write protection: software protection,

SRP	/WP	Status Protection	Description
0	Х	Software	/WP pin has no control. The Status register can be written to after a Write Enable instruction, WEL=1.
		Protection	[Factory Default]
	0	Hardware	When /WP pin is low the Status Register can not be
4	U	Protected	written to.
1	1	Hardware Unprotected	When /WP pin is high the Status register can be written to after a Write Enable instruction, WEL=1.

SRL	Status Register Lock	Description		
0	Non-Lock	Status Register is unlocked		
1	Lock-Down (1) (temporary/Volatile)	Status Register is locked by standard status register write command and can not be written to again until the next power-down, power-up cycle.		
'	One Time Program ⁽²⁾	Status Register is permanently locked by special command flow and can not be written to		
	(Permanently/Non-Volatile)			

- 1. When SRP =1, a power-down, power-up cycle will change SRP =0 state.
- 2. Special One Time Protection feature is available upon special flow; please contact Winbond for details



7.1.8 Erase/Program Suspend Status (SUS)

The Suspend Status bit is a read only bit in the status register (S15) that is set to 1 after executing a Erase/Program Suspend (75h) instruction. The SUS status bit is cleared to 0 by Erase/Program Resume (7Ah) instruction as well as a power-down, power-up cycle.

7.1.9 Security Register Lock Bits (LB[3:1]) - 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 LB[3:1] 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 256-Byte Security Register will become read-only permanently.

7.1.10 Quad Enable (QE) - 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(factory default for Quad Enabled part numbers with ordering option "IQ", non-fixed), the Quad IO2 and IO3 pins are enabled, 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. When the device is in QPI mode, QE bit will remain to be 1. A "Write Status Register" command in QPI mode cannot change QE bit from a "1" to a "0".

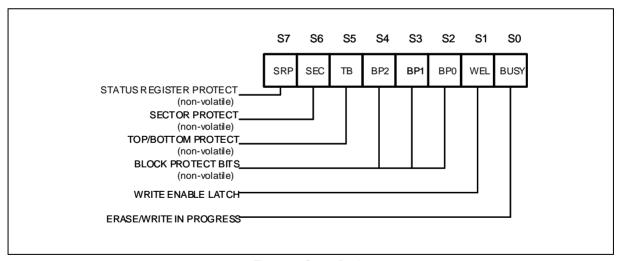


Figure 3a. Status Register-1

S15 S14 S13 S12 S11 S10 S9 S8 SUS CMP LB3 LB2 LB1 (R) QΕ SRL SUSPEND STATUS COMPLEMENT PROTECT (non-volatile) SECURITY REGISTER LOCK BITS (non-volatile OTP) Reserved QUAD ENABLE (non volatile) STATUS REGISTER PROTECT 1 (non-volatile)

Figure 3b. Status Register-2

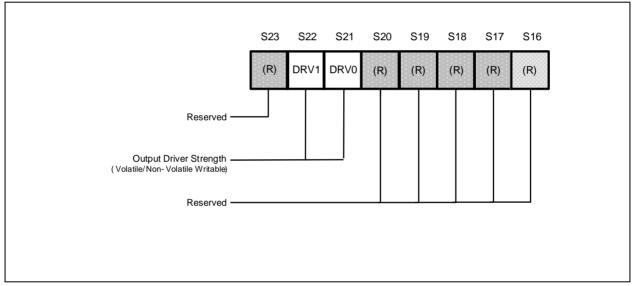


Figure 3c. Status Register-3

7.1.11 Output Driver Strength (DRV1, DRV0) - Volatile/Non-Volatile Writable

The DRV1 & DRV0 bits are used to determine the output driver strength for the Read operations.

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



7.1.12 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.

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7.1.13 Status Register Memory Protection (WPS = 0, CMP = 0)

S	STATUS REGISTER ⁽¹⁾				W25Q64NE (64M-BIT) MEMORY PROTECTION ⁽³⁾			
SEC	тв	BP2	BP1	BP0	PROTECTED BLOCK(S)	PROTECTED ADDRESSES	PROTECTED DENSITY	PROTECTED PORTION ⁽²⁾
Х	Х	0	0	0	NONE	NONE	NONE	NONE
0	0	0	0	1	126 and 127	7E0000h – 7FFFFh	128KB	Upper 1/64
0	0	0	1	0	124 thru 127	7C0000h – 7FFFFFh	256KB	Upper 1/32
0	0	0	1	1	120 thru 127	780000h – 7FFFFh	512KB	Upper 1/16
0	0	1	0	0	112 thru 127	700000h – 7FFFFh	1MB	Upper 1/8
0	0	1	0	1	96 thru 127	600000h – 7FFFFh	2MB	Upper 1/4
0	0	1	1	0	64 thru 127	400000h – 7FFFFFh	4MB	Upper 1/2
0	1	0	0	1	0 and 1	000000h – 01FFFFh	128KB	Lower 1/64
0	1	0	1	0	0 thru 3	000000h – 03FFFFh	256KB	Lower 1/32
0	1	0	1	1	0 thru 7	000000h – 07FFFFh	512KB	Lower 1/16
0	1	1	0	0	0 thru 15	000000h – 0FFFFFh	1MB	Lower 1/8
0	1	1	0	1	0 thru 31	000000h – 1FFFFFh	2MB	Lower 1/4
0	1	1	1	0	0 thru 63	000000h – 3FFFFh	4MB	Lower 1/2
Х	Х	1	1	1	0 thru 127	000000h – 7FFFFh	8MB	ALL
1	0	0	0	1	127	7FF000h – 7FFFFFh	4KB	U – 1/2048
1	0	0	1	0	127	7FE000h – 7FFFFFh	8KB	U – 1/1024
1	0	0	1	1	127	7FC000h – 7FFFFFh	16KB	U – 1/512
1	0	1	0	Х	127	7F8000h – 7FFFFFh	32KB	U – 1/256
1	1	0	0	1	0	000000h – 000FFFh	4KB	L – 1/2048
1	1	0	1	0	0	000000h – 001FFFh	8KB	L – 1/1024
1	1	0	1	1	0	000000h – 003FFFh	16KB	L – 1/512
1	1	1	0	Х	0	000000h – 007FFFh	32KB	L – 1/256

Notes:

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



7.1.14 Status Register Memory Protection (WPS = 0, CMP = 1)

STATUS REGISTER ⁽¹⁾					W25Q64NE (64M-BIT) MEMORY PROTECTION(3)			
SEC	ТВ	BP2	BP1	BP0	PROTECTED BLOCK(S)	PROTECTED ADDRESSES	PROTECTED DENSITY	PROTECTED PORTION ⁽²⁾
Х	Х	0	0	0	0 thru 127	000000h – 7FFFFFh	8MB	ALL
0	0	0	0	1	0 thru 125	000000h – 7DFFFFh	8,064KB	Lower 63/64
0	0	0	1	0	0 thru 123	000000h – 7BFFFFh	7,936KB	Lower 31/32
0	0	0	1	1	0 thru 119	000000h – 77FFFFh	7,680KB	Lower 15/16
0	0	1	0	0	0 thru 111	000000h – 6FFFFFh	7MB	Lower 7/8
0	0	1	0	1	0 thru 95	000000h – 5FFFFFh	5MB	Lower 3/4
0	0	1	1	0	0 thru 63	000000h – 3FFFFFh	4MB	Lower 1/2
0	1	0	0	1	2 thru 127	020000h – 7FFFFFh	8,064KB	Upper 63/64
0	1	0	1	0	4 thru 127	040000h – 7FFFFFh	7,936KB	Upper 31/32
0	1	0	1	1	8 thru 127	080000h – 7FFFFFh	7,680KB	Upper 15/16
0	1	1	0	0	16 thru 127	100000h – 7FFFFh	7MB	Upper 7/8
0	1	1	0	1	32 thru 127	200000h – 7FFFFh	5MB	Upper 3/4
0	1	1	1	0	64 thru 127	400000h – 7FFFFFh	4MB	Upper 1/2
Х	Х	1	1	1	NONE	NONE	NONE	NONE
1	0	0	0	1	0 thru 127	000000h – 7FEFFFh	8,188KB	L - 2047/2048
1	0	0	1	0	0 thru 127	000000h – 7FDFFFh	8,184KB	L – 1023/1024
1	0	0	1	1	0 thru 127	000000h – 7FBFFFh	8,176KB	L – 511/512
1	0	1	0	Х	0 thru 127	000000h – 7F7FFFh	8,160KB	L – 255/256
1	1	0	0	1	0 thru 127	001000h – 7FFFFFh	8,188KB	L – 2047/2048
1	1	0	1	0	0 thru 127	002000h – 7FFFFFh	8,184KB	L – 1023/1024
1	1	0	1	1	0 thru 127	004000h – 7FFFFFh	8,176KB	L – 511/512
1	1	1	0	Х	0 thru 127	008000h – 7FFFFh	8,160KB	L – 255/256

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 instruction set of the W25Q64NE consists of thirty four basic instructions that are fully controlled through the SPI bus (see Instruction Set table1-3). 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 W25Q64NE consists of 32 basic instructions that are fully controlled through the SPI bus (see Instruction Set Table 3). 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 4 through 36. 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.

