

### I<sup>2</sup>C Automotive Temperature Serial EEPROM 16K (2048 x 8)

#### DATASHEET

#### Features

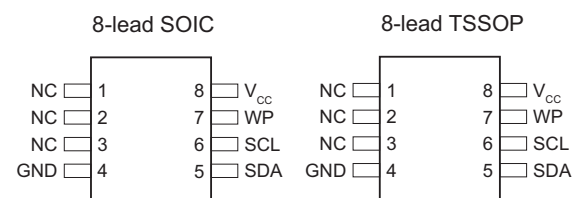
- Standard-voltage operation
  - $V_{CC} = 2.5V$  to  $5.5V$
- Automotive temperature range  $-40^{\circ}C$  to  $125^{\circ}C$
- Internally organized 2048 x 8 (16K)
- 2-wire serial interface compatible with I<sup>2</sup>C
- Schmitt Trigger, filtered inputs for noise suppression
- Bidirectional data transfer protocol
- 400kHz compatibility
- Write protect pin for hardware data protection
- 16-byte page write modes
- Partial page writes are allowed
- Self-timed write cycle (5ms max)
- High-reliability
  - Endurance: 1 million write cycles
  - Data retention: 100 years
- 8-lead JEDEC SOIC and 8-lead TSSOP packages

#### Description

The Atmel® AT24C16C provides 16384 bits of Serial Electrically Erasable and Programmable Read-Only Memory (EEPROM) organized as 2048 words of eight bits each. The device is optimized for use in many automotive applications where low-power and low-voltage operation are essential. AT24C16C is available in space saving 8-lead JEDEC SOIC and 8-lead TSSOP packages and is accessed via a 2-wire serial interface. This device operates from 2.5V to 5.5V.

**Figure 1. Pin Configurations**

Pin Name	Function
SDA	Serial Data
SCL	Serial Clock Input
WP	Write Protect
NC	No Connect

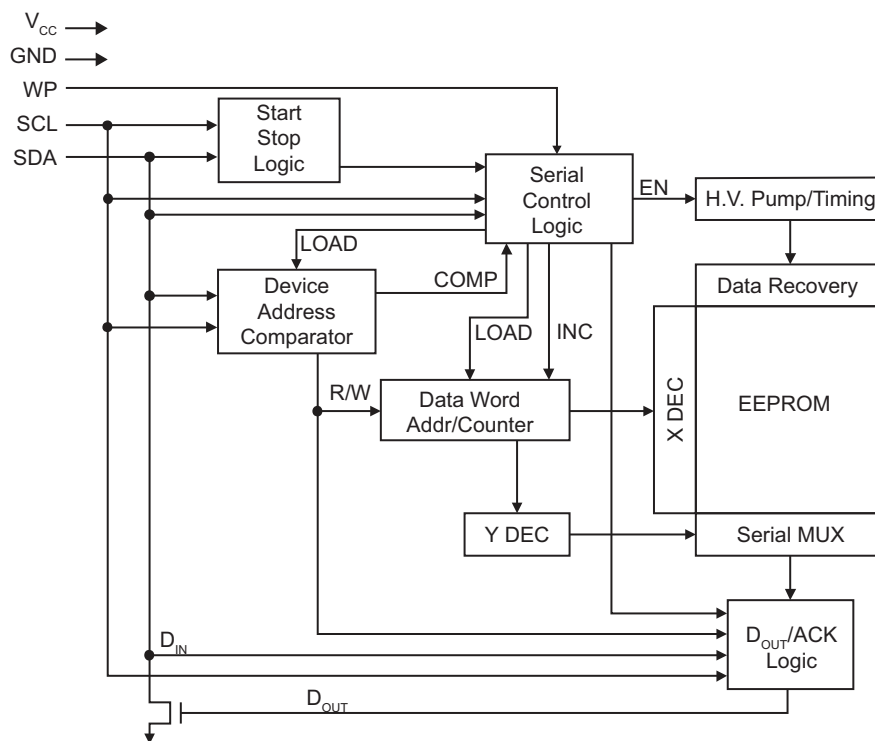


## 1. Absolute Maximum Ratings\*

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.

## 2. Block Diagram



### 3. Pin Description

**Serial Clock (SCL):** The SCL input is used to positive edge clock data into each EEPROM device and negative edge clock data out of each device.

**Serial Data (SDA):** The SDA pin is bi-directional for serial data transfer. This pin is open-drain driven and may be wire-ORed with any number of other open-drain or open-collector devices.

**Device/Page Addresses ( $A_2$ ,  $A_1$ ,  $A_0$ ):** I<sup>2</sup>C signals  $A_0$ ,  $A_1$ , and  $A_2$  (device package pins 1, 2, and 3) are no connects. AT24C16C does not use the device address pins, which limits the number of devices on a single bus to one.

**Write Protect (WP):** AT24C16C has a Write Protect pin that provides hardware data protection. The Write Protect pin allows normal read/write operations when connected to ground (GND). When the Write Protect pin is connected to  $V_{CC}$ , the write protection feature is enabled and operates as shown in the following table.

**Table 3-1. Write Protect**

WP Pin Status	Part of the Array Protected
	Atmel AT24C16C
At $V_{CC}$	Full (16K) Array
At GND	Normal Read/Write Operations

## 4. Memory Organization

**AT24C16C, 16K Serial EEPROM:** Internally organized with 128 pages of 16 bytes each, the 16K requires an 11-bit data word address for random word addressing.

