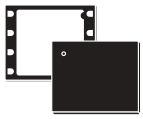
M25P128

128 Mbit (Multilevel), Low Voltage, Serial Flash Memory With 50MHz SPI Bus Interface

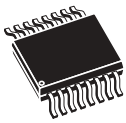
PRELIMINARY DATA

Feature summary

- 128 Mbit of Flash Memory
- Page Program (up to 256 Bytes) in 2.5ms (typical)
- Sector Erase (2Mbit)
- Bulk Erase (128Mbit)
- 2.7 to 3.6V Single Supply Voltage
- SPI Bus Compatible Serial Interface
- 50MHz Clock Rate (maximum)
- Electronic Signature
  - JEDEC Standard Two-Byte Signature (2018h)
- More than 10000 Erase/Program Cycles per Sector
- More than 20-Year Data Retention
- Packages
  - ECOPACK® (RoHS compliant)



VDFPN8 (ME)
8x6mm (MLP8)



SO16 (MF)
300 mils width

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1 Summary description

The M25P128 is a multilevel 128Mbit (16Mbit x 8) Serial Flash Memory, with advanced write protection mechanisms, accessed by a high speed SPI-compatible bus.

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

The memory is organized as 64 sectors, each containing 1024 pages. Each page is 256 bytes wide. Thus, the whole memory can be viewed as consisting of 65536 pages, or 16777216 bytes.

The whole memory can be erased using the Bulk Erase instruction, or a sector at a time, using the Sector Erase instruction.

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. ECOPACK® packages are Lead-free and RoHS compliant. ECOPACK is an ST trademark. ECOPACK specifications are available at: *www.st.com*.

Figure 1. Logic Diagram

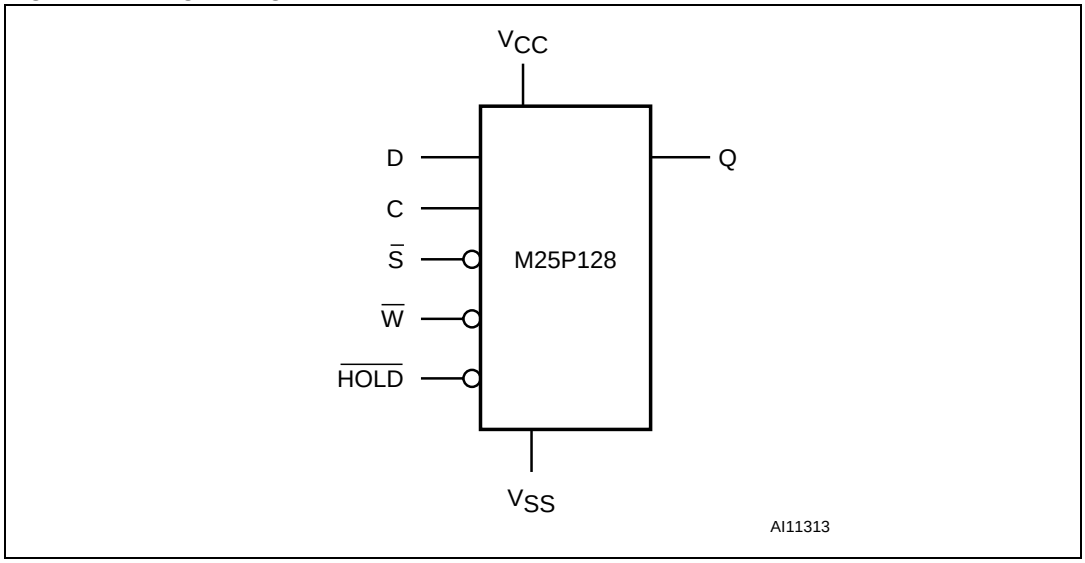
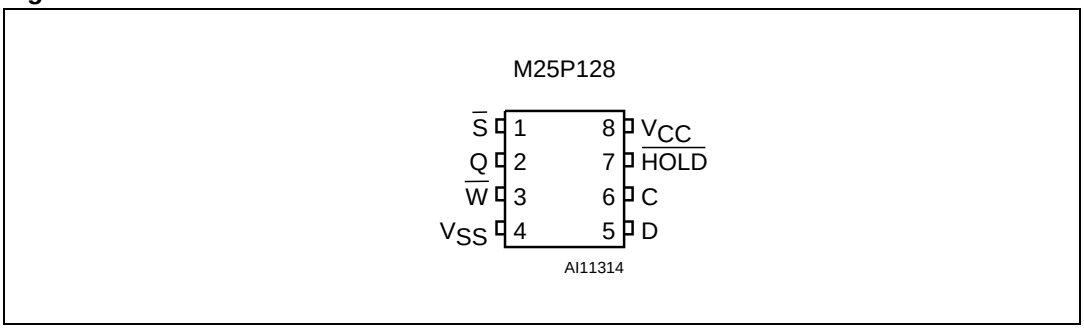


Table 1. Signal Names

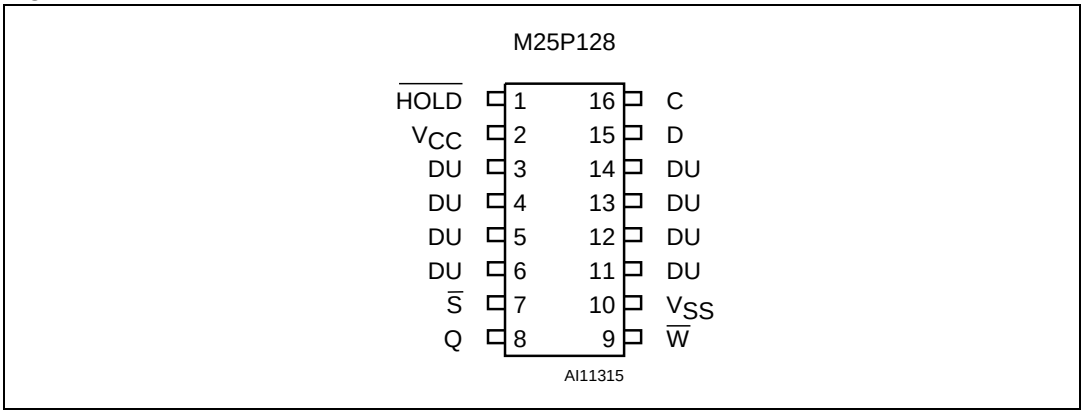
C	Serial Clock
D	Serial Data Input
Q	Serial Data Output
$\overline{S}$	Chip Select
$\overline{W}$	Write Protect
$\overline{HOLD}$	Hold
V_{CC}	Supply Voltage
V_{SS}	Ground

Figure 2. VDFPN Connections



1. There is an exposed die paddle on the underside of the MLP8 package. This is pulled, internally, to V_{SS}, and must not be allowed to be connected to any other voltage or signal line on the PCB.
2. See *Package mechanical* section for package dimensions, and how to identify pin-1.

Figure 3. SO Connections



1. DU = Don't Use
2. See *Package mechanical* section for package dimensions, and how to identify pin-1.

2 Signal description

2.1 Serial data output (Q)

This output signal is used to transfer data serially out of the device. Data is shifted out on the falling edge of Serial Clock (C).

2.2 Serial data input (D)

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 (C).

2.3 Serial clock (C)

This input signal provides the timing of the serial interface. Instructions, addresses, or data present at Serial Data Input (D) are latched on the rising edge of Serial Clock (C). Data on Serial Data Output (Q) changes after the falling edge of Serial Clock (C).

2.4 Chip Select ($\overline{S}$)

When this input signal is High, the device is deselected and Serial Data Output (Q) is at high impedance. Unless an internal Program, Erase or Write Status Register cycle is in progress, the device will be in the Standby Power mode. Driving Chip Select ($\overline{S}$) Low selects the device, placing it in the Active Power mode.

After Power-up, a falling edge on Chip Select ($\overline{S}$) is required prior to the start of any instruction.

2.5 Hold ($\overline{HOLD}$)

The Hold ($\overline{HOLD}$) signal is used to pause any serial communications with the device without deselecting the device.

During the Hold condition, the Serial Data Output (Q) is high impedance, and Serial Data Input (D) and Serial Clock (C) are Don't Care.

To start the Hold condition, the device must be selected, with Chip Select ($\overline{S}$) driven Low.

2.6 Write Protect ($\overline{W}$)

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 BP2, BP1 and BP0 bits of the Status Register).

3 SPI modes

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

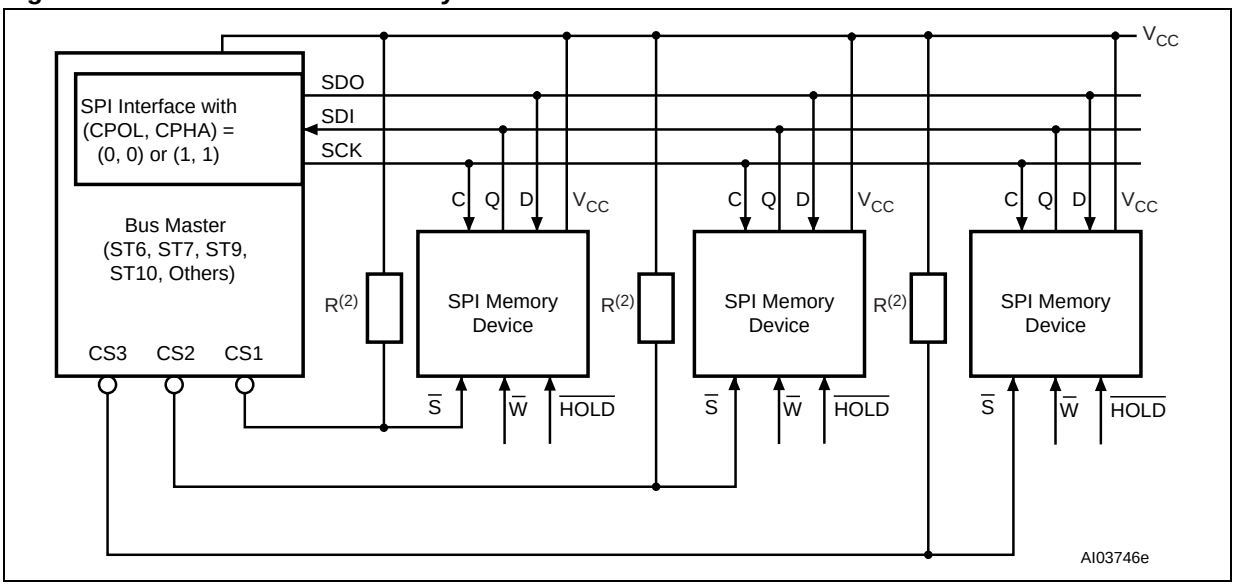
- CPOL=0, CPHA=0
- CPOL=1, CPHA=1

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

The difference between the two modes, as shown in *Figure 5*, is the clock polarity when the bus master is in Stand-by mode and not transferring data:

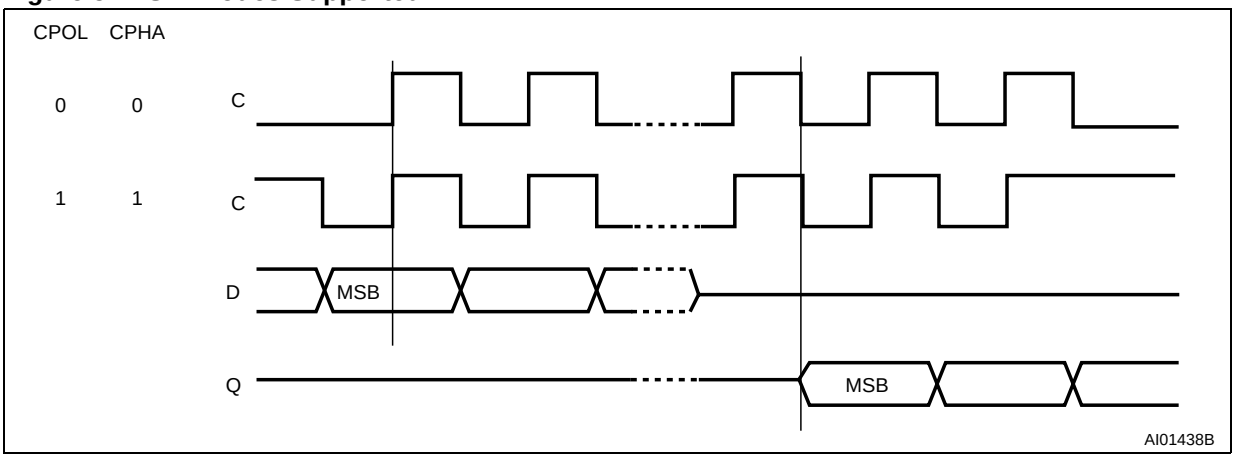
- C remains at 0 for (CPOL=0, CPHA=0)
- C remains at 1 for (CPOL=1, CPHA=1)

Figure 4. Bus Master and Memory Devices on the SPI Bus



1. The Write Protect ($\overline{W}$) and Hold ($\overline{HOLD}$) signals should be driven, High or Low as appropriate.

Figure 5. SPI Modes Supported



4 Operating features

4.1 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 (of duration t_{PP}).

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.

For optimized timings, it is recommended to use the Page Program (PP) instruction to program all consecutive targeted Bytes in a single sequence versus using several Page Program (PP) sequences with each containing only a few Bytes (see *Section 6.8: Page Program (PP)* and *Table 14: AC Characteristics*).

4.2 Sector Erase and Bulk Erase

The Page Program (PP) instruction allows bits to be reset from 1 to 0. Before this can be applied, the bytes of memory need to have been erased to all 1s (FFh). This can be achieved either a sector at a time, using the Sector Erase (SE) instruction, or throughout the entire memory, using the Bulk Erase (BE) instruction. This starts an internal Erase cycle (of duration t_{SE} or t_{BE}).

The Erase instruction must be preceded by a Write Enable (WREN) instruction.

4.3 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 (t_W, t_{PP}, t_{SE}, or t_{BE}). 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.

4.4 Active power and standby power modes

When Chip Select ($\overline{S}$) is Low, the device is selected, and in the Active Power mode.

When Chip Select ($\overline{S}$) is High, the device is deselected, but could remain in the Active Power mode until all internal cycles have completed (Program, Erase, Write Status Register). The device then goes in to the Standby Power mode. The device consumption drops to I_{CC1}.

4.5 Status Register

The Status Register contains a number of status and control bits that can be read or set (as appropriate) by specific instructions. See *Section 6.4: Read Status Register (RDSR)* for a detailed description of the Status Register bits.

4.6 Protection modes

The environments where non-volatile memory devices are used can be very noisy. No SPI device can operate correctly in the presence of excessive noise. To help combat this, the M25P128 features the following data protection mechanisms:

- Power On Reset and an internal timer (t_{PUW}) can provide protection against inadvertant changes while the power supply is outside the operating specification.
- Program, Erase and Write Status Register instructions are checked that they consist of a number of clock pulses that is a multiple of eight, before they are accepted for execution.
- 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 ($\overline{W}$) signal allows the Block Protect (BP2, BP1, BP0) bits and Status Register Write Disable (SRWD) bit to be protected. This is the Hardware Protected Mode (HPM).

Table 2. Protected Area Sizes

Status Register Content			Memory Content	
BP2 Bit	BP1 Bit	BP0 Bit	Protected Area	Unprotected Area
0	0	0	none	All Sectors (Sectors 0 to 63)(1)
0	0	1	Upper 64th (1 Sector, 2Mb)	Sectors 0 to 62
0	1	0	Upper 32nd (2 Sectors, 4Mb)	Sectors 0 to 61
0	1	1	Upper 16nd (4 Sectors, 8Mb)	Sectors 0 to 59
1	0	0	Upper 8nd (8 Sectors, 16Mb)	Sectors 0 to 55
1	0	1	Upper Quarter (16 Sectors, 32Mb)	Lower 3 Quarters (Sectors 0 to 47)
1	1	0	Upper Half (32 Sectors, 64Mb)	Lower Half (Sectors 0 to 31)
1	1	1	All sectors (64 Sectors, 128Mb)	none

1. The device is ready to accept a Bulk Erase instruction if, and only if, all Block Protect (BP2, BP1, BP0) are 0.

4.7 Hold condition

The Hold ($\overline{HOLD}$) signal is used to pause any serial communications with the device without resetting the clocking sequence. 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 ($\overline{S}$) Low.

The Hold condition starts on the falling edge of the Hold ($\overline{HOLD}$) signal, provided that this coincides with Serial Clock (C) being Low (as shown in *Figure 6*).

The Hold condition ends on the rising edge of the Hold ($\overline{HOLD}$) signal, provided that this coincides with Serial Clock (C) being Low.

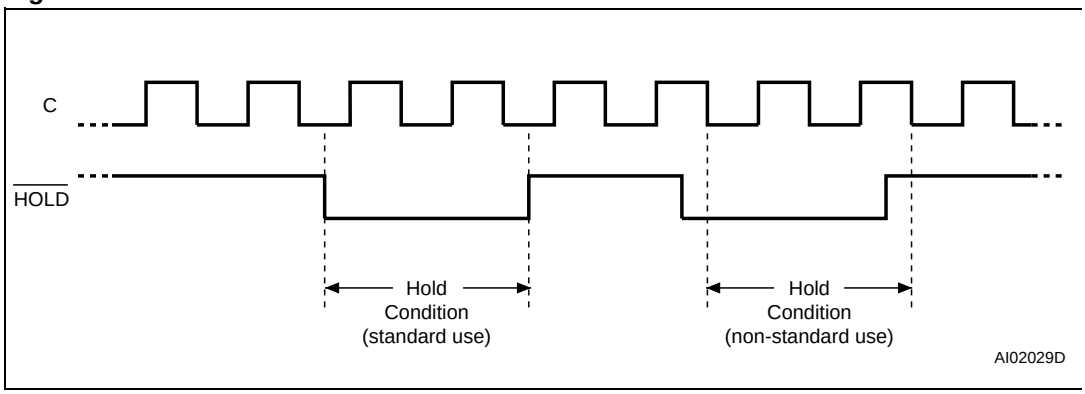
If the falling edge does not coincide with Serial Clock (C) being Low, the Hold condition starts after Serial Clock (C) next goes Low. Similarly, if the rising edge does not coincide with Serial Clock (C) being Low, the Hold condition ends after Serial Clock (C) next goes Low. (This is shown in *Figure 6*).

During the Hold condition, the Serial Data Output (Q) is high impedance, and Serial Data Input (D) and Serial Clock (C) are Don't Care.

Normally, the device is kept selected, with Chip Select ($\overline{S}$) driven Low, for the whole duration of the Hold condition. This is to ensure that the state of the internal logic remains unchanged from the moment of entering the Hold condition.

If Chip Select ($\overline{S}$) 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 ($\overline{HOLD}$) High, and then to drive Chip Select ($\overline{S}$) Low. This prevents the device from going back to the Hold condition.

Figure 6. Hold Condition Activation



5 Memory Organization

The memory is organized as:

- 16777216 bytes (8 bits each)
- 64 sectors (2Mbits, 262144 bytes each)
- 65536 pages (256 bytes 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) but not Page Erasable.

