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**SPI Serial EEPROM  
512-Kbit (65,536 x 8)**

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**DATASHEET**

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**Features**

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- Serial Peripheral Interface (SPI) Compatible
- Supports SPI Modes 0 (0,0) and 3 (1,1)
- Datasheet Describes Mode 0 Operation
- Low-voltage Operation
  - 1.8 ( $V_{CC} = 1.8V$  to 5.5V)
- 20MHz Clock Rate (4.5V to 5.5V)
- 128-byte Page Mode and Byte Write Operation Supported
- Block Write Protection
  - Protect  $\frac{1}{4}$ ,  $\frac{1}{2}$ , or Entire Array
- Write Protect ( $\overline{WP}$ ) Pin and Write Disable Instructions for Both Hardware and Software Data Protection
- Self-timed Write Cycle (5ms Max)
- High Reliability
  - Endurance: 1,000,000 Write Cycles
  - Data Retention: 40 Years
- Lead-free/Halogen-free Devices
- 8-lead JEDEC SOIC, 8-lead TSSOP, and 8-pad UDFN Packages
- Die Sale Options: Wafer Form, Waffle Pack, and Bumped Die

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**Description**

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The Atmel® AT25512 provides 524,288 bits of Serial Electrically Erasable Programmable Read-Only Memory (EEPROM) organized as 65,536 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 devices are available in space saving 8-lead JEDEC SOIC, 8-lead TSSOP, and 8-pad UDFN packages. In addition, the device operates from 1.8V to 5.5V.

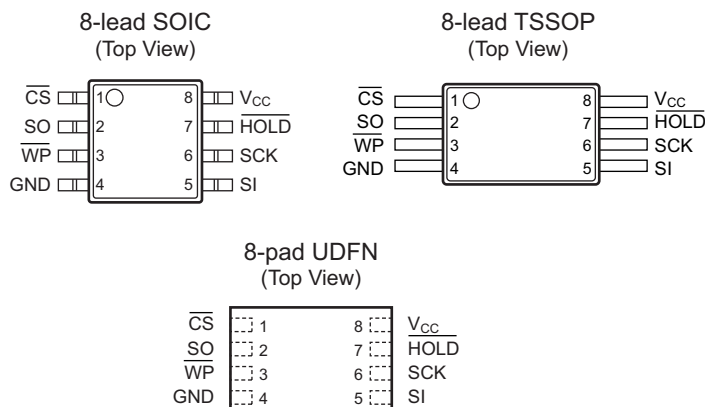
The AT25512 is enabled through the Chip Select pin ( $\overline{CS}$ ) and accessed via a 3-wire interface consisting of Serial Data Input (SI), Serial Data Output (SO), and Serial Clock (SCK). All programming cycles are completely self-timed, and no separate erase cycle is required before write.

Block Write Protection is enabled by programming the status register with top  $\frac{1}{4}$ , top  $\frac{1}{2}$ , or entire array 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 HOLD pin may be used to suspend any serial communication without resetting the serial sequence.

## 1. Pin Configurations and Pinouts

**Figure 1. Pin Configurations**

Name	Function
$\overline{CS}$	Chip Select
SO	Serial Data Output
$\overline{WP}$	Write Protect
GND	Ground
SI	Serial Data Input
SCK	Serial Data Clock
$\overline{HOLD}$	Suspends Serial Input
$V_{CC}$	Power Supply



Note: Drawings are not to scale.

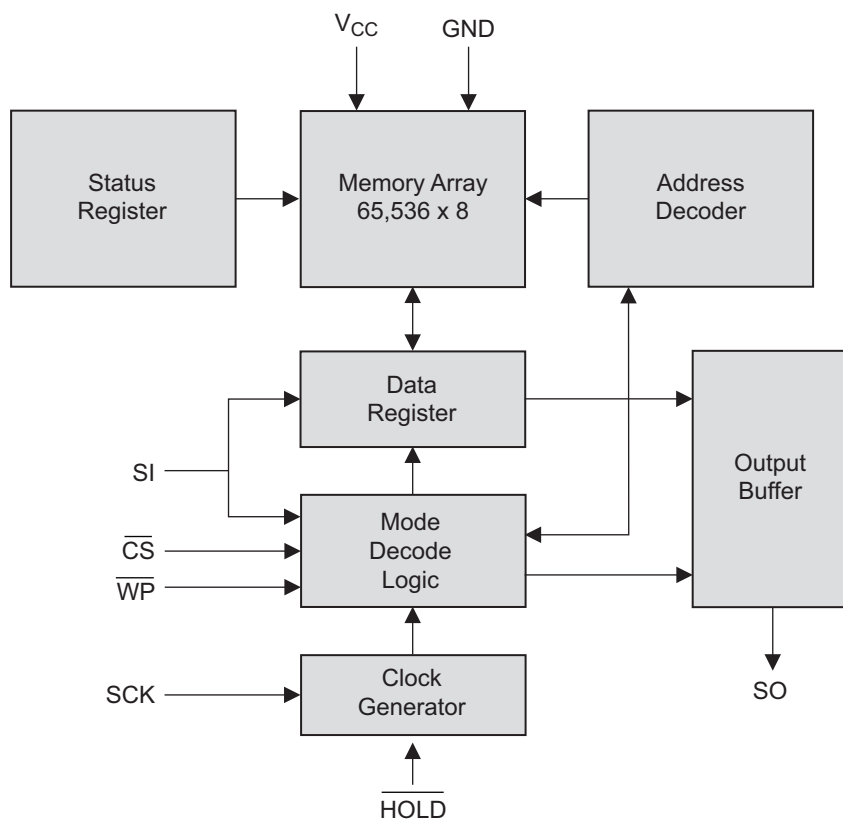
## 2. Absolute Maximum Ratings\*

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 . . . . .	.5.0mA

\*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.

### 3. Block Diagram

Figure 3-1. Block Diagram



## 4. Electrical Specifications

**Table 4-1. Pin Capacitance<sup>(1)</sup>**

Applicable over recommended operating range from  $T_A = 25^\circ\text{C}$ ,  $f = 1.0\text{MHz}$ ,  $V_{CC} = 5.0\text{V}$  (unless otherwise noted).

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

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

**Table 4-2. DC Characteristics**

Applicable over recommended operating range from  $T_{AI} = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $V_{CC} = 1.8\text{V}$  to  $5.5\text{V}$ , (unless otherwise noted).