### 4.1 Pin Capacitance<sup>(1)</sup>

Symbol	Test Condition	Max	Units	Conditions
$C_{I/O}$	Input/Output Capacitance (SDA)	8	pF	$V_{I/O} = 0V$
$C_{IN}$	Input Capacitance (SCL)	6	pF	$V_{IN} = 0V$

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

### 4.2 DC Characteristics

Applicable over recommended operating range from:  $T_A = -40^{\circ}C$  to  $+125^{\circ}C$ ,  
 $V_{CC} = +2.5V$  to  $+5.5V$  (unless otherwise noted).

Symbol	Parameter	Test Condition	Min	Typ	Max	Units
$V_{CC1}$	Supply Voltage		2.5		5.5	V
$I_{CC}$	Supply Current $V_{CC} = 5.0V$	Read at 100kHz		0.4	1.0	mA
$I_{CC}$	Supply Current $V_{CC} = 5.0V$	Write at 100kHz		2.0	3.0	mA
$I_{SB1}$	Standby Current $V_{CC} = 2.5V$	$V_{IN} = V_{CC}$ or $V_{SS}$		1.6	4.0	$\mu A$
$I_{SB2}$	Standby Current $V_{CC} = 5.0V$	$V_{IN} = V_{CC}$ or $V_{SS}$		4.0	6.0	$\mu A$
$I_{LI}$	Input Leakage Current	$V_{IN} = V_{CC}$ or $V_{SS}$		0.10	3.0	$\mu A$
$I_{LO}$	Output Leakage Current	$V_{OUT} = V_{CC}$ or $V_{SS}$		0.05	3.0	$\mu A$
$V_{IL}$	Input Low Level <sup>(1)</sup>		-0.6		$V_{CC} \times 0.3$	V
$V_{IH}$	Input High Level <sup>(1)</sup>		$V_{CC} \times 0.7$		$V_{CC} + 0.5$	V
$V_{OL2}$	Output Low Level $V_{CC} = 3.0V$	$I_{OL} = 2.1mA$			0.4	V
$V_{OL1}$	Output Low Level $V_{CC} = 1.8V$	$I_{OL} = 0.15mA$			0.2	V

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

### 4.3 AC Characteristics

Applicable over recommended operating range from  $T_A = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ,  $V_{CC} = +2.5\text{V}$  to  $+5.5\text{V}$ ,  $CL = 1$  TTL Gate and  $100\text{pF}$  (unless otherwise noted).

Symbol	Parameter	Atmel AT24C16C		Units
		Min	Max	
$f_{SCL}$	Clock Frequency, SCL		400	kHz
$t_{LOW}$	Clock Pulse Width Low	1.2		$\mu\text{s}$
$t_{HIGH}$	Clock Pulse Width High	0.6		$\mu\text{s}$
$t_I$	Noise Suppression Time <sup>(1)</sup>		50	ns
$t_{AA}$	Clock Low to Data Out Valid	0.1	0.9	$\mu\text{s}$
$t_{BUF}$	Time the bus must be free before a new transmission can start <sup>(2)</sup>	1.2		$\mu\text{s}$
$t_{HD.STA}$	Start Hold Time	0.6		$\mu\text{s}$
$t_{SU.STA}$	Start Set-up Time	0.6		$\mu\text{s}$
$t_{HD.DAT}$	Data In Hold Time	0		$\mu\text{s}$
$t_{SU.DAT}$	Data In Set-up Time	100		ns
$t_R$	Inputs Rise Time <sup>(2)</sup>		300	ns
$t_F$	Inputs Fall Time <sup>(2)</sup>		300	ns
$t_{SU.STO}$	Stop Set-up Time	0.6		$\mu\text{s}$
$t_{DH}$	Data Out Hold Time	50		ns
$t_{WR}$	Write Cycle Time		5	ms
Endurance <sup>(2)</sup>	5.0V, $25^{\circ}\text{C}$ , Page Mode	1M		Write Cycles

- Note: 1. This parameter is characterized and is not 100% tested ( $T_A = 25^{\circ}\text{C}$ ).  
 2. This parameter is characterized.

## 5. Device Operation

**Clock and Data Transitions:** The SDA pin is normally pulled high with an external device. Data on the SDA pin may change only during SCL low time periods (see Figure 5-4 on page 7). Data changes during SCL high periods will indicate a start or stop condition as defined below.

**Start Condition:** A high-to-low transition of SDA with SCL high is a start condition which must precede any other command (see Figure 5-5 on page 7).

**Stop Condition:** A low-to-high transition of SDA with SCL high is a stop condition. After a read sequence, the stop command will place the EEPROM in a standby power mode (see Figure 5-5 on page 7).

**Acknowledge:** All addresses and data words are serially transmitted to and from the EEPROM in 8-bit words. The EEPROM sends a zero to acknowledge that it has received each word. This happens during the ninth clock cycle.

**Standby Mode:** AT24C16C features a low-power standby mode which is enabled:

- Upon power-up.
- After the receipt of the stop bit and the completion of any internal operations.

