S25FL Family (Serial Peripheral Interface)
S25FL004D

4 Megabit CMOS 3.0 Volt Flash Memory with 50 Mhz SPI Bus Interface

ADVANCE INFORMATION

Distinctive Characteristics

ARCHITECTURAL ADVANTAGES

- **Single power supply operation**
  - — Full voltage range: 2.7 to 3.6 V read and program operations
- **Memory Architecture**
  - — Eight sectors with 512 Kb each
- **Program**
  - — Page Program (up to 256 bytes) in 1.5 ms (typical)
  - — Program cycles are on a page by page basis
- **Erase**
  - — 0.5 s typical sector erase time
  - — 4 s typical bulk erase time
- **Endurance**
  - — 100,000 cycles per sector typical
- **Data Retention**
  - — 20 years typical
- **Device ID**
  - — Electronic signature
- **Process Technology**
  - — Manufactured on 0.25 µm process technology
- **Package Option**
  - — Industry Standard Pinouts
  - — 8-pin SO (208mil) package
  - — 8-contact WSON leadless package (6x5mm)

PERFORMANCE CHARACTERISTICS

- **Speed**
  - — 50 MHz clock rate (maximum)
- **Power Saving Standby Mode**
  - — Standby Mode 1 µA (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 S25FL004D device is a 3.0 Volt (2.7 V to 3.6 V) single power supply Flash memory device. S25FL004D consists of eight sectors, each with 512 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.

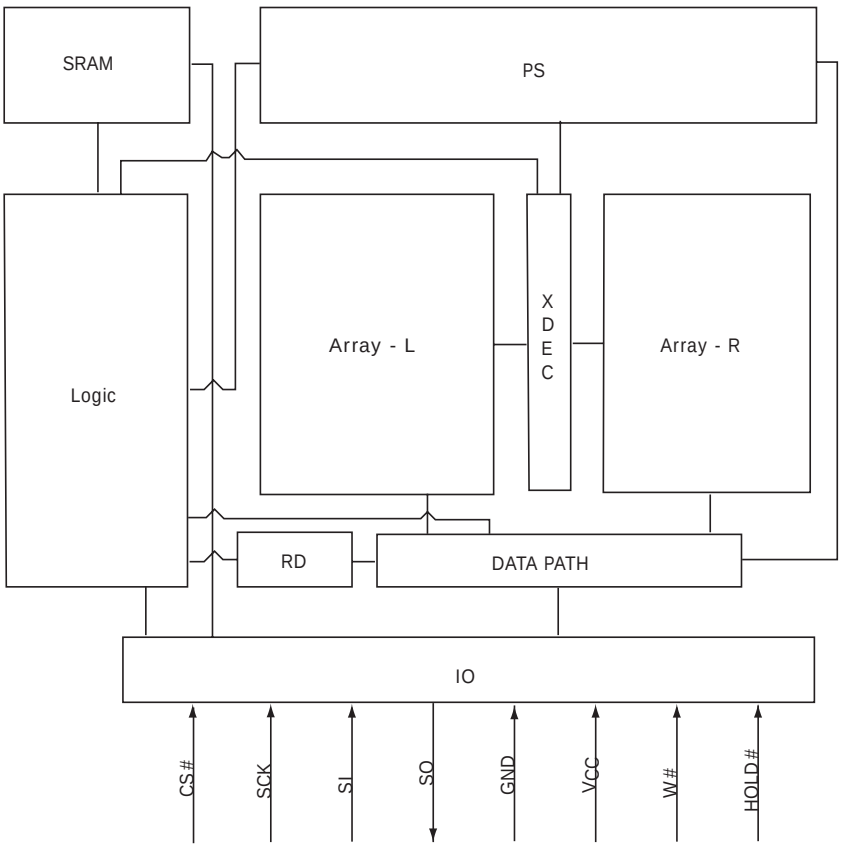
The memory can be programmed 1 to 256 bytes at a time, using the Page Program instruction.

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.

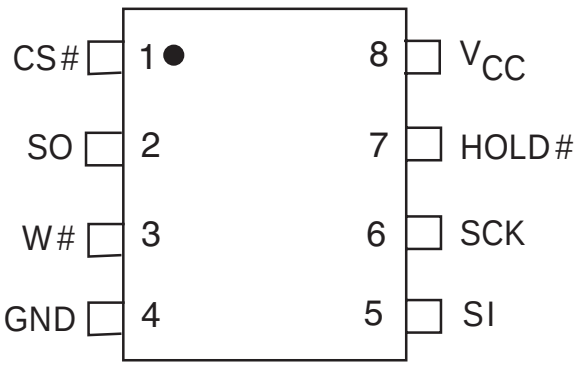
Table of Contents

Block Diagram

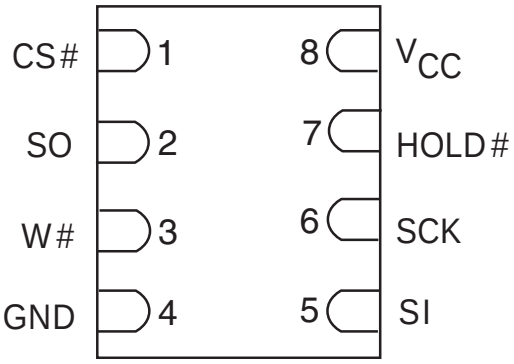


Connection Diagrams

8-pin Plastic Small Outline Package (SO)