8.1.1 Manufacturer and Device Identification

MANUFACTURER ID	(MF7-MF0)		
Winbond Serial Flash	EFh		
Device ID	(ID7-ID0)	(ID15-ID0)	
Instruction	ABh, 90h, 92h, 94h	9Fh	
W25Q64NE-IQ	16h	6517	



8.1.2 Instruction Set Table 1 (Standard SPI Instructions)(1)

0.1.2 Instruction Set Table 1 (Standard St Finstructions)								
Data Input Output	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
Number of Clock ₍₁₋₁₋₁₎	8	8	8	8	8	8	8	
Write Enable	06h							
Volatile SR Write Enable	50h							
Write Disable	04h							
Release Power-down / ID	ABh	Dummy	Dummy	Dummy	(ID7-ID0) ⁽²⁾			
Manufacturer/Device ID	90h	Dummy	Dummy	00h	(MF7-MF0) (ID7-ID0)			
JEDEC ID	9Fh	(MF7-MF0)	(ID15-ID8)	(ID7-ID0)				
Read Unique ID	4Bh	Dummy	Dummy	Dummy	Dummy	(UID63-0)		
Read Data	03h	A23-A16	A15-A8	A7-A0	(D7-D0)			
Fast Read	0Bh	A23-A16	A15-A8	A7-A0	Dummy	(D7-D0)		
Page Program	02h	A23-A16	A15-A8	A7-A0	D7-D0	D7-D0 ⁽³⁾		
Sector Erase (4KB)	20h	A23-A16	A15-A8	A7-A0				
Block Erase (32KB)	52h	A23-A16	A15-A8	A7-A0				
Block Erase (64KB)	D8h	A23-A16	A15-A8	A7-A0				
Chip Erase	C7h/60h							
Read Status Register-1	05h	(S7-S0) ⁽²⁾						
Write Status Register-1 ⁽⁴⁾	01h	(S7-S0)						
Read Status Register-2	35h	(S15-S8) ⁽²⁾						
Write Status Register-2	31h	(S15-S8)						
Read Status Register-3	15h	(S23-S16) ⁽²⁾						
Write Status Register-3	11h	(S23-S16)						
Read SFDP Register	5Ah	A23-A16	A15-A8	A7-A0	Dummy	(D7-D0)		
Erase Security Register ⁽⁴⁾	44h	A23-A16	A15-A8	A7-A0				
Program Security Register ⁽⁴⁾	42h	A23-A16	A15-A8	A7-A0	D7-D0	D7-D0 ⁽⁵⁾		
Read Security Register ⁽⁵⁾	48h	A23-A16	A15-A8	A7-A0	Dummy	(D7-D0)		
Erase / Program Suspend ⁽⁶⁾	75h							
Erase / Program Resume ⁽⁶⁾	7Ah							
Power-down	B9h							
Enter QPI Mode	38h							
Initial POR /Enable Reset	66h							
Initial POR /Reset Device	99h							



8.1.3 Instruction Set Table 2 (Dual/Quad SPI Instructions)

Data Input Output	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
Number of Clock ₍₁₋₁₋₂₎	8	8	8	8	4	4	4	4
Fast Read Dual Output	3Bh	A23-A16	A15-A8	A7-A0	Dummy	Dummy	(D7-D0) ⁷⁾	
Number of Clock(1-2-2)	8	4	4	4	4	4	4	4
Fast Read Dual I/O	BBh	A23-A16	A15-A8	A7-A0	Dummy ⁽¹²⁾	(D7-D0)		
Mftr./Device ID Dual I/O	92h	A23-A16	A15-A8	00	Dummy ⁽¹²⁾	(MF7-MF0)	(ID7-ID0)	
Number of Clock(1-1-4)	8	8	8	8	2	2	2	2
Quad Input Page Program	32h	A23-A16	A15-A8	A7-A0	(D7-D0) ⁽⁹⁾	(D7-D0) ⁽³⁾		
Number of Clock(1-4-4)	8	2	2	2	2	2	2	2
Mftr./Device ID Quad I/O	94h	A23-A16	A15-A8	00	Dummy ⁽¹²⁾	Dummy	Dummy	(MF7-MF0)
Fast Read Quad I/O	EBh	A23-A16	A15-A8	A7-A0	Dummy ⁽¹²⁾	Dummy	Dummy	(D7-D0)
Set Burst with Wrap	77h	Dummy	Dummy	Dummy	W8-W0			

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8.1.4 Instruction Set Table 3 (QPI Instructions) (1)

Data Input Output	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Number of Clock (4-4-4)	2	2	2	2	2	2	2
Write Enable	06h						
Volatile SR Write Enable	50h						
Write Disable	04h						
Release Power-down / ID	ABh	Dummy	Dummy	Dummy	(ID7-ID0) ⁽²⁾		
Manufacturer/Device ID	90h	Dummy	Dummy	00h	(MF7-MF0)	(ID7-ID0)	
JEDEC ID	9Fh	(MF7-MF0)	(ID15-ID8)	(ID7-ID0)			
Set Read Parameters	C0h	P7-P0					
Fast Read	0Bh	A23-A16	A15-A8	A7-A0	Dummy	(D7-D0)	
Fast Read Quad I/O	EBh	A23-A16	A15-A8	A7-A0	M7-M0	(D7-D0)	
Page Program	02h	A23-A16	A15-A8	A7-A0	D7-D0 ⁽⁹⁾	D7-D0 ⁽³⁾	
Sector Erase (4KB)	20h	A23-A16	A15-A8	A7-A0			
Block Erase (32KB)	52h	A23-A16	A15-A8	A7-A0			
Block Erase (64KB)	D8h	A23-A16	A15-A8	A7-A0			
Chip Erase	C7h/60h						
Read Status Register-1	05h	(S7-S0) ⁽²⁾					
Write Status Register-1	01h	(S7-S0)					
Read Status Register-2	35h	(S15-S8) ⁽²⁾					
Write Status Register-2	31h	(S15-S8)					
Write Status Register-2	31h	(S15-S8)					
Read Status Register-3	15h	(S23-S16) ⁽²⁾					
Erase / Program Suspend	75h						
Erase / Program Resume	7Ah						
Power-down	B9h						
Enable Reset	66h						
Reset Device	99h						
Exit QPI Mode	FFh			·			

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Note:

- 1. Data bytes are shifted with Most Significant Bit first. Byte fields with data in parenthesis "D7-D0" indicate data output from the device on either 1, 2 or 4 IO pins. "D7-D0" indicates single I/O pin; "D7-D0 /2" indicates 2 I/O pins; "D7-D0 /4" indicates 4 I/O pins.
- 2. The Status Register contents and Device ID will repeat continuously until /CS terminates the instruction.
- 3. At least one byte of data input is required for Page Program, Quad Page Program and Program Security Registers, up to 256 bytes of data input. If more than 256 bytes of data are sent to the device, the addressing will wrap to the beginning of the page and overwrite previously sent data.
- Security Register Address:

```
Security Register 1: A23-16 = 00h: A15-8 = 10h: A7-0 = byte address
Security Register 2: A23-16 = 00h; A15-8 = 20h; A7-0 = byte address
Security Register 3: A23-16 = 00h; A15-8 = 30h; A7-0 = byte address
```

Dual SPI address input format:

```
IO0 = A22, A20, A18, A16, A14, A12, A10, A8 A6, A4, A2, A0, M6, M4, M2, M0
IO1 = A23, A21, A19, A17, A15, A13, A11, A9 A7, A5, A3, A1, M7, M5, M3, M1
```

Dual SPI data input/output format:

```
IO0 = (D6, D4, D2, D0)
IO1 = (D7, D5, D3, D1)
```

Quad SPI address input format:

```
Set Burst with Wrap input format:
IO0 = A20, A16, A12, A8, A4, A0, M4, M0
                                                      100 = x. x. x. x. x. x. W4. x
IO1 = A21, A17, A13, A9, A5, A1, M5, M1
                                                      IO1 = x, x, x, x, x, x, W5, x
IO2 = A22, A18, A14, A10, A6, A2, M6, M2
                                                      102 = x. x. x. x. x. x. W6. x
IO3 = A23, A19, A15, A11, A7, A3, M7, M3
                                                      103 = x, x, x, x, x, x, x, x
```

Quad SPI data input/output format:

```
IO0 = (\dot{D}4, D0, ....)
IO1 = (D5, D1, ....)
IO2 = (D6, D2, ....)
IO3 = (D7, D3, ....)
```

9. Fast Read Quad I/O data output format:

```
IO0 = (x, x, x, x, D4, D0, D4, D0)
IO1 = (x, x, x, x, D5, D1, D5, D1)
IO2 = (x, x, x, x, D6, D2, D6, D2)
IO3 = (x, x, x, x, D7, D3, D7, D3)
```

