Features

- **Serial Peripheral Interface (SPI) Compatible**
- **Supports SPI Modes 0 (0,0) and 3 (1,1)**
- **Low Voltage and Standard Voltage Operation**
  - **5.0 (V_{CC} = 4.5V to 5.5V)**
  - **2.7 (V_{CC} = 2.7V to 5.5V)**
  - **1.8 (V_{CC} = 1.8V to 3.6V)**
- **2.1 MHz Clock Rate**
- **32-Byte Page Mode**
- **Block Write Protection**
  - **Protect 1/4, 1/2, or Entire Array**
- **Write Protect ($\overline{WP}$) Pin and Write Disable Instructions for Both Hardware and Software Data Protection**
- **Self-Timed Write Cycle (5 ms Typical)**
- **High Reliability**
  - **Endurance: 100,000 Cycles**
  - **Data Retention: 100 Years**
- **Automotive Grade and Extended Temperature Devices Available**
- **8-Pin PDIP, 14-pin, 16-pin JEDEC SOIC, and 20-Pin TSSOP Packages**

Description

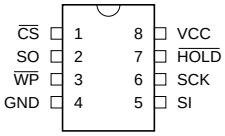
The AT25128 provides 131,072 bits of serial electrically erasable programmable read only memory (EEPROM) organized as 16,384 words of 8 bits each. The device is optimized for use in many industrial and commercial applications where low power and low voltage operation are essential. The AT25128 is available in space saving 8-pin PDIP, JEDEC SOIC, and 14-pin and 20-pin TSSOP packages.

(continued)

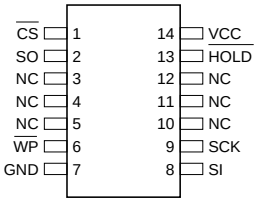
Pin Configurations

Pin Name	Function
$\overline{CS}$	Chip Select
SCK	Serial Data Clock
SI	Serial Data Input
SO	Serial Data Output
GND	Ground
V_{CC}	Power Supply
$\overline{WP}$	Write Protect
$\overline{HOLD}$	Suspends Serial Input
NC	No Connect
DC	Don't Connect

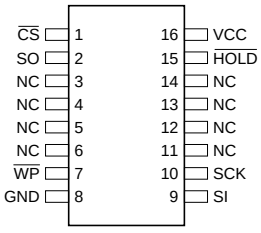
8-Pin PDIP



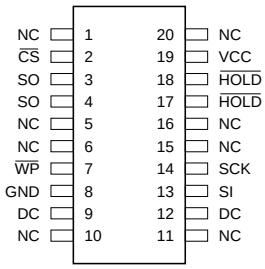
14-Pin SOIC



16-Lead SOIC



20-Lead TSSOP*



* Note: Pins 3, 4 and 17, 18 are internally connected for 14-lead TSSOP socket compatibility.

SPI Serial E^2PROMs

128K (16384 x 8)

AT25128
Preliminary

Description (Continued)

The AT25128 is enabled through the Chip Select pin ($\overline{CS}$) and accessed via a 3-wire interface consisting of Serial Data Input (SI), Serial Data Output (SO), and Serial Clock (SCK). All programming cycles are completely self-timed, and no separate ERASE cycle is required before WRITE.

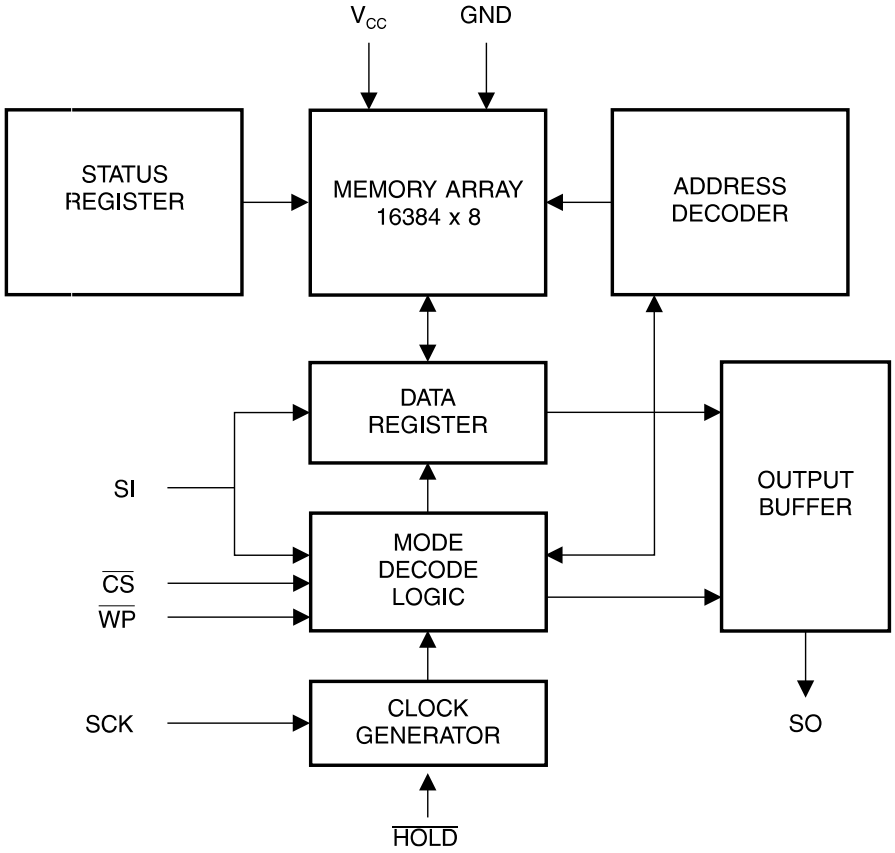
BLOCK WRITE protection is enabled by programming the status register with one of four blocks of write protection. Separate program enable and program disable instructions are provided for additional data protection. Hardware data protection is provided via the $\overline{WP}$ pin to protect against inadvertent write attempts to the status register. The $\overline{HOLD}$ pin may be used to suspend any serial communication without resetting the serial sequence.

