

W25Q32JV



**3V 32M-BIT
SERIAL FLASH MEMORY WITH
DUAL, QUAD SPI**

For Industrial & Industrial Plus Grade



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1. GENERAL DESCRIPTIONS

The W25Q32J V (32M-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 2.7V to 3.6V power supply with current consumption as low as 1μA for power-down.

The W25Q32J V array is organized into 16,384 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 W25Q32J V has 1,024 erasable sectors and 64 erasable blocks respectively. The small 4KB sectors allow for greater flexibility in applications that require data and parameter storage. (See Figure 2.)

The W25Q32J V 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 133MHz are supported allowing equivalent clock rates of 266MHz (133MHz x 2) for Dual I/O and 532MHz (133MHz x 4) for Quad I/O when using the Fast Read Dual/Quad I/O instructions. These transfer rates can outperform standard Asynchronous 8 and 16-bit Parallel Flash memories.

Additionally, the device supports J EDEC standard manufacturer and device ID and SFDP Register, a 64-bit Unique Serial Number and three 256-bytes Security Registers.

2. FEATURES

- **New Family of SpiFlash Memories**
 - W25Q32J V: 32M-bit / 4M-byte
 - Standard SPI: CLK, /CS, DI, DO
 - Dual SPI: CLK, /CS, IO₀, IO₁
 - Quad SPI: CLK, /CS, IO₀, IO₁, IO₂, IO₃
 - Software & Hardware Reset⁽¹⁾
- **Highest Performance Serial Flash**
 - 133MHz Single, Dual/Quad SPI clocks
 - 266/532MHz equivalent Dual/Quad SPI
 - 66MB/S continuous data transfer rate
 - Min. 100K Program-Erase cycles per sector
 - More than 20-year data retention
- **Efficient “Continuous Read”**
 - Continuous Read with 8/16/32/64-Byte Wrap
 - As few as 8 clocks to address memory
 - Allows true XIP (execute in place) operation
 - Outperforms X16 Parallel Flash
- **Low Power, Wide Temperature Range**
 - Single 2.7V to 3.6V supply
 - <1μA Power-down (typ.)
 - -40°C to +85°C operating range
 - -40°C to +105°C operating range
- **Flexible Architecture with 4KB sectors**
 - Uniform Sector/Block Erase (4K/32K/64K-Byte)
 - Program 1 to 256 byte per programmable page
 - Erase/Program Suspend & Resume
- **Advanced Security Features**
 - Software and Hardware Write-Protect
 - Special OTP protection⁽²⁾
 - Top/Bottom, Complement array protection
 - Individual Block/Sector array protection
 - 64-Bit Unique ID for each device
 - Discoverable Parameters (SFDP) Register
 - 3X256-Bytes Security Registers
 - Volatile & Non-volatile Status Register Bits
- **Space Efficient Packaging**
 - 8-pin SOIC/VSOP 150/208-mil
 - 16-pin SOIC 300-mil
 - 8-pin PDIP 300-mil
 - 8-pad WSON 6x5-mm/8x6-mm
 - 8-pad USON 4x3-mm
 - 8-pad XSON 4x4-mm
 - 24-ball TFBGA 8x6-mm (6x4/5x5 ball array)
 - Contact Winbond for KGD and other options

