1. Features

- Write Protect Pin for Hardware Data Protection
  - Utilizes Different Array Protection Compared to the AT24C02B/04B
- Medium-voltage and Standard-voltage Operation
  - 2.5 (V_{CC} = 2.5V to 5.5V)
- Automotive Temperature Range –40°C to 125°C
- Internally Organized 256 x 8 (2K), 512 x 8 (4k)
- Two-wire Serial Interface
- Schmitt Trigger, Filtered Inputs for Noise Suppression
- Bidirectional Data Transfer Protocol
- 400 kHz (2.5V) Compatibility
- Write Protect Pin for Hardware Data Protection
- 8-byte Page (2k), 16-byte Page (4k) Write Modes
- Partial Page Writes are Allowed
- Self-timed Write Cycle (5 ms max)
- High-reliability
  - Endurance: 1 Million Write Cycles
  - Data Retention: 100 Years
- 8-lead JEDEC SOIC and 8-lead TSSOP Packages

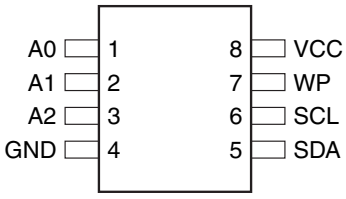
2. Description

The AT24HC02B/04B provides 2048/4096 bits of serial electrically erasable and programmable read-only memory (EEPROM) organized as 256/512 words of 8 bits each. The device is optimized for use in many automotive applications where low-power and low-voltage operation are essential. The AT24HC02B/04B is available in space-saving 8-lead JEDEC SOIC and 8-lead TSSOP packages and is accessed via a two-wire serial interface. In addition, the entire family is available in 2.5V (2.5V to 5.5V) versions.

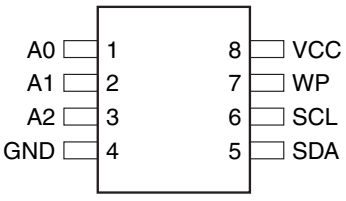
Table 2-1. Pin Configurations

Pin Name	Function
A0 – A2	Address Inputs
SDA	Serial Data
SCL	Serial Clock Input
WP	Write Protect
NC	No Connect

8-lead SOIC



8-lead TSSOP



Two-wire Automotive Temperature Serial EEPROM

2K (256 x 8)

4k (512 x 8)

AT24HC02B
AT24HC04B

5192C–SEEPR–01/09

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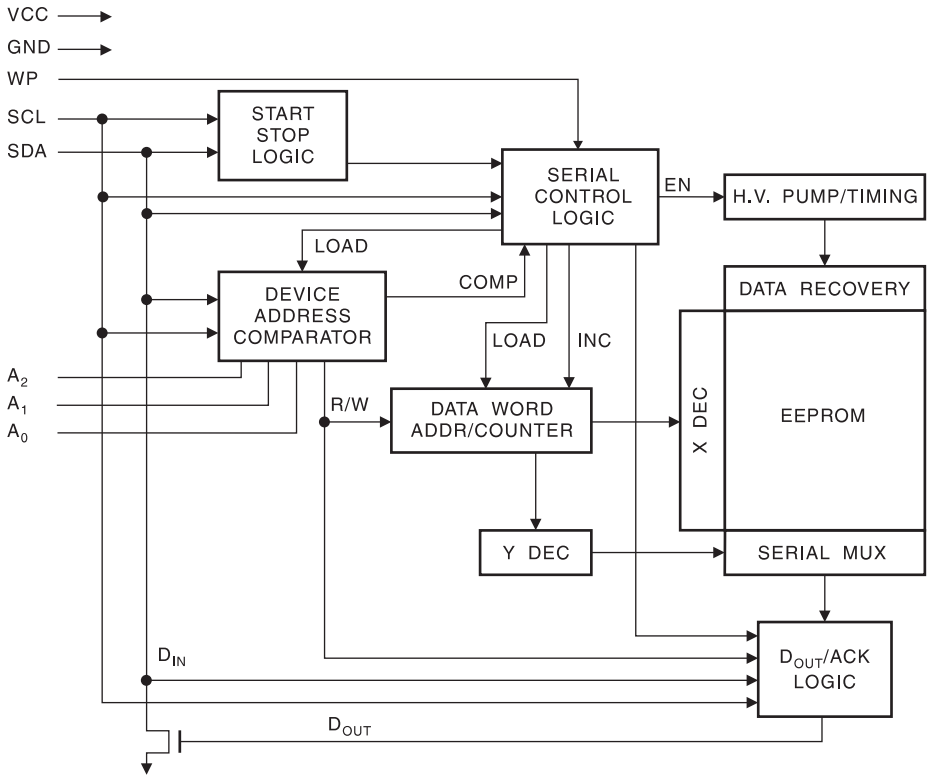
Absolute Maximum Ratings

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.

