Features

- **AT24C04A is a AT24C04 with Upper Half Memory Write Protect Capability**
- **Low Voltage and Standard Voltage Operation**
  - **5.0 (V_{CC} = 4.5V to 5.5V)**
  - **2.7 (V_{CC} = 2.7V to 5.5V)**
  - **2.5 (Vcc = 2.5V to 5.5V)**
  - **1.8 (V_{CC} = 1.8V to 5.5V)**
- **Internally Organized 512 x 8**
- **2-Wire Serial Interface**
- **Bidirectional Data Transfer Protocol**
- **100 kHz (1.8V, 2.5V and 2.7V) and 400 kHz (5V) Compatibility**
- **16-Byte Page Write Modes**
- **Partial Page Writes Are Allowed**
- **Self-Timed Write Cycle (10 ms max)**
- **High Reliability**
  - **Endurance: 1 Million Cycles**
  - **Data Retention: 100 Years**
- **Automotive Grade and Extended Temperature Devices Available**
- **8-Pin and 14-Pin JEDEC SOIC and 8-Pin PDIP Packages**

2-Wire Serial E^{2}PROM

4K (512 x 8)

AT24C04A

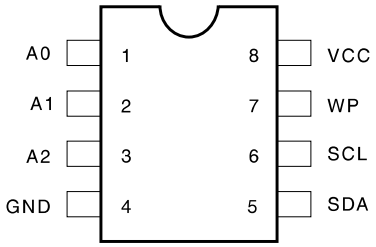
Description

The AT24C04A provides 4096 bits of serial electrically erasable and programmable read only memory (E^{2}PROM) organized as 512 words of 8 bits each. The device is optimized for use in many industrial and commercial applications where low power and low voltage operations are essential. *The AT24C04A operates identical to the AT24C04, except the upper half of memory can be write protected, versus full protection on the AT24C04.* The AT24C04A is available in space saving 8-pin PDIP, 8-pin and 14-pin SOIC packages and is accessed via a 2-wire serial interface. In addition, the AT24C04A is available in 5.0V (4.5V to 5.5V), 2.7V (2.7V to 5.5V), 2.5V (2.5V to 5.5V) and 1.8V (1.8V to 5.5V) versions.

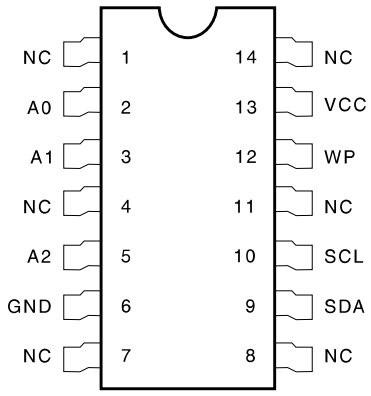
Pin Configurations

Pin Name	Function
A_0 to A_2	Address Inputs
SDA	Serial Data
SCL	Serial Clock Input
WP	Write Protect
NC	No Connect

