

S25FL Family (Serial Peripheral Interface)

S25FL002D, S25FL001D

**2 Megabit, 1 Megabit CMOS 3.0 Volt Flash Memory
with 25 MHz SPI Bus Interface**



**PRELIMINARY
INFORMATION**

Distinctive Characteristics

ARCHITECTURAL ADVANTAGES

- **Single power supply operation**
 - Full voltage range: 2.7 to 3.6 V read and program operations
- **Memory Architecture**
 - 2 Mb – Four sectors with 512 Kb each
 - 1 Mb – Four sectors with 256 Kb each
- **Program**
 - Page Program (up to 256 bytes) in 6 ms (typical)
 - Program cycles are on a page by page basis
- **Erase**
 - 0.25 s typical sector erase time (S25FL001D)
 - 0.5 s typical sector erase time (S25FL002D)
 - 1.0 s typical bulk erase time (S25FL001D)
 - 2.0 s typical bulk erase time (S25FL002D)
- **Endurance**
 - 100,000 cycles per sector typical
- **Data Retention**
 - 20 years typical
- **Device ID**
 - Electronic signature
- **Process Technology**
 - Manufactured on 0.25 μ m process technology

■ Package Option

- Industry Standard Pinouts
- 150 mil 8-pin SO package for 1Mb and 2Mb
- 208 mil 8-pin SO package for 2Mb only
- 8-contact WSON leadless package (6x5 mm)

PERFORMANCE CHARACTERISTICS

■ Speed

- 25 MHz clock rate (maximum)

■ Power Saving Standby Mode

- Standby Mode 1 μ A (typical)

Memory Protection Features

■ Memory Protection

- W# pin works in conjunction with Status Register Bits to protect specified memory areas
- Status Register Block Protection bits (BP1, BP0) in status register configure parts of memory as read-only

SOFTWARE FEATURES

■ SPI Bus Compatible Serial Interface

General Description

The S25FL002D and S25FL001D devices are 3.0 Volt (2.7 V to 3.6 V) single power supply Flash memory devices. S25FL002D consists of four sectors, each with 512 Kb memory. S25FL001D consists of four sectors, each with 256 Kb memory.

Data appears on SI input pin when inputting data into the memory and on the SO output pin when outputting data from the memory. The devices are designed to be programmed in-system with the standard system 3.0 Volt V_{CC} supply.

The memory can be programmed 1 to 256 bytes at a time, using the Page Program instruction.

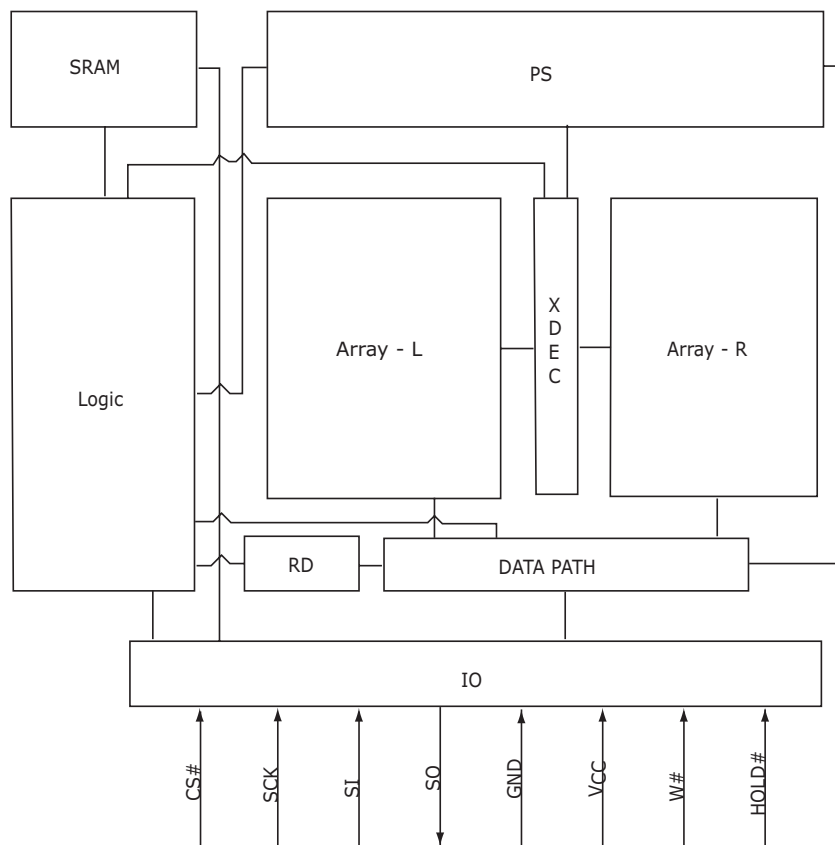
The memory supports Sector Erase and Bulk Erase instructions.

Each device requires only a 3.0 Volt power supply (2.7 V to 3.6 V) for both read and write functions. Internally generated and regulated voltages are provided for the program operations. This device does not require V_{PP} supply.

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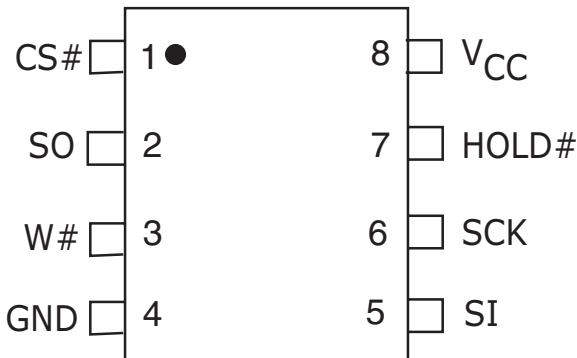
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Block Diagram

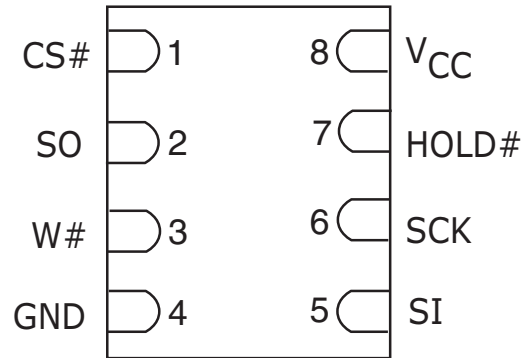


Connection Diagrams

8-pin Plastic Small Outline Package (SO)



8-contact WSON Package



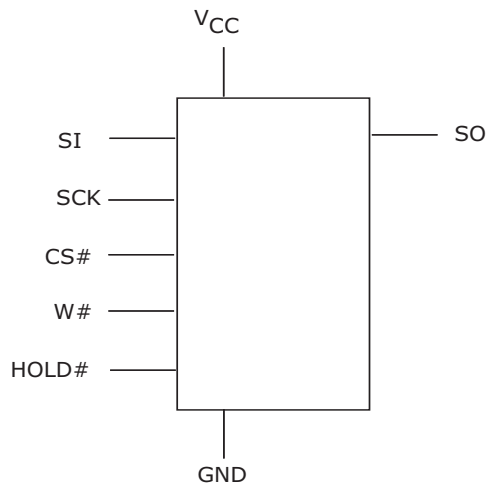
Note:

1. 8-pin Plastic Small Outline Package (208 mils) offered for 2Mb density only.

Input/Output Descriptions

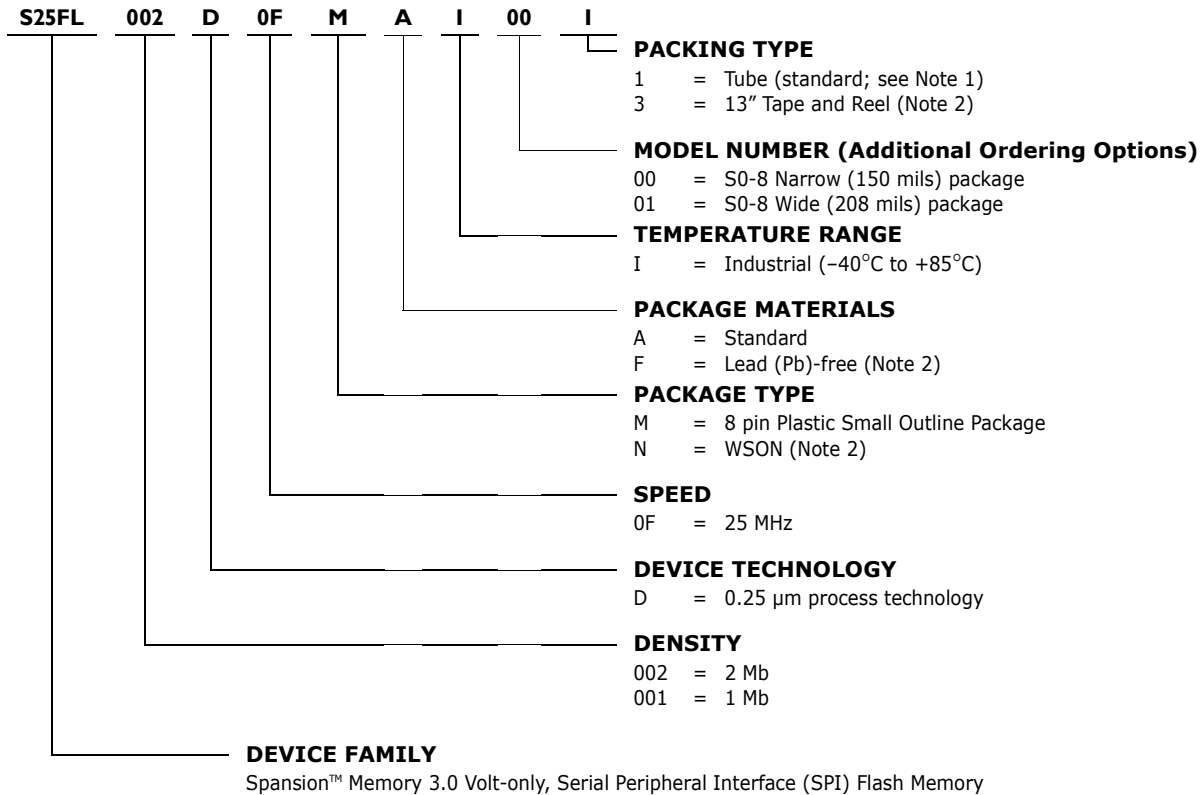
SCK	=	Serial Clock Input
SI	=	Serial Data Input
SO	=	Serial Data Output
CS#	=	Chip Select Input
W#	=	Write Protect Input
HOLD#	=	Hold Input
V _{CC}	=	Supply Voltage Input
GND	=	Ground Input

Logic Symbol



Ordering Information

The order number (Valid Combination) is formed by the following:



S25FL Valid Combinations					Package Marking (Note 3)
Base Ordering Part Number	Speed Option	Package & Temperature	Model Number	Packing Type	
S25FL002D	0F	MAI, MFI, NFI	00, 01	1, 3 (Note 1)	FL002D + (Temp) + (Last Digit of Model Number) (Note 4)
S25FL001D			00		FL001D + (Temp) + (Last Digit of Model Number) (Note 4)

Notes:

1. Type 1 is standard. Specify other options as required.
2. Contact your local sales office for availability.
3. Package marking omits leading "S25" and speed, package, and leading digit of model number from ordering part number.
4. If "Last Digit of Model Number" is '2', then this signifies a Lead (Pb)-free package. For example: FL002DI2
If "Last Digit of Model Number" is '0', this signifies a standard package. For example: FL002DI0.