Figure 2-1. 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 (A2, A1, A0): The A2, A1 and A0 pins are device address inputs that are hard wired for the AT24HC02B. As many as eight 2K devices may be addressed on a single bus system (device addressing is discussed in detail under the Device Addressing section).

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The AT24HC04B uses the A2 and A1 inputs for hardware addressing, and a total of four 4K devices may be addressed on a single bus system. The A0 pin is a no-connect.

WRITE PROTECT (WP): The AT24HC02B/04B have 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
	AT24HC02B/04B
At V_{CC}	Upper Half (1K/2K) Array
At GND	Normal Read/Write Operations

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4. Memory Organization

AT24HC02B, 2K SERIAL EEPROM: Internally organized with 32 pages of 8 bytes each, the 2K requires an 8-bit data word address for random word addressing.

AT24HC04B, 4K SERIAL EEPROM: Internally organized with 32 pages of 16 bytes each. Random word addressing requires a 9-bit data word address.

Table 4-1. Pin Capacitance[1]

Applicable over recommended operating range from T_A = 25°C, f = 1.0 MHz, V_{CC} = +2.5V

Symbol	Test Condition	Max	Units	Conditions
$C_{I/O}$	Input/Output Capacitance (SDA)	8	pF	$V_{I/O}$ = 0V
C_{IN}	Input Capacitance (A_0, A_1, A_2, SCL)	6	pF	V_{IN} = 0V

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

Table 4-2. DC Characteristics

Applicable over recommended operating range from: T_A = –40°C to +125°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 100 kHz		0.4	1.0	mA
I_{CC}	Supply Current V_{CC} = 5.0V	Write at 100 kHz		2.0	3.0	mA
I_{SB1}	Standby Current V_{CC} = 2.5V	V_{IN} = V_{CC} or V_{SS}		1.6	4.0	µA
I_{SB2}	Standby Current V_{CC} = 5.0V	V_{IN} = V_{CC} or V_{SS}		8.0	18.0	µA
I_{LI}	Input Leakage Current	V_{IN} = V_{CC} or V_{SS}		0.10	3.0	µA
I_{LO}	Output Leakage Current	V_{OUT} = V_{CC} or V_{SS}		0.05	3.0	µA
V_{IL}	Input Low Level[1]		–0.6		V_{CC} x 0.3	V
V_{IH}	Input High Level[1]		V_{CC} x 0.7		V_{CC} + 0.5	V
V_{OL}	Output Low Level V_{CC} = 2.5V	I_{OL} = 3.0 mA			0.4	V

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

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Table 4-3. AC Characteristics

Applicable over recommended operating range from T_A = –40°C to +125°C, V_{CC} = +2.5V to +5.5V, CL = 1 TTL Gate and 100 pF (unless otherwise noted)

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

Notes: 1. This parameter is characterized and is not 100% tested (T_A = 25°C).
2. This parameter is ensured by characterization only.

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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 to Figure 7-2 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 to Figure 7-3 on page 8).

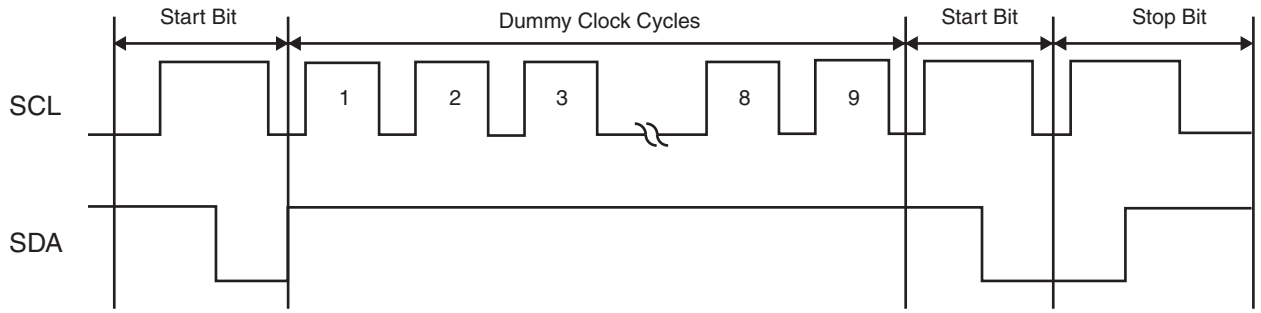
STOP CONDITION: A low-to-high transition of SDA with SCL high is a stop condition. After a read sequence, the stop command will place the EEPROM in a standby power mode (see Figure 7-3 on page 8).