Absolute Maximum Ratings*

Operating Temperature	-55°C to +125°C
Storage Temperature	-65°C to +150°C
Voltage on Any Pin with Respect to Ground	-1.0V to +7.0V
Maximum Operating Voltage	6.25V
DC Output Current	5.0 mA

*NOTICE: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Block Diagram



Pin Capacitance [1]

Applicable over recommended operating range from T_A = 25°C, f = 1.0 MHz, V_{CC} = +5.0V (unless otherwise noted).

	Test Conditions	Max	Units	Conditions
C_{OUT}	Output Capacitance (SO)	8	pF	V_{OUT} = 0V
C_{IN}	Input Capacitance ($\overline{CS}$, SCK, SI, $\overline{WP}$, $\overline{HOLD}$)	6	pF	V_{IN} = 0V

Note: 1. This parameter is characterized and is not 100% tested.

DC Characteristics

Applicable over recommended operating range from: T_{AI} = -40°C to +85°C, V_{CC} = +1.8V to +5.5V, T_{AC} = 0°C to +70°C, V_{CC} = +1.8V to +5.5V (unless otherwise noted).

Symbol	Parameter	Test Condition		Min	Typ	Max	Units
V_{CC1}	Supply Voltage			1.8		3.6	V
V_{CC2}	Supply Voltage			2.7		5.5	V
V_{CC3}	Supply Voltage			4.5		5.5	V
I_{CC1}	Supply Current	V_{CC} = 5.0V at 1 MHz, SO = Open				3.0	mA
I_{CC2}	Supply Current	V_{CC} = 5.0V at 2 MHz, SO = Open				5.0	mA
I_{SB1}	Standby Current	V_{CC} = 1.8V	$\overline{CS}$ = V_{CC}			0.1	µA
I_{SB2}	Standby Current	V_{CC} = 2.7V	$\overline{CS}$ = V_{CC}		0.2	0.5	µA
I_{SB3}	Standby Current	V_{CC} = 5.0V	$\overline{CS}$ = V_{CC}		0.5	2.0	µA
I_{IL}	Input Leakage	V_{IN} = 0V to V_{CC}		-3.0		3.0	µA
I_{OL}	Output Leakage	V_{IN} = 0V to V_{CC}, T_{AC} = 0°C to 70°C		-3.0		3.0	µA
V_{IL} [1]	Input Low Voltage			-1.0		V_{CC} x 0.3	V
V_{IH} [1]	Input High Voltage			V_{CC} x 0.7		V_{CC} + 0.5	V
V_{OL1}	Output Low Voltage	4.5V ≤ V_{CC} ≤ 5.5V	I_{OL} = 3.0 mA			0.4	V
V_{OH1}	Output High Voltage		I_{OH} = -1.6 mA	V_{CC} - 0.8			V
V_{OL2}	Output Low Voltage	1.8V ≤ V_{CC} ≤ 3.6V	I_{OL} = 0.15 mA			0.2	V
V_{OH2}	Output High Voltage		I_{OH} = -100 µA	V_{CC} - 0.2			V

Note: 1. V_{IL} min and V_{IH} max are reference only and are not tested.

AC Characteristics

Applicable over recommended operating range from T_A = -40°C to +85°C, V_{CC} = As Specified, CL = 1 TTL Gate and 100 pF (unless otherwise noted).