**Memory Reset:** After an interruption in protocol, power loss or system reset, any 2-wire part can be reset by following these steps:

1. Clock up to nine cycles,
2. Look for SDA high in each cycle while SCL is high,
3. Create a start condition.

Figure 5-1. Memory Reset

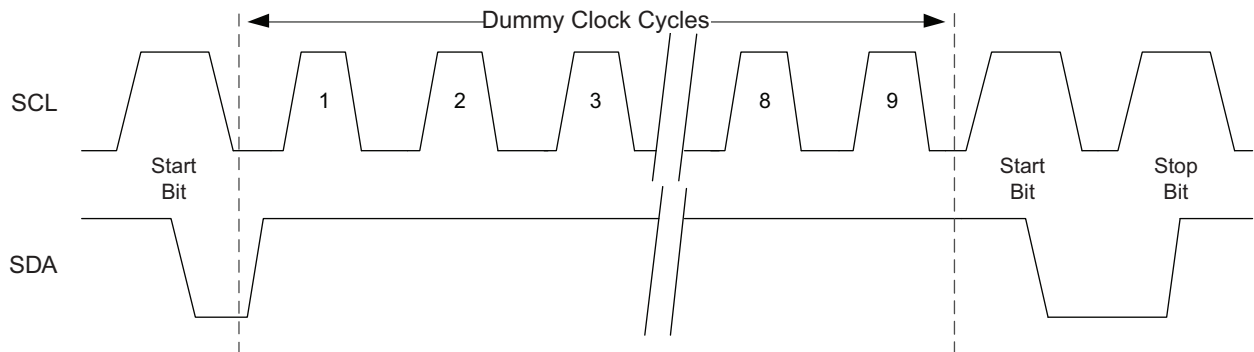
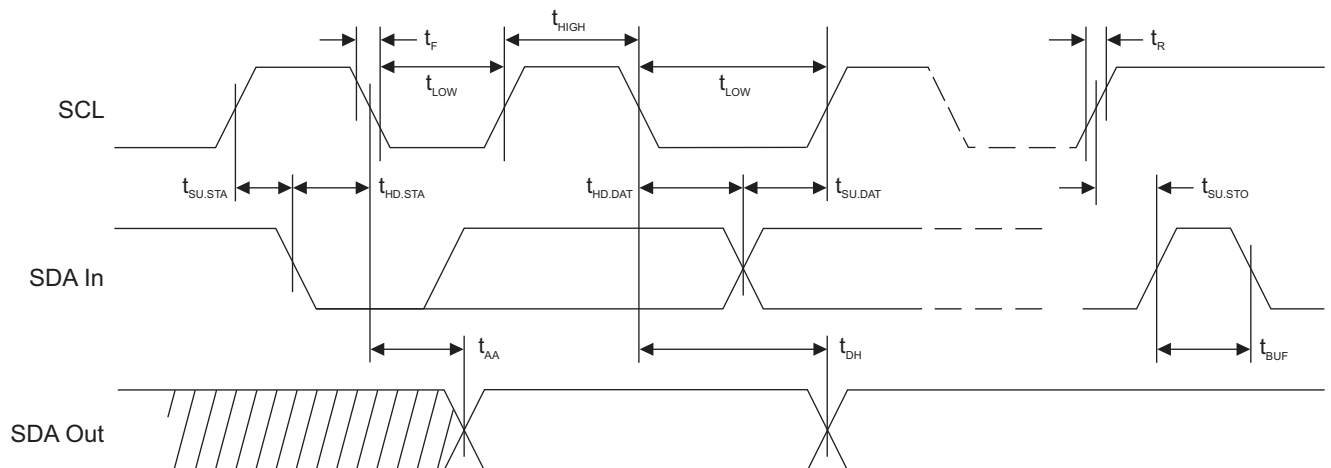