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.

STANDBY MODE: The AT24HC02B/04B features a low-power standby mode which is enabled: (a) upon power-up and (b) after the receipt of the STOP bit and the completion of any internal operations.

SOFTWARE RESET: After an interruption in protocol, power loss or system reset, any two-wire part can be protocol reset by following these steps (a) Create a start bit condition. (b) Clock nine cycles. (c) Create another start bit followed by stop bit condition as shown below. The device is ready for next communication after above steps have been completed.

Figure 5-1. Software Reset Protocol



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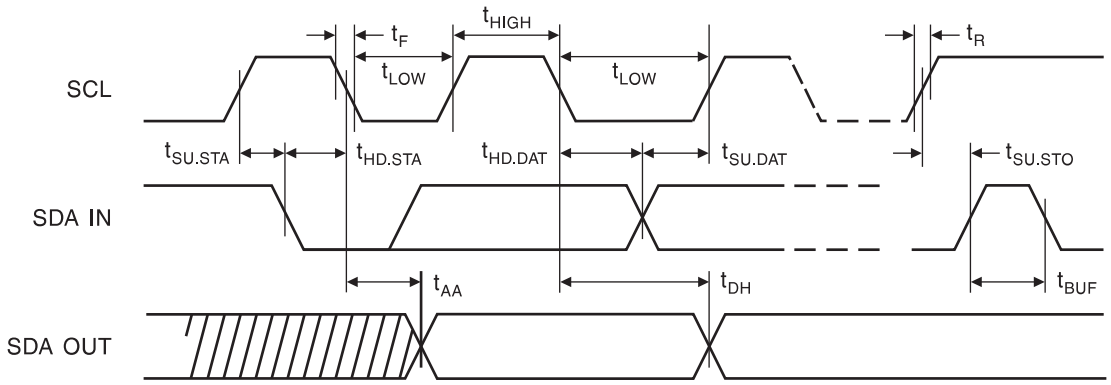
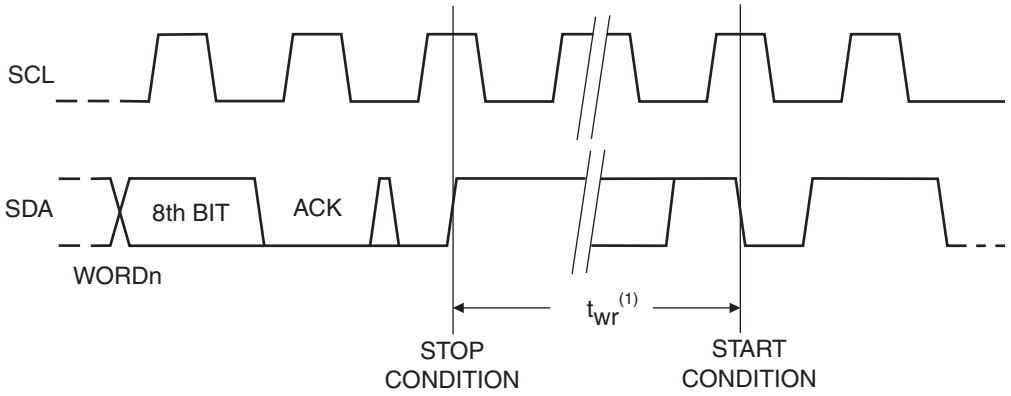
6. Bus Timing

Figure 6-1. SCL: Serial Clock, SDA: Serial Data I/O



7. Write Cycle Timing

Figure 7-1. 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 7-2. Data Validity

