# AT24CS64

# I²C-Compatible (Two-Wire) Serial EEPROM with a Unique, Factory Programmed 128-Bit Serial Number 64-Kbit (8,192 x 8)

## Features

- Low-Voltage Operation:
  - $V_{CC}$ = 1.7V to 5.5V
- Internally Organized as 8,192 x 8 (64K)
- 128-Bit Unique Factory-Programmed Serial Number
  - Permanent read-only value
  - Unique across entire CS Series of Serial EEPROMs
- Industrial Temperature Range: -40°C to +85°C
- I²C-Compatible (Two-Wire) Serial Interface:
  - 100 kHz Standard mode, 1.7V to 5.5V
  - 400 kHz Fast mode, 1.7V to 5.5V
  - 1 MHz Fast Mode Plus (FM+), 2.5V to 5.5V
- Schmitt Triggers, Filtered Inputs for Noise Suppression
- Bidirectional Data Transfer Protocol
- Write-Protect Pin for Full Array Hardware Data Protection
- Ultra Low Active Current (3 mA maximum) and Standby Current (6 µA maximum)
- 32-byte Page Write Mode:
  - Partial page writes allowed
- Random and Sequential Read Modes
- Self-Timed Write Cycle within 5 ms Maximum
- ESD Protection > 4,000V
- High Reliability:
  - Endurance: 1,000,000 write cycles
  - Data retention: 100 years
- Green Package Options (Lead-free/Halide-free/RoHS compliant)
- Die Sale Options: Wafer Form and Tape and Reel Available

## Packages

- 8-Lead SOIC, 8-Lead TSSOP and 8-Pad UDFN

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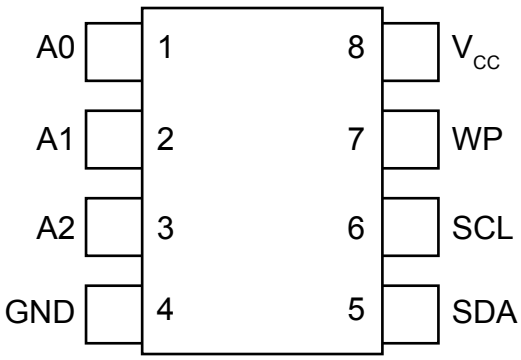
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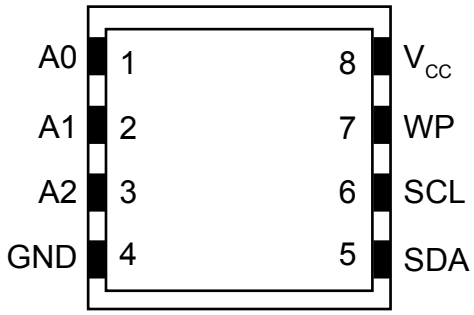
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# 1. Package Types (not to scale)

**8-Lead SOIC/TSSOP**
(Top View)




**8-Pad UDFN**
(Top View)



# 2. Pin Descriptions

The descriptions of the pins are listed in Table 2-1.

**Table 2-1. Pin Function Table**

| Name | 8-Lead SOIC | 8-Lead TSSOP | 8-Pad UDFN(1) | Function |
|---|---|---|---|---|
| A0(2) | 1 | 1 | 1 | Device Address Input |
| A1(2) | 2 | 2 | 2 | Device Address Input |
| A2(2) | 3 | 3 | 3 | Device Address Input |
| GND | 4 | 4 | 4 | Ground |
| SDA | 5 | 5 | 5 | Serial Data |
| SCL | 6 | 6 | 6 | Serial Clock |
| WP(2) | 7 | 7 | 7 | Write-Protect |
| $V_{CC}$ | 8 | 8 | 8 | Device Power Supply |

**Note:**

1. The exposed pad on this package can be connected to GND or left floating.
2. If the A0, A1, A2 and WP pins are not driven, they are internally pulled down to GND. In order to operate in a wide variety of application environments, the pull-down mechanism is intentionally designed to be somewhat strong. Once these pins are biased above the CMOS input buffer's trip point (~0.5 x $V_{CC}$), the pull-down mechanism disengages. Microchip recommends connecting these pins to a known state whenever possible.