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

```
CLK#0 1 2 3
                                                    8
                                                        9
                              4
                                   5
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. The number of dummy clocks for QPI Fast Read, QPI Fast Read Quad I/O & QPI Burst Read is controlled by read parameter P7 - P4.
- 12. The first dummy is M7-M0 should be set to Fxh/FFh to disable continuous read, M5-M4=[1:0] is enable continuous read



8.2 Instruction Descriptions

8.2.1 Write Enable (06h)

The Write Enable instruction (Figure 4) 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.

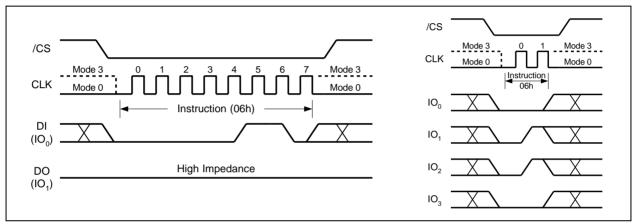


Figure 4. Write Enable Instruction for SPI Mode (left) or QPI Mode (right)

8.2.2 Write Enable for Volatile Status Register (50h)

The non-volatile Status Register bits described in section 8.1 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 5) 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.

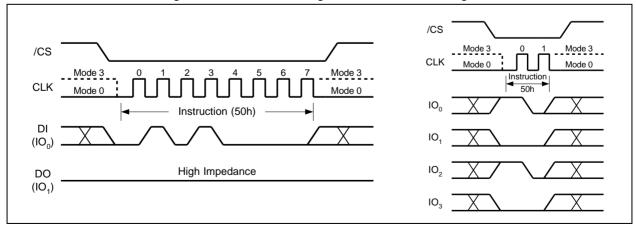


Figure 5. Write Enable for Volatile Status Register Instruction for SPI Mode (left) or QPI Mode (right)

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8.2.3 Write Disable (04h)

The Write Disable instruction (Figure 6) 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 and Chip Erase instructions.

Write Disable instruction can also be used to invalidate the Write Enable for Volatile Status Register instruction.

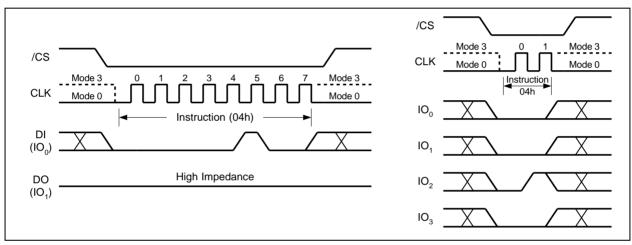


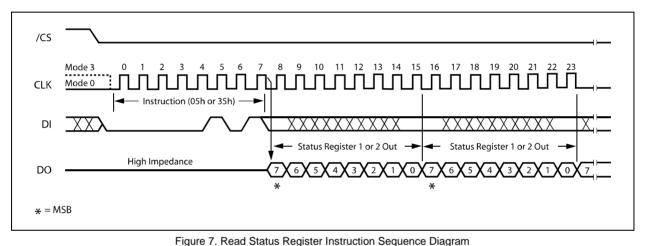
Figure 6. Write Disable Instruction for SPI Mode (left) or QPI Mode (right)



8.2.4 Read Status Register-1(05h) and Read Status Register-2(35h)

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 or "35h" for Status Register-2 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 7. The Status Register bits are shown in figure 3a and 3b and include the BUSY, WEL, BP2-BP0, TB, SEC, SRP, SRL, QE, LB[3:1], CMP and SUS bits (see Status Register section earlier in this datasheet).

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 7. The instruction is completed by driving /CS high.



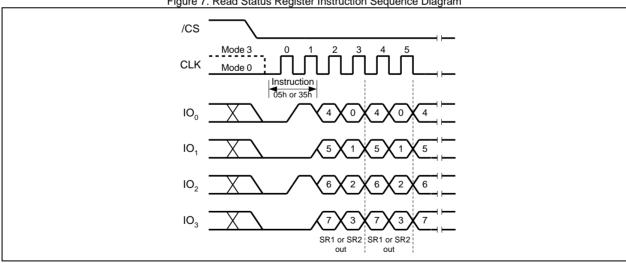


Figure 8b. Read Status Register Instruction (QPI Mode)



8.2.5 Write Status Register-1 (01h), Status Register-2 (31h)

The Write Status Register instruction allows the Status Registers to be written. The writable Status Register bits include: SRP, SEC, TB, BP[2:0] in Status Register-1; CMP, LB[3:1], QE, SRL in Status Register-2. 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", 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). However, SRL and LB[3:1] cannot be changed from "1" to "0" because of the OTP protection for these bits. Upon power off or the execution of a Software/Hardware Reset or Power-down instruction,, 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), after /CS is driven 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), after /CS is driven high, the Status Register bits will be refreshed to the new values within the time period of tSHSL2 (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.

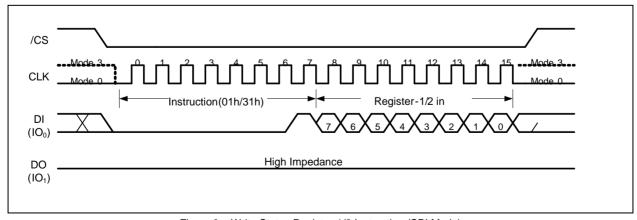


Figure 9a. Write Status Register-1/2 Instruction (SPI Mode)

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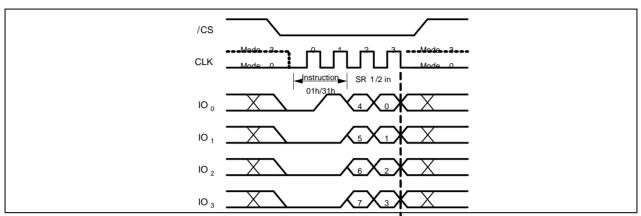


Figure 9b. Write Status Register-1/2 Instruction (QPI Mode)

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 fR (see AC Electrical Characteristics).

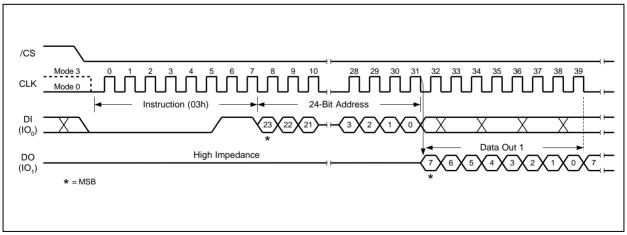


Figure 10. Read Data Instruction Sequence Diagram



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 FR (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".

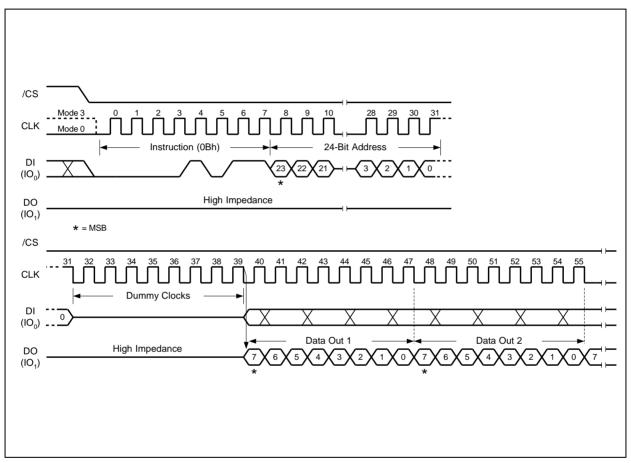


Figure 11a. Fast Read Instruction Sequence Diagram(SPI Mode)



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 2, 4, 6 or 8. The default number of dummy clocks upon power up or after a Reset instruction is 2.

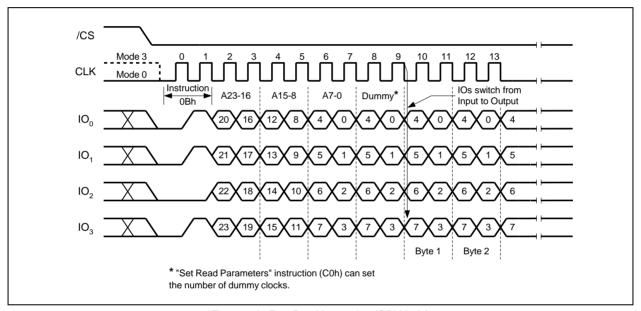


Figure 11b. Fast Read Instruction (QPI Mode)



8.2.8 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; IO₀ and IO₁. This allows data to be transferred from the W25Q64NE 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 FR (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.

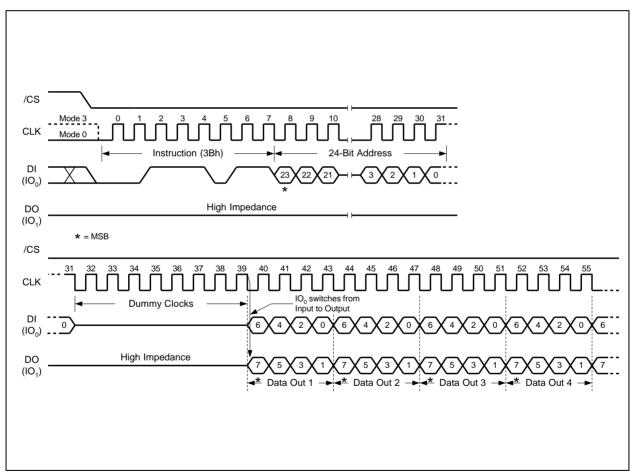


Figure 12. Fast Read Dual Output Instruction Sequence Diagram



8.2.9 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.

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 FFFFh on IOO for the next instruction (16 clocks), to ensure M4 = 1 and return the device to normal operation.

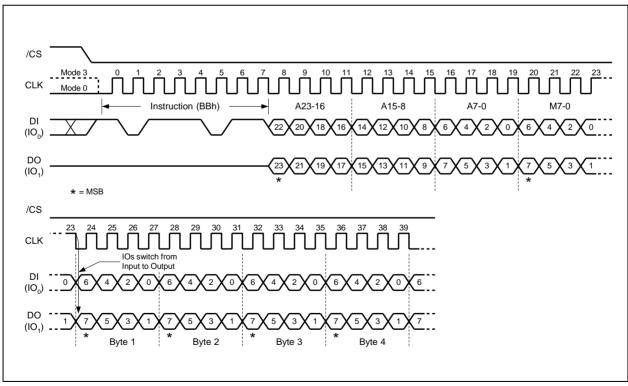


Figure 14a. Fast Read Dual I/O Instruction Sequence (Initial instruction or previous M5-4 ± 10)

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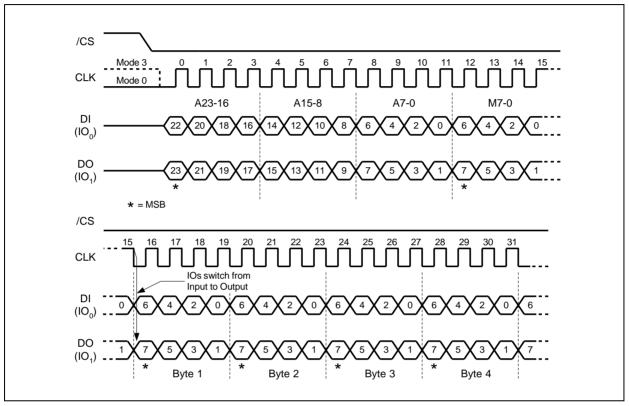


Figure 14b. Fast Read Dual I/O Instruction (Previous instruction set M5-4 = 10, SPI Mode only)



8.2.10 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 IO₀, IO₁, IO₂ and IO₃ and four Dummy clock 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 Fast Read Quad I/O Instruction.