Symbol	Parameter	Test Condition	Min	Typ	Max	Units
$V_{CC1}$	Supply Voltage		1.8		5.5	V
$V_{CC2}$	Supply Voltage		2.7		5.5	V
$V_{CC3}$	Supply Voltage		4.5		5.5	V
$I_{CC1}$	Supply Current	$V_{CC} = 5.0\text{V}$ at 20MHz, SO = Open, Read		9.0	10.0	mA
$I_{CC2}$	Supply Current	$V_{CC} = 5.0\text{V}$ at 10MHz, SO = Open, Read, Write		5.0	7.0	mA
$I_{CC3}$	Supply Current	$V_{CC} = 5.0\text{V}$ at 1MHz, SO = Open, Read, Write		2.2	3.5	mA
$I_{SB1}$	Standby Current	$V_{CC} = 1.8\text{V}$ , $\overline{CS} = V_{CC}$		0.2	3.0	$\mu\text{A}$
$I_{SB2}$	Standby Current	$V_{CC} = 2.7\text{V}$ , $\overline{CS} = V_{CC}$		0.5	3.0	$\mu\text{A}$
$I_{SB3}$	Standby Current	$V_{CC} = 5.0\text{V}$ , $\overline{CS} = V_{CC}$		2.0	5.0	$\mu\text{A}$
$I_{IL}$	Input Leakage	$V_{IN} = 0\text{V}$ to $V_{CC}$	-3.0		3.0	$\mu\text{A}$
$I_{OL}$	Output Leakage	$V_{IN} = 0\text{V}$ to $V_{CC}$ , $T_{AC} = 0^\circ\text{C}$ to $70^\circ\text{C}$	-3.0		3.0	$\mu\text{A}$
$V_{IL}^{(1)}$	Input Low-voltage		-1.0		$V_{CC} \times 0.3$	V
$V_{IH}^{(1)}$	Input High-voltage		$V_{CC} \times 0.7$		$V_{CC} + 0.5$	V
$V_{OL1}$	Output Low-voltage	$3.6 \leq V_{CC} \leq 5.5\text{V}$	$I_{OL} = 3.0\text{mA}$		0.4	V
$V_{OH1}$	Output High-voltage		$I_{OH} = -1.6\text{mA}$	$V_{CC} - 0.8$		V
$V_{OL2}$	Output Low-voltage	$1.8\text{V} \leq V_{CC} \leq 3.6\text{V}$	$I_{OL} = 0.15\text{mA}$		0.2	V
$V_{OH2}$	Output High-voltage		$I_{OH} = -100\mu\text{A}$	$V_{CC} - 0.2$		V

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

**Table 4-3. AC Characteristics**

Applicable over recommended operating range from  $T_{AI} = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{CC} = \text{As Specified}$ ,  $CL = 1$  TTL Gate and 30pF (unless otherwise noted).

Symbol	Parameter	Voltage	Min	Max	Units
$f_{SCK}$	SCK Clock Frequency	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	0 0 0	20 10 5	MHz
$t_{RI}$	Input Rise Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5		2 2 2	$\mu\text{s}$
$t_{FI}$	Input Fall Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5		2 2 2	$\mu\text{s}$
$t_{WH}$	SCK High Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	20 40 80		ns
$t_{WL}$	SCK Low Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	20 40 80		ns
$t_{CS}$	$\overline{CS}$ High Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	100 100 200		ns
$t_{CSS}$	$\overline{CS}$ Setup Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	100 100 200		ns
$t_{CSH}$	$\overline{CS}$ Hold Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	100 100 200		ns
$t_{SU}$	Data In Setup Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	5 10 20		ns
$t_H$	Data In Hold Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	5 10 20		ns
$t_{HD}$	$\overline{Hold}$ Setup Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	5 10 20		ns
$t_{CD}$	$\overline{Hold}$ Hold Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	5 10 20		ns
$t_V$	Output Valid	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	0 0 0	20 40 80	ns
$t_{HO}$	Output Hold Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	0 0 0		ns

**Table 4-3. AC Characteristics (Continued)**

Applicable over recommended operating range from  $T_{AI} = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{CC} = \text{As Specified}$ ,  $CL = 1 \text{ TTL Gate and } 30\text{pF}$  (unless otherwise noted).

Symbol	Parameter	Voltage	Min	Max	Units
$t_{LZ}$	$\overline{\text{Hold}}$ to Output Low Z	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5	0 0 0	25 50 100	ns
$t_{HZ}$	$\overline{\text{Hold}}$ to Output High Z	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5		25 50 100	ns
$t_{DIS}$	Output Disable Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5		25 50 100	ns
$t_{WC}$	Write Cycle Time	4.5 – 5.5 2.7 – 5.5 1.8 – 5.5		5 5 5	ms
Endurance <sup>(1)</sup>	5.0V, 25°C, Page Mode		1,000,000		Write Cycles

Note: 1. This parameter is characterized and is not 100% tested. Contact Atmel for further information.

## 5. Serial Interface Description

**Master:** The device that generates the serial clock.

**Slave:** Because the Serial Clock pin (SCK) is always an input, AT25512 always operates as a slave.

**Transmitter/Receiver:** AT25512 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 Opcode:** After the device is selected with  $\overline{\text{CS}}$  going low, the first byte will be received. This byte contains the opcode that defines the operations to be performed.