Valid Combinations

Valid Combinations list configurations planned to be supported in volume for this device.

Signal Description

Signal Data Output (SO): This output signal is used to transfer data serially out of the device. Data is shifted out on the falling edge of Serial Clock (SCK).

Serial Data Input (SI): This input signal is used to transfer data serially into the device. It receives instructions, addresses, and the data to be programmed. Values are latched on the rising edge of Serial Clock (SCK).

Serial Clock (SCK): This input signal provides the timing of the serial interface. Instructions, addresses, and data present at the Serial Data input (SI) are latched on the rising edge of Serial Clock (SCK). Data on Serial Data Output (SO) changes after the falling edge of Serial Clock (SCK).

Chip Select (CS#): When this input signal is High, the device is deselected and Serial Data Output (SO) is at high impedance. Unless an internal Program, Erase or Write Status Register cycle is in progress, the device will be in Standby mode. Driving Chip Select (CS#) Low enables the device, placing it in the active power mode.

After Power-up, a falling edge on Chip Select (CS#) is required prior to the start of any instruction.

Hold (HOLD#): The Hold (HOLD#) signal is used to pause any serial communications with the device without deselecting the device.

During the Hold instruction, the Serial Data Output (SO) is high impedance, and Serial Data Input (SI) and Serial Clock (SCK) are Don't Care.

To start the Hold condition, the device must be selected, with Chip Select (CS#) driven Low.

Write Protect (W#): The main purpose of this input signal is to freeze the size of the area of memory that is protected against program or erase instructions (as specified by the values in the BP1 and BP0 bits of the Status Register).

SPI Modes

These devices can be driven by a micro controller with its SPI peripheral running in either of the two following modes:

- CPOL = 0, CPHA = 0
- CPOL = 1, CPHA = 1

For these two modes, input data is latched in on the rising edge of Serial Clock (SCK), and output data is available from the falling edge of Serial Clock (SCK).

The difference between the two modes, as shown in [Figure 2](#), is the clock polarity when the bus master is in Standby and not transferring data:

- SCK remains at 0 for (CPOL = 0, CPHA = 0)
- SCK remains at 1 for (CPOL = 1, CPHA = 1)

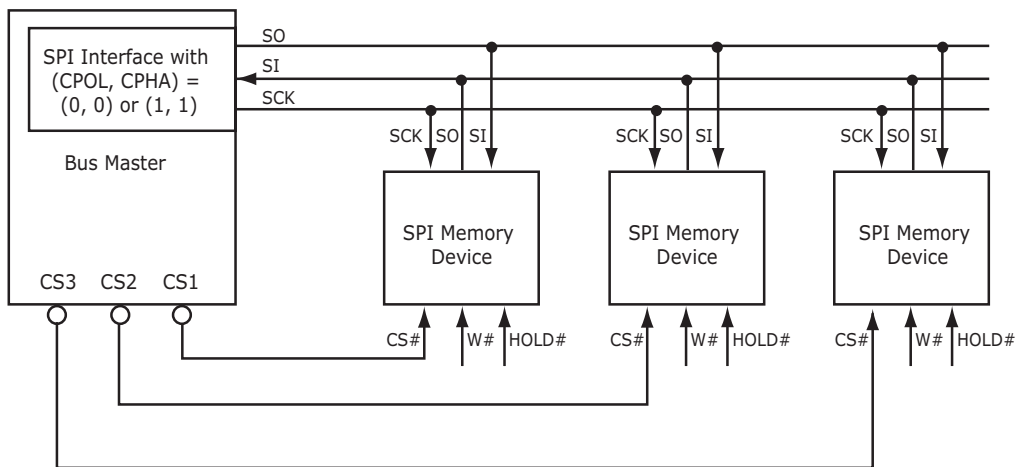


Figure 1. Bus Master and Memory Devices on the SPI Bus

Note: The Write Protect ($W\#$) and Hold ($HOLD\#$) signals should be driven, High or Low as appropriate.

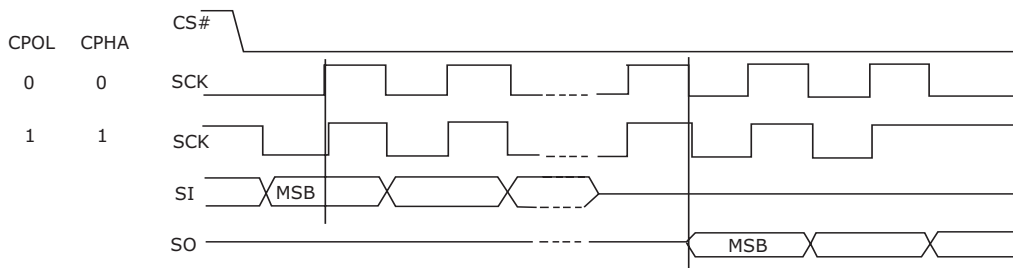


Figure 2. SPI Modes Supported

Operating Features

All data into and out of the device is shifted in 8-bit chunks.

Page Programming

To program one data byte, two instructions are required: Write Enable (WREN), which is one byte, and a Page Program (PP) sequence, which consists of four bytes plus data. This is followed by the internal Program cycle. To spread this overhead, the Page Program (PP) instruction allows up to 256 bytes to be programmed at a time (changing bits from 1 to 0), provided that they lie in consecutive addresses on the same page of memory.

Sector Erase, or Bulk Erase

The Page Program (PP) instruction allows bits to be programmed from 1 to 0. Before this can be applied, the bytes of the memory need to be first erased to all 1's (FFh) before any programming. This can be achieved in two ways: 1) a sector at a time using the Sector Erase (SE) instruction, or 2) throughout the entire memory, using the Bulk Erase (BE) instruction.

Polling During a Write, Program, or Erase Cycle

A further improvement in the time to Write Status Register (WRSR), Program (PP) or Erase (SE or BE) can be achieved by not waiting for the worst-case delay. The Write in Progress (WIP) bit is provided in the Status Register so that the application program can monitor its value, polling it to establish when the previous Write cycle, Program cycle, or Erase cycle is complete.

Active Power and Standby Power Modes

When Chip Select (CS#) is Low, the device is enabled, and in the Active Power mode. When Chip Select (CS#) is High, the device is disabled, but could remain in the Active Power mode until all internal cycles have completed (Program, Erase, Write Status Register). The device then goes into the Standby Power mode. The device consumption drops to I_{SB} . This can be used as an extra software protection mechanism, when the device is not in active use, to protect the device from inadvertent Write, Program, or Erase instructions.

Status Register

The Status Register contains a number of status and control bits, as shown in [Figure 7](#), that can be read or set (as appropriate) by specific instructions

- **WIP bit:** The Write In Progress (WIP) bit indicates whether the memory is busy with a Write Status Register, Program or Erase cycle.
- **WEL bit:** The Write Enable Latch (WEL) bit indicates the status of the internal Write Enable Latch.
- **BP1, BP0 bits:** The Block Protect (BP1, BP0) bits are non-volatile. They define the size of the area to be software protected against Program and Erase instructions.
- **SRWD bit:** The Status Register Write Disable (SRWD) bit is operated in conjunction with the Write Protect (W#) signal. The Status Register Write Disable (SRWD) bit and Write Protect (W#) signal allow the device to be put in the Hardware Protected mode. In this mode, the non-volatile bits of the Status Register (SRWD, BP1, BP0) become read-only bits.

Protection Modes

The SPI memory device boasts the following data protection mechanisms:

- All instructions that modify data must be preceded by a Write Enable (WREN) instruction to set the Write Enable Latch (WEL) bit. This bit is returned to its reset state by the following events:
 - Power-up
 - Write Disable (WRDI) instruction completion
 - Write Status Register (WRSR) instruction completion
 - Page Program (PP) instruction completion
 - Sector Erase (SE) instruction completion
 - Bulk Erase (BE) instruction completion
- The Block Protect (BP1, BP0) bits allow part of the memory to be configured as read-only. This is the Software Protected Mode (SPM).
- The Write Protect (W#) signal works in cooperation with the Status Register Write Disable (SRWD) bit to enable write-protection. This is the Hardware Protected Mode (HPM).
- Program, Erase and Write Status Register instructions are checked to verify that they consist of a number of clock pulses that is a multiple of eight, before they are accepted for execution.

Table 1. Protected Area Sizes (S25FL002D).

Protected Memory Area	Status Register Content		Memory Content	
	BP1 Bit	BP0 Bit	Protected Area	Unprotected Area
0%	0	0	none	00000–3FFFF
25%	0	1	30000–3FFFF	00000–2FFFF
50%	1	0	20000–3FFFF	00000–1FFFF
100%	1	1	00000–3FFFF	none

Table 2. Protected Area Sizes (S25FL001D).

Protected Memory Area	Status Register Content		Memory Content	
	BP1 Bit	BP0 Bit	Protected Area	Unprotected Area
0%	0	0	none	00000–1FFFF
25%	0	1	18000–1FFFF	00000–17FFF
50%	1	0	10000–1FFFF	00000–0FFFF
100%	1	1	00000–1FFFF	none

Note: The device is ready to accept a Bulk Erase (BE) instruction, if and only if, both Block Protect (BP1 and BP0) are 0.

Hold Condition Modes

The Hold (HOLD#) signal is used to pause any serial communications with the device without resetting the clocking sequence. Hold (HOLD#) signal gates the clock input to the device. However, taking this signal Low does not terminate any Write Status Register, Program or Erase Cycle that is currently in progress.

To enter the Hold condition, the device must be selected, with Chip Select (CS#) Low. The Hold condition starts on the falling edge of the Hold (HOLD#) signal, provided that this coincides with Serial Clock (SCK) being Low (as shown in [Figure 3](#)).

The Hold condition ends on the rising edge of the Hold (HOLD#) signal, provided that this coincides with Serial Clock (SCK) being Low.

If the falling edge does not coincide with Serial Clock (SCK) being Low, the Hold condition starts after Serial Clock (SCK) next goes Low. Similarly, if the rising edge does not coincide with Serial Clock (SCK) being Low, the Hold condition ends after Serial Clock (SCK) next goes Low ([Figure 3](#)). During the Hold condition, the Serial Data Output (SO) is high impedance, and Serial Data Input (SI) and Serial Clock (SCK) are Don't Care.

Normally, the device remains selected, with Chip Select (CS#) driven Low, for the entire duration of the Hold condition. This ensures that the state of the internal logic remains unchanged from the moment of entering the Hold condition.

Note: Driving Chip Select (CS#) high while HOLD# is still low is not a valid operation.