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 IOO for the next instruction (8 clocks), to ensure M4 = 1 and return the device to normal operation.

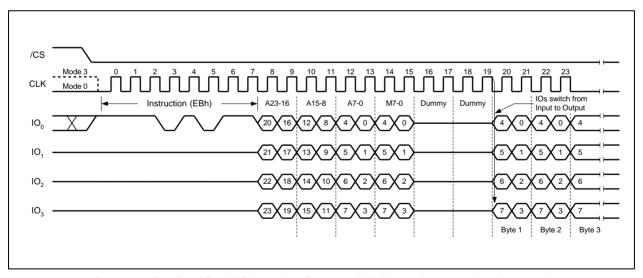


Figure 15a. Fast Read Quad I/O Instruction Sequence (Initial instruction or previous M5-4 ≠ 10)

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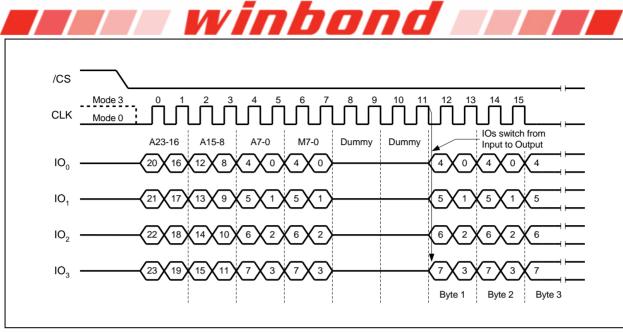


Figure 15b. Fast Read Quad I/O Instruction (Previous instruction set M5-4 = 10, SPI Mode)

Fast Read Quad I/O with "8/16/32/64-Byte Wrap Around"

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" command prior to EBh. The "Set Burst with Wrap" 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 a 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.



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 19c. 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 2, 4, 6 or 8. The default number of dummy clocks upon power up or after a Reset instruction is 2. 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.

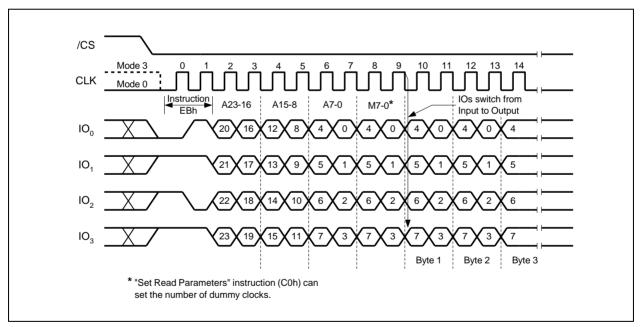


Figure 24c. Fast Read Quad I/O Instruction (Initial instruction or previous M5-4≠10, QPI Mode)

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8.2.11 Set Burst with Wrap (77h)

The Set Burst with Wrap (77h) instruction is used in conjunction with "Fast Read Quad I/O" instruction 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.

14/0	\A/F	W4	= 0	W4 =1 (DEFAULT)		
W6, W5		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" Quad I/O" instruction 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 is 1. In the case of a system Reset while W4 = 0, it is recommended that the controller issues a Set Burst with Wrap instruction to reset W4 = 1 prior to any normal Read instructions since W25Q64NE does not have a hardware Reset Pin.

The Wrap Length set by W6-4 in Standard SPI mode is not valid in QPI mode.

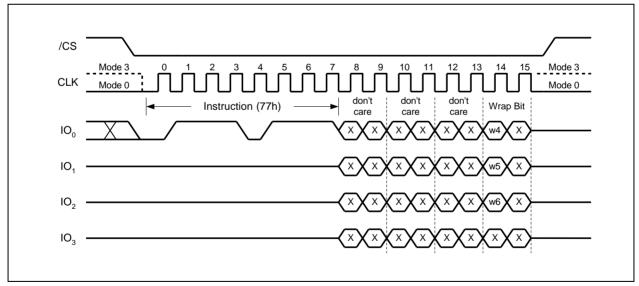


Figure 17. Set Burst with Wrap Instruction Sequence



8.2.12 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 18.

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 exceed 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 can not 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.

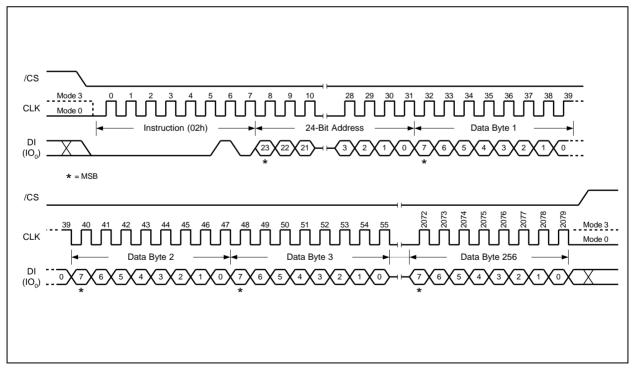


Figure 18a. Page Program Instruction Sequence Diagram

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/CS Mode 3 CLK Mode 0 Mode 0 Instruction A23-16 A15-8 A7-0 Byte1 Byte 2 Byte 3 Byte 255 | Byte 256 IO_0 IO₁ 10_2 10 6 2 6 2 6 6 10_3 3 3

Figure 18b. Page Program Instruction (QPI Mode)



8.2.13 Quad Input Page Program (32h)

The Quad Page Program instruction allows up to 256 bytes of data to be programmed at previously erased (FFh) memory locations using four pins: IO₀, IO₁, IO₂, and IO₃. The Quad 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 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 Page Program the Quad Enable in Status Register-2 must be set (QE=1). A Write Enable instruction must be executed before the device will accept the Quad 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 Page Program are identical to standard Page Program. The Quad Page Program instruction sequence is shown in figure 20.

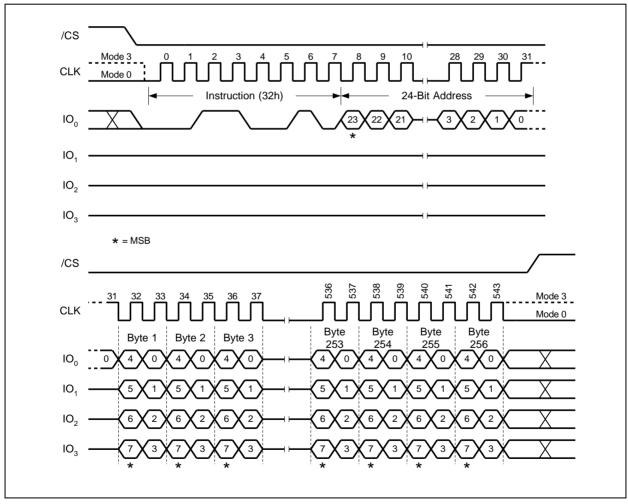


Figure 20. Quad Input Page Program Instruction Sequence Diagram

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8.2.14 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 31a & 31b.

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 tse (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.

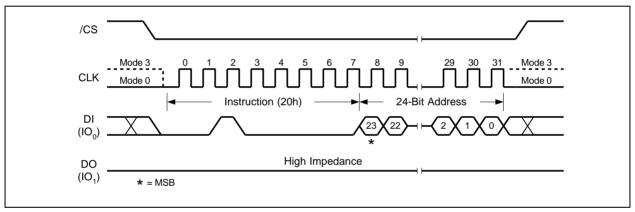


Figure 31a. Sector Erase Instruction (SPI Mode)

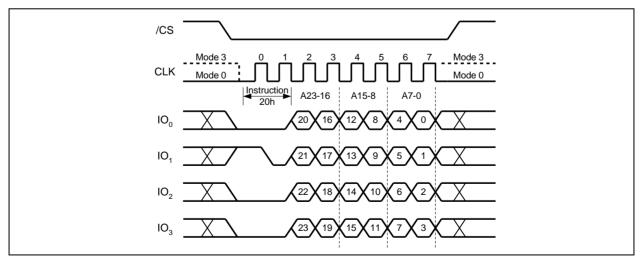


Figure 31b. Sector Erase Instruction (QPI Mode)

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8.2.15 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 32a & 32b.

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 tbell (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.

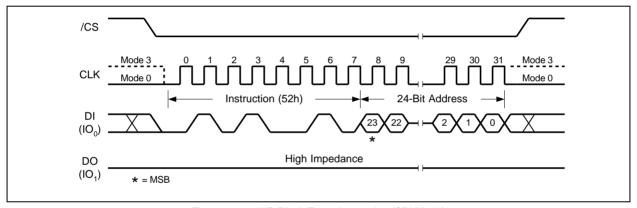


Figure 32a. 32KB Block Erase Instruction (SPI Mode)

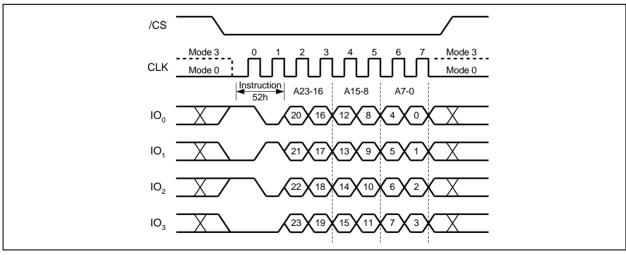


Figure 32b. 32KB Block Erase Instruction (QPI Mode)

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8.2.16 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 33a & 33b.

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 tbe (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.

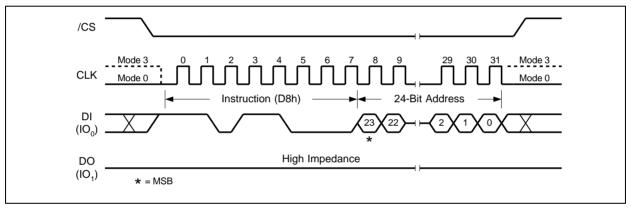


Figure 33a. 64KB Block Erase Instruction (SPI Mode)

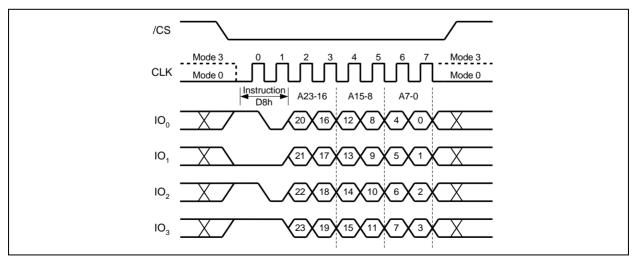


Figure 33b. 64KB Block Erase Instruction (QPI Mode)



8.2.17 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 34.

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 tce (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.

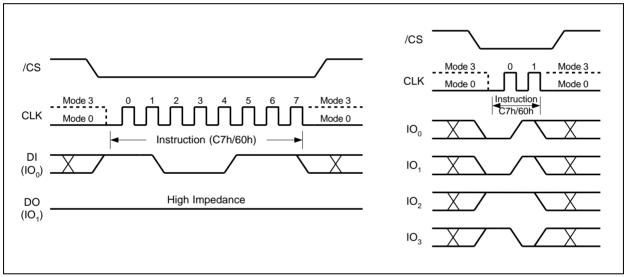


Figure 34. Chip Erase Instruction for SPI Mode (left) or QPI Mode (right)

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8.2.18 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 35a & 35b.