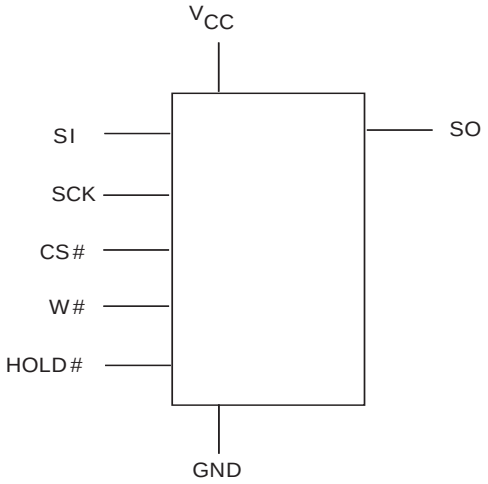
8-contact WSON Package



Input/Output Descriptions

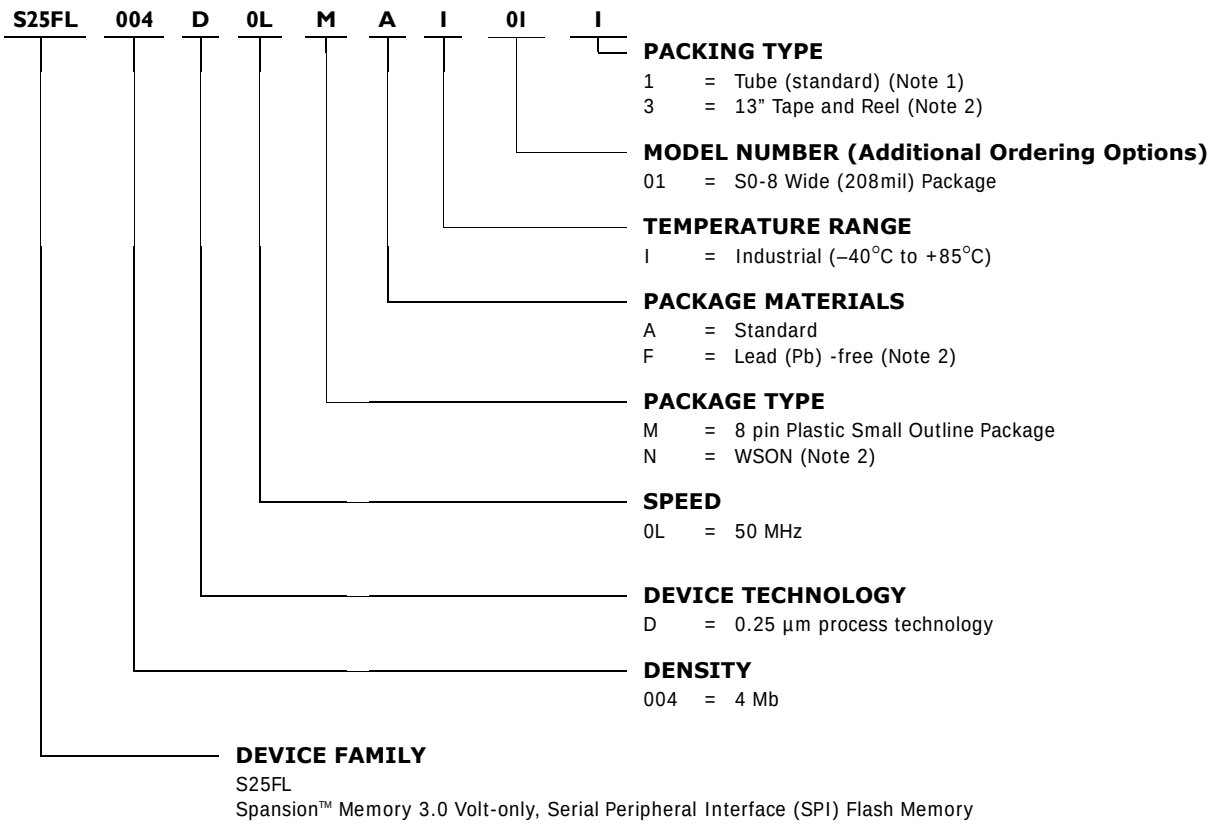
SCK	=	Serial Clock Input
SI	=	Serial Data Input
SO	=	Serial Data Output
CS#	=	Chip Select Input
W#	=	Write Protect Input
HOLD#	=	Hold Input
V_{CC}	=	Supply Voltage Input
GND	=	Ground Input

Logic Symbol



Ordering Information

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



S25FL Valid Combinations					
Base Ordering Part Number	**Speed Option**	**Package & Temperature**	**Model Number**	**Packing Type**	**Package Marking**
S25FL004D	0L	MAI, MFI, NFI	01	1, 3 (Note 1)	FL004D + (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 3, this signifies a S08-Wide body Lead (Pb)-free package. For example: FL004DI3. If "Last Digit of Model Number" is 1, this signifies a S08-Wide body standard package. For example: FL004DI1.*

Valid Combinations

Valid Combination configuration planned to be supported for this device. **Note**: Ordering part number and package marking is pending final product introduction. Contact your sales representative for further information.

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 microcontroller 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)

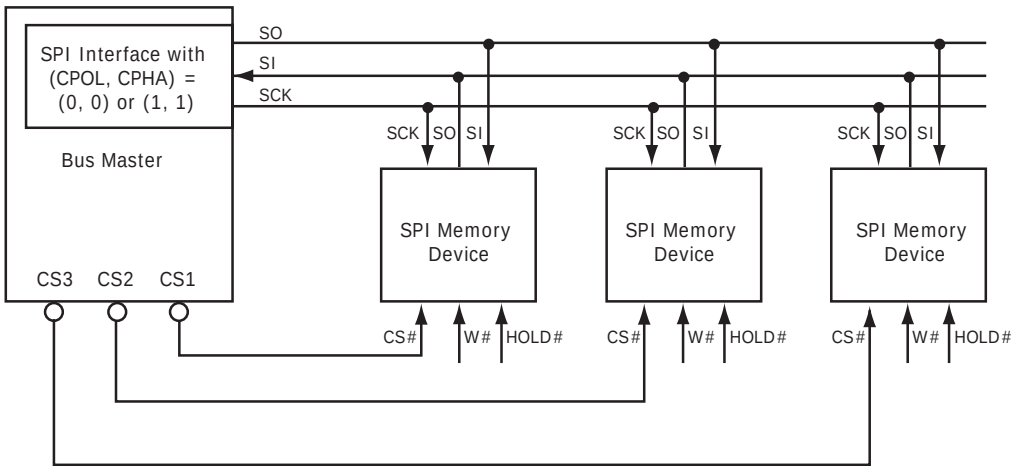


Figure I. Bus Master and Memory Devices on the SPI Bus

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

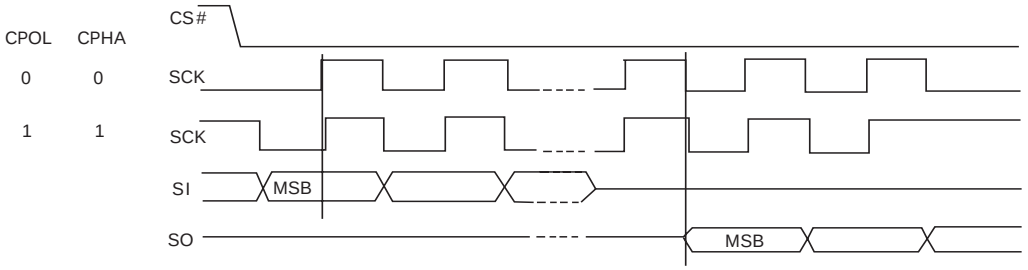


Figure 2. SPI Modes Supported

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 Deep Power Down on 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.
- **BP2, BP1, BP0 bits:** The Block Protect (BP2, 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, BP2, 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 (BP2, 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 I. Protected Area Sizes (S25FL004D).

Protected Memory Area (Top Level)	Status Register Content			Memory Content	
	BP2 Bit	BP1 Bit	BP0	Protected Area	Unprotected Area
0	0	0	0	none	00000–7FFFF
1/8	0	0	1	70000–7FFFF	00000–6FFFF
1/4	0	1	0	60000–7FFFF	00000–5FFFF
1/2	0	1	1	40000–7FFFF	00000–3FFFF
All	1	0	0	00000-7FFFF	none
All	1	0	1	00000-7FFFF	none
All	1	1	0	00000-7FFFF	none
All	1	1	1	00000-7FFFF	none

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.

If Chip Select (CS#) goes High while the device is in the Hold condition, this has the effect of resetting the internal logic of the device. To restart communication with the device, it is necessary to drive Hold (HOLD#) High, and then to drive Chip Select (CS#) Low. This prevents the device from going back to the Hold condition.

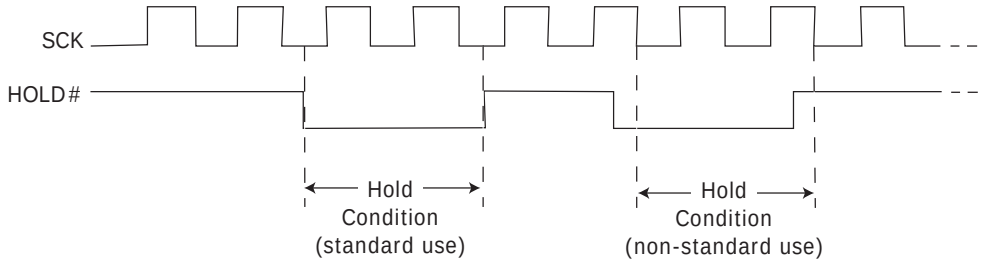


Figure 3. Hold Condition Activation

Memory Organization

The memory is organized as:

- S25FL004D: Eight sectors of 512 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 2. Sector Address Table – S25FL004D

Sector	Address Range	
SA7	70000h	7FFFFh
SA6	60000h	6FFFFh
SA5	50000h	5FFFFh
SA4	40000h	4FFFFh
SA3	30000h	3FFFFh
SA2	20000h	2FFFFh
SA1	10000h	1FFFFh
SA0	00000h	0FFFFh

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 3.