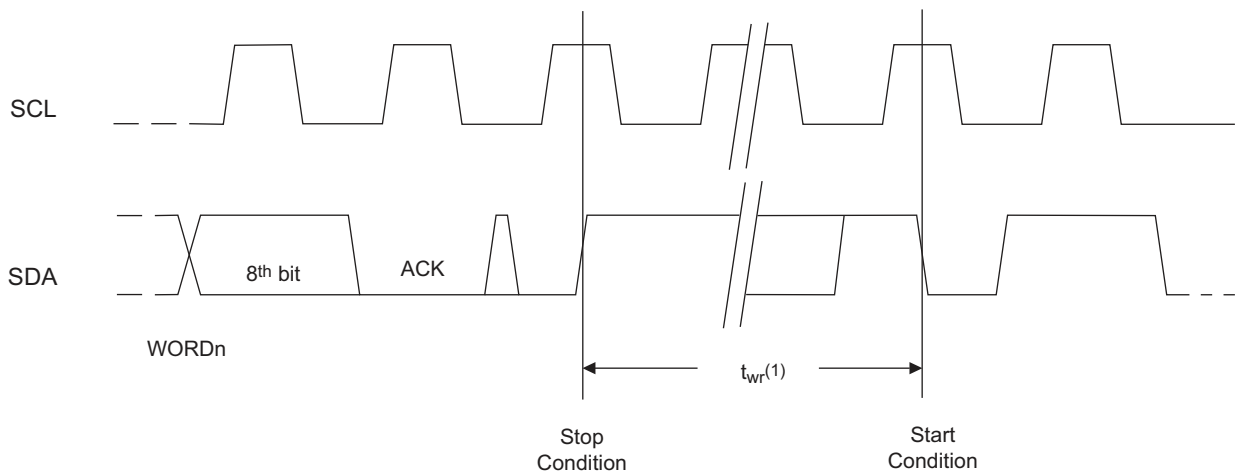
Figure 5-2. Bus Timing

SCL: Serial Clock, SDA: Serial Data I/O



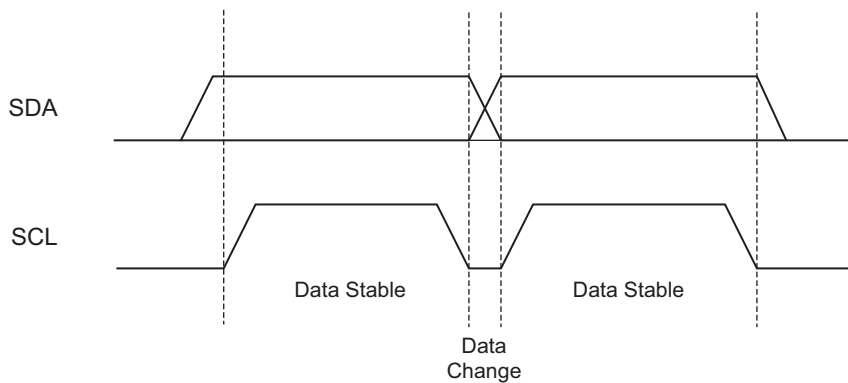
**Figure 5-3. Write Cycle Timing**

SCL: Serial Clock, SDA: Serial Data I/O

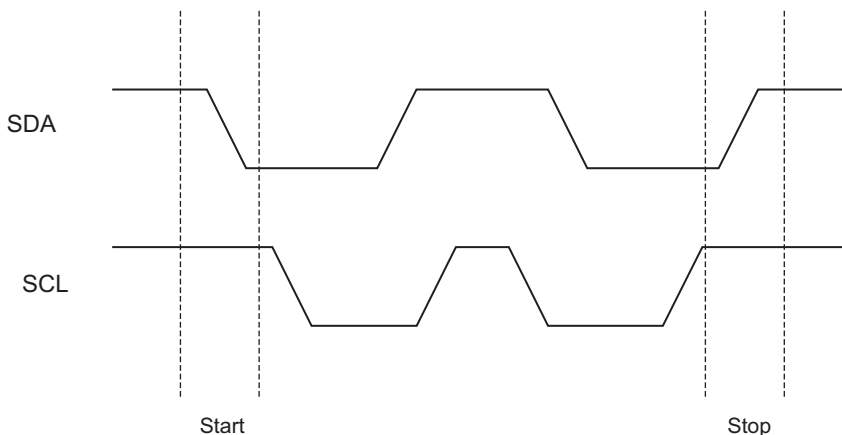


Note: 1. The write cycle time  $t_{WR}$  is the time from a valid stop condition of a write sequence to the end of the internal clear/write cycle.

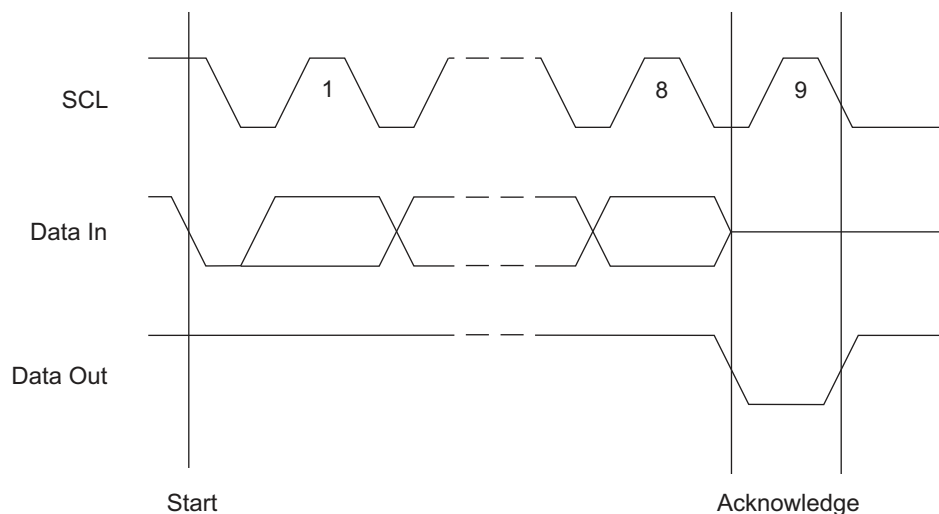
**Figure 5-4. Data Validity**



**Figure 5-5. Start and Stop Definition**



**Figure 5-6. Output Acknowledge**



## 6. Device Addressing

The 16K EEPROM requires an 8-bit device address word following a start condition to enable the chip for a read or write operation (see [Figure 8-1 on page 9](#)).

The device address word consists of a mandatory one, zero sequence for the first four most significant bits as shown. This is common to all the Serial EEPROM devices.

The next three bits are used for memory page addressing. These page addressing bits on the 16K devices should be considered the most significant bits of the data word address which follows.

The eighth bit of the device address is the read/write operation select bit. A read operation is initiated if this bit is high and a write operation is initiated if this bit is low.

If the device address meets the requirements listed above, the device will acknowledge with a zero by pulling the SDA signal low. If the comparison is not made, the device will return to a standby state and the SDA signal will float high.

## 7. Write Operations

**Byte Write:** A write operation requires an 8-bit data word address following the device address word and acknowledgment. Upon receipt of this address, the EEPROM will again respond with a zero and then clock in the first 8-bit data word. Following receipt of the 8-bit data word, the EEPROM will output a zero and the addressing device, such as a microcontroller, must terminate the write sequence with a stop condition. At this time the EEPROM enters an internally timed write cycle,  $t_{WR}$ , to the nonvolatile memory. All inputs are disabled during this write cycle and the EEPROM will not respond until the write is complete (see [Figure 8-2 on page 9](#)).