The Write Status Register instruction (01h) 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 instruction (01h) 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 SUS bit in the Status Register equals to 0 and the BUSY bit equals to 1 while a Sector or Block Erase or a Page Program operation is on-going. If the SUS 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.

Note that once the Suspend instruction (75h) is accepted, the following Power-down instruction (B9h) will be ignored.

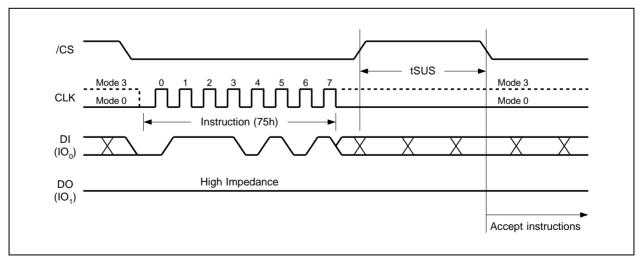


Figure 35a. Erase/Program Suspend Instruction (SPI Mode)

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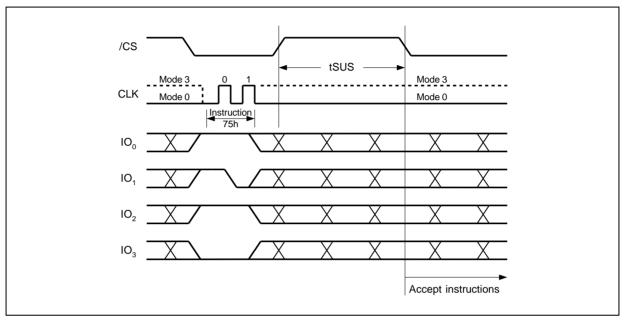


Figure 35b. Erase/Program Suspend Instruction (QPI Mode)

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8.2.19 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 36a & 36b.

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 "tsus" following a previous Resume instruction.

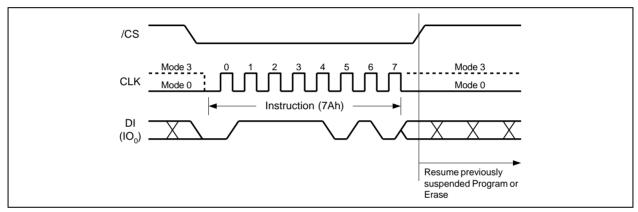


Figure 36a. Erase/Program Resume Instruction (SPI Mode)

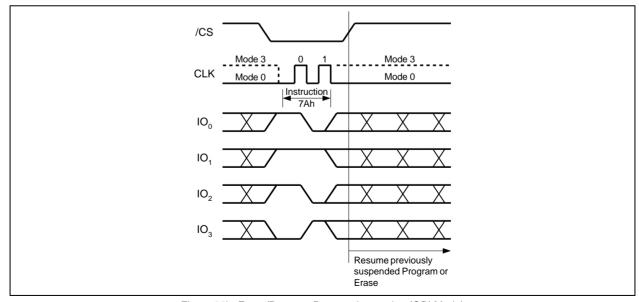


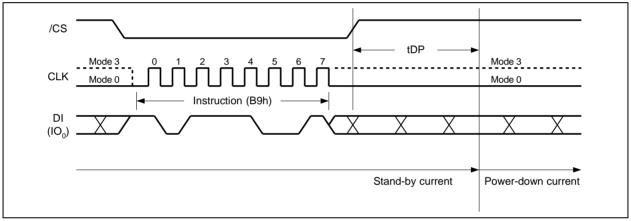
Figure 36b. Erase/Program Resume Instruction (QPI Mode)

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8.2.20 Power-down (B9h)

Although the standby current during normal operation is relatively low, standby current can be further reduced with the Power-down instruction. The lower power consumption makes the 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 37a & 37b.

The /CS pin must be driven high after the eighth bit has been latched. If this is not done the Power-down instruction will not be executed. After /CS is driven high, the power-down state will entered within the time duration of tDP (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, 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 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.



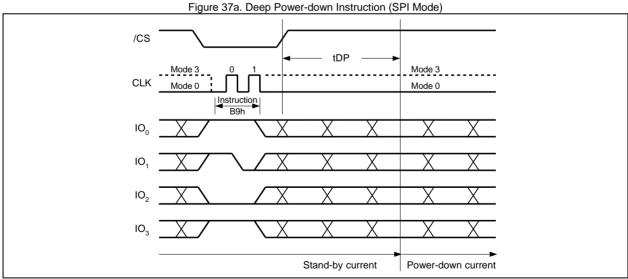


Figure 37b. Deep Power-down Instruction (QPI Mode)

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8.2.21 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 38a & 38b. Release from power-down will take the time duration of tress (See AC Characteristics) before the device will resume normal operation and other instructions are accepted. The /CS pin must remain high during the tress 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 W25Q64NE is listed in Manufacturer and Device Identification table. The Device ID can be read continuously. The instruction is completed by driving /CS high.

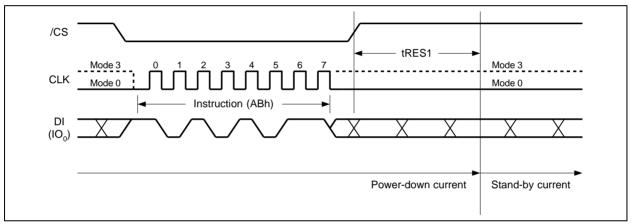


Figure 38a. Release Power-down Instruction (SPI Mode)

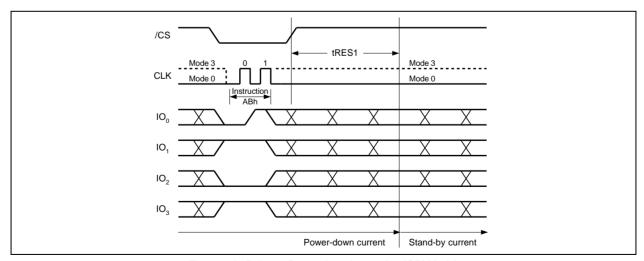


Figure 38b. Release Power-down Instruction (QPI Mode)

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Figure 38c. Release Device ID Instruction (SPI Mode)

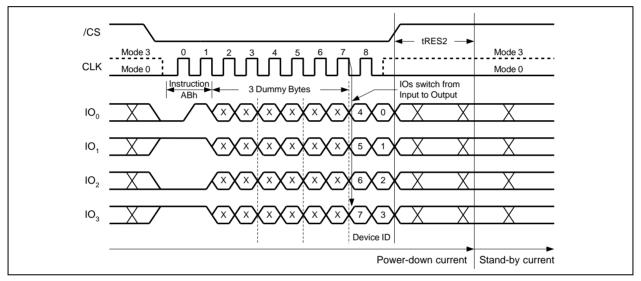


Figure 38d. Device ID Instruction (QPI Mode)



8.2.22 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 Winbond (EFh) and the Device ID are shifted out on the falling edge of CLK with most significant bit (MSB) first as shown in figure 29. The Device ID values for the W25Q64NE is 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.

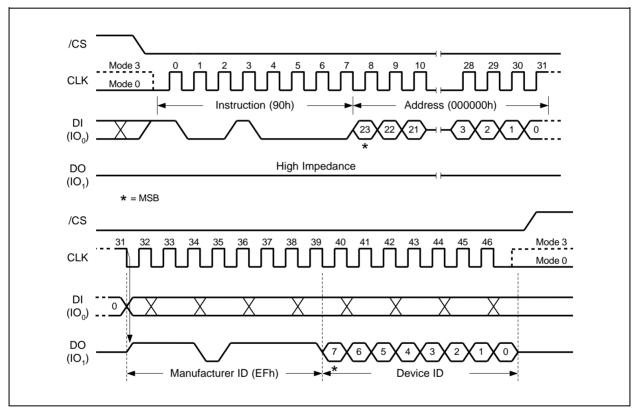


Figure 29. Read Manufacturer / Device ID Diagram



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

The 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, with the capability to input the Address bits two bits per clock. After which, the Manufacturer ID for Winbond (EFh) 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 30. The Device ID values for the W25Q64NE is 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.

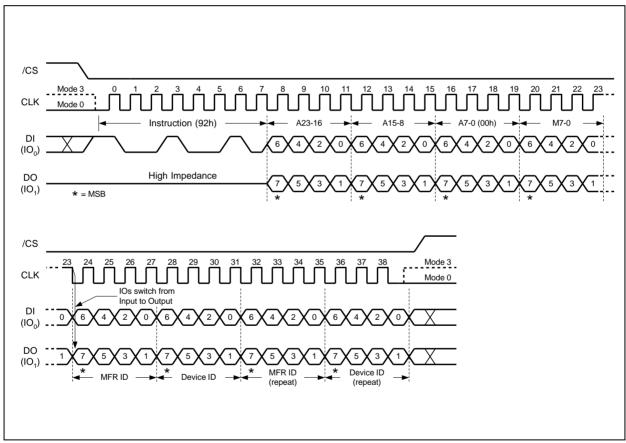


Figure 30. Read Manufacturer / Device ID Dual I/O Diagram

Note:

The "Continuous Read Mode" bits M7-0 must be set to Fxh to be compatible with Fast Read Dual I/O instruction.

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8.2.24 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, with the capability to input the Address bits four bits per clock. After which, the Manufacturer ID for Winbond (EFh) 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 31. The Device ID values for the W25Q64NE is 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.

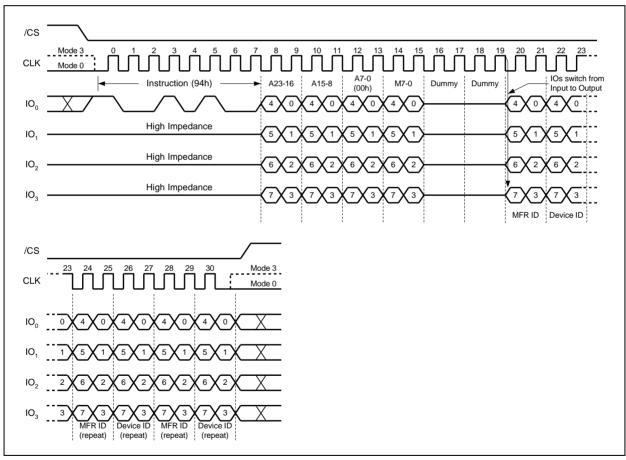


Figure 31. Read Manufacturer / Device ID Quad I/O Diagram

Note:

The "Continuous Read Mode" bits M7-0 must be set to Fxh to be compatible with Fast Read Quad I/O instruction.



8.2.25 Read Unique ID Number (4Bh)

The Read Unique ID Number instruction accesses a factory-set read-only 64-bit number that is unique to each W25Q64NE 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 a four bytes of dummy clocks. After which, the 64-bit ID is shifted out on the falling edge of CLK as shown in figure 32.

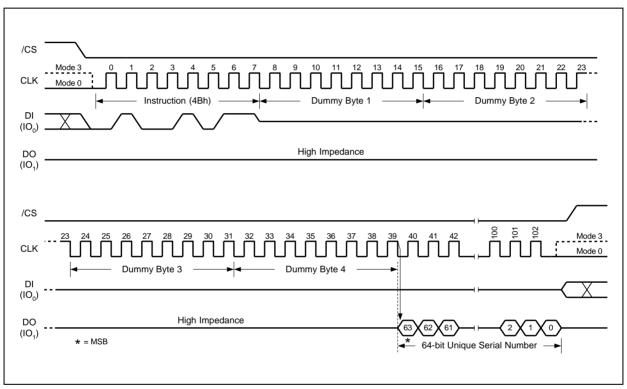


Figure 32. Read Unique ID Number Instruction Sequence

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8.2.26 Read JEDEC ID (9Fh)

