



## DESCRIPTION

A24C02A provides 2048 bits of serial electrically erasable and programmable read-only memory (EEPROM), organized as 256 words of 8 bits each.

The A24C02A is optimized for use in many industrial and commercial applications where low-power and low-voltage operation is essential.

The A24C02A is available in SOP8, TSSOP8, DFN8, SOT-25 and TSOT-25 packages.

AEC-Q100 Qualified is available in SOP8, TSSOP8, DFN8 and SOT-25 packages.

## ORDERING INFORMATION

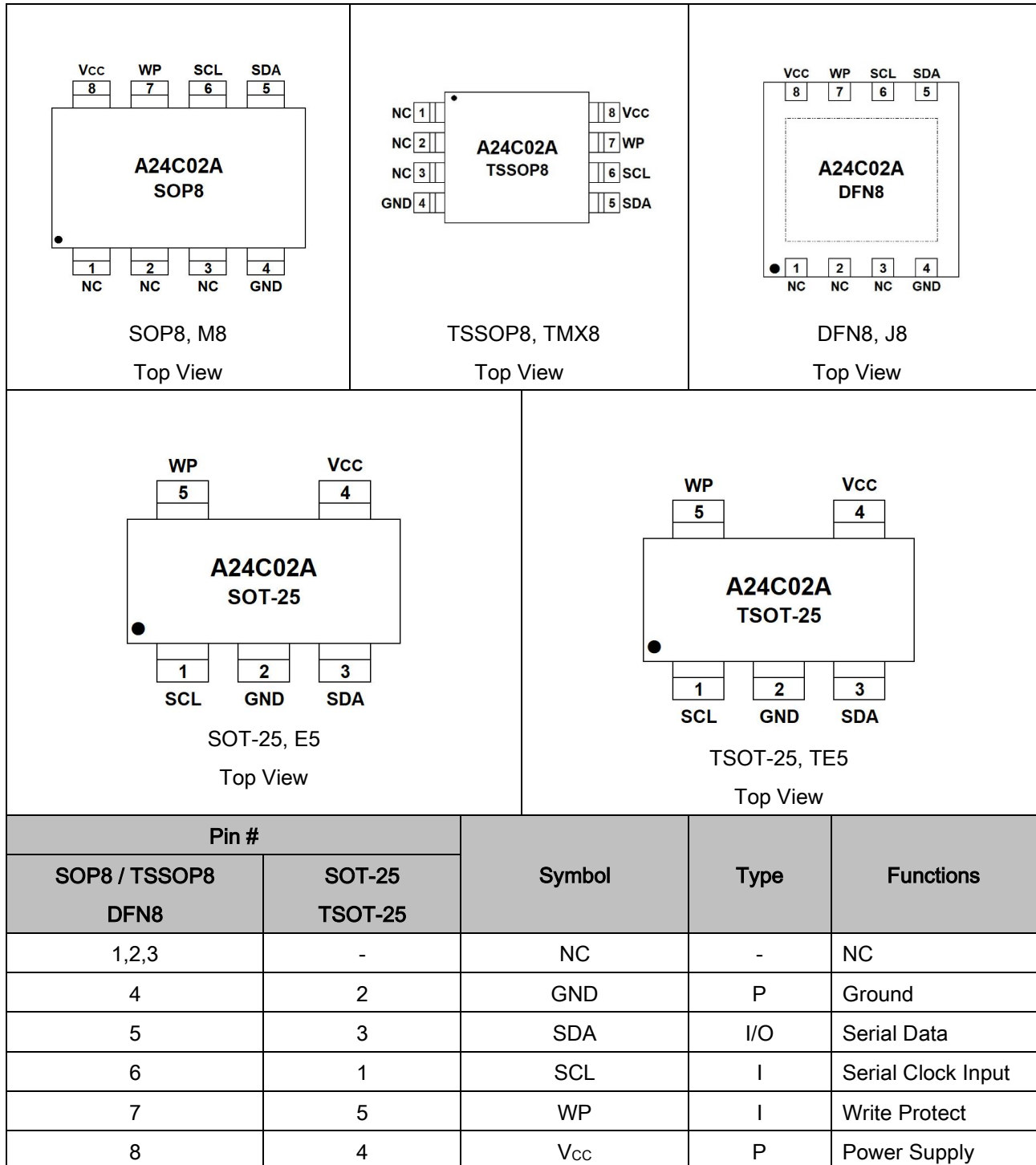
| Package Type                             | Part Number  |                 |
|--|--|-----------------|
| SOP8<br>AEC-Q100<br>SPQ: 2,500pcs/Reel   | M8   | A24C02AM8VR-X   |
| TSSOP8<br>AEC-Q100<br>SPQ: 3,000pcs/Reel | TMX8   | A24C02ATMX8VR-X |
| DFN8<br>AEC-Q100<br>SPQ: 3,000pcs/Reel   | J8   | A24C02AJ8VR-X   |
| SOT-25<br>AEC-Q100<br>SPQ: 3,000pcs/Reel | E5   | A24C02AE5VR-X   |
| TSOT-25<br>SPQ: 3,000pcs/Reel            | TE5  | A24C02ATE5VR-X  |
| Note                                     | X: Temperature, AEC-Q<br>B : -40°C to +105°C<br>C : -40°C to +125°C<br>Q : AEC-Q100<br>V: Halogen Free Package<br>R: Tape & Reel |                 |
| AiT provides all RoHS products           |  |                 |