Note: 1. Hardware /RESET pin is only available on SOIC-16 & TFBGA packages

2. Please contact Winbond for details.



3. PACKAGE TYPES AND PIN CONFIGURATIONS

3.1 Pin Configuration SOIC 150/208-mil & VSOP 208-mil

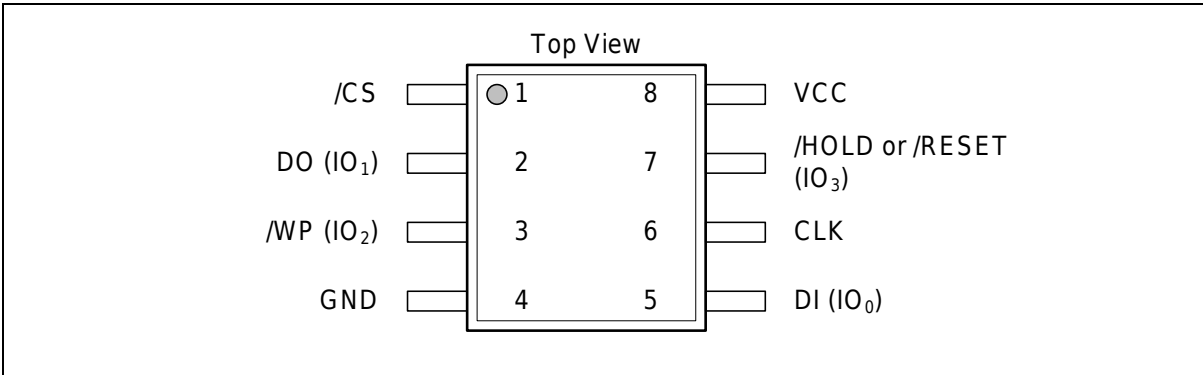


Figure 1a. W25Q32JV Pin Assignments, 8-pin SOIC 208-mil (Package Code SN/SS/ST)

3.2 Pad Configuration WSON 6x5-mm/ 8X6-mm, XSON 4x4-mm, USON 4x3-mm

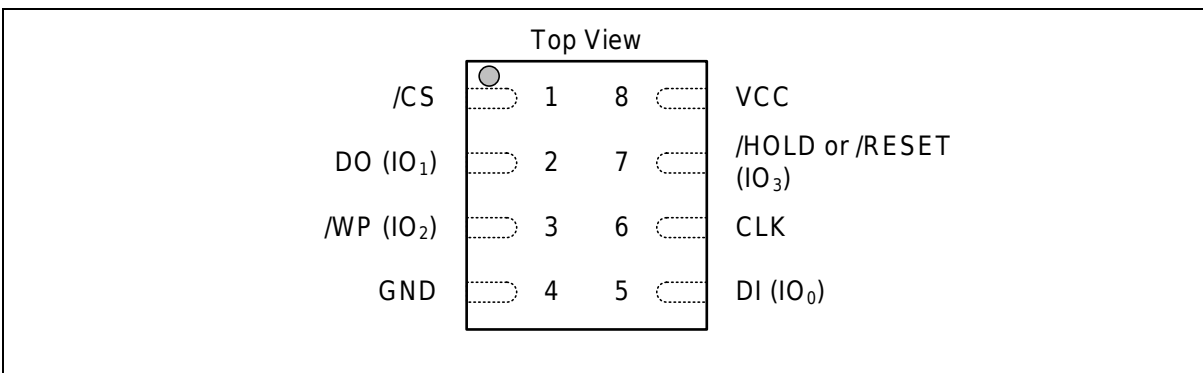


Figure 1b. W25Q32JV Pad Assignments, 8-pad WSON 6x5/8x6-mm, XSON 4x4-mm, USON 4x3-mm (Package Code ZP/ZE, XG,UU)

3.3 Pin Description SOIC 150/208-mil, VSOP 208-mil, WSON 6x5-mm/8x6-mm, XSON4x4-mm, USON 4x3-mm

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

Notes:

- IO₀ and IO₁ are used for Standard and Dual SPI instructions
- IO₀ – IO₃ are used for Quad SPI instructions, /HOLD (or /RESET) function is only available for Standard/Dual SPI.