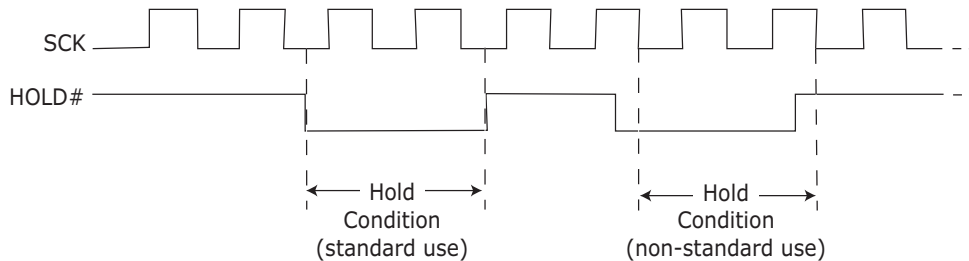


Figure 3. Hold Condition Activation

Memory Organization

The memory is organized as:

- S25FL002D: Four sectors of 512 Kbit each
- S25FL001D: Four sectors of 256 Kbit each
- Each page can be individually programmed (bits are programmed from 1 to 0).
- The device is Sector, or Bulk erasable (bits are erased from 0 to 1).

Table 3. Sector Address Table – S25FL002D

Sector	Address Range	
SA3	30000h	3FFFFh
SA2	20000h	2FFFFh
SA1	10000h	1FFFFh
SA0	00000h	0FFFFh

Table 4. Sector Address Table – S25FL001D

Sector	Address Range	
SA3	18000h	1FFFFh
SA2	10000h	17FFFh
SA1	08000h	0FFFFh
SA0	00000h	07FFFh

Instructions

All instructions, addresses, and data are shifted in and out of the device, starting with the most significant bit. Serial Data Input (SI) is sampled on the first rising edge of Serial Clock (SCK) after Chip Select (CS#) is driven Low. Then, the one-byte instruction code must be shifted in to the device, most significant bit first, on Serial Data Input (SI), each bit being latched on the rising edges of Serial Clock (SCK). The instruction set is listed in Table 5.

Every instruction sequence starts with a one-byte instruction code. Depending on the instruction, this might be followed by address bytes, or by data bytes, or by both or none. Chip Select (CS#) must be driven High after the last bit of the instruction sequence has been shifted in.

In the case of a Read Data Bytes (READ), Read Status Register (RDSR), Fast Read (FAST_READ) and Read ID (READ_ID), the shifted-in instruction sequence is followed by a data-out sequence. Chip Select (CS#) can be driven High after any bit of the data-out sequence is being shifted out to terminate the transaction.

In the case of a Page Program (PP), Sector Erase (SE), Bulk Erase (BE), Write Status Register (WRSR), Write Enable (WREN), or Write Disable (WRDI) instruction, Chip Select (CS#) must be driven High exactly at a byte boundary, otherwise the instruction is rejected, and is not executed. That is, Chip Select (CS#) must be driven High when the number of clock pulses after Chip Select (CS#) being driven Low is an exact multiple of eight.

All attempts to access the memory array during a Write Status Register cycle, Program cycle or Erase cycle are ignored, and the internal Write Status Register cycle, Program cycle or Erase cycle continues unaffected

Table 5. Instruction Set.

Instruction	Description	One-Byte Instruction Code	Address Bytes	Dummy Byte	Data Bytes
Status Register Operations					
WREN	Write Enable	06H (0000 0110)	0	0	0
WRDI	Write Disable	04H (0000 0100)	0	0	0
WRSR	Write to Status Register	01H (0000 0001)	0	0	1
RDSR	Read from Status Register	05H (0000 0101)	0	0	1 to Infinity
Read Operations					
READ	Read Data Bytes	03H (0000 0011)	3	0	1 to Infinity
FAST_READ	Read Data Bytes at Higher Speed	0BH (0000 1011)	3	1	1 to Infinity
READ_ID	Read ID	ABH (1010 1011)	0	3	1 to Infinity
Erase Operations					
SE	Sector Erase	D8H (1101 1000)	3	0	0
BE	Bulk (Chip) Erase	C7H (1100 0111)	0	0	0
Program Operations					
PP	Page Program	02H (0000 0010)	3	0	1 to 256
Dummy Power Savings Mode Operations					
SP	Software Protect	B9H (1011 1001)	0	0	0
RES	Release from Software Protect	ABH (1010 1011)	0	0	0
	Release from Software Protect and Read Electronic Signature	ABH (1010 1011)	0	3	1 to Infinity

Write Enable (WREN)

The Write Enable (WREN) instruction (Figure 4) sets the Write Enable Latch (WEL) bit. The Write Enable Latch (WEL) bit must be set prior to every Page Program (PP), Erase (SE or BE) and Write Status Register (WRSR) instruction. The Write Enable (WREN) instruction is entered by driving Chip Select (CS#) Low, sending the instruction code, and then driving Chip Select (CS#) High.

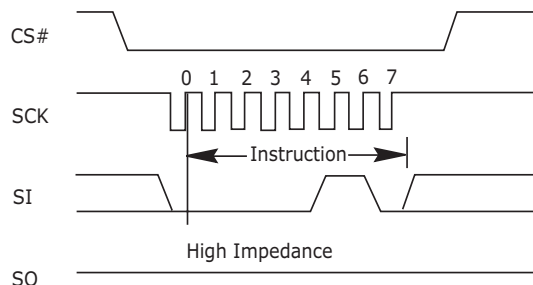


Figure 4. Write Enable (WREN) Instruction Sequence

Write Disable (WRDI)

The Write Disable (WRDI) instruction (Figure 5) resets the Write Enable Latch (WEL) bit. The Write Disable (WRDI) instruction is entered by driving Chip Select (CS#) Low, sending the instruction code, and then driving Chip Select (CS#) High.

The Write Enable Latch (WEL) bit is reset under the following conditions:

- Power-up
- Write Disable (WRDI) instruction completion
- Write Status Register (WRSR) instruction completion
- Page Program (PP) instruction completion
- Sector Erase (SE) instruction completion
- Bulk Erase (BE) instruction completion

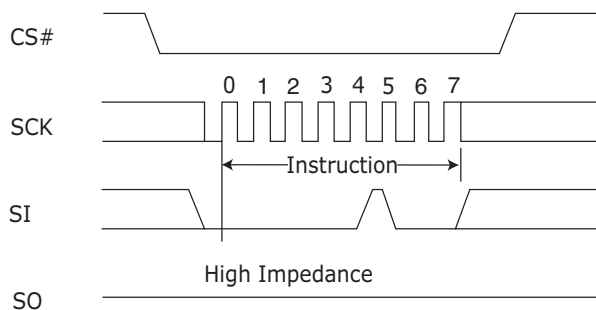


Figure 5. Write Disable (WRDI) Instruction Sequence

Read Status Register (RDSR)

The Read Status Register (RDSR) instruction allows the Status Register to be read. The Status Register may be read at any time, even while a Program, Erase, or Write Status Register cycle is in progress. When one of these cycles is in progress, it is recommended to check the Write In Progress (WIP) bit before

sending a new instruction to the device. It is also possible to read the Status Register continuously, as shown in Figure 6.

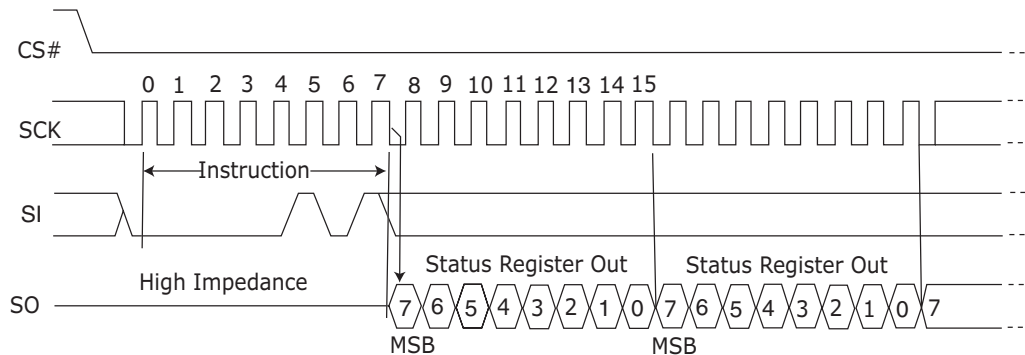


Figure 6. Read Status Register (RDSR) Instruction Sequence

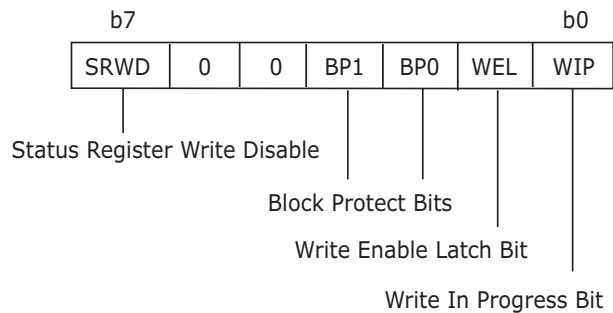


Figure 7. Status Register Format

The status and control bits of the Status Register are as follows:

SRWD bit: The Status Register Write Disable (SRWD) bit is operated in conjunction with the Write Protect (W#) signal. The Status Register Write Disable (SRWD) bit and Write Protect (W#) signal allow the device to be put in the Hardware Protected mode (when the Status Register Write Disable (SRWD) bit is set to 1, and Write Protect (W#) is driven Low). In this mode, the non-volatile bits of the Status Register (SRWD, BP1, BP0) become read-only bits and the Write Status Register (WRSR) instruction is no longer accepted for execution.

BP1, BP0 bits: The Block Protect (BP1, BP0) bits are non-volatile. They define the size of the area to be software protected against Program and Erase instructions. These bits are written with the Write Status Register (WRSR) instruction. When one or both of the Block Protect (BP1, BP0) bits is set to 1, the relevant memory area (as defined in Table 1 and Table 2) becomes protected against Page Program (PP), and Sector Erase (SE) instructions. The Block Protect (BP1, BP0) bits can be written provided that the Hardware Protected mode has not been set. The Bulk Erase (BE) instruction is executed if, and only if, both Block Protect (BP1, BP0) bits are 0.

WEL bit: The Write Enable Latch (WEL) bit indicates the status of the internal Write Enable Latch. When set to 1, the internal Write Enable Latch is set; when set to 0, the internal Write Enable Latch is reset and no Write Status Register, Program or Erase instruction is accepted.

WIP bit: The Write In Progress (WIP) bit indicates whether the memory is busy with a Write Status Register, Program or Erase cycle. This bit is a read only bit and is read by executing a RDSR instruction. If this bit is 1, such a cycle is in progress, if it is 0, no such cycle is in progress.

Write Status Register (WRSR)

The Write Status Register (WRSR) instruction allows new values to be written to the Status Register. Before it can be accepted, a Write Enable (WREN) instruction must previously have been executed. After the Write Enable (WREN) instruction has been decoded and executed, the device sets the Write Enable Latch (WEL).

The Write Status Register (WRSR) instruction is entered by driving Chip Select (CS#) Low, followed by the instruction code and the data byte on Serial Data Input (SI).

The instruction sequence is shown in [Figure 8](#).

The Write Status Register (WRSR) instruction has no effect on bits b6, b5, b4, b1 and b0 of the Status Register. Bits b6, b5 and b4 are always read as 0.

Chip Select (CS#) must be driven High after the eighth bit of the data byte has been latched in. If not, the Write Status Register (WRSR) instruction is not executed. As soon as Chip Select (CS#) is driven High, the self-timed Write Status Register cycle (whose duration is t_W) is initiated. While the Write Status Register cycle is in progress, the Status Register may still be read to check the value of the Write In Progress (WIP) bit. The Write In Progress (WIP) bit is 1 during the self-timed Write Status Register cycle, and is 0 when it is completed. At some unspecified time before the cycle is completed, the Write Enable Latch (WEL) is reset.