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) or Release from Deep Power Down and Read Electronic Signature (RES) instruction, 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 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 3. 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
RDSR	Read from Status Register	05H (0000 0101)	0	0	1 to Infinity
WRSR	Write to Status Register	01H (0000 0001)	0	0	1
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
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
Deep Power Down Savings Mode Operations					
DP	Deep Power Down	B9H (1011 1001)	0	0	0
RES	Release from Deep Power Down	ABH (1010 1011)	0	0	0
	Release from Deep Power Down 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.

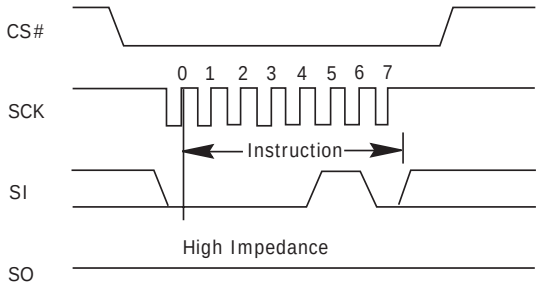


Figure 4. Write Enable (WREN) Instruction Sequence

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

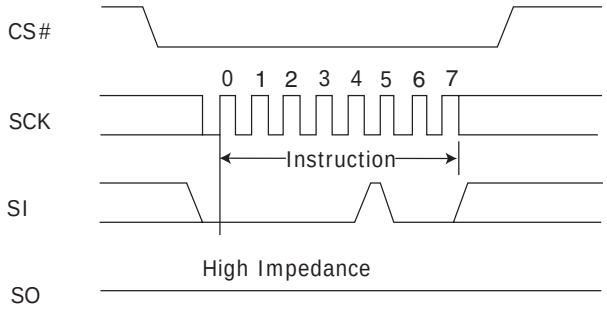


Figure 5. Write Disable (WRDI) Instruction Sequence

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.

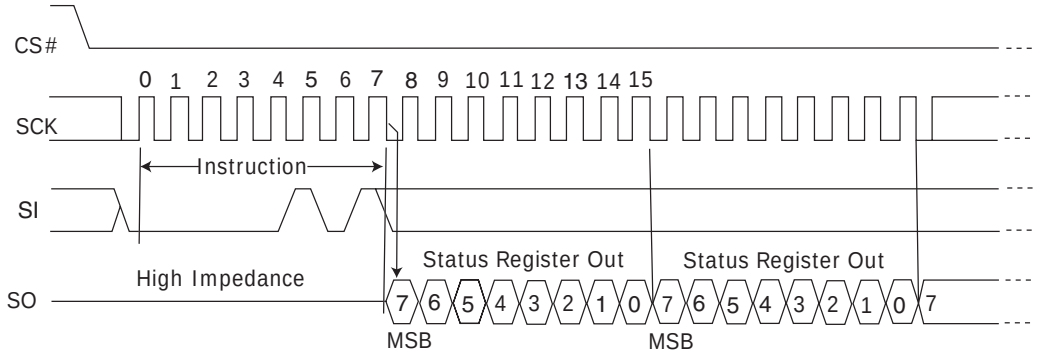


Figure 6. Read Status Register (RDSR) Instruction Sequence

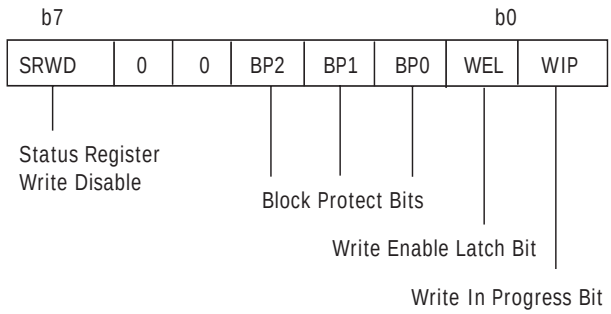


Figure 7. Status Register Format

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, BP2, BP1, BP0) become read-only bits and the Write Status Register (WRSR) instruction is no longer accepted for execution.

BP2, BP1, BP0 bits: The Block Protect (BP2, 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 (BP2, BP1, BP0) bits is set to 1, the relevant memory area (as defined in Table 1) becomes protected against Page Program (PP), and Sector Erase (SE) instructions. The Block Protect (BP2, 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, all Block Protect (BP2, 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, b1 and b0 of the Status Register. Bits b6, b5 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 (BP2, BP1, BP0) bits, to define the size of the area that is to be treated as read-only, as defined in Table 1. 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.

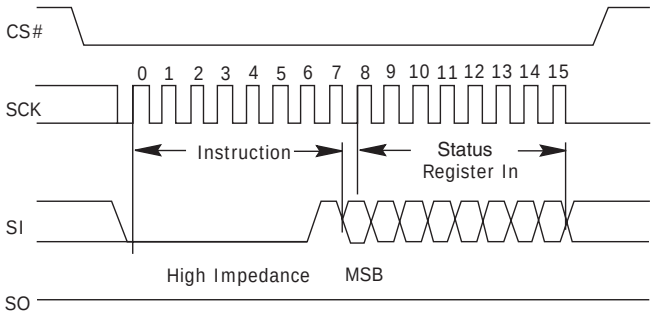


Figure 8. Write Status Register (WRSR) Instruction Sequence

Table 4. 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) The values in the SRWD, BP2, BP1 and BP0 bits can be changed	Protected against Page Program and Erase (SE, BE)	Ready to accept Page Program and Sector Erase Instructions
1	0				
0	0				
0	1	Hardware Protected (HPM)	Status Register is Hardware write protected The values in the SRWD, BP2, 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 (BP2, BP1, BP0) bits of the Status Register, as shown in Table 1.

The protection features of the device are summarized in Table 4.

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 (BP2, 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 (BP2, BP1, BP0) bits of the Status Register, can be used.

Read Data Bytes (READ)

The READ instruction reads the memory at the specified SCK frequency (f_{SCK}) with a maximum speed of 33 MHz.

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 (A23-A0), 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.

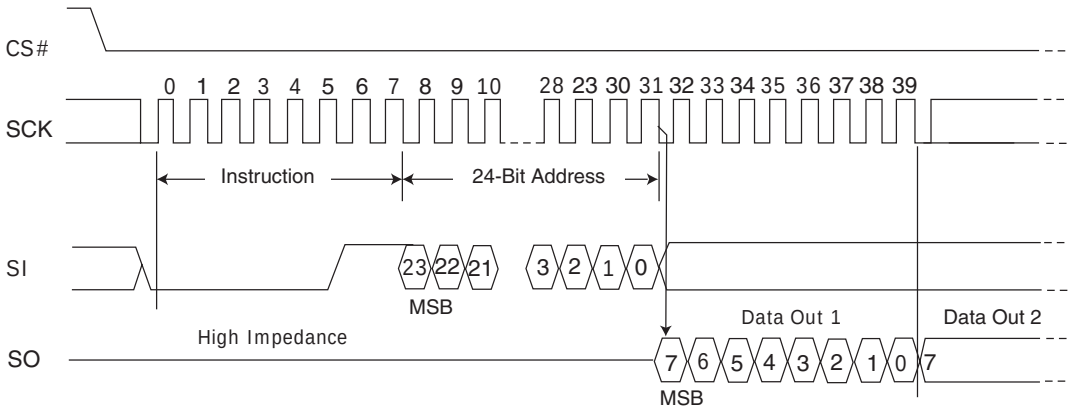


Figure 9. Read Data Bytes (READ) Instruction Sequence

Read Data Bytes at Higher Speed (FAST_READ)

The FAST_READ instruction reads the memory at the specified SCK frequency (f_{SCK}) with a maximum speed of 50 MHz. 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) 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.