Figure 7. Block Diagram

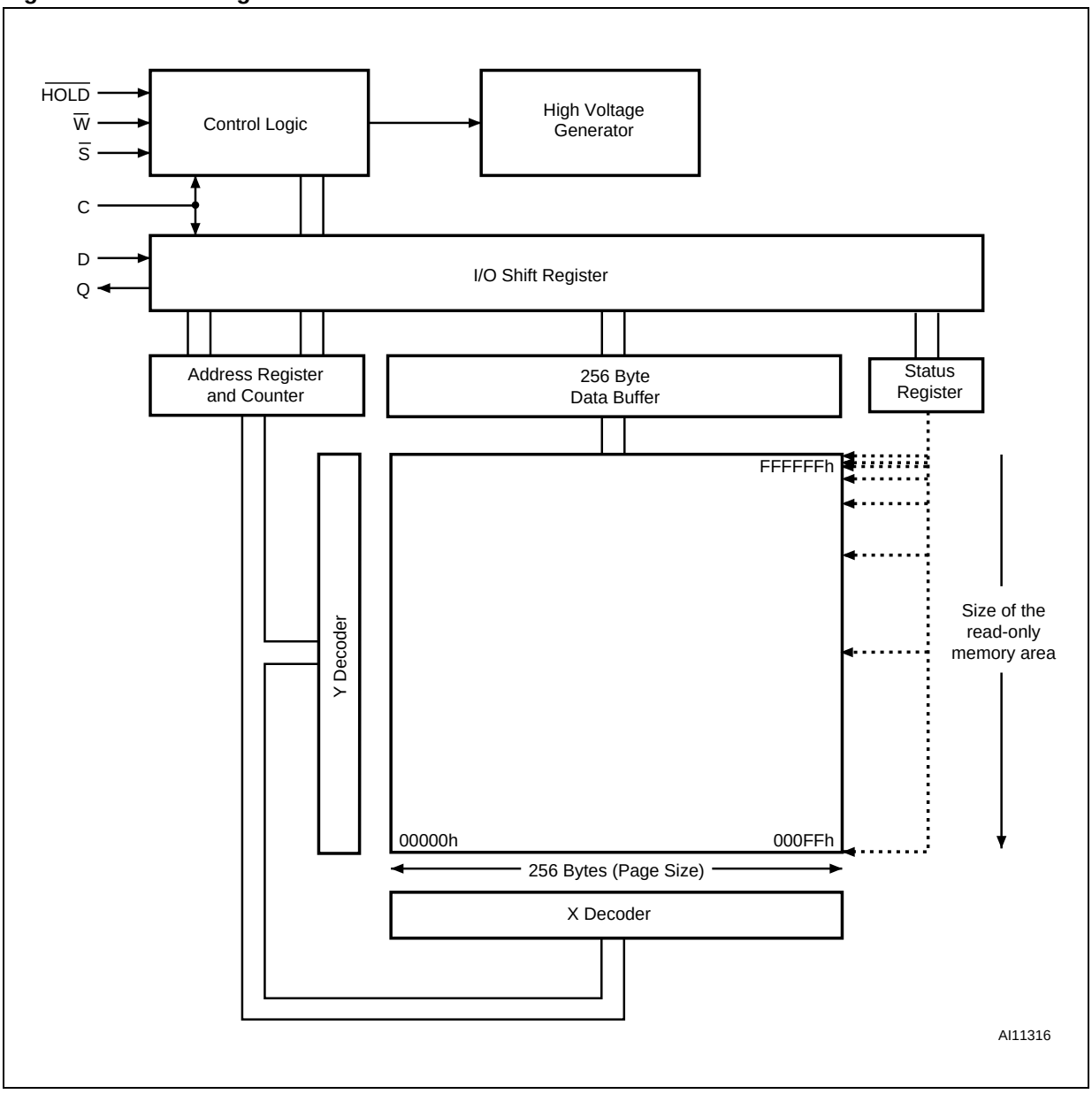


Table 3. Memory Organization

Sector	Address Range	
63	FC0000h	FFFFFFh
62	F80000h	FBFFFFh
61	F40000h	F7FFFFh
60	F00000h	F3FFFFh
59	EC0000h	EFFFFFh
58	E80000h	EBFFFFh
57	E40000h	E7FFFFh
56	E00000h	E3FFFFh
55	DC0000h	DFFFFFh
54	D80000h	DBFFFFh
53	D40000h	D7FFFFh
52	D00000h	D3FFFFh
51	CC0000h	CFFFFFh
50	C80000h	CBFFFFh
49	C40000h	C7FFFFh
48	C00000h	C3FFFFh
47	BC0000h	BFFFFFh
46	B80000h	BBFFFFh
45	B40000h	B7FFFFh
44	B00000h	B3FFFFh
43	AC0000h	AFFFFFh
42	A80000h	ABFFFFh
41	A40000h	A7FFFFh
40	A00000h	A3FFFFh
39	9C0000h	9FFFFFh
38	980000h	9BFFFFh
37	940000h	97FFFFh
36	900000h	93FFFFh
35	8C0000h	8FFFFFh
34	880000h	8BFFFFh
33	840000h	87FFFFh
32	800000h	83FFFFh
31	7C0000h	7FFFFFh
30	780000h	7BFFFFh
29	740000h	77FFFFh

Table 3. Memory Organization (continued)

Sector	Address Range	
28	700000h	73FFFFh
27	6C0000h	6FFFFFh
26	680000h	6BFFFFh
25	640000h	67FFFFh
24	600000h	63FFFFh
23	5C0000h	5FFFFFh
22	580000h	5BFFFFh
21	540000h	57FFFFh
20	500000h	53FFFFh
19	4C0000h	4FFFFFh
18	480000h	4BFFFFh
17	440000h	47FFFFh
16	400000h	43FFFFh
15	3C0000h	3FFFFFh
14	380000h	3BFFFFh
13	340000h	37FFFFh
12	300000h	33FFFFh
11	2C0000h	2FFFFFh
10	280000h	2BFFFFh
9	240000h	27FFFFh
8	200000h	23FFFFh
7	1C0000h	1FFFFFh
6	180000h	1BFFFFh
5	140000h	17FFFFh
4	100000h	13FFFFh
3	0C0000h	0FFFFFh
2	080000h	0BFFFFh
1	040000h	07FFFFh
0	000000h	03FFFFh

6 Instructions

All instructions, addresses and data are shifted in and out of the device, most significant bit first.

Serial Data Input (D) is sampled on the first rising edge of Serial Clock (C) after Chip Select ($\overline{S}$) is driven Low. Then, the one-byte instruction code must be shifted in to the device, most significant bit first, on Serial Data Input (D), each bit being latched on the rising edges of Serial Clock (C).

The instruction set is listed in *Table 4*.

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.

In the case of a Read Data Bytes (READ), Read Data Bytes at Higher Speed (Fast_Read), Read Status Register (RDSR) or Read Identification (RDID) instruction, the shifted-in instruction sequence is followed by a data-out sequence. Chip Select ($\overline{S}$) can be driven High after any bit of the data-out sequence is being shifted out.

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), Chip Select ($\overline{S}$) must be driven High exactly at a byte boundary, otherwise the instruction is rejected, and is not executed. That is, Chip Select ($\overline{S}$) must driven High when the number of clock pulses after Chip Select ($\overline{S}$) 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 4. Instruction Set

Instruction	Description	One-byte Instruction Code		Address Bytes	Dummy Bytes	Data Bytes
WREN	Write Enable	0000 0110	06h	0	0	0
WRDI	Write Disable	0000 0100	04h	0	0	0
RDID	Read Identification	1001 1111	9Fh	0	0	1 to 3
RDSR	Read Status Register	0000 0101	05h	0	0	1 to ∞
WRSR	Write Status Register	0000 0001	01h	0	0	1
READ	Read Data Bytes	0000 0011	03h	3	0	1 to ∞
FAST_READ	Read Data Bytes at Higher Speed	0000 1011	0Bh	3	1	1 to ∞
PP	Page Program	0000 0010	02h	3	0	1 to 256
SE	Sector Erase	1101 1000	D8h	3	0	0
BE	Bulk Erase	1100 0111	C7h	0	0	0

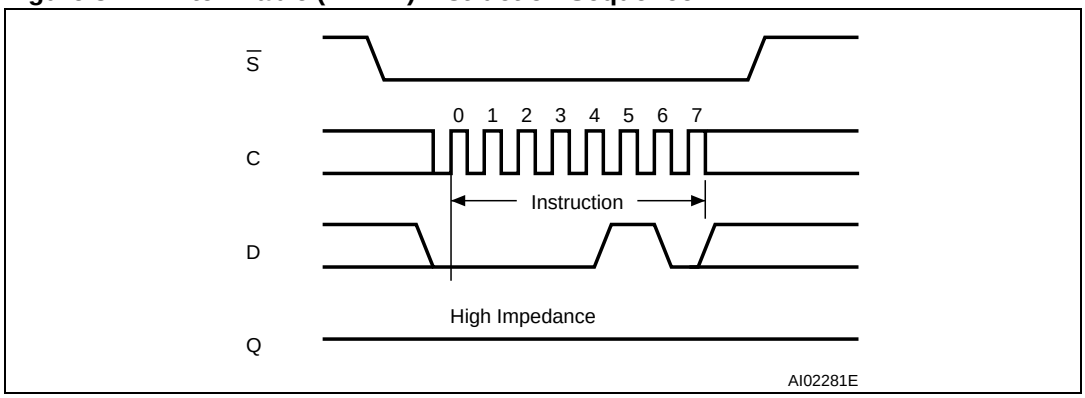
6.1 Write Enable (WREN)

The Write Enable (WREN) instruction (*Figure 8*) sets the Write Enable Latch (WEL) bit.

The Write Enable Latch (WEL) bit must be set prior to every Page Program (PP), Sector Erase (SE), Bulk Erase (BE) and Write Status Register (WRSR) instruction.

The Write Enable (WREN) instruction is entered by driving Chip Select ($\overline{S}$) Low, sending the instruction code, and then driving Chip Select ($\overline{S}$) High.

Figure 8. Write Enable (WREN) Instruction Sequence



6.2 Write Disable (WRDI)

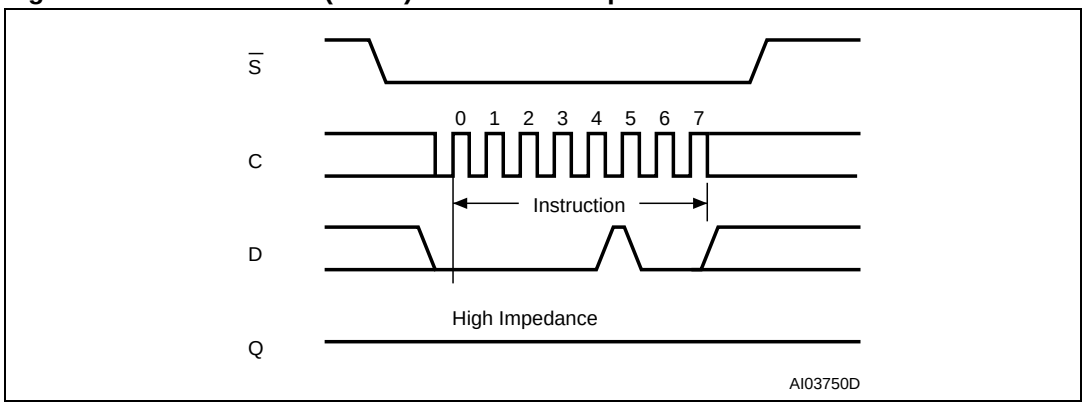
The Write Disable (WRDI) instruction (*Figure 9*) resets the Write Enable Latch (WEL) bit.