## 2.1 Device Address Inputs (A0, A1, A2)

The A0, A1 and A2 pins are device address inputs that are hard-wired (directly to GND or to $V_{CC}$) for compatibility with other two-wire Serial EEPROM devices. When the pins are hard-wired, as many as eight devices may be addressed on a single bus system. A device is selected when a corresponding hardware and software match is true. If these pins are left floating, the A0, A1 and A2 pins will be internally pulled down to GND. However, due to capacitive coupling that may appear in customer applications, Microchip recommends always connecting the address pins to a known state. When using a pull-up resistor, Microchip recommends using 10 kΩ or less.

## 2.2 Ground

The ground reference for the power supply. GND should be connected to the system ground.

## 2.3 Serial Data (SDA)

The SDA pin is an open-drain bidirectional input/output pin used to serially transfer data to and from the device. The SDA pin must be pulled high using an external pull-up resistor (not to exceed 10 kΩ in value) and may be wire-ORed with any number of other open-drain or open-collector pins from other devices on the same bus.

## 2.4 Serial Clock (SCL)

The SCL pin is used to provide a clock to the device and to control the flow of data to and from the device. Command and input data present on the SDA pin is always latched in on the rising edge of SCL, while output data on the SDA pin is clocked out on the falling edge of SCL. The SCL pin must either be forced high when the serial bus is idle or pulled high using an external pull-up resistor.

## 2.5 Write-Protect (WP)

The write-protect input, when connected to GND, allows normal write operations. When the WP pin is connected directly to $V_{CC}$, all write operations to the protected memory are inhibited.

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If the pin is left floating, the WP pin will be internally pulled down to GND. However, due to capacitive coupling that may appear in customer applications, Microchip recommends always connecting the WP pin to a known state. When using a pull-up resistor, Microchip recommends using 10 kΩ or less.

**Table 2-2. Write-Protect**

| WP Pin Status | Part of the Array Protected |
|---|---|
| At $V_{CC}$ | Full Array |
| At GND | Normal Write Operations |

## 2.6 Device Power Supply ($V_{CC}$)

The Device Power Supply ($V_{CC}$) pin is used to supply the source voltage to the device. Operations at invalid $V_{CC}$ voltages may produce spurious results and should not be attempted.