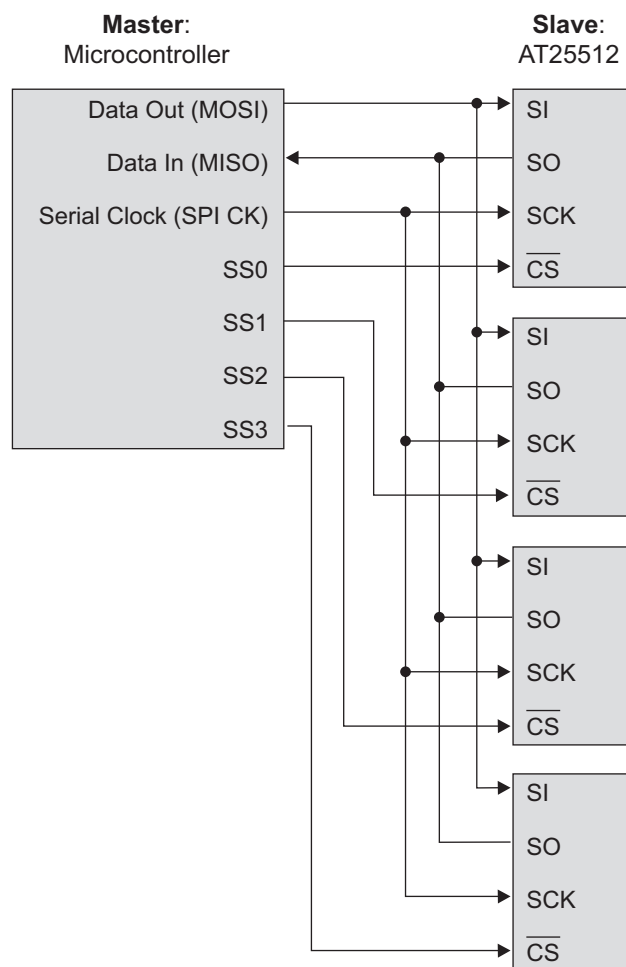
**Invalid Opcode:** If an invalid opcode is received, no data will be shifted into AT25512, and the Serial Output pin (SO) will remain in a high impedance state until the falling edge of  $\overline{\text{CS}}$  is detected again. This will reinitialize the serial communication.

**Chip Select:** AT25512 is selected when the  $\overline{\text{CS}}$  pin is low. When the device is not selected, data will not be accepted via the SI pin, and the SO pin will remain in a high impedance state.

**Hold:** The  $\overline{\text{HOLD}}$  pin is used in conjunction with the  $\overline{\text{CS}}$  pin to select AT25512. When the device is selected and a serial sequence is underway,  $\overline{\text{Hold}}$  can be used to pause the serial communication with the master device without resetting the serial sequence. To pause, the  $\overline{\text{HOLD}}$  pin must be brought low while the SCK pin is low. To resume serial communication, the  $\overline{\text{HOLD}}$  pin is brought high while the SCK pin is low (SCK may still toggle during 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 ( $\overline{\text{WP}}$ ) will allow normal read/write operations when held high. When the  $\overline{\text{WP}}$  pin is brought low, and WPEN bit is one, all write operations to the status register are inhibited.  $\overline{\text{WP}}$  going low while  $\overline{\text{CS}}$  is still low will interrupt a write to the status register. If the internal write cycle has already been initiated,  $\overline{\text{WP}}$  going low will have no effect on any write operation to the status register. The  $\overline{\text{WP}}$  pin function is blocked when the WPEN bit in the status register is zero. This will allow the user to install the AT25512 device in a system with the  $\overline{\text{WP}}$  pin tied to ground, and still be able to write to the status register. All  $\overline{\text{WP}}$  pin functions are enabled when the WPEN bit is set to one.

**Figure 5-1. SPI Serial Interface**



## 6. Functional Description

The AT25512 is designed to interface directly with the Synchronous Serial Peripheral Interface (SPI) of the 6800 type series of microcontrollers.

The AT25512 utilizes an 8-bit instruction register. The list of instructions and their operation codes are contained in Table 7-3. All instructions, addresses, and data are transferred with the MSB first and start with a high-to-low  $\overline{CS}$  transition.

**Table 6-1. Instruction Set For AT25512**

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 6-2. 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 6-3. 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 <i>is not</i> write enabled. Bit 1 = 1 indicates the device is write enabled.
Bit 2 (BP0)	See Table 6-4 on page 9.
Bit 3 (BP1)	See Table 6-4 on page 9.
Bits 4 – 6 are zeros when the device is not in an internal write cycle.	
Bit 7 (WPEN)	See Table 6-5 on page 9.
Bits 0 – 7 are ones during an internal write cycle.	



**Write Status Register (WRSR):** The WRSR instruction allows the user to select one of four levels of protection. AT25512 is divided into four array segments:

- None or
- Top quarter ( $\frac{1}{4}$ ) or
- Top half ( $\frac{1}{2}$ ) 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 6-4](#).

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 6-4. Block Write Protect Bits**

Level	Status Register Bits		Array Addresses Protected
	BP1	BP0	AT25512
0	0	0	None
1( $\frac{1}{4}$ )	0	1	C000h – FFFFh
2( $\frac{1}{2}$ )	1	0	8000h – FFFFh
3(All)	1	1	0000h – FFFFh

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 one. Hardware Write Protection is disabled when *either* the  $\overline{WP}$  pin is high or the WPEN bit is zero. When the device is Hardware Write Protected, writes to the Status Register, including the Block Protect bits and the WPEN bit, and the Block Protect 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 zero, as long as the  $\overline{WP}$  pin is held low.

**Table 6-5. WPEN Operation**

WPEN	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 AT25512 via the SO 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 (see Table 6-6). 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 AT25512, two separate instructions must be executed. First, the device *must be write enabled* via the Write Enable (WREN) Instruction. Then a 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 opcode is transmitted via the SI line followed by the byte address and the data (D7 – D0) to be programmed (see Table 6-6). 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 AT25512 is capable of a 128-byte Page Write operation. After each byte of data is received, the seven low order address bits are internally incremented by one; the high order bits of the address will remain constant. If more than 128 bytes of data are transmitted, the address counter will roll over and the previously written data will be overwritten. AT25512 is automatically returned to the write disable state at the completion of a write cycle.