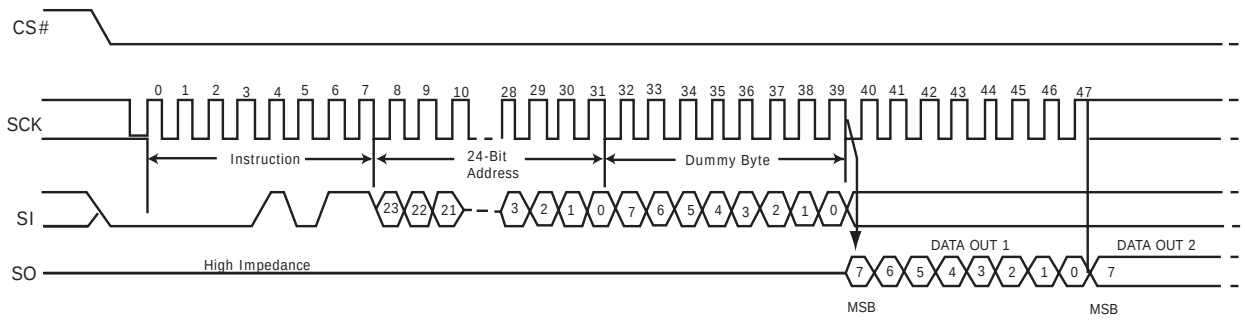


Figure 10. Read Data Bytes at Higher Speed (FAST_READ) Instruction Sequence

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 (BP2, BP1, BP0) bits (see Table 1) is not executed.

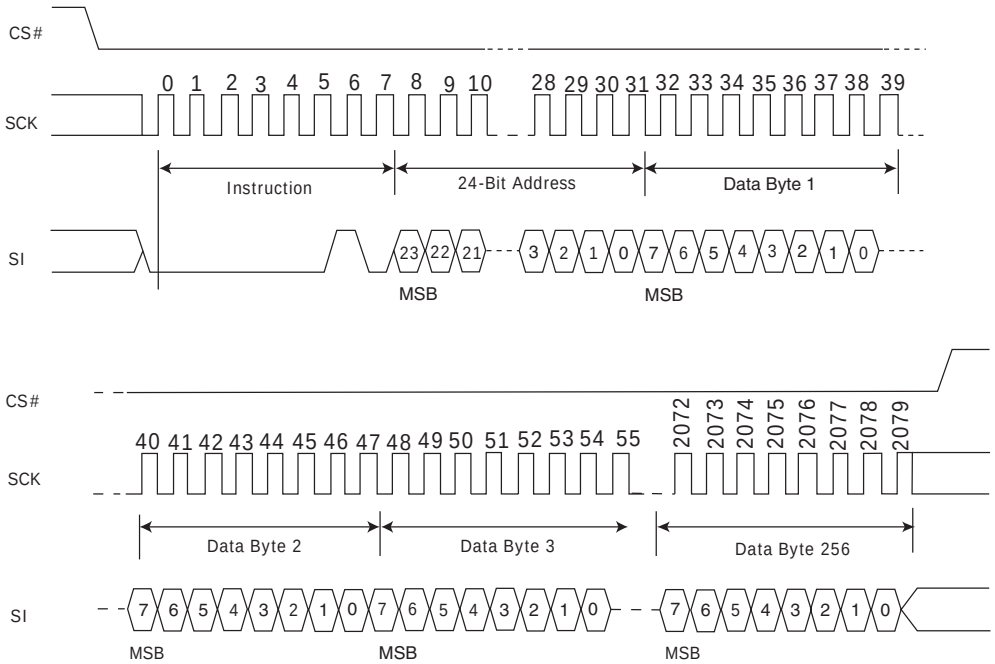


Figure II. Page Program (PP) Instruction Sequence

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) 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 tSE) 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 (BP2, BP1, BP0) bits (see Table 1) is not executed.

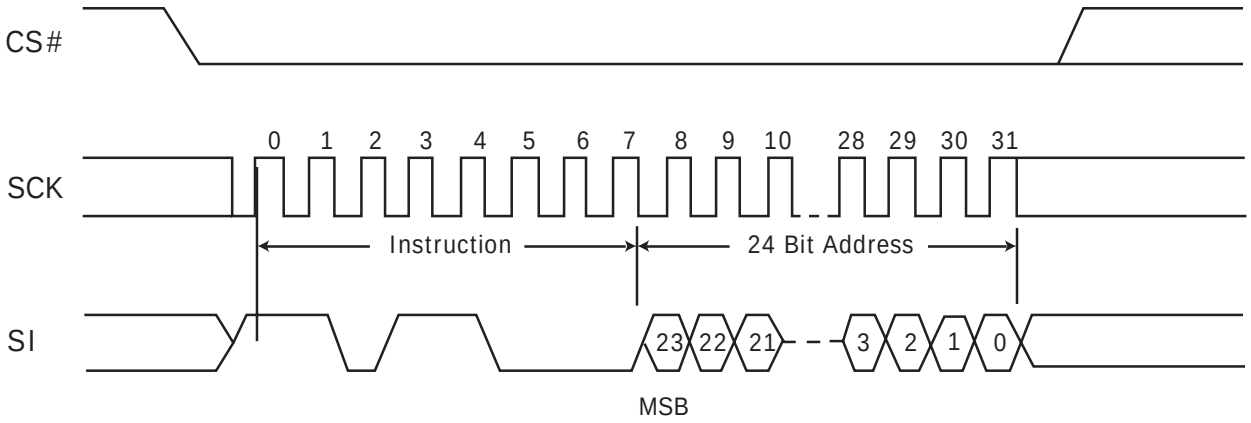


Figure 12. Sector Erase (SE) Instruction Sequence

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 all the Block Protect (BP2, BP1, BP0) bits (see Table 1) are set to 0. The Bulk Erase (BE) instruction is ignored if one or more sectors are protected.

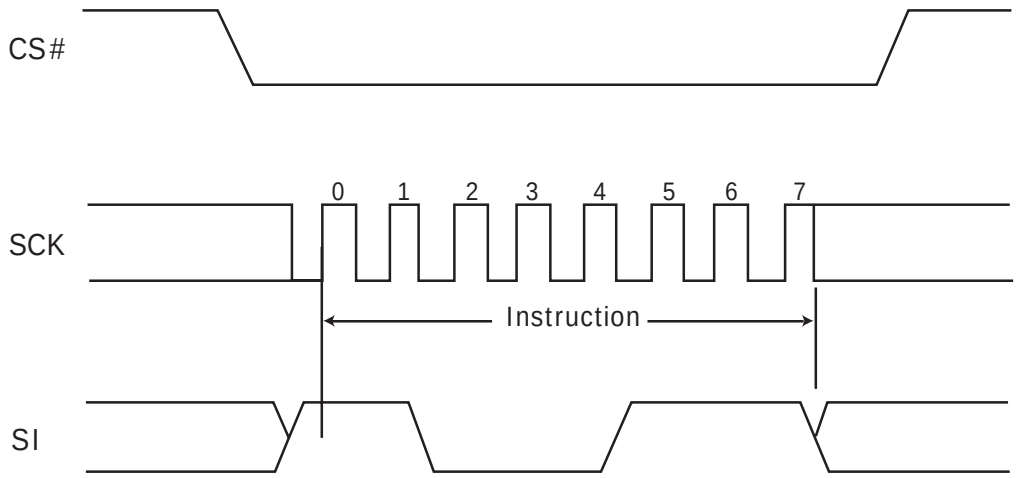


Figure 13. Bulk Erase (BE) Instruction Sequence

Deep Power Down (DP)

The Deep Power Down (DP) instruction puts the device in the lowest current mode of 1 µA typical.