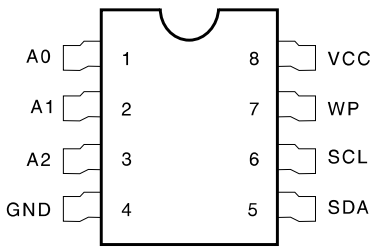
8-Pin PDIP



14-Pin SOIC



8-Pin SOIC

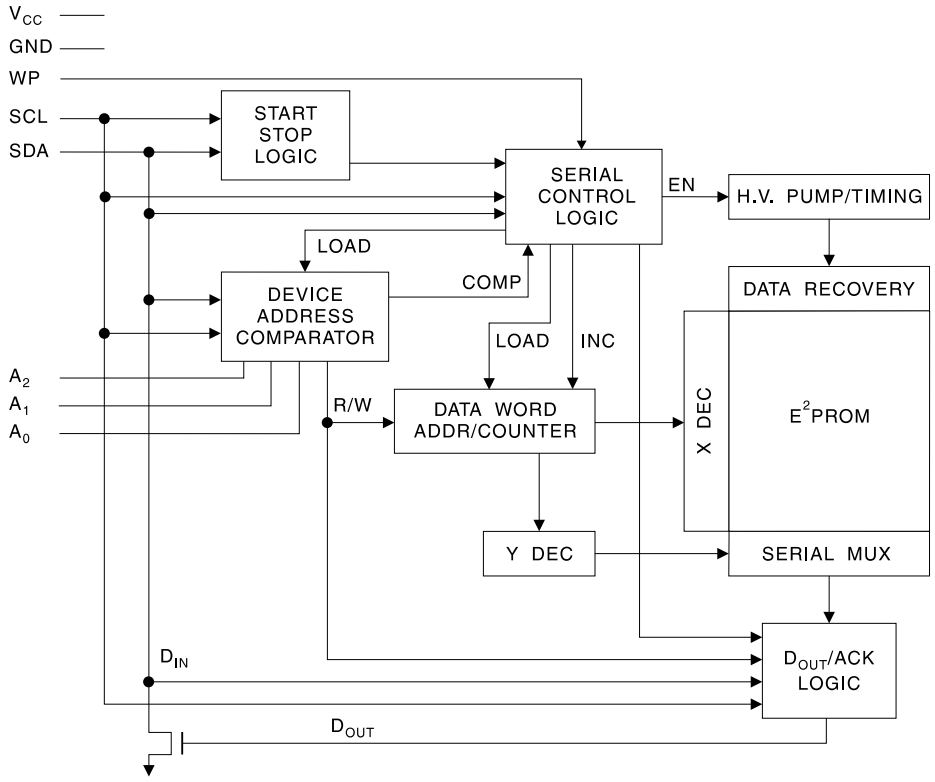


Absolute Maximum Ratings*

Operating Temperature	-55°C to +125°C
Storage Temperature	-65°C to +150°C
Voltage on Any Pin with Respect to Ground	-0.1V to +7.0V
Maximum Operating Voltage	6.25V
DC Output Current	5.0 mA

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

Block Diagram



Pin Description

SERIAL CLOCK (SCL): The SCL input is used to positive edge clock data into each E^2PROM device and negative edge clock data out of each device.

SERIAL DATA (SDA): The SDA pin is bidirectional 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.

The AT24C04A uses the A2 and A1 inputs for hard wire addressing and a total of four 4K devices may be addressed on a single bus system. The A0 pin is a no connect.

(continued)

Pin Description (Continued)

WRITE PROTECT (WP): The AT24C04A 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.

WP Pin Status	Part of the Array Protected
	24C04A
At V_{CC}	Upper Half (2K) Array
At GND	Normal Read/Write Operations

Memory Organization

AT24C04A, 4K Serial E^2PROM: The 4K is internally organized with 256 pages of 2-bytes each. Random word addressing requires a 9 bit data word address.

Pin Capacitance (1)

Applicable over recommended operating range from T_A = 25°C, f = 1.0 MHz, V_{CC} = +1.8V.

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.

DC Characteristics

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

Symbol	Parameter	Test Condition	Min	Typ	Max	Units
V_{CC1}	Supply Voltage		1.8		5.5	V
V_{CC2}	Supply Voltage		2.5		5.5	V
V_{CC3}	Supply Voltage		2.7		5.5	V
V_{CC4}	Supply Voltage		4.5		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} = 1.8V	V_{IN} = V_{CC} or V_{SS}		0.6	3.0	µA
I_{SB2}	Standby Current V_{CC} = 2.5V	V_{IN} = V_{CC} or V_{SS}		1.4	4.0	µA
I_{SB3}	Standby Current V_{CC} = 2.7V	V_{IN} = V_{CC} or V_{SS}		1.6	4.0	µA
I_{SB4}	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)		-1.0		V_{CC} x 0.3	V
V_{IH}	Input High Level (1)		V_{CC} x 0.7		V_{CC} + 0.5	V
V_{OL2}	Output Low Level V_{CC} = 3.0V	I_{OL} = 2.1 mA			0.4	V
V_{OL1}	Output Low Level V_{CC} = 1.8V	I_{OL} = 0.15 mA			0.2	V

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

AC Characteristics

Applicable over recommended operating range from T_A = -40°C to +85°C, V_{CC} = +1.8V to +5.5V, CL = 1 TTL Gate and 100 pF (unless otherwise noted).