## FEATURES

- Compatible with all I<sup>2</sup>C bidirectional data transfer protocol
- Memory Array:  
2K bits (256X 8) of EEPROM  
Page size: 16 bytes
- Extended Temperature Range  
B : -40°C to +105°C  
C : -40°C to +125°C  
Q : -40°C to +125°C (AEC-Q100 Certificated)
- Single Supply Voltage and High Speed:  
1MHz  
Random and sequential Read modes
- Write:  
Byte Write within 3 ms  
Page Write within 3 ms  
Partial Page Writes Allowed
- Write Protect Pin for Hardware Data Protection
- Schmitt Trigger, Filtered Inputs for Noise Suppression
- High-Reliability  
Endurance: 4 Million Write Cycles  
Data Retention: 100 Years
- Enhanced ESD/Latch-up Protection  
HBM 8000V



**PIN DESCRIPTION**



**ABSOLUTE MAXIMUM RATINGS**

|  |                                  |
|--|----------------------------------|
| DC Supply Voltage                      | -0.3V ~ +6.5V                    |
| Input / Output Voltage                 | GND-0.3V ~ V <sub>CC</sub> +0.3V |
| Storage Temperature                    | -65°C ~ +150°C                   |
| Electrostatic Pulse (Human Body Model) | 8000V                            |

Stresses above may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**PIN CAPACITANCE**

Applicable over recommended operating range from: T<sub>A</sub> = 25°C, f = 1.0MHz, V<sub>CC</sub> = +2.5V

| Parameter                           | Symbol           | Condition            | Min. | Typ. | Max. | Unit |
|-------------------------------------|------------------|----------------------|------|------|------|------|
| Input/ Output Capacitance (SDA)     | C <sub>I/O</sub> | V <sub>I/O</sub> =0V | -    | -    | 8    | pF   |
| Input Capacitance (A0, A1, A2, SCL) | C <sub>IN</sub>  | V <sub>IN</sub> =0V  | -    | -    | 6    | pF   |

**DC ELECTRICAL CHARACTERISTICS**

Applicable over recommended operating range, unless otherwise noted

|           |                                  |  |
|-----------|----------------------------------|--|
| A24C02A-B | T <sub>A</sub> = -40°C to +105°C | V <sub>CC</sub> = +1.7V to +5.5V@400kHz<br>V <sub>CC</sub> = +2.5V to +5.5V@1MHz<br>C <sub>L</sub> =100 pF |
| A24C02A-C | T <sub>A</sub> = -40°C to +125°C |  |
| A24C02A-Q | T <sub>A</sub> = -40°C to +125°C |  |

| Parameter                               | Symbol           | Condition   | Min.                 | Typ. | Max.                  | Unit |
|---|------------------|---|----------------------|------|-----------------------|------|
| Supply Current V <sub>CC</sub> = 5.0V   | I <sub>CCR</sub> | Read at 400kHz  | -                    | 0.14 | 0.3                   | mA   |
| Supply Current V <sub>CC</sub> = 5.0V   | I <sub>CCW</sub> | Write at 400kHz                                       | -                    | 0.28 | 0.5                   | mA   |
| Supply Current V <sub>CC</sub> = 5.0V   | I <sub>SB</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or V <sub>SS</sub>  | -                    | 0.03 | 2.0                   | μA   |
| Input Leakage Current                   | I <sub>LI</sub>  | V <sub>IN</sub> = V <sub>CC</sub> or V <sub>SS</sub>  | -                    | 0.10 | 1.0                   | μA   |
| Output Leakage Current                  | I <sub>LO</sub>  | V <sub>OUT</sub> = V <sub>CC</sub> or V <sub>SS</sub> | -                    | 0.05 | 1.0                   | μA   |
| Input Low Level                         | V <sub>IL</sub>  | V <sub>CC</sub> = 1.7V to 5.5V                        | -0.3                 | -    | V <sub>CC</sub> x 0.3 | V    |
| Input High Level                        | V <sub>IH</sub>  | V <sub>CC</sub> = 1.7V to 5.5V                        | V <sub>CC</sub> x0.7 | -    | V <sub>CC</sub> + 0.3 | V    |
| Output Low Level V <sub>CC</sub> = 1.7V | V <sub>OL1</sub> | I <sub>OL</sub> = 0.15mA                              | -                    | -    | 0.2                   | V    |
| Output Low Level V <sub>CC</sub> = 5.0V | V <sub>OL2</sub> | I <sub>OL</sub> = 3.0mA                               | -                    | -    | 0.4                   | V    |



## AC ELECTRICAL CHARACTERISTICS <sup>(2)</sup>

Applicable over recommended operating range, unless otherwise noted

|           |                                  |  |
|-----------|----------------------------------|--|
| A24C02A-B | T <sub>A</sub> = -40°C to +105°C | V <sub>CC</sub> = +1.7V to +5.5V@400kHz                          |
| A24C02A-C | T <sub>A</sub> = -40°C to +125°C |  |
| A24C02A-Q | T <sub>A</sub> = -40°C to +125°C | V <sub>CC</sub> = +2.5V to +5.5V@1MHz<br>C <sub>L</sub> = 100 pF |