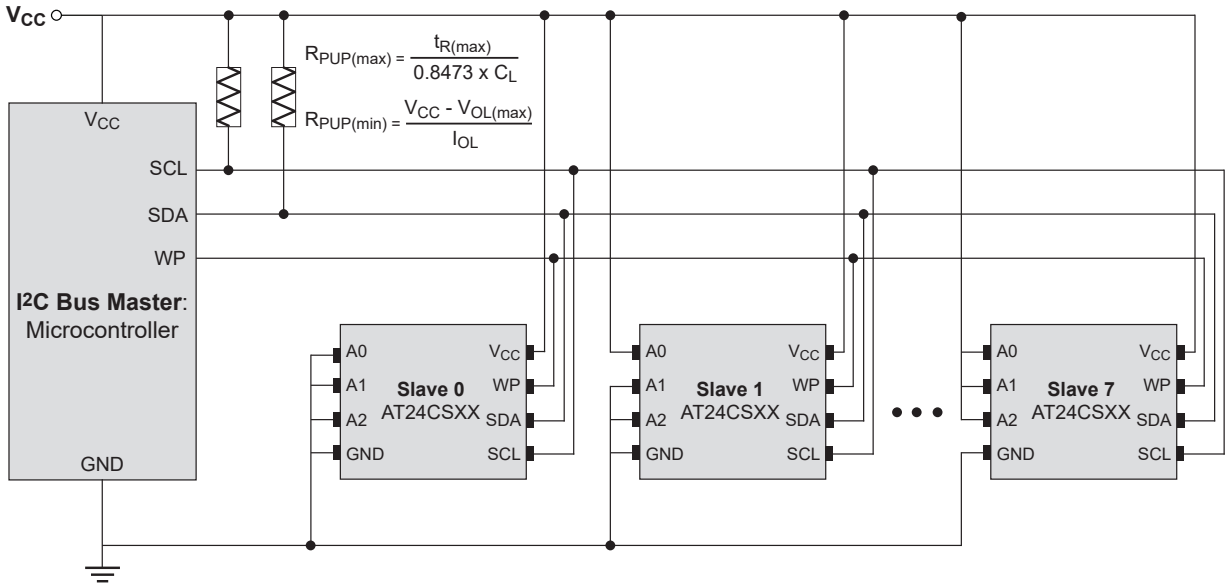

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# 3. Description

The AT24CS64 provides 65,536 bits of Serial Electrically Erasable and Programmable Read-Only Memory (EEPROM) organized as 8,192 words of 8 bits each. The device's cascading feature allows up to eight devices to share a common two-wire bus. 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 SOIC, 8-lead TSSOP and 8-pad UDFN packages. All packages operate from 1.7V to 5.5V.

The AT24CS64 provides the additional feature of a factory programmed, ensured unique 128-bit serial number, while maintaining all of the traditional features available in the 64-Kbit Serial EEPROM. The time consuming step of performing and ensuring true serialization of product on a manufacturing line can be removed from the production flow by employing the CS Series Serial EEPROM. The 128-bit serial number is programmed and permanently locked from future writing during the Microchip production process. Further, this 128-bit location does not consume any of the user read/write area of the 64-Kbit Serial EEPROM. The uniqueness of the serial number is ensured across the entire CS Series of Serial EEPROMs, regardless of the size of the memory array or the type of interface protocol. This means that as an application's needs for memory size or interface protocol evolve in future generations, any previously deployed serial number from any Microchip CS Series Serial EEPROM part will remain valid.

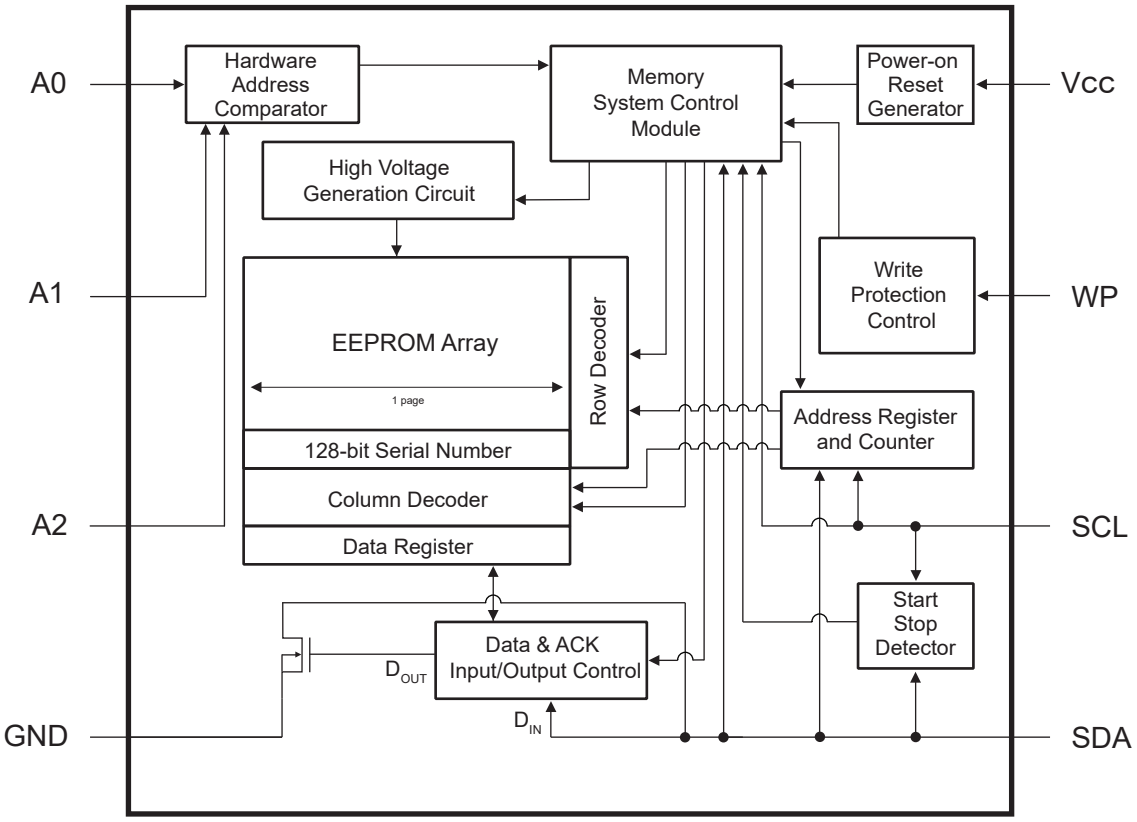
## 3.1 System Configuration Using Two-Wire Serial EEPROMs