Symbol	Parameter	2.7-, 2.5-, 1.8-volt		5.0-volt		Units
		Min	Max	Min	Max	
f_{SCL}	Clock Frequency, SCL		100		400	kHz
t_{LOW}	Clock Pulse Width Low	4.7		1.2		µs
t_{HIGH}	Clock Pulse Width High	4.0		0.6		µs
t_I	Noise Suppression Time (1)		100		50	ns
t_{AA}	Clock Low to Data Out Valid	0.1	4.5	0.1	0.9	µs
t_{BUF}	Time the bus must be free before a new transmission can start (1)	4.7		1.2		µs
$t_{HD.STA}$	Start Hold Time	4.0		0.6		µs
$t_{SU.STA}$	Start Set-up Time	4.7		0.6		µs
$t_{HD.DAT}$	Data In Hold Time	0		0		µs
$t_{SU.DAT}$	Data In Set-up Time	200		100		ns
t_R	Inputs Rise Time (1)		1.0		0.3	µs
t_F	Inputs Fall Time (1)		300		300	ns
$t_{SU.STO}$	Stop Set-up Time	4.7		0.6		µs
t_{DH}	Data Out Hold Time	100		50		ns
t_{WR}	Write Cycle Time		10		10	ms

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

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 (refer to Data Validity timing diagram). Data changes during SCL high periods will indicate a start or stop condition as defined below.

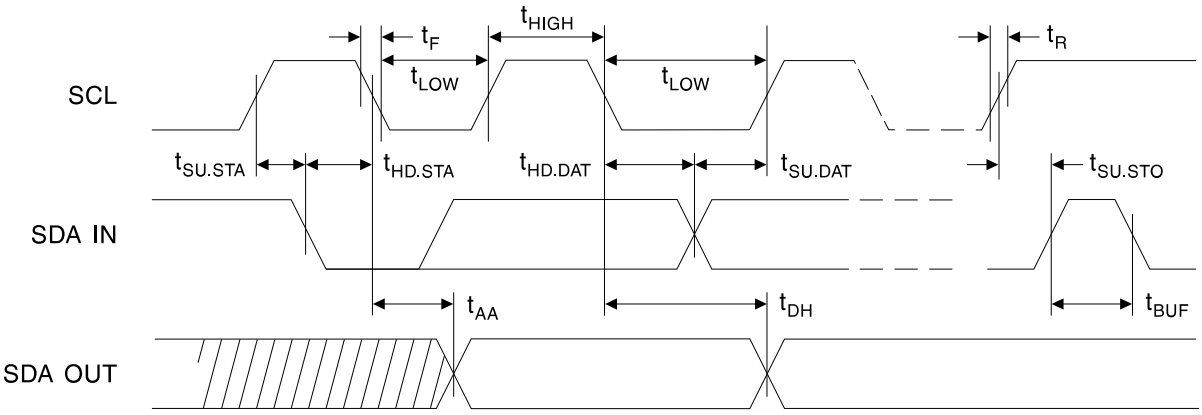
START CONDITION: A high-to-low transition of SDA with SCL high is a start condition which must precede any other command (refer to Start and Stop Definition timing diagram).

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 E^2PROM in a standby power mode (refer to Start and Stop Definition timing diagram).