It is recommended that the standard Standby mode be used for the lowest power current draw, as well as the Deep Power Down (DP) 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 Deep Power Down (DP) 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 puts the device in Deep Power Down mode. The Deep Power Down mode can only be entered by executing the Deep Power Down (DP) instruction to reduce the standby current (from I_{SB} to I_{DP} as specified in Table 6). As soon as Chip Select (CS#) is driven high, it requires a delay of t_{DP} currently in progress before Deep Power Down mode is entered.

Once the device has entered the Deep Power Down mode, all instructions are ignored except the Release from Deep Power Down (RES) and Read Electronic Signature. This releases the device from the Deep Power Down mode. The Release from Deep Power Down and Read Electronic Signature (RES) instruction also allows the Electronic Signature of the device to be output on Serial Data Output (SO).

The Deep Power Down mode automatically stops at Power-down, and the device always powers up in the Standby mode.

Any Deep Power Down (DP) instruction, while an Erase, Program or WRSR cycle is in progress, is rejected without having any effect on the cycle in progress.

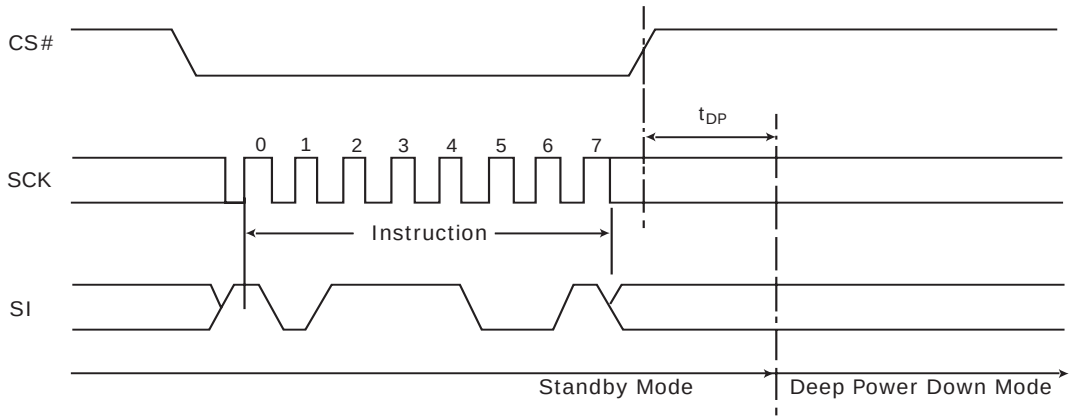


Figure 14. Deep Power Down (DP) Instruction Sequence

Release from Deep Power Down (RES)

The Release from Deep Power Down (RES) instruction provides the only way to exit the Deep Power Down mode. Once the device has entered the Deep Power Down mode, all instructions are ignored except the Release from Deep Power Down (RES) instruction. Executing this instruction takes the device out of Deep Power Down mode.

The Release from Deep Power Down (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 Deep Power Down 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 8. Once in the Stand-by Power mode, the device waits to be selected, so that it can receive, decode and execute instructions.

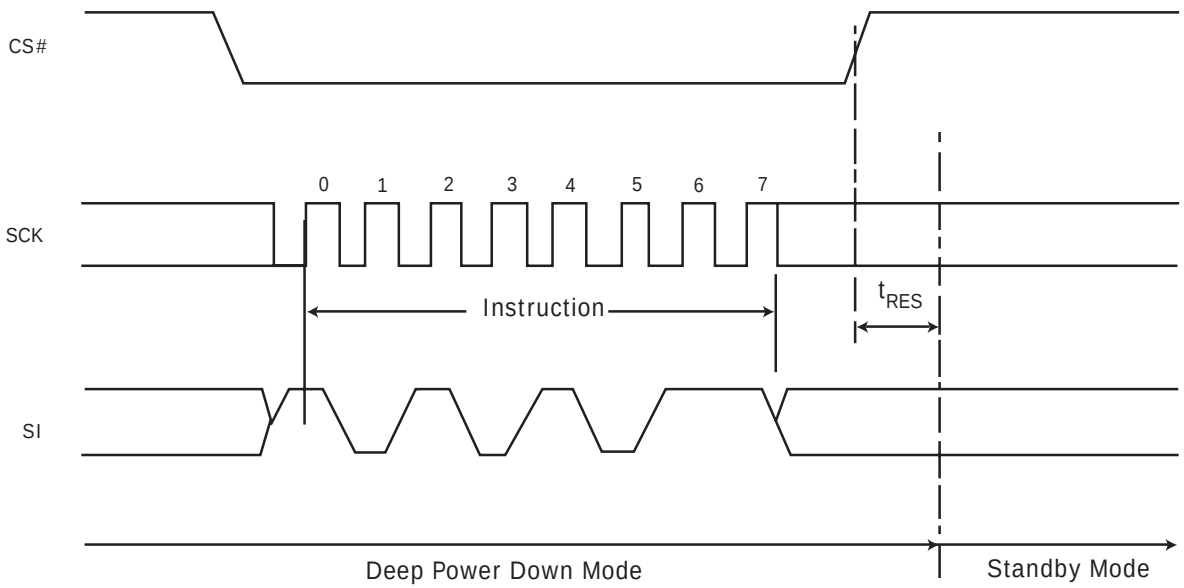


Figure 15. Release from Deep Power Down Instruction Sequence

Release from Deep Power Down and Read Electronic Signature (RES)

Once the device has entered Deep Power Down 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 DP 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 device features an 8-bit Electronic Signature, whose value for the S25FL004D is 12h. This can be read using RES 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 Release from Deep Power Down and Read Electronic Signature (RES) is terminated by driving Chip Select (CS#) High after the Electronic Signature has been read at least once. Sending additional clock cycles on Serial Clock (SCK), while Chip Select (CS#) is driven Low, causes the Electronic Signature to be output repeatedly.

When Chip Select is driven High, the device is put in the Stand-by Power mode. If the device was not previously in the Deep Power Down mode, the transition to the Stand-by Power mode is immediate. If the device was previously in the Deep Power Down mode, though, the transition to the Standby mode is delayed by t_{RES}, and Chip Select (CS#) must remain High for at lease $t_{RES(max)}$, as specified in Table 8. Once in the Stand-by Power mode, the device waits to be selected, so that it can receive, decode and execute instructions.

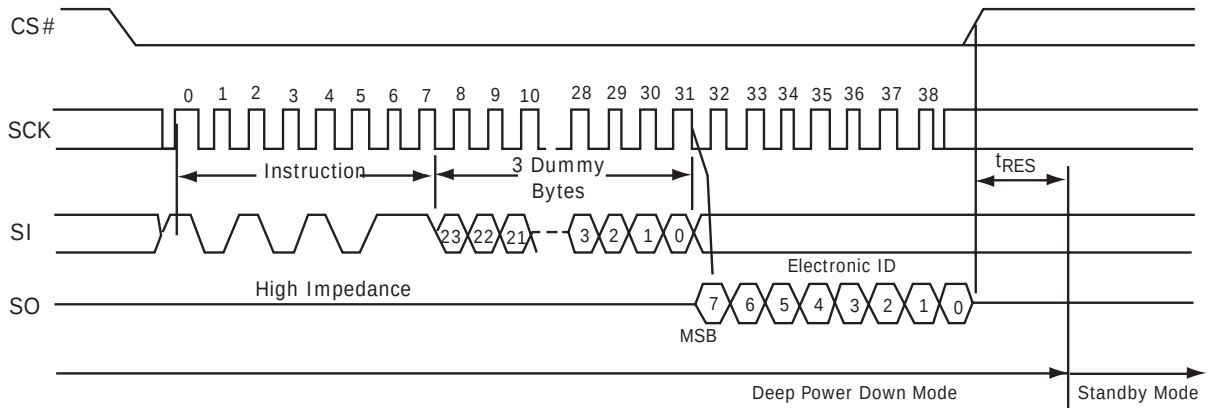


Figure 16. Release from Deep Power Down and Read Electronic Signature (RES) Instruction Sequence

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 correct value as follows:

- V_{CC} (min) at power-up, and then for a further delay of t_{PU} (as described in Table 5)
- 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.