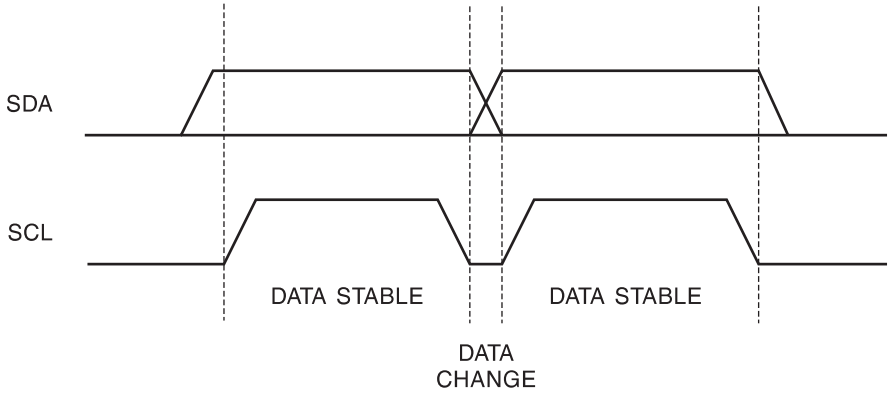


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Figure 7-3. Start and Stop Definition

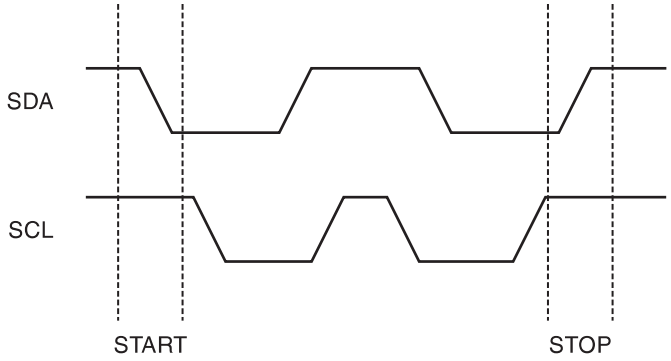
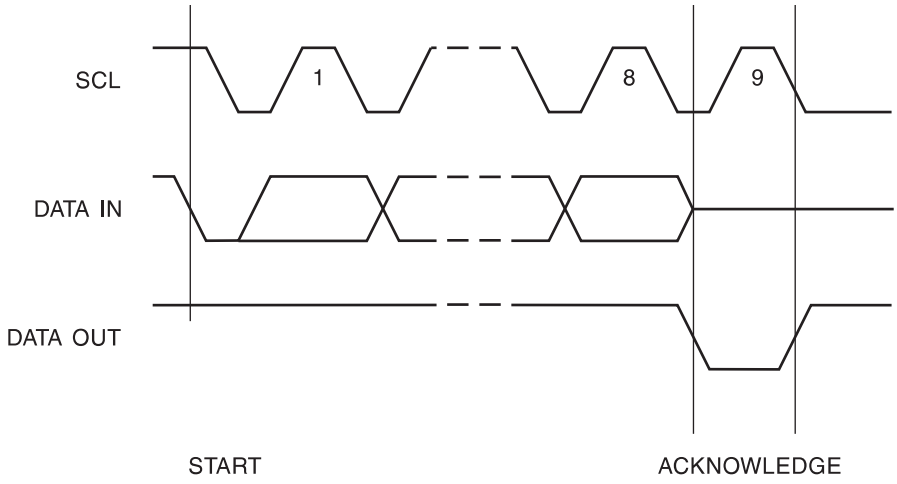


Figure 7-4. Output Acknowledge



8. Device Addressing

The 2Kand 4K 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 to Figure 10-1 on page 10).

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 the A2, A1 and A0 device address bits for the 2K EEPROM. These 3 bits must compare to their corresponding hardwired input pins.

The 4K EEPROM only uses the A2 and A1 device address bits with the third bit being a memory address bit (See Figure 10-1). The two device address bits must compare to their corresponding hardwired input pins. The A0 pin is no-connect.

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.

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9. 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 10-2 on page 10).

PAGE WRITE: The 2K EEPROM is capable of an 8-byte page write, and the 4K EEPROM device 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 seven (2K) or sixtenn (4K) 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 10-3 on page 11).

The data word address lower three bits (2K) or four (4K) 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 eight (2K) or sixteen (4K) 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.