Symbol	Parameter	Voltage	Min	Max	Units
f_{SCK}	SCK Clock Frequency	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	0 0 0	2.1 2.1 0.5	MHz
t_{RI}	Input Rise Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6		2 2 2	µs
t_{FI}	Input Fall Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6		2 2 2	µs
t_{WH}	SCK High Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	200 300 800		ns
t_{WL}	SCK Low Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	200 200 800		ns
t_{CS}	$\overline{CS}$ High Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	250 250 1000		ns
t_{CSS}	$\overline{CS}$ Setup Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	250 250 1000		ns
t_{CSH}	$\overline{CS}$ Hold Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	250 250 1000		ns
t_{SU}	Data In Setup Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	50 50 100		ns
t_H	Data In Hold Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	50 50 100		ns
t_{HD}	$\overline{Hold}$ Setup Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	100 100 400		ns
t_{CD}	$\overline{Hold}$ Hold Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	100 100 400		ns
t_V	Output Valid	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	0 0 0	200 200 800	ns
t_{HO}	Output Hold Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	0 0 0		ns
t_{LZ}	$\overline{Hold}$ to Output Low Z	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6	0 0 0	100 100 100	ns

(continued)

AC Characteristics (Continued)

Symbol	Parameter	Voltage	Min	Max	Units
t_{HZ}	$\overline{\text{Hold}}$ to Output High Z	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6		100 100 100	ns
t_{DIS}	Output Disable Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6		250 250 1000	ns
t_{WC}	Write Cycle Time	4.5 - 5.5 2.7 - 5.5 1.8 - 3.6		5 10 20	ms

Serial Interface Description

MASTER: The device that generates the serial clock.

SLAVE: Because the Serial Clock pin (SCK) is always an input, the AT25128 always operates as a slave.

TRANSMITTER/RECEIVER: The AT25128 has separate pins designated for data transmission (SO) and reception (SI).

MSB: The Most Significant Bit (MSB) is the first bit transmitted and received.

SERIAL OP-CODE: After the device is selected with $\overline{CS}$ going low, the first byte will be received. This byte contains the op-code that defines the operations to be performed.

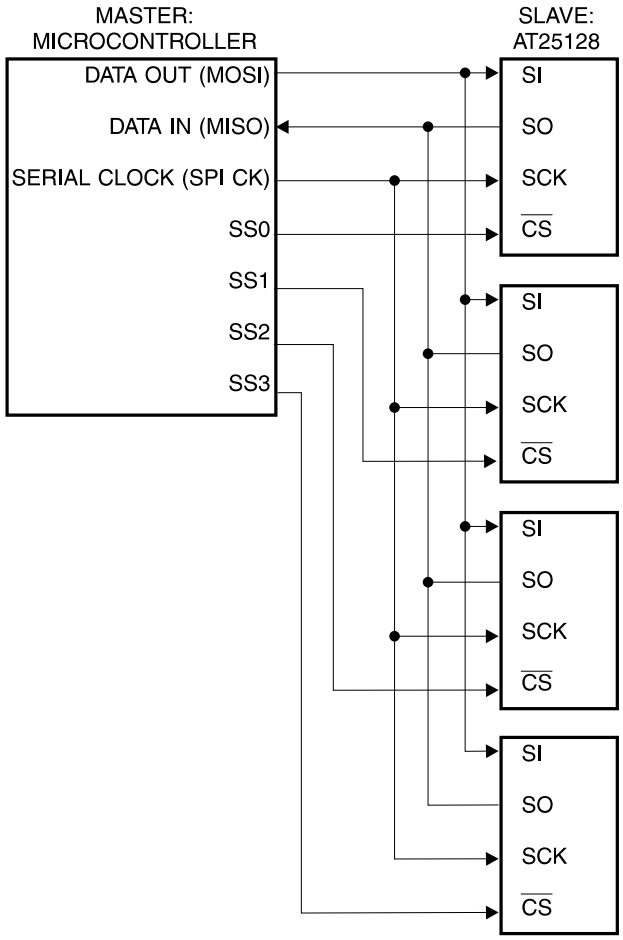
INVALID OP-CODE: If an invalid op-code is received, no data will be shifted into the AT25128, and the serial output pin (SO) will remain in a high impedance state until the falling edge of $\overline{CS}$ is detected again. This will reinitialize the serial communication.

CHIP SELECT: The AT25128 is selected when the $\overline{CS}$ pin is low. When the device is not selected, data will not be accepted via the SI pin, and the serial output pin (SO) will remain in a high impedance state.

HOLD: The $\overline{HOLD}$ pin is used in conjunction with the $\overline{CS}$ pin to select the AT25128. When the device is selected and a serial sequence is underway, $\overline{HOLD}$ can be used to pause the serial communication with the master device without resetting the serial sequence. To pause, the $\overline{HOLD}$ pin must be brought low while the SCK pin is low. To resume serial communication, the $\overline{HOLD}$ pin is brought high while the SCK pin is low (SCK may still toggle during $\overline{HOLD}$). Inputs to the SI pin will be ignored while the SO pin is in the high impedance state.