For compatibility reasons, the W25Q64NE 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 Winbond (EFh) 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 43a & 43b. For memory type and capacity values refer to Manufacturer and Device Identification table.

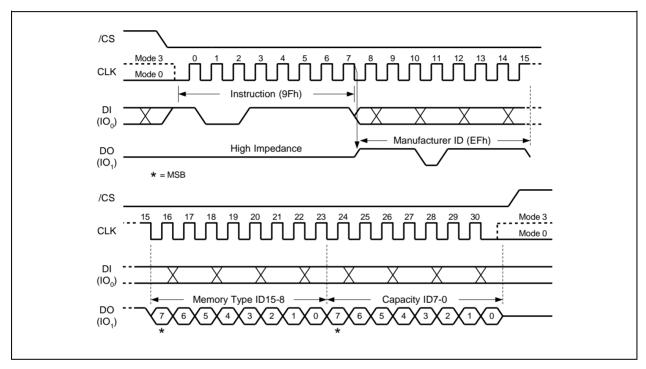


Figure 43a. Read JEDEC ID Instruction (SPI Mode)

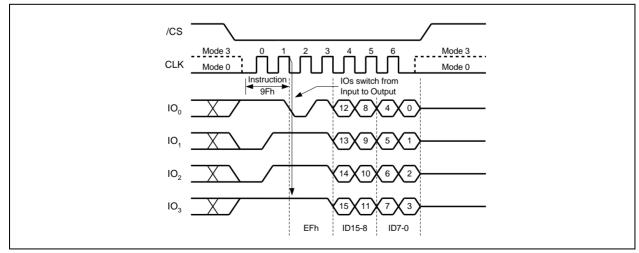


Figure 43b. Read JEDEC ID Instruction (QPI Mode)



8.2.27 Read SFDP Register (5Ah)

The W25Q64NE 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-serials that is published in 2011. Most Winbond SpiFlash Memories shipped after June 2011 (date code 1124 and beyond) support the SFDP feature as specified in the applicable datasheet.

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 44. For SFDP register values and descriptions, please refer to the Winbond 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.

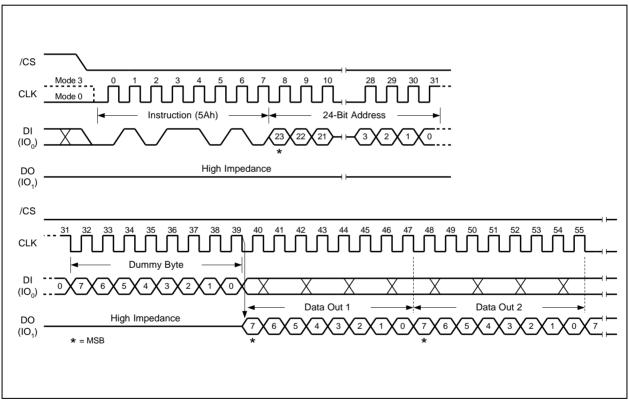


Figure 44. Read SFDP Register Instruction Sequence Diagram(SPI mode only)

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8.2.28 Erase Security Registers (44h)

The W25Q64NE offers three 256-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	A11-8	A7-0
Security Register #1	00h	0001	0000	Don't Care
Security Register #2	00h	0010	0000	Don't Care
Security Register #3	00h	0011	0000	Don't Care

The Erase Security Register instruction sequence is shown in Figure 45. 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 tse (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 LB[3:1] 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 (See 7.1.9 for detail descriptions).

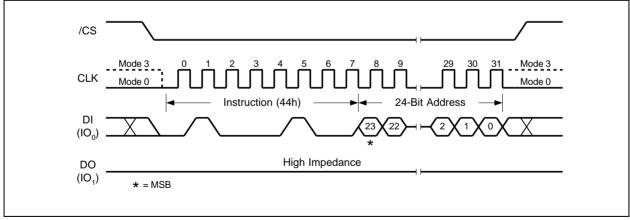


Figure 45. Erase Security Registers Instruction Sequence(SPI mode only)



8.2.29 Program Security Registers (42h)

The Program Security Register instruction is similar to the Page Program instruction. It allows from one byte to 256 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	A11-8	A7-0
Security Register #1	00h	0001	0000	Byte Address
Security Register #2	00h	0010	0000	Byte Address
Security Register #3	00h	0011	0000	Byte Address

The Program Security Register instruction sequence is shown in Figure 46. The Security Register Lock Bits LB[3:1] 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 7.1.9, 7.2.21 for detail descriptions).

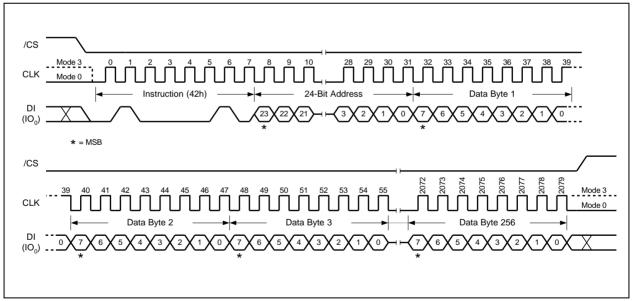


Figure 46. Program Security Registers Instruction Sequence(SPI mode only)

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8.2.30 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 three 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 FFh), it will reset to 00h, the first byte of the register, and continue to increment. The instruction is completed by driving /CS high. The 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 FR (see AC Electrical Characteristics).

ADDRESS	A23-16	A15-12	A11-8	A7-0
Security Register #1	00h	0001	0000	Byte Address
Security Register #2	00h	0010	0000	Byte Address
Security Register #3	00h	0011	0000	Byte Address

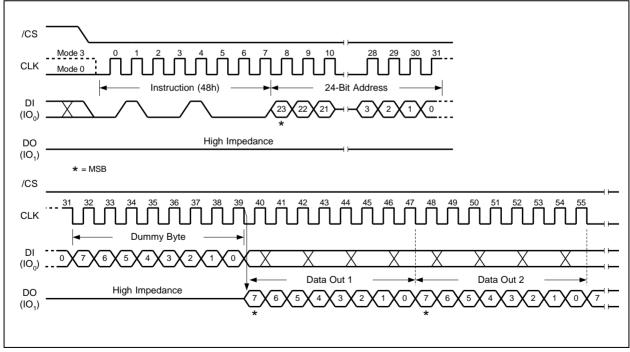


Figure 47. Read Security Registers Instruction Sequence(SPI mode only)



8.2.31 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)" . "Wrap Around" feature is not available in QPI mode.

In Standard SPI mode, the "Set Read Parameters (is not available)" 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 1-2 for details. The "Wrap Length" is set by W5-4 bit in the "Set Burst with Wrap (77h)" instruction.

P5 – P4	DUMMY CLOCKS	MAXIMUM READ FREQ.
0 0	2	20MHz
0 1	4	55MHz
1 0	6	80MHz
1 1	8	80MHz

Note: 4-bytes address alignment for read address start from A1,A0=0,0

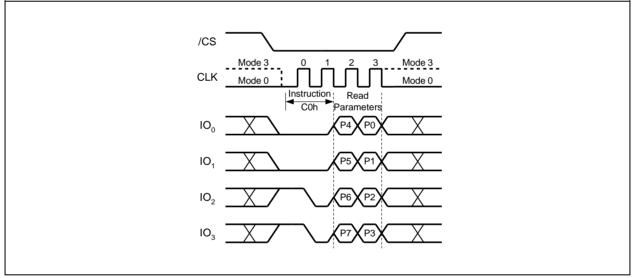


Figure 48. Set Read Parameters Instruction (QPI Mode only)



8.2.32 Enter QPI Mode (38h)

The W25Q64NE 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 Winbond serial flash memories. See Instruction Set Table 1-3 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 3 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 setting will remain unchanged.

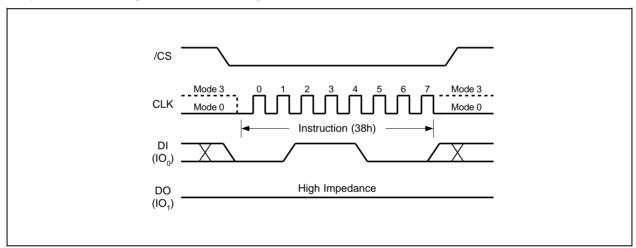


Figure 50. Enter QPI Instruction (SPI Mode only)



8.2.33 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 will remain unchanged.

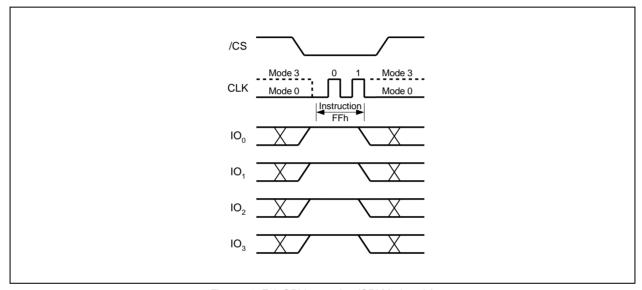


Figure 51. Exit QPI Instruction (QPI Mode only)

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8.2.34 Initial reset / Enable Reset (66h) and Reset Device (99h)

Initial Reset must issue after Vcc(min).

Because of the small package and the limitation on the number of pins, the W25Q64NE 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.

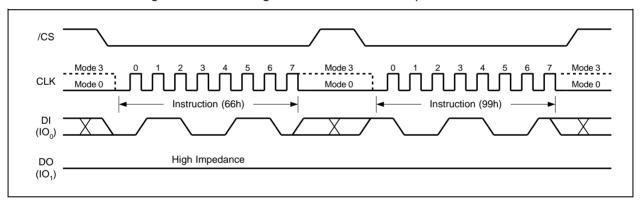


Figure 56a. Enable Reset and Reset Instruction Sequence (SPI Mode)

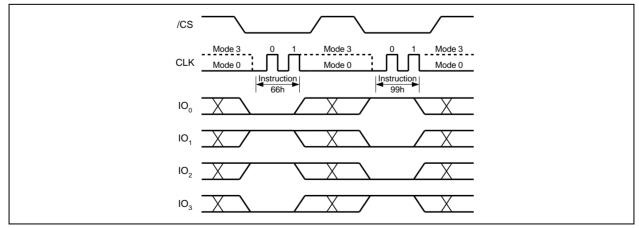


Figure 56b. Enable Reset and Reset Instruction Sequence (QPI Mode)



9. ELECTRICAL CHARACTERISTICS

9.1 Absolute Maximum Ratings (1)

PARAMETERS	SYMBOL	CONDITIONS	RANGE	UNIT
Supply Voltage	VCC		-0.6 to 2.5V	V
Voltage Applied to Any Pin	Vio	Relative to Ground	-0.6 to VCC+0.4	V
Transient Voltage on any Pin	VIOT	<20nS Transient Relative to Ground	-2.0V to VCC+2.0V	٧