**Page Write:** The EEPROM is capable of 16-byte page writes.

A Page Write is initiated the same as a Byte Write, but the microcontroller does not send a stop condition after the first data word is clocked in. Instead, after the EEPROM acknowledges receipt of the first data word, the microcontroller can transmit up to fifteen more data words. The EEPROM will respond with a zero after each data word received. The microcontroller must terminate the page write sequence with a stop condition (see [Figure 8-3 on page 10](#)).

The data word address lower four bits are internally incremented following the receipt of each data word. The higher data word address bits are not incremented, retaining the memory page row location. When the word address, internally generated, reaches the page boundary, the following byte is placed at the beginning of the same page. If more than sixteen data words are transmitted to the EEPROM, the data word address will roll-over and previous data will be overwritten.



**Acknowledge Polling:** Once the internally timed write cycle has started and the EEPROM inputs are disabled, acknowledge polling can be initiated. This involves sending a start condition followed by the device address word. The read/write bit is representative of the operation desired. Only if the internal write cycle has completed will the EEPROM respond with a zero, allowing the read or write sequence to continue.

## 8. Read Operations

Read operations are initiated the same way as write operations with the exception that the read/write select bit in the device address word is set to one. There are three read operations: Current Address Read, Random Address Read, and Sequential Read.

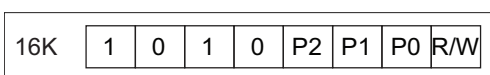
**Current Address Read:** The internal data word address counter maintains the last address accessed during the last read or write operation, incremented by one. This address stays valid between operations as long as the chip power is maintained. The address roll-over during read is from the last byte of the last memory page to the first byte of the first page. The address roll-over during write is from the last byte of the current page to the first byte of the same page.

Once the device address with the read/write select bit set to one is clocked in and acknowledged by the EEPROM, the current address data word is serially clocked out. The microcontroller does not respond with an input zero but does generate a following stop condition (see [Figure 8-4 on page 10](#)).

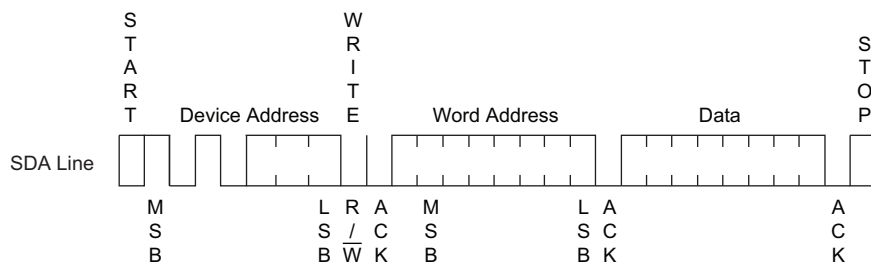
**Random Read:** A Random Read requires a dummy byte write sequence to load in the data word address. Once the device address word and data word address are clocked in and acknowledged by the EEPROM, the microcontroller must generate another start condition. The microcontroller now initiates a current address read by sending a device address with the read/write select bit high. The EEPROM acknowledges the device address and serially clocks out the data word. The microcontroller does not respond with a zero but does generate a following stop condition (see [Figure 8-5 on page 10](#)).

**Sequential Read:** Sequential Reads are initiated by either a Current Address Read or a Random Address Read. After the microcontroller receives a data word, it responds with an acknowledge. As long as the EEPROM receives an acknowledge, it will continue to increment the data word address and serially clock out sequential data words. When the memory address limit is reached, the data word address will roll-over and the Sequential Read will continue. The Sequential Read operation is terminated when the microcontroller does not send an acknowledge (pull the SDA signal low), but does generate the stop condition. (see [Figure 8-6 on page 10](#)).