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10. 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 10-5 on page 11).

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 10-4 on page 11).

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 10-6 on page 11).

Figure 10-1. Device Address

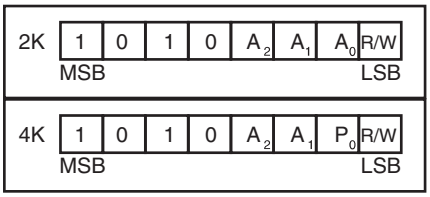

Figure 10-2. Byte Write

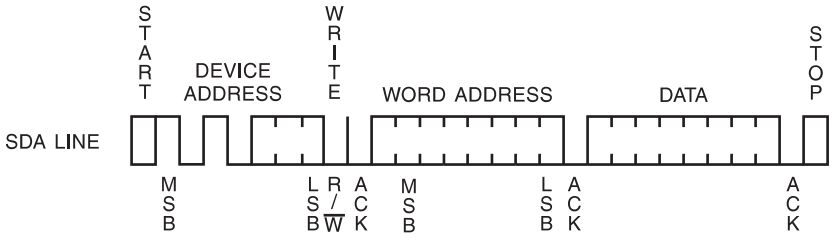

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Figure 10-3. Page Write

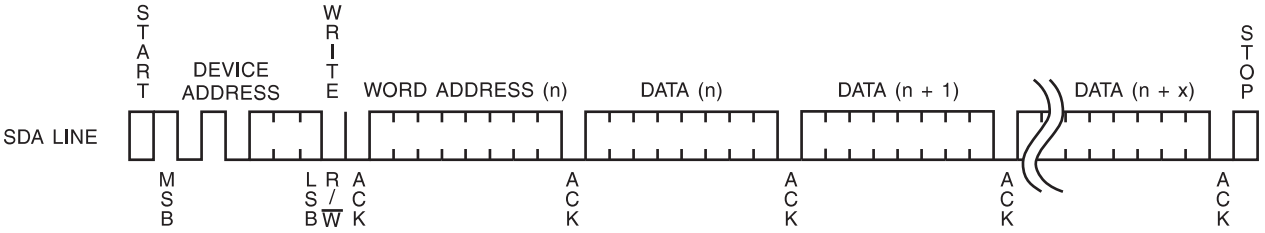


Figure 10-4. Current Address Read

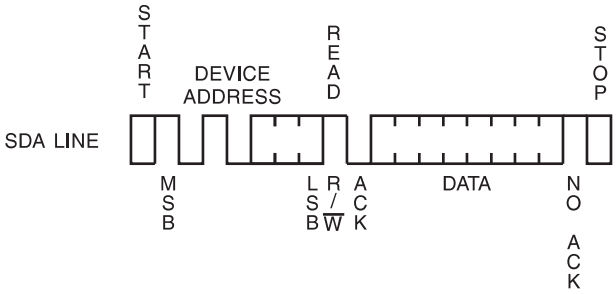


Figure 10-5. Random Read

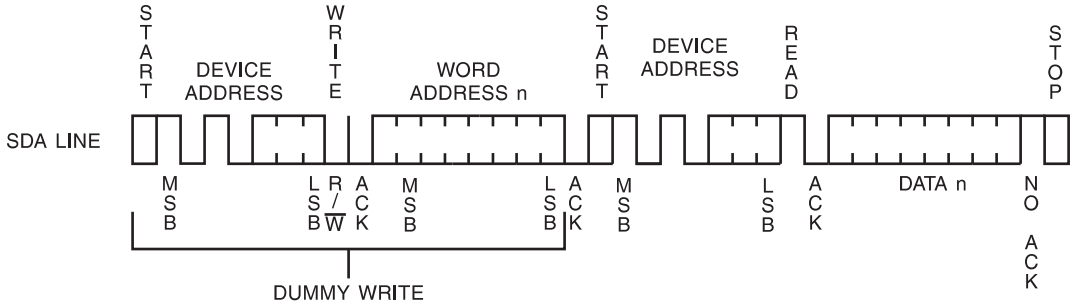
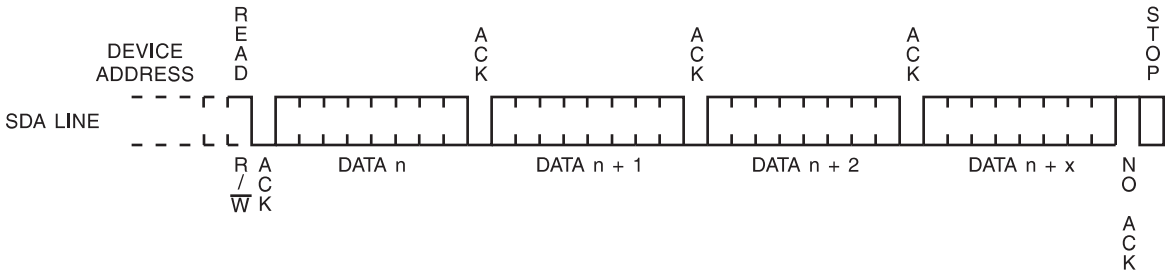