| Parameter   | Symbol              | 1.7V ≤ V <sub>CC</sub> < 2.5V |      |      | 2.5V ≤ V <sub>CC</sub> < 5.5V |      |      | Unit         |
|---|---------------------|-------------------------------|------|------|-------------------------------|------|------|--------------|
|   |                     | Min.                          | Typ. | Max. | Min.                          | Typ. | Max. |              |
| Clock Frequency, SCL  | f <sub>SCL</sub>    | -                             | -    | 400  | -                             | -    | 1000 | kHz          |
| Clock Pulse Width Low   | t <sub>LOW</sub>    | 1.3                           | -    | -    | 0.5                           | -    | -    | μs           |
| Clock Pulse Width High  | t <sub>HIGH</sub>   | 0.6                           | -    | -    | 0.26                          | -    | -    | μs           |
| Noise Suppression Time  | t <sub>i</sub>      | -                             | -    | 50   | -                             | -    | 50   | ns           |
| Clock Low to Data Out Valid                                   | t <sub>AA</sub>     | -                             | -    | 0.9  | -                             | -    | 0.45 | μs           |
| Time the bus must be free before a new transmission can start | t <sub>BUF</sub>    | 1.3                           | -    | -    | 0.5                           | -    | -    | μs           |
| Start Hold Time   | t <sub>HD,STA</sub> | 0.6                           | -    | -    | 0.25                          | -    | -    | μs           |
| Start Setup Time  | t <sub>SU,STA</sub> | 0.6                           | -    | -    | 0.25                          | -    | -    | μs           |
| Data In Hold Time   | t <sub>HD,DAT</sub> | 0                             | -    | -    | 0                             | -    | -    | μs           |
| Data In Setup Time  | t <sub>SU,DAT</sub> | 100                           | -    | -    | 100                           | -    | -    | ns           |
| Inputs Rise Time <sup>(1)</sup>                               | t <sub>R</sub>      | -                             | -    | 0.3  | -                             | -    | 0.12 | μs           |
| Inputs Fall Time <sup>(1)</sup>                               | t <sub>F</sub>      | -                             | -    | 0.3  | -                             | -    | 0.12 | μs           |
| Stop Setup Time   | t <sub>SU,STO</sub> | 0.6                           | -    | -    | 0.25                          | -    | -    | μs           |
| Data Out Hold Time  | t <sub>DH</sub>     | 50                            | -    | -    | 50                            | -    | -    | ns           |
| Write Cycle Time  | t <sub>WR</sub>     | -                             | 1.9  | 3    | -                             | 1.9  | 3    | ms           |
| 5.0V, 25°C, Byte Mode <sup>(1)</sup>                          | Endurance           | 1M                            | -    | -    | 1M                            | -    | -    | Write Cycles |

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

(2): AC measurement conditions: R<sub>L</sub> (connects to V<sub>CC</sub>): 1.3K

Input pulse voltages: 0.3 V<sub>CC</sub> to 0.7V<sub>CC</sub>

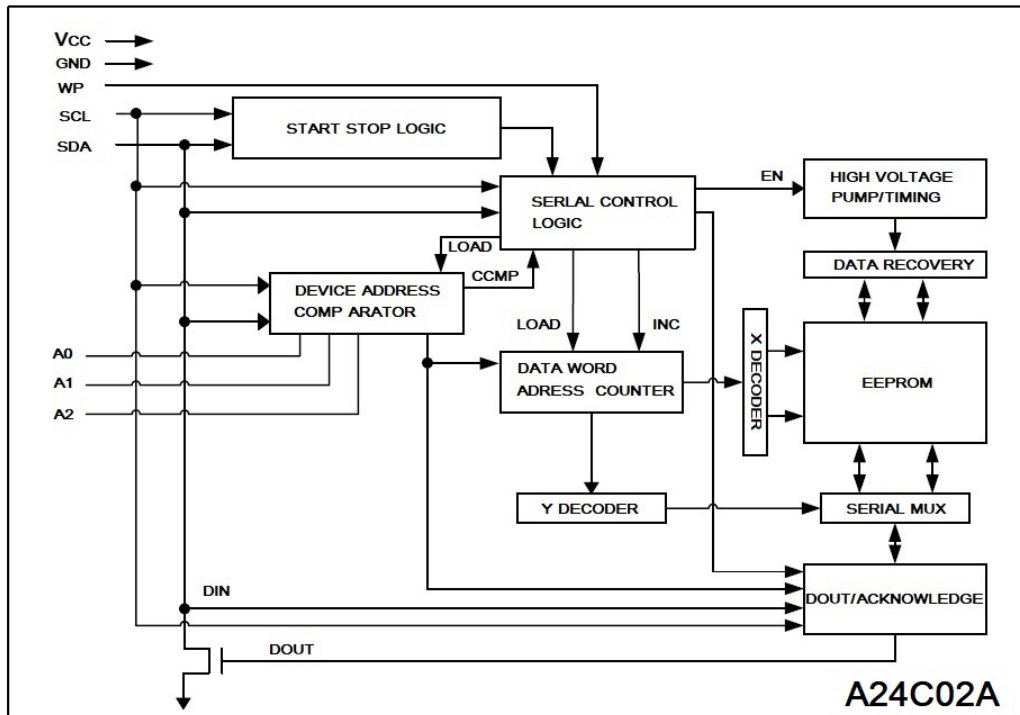
Input rise and fall time: 50ns

Input and output timing reference voltages: 0.5V<sub>CC</sub>

The value of R<sub>L</sub> should be concerned according to the actual loading on the user's system.



**BLOCK DIAGRAM**



**DETAILED INFORMATION**

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

**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.

**WRITE PROTECT (WP):** The A24C02A 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 Protection pin is connected to V<sub>CC</sub>, the write protection feature is enabled and operates as shown in the following Table 1.