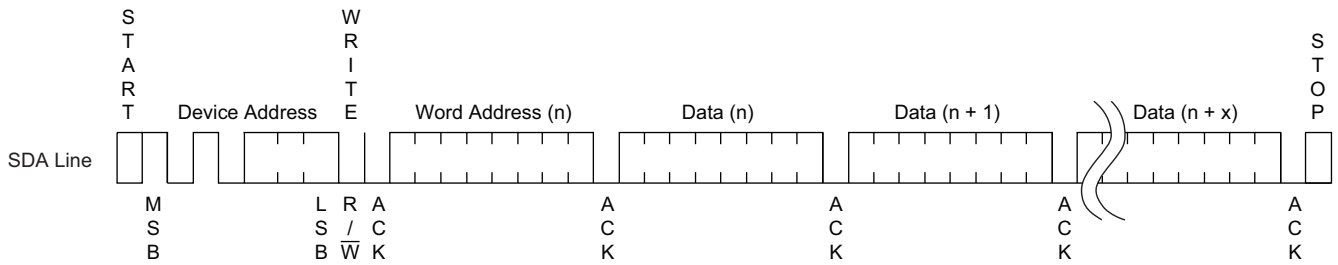
**Figure 8-1. Device Address**



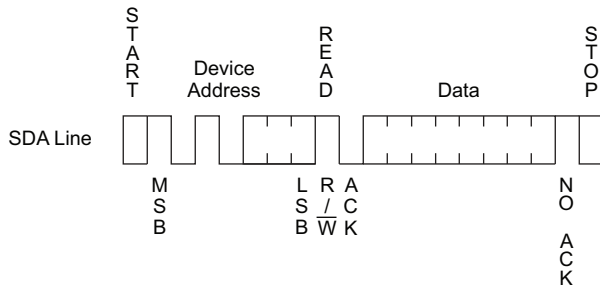
**Figure 8-2. Byte Write**



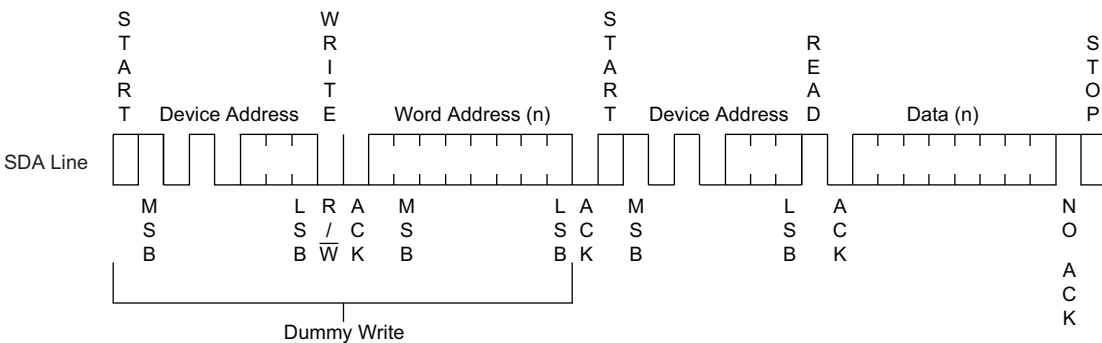
**Figure 8-3. Page Write**



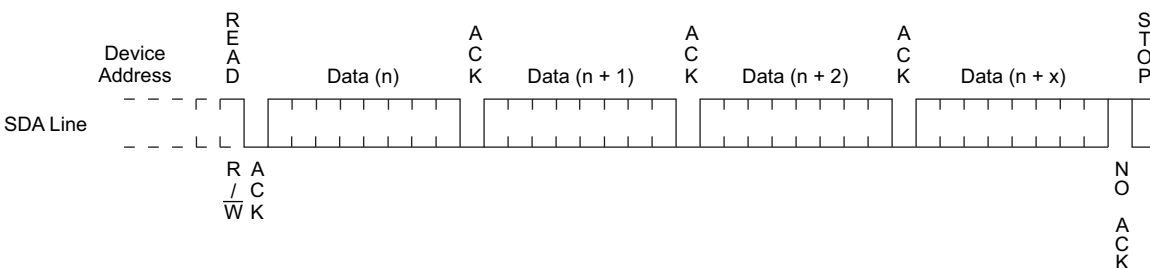
**Figure 8-4. Current Address Read**



**Figure 8-5. Random Read**



**Figure 8-6. Sequential Read**



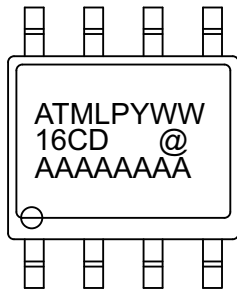
## 8.1 Power Recommendation

The device internal POR (Power-On Reset) threshold is just below the minimum operating voltage of the device. Power shall rise monotonically from 0.0Vdc to full  $V_{CC}$  in less than 1ms. Hold at full  $V_{CC}$  for at least 100 $\mu$ s before the first operation. Power shall drop from full  $V_{CC}$  to 0.0Vdc in less than 1ms. Power dropping to a non-zero level and then slowly going to zero is *not* recommended. Power shall remain off (0.0Vdc) for 0.5s minimum. Please consult Atmel if your power conditions do not meet the above recommendations.