The Write Status Register (WRSR) instruction allows the user to change the values of the Block Protect (BP1, BP0) bits, to define the size of the area that is to be treated as read-only, as defined in [Table 1](#) and [Table 2](#). The Write Status Register (WRSR) instruction also allows the user to set or reset the Status Register Write Disable (SRWD) bit in accordance with the Write Protect (W#) signal. The Status Register Write Disable (SRWD) bit and Write Protect (W#) signal allow the device to be put in the Hardware Protected Mode (HPM). The Write Status Register (WRSR) instruction cannot be executed once the Hardware Protected Mode (HPM) is entered.

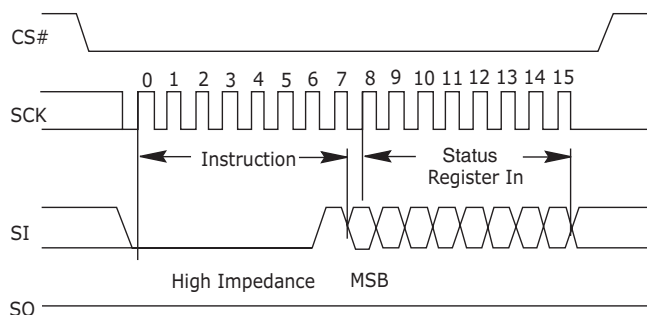


Figure 8. Write Status Register (WRSR) Instruction Sequence

Table 6. Protection Modes

W# Signal	SRWD Bit	Mode	Write Protection of the Status Register	Protected Area (Note 1)	Unprotected Area (Note 1)
1	1	Software Protected (SPM)	Status Register is Writeable (if the WREN instruction has set the WEL bit)	Protected against Page Program and Erase (SE, BE)	Ready to accept Page Program and Sector Erase Instructions
1	0		The values in the SRWD, BP1 and BP0 bits can be changed		
0	0				
0	1	Hardware Protected (HPM)	Status Register is Hardware write protected The values in the SRWD, BP1 and BP0 bits cannot be changed	Protected against Page Program and Erase (SE, BE)	Ready to accept Page Program and Sector Erase Instructions

5. As defined by the values in the Block Protect (BP1, BP0) bits of the Status Register, as shown in Table 1 and Table 2.

The protection features of the device are summarized in Table 6.

When the Status Register Write Disable (SRWD) bit of the Status Register is 0 (its initial delivery state), it is possible to write to the Status Register provided that the Write Enable Latch (WEL) bit has previously been set by a Write Enable (WREN) instruction, regardless of the whether Write Protect (W#) is driven High or Low.

When the Status Register Write Disable (SRWD) bit of the Status Register is set to 1, two cases need to be considered, depending on the state of Write Protect (W#):

- If Write Protect (W#) is driven High, it is possible to write to the Status Register provided that the Write Enable Latch (WEL) bit has previously been set by a Write Enable (WREN) instruction.
- If Write Protect (W#) is driven Low, it is not possible to write to the Status Register even if the Write Enable Latch (WEL) bit has previously been set by a Write Enable (WREN) instruction. (Attempts to write to the Status Register are rejected, and are not accepted for execution). As a consequence, all the data bytes in the memory area that are software protected (SPM) by the Block Protect (BP1, BP0) bits of the Status Register, are also hardware protected against data modification.

Regardless of the order of the two events, the Hardware Protected Mode (HPM) can be entered:

- by setting the Status Register Write Disable (SRWD) bit after driving Write Protect (W#) Low
- or by driving Write Protect (W#) Low after setting the Status Register Write Disable (SRWD) bit.

The only way to exit the Hardware Protected Mode (HPM) once entered is to pull Write Protect (W#) High.

If Write Protect (W#) is permanently tied High, the Hardware Protected Mode (HPM) can never be activated, and only the Software Protected Mode (SPM), using the Block Protect (BP1, BP0) bits of the Status Register, can be used.

Read Data Bytes (READ)

The device is first selected by driving Chip Select (CS#) Low. The instruction code for the Read Data Bytes (READ) instruction is followed by a 3-byte address (address bits A23 to A18 are Don't Care), each bit being latched-in during the rising edge of Serial Clock (SCK). Then the memory contents, at that address, are

shifted out on Serial Data Output (SO), each bit being shifted out, at a frequency f_{SCK} , during the falling edge of Serial Clock (SCK).

The instruction sequence is shown in Figure 9. The first byte addressed can be at any location. The address is automatically incremented to the next higher address after each byte of data is shifted out. The whole memory can, therefore, be read with a single Read Data Bytes (READ) instruction. When the highest address is reached, the address counter rolls over to 00000h, allowing the read sequence to be continued indefinitely.

The Read Data Bytes (READ) instruction is terminated by driving Chip Select (CS#) High. Chip Select (CS#) can be driven High at any time during data output. Any Read Data Bytes (READ) instruction, while a Program, Erase, or Write cycle is in progress, is rejected without having any effect on the cycle that is in progress.

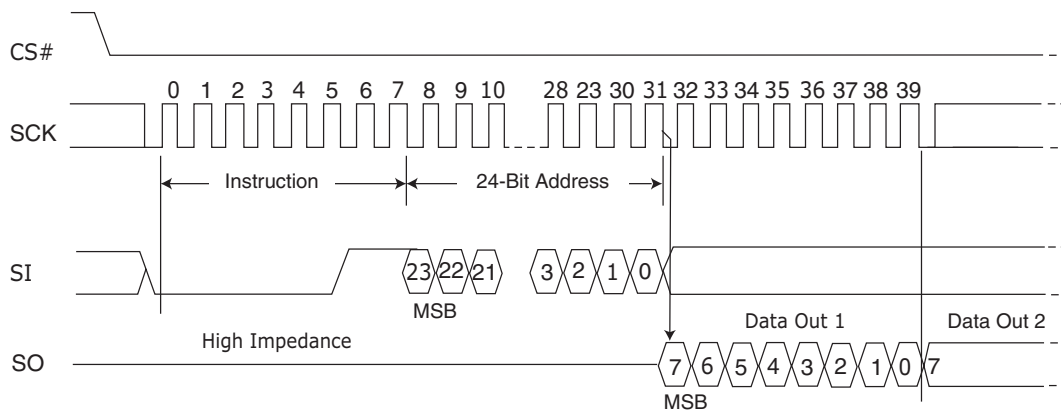


Figure 9. Read Data Bytes (READ) Instruction Sequence

Read Data Bytes at Higher Speed (FAST_READ)

The Fast Read (FAST_READ) instruction implemented in this device is compatible with industry standard Fast Read (FAST_READ) operations. The device is first selected by driving Chip Select (CS#) Low. The instruction code for (FAST_READ) instruction is followed by a 3-byte address (A23-A0 for 2Mbit devices) and a dummy byte, each bit being latched-in during the rising edge of Serial Clock (SCK). Then the memory contents, at that address, are shifted out on Serial Data Output (SO), each bit being shifted out, at a maximum frequency F_{SCK} , during the falling edge of Serial Clock (SCK).

The instruction sequence is shown in Figure 10. The first byte addressed can be at any location. The address is automatically incremented to the next higher address after each byte of data is shifted out. The whole memory can, therefore, be read with a single (FAST_READ) instruction. When the highest address is reached, the address counter rolls over to 00000h, allowing the read sequence to be continued indefinitely.

The (FAST_READ) instruction is terminated by driving Chip Select (CS#) High. Chip Select (CS#) can be driven High at any time during data output. Any

(FAST_READ) instruction, while an Erase, Program or Write cycle is in progress, is rejected without having any effects on the cycle that is in progress.

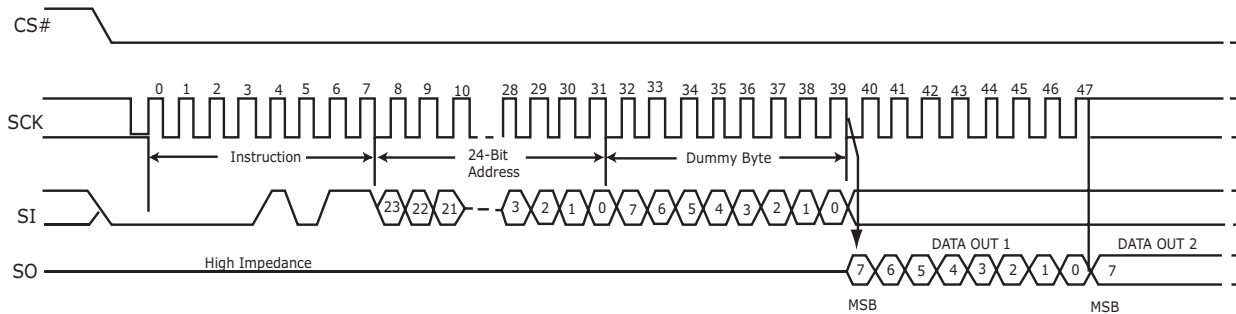


Figure 10. Fast Read (FAST_READ) Instruction Sequence

Page Program (PP)

The Page Program (PP) instruction allows bytes to be programmed in the memory (changing bits from 1 to 0). Before it can be accepted, a Write Enable (WREN) instruction must previously have been executed. After the Write Enable (WREN) instruction has been decoded, the device sets the Write Enable Latch (WEL).

The Page Program (PP) instruction is entered by driving Chip Select (CS#) Low, followed by the instruction code, three address bytes and at least one data byte on Serial Data Input (SI). Chip Select (CS#) must be driven Low for the entire duration of the sequence.

The instruction sequence is shown in [Figure 11](#).

If more than 256 bytes are sent to the device, the addressing will wrap to the beginning of the same page, previously latched data are discarded and the last 256 data bytes are guaranteed to be programmed correctly within the same page. If fewer than 256 Data bytes are sent to device, they are correctly programmed at the requested addresses without having any effects on the other bytes of the same page.

Chip Select (CS#) must be driven High after the eighth bit of the last data byte has been latched in, otherwise the Page Program (PP) instruction is not executed. As soon as Chip Select (CS#) is driven High, the self-timed Page Program cycle (whose duration is t_{pp}) is initiated. While the Page Program cycle is in progress, the Status Register may be read to check the value of the Write In Progress (WIP) bit. The Write In Progress (WIP) bit is 1 during the self-timed Page Program cycle, and is 0 when it is completed. At some unspecified time before the cycle is completed, the Write Enable Latch (WEL) bit is reset.

A Page Program (PP) instruction applied to a page that is protected by the Block Protect (BP1, BP0) bits (see [Table 1](#) and [Table 2](#)) is not executed.