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## 3.2 Block Diagram





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# 4. Electrical Characteristics

## 4.1 Absolute Maximum Ratings

| | |
|---|---|
| **Temperature under bias** | -55°C to +125°C |
| **Storage temperature** | -65°C to +150°C |
| **$V_{CC}$** | 6.25V |
| **Voltage on any pin with respect to ground** | -1.0V to +7.0V |
| **DC output current** | 5.0 mA |
| **ESD protection** | >4 kV |

**Note:** Stresses above 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 above those indicated in the operation listings of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## 4.2 DC and AC Operating Range

**Table 4-1. DC and AC Operating Range**

| AT24CS64 | | |
|---|---|---|
| Operating Temperature (Case) | Industrial Temperature Range | -40°C to +85°C |
| $V_{CC}$ Power Supply | Low-Voltage Grade | 1.7V to 5.5V |

## 4.3 DC Characteristics

**Table 4-2. DC Characteristics**

| Parameter | Symbol | Minimum | Typical(1) | Maximum | Units | Test Conditions |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{CC1}$ | 1.7 | — | 5.5 | V | |
| Supply Current | $I_{CC1}$ | — | 0.4 | 1.0 | mA | $V_{CC}$ = 5.0V, Read at 400 kHz |
| Supply Current | $I_{CC2}$ | — | 2.0 | 3.0 | mA | $V_{CC}$ = 5.0V, Write at 400 kHz |
| Standby Current | $I_{SB1}$ | — | — | 1.0 | µA | $V_{CC}$ = 1.7V, $V_{IN}$ = $V_{CC}$ or GND |
| | | — | — | 6.0 | µA | $V_{CC}$ = 5.0V, $V_{IN}$ = $V_{CC}$ or GND |
| Input Leakage Current | $I_{LI}$ | — | 0.10 | 3.0 | µA | $V_{IN}$ = $V_{CC}$ or GND |
| Output Leakage Current | $I_{LO}$ | — | 0.05 | 3.0 | µA | $V_{OUT}$ = $V_{CC}$ or GND |
| Input Low Level | $V_{IL}$ | -0.6 | — | $V_{CC}$ x 0.3 | V | Note 2 |
| Input High Level | $V_{IH}$ | $V_{CC}$ x 0.7 | — | $V_{CC}$ + 0.5 | V | Note 2 |
| Output Low Level | $V_{OL1}$ | — | — | 0.2 | V | $V_{CC}$ = 1.7V, $I_{OL}$ = 0.15 mA |
| Output Low Level | $V_{OL2}$ | — | — | 0.4 | V | $V_{CC}$ = 3.0V, $I_{OL}$ = 2.1 mA |


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**Note:**

1. Typical values characterized at $T_A$ = +25°C unless otherwise noted.
2. This parameter is characterized but is not 100% tested in production.