Table1: Write Protect

| WP Pin Status      | A24C02A                      |
|--------------------|------------------------------|
| At V <sub>CC</sub> | Full (2K) Array              |
| At GND             | Normal Read/Write Operations |



## FUNCTION DESCRIPTION

### 1. Memory Organization

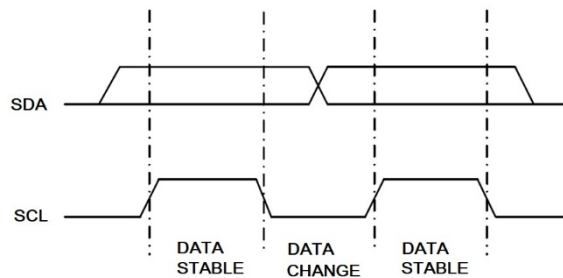
**A24C02A, 2K SERIAL EEPROM:** Internally organized with 16 pages of 16 bytes each, the 2K requires an 8-bit data word address for random word addressing.

### 2. Device Operation

#### CLOCK and DATA TRANSITIONS:

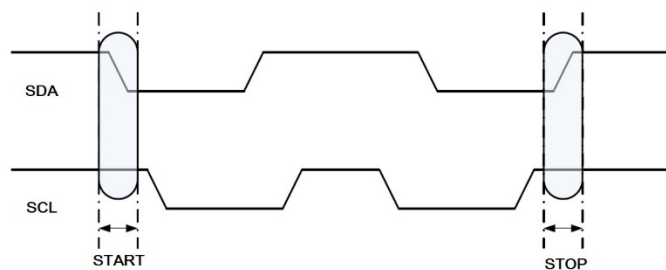
The SDA pin is normally pulled high with an external device. Data on the SDA pin may change only during SCL low time periods (see Figure 1). Data changes during SCL high periods will indicate a start or stop condition as defined.

Figure 1 Data Validity



**START CONDITION:** A high-to-low transition of SDA with SCL high is a start condition which must precede any other command (see Figure 2).

Figure 2 Start and Stop Definition

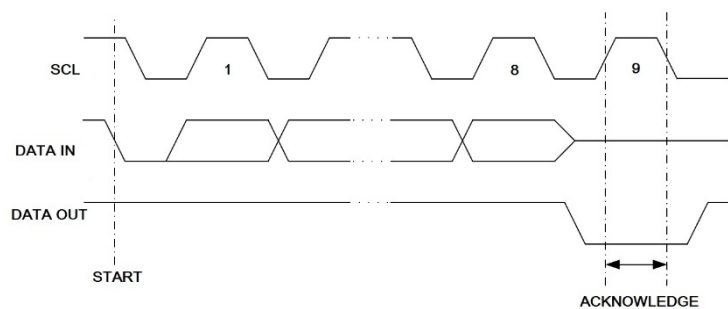


**STOP CONDITION:** A low-to-high transition of SDA with SCL high is a stop condition. After a read sequence, the stop command will place the EEPROM in a standby power mode (see Figure 2).

#### ACKNOWLEDGE:

All addresses and data words are serially transmitted to and from the EEPROM in 8-bit words. The EEPROM sends a "0" to acknowledge that it has received each word. This happens during the ninth clock cycle.

Figure 3 Output Acknowledge





**STANDBY MODE:** The A24C02A features a low-power standby mode which is enabled:

- (a) Upon power-up
- (b) After the receipt of the STOP bit and the completion of any internal operations.

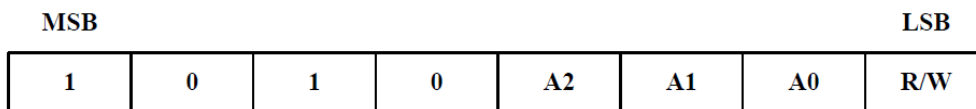
**MEMORY RESET:** After the protocol is interrupted, power loss or system reset, any two-wire part can be reset by following these steps:

1. Clock up to 9 cycles.
2. Look for SDA high in each cycle while SCL is high.
3. Create a start condition and a stop condition.

### 3. Device Addressing

The 2K EEPROM devices all require an 8-bit device address word following a start condition to enable the chip for a read or write operation (see Figure 4).

Figure 4 Device Address



The device address word consists of a mandatory "1", "0" sequence for the first four most significant bits as shown. This is common to all the Serial EEPROM devices. The next 3 bits are fixed to zero.

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.

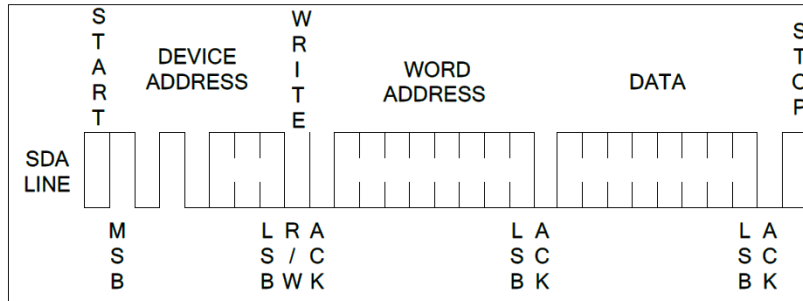
Upon a compare of the device address, the EEPROM will output a "0". If a compare is not made, the chip will return to a standby state.

### 4. 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 "0" and then clock in the first 8-bit data word. Following receipt of the 8-bit data word, the EEPROM will output a "0" 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 5).