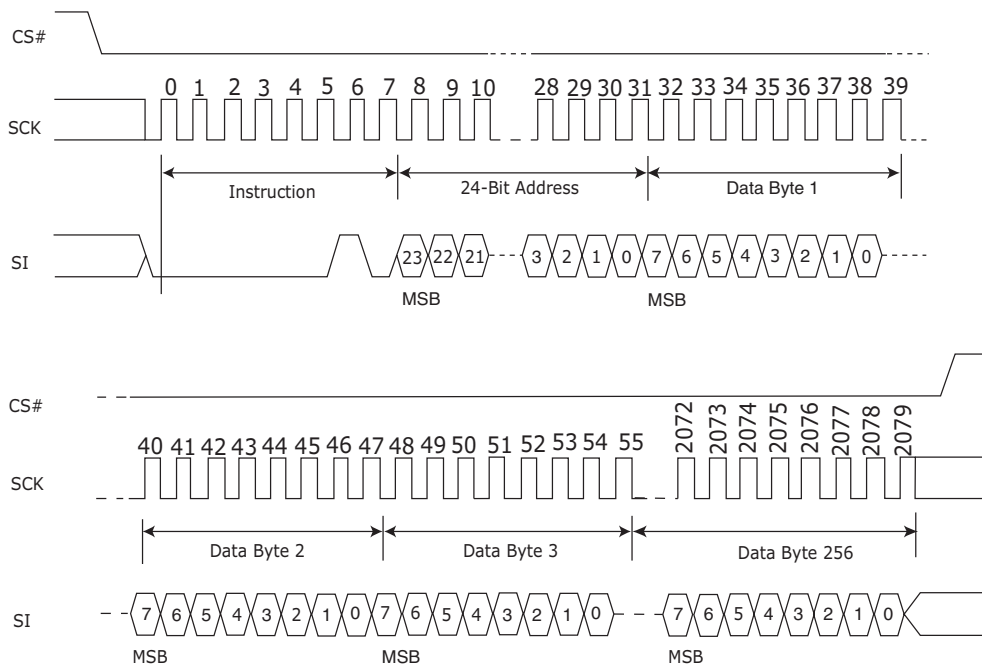


Figure II. Page Program (PP) Instruction Sequence

Sector Erase (SE)

The Sector Erase (SE) instruction sets to 1 (FFh) all bits inside the chosen sector. Before it can be accepted, a Write Enable (WREN) instruction must previously have been executed. After the Write Enable (WREN) instruction has been decoded, the device sets the Write Enable Latch (WEL).

The Sector Erase (SE) instruction is entered by driving Chip Select (CS#) Low, followed by the instruction code, and three address bytes on Serial Data Input (SI). Any address inside the Sector (see Table 1 and Table 2) is a valid address for the Sector Erase (SE) instruction. Chip Select (CS#) must be driven Low for the entire duration of the sequence.

The instruction sequence is shown in Figure 12.

Chip Select (CS#) must be driven High after the eighth bit of the last address byte has been latched in, otherwise the Sector Erase (SE) instruction is not executed. As soon as Chip Select (CS#) is driven High, the self-timed Sector Erase cycle (whose duration is t_{SE}) is initiated. While the Sector Erase cycle is in progress, the Status Register may be read to check the value of the Write In Progress (WIP) bit. The Write In Progress (WIP) bit is 1 during the self-timed Sector Erase cycle, and is 0 when it is completed. At some unspecified time before the cycle is completed, the Write Enable Latch (WEL) bit is reset.

A Sector Erase (SE) instruction applied to any memory area that is protected by the Block Protect (BP1, BP0) bits (see Table 1 and Table 2) is not executed.

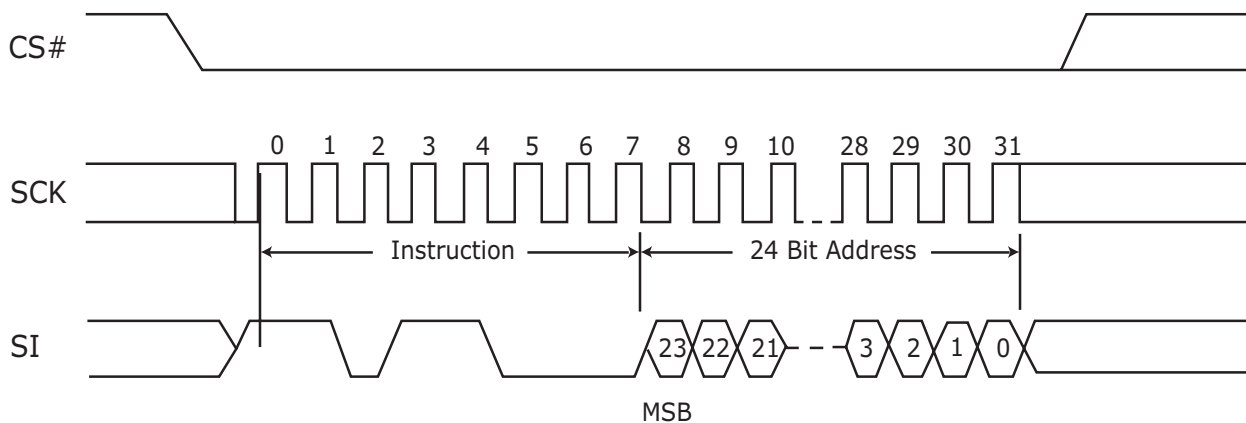


Figure 12. Sector Erase (SE) Instruction Sequence

Bulk Erase (BE)

The Bulk Erase (BE) instruction sets to 1 (FFh) all bits inside the entire memory. Before it can be accepted, a Write Enable (WREN) instruction must previously have been executed. After the Write Enable (WREN) instruction has been decoded, the device sets the Write Enable Latch (WEL).

The Bulk Erase (BE) instruction is entered by driving Chip Select (CS#) Low, followed by the instruction code, on Serial Data Input (SI). No address is required for the Bulk Erase (BE) instruction. Chip Select (CS#) must be driven Low for the entire duration of the sequence.

The instruction sequence is shown in [Figure 13](#).

Chip Select (CS#) must be driven High after the eighth bit of the last address byte has been latched in, otherwise the Bulk Erase (BE) instruction is not executed.

As soon as Chip Select (CS#) is driven High, the self-timed Bulk Erase cycle (whose duration is t_{BE}) is initiated. While the Bulk Erase cycle is in progress, the Status Register may be read to check the value of the Write In Progress (WIP) bit. The Write In Progress (WIP) bit is 1 during the self-timed Bulk Erase cycle, and is 0 when it is completed. At some unspecified time before the cycle is completed, the Write Enable Latch (WEL) bit is reset.

A Bulk Erase (BE) instruction is executed only if both the Block Protect (BP1, BP0) bits (see [Table 1](#) and [Table 2](#)) are set to 0. The Bulk Erase (BE) instruction is ignored if one or more sectors are protected.

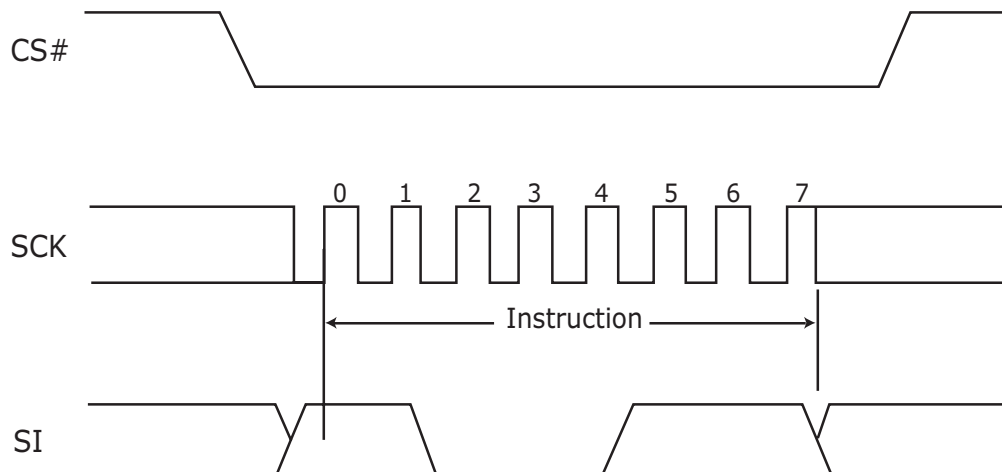


Figure I3. Bulk Erase (BE) Instruction Sequence

Software Protect (SP)

The Software Protect (SP) instruction implemented in this device is compatible with industry-standard Software Protect (SP) operation. For this device, this instruction has no real function since the Standby Current (I_{SB}) on this device is the same as the Deep Power-down Current in our competitor's devices.

It is recommended that the standard Standby mode be used for the lowest power current draw, as well as the Software Protect (SP) as an extra software protection mechanism when this device is not in active use. In this mode, the device ignores all Write, Program and Erase instructions. Chip Select (CS#) must be driven Low for the entire duration of the sequence.

The Software Protect (SP) instruction is entered by driving Chip Select (CS#) Low, followed by the instruction code on Serial Data Input (SI). Chip Select (CS#) must be driven Low for the entire duration of the sequence.

The instruction sequence is shown in [Figure 14](#).

Driving Chip Select (CS#) High after the eighth bit of the instruction code has been latched in deselects the device, and puts the device in the Standby mode (if there is no internal cycle currently in progress). As soon as Chip Select (CS#) is driven high, it requires a delay of t_{SP} currently in progress before Software Protect mode is entered.

Once the device has entered the Software Protect mode, all instructions are ignored except the Release from Software Protect (RES) or Read ID (READ_ID) instruction. The Release from Software Protect and Read Electronic Signature (RES) instruction also allows the Electronic Signature of the device to be output on Serial Data Output (SO).

The Software Protect mode automatically stops at Power-down, and the device always Powers-up in the Standby mode.

Any Software Protect (SP) instruction, while an Erase, Program or WRSR cycle is in progress, is rejected without having any effect on the cycle in progress.

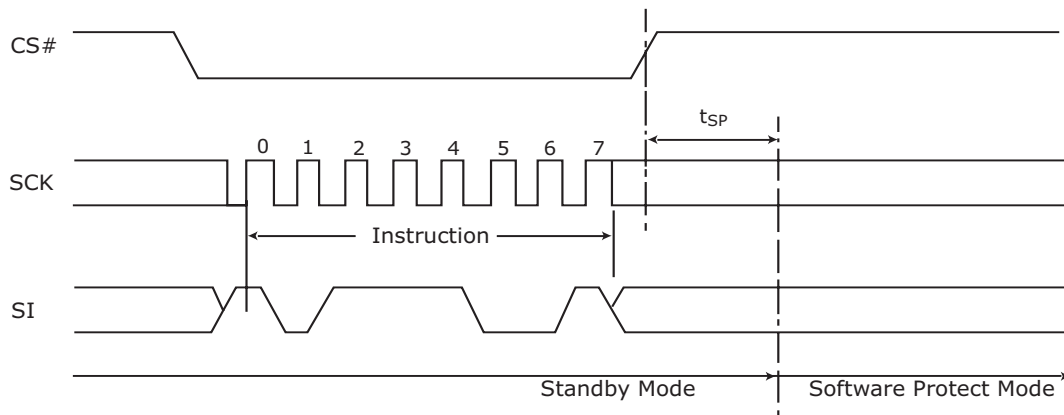


Figure 14. Software Protection (SP) Instruction Sequence

Release from Software Protect (RES)

The Release from Software Protect (RES) instruction provides the only way to exit the Software Protect mode. Once the device has entered the Software Protect mode, all instructions are ignored except the Release from Software Protect (RES) instruction.

The Release from Software Protect (RES) instruction is entered by driving Chip Select (CS#) Low, followed by the instruction code on Serial Data Input (SI). Chip Select (CS#) must be driven Low for the entire duration of the sequence.