## 4.4 AC Characteristics

**Table 4-3. AC Characteristics(1)**

| Parameter | Symbol | Fast Mode | | Fast Mode Plus | | Units |
|---|---|---|---|---|---|---|
| | | $V_{cc}$ = 1.7V to 2.5V | | Vcc = 2.5V to 5.5V | | |
| | | Min. | Max. | Min. | Max. | |
| Clock Frequency, SCL | $f_{SCL}$ | — | 400 | — | 1000 | kHz |
| Clock Pulse Width Low | $t_{LOW}$ | 1200 | — | 500 | — | ns |
| Clock Pulse Width High | $t_{HIGH}$ | 600 | — | 400 | — | ns |
| Noise Suppression Time | $t_I$ | — | 100 | — | 50 | ns |
| Clock Low to Data Out Valid | $t_{AA}$ | 100 | 900 | 50 | 450 | ns |
| Bus Free Time between Stop and Start | $t_{BUF}$ | 1300 | — | 500 | — | ns |
| Start Hold Time | $t_{HD.STA}$ | 600 | — | 250 | — | ns |
| Start Set-up Time | $t_{SU.STA}$ | 600 | — | 250 | — | ns |
| Data In Hold Time | $t_{HD.DAT}$ | 0 | — | 0 | — | ns |
| Data In Set-up Time | $t_{SU.DAT}$ | 100 | — | 100 | — | ns |
| Inputs Rise Time(2) | $t_R$ | — | 300 | — | 300 | ns |
| Inputs Fall Time(2) | $t_F$ | — | 300 | — | 100 | ns |
| Stop Set-up Time | $t_{SU.STO}$ | 600 | — | 250 | — | ns |
| Data Out Hold Time | $t_{DH}$ | 50 | — | 50 | — | ns |
| Write Cycle Time | $t_{WR}$ | — | 5 | — | 5 | ms |

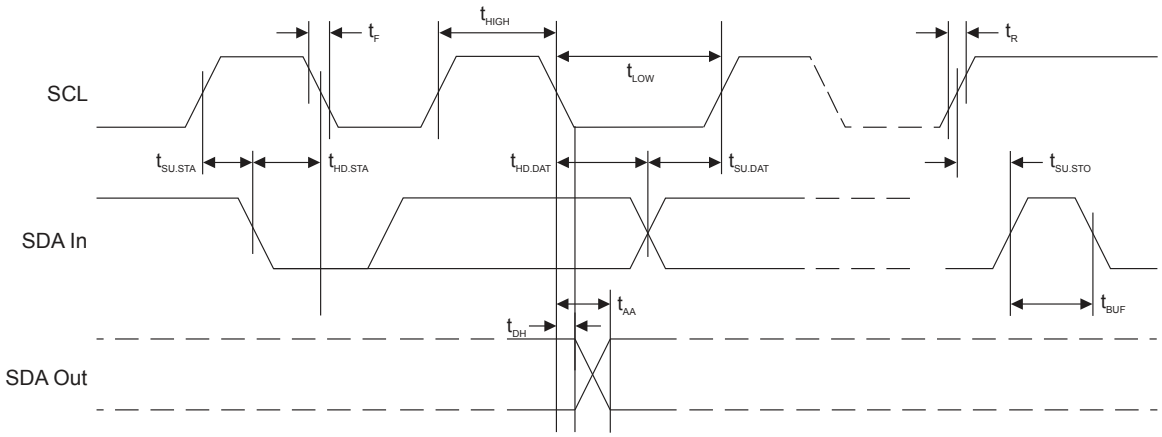
**Note:**

1. AC measurement conditions:
   - $R_{PUP}$ (SDA bus line pull-up resistor to $V_{CC}$): 1.3 kΩ (1000 kHz), 4 kΩ (400 kHz), 10 kΩ (100 kHz)
   - Input pulse voltages: 0.3 $V_{CC}$ to 0.7 $V_{CC}$
   - Input rise and fall times: ≤ 50 ns
   - Input and output timing reference voltages: 0.5 x $V_{CC}$
2. This parameter is ensured by characterization and is not 100% tested.

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**Figure 4-1. Bus Timing**




## 4.5 Electrical Specifications

### 4.5.1 Power-Up Requirements and Reset Behavior

During a power-up sequence, the $V_{CC}$ supplied to the AT24CS64 should monotonically rise from GND to the minimum $V_{CC}$ level, as specified in Table 4-1, with a slew rate no faster than 0.1 V/µs.