The Write Disable (WRDI) instruction is entered by driving Chip Select ($\overline{S}$) Low, sending the instruction code, and then driving Chip Select ($\overline{S}$) 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 9. Write Disable (WRDI) Instruction Sequence



6.3 Read Identification (RDID)

The Read Identification (RDID) instruction allows the 8-bit manufacturer identification to be read, followed by two bytes of device identification. The manufacturer identification is assigned by JEDEC, and has the value 20h for STMicroelectronics. The device identification is assigned by the device manufacturer, and indicates the memory type in the first byte (20h), and the memory capacity of the device in the second byte (18h).

Any Read Identification (RDID) instruction while an Erase or Program cycle is in progress, is not decoded, and has no effect on the cycle that is in progress.

The device is first selected by driving Chip Select ($\overline{S}$) Low. Then, the 8-bit instruction code for the instruction is shifted in. This is followed by the 24-bit device identification, stored in the memory, being shifted out on Serial Data Output (Q), each bit being shifted out during the falling edge of Serial Clock (C).

The instruction sequence is shown in *Figure 10*.

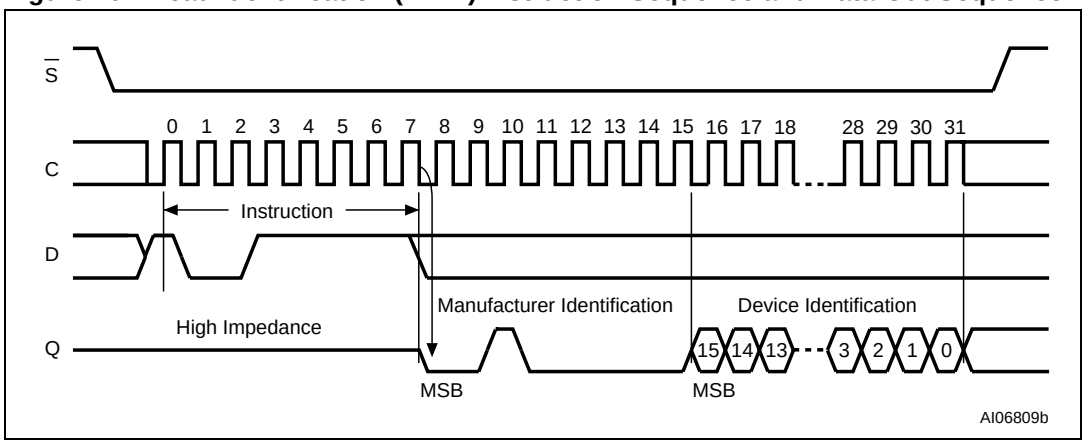
The Read Identification (RDID) instruction is terminated by driving Chip Select ($\overline{S}$) High at any time during data output.

When Chip Select ($\overline{S}$) is driven High, the device is put in the Standby Power mode. Once in the Standby Power mode, the device waits to be selected, so that it can receive, decode and execute instructions.

Table 5. Read Identification (RDID) Data-Out Sequence

Manufacturer Identification	Device Identification	
	Memory Type	Memory Capacity
20h	20h	18h

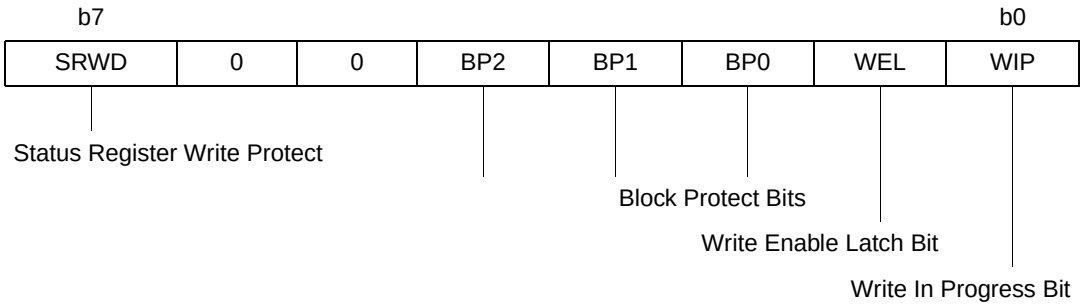
Figure 10. Read Identification (RDID) Instruction Sequence and Data-Out Sequence



6.4 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 11*.

Table 6. Status Register Format



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

6.4.1 WIP bit

The Write In Progress (WIP) bit indicates whether the memory is busy with a Write Status Register, Program or Erase cycle. When set to 1, such a cycle is in progress, when reset to 0 no such cycle is in progress.

6.4.2 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.

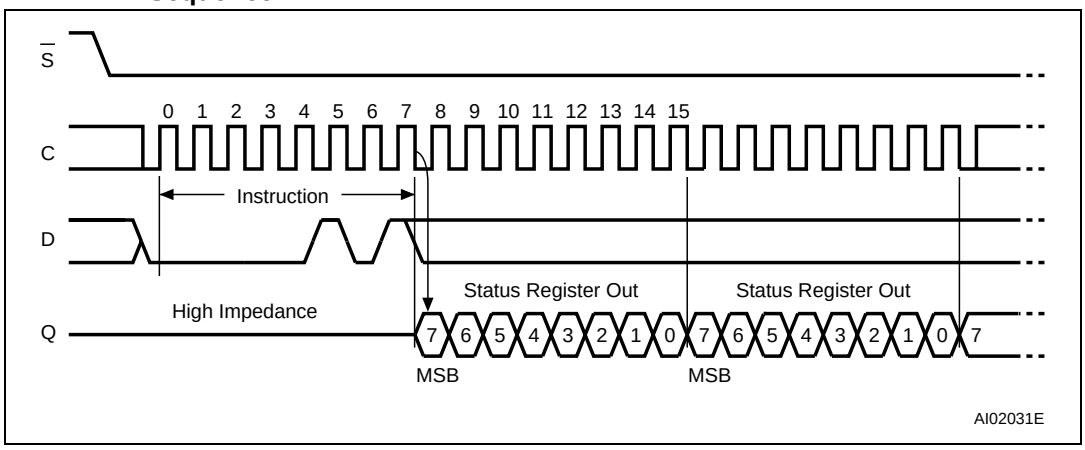
6.4.3 BP2, BP1, BP0 bits

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 more of the Block Protect (BP2, BP1, BP0) bits is set to 1, the relevant memory area (as defined in *Table 2*) 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.

6.4.4 SRWD bit

The Status Register Write Disable (SRWD) bit is operated in conjunction with the Write Protect ($\overline{W}$) signal. The Status Register Write Disable (SRWD) bit and Write Protect ($\overline{W}$) 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 ($\overline{W}$) 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.

Figure 11. Read Status Register (RDSR) Instruction Sequence and Data-Out Sequence



6.5 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 ($\overline{S}$) Low, followed by the instruction code and the data byte on Serial Data Input (D).

The instruction sequence is shown in *Figure 12*.

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

Chip Select ($\overline{S}$) 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 ($\overline{S}$) 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. When 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 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 ($\overline{W}$) signal. The Status Register Write Disable (SRWD) bit and Write Protect ($\overline{W}$) signal allow the device to be put in the Hardware Protected Mode (HPM). The Write Status Register (WRSR) instruction is not executed once the Hardware Protected Mode (HPM) is entered.

Table 7. Protection Modes

$\overline{W}$ Signal	SRWD Bit	Mode	Write Protection of the Status Register	Memory Content	
				Protected Area(1)	Unprotected Area(1)
1	0	Software Protected (SPM)	Status Register is Writable (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, Sector Erase and Bulk Erase	Ready to accept Page Program and Sector Erase instructions
0	0				
1	1				
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, Sector Erase and Bulk Erase	Ready to accept Page Program and Sector Erase instructions

1. As defined by the values in the Block Protect (BP2, BP1, BP0) bits of the Status Register, as shown in *Table 2: Protected Area Sizes*.

The protection features of the device are summarized in *Table 7*

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 ($\overline{W}$) 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 ($\overline{W}$):

- If Write Protect ($\overline{W}$) 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 ($\overline{W}$) 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.

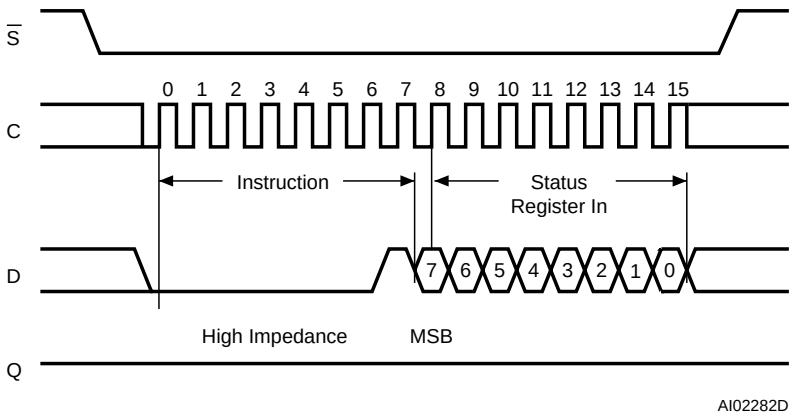
Regardless of the order of the two events, the Hardware Protected Mode (HPM) can be entered:

- by setting the Status Register Write Disable (SRWD) bit after driving Write Protect ($\overline{W}$) Low
- or by driving Write Protect ($\overline{W}$) 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 ($\overline{W}$) High.

If Write Protect ($\overline{W}$) 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.

Figure 12. Write Status Register (WRSR) Instruction Sequence



6.6 Read Data Bytes (READ)

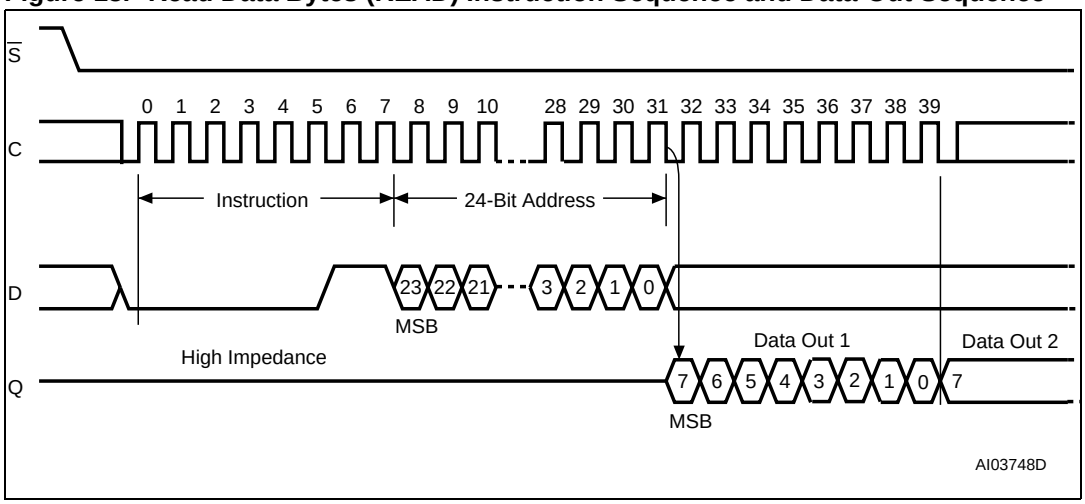
The device is first selected by driving Chip Select ($\overline{S}$) Low. The instruction code for the Read Data Bytes (READ) instruction is followed by a 3-byte address (A23-A0), each bit being latched-in during the rising edge of Serial Clock (C). Then the memory contents, at that address, is shifted out on Serial Data Output (Q), each bit being shifted out, at a maximum frequency f_R, during the falling edge of Serial Clock (C).