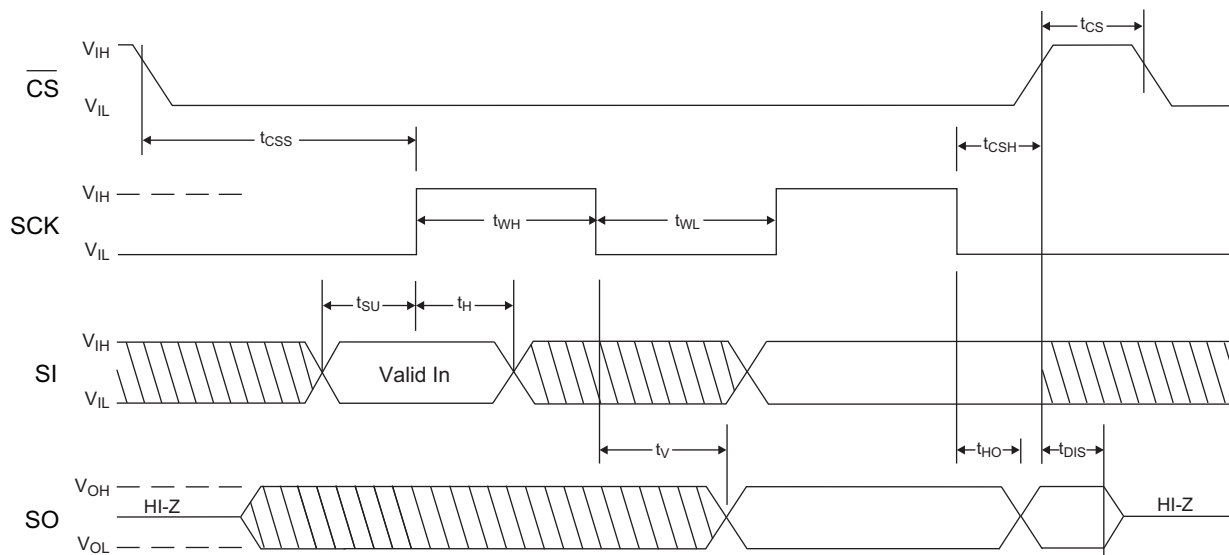
**Note:** If the device is not Write Enabled (WREN), the device will ignore the Write instruction and will return to the standby state, when  $\overline{CS}$  is brought high. A new CS falling edge is required to re-initiate the serial communication.