Figure 10-6. Sequential Read



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11. AT24HC02B Ordering Information

Ordering Code	Package	Operation Range
AT24HC02BN-SP25-B[1]	8S1	Lead-free/Halogen-free/NiPdAu Lead Finish/Automotive Temperature (–40°C to 125°C)
AT24HC02BN-SP25-T[2]	8S1	
AT24HC02B-TP25-B[1]	8A2	
AT24HC02B-TP25-T[2]	8A2	

Notes: 1. "-B" denotes bulk.
2. "-T" denotes tape and reel. SOIC = 4K per reel. TSSOP = 5K per reel.

Package Type	
8S1	8-lead, 0.150" Wide, Plastic Gull Wing Small Outline (JEDEC SOIC)
8A2	8-lead, 0.170" Wide, Thin Shrink Small Outline Package (TSSOP)
Options	
–2.5	Low-voltage (2.5V to 5.5V)

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12. AT24HC04B Ordering Information

Ordering Code	Package	Operation Range
AT24HC04BN-SP25-B[1]	8S1	Lead-free/Halogen-free/NiPdAu Lead Finish/Automotive Temperature (–40°C to 125°C)
AT24HC04BN-SP25-T[2]	8S1	
AT24HC04B-TP25-B[1]	8A2	
AT24HC04B-TP25-T[2]	8A2	

Notes: 1. "-B" denotes bulk.
2. "-T" denotes tape and reel. SOIC = 4K per reel. TSSOP = 5K per reel.

Package Type	
8S1	8-lead, 0.150" Wide, Plastic Gull Wing Small Outline (JEDEC SOIC)
8A2	8-lead, 0.170" Wide, Thin Shrink Small Outline Package (TSSOP)
Options	
–2.5	Low-voltage (2.5V to 5.5V)

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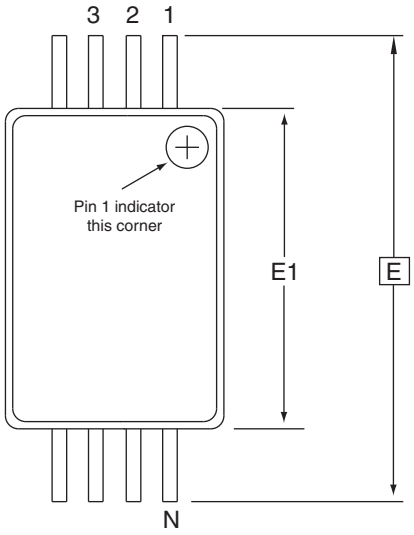
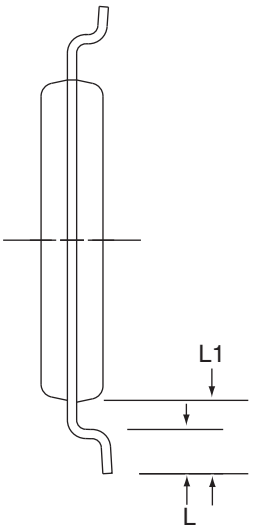
13. Packaging Information

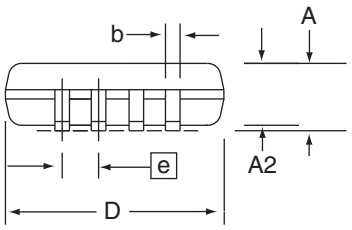
13.1 8A2 - TSSOP



Top View



End View



Side View

COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
D	2.90	3.00	3.10	2, 5
E		6.40 BSC		
E1	4.30	4.40	4.50	3, 5
A	–	–	1.20	
A2	0.80	1.00	1.05	
b	0.19	–	0.30	4
e		0.65 BSC		
L	0.45	0.60	0.75	
L1		1.00 REF		