3.4 Pin Configuration SOIC 300-mil

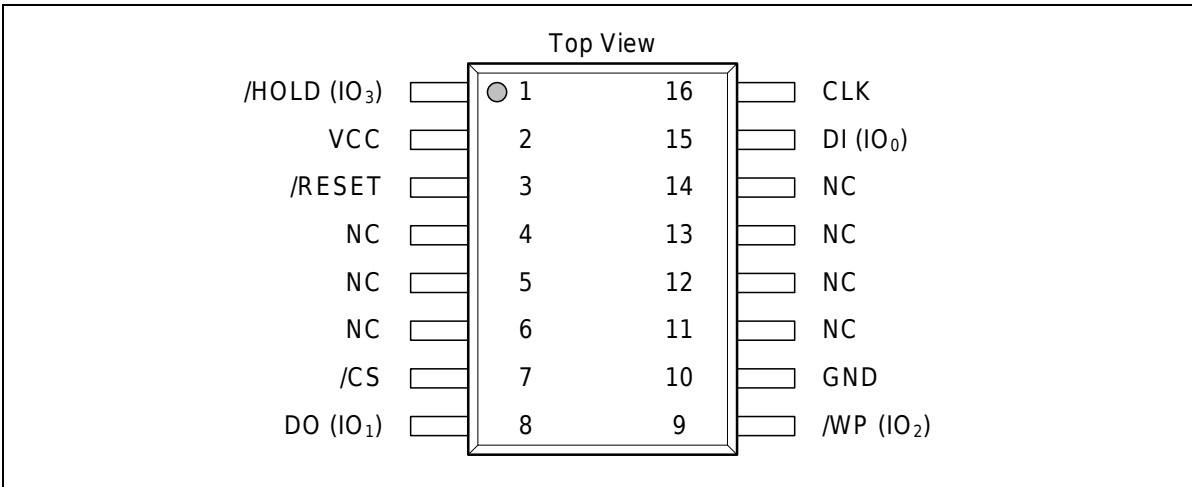


Figure 1c. W25Q32JV Pin Assignments, 16-pin SOIC 300-mil (Package Code SF)

3.5 Pin Description SOIC 300-mil

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

Notes:

1. IO0 and IO1 are used for Standard and Dual SPI instructions.
2. IO0 – IO3 are used for Quad SPI instructions, /HOLD (or /RESET) function is only available for Standard/Dual SPI.
3. The /RESET pin is a dedicated hardware reset pin regardless of device settings or operation states. If the hardware reset function is not used, this pin can be left floating or connected to VCC in the system.



3.6 Ball Configuration TFBGA 8x6-mm (5x5 or 6x4 Ball Array)

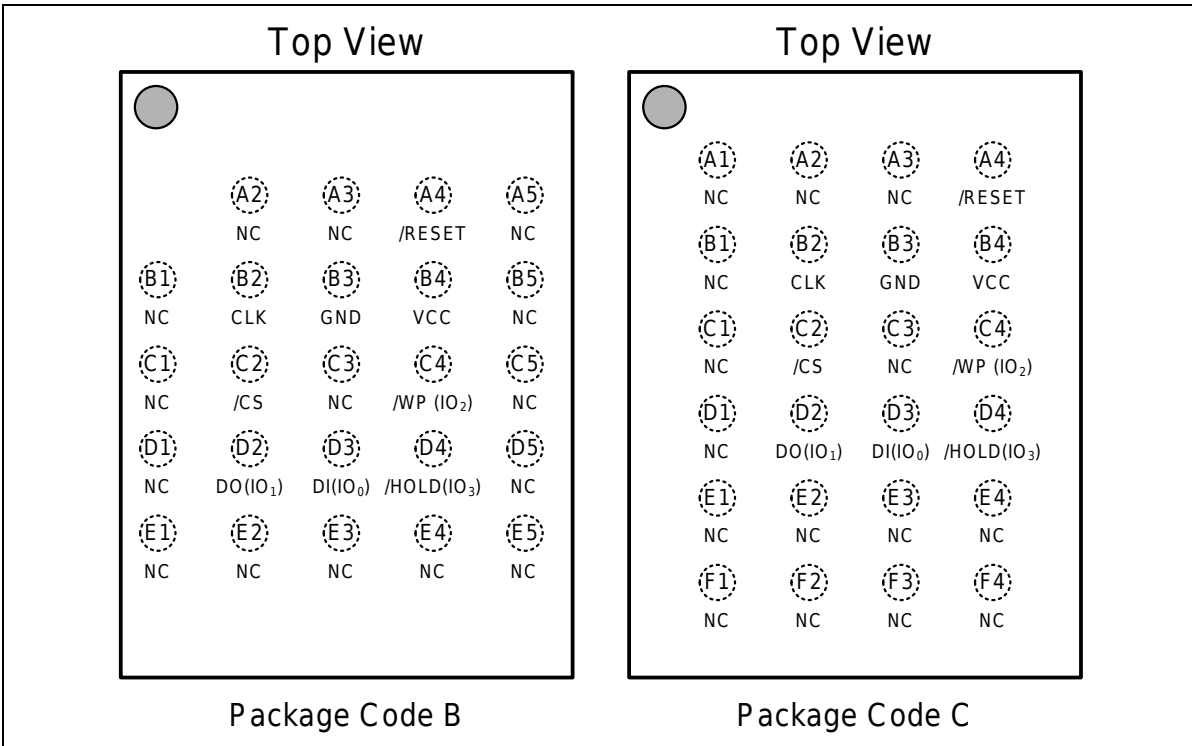


Figure 1d. W25Q32JV Ball Assignments, 24-ball TFBGA 8x6-mm, 5X5 and 6x4 (Package Code TB, TC)