#### 4.5.1.1 Device Reset

To prevent inadvertent write operations or any other spurious events from occurring during a power-up sequence, the AT24CS64 includes a Power-on Reset (POR) circuit. Upon power-up, the device will not respond to any commands until the $V_{CC}$ level crosses the internal voltage threshold ($V_{POR}$) that brings the device out of Reset and into Standby mode.

The system designer must ensure the instructions are not sent to the device until the $V_{CC}$ supply has reached a stable value greater than or equal to the minimum $V_{CC}$ level. Additionally, once the $V_{CC}$ is greater than or equal to the minimum $V_{CC}$ level, the bus master must wait at least $t_{PUP}$ before sending the first command to the device. See Table 4-4 for the values associated with these power-up parameters.

**Table 4-4. Power-up Conditions(1)**

| Symbol | Parameter | Min. | Max. | Units |
|---|---|---|---|---|
| $t_{PUP}$ | Time required after $V_{CC}$ is stable before the device can accept commands | 100 | — | µs |
| $V_{POR}$ | Power-on Reset Threshold Voltage | — | 1.5 | V |
| $t_{POFF}$ | Minimum time at $V_{CC}$ = 0V between power cycles | 500 | — | ms |

**Note:**

1. These parameters are characterized but they are not 100% tested in production.

If an event occurs in the system where the $V_{CC}$ level supplied to the AT24CS64 drops below the maximum $V_{POR}$ level specified, it is recommended that a full power cycle sequence be performed by first driving the $V_{CC}$ pin to GND, waiting at least the minimum $t_{POFF}$ time and then performing a new power-up sequence in compliance with the requirements defined in this section.

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### 4.5.2 Pin Capacitance

**Table 4-5. Pin Capacitance[1]**

| Symbol | Test Condition | Max. | Units | Conditions |
|---|---|---|---|---|
| $C_{I/O}$ | Input/Output Capacitance (SDA) | 8 | pF | $V_{I/O}$ = 0V |
| $C_{IN}$ | Input Capacitance (A0, A1, A2 and SCL) | 6 | pF | $V_{IN}$ = 0V |

**Note:**

1. This parameter is characterized but is not 100% tested in production.

### 4.5.3 EEPROM Cell Performance Characteristics

**Table 4-6. EEPROM Cell Performance Characteristics**

| Operation | Test Condition | Min. | Max. | Units |
|---|---|---|---|---|
| Write Endurance[1] | $T_A$ = 25°C, $V_{CC}$ = 3.3V, Page Write mode | 1,000,000 | — | Write Cycles |
| Data Retention[1] | $T_A$ = 55°C | 100 | — | Years |

**Note:**

1. Performance is determined through characterization and the qualification process.


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# 5. Device Operation and Communication

The AT24CS64 operates as a slave device and utilizes a simple $I^2C$-compatible two-wire digital serial interface to communicate with a host controller, commonly referred to as the bus master. The master initiates and controls all read and write operations to the slave devices on the serial bus, and both the master and the slave devices can transmit and receive data on the bus.

The serial interface is comprised of just two signal lines: Serial Clock (SCL) and Serial Data (SDA). The SCL pin is used to receive the clock signal from the master, while the bidirectional SDA pin is used to receive command and data information from the master as well as to send data back to the master. Data is always latched into the AT24CS64 on the rising edge of SCL and always output from the device on the falling edge of SCL. Both the SCL and SDA pins incorporate integrated spike suppression filters and Schmitt Triggers to minimize the effects of input spikes and bus noise.

All command and data information is transferred with the Most Significant bit (MSb) first. During bus communication, one data bit is transmitted every clock cycle, and after eight bits (one byte) of data have been transferred, the receiving device must respond with either an Acknowledge (ACK) or a No-Acknowledge (NACK) response bit during a ninth clock cycle (ACK/NACK clock cycle) generated by the master. Therefore, nine clock cycles are required for every one byte of data transferred. There are no unused clock cycles during any read or write operation, so there must not be any interruptions or breaks in the data stream during each data byte transfer and ACK or NACK clock cycle.