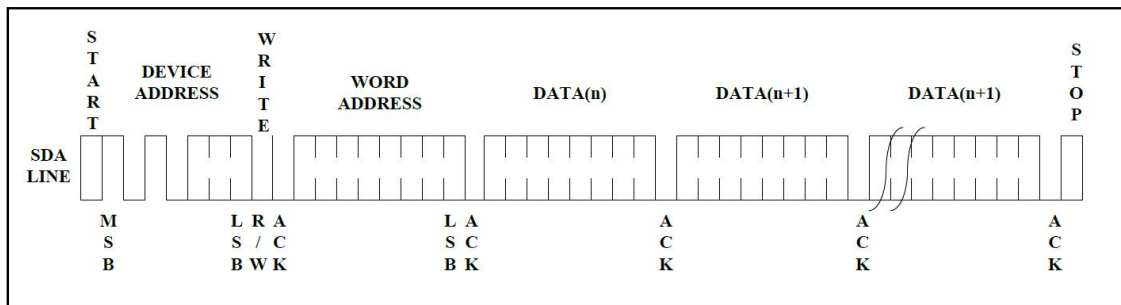


Figure 5 Byte Write



**PAGE WRITE:** 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 "0" after each data word received. The microcontroller must terminate the page write sequence with a stop condition (see Figure 6).

Figure 6 Page Write



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 "0", allowing the read or write sequence to continue.

### 5. Read Operations

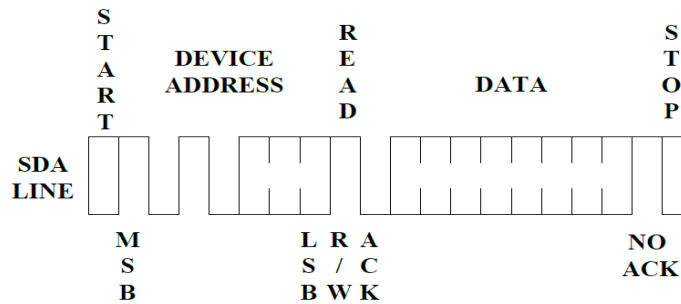
Read operations are initiated the same way as write operations with the exception that the read/write select bit in the device address word is set to "1". There are three read operations: current address read, random address read and sequential read.





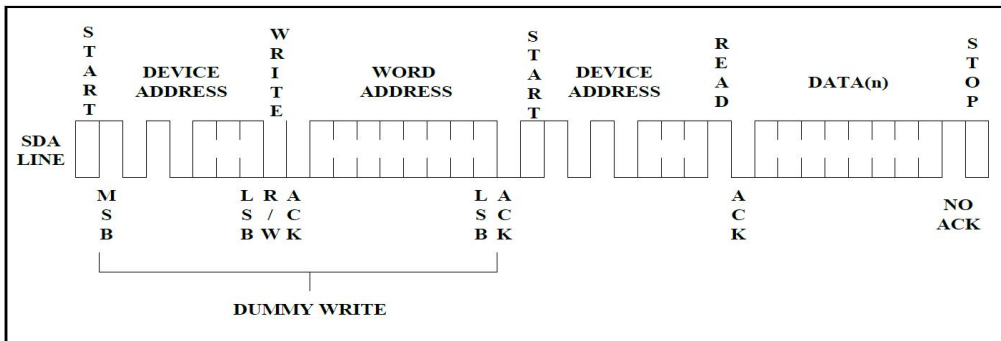
**CURRENT ADDRESS READ:** The internal data word address counter maintains the last address accessed during the last read or write operation, incremented by one. This address stays valid between operations as long as the chip power is maintained. The address "roll over" during read is from the last byte 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 "1" 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 "0" but does generate a following stop condition (see Figure 7).

Figure 7 Current Address Read



**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 "0" but does generate a following stop condition (see Figure 8)

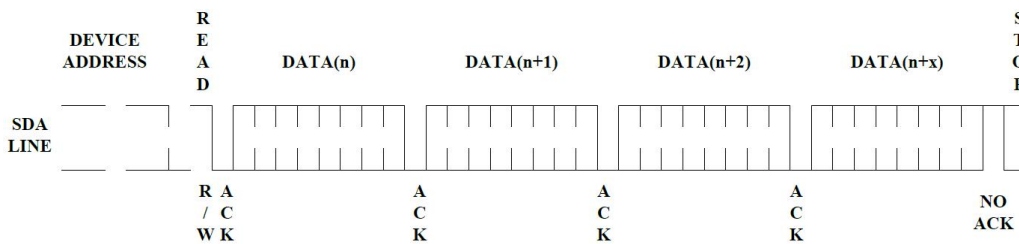
Figure 8 Random Read





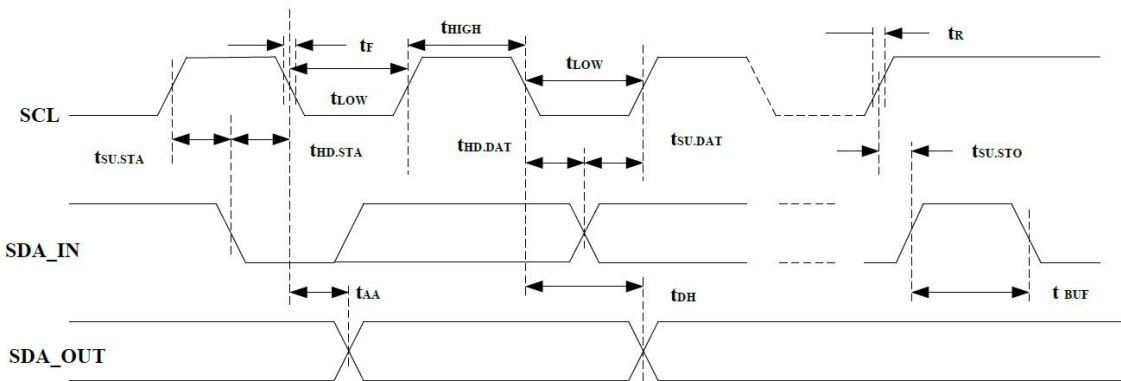
**SEQUENTIAL READ:** Sequential reads are initiated by either a current address read or a random address read. After the microcontroller receives a data word, it responds with an acknowledge. As long as the EEPROM receives an acknowledge, it will continue to increment the data word address and serially 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 respond with a "0" but does generate a following stop condition (see Figure 9).