The instruction sequence is shown in [Figure 15](#).

Driving Chip Select (CS#) High after the 8-bit instruction byte has been received by the device, but before the whole of the 8-bit Electronic Signature has been transmitted for the first time, still insures that the device is put into Standby mode. If the device was previously in the Software Protect mode, though, the transition to the Stand-by Power mode is delayed by t_{RES} , and Chip Select (CS#) must remain High for at least $t_{RES(max)}$, as specified in Table 7. Once in the Stand-by Power mode, the device waits to be selected, so that it can receive, decode and execute instructions.

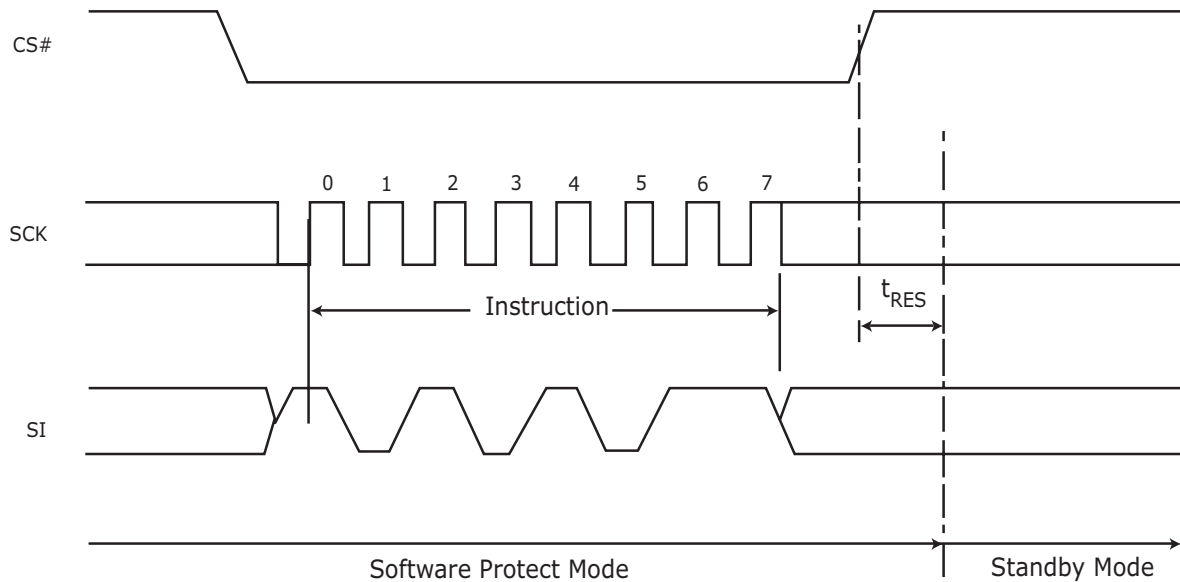


Figure I5. Release from Software Protect (RES) Instruction Sequence

Release from Software Protection and Read Electronic Signature (RES), and Read ID (READ_ID)

Once the device has entered SP mode, all instructions are ignored except the RES instruction. The RES instruction can also be used to read the 8-bit Electronic Signature of the device on the SO pin. The RES instruction always provides access to the Electronic Signature of the device (except while an Erase, Program or WRSR cycle is in progress), and can be applied even if SP mode has not been entered. Any RES instruction executed while an Erase, Program or WRSR cycle is in progress is not decoded, and has no effect on the cycle in progress.

The Read ID (READ_ID) instruction can be used to read, on Serial Data Output (SO), the 8-bit Electronic Signature of the device.

Except while an Erase, Program or Write Status Register cycle is in progress, the Read ID (READ_ID) instruction always provides access to the Electronic Signature of the device, and can be applied even if the Software Protect mode has not been entered.

Any Read ID (READ_ID) instruction while an Erase, Program or Write Status Register cycle is in progress, is not decoded, and has no effect on the cycle that is in progress.

The device features an 8-bit Electronic Signature, whose value for the S25FL002D is 11h, S25FL002D is 10h. This can be read using Read ID (READ_ID) instruction.

The device is first selected by driving Chip Select (CS#) Low. The instruction code is followed by 3 dummy bytes, each bit being latched-in on Serial Data Input (SI) during the rising edge of Serial Clock (SCK). Then, the 8-bit Electronic Signature, stored in the memory, is shifted out on Serial Data Output (SO), each bit being shifted out during the falling edge of Serial Clock (SCK).

The instruction sequence is shown in [Figure 16](#).

The Read ID (READ_ID) instruction is terminated by driving Chip Select (CS#) High after the Electronic Signature has been read at least once. Sending addi-

tional clock cycles on Serial Clock (SCK), while Chip Select (CS#) is driven Low, causes the Electronic Signature to be output repeatedly.

When Chip Select (CS#) is driven High, the device is put in the Stand-by Power mode. If the device was not previously in the Software Protect mode, which occurs when the Read ID (READ_ID) instruction is initiated, the transition to the Stand-by Power mode is immediate. If the device was previously in the Software Protect mode, though, the transition to the Standby mode is delayed by t_{RES} , and Chip Select (CS#) must remain High for at least $t_{RES(max)}$, as specified in Table 9. Once in the Stand-by Power mode, the device waits to be selected, so that it can receive, decode and execute instructions.

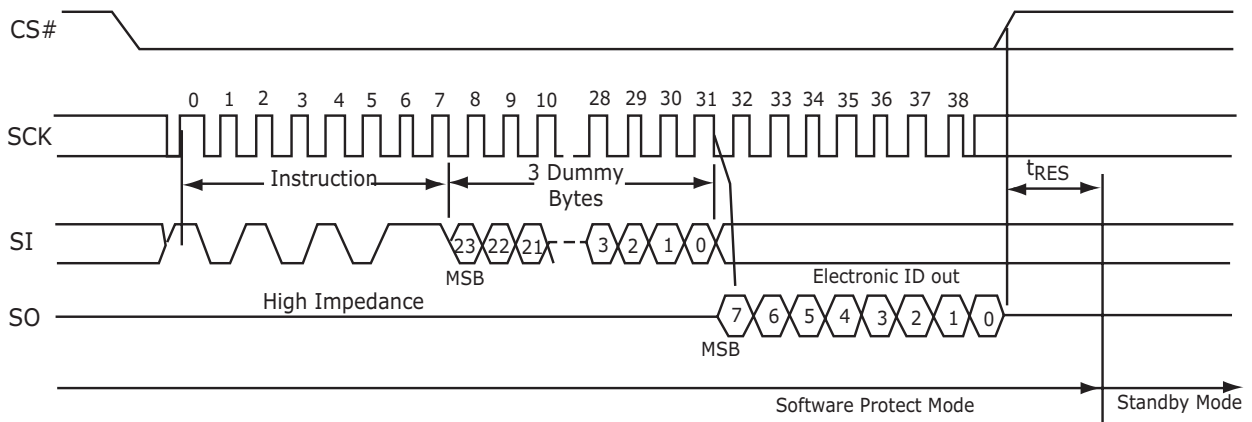


Figure 16. Release from Software Protection and Read Electronic Signature (RES), and Read ID (READ_ID) Instruction Sequence

Power-up and Power-down

The device must not be selected at power-up or power-down (that is, CS# must follow the voltage applied on V_{CC}) until V_{CC} reaches the minimum correct value, as follows:

- V_{CC} (min) at power-up, and then for a further delay of t_{PU} (as described in Table 7)
- V_{SS} at power-down

A simple pull-up resistor on Chip Select (CS#) can usually be used to insure safe and proper power-up and power-down. To avoid data corruption and inadvertent write operations during power up, a Power On Reset (POR) circuit is included. The logic inside the device is held reset while V_{CC} is less than the POR threshold value (V_{POR}). All operations are disabled, and the device does not respond to any instructions.

The device ignores all instructions until a time delay of t_{PU} (as described in Table 7) has elapsed after the moment that V_{CC} rises above the minimum V_{CC} threshold. However, correct operation of the device is not guaranteed if by this time V_{CC} is still below V_{CC} (min). No Read, Write Status Register, Program or Erase instructions should be sent until t_{PU} after V_{CC} reaches the minimum V_{CC} threshold.

At power-up, the device is in Standby mode (not Software Protect mode) and the WEL bit is reset.

Normal precautions must be taken for supply rail decoupling to stabilize the V_{CC} feed. Each device in a system should have the V_{CC} rail decoupled by a suitable capacitor close to the package pins (this capacitor is generally of the order of 0.1 μ F).

At power-down, when V_{CC} drops from the operating voltage to below the minimum V_{CC} threshold, all operations are disabled and the device does not respond to any instructions. (The designer needs to be aware that if a power-down occurs while a Write, Program or Erase cycle is in progress, data corruption can result.)

*Note: Program, Erase, and Write Commands are not allowed and are not recommended during this period, as the state of the device operation is unknown during t_{PU} .

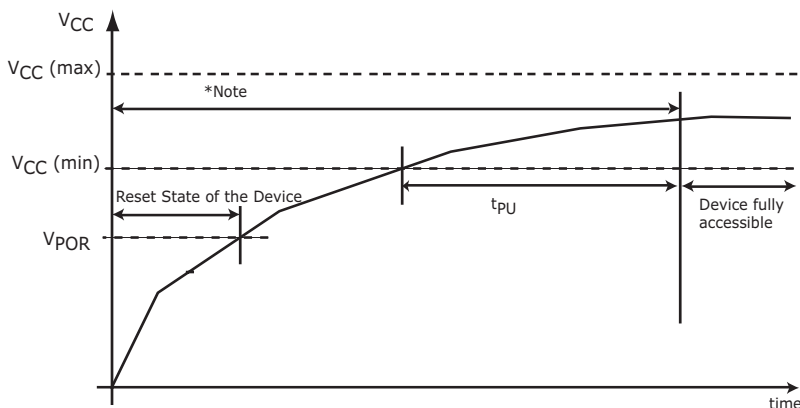


Figure 17. Power-Up Timing

Table 7. Power-Up Timing

Symbol	Parameter	Min	Max	Unit
t_{PU}	V_{CC} (min) to CS# Low	2		ms
V_{POR}	POR Threshold Value	2.2	2.4	V

Initial Delivery State

The device is delivered with all bits set to 1 (each byte contains FFh). The Status Register contains 00h (all Status Register bits are 0).

Maximum Rating

Stressing the device above the rating listed in the **Absolute Maximum Ratings** section below may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the Operating sections of this specification is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

Absolute Maximum Ratings

Ambient Storage Temperature -65°C to $+150^{\circ}\text{C}$
Voltage with Respect to Ground:
All Inputs and I/Os. -0.3 V to 4.5 V

Operating Ranges

Ambient Operating Temperature (T_A)

Commercial 0°C to $+70^{\circ}\text{C}$
Industrial -40°C to $+85^{\circ}\text{C}$

Positive Power Supply

Voltage Range 2.7 V to 3.6 V

Operating ranges define those limits between which functionality of the device is guaranteed.

DC Characteristics

This section summarizes the DC and AC Characteristics of the device. Designers should check that the operating conditions in their circuit match the measurement conditions specified in the Test Specifications in Table 8, when relying on the quoted parameters.