The instruction sequence is shown in *Figure 13*.

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 000000h, allowing the read sequence to be continued indefinitely.

The Read Data Bytes (READ) instruction is terminated by driving Chip Select ($\overline{S}$) High. Chip Select ($\overline{S}$) can be driven High at any time during data output. Any Read Data Bytes (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 13. Read Data Bytes (READ) Instruction Sequence and Data-Out Sequence



6.7 Read Data Bytes at Higher Speed (FAST_READ)

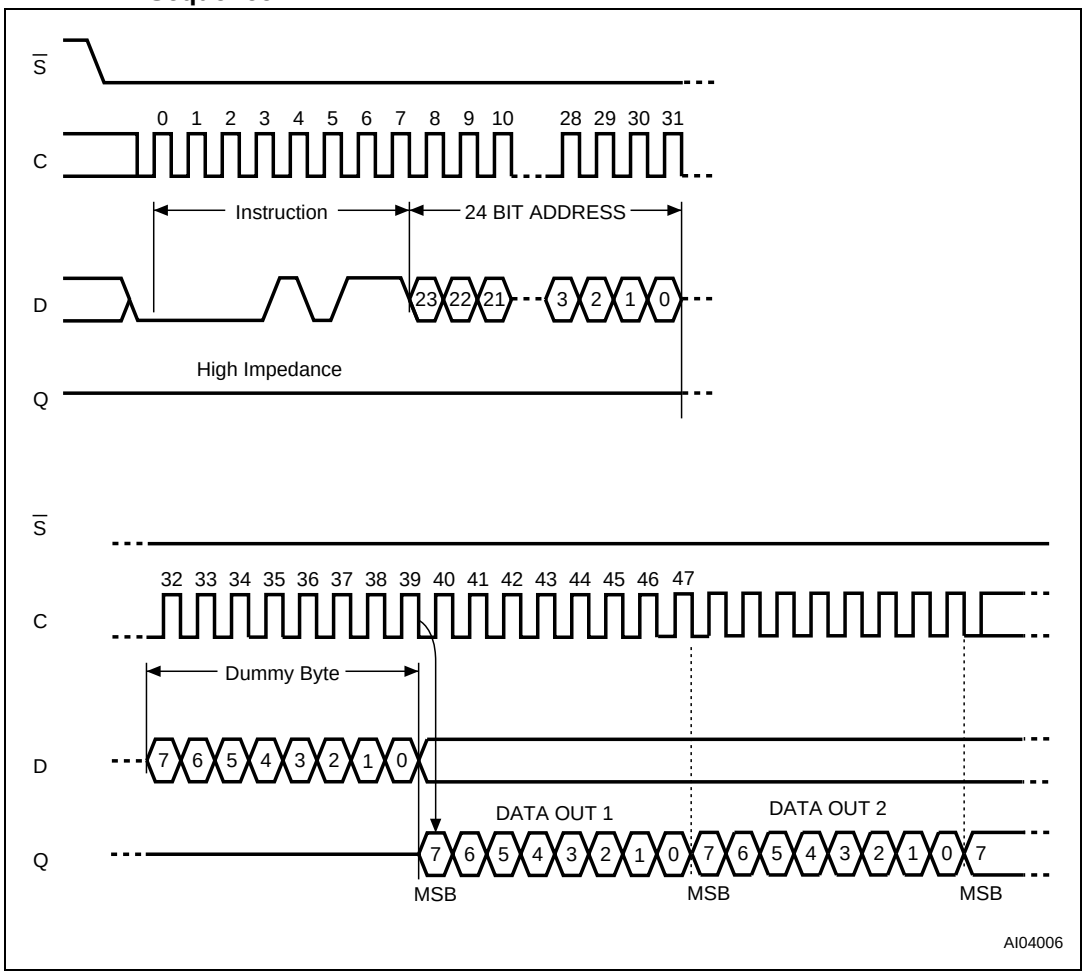
The device is first selected by driving Chip Select ($\overline{S}$) Low. The instruction code for the Read Data Bytes at Higher Speed (FAST_READ) instruction is followed by a 3-byte address (A23-A0) and a dummy byte, each bit being latched-in during the rising edge of Serial Clock (C). Then the memory contents, at that address, is shifted out on Serial Data Output (Q), each bit being shifted out, at a maximum frequency f_C, during the falling edge of Serial Clock (C).

The instruction sequence is shown in *Figure 14*.

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 at Higher Speed (FAST_READ) instruction. When the highest address is reached, the address counter rolls over to 000000h, allowing the read sequence to be continued indefinitely.

The Read Data Bytes at Higher Speed (FAST_READ) instruction is terminated by driving Chip Select ($\overline{S}$) High. Chip Select ($\overline{S}$) can be driven High at any time during data output. Any Read Data Bytes at Higher Speed (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 14. Read Data Bytes at Higher Speed (FAST_READ) Instruction and Data-Out Sequence



6.8 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 ($\overline{S}$) Low, followed by the instruction code, three address bytes and at least one data byte on Serial Data Input (D). If the 8 least significant address bits (A7-A0) are not all zero, all transmitted data that goes beyond the end of the current page are programmed from the start address of the same page (from the address whose 8 least significant bits (A7-A0) are all zero). Chip Select ($\overline{S}$) must be driven Low for the entire duration of the sequence. The instruction sequence is shown in *Figure 15*.

If more than 256 bytes are sent to the device, previously latched data are discarded and the last 256 data bytes are guaranteed to be programmed correctly within the same page. If less 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.

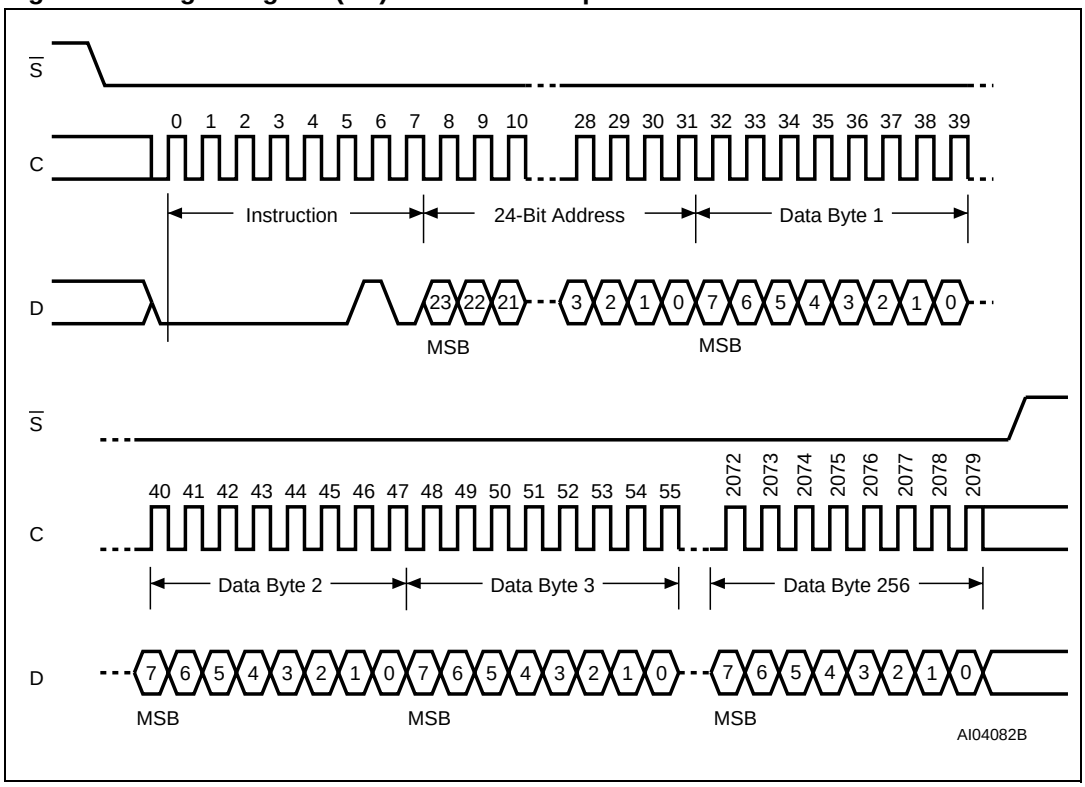
For optimized timings, it is recommended to use the Page Program (PP) instruction to program all consecutive targeted Bytes in a single sequence versus using several Page Program (PP) sequences with each containing only a few Bytes (see *Table 14: AC Characteristics*).

Chip Select ($\overline{S}$) 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 ($\overline{S}$) 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 which is protected by the Block Protect (BP2, BP1, BP0) bits (see *Table 2* and *Table 3*) is not executed.

Figure 15. Page Program (PP) Instruction Sequence



6.9 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).