**Table 6-6. Address Key**

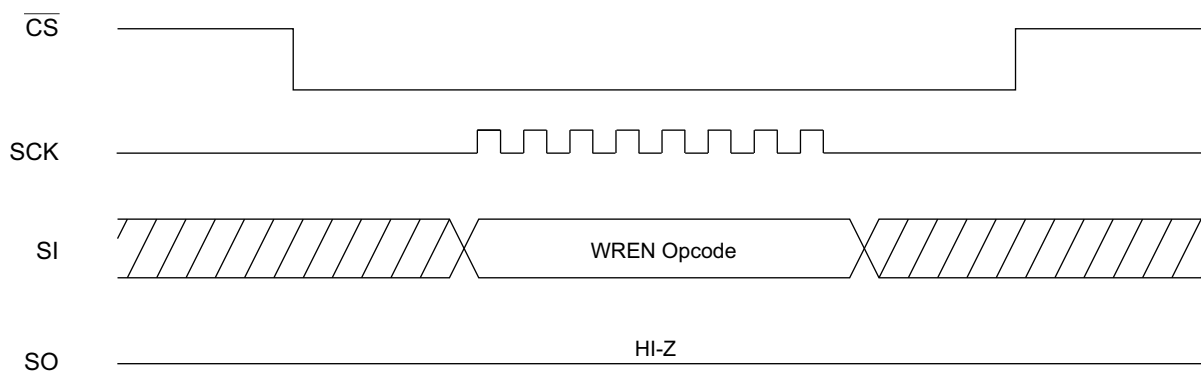
Address	AT25512
$A_N$	$A_{15} - A_0$

## 7. Timing Diagrams (SPI Mode 0 (0, 0))

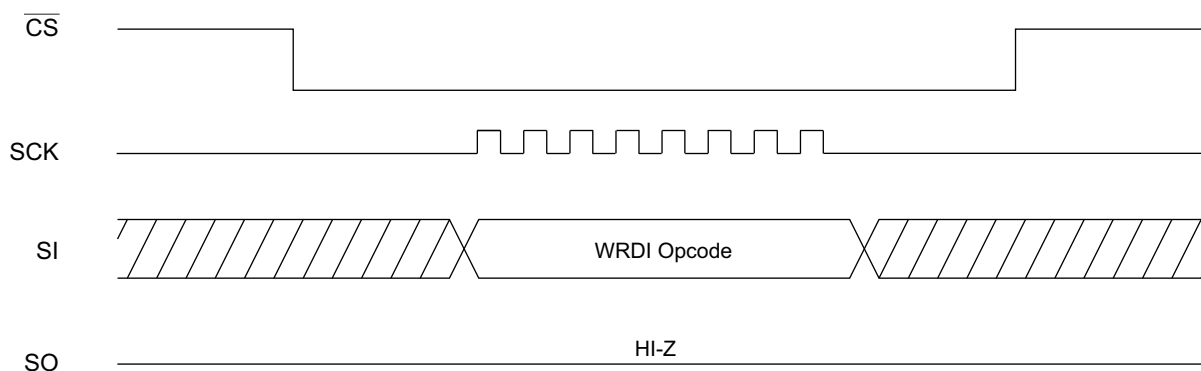
**Figure 7-1. Synchronous Data Timing**



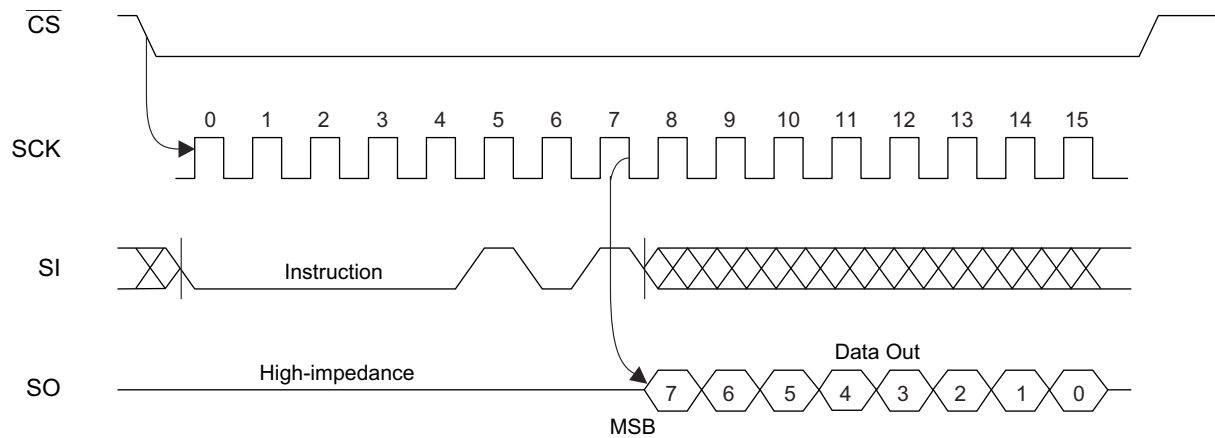
**Figure 7-2. WREN Timing**



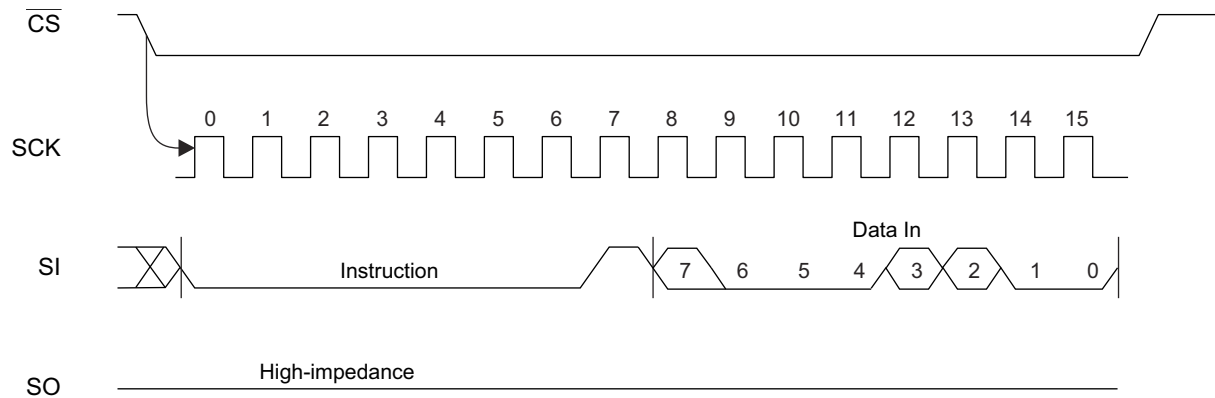
**Figure 7-3. WRDI Timing**



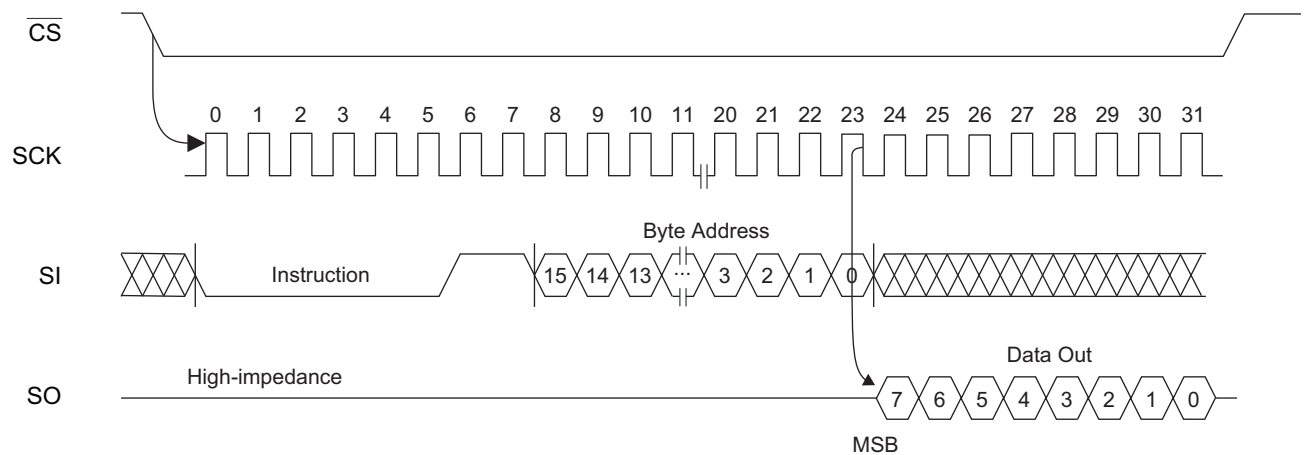
**Figure 7-4. RDSR Timing**



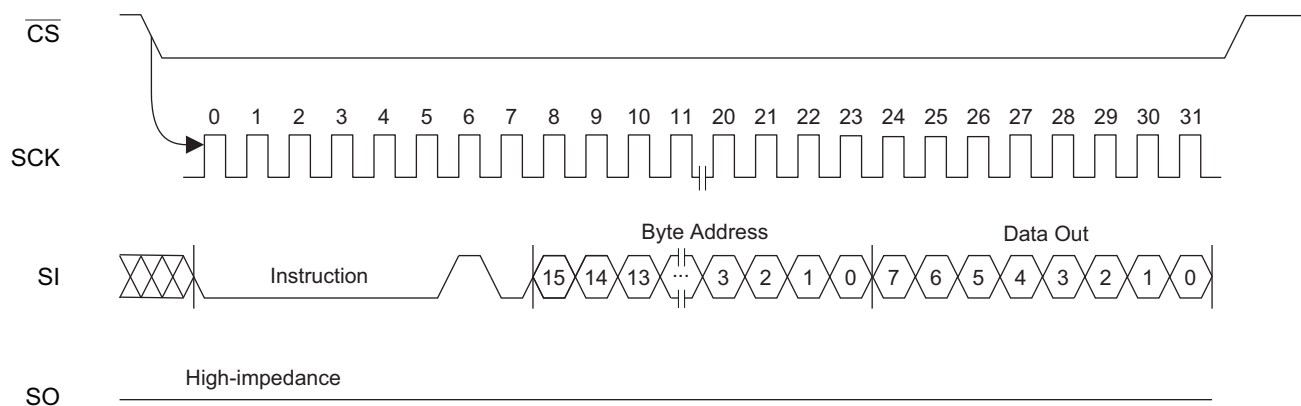
**Figure 7-5. WRSR Timing**



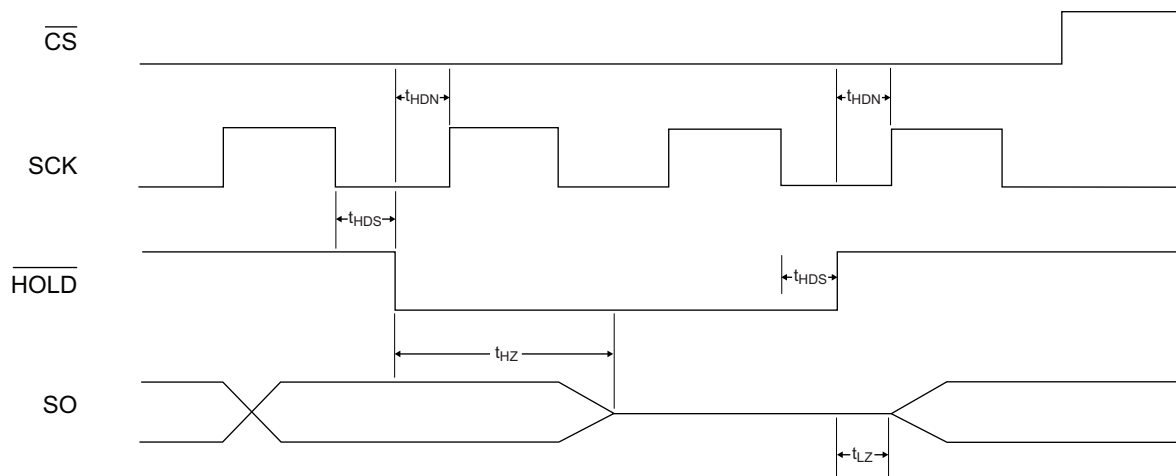
**Figure 7-6. Read Timing**



**Figure 7-7. Write Timing**

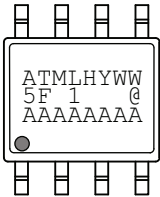
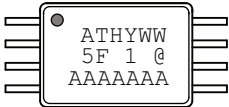
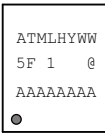


**Figure 7-8. Hold Timing**



## 8. Part Marking Scheme

### AT25512: Package Marking Information


8-lead SOIC	8-lead TSSOP	8-lead DFN
 <p>ATMLHYWW 5F 1 @ AAAAAAA</p>	 <p>ATHYWW 5F 1 @ AAAAAAA</p>	<p>6.0 x 4.9 mm Body</p>  <p>ATMLHYWW 5F 1 @ AAAAAAA</p>

Note 1: ● designates pin 1

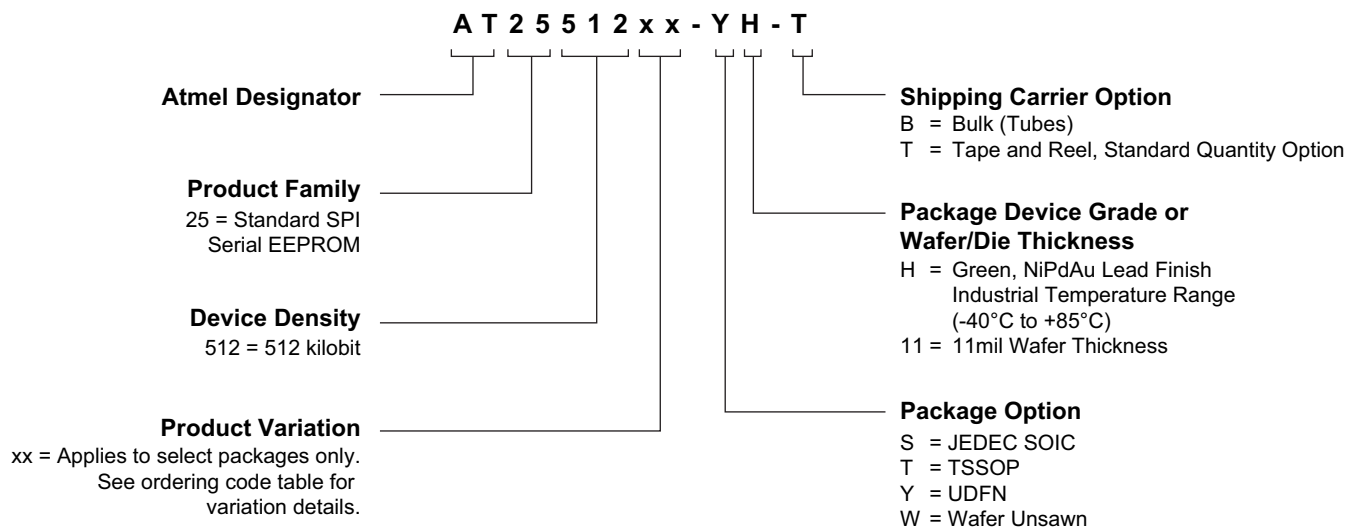
Note 2: Package drawings are not to scale

Catalog Number Truncation			
AT25512		Truncation Code ###:5F	
Date Codes			Voltages