Storage Temperature	TSTG		-65 to +150	°C
Lead Temperature	TLEAD		See Note (2)	°C
Electrostatic Discharge Voltage	VESD	Human Body Model(3)	-2000 to +2000	V

Notes:

- 1. This device has been designed and tested for the specified operation ranges. Proper operation outside of these levels is not guaranteed. Exposure to absolute maximum ratings may affect device reliability. Exposure beyond absolute maximum ratings may cause permanent damage.
- 2. Compliant with JEDEC Standard J-STD-20C for small body Sn-Pb or Pb-free (Green) assembly and the European directive on restrictions on hazardous substances (RoHS) 2002/95/EU.
- 3. JEDEC Std JESD22-A114A (C1=100pF, R1=1500 ohms, R2=500 ohms).

9.2 Operating Ranges

PARAMETER	SYMBOL	CONDITIONS	SP	UNIT	
PARAIVIETER			MAX	UNIT	
Supply Voltage	VCC	$F_R = 84MHz$, $f_R = 33MHz$	1.14	1.26	٧
Ambient Temperature, Operating	TA	Industrial	-40	+85	°C

Note:

1. VCC voltage during Read can operate across the min and max range but should not exceed ±10% of the programming (erase/write) voltage.

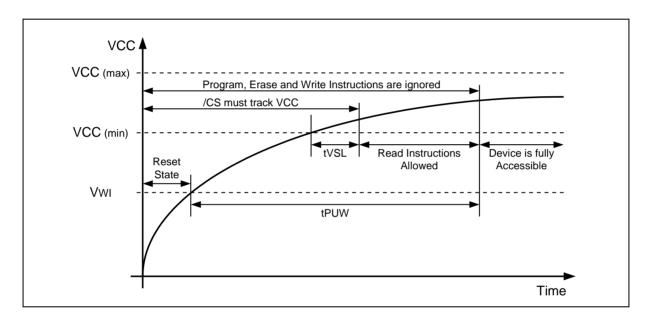


9.3 Power-up timing (POR)

DADAMETER	CVMDOL	SPEC	LINUT	
PARAMETER	SYMBOL	MIN	MAX	UNIT
VCC (min) to /CS Low	tVSL ⁽¹⁾	10		μs
Time Delay Before Write Instruction	tPUW ⁽¹⁾	1		ms
Write Inhibit Threshold Voltage	VWI ⁽¹⁾	0.9	1.1	V

Note:

1. These parameters are characterized only.



9.3.1 Reset command after power-on

Power-up Timing and Initial Reset Instruction

Dovometer	Cumb al	spec	l Init	
Parameter	Symbol	MIN	MAX	Unit
VCC (min) to /CS Low	tVSL ⁽¹⁾	0		μs
Initial Reset (66h+99h)	tREST ⁽²⁾	35		μs

Note:

- 1. These parameters are characterized only.
- 2. Initial Reset instruction is recommended for 1.2v application

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VCC(max) VCC(min) VCC(min) VCC(min) VCC(min) VCC(min) Time

Figure 35a. Power-up Timing and Voltage Levels

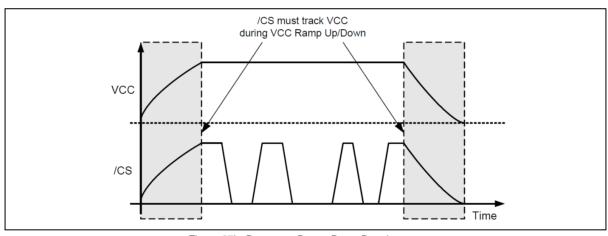


Figure 37b. Power-up, Power-Down Requirement



9.4 DC Electrical Characteristics: Industrial⁽¹⁾:

DADAMETED	OVMDOL	CONDITIONS		SPEC		LINUT
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Input Capacitance	CIN	VIN = 0V			6	pF
Output Capacitance	Cout	Vout = 0V			8	pF
Input Leakage	ILI				±2	μA
I/O Leakage	ILO				±2	μΑ
Standby Current	Icc1	/CS = VCC, VIN = GND or VCC		10	35	μA
Power-down Current	Icc2	/CS = VCC, VIN = GND or VCC		0.5	8	μA
Current Read Data / Dual /Quad 50MHz	Icc3 ⁽²⁾	C = 0.1 VCC / 0.9 VCC DO = Open		6	10	mA
Current Read Data / Dual /Quad 84MHz	ICC3 ⁽²⁾	C = 0.1 VCC / 0.9 VCC DO = Open		10	15	mA
Current Write Status Register	Icc4	/CS = VCC		15	20	mA
Current Page Program	Icc5	/CS = VCC		15	20	mA
Current Sector/Block Erase	Icc6	/CS = VCC		15	20	mA
Current Chip Erase	Icc7	/CS = VCC		15	20	mA
Input Low Voltage	Vil		-0.5		VCC x 0.3	V
Input High Voltage	Vih		VCC x 0.7		VCC + 0.4	V
Output Low Voltage	Vol	IoI = 100 μA			0.2	V
Output High Voltage	Voh	Ioh = -100 μA	VCC - 0.2			V

Notes:

- Tested on sample basis and specified through design and characterization data. TA = 25° C, VCC = 1.2V 1.
- Checker Board Pattern.



9.5 AC Measurement Conditions

PARAMETER	SYMBOL	SF	UNIT	
PARAMETER	STIMIBOL	SPEC MIN	01411	
Load Capacitance	CL	30		pF
Input Rise and Fall Times	TR, TF		5	ns
Input Pulse Voltages	VIN	0.1 VCC to 0.9 VCC		V
Input Timing Reference Voltages	IN	0.3 VCC to 0.7 VCC		V
Output Timing Reference Voltages	Оит	0.5 VCC	to 0.5 VCC	V

Note:

1. Output Hi-Z is defined as the point where data out is no longer driven.

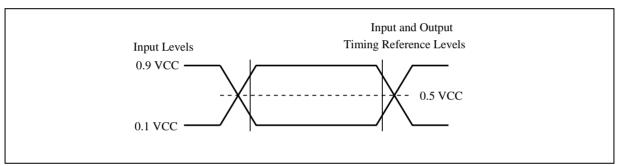


Figure 38. AC Measurement I/O Waveform



9.6 AC Electrical Characteristics:

DESCRIPTION	CVMDOL	A1.T		SPEC	;	UNIT
DESCRIPTION	SYMBOL	ALT	MIN	TYP	MAX	UNII
Clock frequency for all instructions except for Read Data (03h)	F _R	f _C	D.C.		84	MHz
Clock frequency for Read Data instruction (03h)	fR		D.C.		33	MHz
Clock High, Low Time for all instructions	tCLH1, tCLL1 ⁽¹⁾		45% P _C			ns
Clock Rise Time peak to peak	tCLCH ⁽²⁾		0.1			V/ns
Clock Fall Time peak to peak	tCHCL ⁽²⁾		0.1			V/ns
/CS Active Setup Time relative to CLK	tSLCH	tcss	10			ns
/CS Not Active Hold Time relative to CLK	tchsl		10			ns
Data In Setup Time	tDVCH	tDSU	2			ns
Data In Hold Time	tCHDX	tDH	5			ns
/CS Active Hold Time relative to CLK	tchsh		5			ns
/CS Not Active Setup Time relative to CLK	tshch		5			ns
/CS Deselect Time (for Array Read → Array Read)	tsHsL1	tCSH	10			ns
/CS Deselect Time (for Erase/Program → Read SR) Volatile Status Register Write Time	tsHsL2	tCSH	50			ns
Output Disable Time	tshqz ⁽²⁾	tDIS			8	ns
Clock Low to Output Valid	tCLQV	tv			7	ns

Continued – next page



AC Electrical Characteristics (cont'd)

DECODIDETION	OVMDO		SPEC			
ESCRIPTION SYMBOL AI		ALT	MIN	TYP	MAX	UNIT
Output Hold Time	tCLQX	tHO	0			ns
/HOLD Active Setup Time relative to CLK	tHLCH		5			ns
/HOLD Active Hold Time relative to CLK	tсннн		5			ns
/HOLD Not Active Setup Time relative to CLK	thhch		5			ns
/HOLD Not Active Hold Time relative to CLK	tCHHL		5			ns
/HOLD to Output Low-Z	thhqx ⁽²⁾	tLZ			7	ns
/HOLD to Output High-Z	thlqz ⁽²⁾	tHZ			12	ns
Write Protect Setup Time Before /CS Low	twhsL(3)		20			ns
Write Protect Hold Time After /CS High	tshwL ⁽³⁾		100			ns