The device ignores all instructions until a time delay of t_{PU} (as described in Table 5) 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 Write Status Register, Program or Erase instructions should be sent until t_{PU} after V_{CC} reaches the minimum V_{CC} threshold (See Figure 17).

At power-up, the device is in Standby mode (not Deep Power Down mode) and the WEL bit is reset.

During Power-down or voltage drops, the power down must drop below the V_{CC} (low) for a period of minimum t_{PD} for the device to initialize correctly on power up. (See Figure 18).

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 µF).

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.)

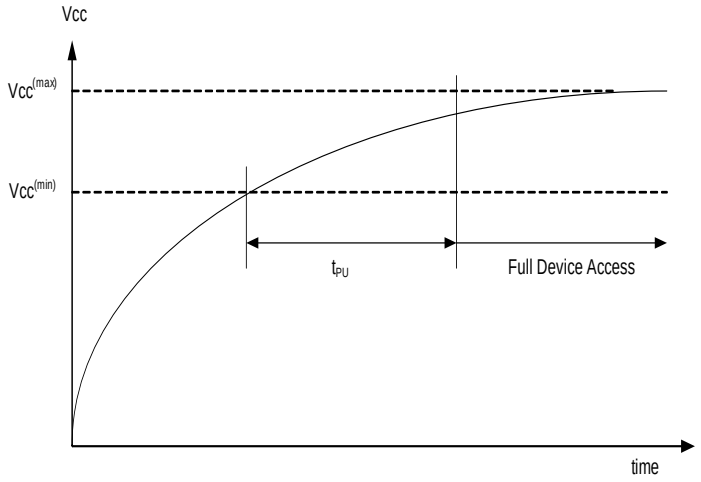


Figure 17. Power-Up Timing

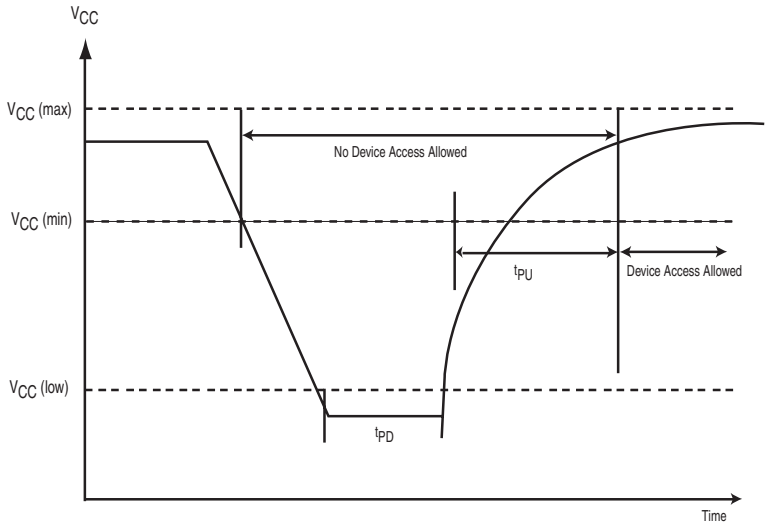


Figure 18. Power-Down and Voltage Drop

Table 5. Power-Up Timing

Symbol	Parameter	Min	Max	Unit
$V_{CC(min)}$	V_{CC} (minimum)	2.7		V
$V_{CC(low)}$	V_{CC} (low)			V
t_{PU}	V_{CC} (min) to device operation	2		ms
t_{PD}	V_{CC} (low) duration			ns

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°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°C

Industrial . . . . . –40°C to +85°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 7, when relying on the quoted parameters.

CMOS Compatible

Table 6. DC Characteristics

Parameter	Description	Test Conditions		Min	Typ.	Max	Unit
V_{CC}	Supply Voltage			2.7	3	3.6	V
I_{CC1}	Active Read Current	SCK = 0.1 V_{CC}/0.9V_{CC}	33 MHz				mA
		SCK = 0.1 V_{CC}/0.9V_{CC}	V_{CC} = 3.0V 50 MHz		9	12	
I_{CC2}	Active Page Program Current	CS# = V_{CC}				23	mA
I_{CC3}	Active WRSR Current	CS# = V_{CC}				23	mA
I_{CC4}	Active Sector Erase Current	CS# = V_{CC}				23	mA
I_{CC5}	Active Bulk Erase Current	CS# = V_{CC}				23	mA
I_{SB}	Standby Current	V_{CC} = 3.0 V CS# = V_{CC}				50	µA
I_{DP}	Deep Power Down Current	V_{CC} = 3.0 V CS# = V_{CC}			1	5	µA
I_{LI}	Input Leakage Current	V_{IN} = GND to V_{CC}				1	µA
I_{LO}	Output Leakage Current	V_{IN} = GND 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 mA, V_{CC} = $V_{CC\ min}$				0.4	V
V_{OH}	Output High Voltage	I_{OH} = –0.1 mA		V_{CC} – 0.2			V

Notes: *Typical values are at T_A = 25°C and 3.0 V.*

Test Conditions

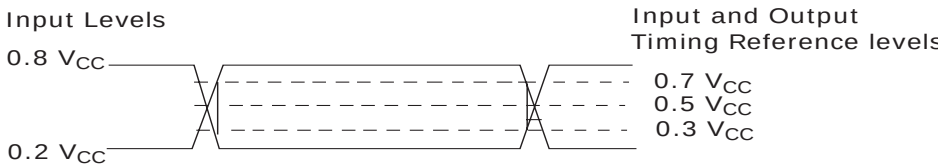


Figure 19. AC Measurements I/O Waveform

Table 7. 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 8. AC Characteristics

Symbol	Parameter	Min	Typ	Max	Unit
F_{SCK}	SCK Clock Frequency READ instruction	D.C.		33	MHz
F_{SCK}	SCK Clock Frequency for: FAST_READ, PP, SE, BE, DP, RES, WREN, WRDI, RDSR, WRSR	D.C.		50	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	9			ns
t_{WL}	SCK Low Time	9			ns
t_{CS}	CS# High Time	100			ns
t_{CSS} (Note 3)	CS# Setup Time	5			ns
t_{CSH} (Note 3)	CS# HOLD Time	5			ns
t_{HD} (Note 3)	HOLD# Setup Time (relative to SCK)	5			ns
t_{CD} (Note 3)	HOLD# Hold Time (relative to SCK)	5			ns
t_{HC}	HOLD# Setup Time (relative to SCK)	5			ns
t_{CH}	HOLD# Hold Time (relative to SCK)	5			ns
t_{V}	Output Valid			9	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_{R}	Input Rise Time			5	ns
t_{F}	Input Fall Time			5	ns
t_{LZ} (Note 3)	HOLD# to Output Low Z			9	ns
t_{HZ} (Note 3)	HOLD# to Output High Z			9	ns
t_{DIS} (Note 3)	Output Disable Time			9	ns
t_{WPS} (Note 3)	Write Protect Setup Time	20			ns
t_{WPH} (Note 3)	Write Protect Hold Time	100			ns
t_{RES}	Release DP Mode			3	µs
t_{DP}	CS# High to Deep Power Down Mode			3	µs
t_{W}	Write Status Register Time			20 (Note 2)	ns
t_{PP}	Page Programming Time		1.5 (Note 1)	2 (Note 2)	ms
t_{SE}	Sector Erase Time		0.5 (Note 1)	0.8 (Note 2)	sec
t_{BE}	Bulk Erase Time		4 (Note 1)	7 (Note 2)	sec

Note:

1. *Typical program and erase times assume the following conditions: 25C, VCC = 3.0V; 10, 000 cycles; checkerboard data pattern*
2. *Under worst-case conditions of 90C; VCC = 2.7V; 100,000 cycles*
3. *Not 100% tested*

AC Characteristics

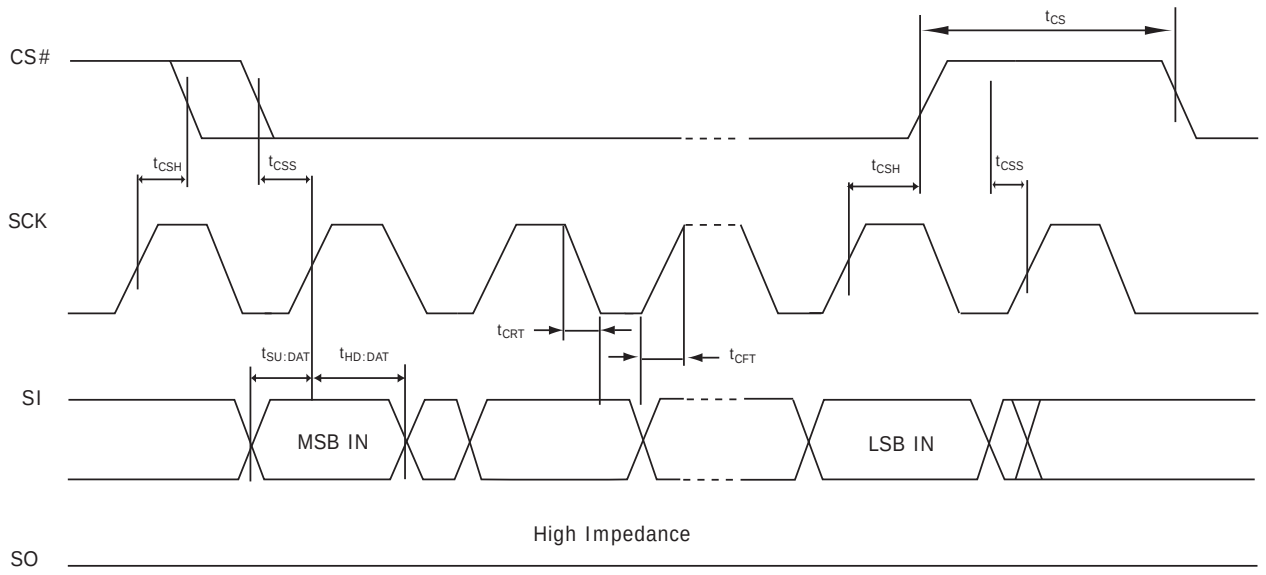


Figure 20. SPI Mode 0 (0,0) Input Timing

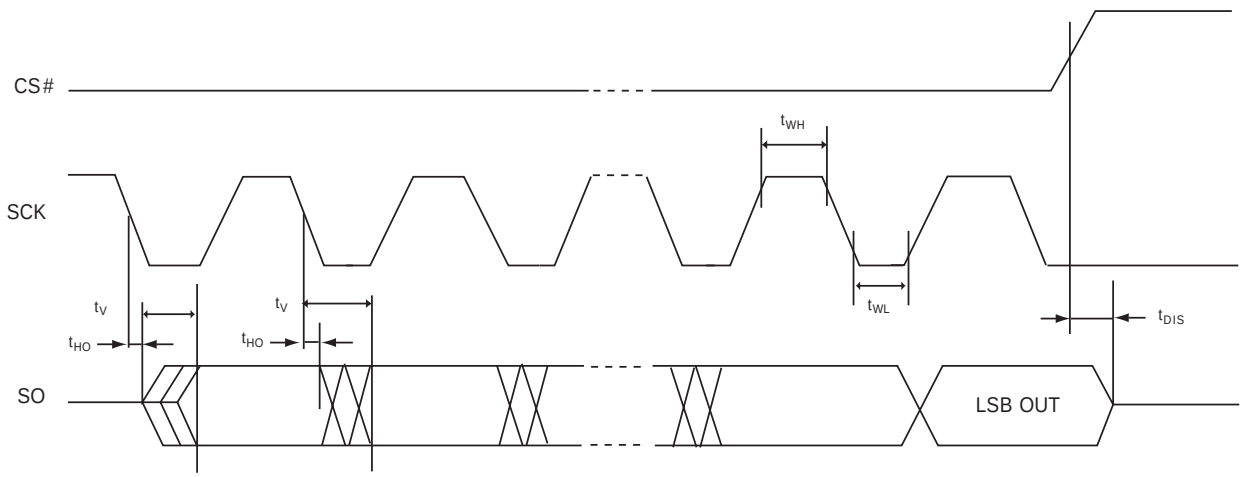


Figure 21. SPI Mode 0 (0,0) Output Timing

AC Characteristics

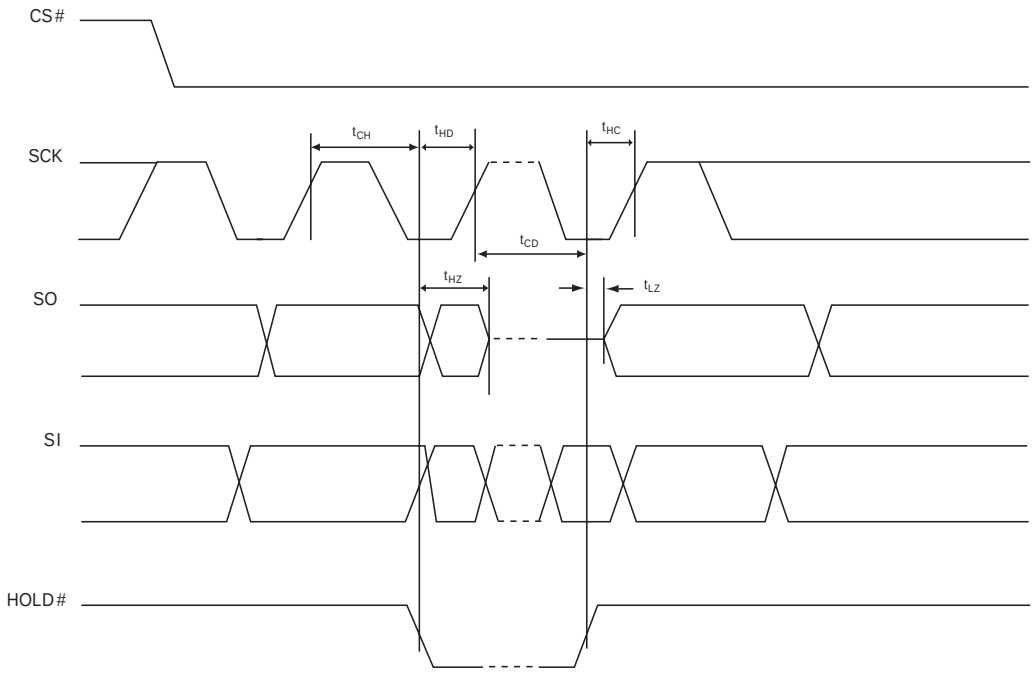


Figure 22. HOLD# Timing

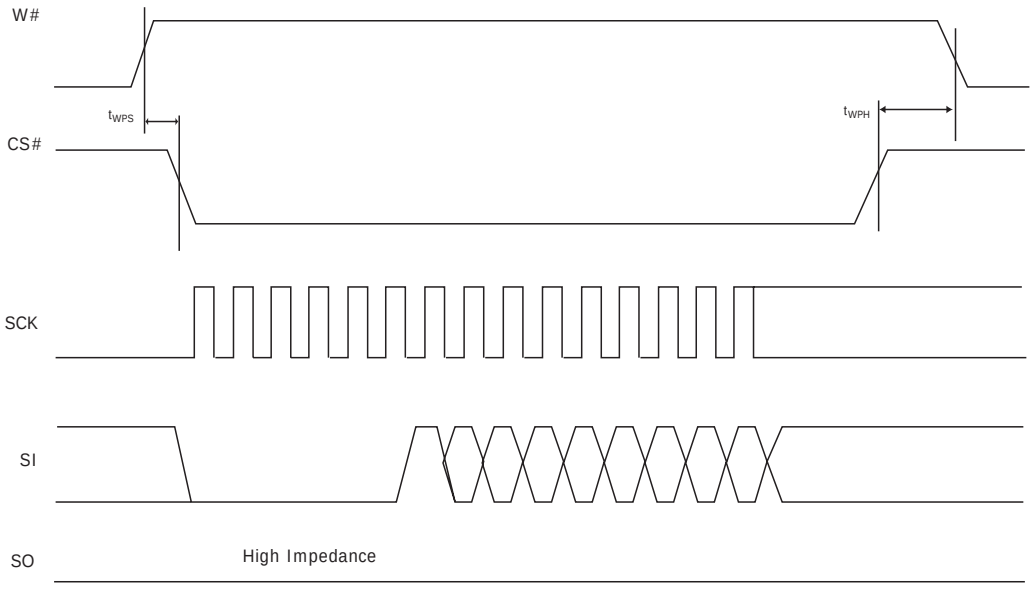
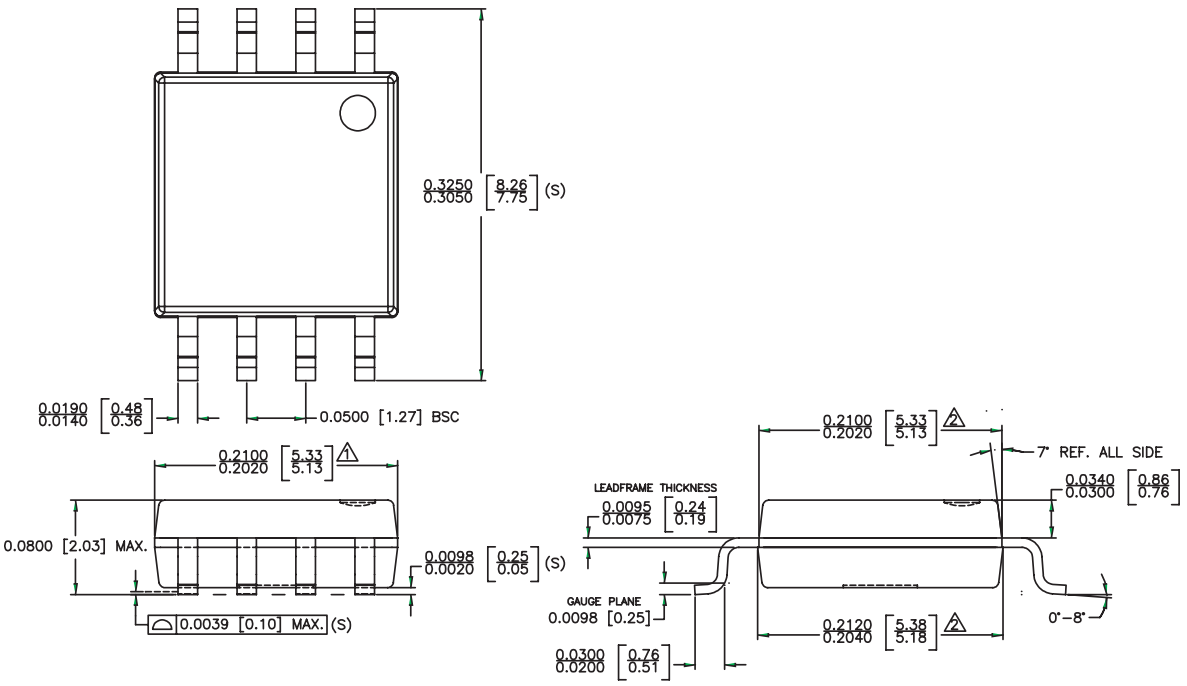


Figure 23. Write Protect Setup and Hold Timing during WRSR when SRWD=I