3.7 Ball Description TFBGA 8x6-mm

BALL NO.	PIN NAME	I/O	FUNCTION
A4	/RESET	I	Reset Input ⁽³⁾
B2	CLK	I	Serial Clock Input
B3	GND		Ground
B4	VCC		Power Supply
C2	/CS	I	Chip Select Input
C4	/WP (IO ₂)	I/O	Write Protect Input (Data Input Output 2) ⁽²⁾
D2	DO (IO ₁)	I/O	Data Output (Data Input Output 1) ⁽¹⁾
D3	DI (IO ₀)	I/O	Data Input (Data Input Output 0) ⁽¹⁾
D4	/HOLD (IO ₃)	I/O	Hold or Reset Input (Data Input Output 3) ⁽²⁾
Multiple	NC		No Connect

Notes:

- IO0 and IO1 are used for Standard and Dual SPI instructions
- IO0 – IO3 are used for Quad SPI instructions, /HOLD (or /RESET) function is only available for Standard/Dual SPI.
- The /RESET pin is a dedicated hardware reset pin regardless of device settings or operation states.
If the hardware reset function is not used, this pin can be left floating or connected to VCC in the system



3.8 Pin Configuration PDIP 300-mil

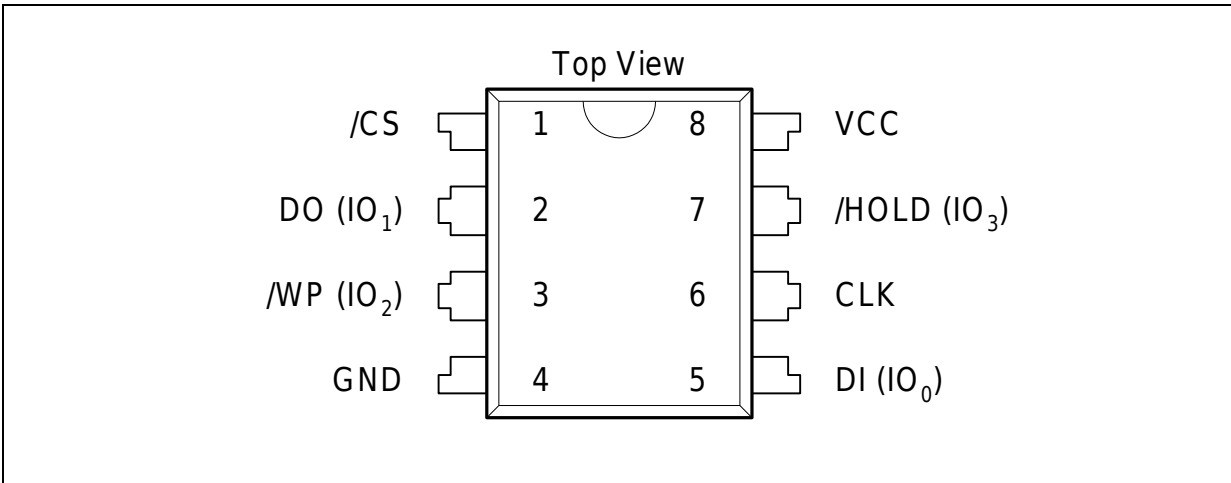


Figure 1e. W25Q32J V Pin Assignments, 8-pin PDIP (Package Code DA)

3.9 Pin Description PDIP 300-mil

PAD NO.	PAD NAME	I/O	FUNCTION
1	/CS	I	Chip Select Input
2	DO (IO ₁)	I/O	Data Output (Data Input Output 1) ⁽¹⁾
3	/WP (IO ₂)	I/O	Write Protect Input (Data Input Output 2) ^{*2}
4	GND		Ground
5	DI (IO ₀)	I/O	Data Input (Data Input Output 0) ⁽¹⁾
6	CLK	I	Serial Clock Input
7	/HOLD (IO ₃) or /RESET (IO ₃)	I/O	Hold or Reset 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 (or /RESET) function is 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 device's 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 and power-down (see "Write Protection" and Figure 58). If needed a pull-up resistor on the /CS pin can be used to accomplish this.

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

The W25Q32JV 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 the /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.

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")

4.6 Reset (/RESET)⁽¹⁾

A dedicated hardware /RESET pin is available on SOIC-16 and TFBGA packages. When it's driven low for a minimum period of ~1μS, this device will terminate any external or internal operations and return to its power-on state.