WRITE PROTECT: The write protect pin ($\overline{WP}$) will allow normal read/write operations when held high. When the $\overline{WP}$ pin is brought low and WPEN bit is “1", all write operations to the status register are inhibited. $\overline{WP}$ going low while $\overline{CS}$ is still low will interrupt a write to the status register. If the internal write cycle has already been initiated, $\overline{WP}$ going low will have no effect on any write operation to the status register. The $\overline{WP}$ pin function is blocked when the WPEN bit in the status register is ”0". This will allow the user to install the AT25128 in a system with the $\overline{WP}$ pin tied to ground and still be able to write to the status register. All $\overline{WP}$ pin functions are enabled when the WPEN bit is set to “1".

SPI Serial Interface



Functional Description

The AT25128 is designed to interface directly with the synchronous serial peripheral interface (SPI) of the 6805 and 68HC11 series of microcontrollers.

The AT25128 utilizes an 8 bit instruction register. The list of instructions and their operation codes are contained in Table 1. All instructions, addresses, and data are transferred with the MSB first.

Table 1. Instruction Set for the AT25128

Instruction Name	Instruction Format	Operation
WREN	0000 X110	Set Write Enable Latch
WRDI	0000 X100	Reset Write Enable Latch
RDSR	0000 X101	Read Status Register
WRSR	0000 X001	Write Status Register
READ	0000 X011	Read Data from Memory Array
WRITE	0000 X010	Write Data to Memory Array

WRITE ENABLE (WREN): The device will power up in the write disable state when V_{CC} is applied. All programming instructions must therefore be preceded by a Write Enable instruction.

WRITE DISABLE (WRDI): To protect the device against inadvertent writes, the Write Disable instruction disables all programming modes. The WRDI instruction is independent of the status of the $\overline{WP}$ pin.

READ STATUS REGISTER (RDSR): The Read Status Register instruction provides access to the status register. The READY/BUSY and Write Enable status of the device can be determined by the RDSR instruction. Similarly, the Block Write Protection bits indicate the extent of protection employed. These bits are set by using the WRSR instruction.

Table 2a. Status Register Format

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
WPEN	X	X	X	BP1	BP0	WEN	$\overline{RDY}$

Table 2b. Read Status Register Bit Definition

Bit	Definition
Bit 0 ($\overline{RDY}$)	Bit 0 = 0 ($\overline{RDY}$) indicates the device is READY. Bit 0 = 1 indicates the write cycle is in progress.
Bit 1 (WEN)	Bit 1= 0 indicates the device *is not* WRITE ENABLED. Bit 1 = 1 indicates the device is WRITE ENABLED.
Bit 2 (BP0)	See Table 3.
Bit 3 (BP1)	See Table 3.
Bits 4-6 are 0s when device is not in an internal write cycle.	
Bit 7 (WPEN)	See Table 4.
Bits 0-7 are 1s during an internal write cycle.	

WRITE STATUS REGISTER (WRSR): The WRSR instruction allows the user to select one of four levels of protection. The AT25128 is divided into four array segments. One quarter (1/4), one half (1/2), or all of the memory segments can be protected. Any of the data within any selected segment will therefore be READ only. The block write protection levels and corresponding status register control bits are shown in Table 3.

The three bits, BP0, BP1, and WPEN are nonvolatile cells that have the same properties and functions as the regular memory cells (e.g. WREN, t_{WC}, RDSR).

Table 3. Block Write Protect Bits

Level	Status Register Bits		Array Addresses Protected
	BP1	BP0	**AT25128**
0	0	0	None
1(1/4)	0	1	3000 - 3FFF
2(1/2)	1	0	2000 - 3FFF
3(All)	1	1	0000 - 3FFF

The WRSR instruction also allows the user to enable or disable the write protect ($\overline{WP}$) pin through the use of the Write Protect Enable (WPEN) bit. Hardware write protection is enabled when the $\overline{WP}$ pin is low and the WPEN bit is "1." Hardware write protection is disabled when *either* the $\overline{WP}$ pin is high or the WPEN bit is "0." When the device is hardware write protected, writes to the Status Register, including the Block Protect bits and the WPEN bit, and the block-protected sections in the memory array are disabled. Writes are only allowed to sections of the memory which are not block-protected.

NOTE: When the WPEN bit is hardware write protected, it cannot be changed back to "0," as long as the $\overline{WP}$ pin is held low.

(continued)

Functional Description (Continued)

Table 4. WPEN Operation

WPEN	$\overline{WP}$	WEN	Protected Blocks	Unprotected Blocks	Status Register
0	X	0	Protected	Protected	Protected
0	X	1	Protected	Writable	Writable
1	Low	0	Protected	Protected	Protected
1	Low	1	Protected	Writable	Protected
X	High	0	Protected	Protected	Protected
X	High	1	Protected	Writable	Writable

READ SEQUENCE (READ): Reading the AT25128 via the SO (Serial Output) pin requires the following sequence. After the $\overline{CS}$ line is pulled low to select a device, the READ op-code is transmitted via the SI line followed by the byte address to be read (A15-A0, Refer to Table 5). Upon completion, any data on the SI line will be ignored. The data (D7-D0) at the specified address is then shifted out onto the SO line. If only one byte is to be read, the $\overline{CS}$ line should be driven high after the data comes out. The READ sequence can be continued since the byte address is automatically incremented and data will continue to be shifted out. When the highest address is reached, the address counter will roll over to the lowest address allowing the entire memory to be read in one continuous READ cycle.