/CS High to Power-down Mode	tDP ⁽²⁾				3	μs
/CS High to Standby Mode without ID Read	tRES1 ⁽²⁾				50	μs
/CS High to next Instruction after Suspend	tsus ⁽²⁾				100	μs
Write Status Register Time	tw			2	40	ms
Byte Program Time (First Byte) (4)	t _{BP1}			15	30	μs
Additional Byte Program Time (After First Byte) (4)	t _{BP2}			2.5	5	μs
Page Program Time	tpp			1.2	5	ms
Sector Erase Time (4KB)	tse			100	800	ms
Block Erase Time (32KB)	tBE₁			300	1500	ms
Block Erase Time (64KB)	tBE ₂			400	2,000	ms
Chip Erase Time	tce			80	160	s

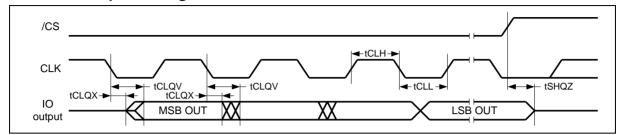
Notes:

- Clock high or Clock low must be more than or equal to 45%Pc. Pc=1/fC(MAX).
- Value guaranteed by design and/or characterization, not 100% tested in production.
- Only applicable as a constraint for a Write Status Register instruction when SRP bit is set to 1.
- For multiple bytes after first byte within a page, tBPN = tBP1 + tBP2 * N (typical) and tBPN = tBP1 + tBP2 * N (max), where N = number of bytes programmed.

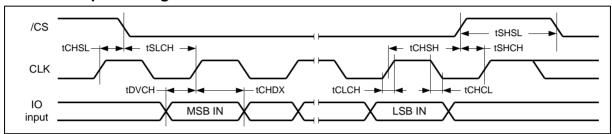
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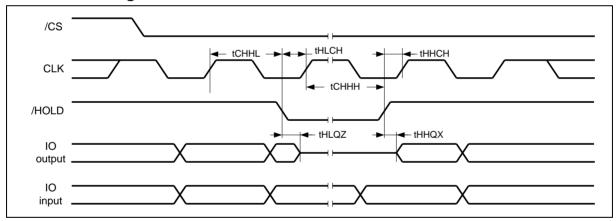
9.7 Serial Output Timing



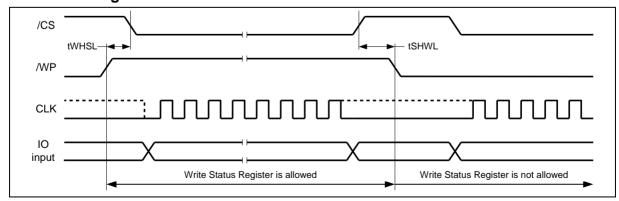
9.8 Serial Input Timing



9.9 /HOLD Timing



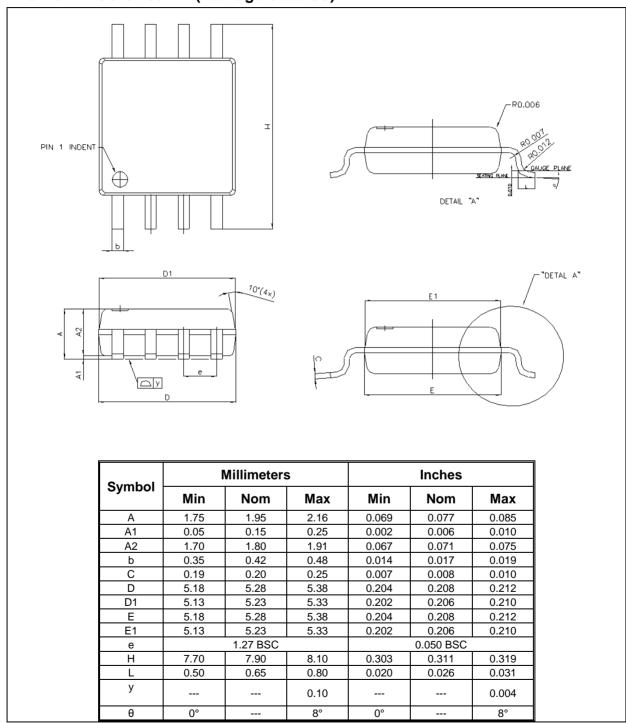
9.10 /WP Timing





10. PACKAGE SPECIFICATIONS

10.1 8-Pin SOIC 208-mil (Package Code SS)

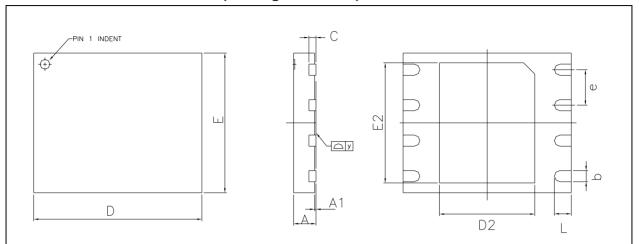


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10.2 8-Pad WSON 6x5-mm (Package Code ZP)



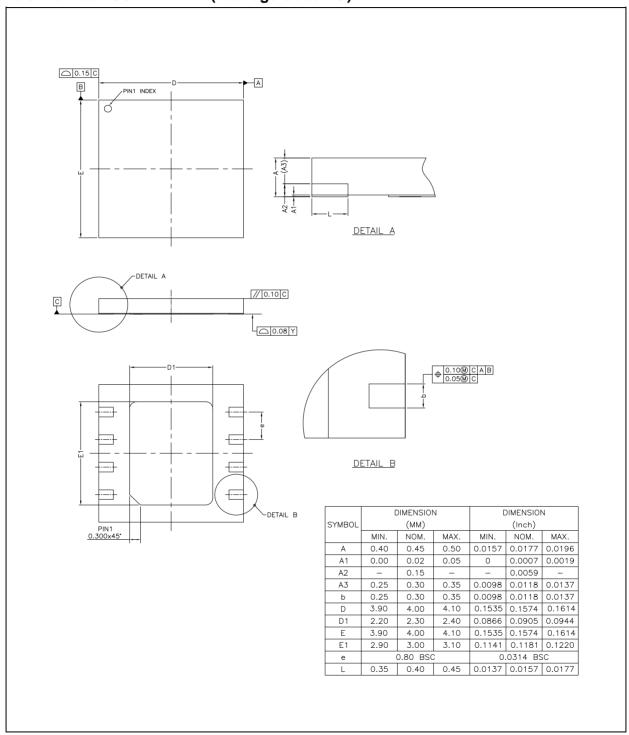
Cumb al	Millimeters			Inches			
Symbol	Min	Nom	Max	Min	Nom	Max	
А	0.70	0.75	0.80	0.028	0.030	0.031	
A1	0.00	0.02	0.05	0.000	0.001	0.002	
b	0.35	0.40	0.48	0.014	0.016	0.019	
С		0.20 REF			0.008 REF		
D	5.90	6.00	6.10	0.232	0.236	0.240	
D2	3.35	3.40	3.45	0.132	0.134	0.136	
Е	4.90	5.00	5.10	0.193	0.197	0.201	
E2	4.25	4.30	4.35	0.167	0.169	0.171	
е	1.27 BSC				0.050 BSC		
L	0.55	0.60	0.65	0.022	0.024	0.026	
у	0.00		0.075	0.000		0.003	

Note:

The metal pad area on the bottom center of the package is not connected to any internal electrical signals. It can be left floating or connected to the device ground (GND pin). Avoid placement of exposed PCB vias under the pad.



10.3 8-Pad XSON 4x4-mm (Package Code XG)

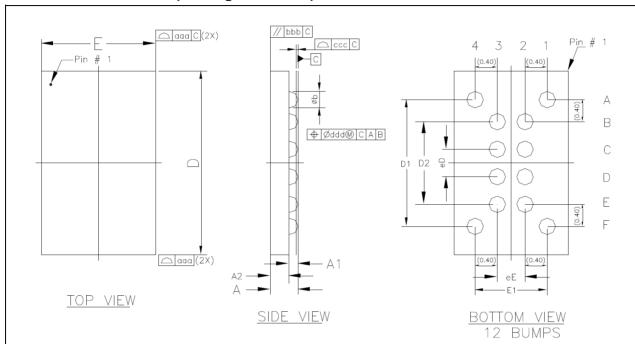


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10.4 12-Ball WLCSP (Package Code BY)



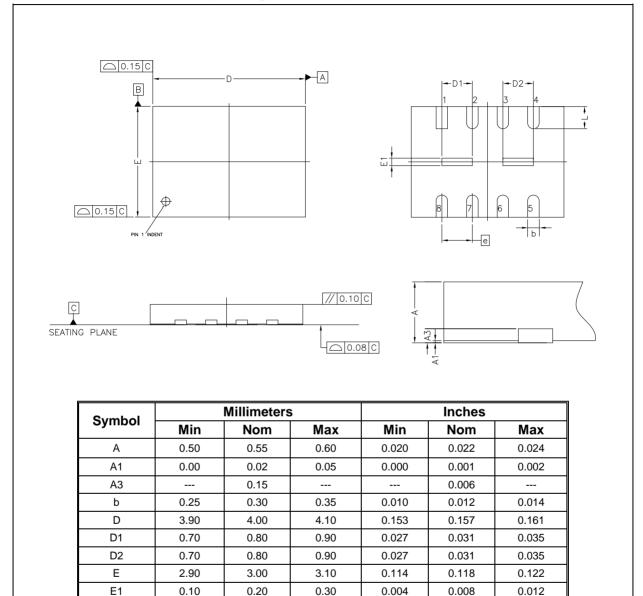
Camala a l	Millimeters			Inches			
Symbol	Min	Nom	Max	Min	Nom	Max	
А	0.329	0.362	0.395	0.013	0.014	0.016	
A1	0.152	0.167	0.182	0.006	0.007	0.007	
A2	0.177	0.195	0.213	0.007	0.008	0.008	
D1		2.300			0.091		
E1		1.300			0.051		
D2		1.500			0.059		
eD		0.500			0.020		
еE		0.500			0.020		
b	0.240	0.300	0.360	0.009	0.012	0.014	
aaa	0.100				0.004		
bbb	0.100			0.004			
ccc	0.030			0.001			
ddd	0.150			0.006			

Notes:

- $1. \quad \hbox{Dimension b is measured at the maximum solder bump diameter, parallel to primary datum C.}$
- 2. Dimension D and E; please contact Winbond for details.
- 3. Under Bump Metallization(UBM) size is 0.3mm, based on Dimension b(nominal value).



10.5 8-Pad USON 4x3-mm (Package Code UU)



Note:

e L

The metal pad area on the bottom center of the package is not connected to any internal electrical signals. It can be left floating or connected to the device ground (GND pin). Avoid placement of exposed PCB vias under the pad.

0.65

0.80 BSC

0.60

0.55

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0.026

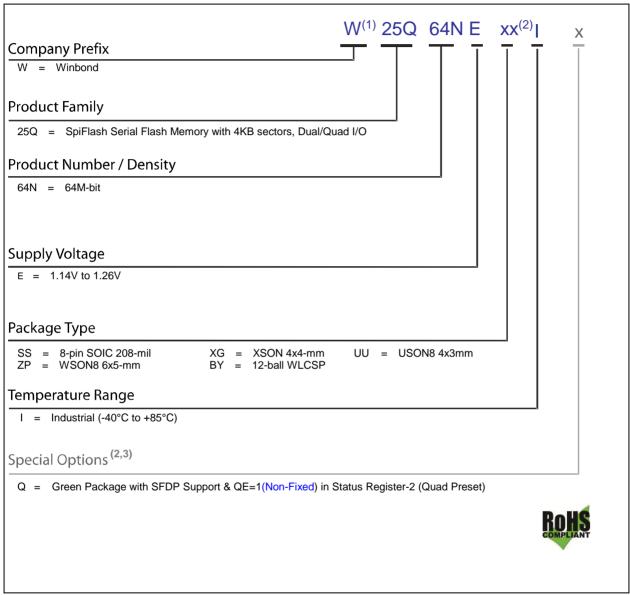
0.031 BSC

0.024

0.022



10.6 Ordering Information



Notes:

- 1. The "W" prefix is not included on the part marking.
- 2. Only the 2nd letter is used for the part marking; WSON package type ZP is not used for the part marking.
- 3. Standard bulk shipments are in Tube (shape E). Please specify alternate packing method, such as Tape and Reel (shape T) or Tray (shape S), when placing orders.
- 4. For shipments with OTP feature enabled, please contact Winbond for details.
- 5. /HOLD function is disabled to support Standard, Dual and Quad I/O without user setting.



10.1 Valid Part Numbers and Top Side Marking

The following table provides the valid part numbers for the W25Q64NE SpiFlash Memory. Please contact Winbond for specific availability by density and package type. Winbond SpiFlash memories use a 12-digit Product Number for ordering. However, due to limited space, the Top Side Marking on all packages uses an abbreviated 10-digit number.

W25Q64NE-IQ valid part numbers:

PACKAGE TYPE	DENSITY	PRODUCT NUMBER	TOP SIDE MARKING
SS SOIC-8 208-mil	64M-bit	W25Q64NESSIQ	25Q64NESIQ
UU USON-8 4x3mm	64M-bit	W25Q64NEUUIQ	Q64NEUUIQ
ZP ⁽¹⁾ WSON-8 6x5-mm	64M-bit	W25Q64NEZPIQ	25Q64NEIQ
XG XSON-8 4x4x0.45-mm	64M-bit	W25Q64NEXGIQ	Q64NEXGIQ
BY 12-ball WLCSP	64M-bit	W25Q64NEBYIQ	Q64NEY •IQYYWW

1. For WSON packages, the package type ZP and ZE is not used in the top side marking.

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11. REVISION HISTORY

VERSION	DATE	PAGE	DESCRIPTION
A1	05/08/2023	All	New Create W25Q64NExxIQ

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