Note:

1. Hardware /RESET pin is available on SOIC-16 or TFBGA; please contact Winbond for this package.



5. BLOCK DIAGRAM

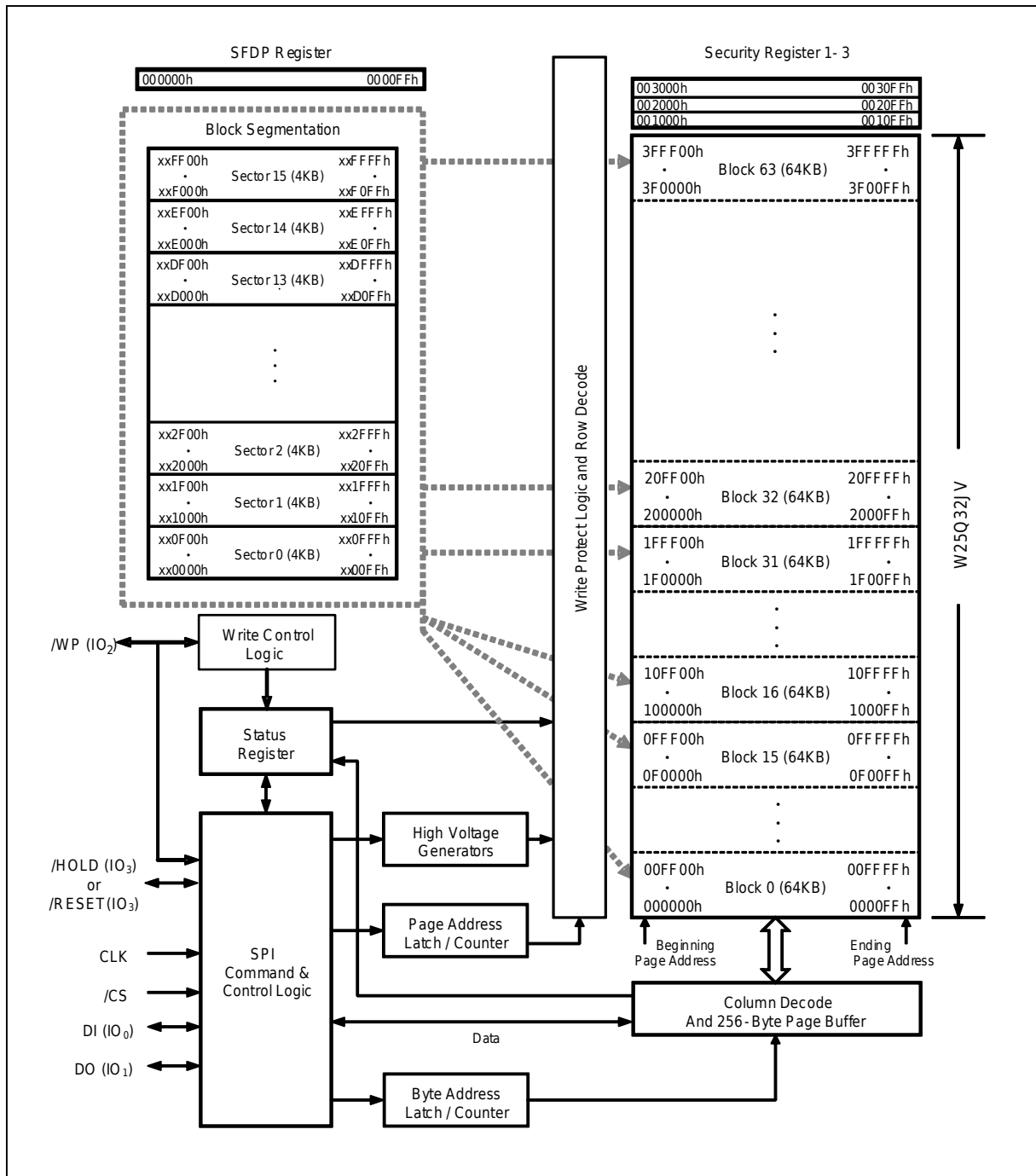


Figure 2. W25Q32JV Serial Flash Memory Block Diagram



6. FUNCTIONAL DESCRIPTIONS

6.1 Standard SPI Instructions

The W25Q32JV is accessed through an SPI compatible bus consisting of four signals: Serial Clock (CLK), Chip Select (/CS), Serial Data Input (DI) and Serial Data Output (DO). Standard SPI instructions use the DI input pin to serially write instructions, addresses or data to the device on the rising edge of CLK. The DO output pin is used to read data or status from the device on the falling edge of CLK.