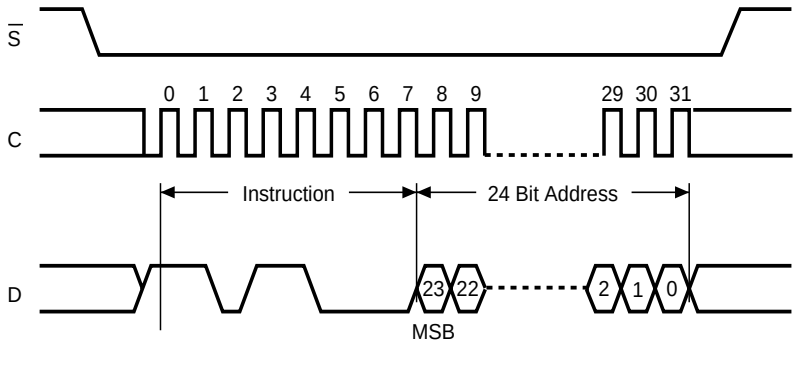
The Sector Erase (SE) instruction is entered by driving Chip Select ($\overline{S}$) Low, followed by the instruction code, and three address bytes on Serial Data Input (D). Any address inside the Sector (see *Table 3*) is a valid address for the Sector Erase (SE) instruction. Chip Select ($\overline{S}$) must be driven Low for the entire duration of the sequence.

The instruction sequence is shown in *Figure 16*.

Chip Select ($\overline{S}$) 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 ($\overline{S}$) 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 a page which is protected by the Block Protect (BP2, BP1, BP0) bits (see *Table 2* and *Table 3*) is not executed.

Figure 16. Sector Erase (SE) Instruction Sequence



6.10 Bulk Erase (BE)

The Bulk Erase (BE) instruction sets all bits to 1 (FFh). 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).

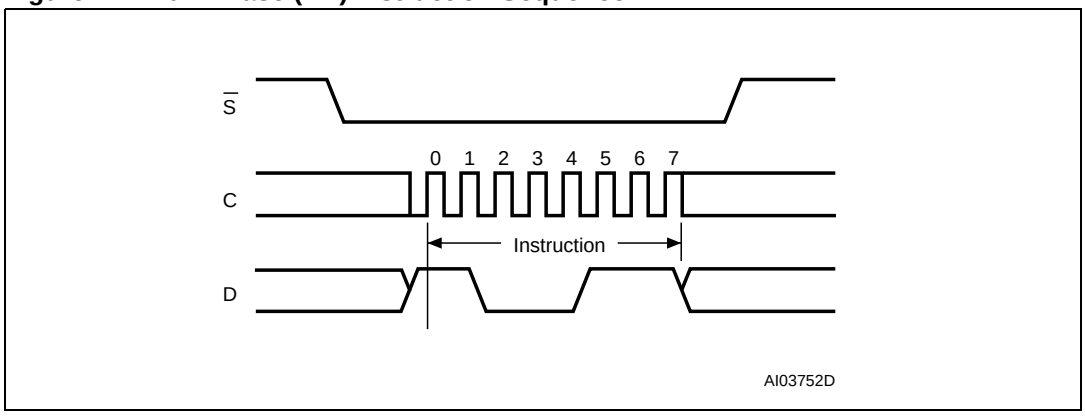
The Bulk Erase (BE) instruction is entered by driving Chip Select ($\overline{S}$) Low, followed by the instruction code on Serial Data Input (D). Chip Select ($\overline{S}$) must be driven Low for the entire duration of the sequence.

The instruction sequence is shown in *Figure 17*.

Chip Select ($\overline{S}$) must be driven High after the eighth bit of the instruction code has been latched in, otherwise the Bulk Erase instruction is not executed. As soon as Chip Select ($\overline{S}$) 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.

The Bulk Erase (BE) instruction is executed only if all Block Protect (BP2, BP1, BP0) bits are 0. The Bulk Erase (BE) instruction is ignored if one, or more, sectors are protected.

Figure 17. Bulk Erase (BE) Instruction Sequence



7 Power-up and power-down

At Power-up and Power-down, the device must not be selected (that is Chip Select ($\overline{S}$) must follow the voltage applied on V_{CC}) until V_{CC} reaches the correct value:

- V_{CC}(min) at Power-up, and then for a further delay of t_{VSL}
- V_{SS} at Power-down

Usually a simple pull-up resistor on Chip Select ($\overline{S}$) can be used to ensure 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 Power On Reset (POR) threshold voltage, V_{WI} – all operations are disabled, and the device does not respond to any instruction.

Moreover, the device ignores all Write Enable (WREN), Page Program (PP), Sector Erase (SE), Bulk Erase (BE) and Write Status Register (WRSR) instructions until a time delay of t_{PUW} has elapsed after the moment that V_{CC} rises above the V_{WI} threshold. However, the 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 the later of:

- t_{PUW} after V_{CC} passed the V_{WI} threshold
- t_{VSL} after V_{CC} passed the V_{CC}(min) level

These values are specified in *Table 8*.

If the delay, t_{VSL}, has elapsed, after V_{CC} has risen above V_{CC}(min), the device can be selected for READ instructions even if the t_{PUW} delay is not yet fully elapsed.

At Power-up, the device is in the following state:

- The device is in the Standby Power mode
- The Write Enable Latch (WEL) bit is reset.

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

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

Figure 18. Power-up Timing

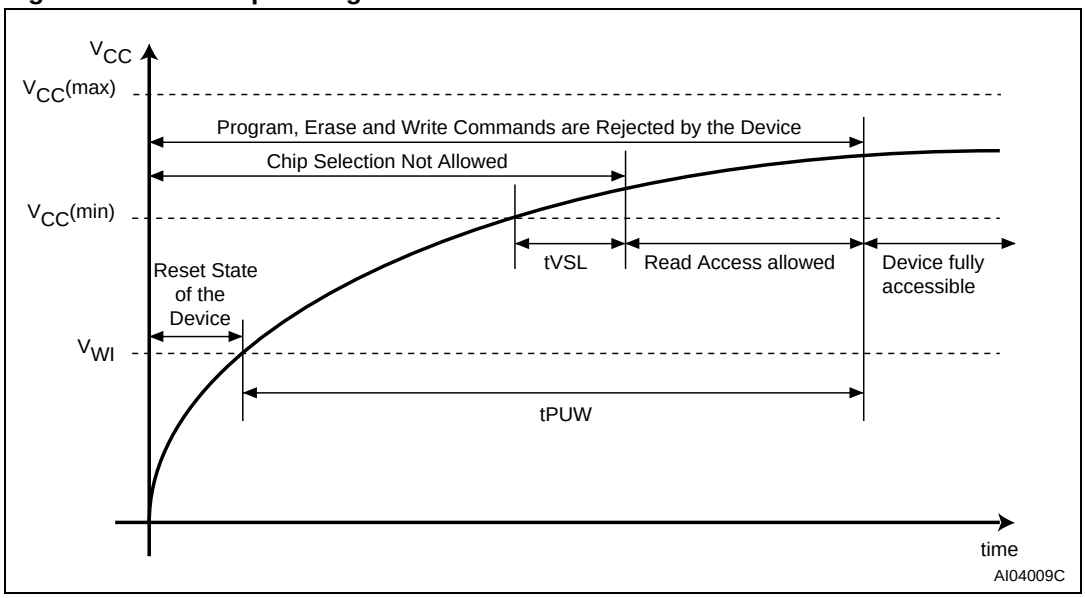


Table 8. Power-Up Timing and V_{WI} Threshold

Symbol	Parameter	Min.	Max.	Unit
t_{VSL} (1)	V_{CC}(min) to $\overline{S}$ Low	60		µs
t_{PUW} (1)	Time delay to Write instruction	1	10	ms
V_{WI}	Write Inhibit Voltage	1.5	2.5	V

1. These parameters are characterized only.

8 Initial delivery state

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

9 Maximum rating

Stressing the device outside the ratings listed in *Table 9* may cause permanent damage to the device. These are stress ratings only, and operation of the device at these, or any other conditions outside 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. Refer also to the STMicroelectronics SURE Program and other relevant quality documents.

Table 9. Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Unit
T_{STG}	Storage Temperature	–65	150	°C
V_{IO}	Input and Output Voltage (with respect to Ground)	–0.5	4.0	V
V_{CC}	Supply Voltage	–0.2	4.0	V
V_{ESD}	Electrostatic Discharge Voltage (Human Body model) (1)	–2000	2000	V

1. JEDEC Std JESD22-A114A (C1=100 pF, R1=1500 Ω, R2=500 Ω)

10 DC and AC parameters

This section summarizes the operating and measurement conditions, and the DC and AC characteristics of the device. The parameters in the DC and AC Characteristic tables that follow are derived from tests performed under the Measurement Conditions summarized in the relevant tables. Designers should check that the operating conditions in their circuit match the measurement conditions when relying on the quoted parameters.

Table 10. Operating Conditions

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Supply Voltage	2.7	3.6	V
T_A	Ambient Operating Temperature	–40	85	°C

Table 11. AC Measurement Conditions

Symbol	Parameter	Min.	Max.	Unit
C_L	Load Capacitance	30		pF
	Input Rise and Fall Times		5	ns
	Input Pulse Voltages	$0.2V_{CC}$ to $0.8V_{CC}$		V
	Input Timing Reference Voltages	$0.3V_{CC}$ to $0.7V_{CC}$		V
	Output Timing Reference Voltages	V_{CC} / 2		V

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

Figure 19. AC Measurement I/O Waveform

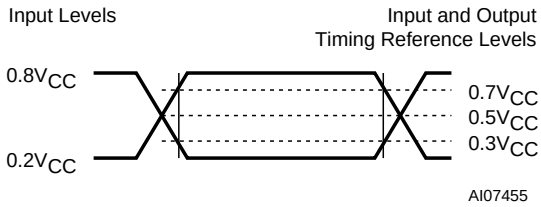


Table 12. Capacitance

Symbol	Parameter	Test Condition	Min.	Max.	Unit
C_{OUT}	Output Capacitance (Q)	V_{OUT} = 0V		8	pF
C_{IN}	Input Capacitance (other pins)	V_{IN} = 0V		6	pF

1. Sampled only, not 100% tested, at T_A=25°C and a frequency of 20 MHz.

Table 13. DC Characteristics

Symbol	Parameter	Test Condition (in addition to those in *Table 10*)	Min.	Max.	Unit
I_{LI}	Input Leakage Current			± 2	µA
I_{LO}	Output Leakage Current			± 2	µA
I_{CC1}	Standby Current	$\overline{S}$ = V_{CC}, V_{IN} = V_{SS} or V_{CC}		100	µA
I_{CC3}	Operating Current (READ)	C = 0.1V_{CC} / 0.9.V_{CC} at 50MHz, Q = open		8	mA
		C = 0.1V_{CC} / 0.9.V_{CC} at 20MHz, Q = open		4	mA
I_{CC4}	Operating Current (PP)	$\overline{S}$ = V_{CC}		20	mA
I_{CC5}	Operating Current (WRSR)	$\overline{S}$ = V_{CC}		20	mA
I_{CC6}	Operating Current (SE)	$\overline{S}$ = V_{CC}		20	mA
I_{CC7}	Operating Current (BE)	$\overline{S}$ = V_{CC}		20	mA
V_{IL}	Input Low Voltage		– 0.5	0.3V_{CC}	V
V_{IH}	Input High Voltage		0.7V_{CC}	V_{CC}+0.2	V
V_{OL}	Output Low Voltage	I_{OL} = 1.6mA		0.4	V
V_{OH}	Output High Voltage	$_{IOH}$ = –100µA	V_{CC}–0.2		V