Y = Year	M = Month	WW = Work Week of Assembly	% = Minimum Voltage
2: 2012    6: 2016	A: January	02: Week 2	1: 1.8V min
3: 2013    7: 2017	B: February	04: Week 4	
4: 2014    8: 2018	...	...	
5: 2015    9: 2019	L: December	52: Week 52	
Country of Assembly		Lot Number	Grade/Lead Finish Material
@ = Country of Assembly		AAA...A = Atmel Wafer Lot Number	H: Industrial/NiPdAu
Trace Code			Atmel Truncation
XX = Trace Code (Atmel Lot Numbers Correspond to Code) Example: AA, AB.... YZ, ZZ			AT: Atmel ATM: Atmel ATML: Atmel

8/21/12

 Package Mark Contact: DL-CSO-Assy_eng@atmel.com	<b>TITLE</b> <b>25512SM</b> , AT25512 Standard Package Marking Information	<b>DRAWING NO.</b> 25512SM	<b>REV.</b> C
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## 9. Ordering Code Detail



## 10. Ordering Information

Atmel Ordering Code	Lead Finish	Package	Delivery Information		Operation Range
			Form	Quantity	
AT25512N-SH-B	NiPdAu (Lead-free/Halogen-free)	8S1	Bulk (Tubes)	100 per Tube	Industrial Temperature (-40°C to 85°C)
AT25512N-SH-T			Tape and Reel	4,000 per Reel	
AT25512-TH-B		8X	Bulk (Tubes)	100 per Tube	
AT25512-TH-T			Tape and Reel	5,000 per Reel	
AT25512Y7-YH-T		8Y7	Tape and Reel	5,000 per Reel	
AT25512-W-11 <sup>(1)</sup>	N/A	Wafer Sale	Note 1		