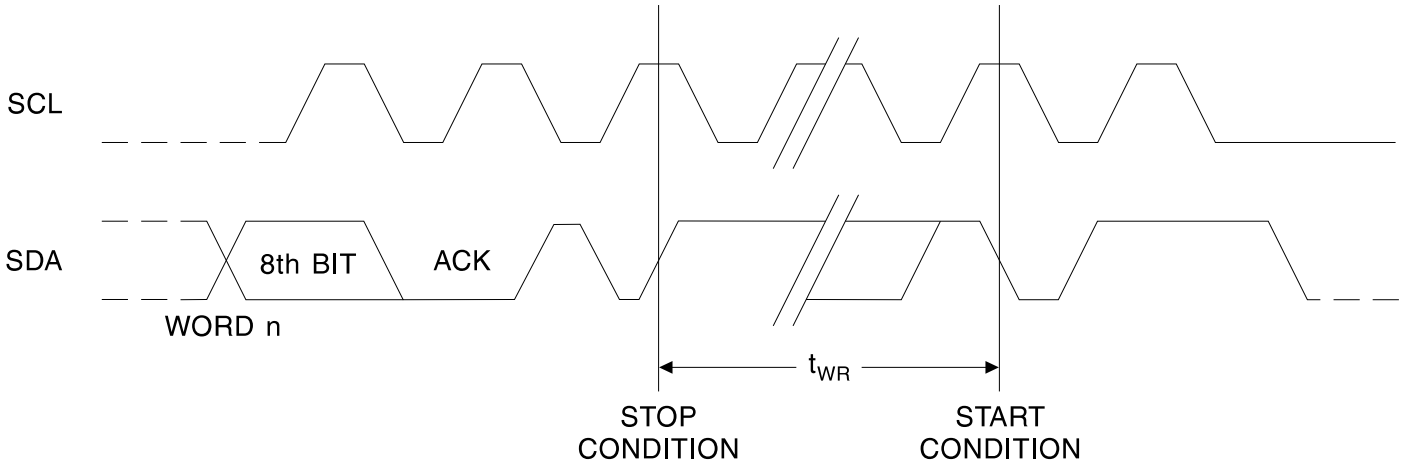
ACKNOWLEDGE: All addresses and data words are serially transmitted to and from the E^2PROM in 8 bit words. The E^2PROM sends a zero to acknowledge that it has received each word. This happens during the ninth clock cycle.

STANDBY MODE: The AT24C04A 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.