Figure 9 Sequential Read



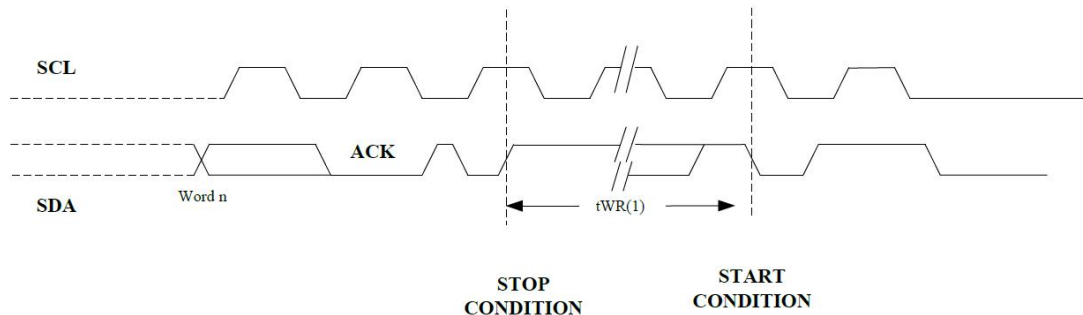
**BUS TIMING**

Figure 10 SCL: Serial Clock, SDA: Serial Data I/O



**WRITE CYCLE TIMING**

Figure 11 SCL: Serial Clock, SDA: Serial Data I/O

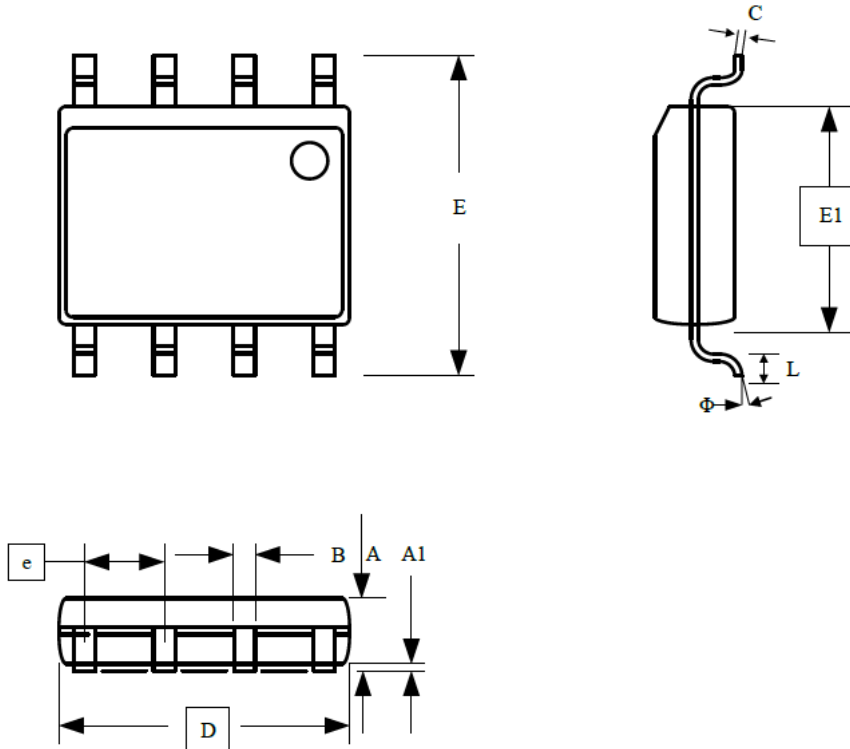


NOTE: The write cycle time  $t_{WR}$  is the time from a valid stop condition of a write sequence to the end of the internal clear/write cycle.



**PACKAGE INFORMATION**

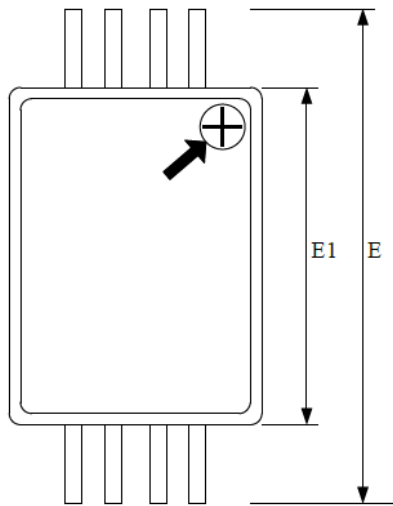
Dimension in SOP8 (Unit: mm)