Notes:
1. This drawing is for general information only. Refer to JEDEC Drawing MO-153, Variation AA, for proper dimensions, tolerances, datums, etc.
2. Dimension D does not include mold Flash, protrusions or gate burrs. Mold Flash, protrusions and gate burrs shall not exceed 0.15 mm (0.006 in) per side.
3. Dimension E1 does not include inter-lead Flash or protrusions. Inter-lead Flash and protrusions shall not exceed 0.25 mm (0.010 in) per side.
4. Dimension b does not include Dambar protrusion. Allowable Dambar protrusion shall be 0.08 mm total in excess of the b dimension at maximum material condition. Dambar cannot be located on the lower radius of the foot. Minimum space between protrusion and adjacent lead is 0.07 mm.
5. Dimension D and E1 to be determined at Datum Plane H.

5/30/02

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	**8A2**, 8-lead, 4.4 mm Body, Plastic Thin Shrink Small Outline Package (TSSOP)	8A2	B

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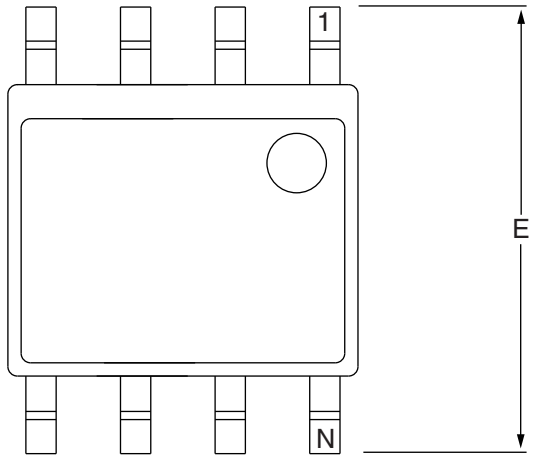
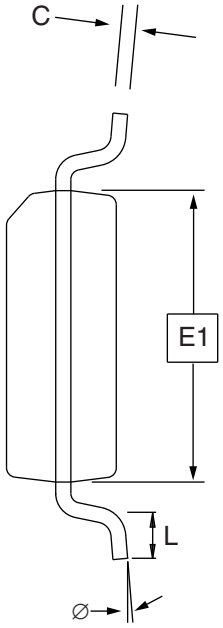
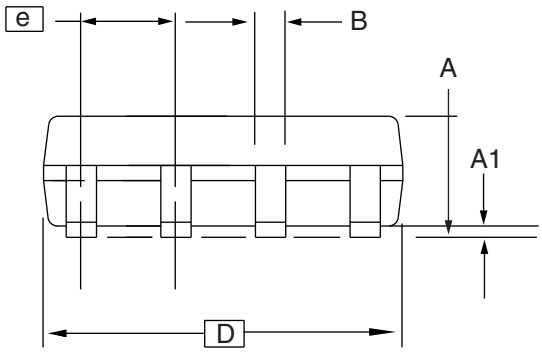
13.2 8S1 – JEDEC SOIC



Top View



End View



Side View

COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	1.35	–	1.75	
A1	0.10	–	0.25	
b	0.31	–	0.51	
C	0.17	–	0.25	
D	4.80	–	5.00	
E1	3.81	–	3.99	
E	5.79	–	6.20	
e	1.27 BSC			
L	0.40	–	1.27	
∅	0°	–	8°	

Note: These drawings are for general information only. Refer to JEDEC Drawing MS-012, Variation AA for proper dimensions, tolerances, datums, etc.

10/7/03

1150 E. Cheyenne Mtn. Blvd. Colorado Springs, CO 80906	**TITLE** **8S1**, 8-lead (0.150" Wide Body), Plastic Gull Wing Small Outline (JEDEC SOIC)	**DRAWING NO.** 8S1	**REV.** B

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14. Revision History

Doc. Rev.	Date	Comments
5192C	1/2009	Removed Preliminary status.
5192B	3/2008	Added information for AT24HC04B. Updated to new template.
5192A	1/2007	Initial document release.

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