Physical Dimensions

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

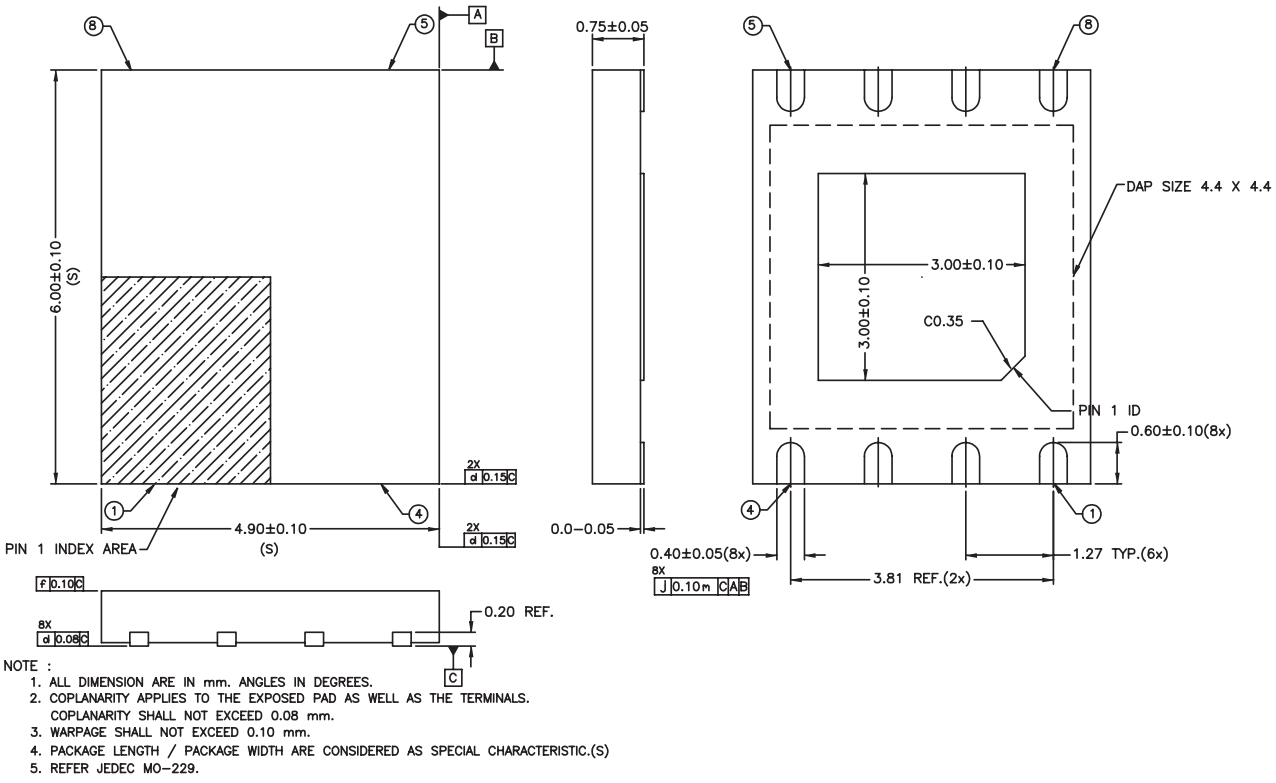


NOTE :

1. ⚠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. ⚠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]

Physical Dimensions

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



NOTE :
1. ALL DIMENSION ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS. COPLANARITY SHALL NOT EXCEED 0.08 mm.
3. WARPAGE SHALL NOT EXCEED 0.10 mm.
4. PACKAGE LENGTH / PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC.(S)
5. REFER JEDEC MO–229.

Revision Summary

Revision A (June 28, 2004)

Initial release.