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

6.2 Dual SPI Instructions

The W25Q32JV supports Dual SPI operation when using instructions such as “Fast Read Dual Output (3Bh)” and “Fast Read Dual I/O (BBh)”. These instructions allow data to be transferred to or from the device at two to three times the rate of ordinary Serial Flash devices. The Dual SPI Read instructions are ideal for quickly downloading code to RAM upon power-up (code-shadowing) or for executing non-speed-critical code directly from the SPI bus (XIP). When using Dual SPI instructions, the DI and DO pins become bidirectional I/O pins: IO0 and IO1.

6.3 Quad SPI Instructions

The W25Q32JV supports Quad SPI operation when using instructions such as “Fast Read Quad Output (6Bh)”, and “Fast Read Quad I/O (EBh)”. These instructions allow data to be transferred to or from the device four to six times the rate of ordinary Serial Flash. When using Quad SPI instructions, the DI and DO pins become bidirectional IO0 and IO1, with the additional I/O pins: IO2, IO3.

6.4 Software Reset & Hardware /RESET pin

The W25Q32JV can be reset to the initial power-on state by a software Reset sequence. This sequence must include two consecutive instructions: Enable Reset (66h) & Reset (99h). If the instruction sequence is successfully accepted, the device will take approximately 30μS (t_{RST}) to reset. No instruction will be accepted during the reset period. For the SOIC-16 and TFBGA packages, W25Q32JV provides a dedicated hardware /RESET pin. Drive the /RESET pin low for a minimum period of ~1μS (t_{RESET*}) will interrupt any on-going external/internal operations and reset the device to its initial power-on state. Hardware /RESET pin has higher priority than other SPI input signals (/CS, CLK, IOs).

Note:

1. Hardware /RESET pin is available on SOIC-16 or TFBGA; please contact Winbond for his package.
2. While a faster /RESET pulse (as short as a few hundred nanoseconds) will often reset the device, a 1us minimum is recommended to ensure reliable operation.
3. There is an internal pull-up resistor for the dedicated /RESET pin on the SOIC-16 package. If the reset function is not needed, this pin can be left floating in the system.



6.5 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 W25Q32JV provides several means to protect the data from inadvertent writes.

6.5.1 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 Registers
- Additional Individual Block/Sector Locks for array protection
- Write Protection using Power-down instruction
- Lock Down write protection for Status Register until the next power-up
- One Time Program (OTP) write protection for array and Security Registers using Status Register*

* Note: This feature is available upon special order. Please contact Winbond for details.

Upon power-up or at power-down, the W25Q32JV will maintain a reset condition while VCC is below the threshold value of V_{WI} , (See Power-up Timing and Voltage Levels and Figure 43). While reset, all operations are disabled and no instructions are recognized. During power-up and after the VCC voltage exceeds V_{WI} , all program and erase related instructions are further disabled for a time delay of t_{PUW} . 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 t_{VSL} time delay is reached, and it must also track the VCC supply level at power-down to prevent adverse command sequence. If needed a pull-up resistor 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, TB, BP[2:0]) bits. These settings allow a portion or the entire memory array to be configured as read only. Used in conjunction with the Write Protect (/WP) pin, changes to the Status Register can be enabled or disabled under hardware control. See Status Register section for further information. Additionally, the Power-down instruction offers an extra level of write protection as all instructions are ignored except for the Release Power-down instruction.

The W25Q32JV also provides another Write Protect method using the Individual Block Locks. Each 64KB block (except the top and bottom blocks, total of 62 blocks) and each 4KB sector within the top/bottom blocks (total of 32 sectors) are equipped with an Individual Block Lock bit. When the lock bit is 0, the corresponding sector or block can be erased or programmed; when the lock bit is set to 1, Erase or Program commands issued to the corresponding sector or block will be ignored. When the device is powered on, all Individual Block Lock bits will be 1, so the entire memory array is protected from Erase/Program. An "Individual Block Unlock (39h)" instruction must be issued to unlock any specific sector or block.

The WPS bit in Status Register-3 is used to decide which Write Protect scheme should be used. When $WPS=0$ (factory default), the device will only utilize CMP, SEC, TB, BP[2:0] bits to protect specific areas of the array; when $WPS=1$, the device will utilize the Individual Block Locks for write protection.