Table 14. AC Characteristics

Test conditions specified in *Table 10* and *Table 11*						
Symbol	**Alt.**	**Parameter**	**Min.**	**Typ.**	**Max.**	**Unit**
f_C	f_C	Clock Frequency for the following instructions: FAST_READ, PP, SE, BE, WREN, WRDI, RDID, RDSR, WRSR	D.C.		50	MHz
f_R		Clock Frequency for READ instructions	D.C.		20	MHz
t_{CH}(1)	t_{CLH}	Clock High Time	9			ns
t_{CL}(1)	t_{CLL}	Clock Low Time	9			ns
t_{CLCH}(2)		Clock Rise Time(3) (peak to peak)	0.1			V/ns
t_{CHCL}(2)		Clock Fall Time(3) (peak to peak)	0.1			V/ns
t_{SLCH}	t_{CSS}	$\overline{S}$ Active Setup Time (relative to C)	5			ns
t_{CHSL}		$\overline{S}$ Not Active Hold Time (relative to C)	5			ns
t_{DVCH}	t_{DSU}	Data In Setup Time	2			ns
t_{CHDX}	t_{DH}	Data In Hold Time	5			ns
t_{CHSH}		$\overline{S}$ Active Hold Time (relative to C)	5			ns
t_{SHCH}		$\overline{S}$ Not Active Setup Time (relative to C)	5			ns
t_{SHSL}	t_{CSH}	$\overline{S}$ Deselect Time	100			ns
t_{SHQZ}(2)	t_{DIS}	Output Disable Time			8	ns
t_{CLQV}	t_V	Clock Low to Output Valid			8	ns
t_{CLQX}	t_{HO}	Output Hold Time	0			ns
t_{HLCH}		$\overline{HOLD}$ Setup Time (relative to C)	5			ns
t_{CHHH}		$\overline{HOLD}$ Hold Time (relative to C)	5			ns
t_{HHCH}		$\overline{HOLD}$ Setup Time (relative to C)	5			ns
t_{CHHL}		$\overline{HOLD}$ Hold Time (relative to C)	5			ns
t_{HHQX}(2)	t_{LZ}	$\overline{HOLD}$ to Output Low-Z			8	ns
t_{HLQZ}(2)	t_{HZ}	$\overline{HOLD}$ to Output High-Z			8	ns
t_{WHSL}(4)		Write Protect Setup Time	20			ns
t_{SHWL}(4)		Write Protect Hold Time	100			ns
t_W		Write Status Register Cycle Time		5	15	ms
t_{PP}(5)		Page Program Cycle Time (256 Bytes)		2.5	7	ms
		Page Program Cycle Time (n Bytes)		2.5		
t_{SE}		Sector Erase Cycle Time		2	6	s
t_{BE}		Bulk Erase Cycle Time		105	250	s

1. t_{CH} and t_{CL} must be greater than or equal to $1/f_C$ (max).
2. Value is guaranteed by characterization, not 100% tested in production.
3. Expressed as a slew-rate.
4. Only applicable as a constraint for WRSR instruction when SRWD is set to 1.
5. Due to the Multi Level Cell technology, when using the Page Program (PP) instruction to program consecutive Bytes, optimized timings are obtained with one sequence including all the Bytes versus several sequences of only a few Bytes. If only a single byte is programmed, the estimated programming time is close to the time needed to program a full page of 256 Bytes. Therefore, it is highly recommended to use the Page Program (PP) instruction with a sequence of 256 consecutive Bytes. ($1 \leq n \leq 256$)