WRITE SEQUENCE (WRITE): In order to program the AT25128, two separate instructions must be executed. First, the device **must be write enabled** via the Write Enable (WREN) Instruction. Then a Write (WRITE) Instruction may be executed. Also, the address of the memory location(s) to be programmed must be outside the protected address field location selected by the Block Write Protection Level. During an internal write cycle, all commands will be ignored except the RDSR instruction.

A Write Instruction requires the following sequence. After the $\overline{CS}$ line is pulled low to select the device, the WRITE op-code is transmitted via the SI line followed by the byte address (A15-A0) and the data (D7-D0) to be programmed (Refer to Table 5). Programming will start after the $\overline{CS}$ pin is brought high. (The LOW to High transition of the $\overline{CS}$ pin must occur during the SCK low time immediately after clocking in the D0 (LSB) data bit.

The READY/BUSY status of the device can be determined by initiating a READ STATUS REGISTER (RDSR) Instruction. If Bit 0 = 1, the WRITE cycle is still in progress. If Bit 0 = 0, the WRITE cycle has ended. Only the READ STATUS REGISTER instruction is enabled during the WRITE programming cycle.

The AT25128 is capable of a 32-byte PAGE WRITE operation. After each byte of data is received, the five low order address bits are internally incremented by one; the high order bits of the address will remain constant. If more than 32-bytes of data are transmitted, the address counter will roll over and the previously written data will be overwritten. The AT25128 is automatically returned to the write disable state at the completion of a WRITE cycle.

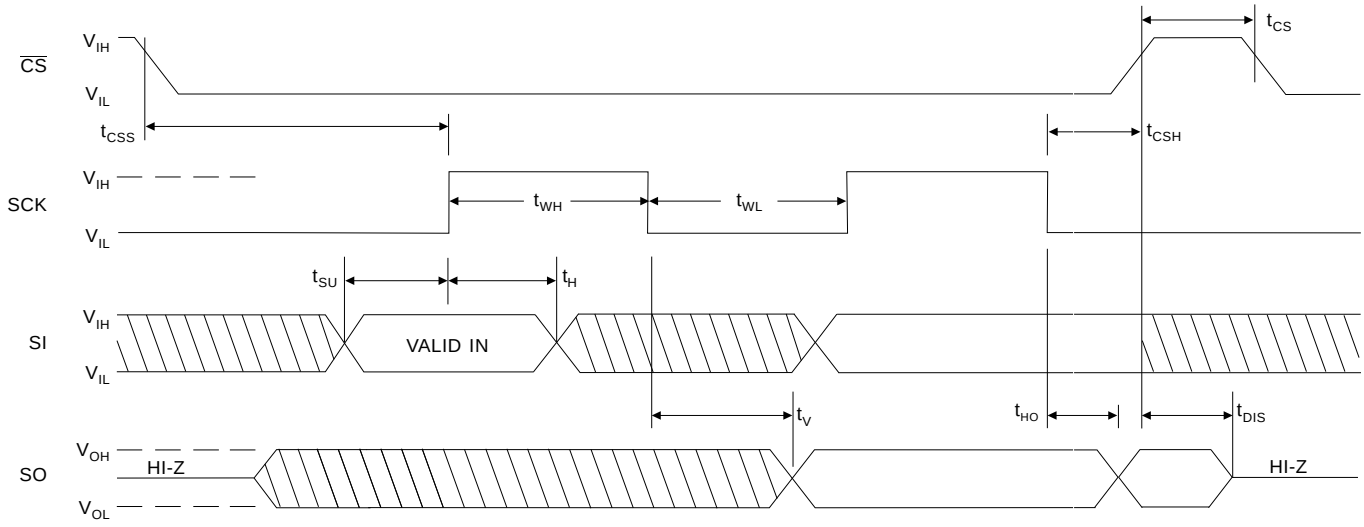
NOTE: If the device is not Write enabled (WREN), the device will ignore the Write instruction and will return to the standby state, when $\overline{CS}$ is brought high. A new CS falling edge is required to re-initiate the serial communication.