CMOS Compatible

Parameter	Description	Test Conditions (Note 1)		Min	Typ.	Max	Unit
V_{CC}	Supply Voltage			2.7	3	3.6	V
I_{CC1}	V_{CC} Active Read Current	$SCK = 0.1 V_{CC}/0.9V_{CC}$	25 MHz $V_{CC} = 3.0V$		9	12	mA
I_{CC2}	V_{CC} Active Page Program Current	$CS\# = V_{CC}$			10	16	mA
I_{CC3}	V_{CC} Active WRSR Current	$CS\# = V_{CC}$				20	mA
I_{CC4}	V_{CC} Active Sector Erase Current	$CS\# = V_{CC}$				20	mA
I_{CC5}	V_{CC} Active Bulk Erase Current	$CS\# = V_{CC}$				20	mA
I_{SB}	Standby Current	$CS\# = V_{CC} = 3.0 V$			1	3	μA
I_{LI}	Input Leakage Current	$V_{IN} = GND \text{ to } V_{CC}$				1	μA
I_{LO}	Output Leakage Current	$V_{IN} = GND \text{ to } V_{CC}$				1	μA
V_{IL}	Input Low Voltage			-0.3		$0.3 V_{CC}$	V
V_{IH}	Input High Voltage			$0.7 V_{CC}$		$V_{CC} + 0.5$	V
V_{OL}	Output Low Voltage	$I_{OL} = 1.6 \text{ mA}, V_{CC} = V_{CC \text{ min}}$				0.4	V
V_{OH}	Output High Voltage	$I_{OH} = -0.1 \text{ mA}$		$V_{CC} - 0.2$			V

Note:

1. Typical values are at $T_A = 25^\circ C$ and 3.0 V.

Test Conditions

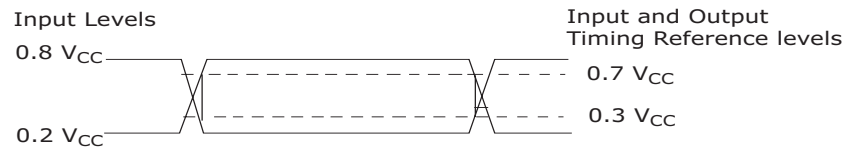


Figure 18. AC Measurements I/O Waveform

Table 8. Test Specifications

Symbol	Parameter	Min	Max	Unit
C_L	Load Capacitance	30		pF
	Input Rise and Fall Times		5	ns
	Input Pulse Voltage	0.2 V_{CC} to 0.8 V_{CC}		V
	Input and Output Timing Reference Voltages	0.3 V_{CC} to 0.7 V_{CC}		V

AC Characteristics

Table 9. AC Characteristics

Symbol	Parameter			Min	Typ	Max	Unit
F_{SCK} (Note 4)	SCK Clock Frequency					25	MHz
t_{CRT}	Clock Rise Time (Slew Rate)			0.1			V/ns
t_{CFT}	Clock Fall Time (Slew Rate)			0.1			V/ns
t_{WH}	SCK High Time			18			ns
t_{WL}	SCK Low Time			18			ns
t_{CS}	CS# High Time			100			ns
t_{CSS} (Note 3)	CS# Setup Time			10			ns
t_{CSH} (Note 3)	CS# HOLD Time			10			ns
t_{HD} (Note 3)	HOLD# Setup Time			10			ns
t_{CD} (Note 3)	HOLD# Hold Time			10			ns
t_{HC}	HOLD Setup Time (relative to SCK)			10			ns
t_{CH}	HOLD Hold Time (relative to SCK)			10			ns
t_V	Output Valid			0		15	ns
t_{HO}	Output Hold Time			0			ns
$t_{HD:DAT}$	Data in Hold Time			5			ns
$t_{SU:DAT}$	Data in Setup Time			5			ns
t_{LZ} (Note 3)	HOLD# to Output Low Z					15	ns
t_{HZ} (Note 3)	HOLD# to Output High Z					20	ns
t_{DIS} (Note 3)	Output Disable Time					15	ns
t_{WPS} (Note 3)	Write Protect Setup Time			20			ns
t_{WPH} (Note 3)	Write Protect Hold Time			100			ns
t_{RES}	Release SP Mode					1.0	μ s
t_{SP}	CS# High to Software Protect Mode					3.0	μ s
t_W	Write Status Register Time				1.6	15 (Note 2)	ms
t_{PP} (Note 1)	Page Programming Time				6 (Note 1)	10 (Note 2)	ms
t_{SE}	Sector Erase Time	512 Kb Sector (S25FL002D)			0.5 (Note 1)	0.8 (Note 2)	sec
		256 Kb Sector (S25FL001D)			0.25 (Note 1)	0.4 (Note 2)	sec
t_{BE}	Bulk Erase Time		1 Mb device		1.0 (Note 1)	1.6 (Note 2)	sec
			2 Mb device		2.0 (Note 1)	3.2 (Note 2)	

Note:

1. Typical program and erase time assume the following conditions: 25°C, $V_{CC} = 3.0V$; 10,000 cycles; checkerboard data pattern.
2. Under worst-case conditions of 90°C; $V_{CC} = 2.7V$; 100,000 cycles.
3. Not 100% tested
4. Both for READ and FAST_READ