## 9. Product Marking

### 8 lead SOIC

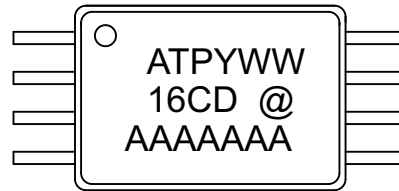
3 Rows of 8 Characters



### 8 lead TSSOP

3 Rows

2 of 6 and 1 of 7 Characters



Catalog Number: AT24C16C

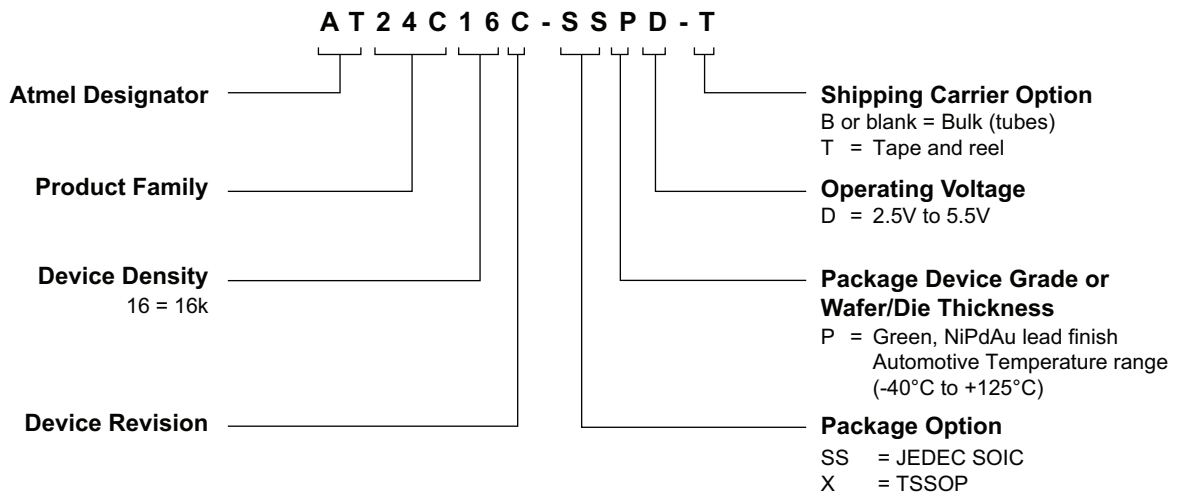
Catalog Truncation: 16C

Date Codes			Voltages
Y = Year	M = Month	WW = Work Week of Assembly	
2: 2012 6: 2016	A: January	02: Week 2	
3: 2013 7: 2017	B: February	04: Week 4	
4: 2014 8: 2018	" " "	" " "	
5: 2015 9: 2019	L: December	52: Week 52	
Trace Code			Grade/Lead Finish Material
XX = Trace Code (ATMEL Lot Numbers to Correspond to Code) (e.g. XX: AA, AB...YZ, ZZ)			P: Automotive/NiPdAu
Lot Number			ATMEL Truncation
AAAAAAA = ATMEL Wafer Lot Number			AT: ATMEL
Country of Assembly			ATM: ATMEL
@ = Country of Assembly			ATML: ATMEL

2/3/12

<p>Package Mark Contact: DL-CSO-Assy_eng@atmel.com</p>	<p>TITLE 24C16CAM, AT24C16C Automotive Marking Information for Package Offering</p>	DRAWING NO.	REV.
		24C16CAM	A

## 10. Ordering Code Details



## 11. Atmel AT24C16C Ordering Information

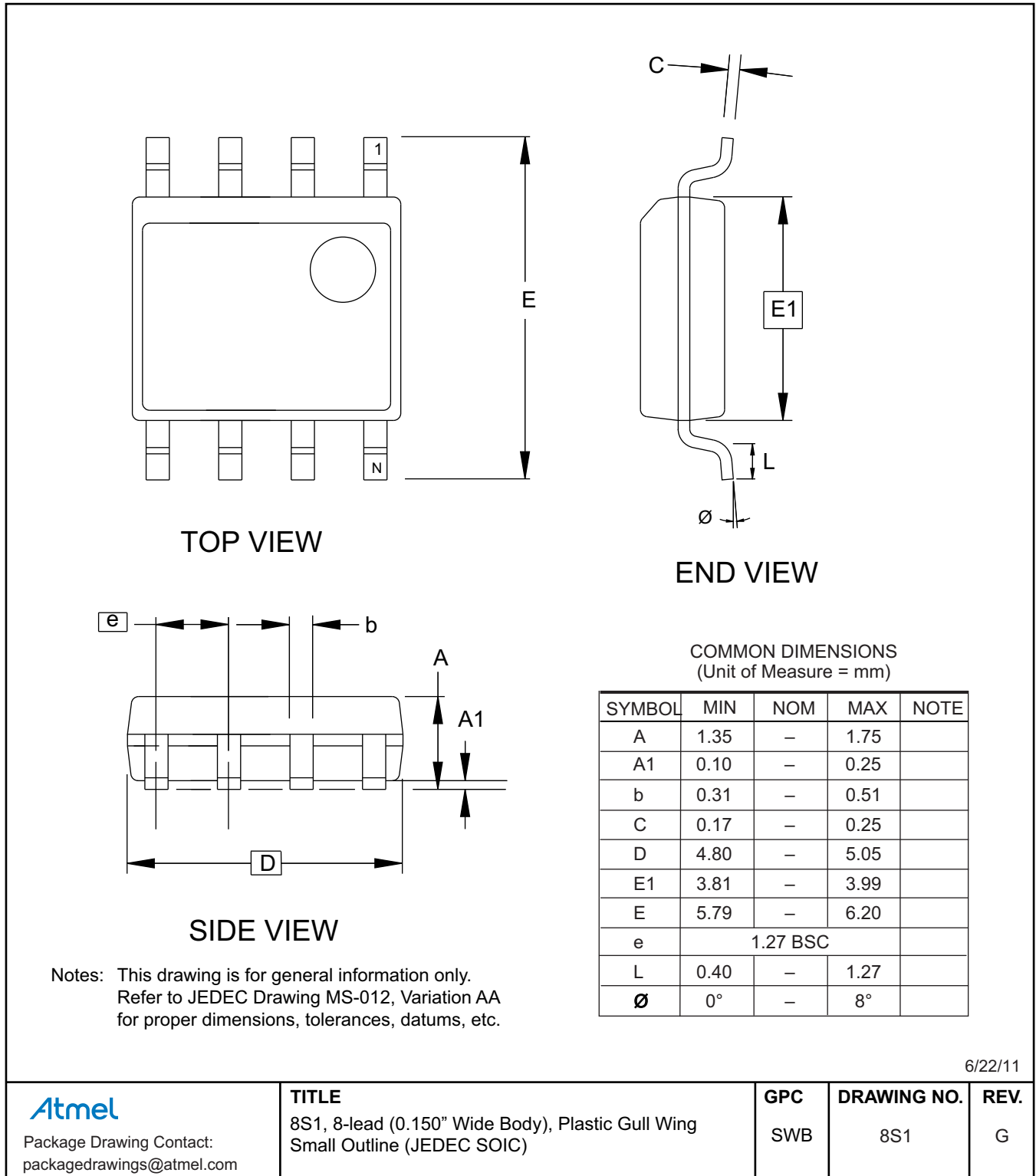
Atmel Ordering Code	Package	Operation Range
AT24C16C-SSPD	8S1	NiPdAu Lead-free/Halogen-free/Automotive Temperature (-40°C to 125°C)
AT24C16C-SSPD-T <sup>(1)</sup>		
AT24C16C-XPDP	8X	
AT24C16C-XPDP-T <sup>(1)</sup>		