Table 5. Address Key

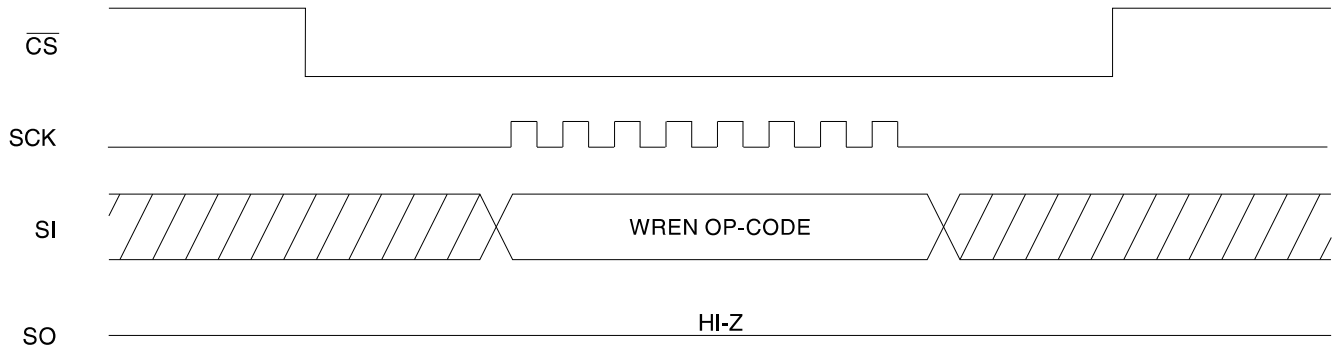
Address	AT25128
A_N	A_{13} - A_0
Don't Care Bits	A_{15} - A_{14}

Timing Diagrams (for SPI Mode 0 (0,0))