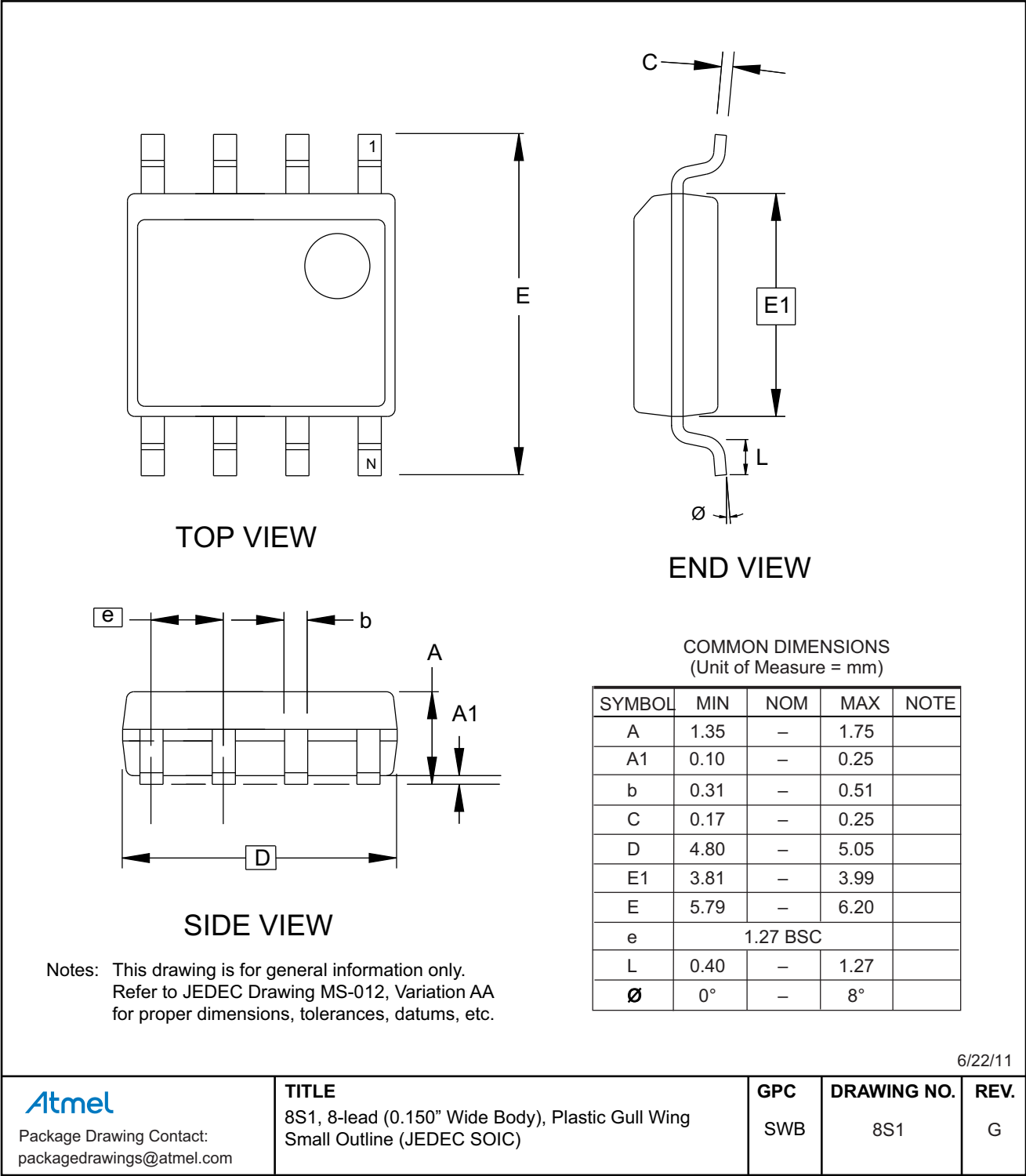
Note: 1. Available in waffle pack, tape and reel, and wafer form; order as SL788 for inkless wafer form. Bumped die available upon request. Please contact Atmel for more details.

Package Type	
8S1	8-lead, 0.150" wide, Plastic Gull Wing Small Outline (JEDEC SOIC)
8X	8-lead, 4.4mm body, Plastic Thin Shrink Small Outline Package (TSSOP)
8Y7	8-pad, 6.0x4.9mm body, 1.27mm pitch, UltraThin SAP, Dual No Lead Package (Sawn) (UDFN)