AC Characteristics

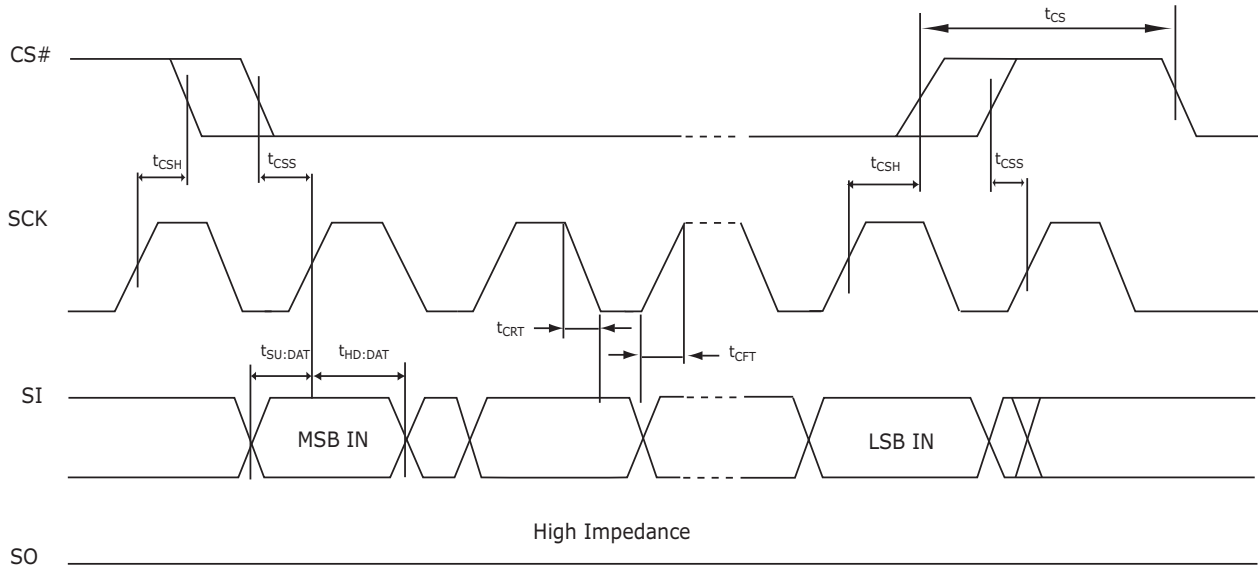


Figure 19. SPI Mode 0 (0,0) Input Timing

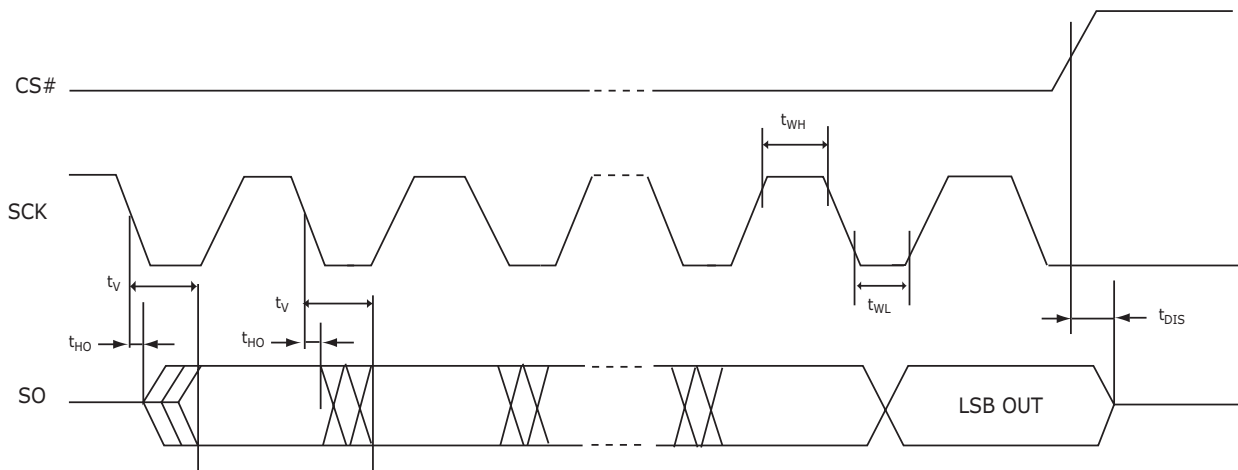


Figure 20. SPI Mode 0 (0,0) Output Timing

AC Characteristics

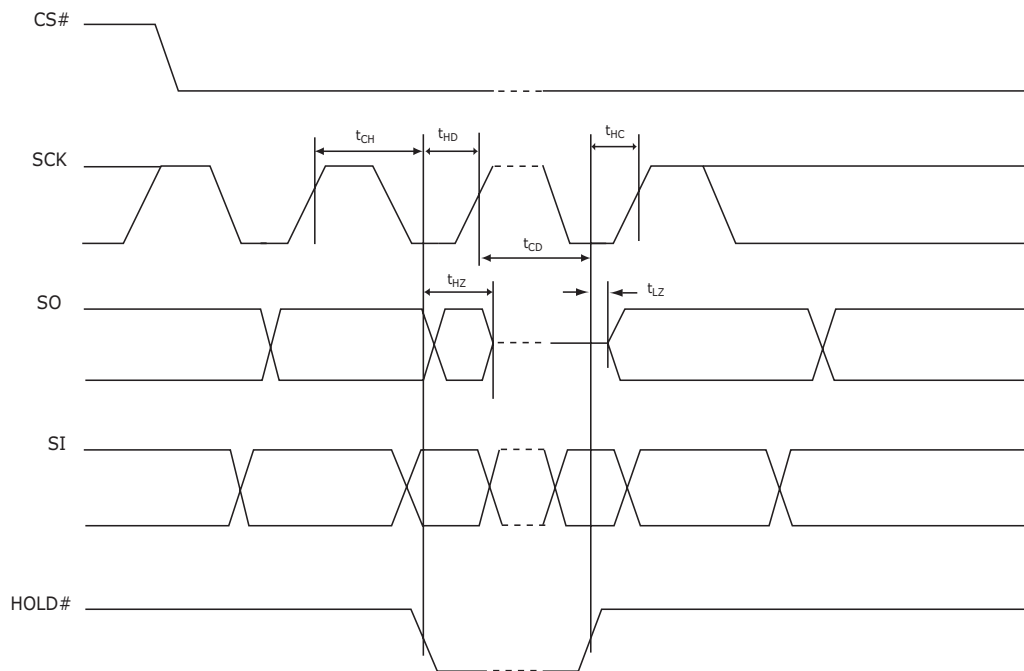


Figure 21. **HOLD#** Timing

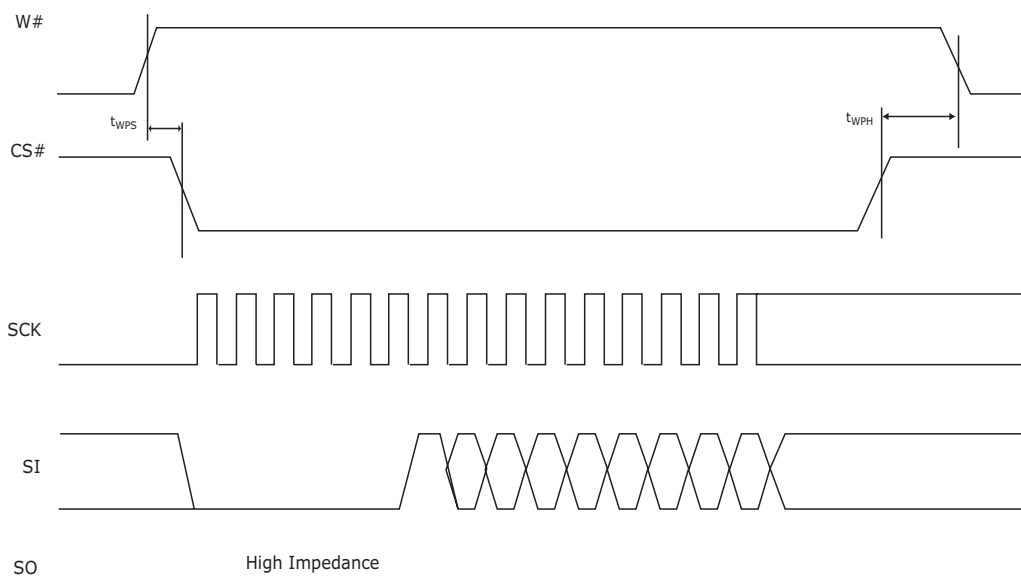
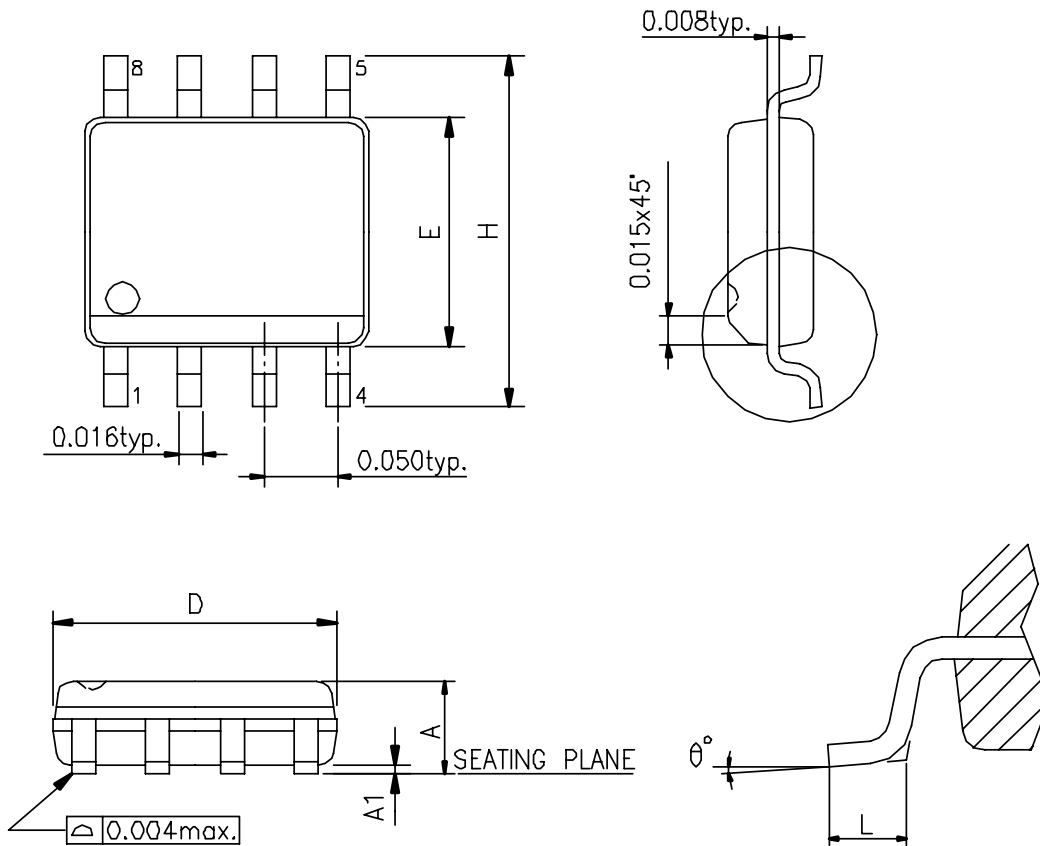


Figure 22. **Write Protect Setup and Hold Timing during WRSR when SRWD=1**

Physical Dimensions

S08 narrow—8-pin Plastic Small Outline 150mils Body Width Package



NOTES:

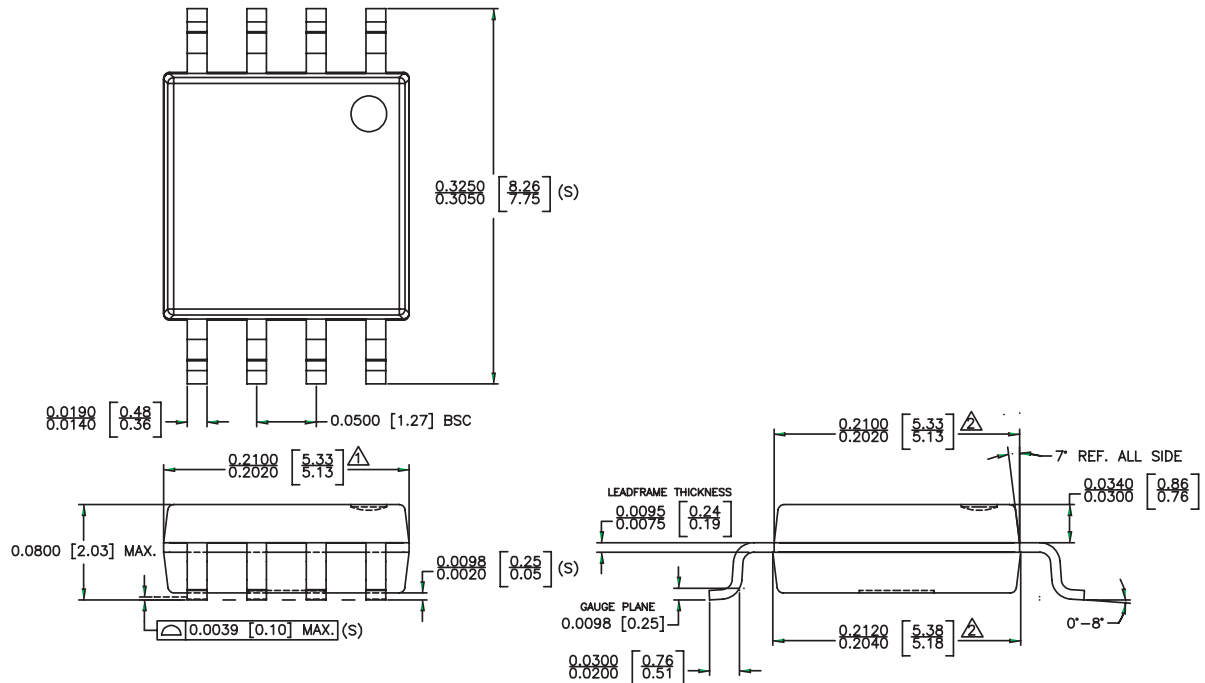
1. JEDEC OUTLINE : MS-012 AA
2. DIMENSIONS "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .15mm (.006in) PER SIDE.
3. DIMENSIONS "E" DOES NOT INCLUDE INTER-LEAD FLASH, OR PROTRUSIONS. INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .25mm (.010in) PER SIDE.

SYMBOLS	MIN.	MAX.
A	0.053	0.069
A1	0.004	0.010
D	0.189	0.196
E	0.150	0.157
H	0.228	0.244
L	0.016	0.050
θ°	0	8

UNIT : INCH

Physical Dimensions

S08 wide—8-pin Plastic Small Outline 208mils Body Width Package



NOTE :

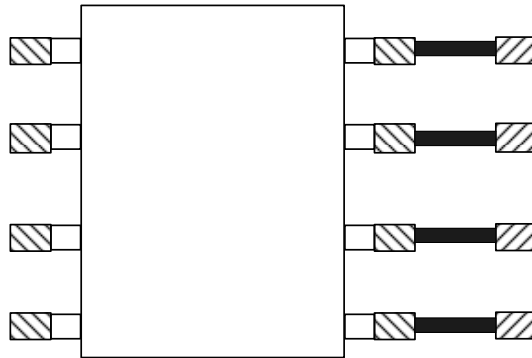
1. DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED 0.006 INCH PER SIDE.
2. DOES NOT INCLUDE INTER-LEAD FLASH OR PROTRUSIONS. INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED 0.010 INCH PER SIDE.
3. THIS PART IS COMPLIANT WITH EIAJ SPECIFICATION EDR-7320.
4. LEAD SPAN/STAND OFF HEIGHT/COPLANARITY ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S)
5. CONTROLLING DIMENSIONS IN INCHES. [mm]

S08 wide—8-pin Plastic Small Outline 208mils Body Width Package (Continued)**Design Note:**

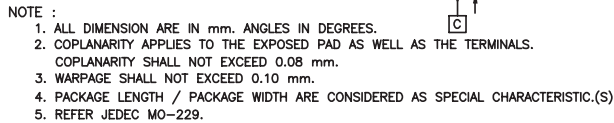
This note is for the S25FL002D device only.

It is recommended that during PCB Layout, pads be placed on the board to accommodate both SpanSion's SO-8 narrow and wide footprints. This will allow for a smooth upgrade path to our 4Mb and 8Mb SPI devices, without the need to re-layout the board.

In order to simplify layout, only one set of pads needs to be added to the board to accommodate the 208 mils SO-8 wide package. Because the pinouts of both the narrow and wide footprint parts are the same, no jumpers need to be placed on the board.



8-Contact WSON (6mm x 5mm) Leadless Package



Revision Summary

Revision A (November 7, 2003)

Initial release.

Revision A+I (June 9, 2004)

Minor corrections, updated 8-pin SOIC package diagram.

Updated notes for Table 9. AC Characteristics.

Removed 512Kb offering.

Removed Page Erase (PE) Functionality.

Added the wide 8-pin SO (208mils) package.

Added design note for 2Mb.

Added the 8-Contact WSON (6mm x 5mm) leadless package.

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