Bus Timing SCL: Serial Clock SDA: Serial Data I/O

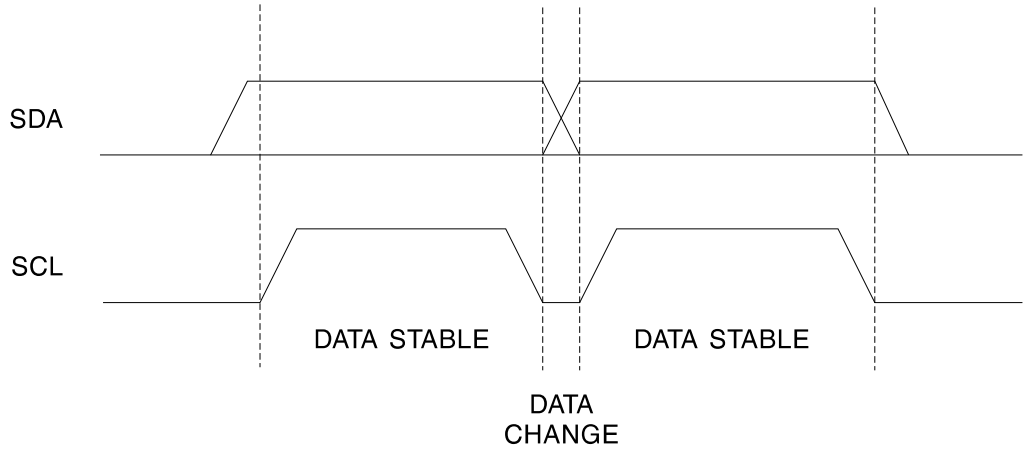


Write Cycle Timing SCL: Serial Clock SDA: Serial Data I/O

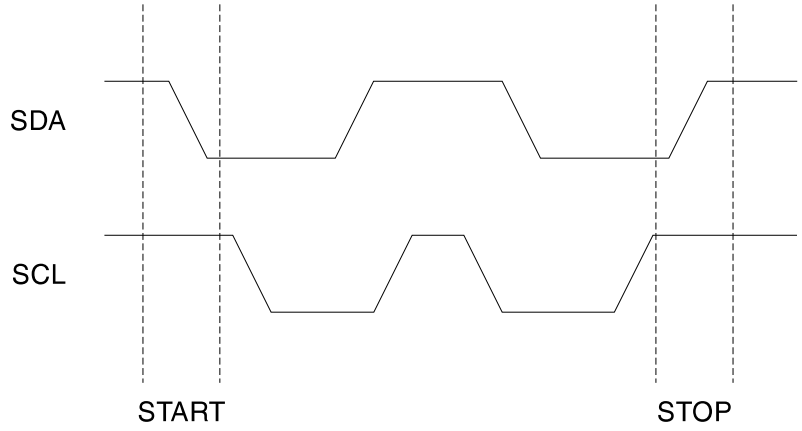


Note: 1. The write cycle time t_{WR} is the time from a valid stop condition of a write sequence to the end of the internal clear/write cycle.

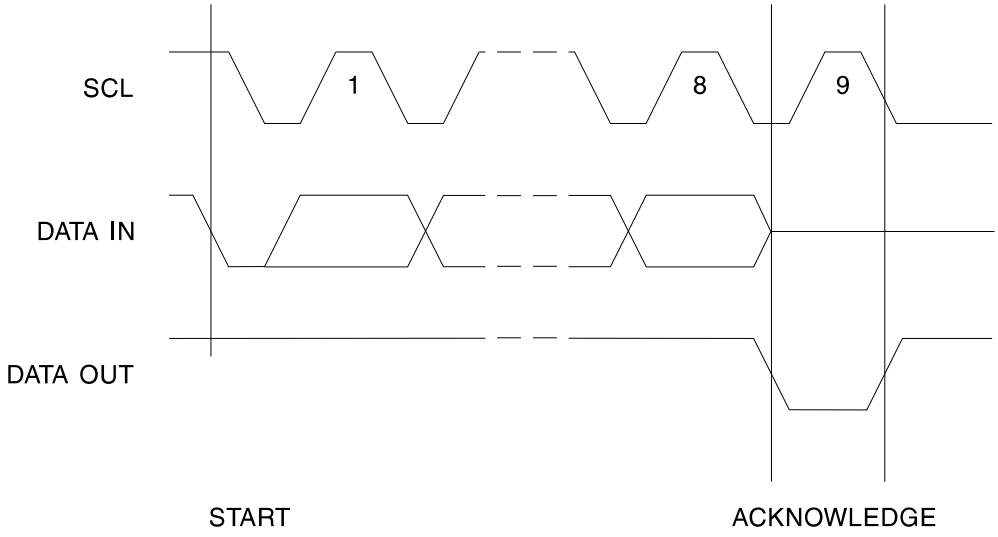
Data Validity



Start and Stop Definition



Output Acknowledge



Device Addressing

The 4K E^2PROM device requires an 8 bit device address word following a start condition to enable the chip for a read or write operation (refer to Figure 1).

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 E^2PROM devices.

The 4K E^2PROM only uses the A2 and A1 device address bits with the third bit being a memory page address bit. The two device address bits must compare to their corresponding hard-wired 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 E^2PROM will output a zero. If a compare is not made, the chip will return to a standby state.

Write Operations

BYTE WRITE: A write operation requires an 8 bit data word address following the device address word and acknowledgement. Upon receipt of this address, the E^2PROM 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 E^2PROM 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 E^2PROM enters an internally-timed write cycle to the nonvolatile memory. All inputs are disabled during this write cycle and the E^2PROM will not respond until the write is complete (refer to Figure 2).

PAGE WRITE: The 4K device is capable of 16-byte 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 E^2PROM acknowledges receipt of the first data word, the microcontroller can transmit up to fifteen more data words. The E^2PROM will respond with a zero after each data word received. The microcontroller must terminate the page write sequence with a stop condition (refer to Figure 3).

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. If more than sixteen data words are transmitted to the E^2PROM, 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 E^2PROM 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 E^2PROM respond with a zero allowing the read or write sequence to continue.