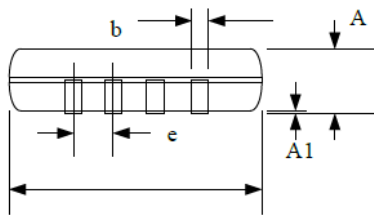
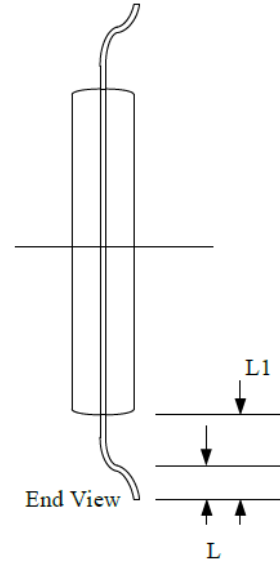
| Symbol | Min     | Max   |
|--------|---------|-------|
| A      | 1.350   | 1.750 |
| A1     | 0.100   | 0.230 |
| B      | 0.390   | 0.480 |
| C      | 0.210   | 0.260 |
| D      | 4.700   | 5.100 |
| E1     | 3.700   | 4.100 |
| E      | 5.800   | 6.200 |
| e      | 1.27BSC |       |
| L      | 0.500   | 0.800 |
| θ      | 0°      | 8°    |



Dimension in TSSOP8 Package (Unit: mm)



Top View

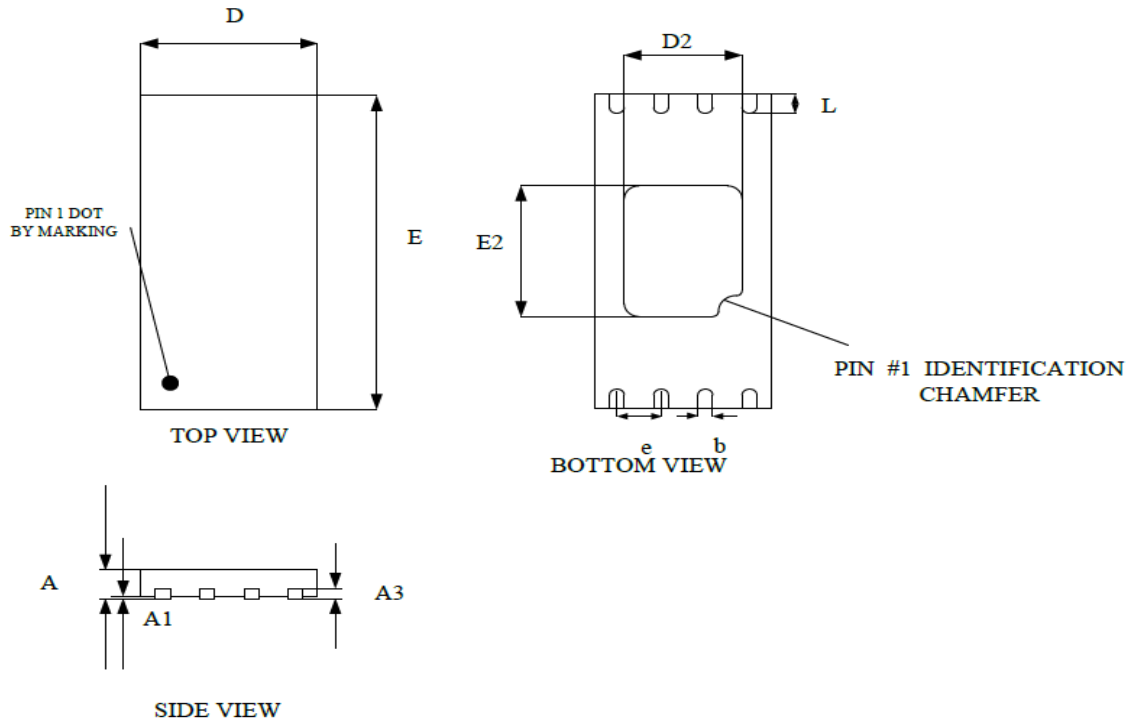


Side View

| Symbol | Min       | Max   |
|--------|-----------|-------|
| D      | 2.900     | 3.100 |
| E      | 6.200     | 6.600 |
| E1     | 4.300     | 4.500 |
| A      | -         | 1.200 |
| A1     | 0.050     | 0.150 |
| b      | 0.210     | 0.300 |
| e      | 0.650 BSC |       |
| L      | 0.450     | 0.750 |
| L1     | 1.000 REF |       |



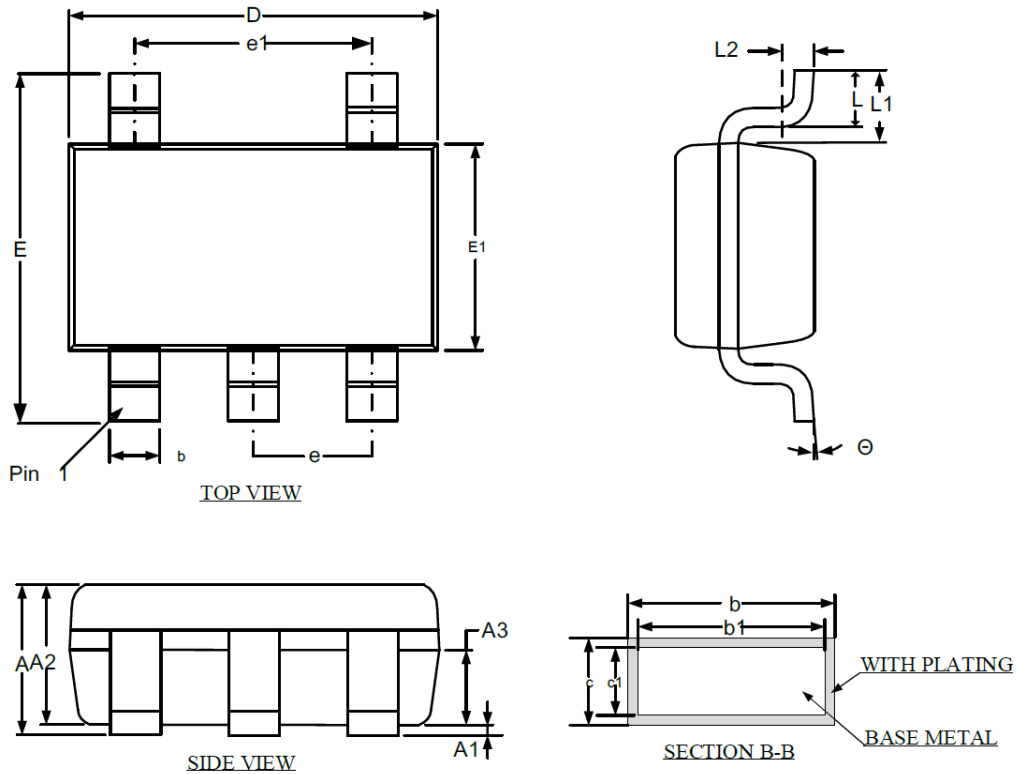
Dimension in DFN8 (Unit: mm)