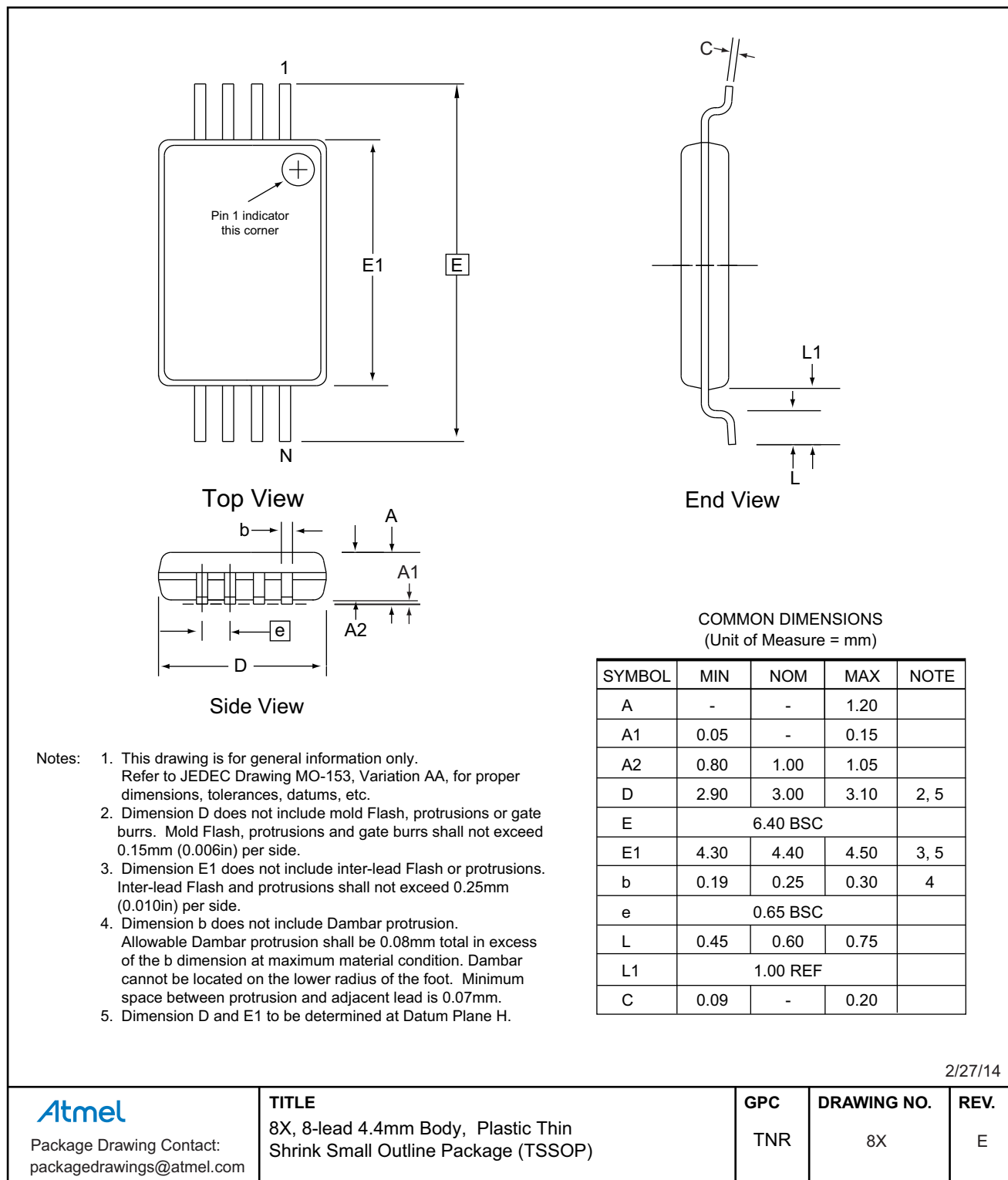


11. Packaging Information

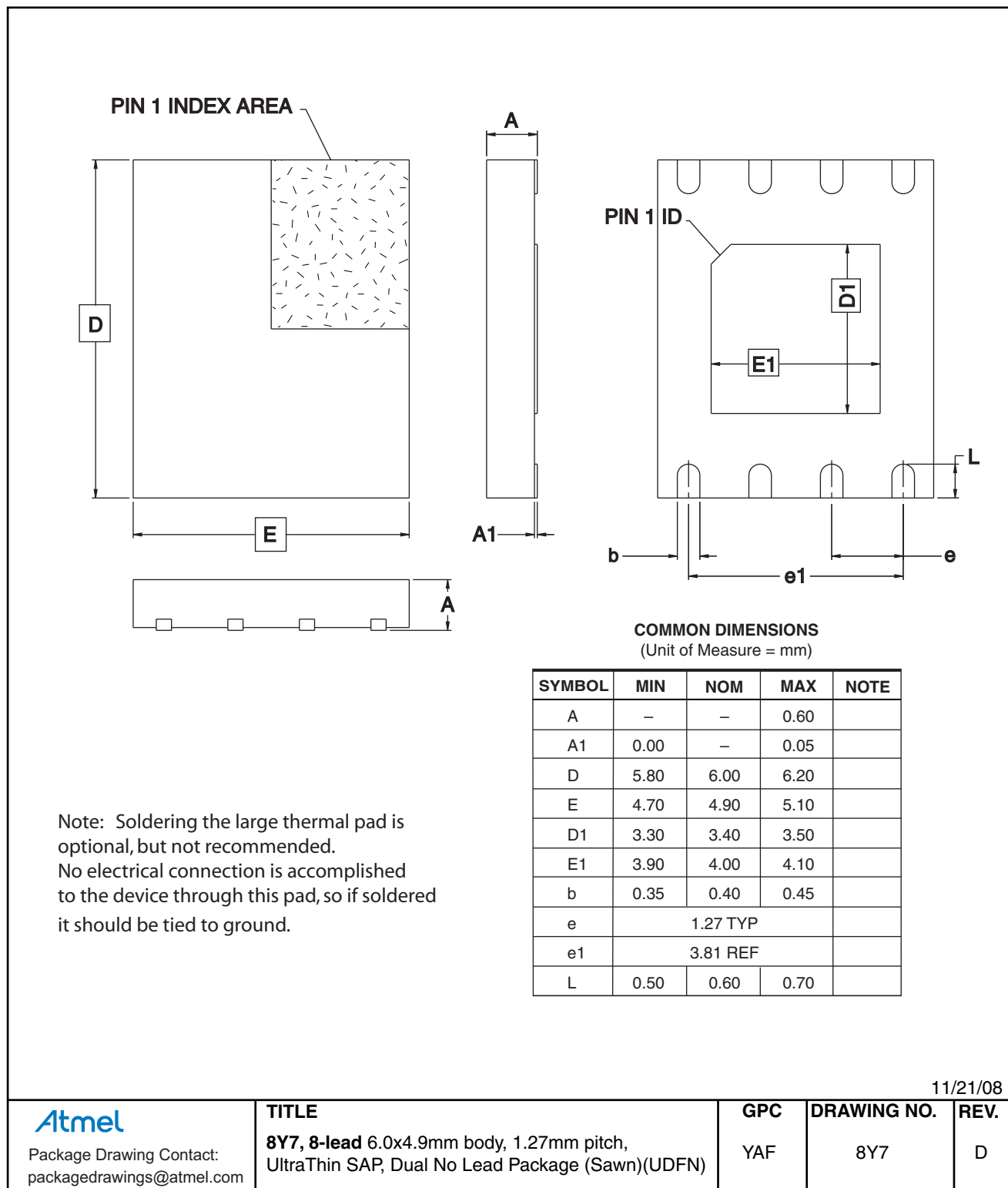
11.1 8S1 — 8-lead JEDEC SOIC



## 11.2 8X — 8-lead TSSOP



### 11.3 8Y7 — 8-pad UDFN



## 12. Revision History

Doc. Rev.	Date	Comments
5165J	01/2015	Updated the 8X package outline drawing and the ordering information section.
5165I	07/2013	Correct ordering code table from 8A2 to 8X package option. Updated footers and disclaimer page.
5165H	08/2012	Updated part markings and package drawings. Updated template.
5165G	09/2009	Updated Part Marking Scheme.
5165F	03/2009	Changed Maximum Operating Voltage from 4.3V to 6.25V in the Absolute Maximum Ratings Table on page 2.
5165E	08/2008	Updated for 1.8V - 5.5V operation.
5165D	05/2008	Added part marking diagram information.
5165C	08/2007	Changed address bit number to seven on page 9. Removed Preliminary status.
5165B	06/2007	Changed spacing on table notes. Reworked figure 4-8. Updated to new template. Changed status to Preliminary.
5165A	01/2007	Initial document release.



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