Figure 20. Serial Input Timing

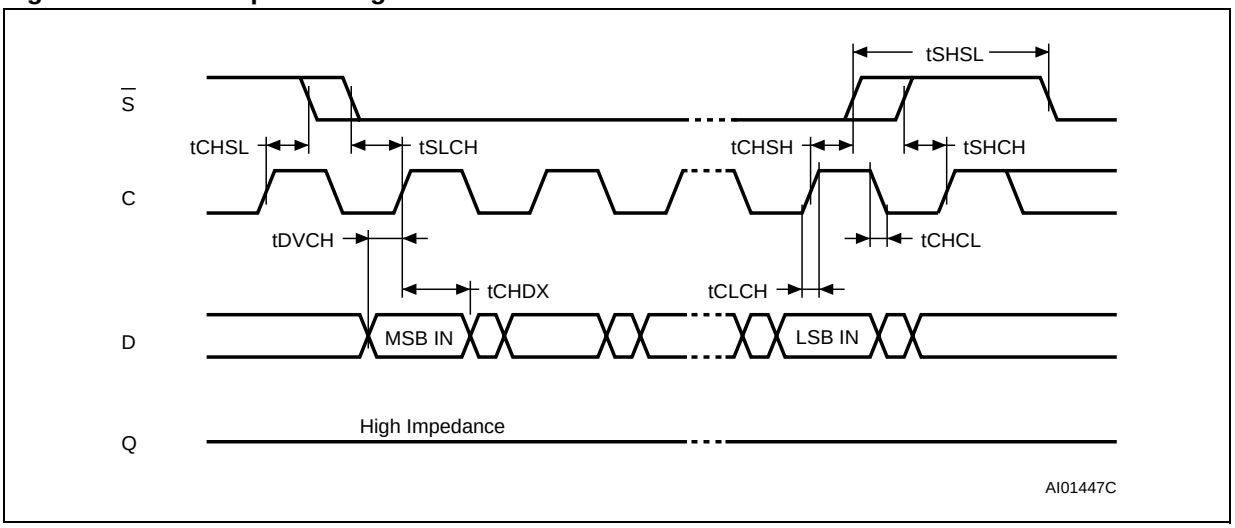


Figure 21. Write Protect Setup and Hold Timing during WRSR when SRWD=1

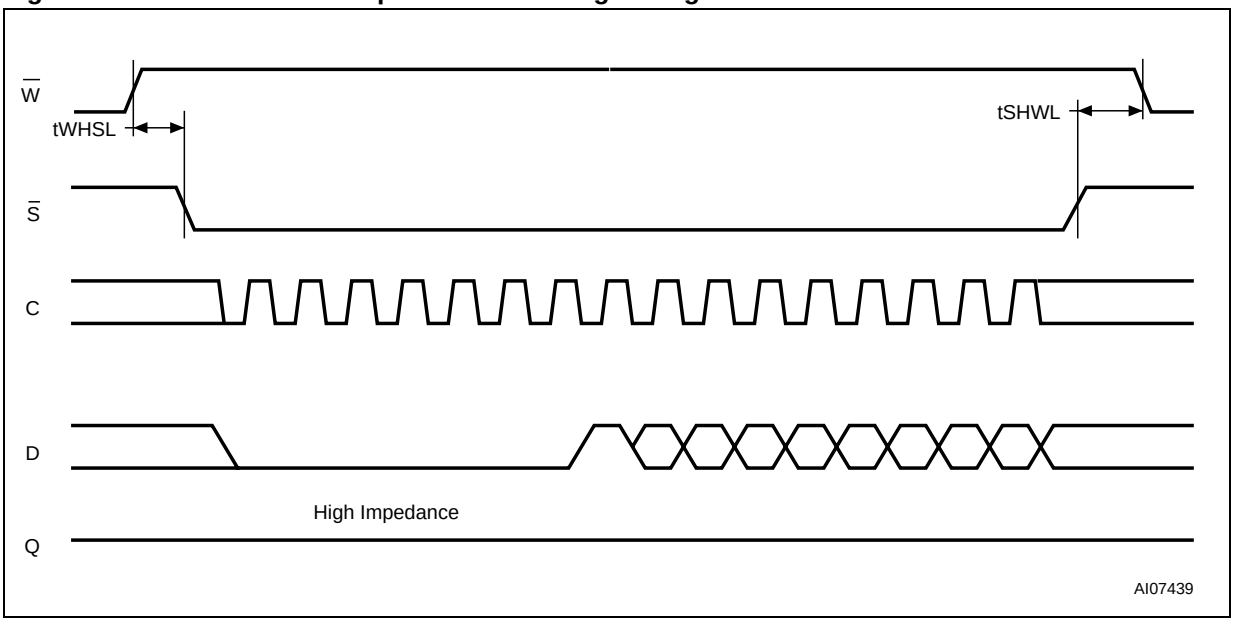


Figure 22. Hold Timing

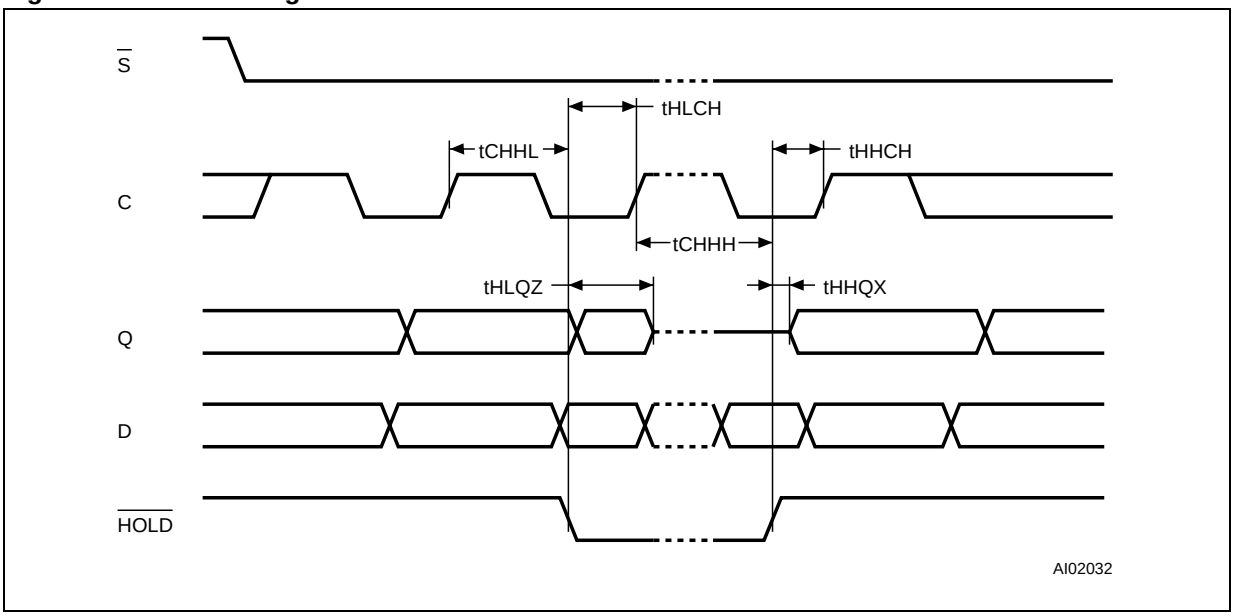
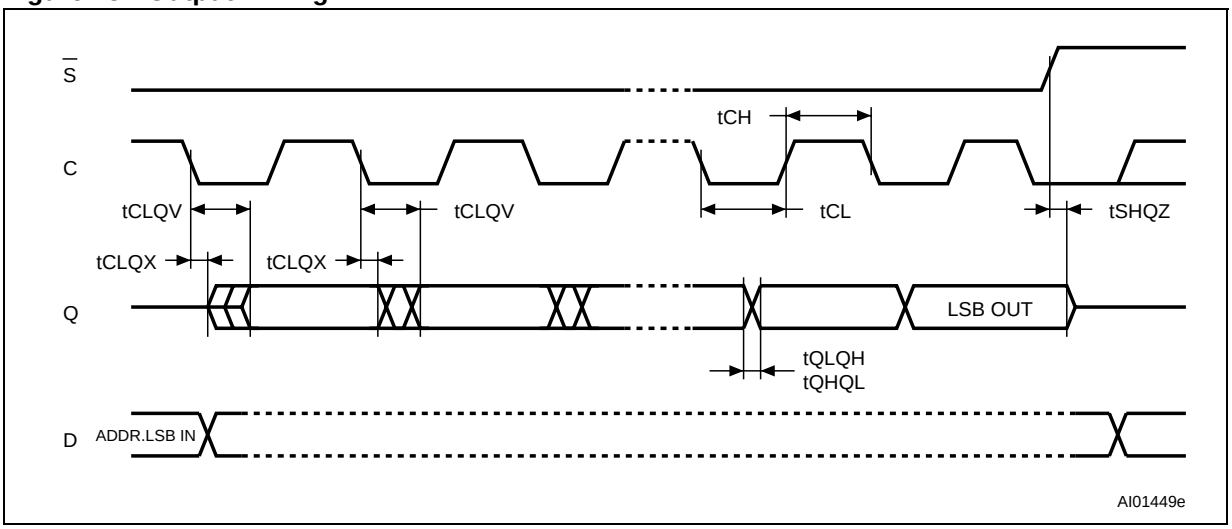
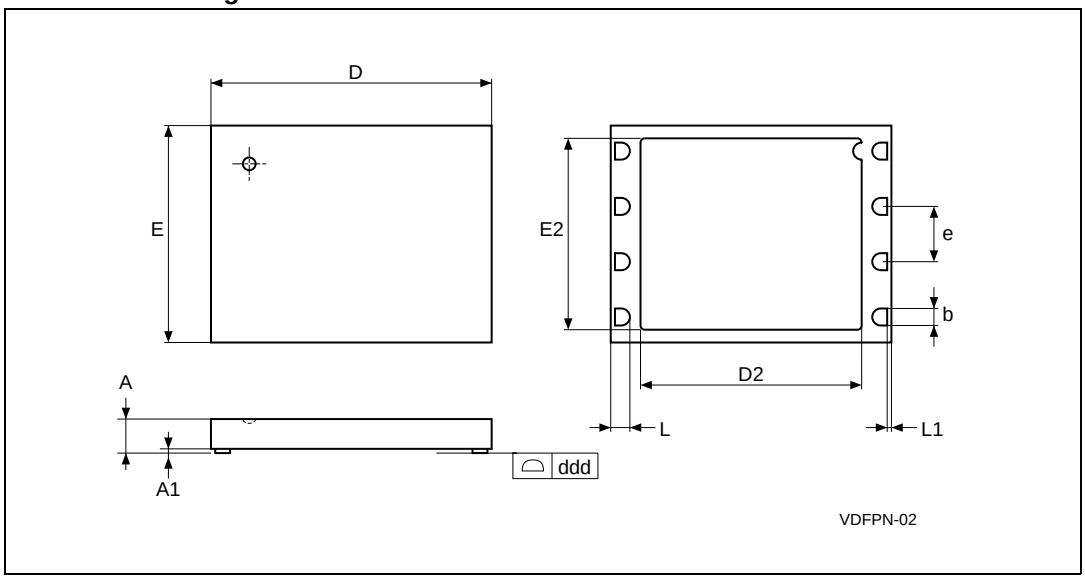


Figure 23. Output Timing



11 Package mechanical

Figure 24. VDFPN8 (MLP8), 8-lead Very thin Dual Flat Package No lead, 8x6mm, Package Outline

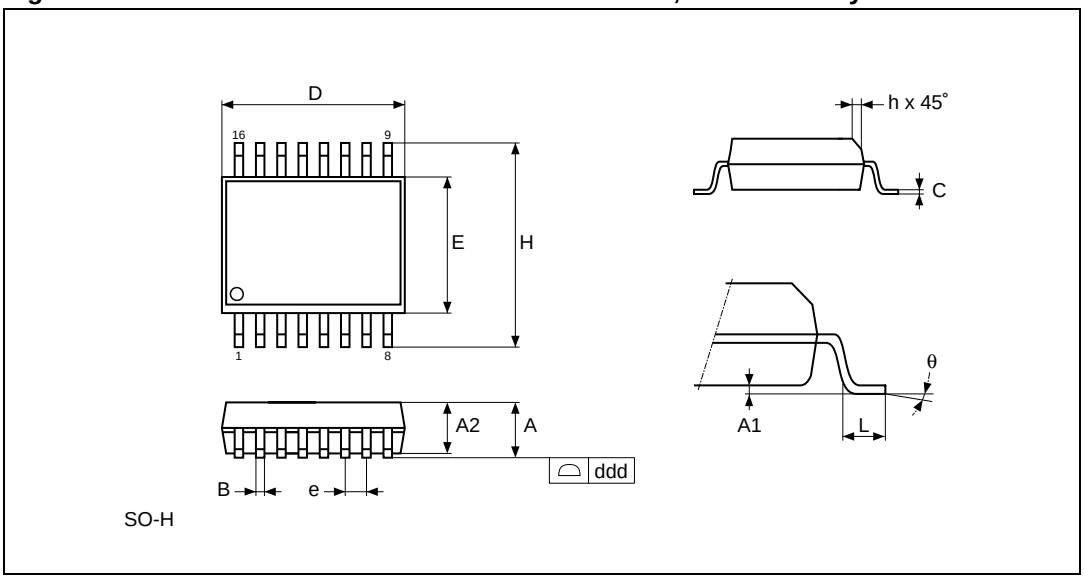


1. Drawing is not to scale.
2. The circle in the top view of the package indicates the position of pin 1.

Table 15. VDFPN8 (MLP8), 8-lead Very thin Dual Flat Package No lead, 8x6mm, Package Mechanical Data

Symbol	millimeters			inches		
	Typ.	Min.	Max.	Typ.	Min.	Max.
A	0.85		1.00	0.0335		0.0394
A1		0.00	0.05		0.0000	0.0020
b	0.40	0.35	0.48	0.0157	0.0138	0.0189
D	8.00			0.3150		
D2	6.40			0.2520		
ddd			0.05			0.0020
E	6.00			0.2362		
E2	4.80			0.1890		
e	1.27	–	–	0.0500	–	–
K		0.20			0.0079	
L	0.50	0.45	0.60	0.0197	0.0177	0.0236
L1			0.15			0.0059
N	8			8		

Figure 25. SO16 wide – 16 lead Plastic Small Outline, 300 mils body width



1. Drawing is not to scale.

Table 16. SO16 wide – 16 lead Plastic Small Outline, 300 mils body width

Symbol	millimeters			inches		
	Typ	Min	Max	Typ	Min	Max
A		2.35	2.65		0.093	0.104
A1		0.10	0.30		0.004	0.012
B		0.33	0.51		0.013	0.020
C		0.23	0.32		0.009	0.013
D		10.10	10.50		0.398	0.413
E		7.40	7.60		0.291	0.299
e	1.27	–	–	0.050	–	–
H		10.00	10.65		0.394	0.419
h		0.25	0.75		0.010	0.030
L		0.40	1.27		0.016	0.050
θ		0°	8°		0°	8°
ddd			0.10			0.004

12 Part numbering

Table 17. Ordering Information Scheme

Example: M25P128 – V MF 6 T P

Device Type

M25P = Serial Flash Memory for Code Storage

Device Function

128 = 128Mit (16Mbx 8)

Operating Voltage

V = V_{CC} = 2.7 to 3.6V

Package

MF = SO16 (300 mil width)

ME = VDFPN8 8x6mm (MLP8)

Device Grade

6 = Industrial temperature range, –40 to 85 °C.
Device tested with standard test flow

Option

blank = Standard Packing

T = Tape and Reel Packing

Plating Technology

P or G = ECOPACK® (RoHs compliant)

For a list of available options (speed, package, etc.) or for further information on any aspect of this device, please contact your nearest ST Sales Office.

The category of second-Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label.

13 Revision history

Table 18. Document Revision History

Date	Revision	Changes
02-May-2005	0.1	First issue.
09-Jun-2005	0.2	*Table 2: Protected Area Sizes* updated. Memory capacity modified in *Section 6.3: Read Identification (RDID)*.
28-Aug-2005	0.3	Updated t_{PP} values in *Table 14: AC Characteristics* and t_{VSL} value in *Table 8: Power-Up Timing and VWI Threshold*. Modified information in *Section 4.1: Page programming* and *Section 6.8: Page Program (PP)*.
20-Jan-2006	1	Document status promoted from Target specification to Preliminary data. Packages are ECOPACK® compliant. Blank option removed under *Plating Technology* in *Table 17*. Read Electronic Signature (RES) instruction removed. I_{CC1} parameter updated in *Table 13: DC Characteristics*.