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 E^2PROM, 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 (refer to Figure 4).

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 E^2PROM, 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 E^2PROM 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 (refer to Figure 5).

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 E^2PROM 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 zero but does generate a following stop condition (refer to Figure 6).

Figure 1. Device Address

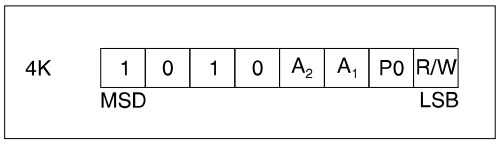


Figure 2. Byte Write

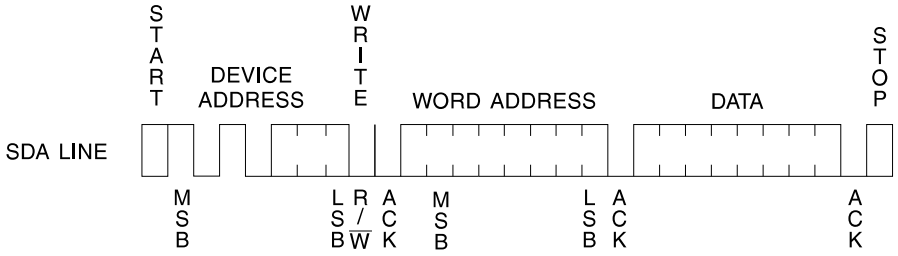


Figure 3. Page Write

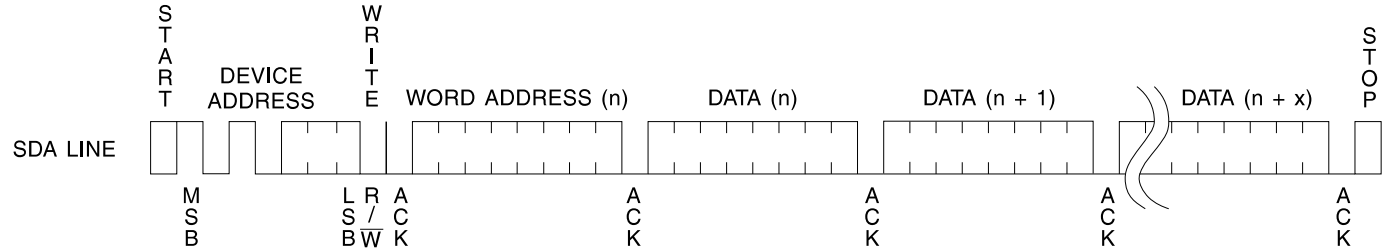


Figure 4. Current Address Read

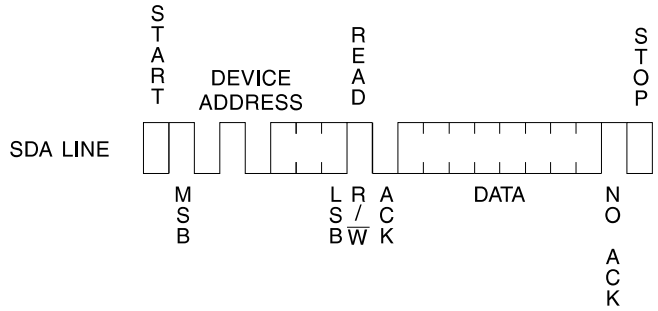


Figure 5. Random Read

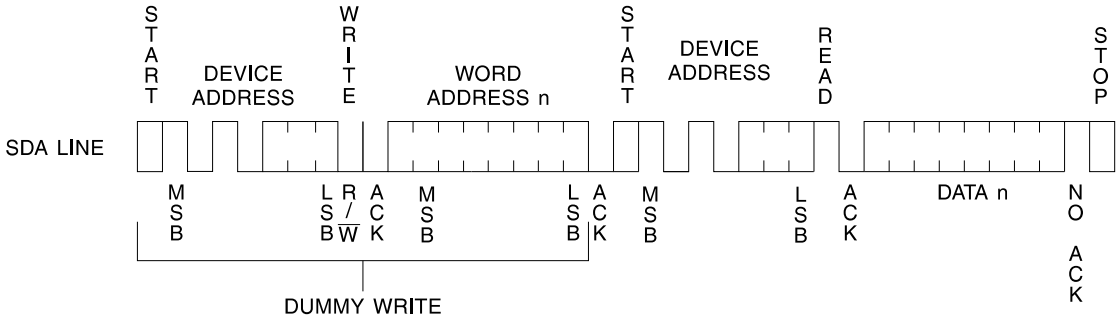
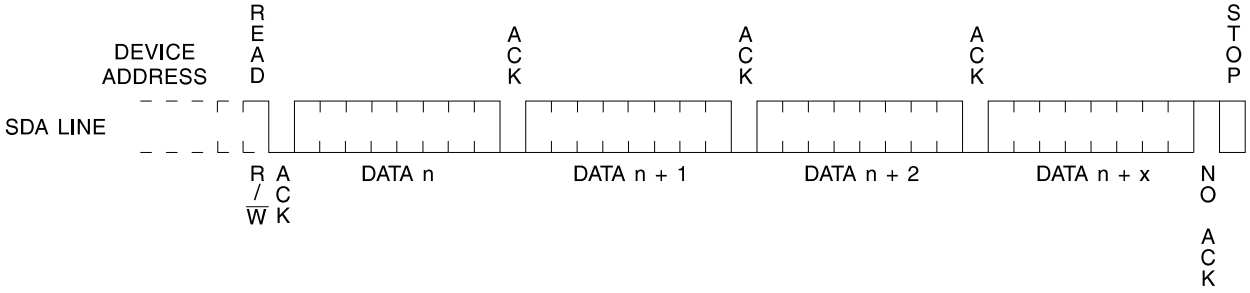


Figure 6. Sequential Read



Ordering Information

t_{WR} (max) (ms)	I_{CC} (max) (μA)	I_{SB} (max) (μA)	f_{MAX} (kHz)	Ordering Code	Package	Operation Range
10	3000	18	400	AT24C04A-10PC AT24C04AN-10SC AT24C04A-10SC	8P3 8S1 14S	Commercial (0°C to 70°C)