7. STATUS AND CONFIGURATION REGISTERS

Three Status and Configuration Registers are provided for W25Q32JV. The Read Status Register-1/2/3 instructions can be used to provide status on the availability of the flash memory array, whether the device is write enabled or disabled, the state of write protection, Quad SPI setting, Security Register lock status, Erase/Program Suspend status, and output driver strength. The Write Status Register instruction can be used to configure the device write protection features, Quad SPI setting, Security Register OTP locks, and output driver strength. Write access to the Status Register is controlled by the state of the non-volatile Status Register Protect bits (SRL), the Write Enable instruction, and during Standard/Dual SPI operations.

7.1 Status Registers

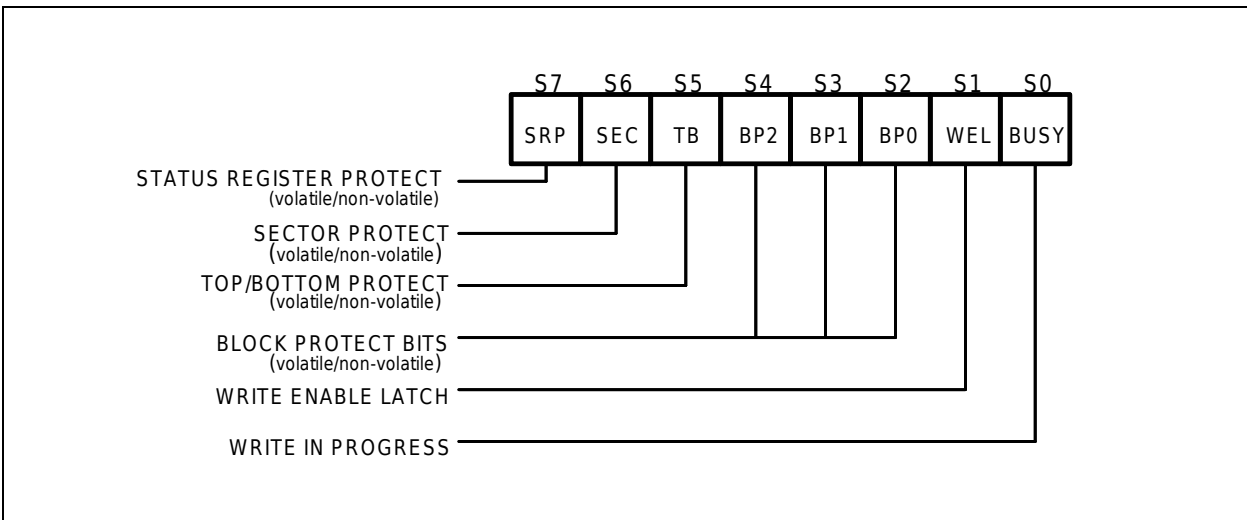


Figure 4a. Status Register-1

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

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

7.1.2 Write Enable Latch (WEL) – Status Only

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

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

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



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

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

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

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

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

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



7.1.1 Status Register Protect (SRP, SRL) – Volatile/Non-Volatile Writable

Three Status and Configuration Registers are provided for W25Q32J V. The Read Status Register-1/2/3 instructions can be used to provide status on the availability of the flash memory array, whether the device is write enabled or disabled, the state of write protection, Quad SPI setting, Security Register lock status, Erase/Program Suspend status, and output driver strength. The Write Status Register instruction can be used to configure the device write protection features, Quad SPI setting, Security Register OTP locks, output driver. 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.

SRL	SRP	/WP	Status Register	Description
0	0	X	Software Protection	/WP pin has no control. The Status register can be written to after a Write Enable instruction, WEL=1. [Factory Default]
0	1	0	Hardware Protected	When /WP pin is low the Status Register locked and cannot be written to.
0	1	1	Hardware Unprotected	When /WP pin is high the Status register is unlocked and can be written to after a Write Enable instruction, WEL=1.
1	X	X	Power Supply Lock-Down	Status Register is protected and cannot be written to again until the next power-down, power-up cycle. ⁽¹⁾
1	X	X	One Time Program ⁽²⁾	Status Register is permanently protected and cannot be written to. (enabled by adding prefix command AAh, 55h)

1. When SRL =1 , a power-down, power-up cycle will change SRL =0 state.
2. Please contact Winbond for details regarding the special instruction sequence.