| Symbol | Min       | Max   |
|--------|-----------|-------|
| A      | 0.500     | 0.600 |
| A1     | 0.000     | 0.050 |
| A3     | 0.15 REF  |       |
| D      | 1.950     | 2.050 |
| E      | 2.950     | 3.050 |
| b      | 0.200     | 0.300 |
| L      | 0.200     | 0.400 |
| D2     | 1.250     | 1.500 |
| E2     | 1.150     | 1.400 |
| e      | 0.500 BSC |       |



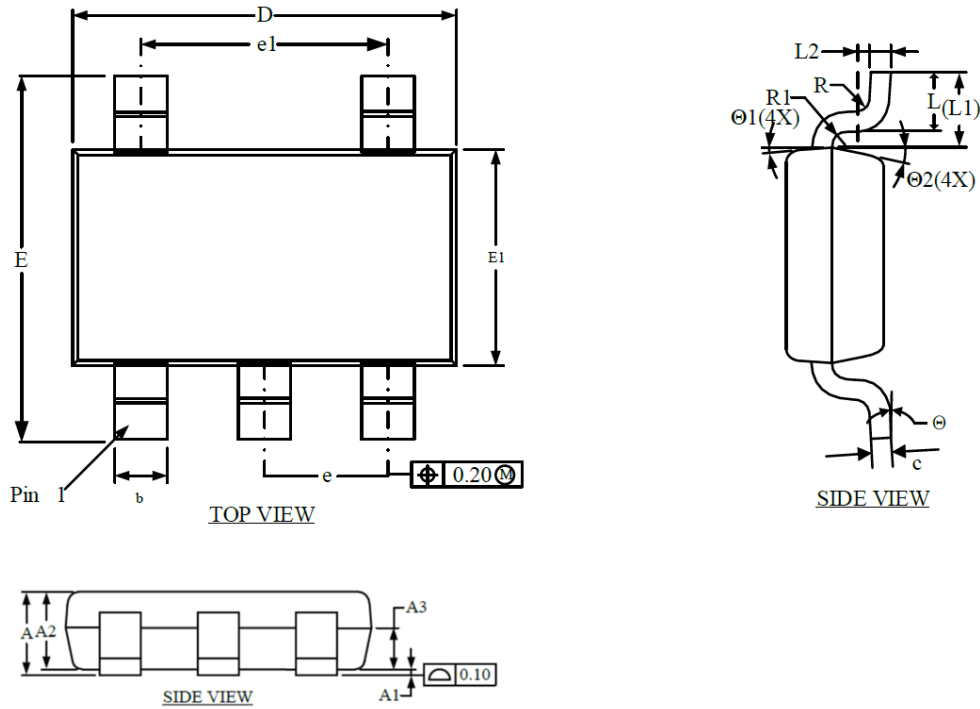
Dimension in SOT-25 (Unit: mm)



| Symbol | Min.      | Max.  |
|--------|-----------|-------|
| A      | -         | 1.350 |
| A1     | 0.040     | 0.150 |
| A2     | 1.000     | 1.200 |
| A3     | 0.550     | 0.750 |
| b      | 0.380     | 0.480 |
| b1     | 0.370     | 0.430 |
| c      | 0.110     | 0.210 |
| c1     | 0.100     | 0.160 |
| D      | 2.720     | 3.120 |
| E      | 2.600     | 3.000 |
| E1     | 1.400     | 1.800 |
| e      | 0.950 BSC |       |
| e1     | 1.900 BSC |       |
| L      | 0.300     | 0.600 |
| L1     | 0.575 REF |       |
| L2     | 0.258 BSC |       |
| θ      | 0°        | 8°    |



Dimension in TSOT-25 (Unit: mm)



| Symbol | Min       | Max   |
|--------|-----------|-------|
| A      | -         | 0.900 |
| A1     | 0.000     | 0.100 |
| A2     | 0.650     | 0.850 |
| A3     | 0.350     | 0.450 |
| b      | 0.300     | 0.500 |
| c      | 0.140     | 0.200 |
| D      | 2.850     | 3.050 |
| E      | 2.650     | 2.950 |
| E1     | 1.600     | 1.700 |
| e      | 0.900     | 1.000 |
| e1     | 1.800     | 2.000 |
| L      | 0.300     | 0.600 |
| L1     | 0.575 REF |       |
| L2     | 0.258 BSC |       |
| R      | -         | 0.25  |
| R1     | -         | 0.25  |
| θ      | 0°        | 8°    |
| θ1     | 3°        | 7°    |
| θ2     | 10°       | 14°   |



## IMPORTANT NOTICE

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