	3000	18	400	AT24C04A-10PI AT24C04AN-10SI AT24C04A-10SI	8P3 8S1 14S	Industrial (-40°C to 85°C)
10	1500	4	100	AT24C04A-10PC-2.7 AT24C04AN-10SC-2.7 AT24C04A-10SC-2.7	8P3 8S1 14S	Commercial (0°C to 70°C)
	1500	4	100	AT24C04A-10PI-2.7 AT24C04AN-10SI-2.7 AT24C04A-10SI-2.7	8P3 8S1 14S	Industrial (-40°C to 85°C)
10	1000	4	100	AT24C04A-10PC-2.5 AT24C04AN-10SC-2.5 AT24C04A-10SC-2.5	8P3 8S1 14S	Commercial (0°C to 70°C)
	1000	4	100	AT24C04A-10PI-2.5 AT24C04AN-10SI-2.5 AT24C04A-10SI-2.5	8P3 8S1 14S	Industrial (-40°C to 85°C)
10	800	3	100	AT24C04A-10PC-1.8 AT24C04AN-10SC-1.8 AT24C04A-10SC-1.8	8P3 8S1 14S	Commercial (0°C to 70°C)
	800	3	100	AT24C04A-10PI-1.8 AT24C04AN-10SI-1.8 AT24C04A-10SI-1.8	8P3 8S1 14S	Industrial (-40°C to 85°C)

Package Type	
8P3	8 Lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)
8S1	8 Lead, 0.150" Wide, Plastic Gull Wing Small Outline (JEDEC SOIC)
14S	14 Lead, 0.150" Wide, Plastic Gull Wing Small Outline (SOIC)
Options	
Blank	Standard Operation (4.5V to 5.5V)
-2.7	Low Voltage (2.7V to 5.5V)
-2.5	Low Voltage (2.5V to 5.5V)
-1.8	Low Voltage (1.8V to 5.5V)