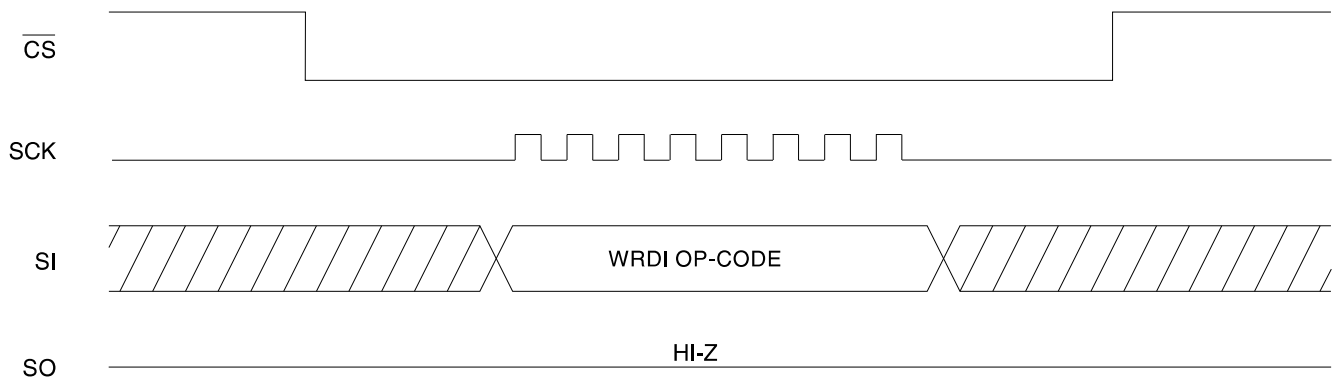
Synchronous Data Timing



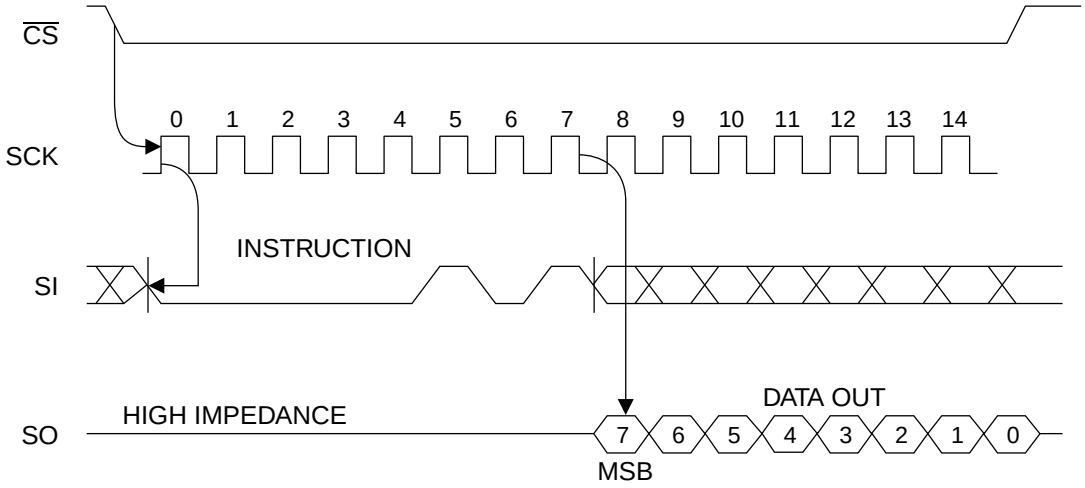
WREN Timing



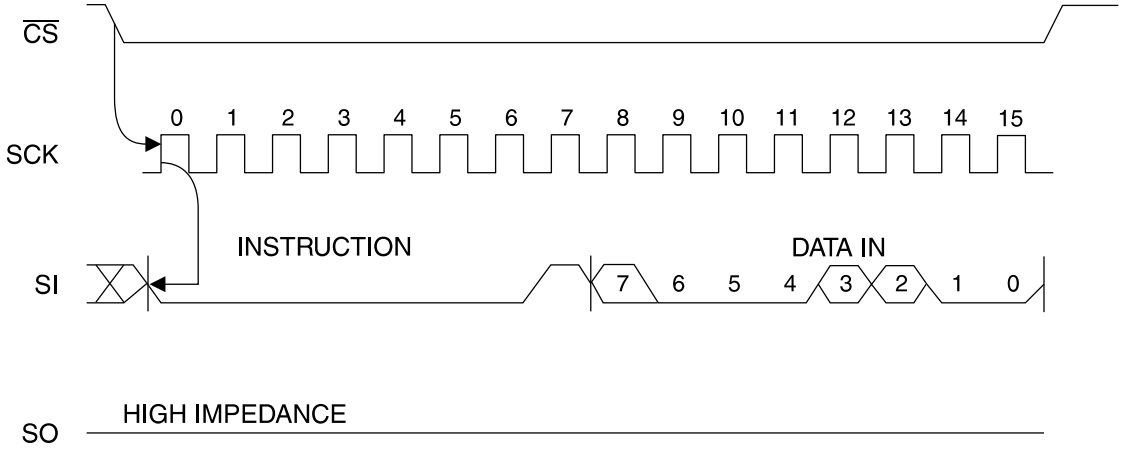
WRDI Timing



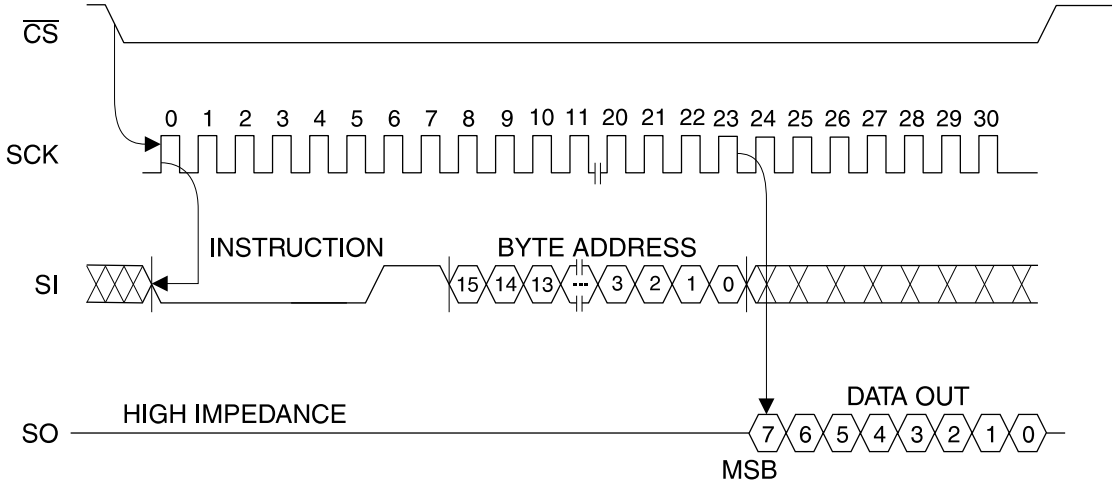
RDSR Timing



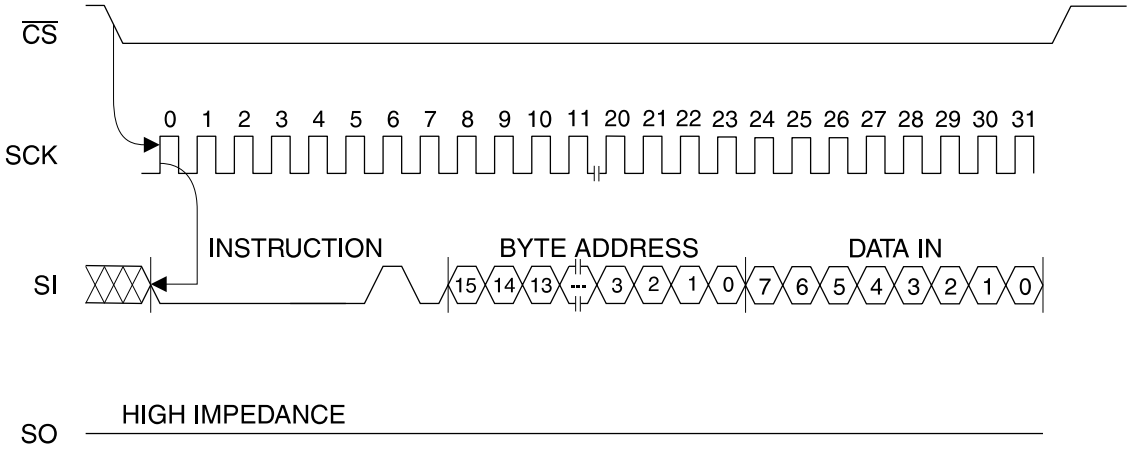
WRSR Timing



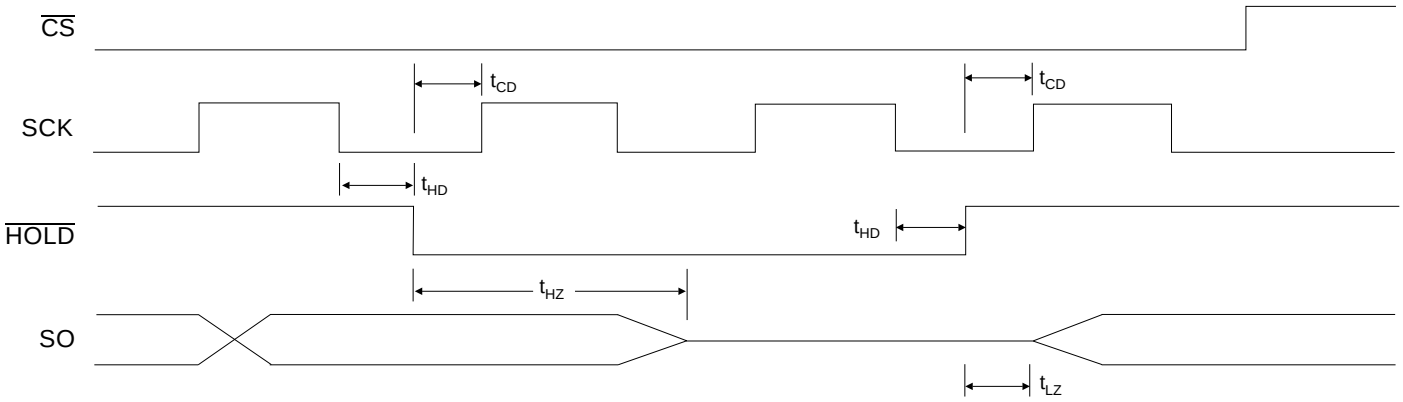
READ Timing



WRITE Timing



$\overline{\text{HOLD}}$ Timing



Ordering Information

t_{WC} (max) (ms)	I_{CC} (max) (µA)	I_{SB} (max) (µA)	f_{MAX} (kHz)	Ordering Code	Package	Operation Range
5	5000	2.0	2100	AT25128-10PC AT25128-10SC AT25128N1-10SC AT25640T2-10TC	8P3 14S 16S1 20T	Commercial (0°C to 70°C)
10	3000	0.5	2100	AT25128-10PC-2.7 AT25128-10SC-2.7 AT25128N1-10SC-2.7 AT25128T2-10TC-2.7	8P3 14S 16S1 20T	Commercial (0°C to 70°C)
20	3000	0.2	500	AT25128-10PC-1.8 AT25128-10SC-1.8 AT25128N1-10SC-1.8 AT25128T2-10TC-1.8	8P3 14S 16S1 20T	Commercial (0°C to 70°C)
5	5000	2.0	2100	AT25128-10PI AT25128-10SI AT25128N1-10SI AT25128T2-10TI	8P3 14S 16S1 20T	Industrial (-40°C to 85°C)
10	3000	0.5	2100	AT25128-10PI-2.7 AT25128-10SI-2.7 AT25128N1-10SI-2.7 AT25128T2-10TI-2.7	8P3 14S 16S1 20T	Industrial (-40°C to 85°C)
20	3000	0.2	500	AT25128-10PI-1.8 AT25128-10SI-1.8 AT25128N1-10SI-1.8 AT25128T2-10TI-1.8	8P3 14S 16S1 20T	Industrial (-40°C to 85°C)

Package Type	
8P3	8-Lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)
14S	14-Lead, 0.150" Wide, Plastic Gull Wing Small Outline Package (JEDEC SOIC)
16S1	16-Lead, 0.150" Wide, Plastic Gull Wing Small Outline Package (JEDEC SOIC)
20T	20-Lead, 0.170" Wide, Thin Super Small Outline Package (TSSOP)
Options	
Blank	Standard Device (4.5V to 5.5V)
-2.7	Low Voltage (2.7V to 5.5V)
-1.8	Low Voltage (1.8V to 3.6V)