- Note: 1. Tape and reel delivery:
- SOIC 4k/reel
  - TSSOP 5k/reel

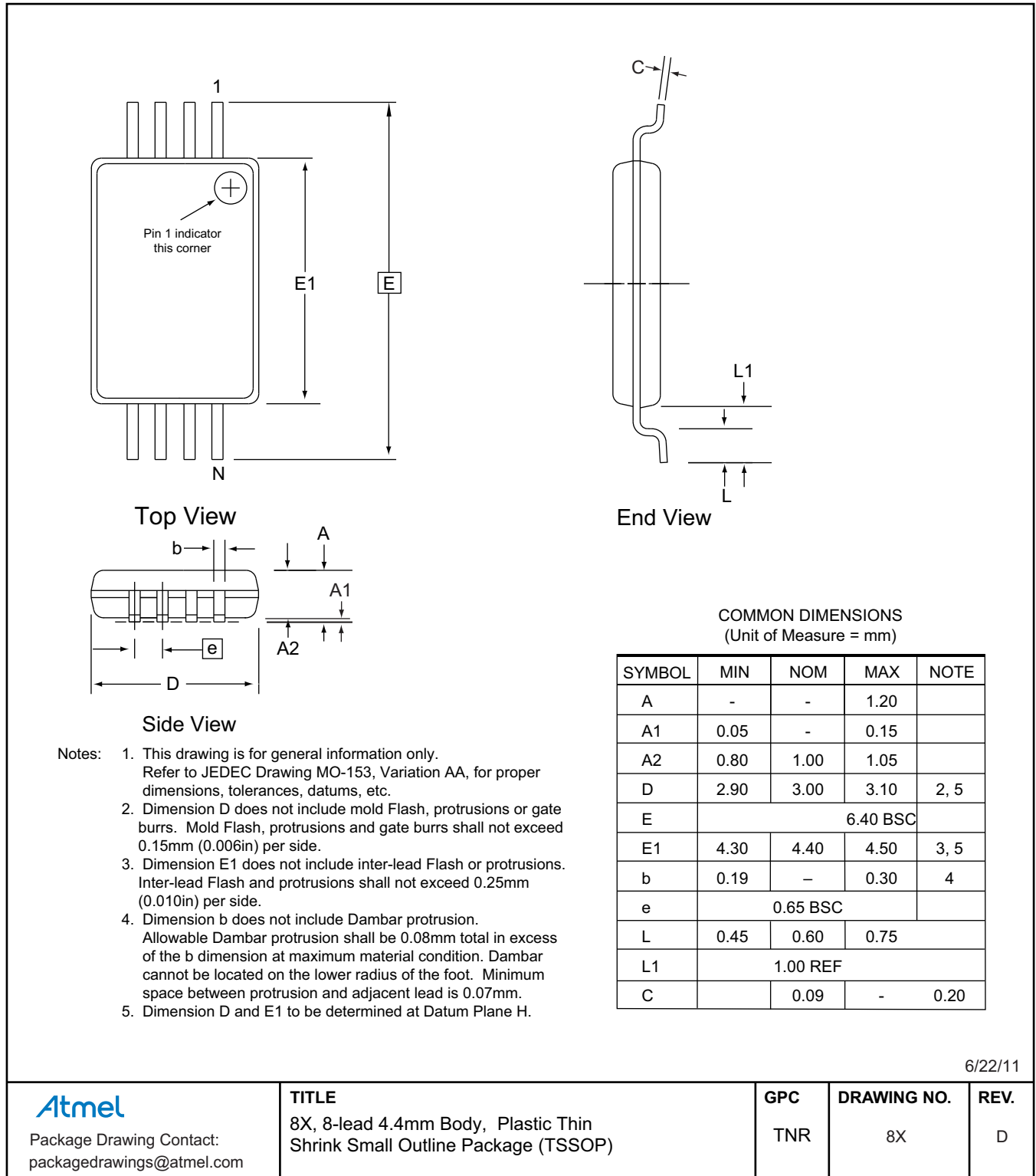
Package Type	
<b>8S1</b>	8-lead, 0.150" wide, Plastic Gull Wing Small Outline (JEDEC SOIC)
<b>8X</b>	8-lead, 0.170" wide, Thin Shrink Small Outline (TSSOP)

## 12. Packaging Information

### 8S1 — 8-lead JEDEC SOIC



## 8X — 8-lead TSSOP



### 13. Revision History

Doc. Rev.	Date	Comments
8799B	08/2012	Remove preliminary status. Update Atmel logos and disclaimer/copy page.
8799A	03/2012	Initial document release





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