During data transfers, data on the SDA pin must only change while SCL is low, and the data must remain stable while SCL is high. If data on the SDA pin changes while SCL is high, then either a Start or a Stop condition will occur. Start and Stop conditions are used to initiate and end all serial bus communication between the master and the slave devices. The number of data bytes transferred between a Start and a Stop condition is not limited and is determined by the master. In order for the serial bus to be idle, both the SCL and SDA pins must be in the logic high state at the same time.

## 5.1 Clock and Data Transition Requirements

The SDA pin is an open-drain terminal and therefore must be pulled high with an external pull-up resistor. SCL is an input pin that can either be driven high or pulled high using an external pull-up resistor. Data on the SDA pin may change only during SCL low time periods. Data changes during SCL high periods will indicate a Start or Stop condition as defined below. The relationship of the AC timing parameters with respect to SCL and SDA for the AT24CS64 are shown in the timing waveform in Figure 4-1. The AC timing characteristics and specifications are outlined in AC Characteristics.

## 5.2 Start and Stop Conditions

### 5.2.1 Start Condition

A Start condition occurs when there is a high-to-low transition on the SDA pin while the SCL pin is at a stable logic '1' state and will bring the device out of Standby mode. The master uses a Start condition to initiate any data transfer sequence; therefore, every command must begin with a Start condition. The device will continuously monitor the SDA and SCL pins for a Start condition but will not respond unless one is detected. Refer to Figure 5-1 for more details.

### 5.2.2 Stop Condition

A Stop condition occurs when there is a low-to-high transition on the SDA pin while the SCL pin is stable in the logic '1' state.

The master can use the Stop condition to end a data transfer sequence with the AT24CS64, which will subsequently return to Standby mode. The master can also utilize a repeated Start condition instead of a Stop condition to end the current data transfer if the master will perform another operation. Refer to Figure 5-1 for more details.


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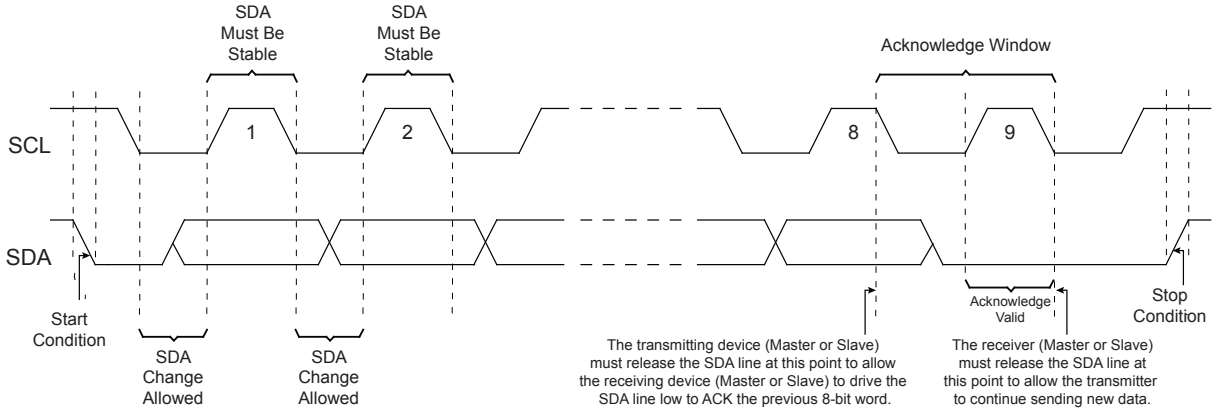
## 5.3 Acknowledge and No-Acknowledge

After every byte of data is received, the receiving device must confirm to the transmitting device that it has successfully received the data byte by responding with what is known as an Acknowledge (ACK).
An ACK is accomplished by the transmitting device first releasing the SDA line at the falling edge of the eighth clock cycle followed by the receiving device responding with a logic '0' during the entire high period of the ninth clock cycle.

When the AT24CS64 is transmitting data to the master, the master can indicate that it is done receiving data and wants to end the operation by sending a logic '1' response to the AT24CS64 instead of an ACK response during the ninth clock cycle. This is known as a No-Acknowledge (NACK) and is accomplished by the master sending a logic '1' during the ninth clock cycle, at which point the AT24CS64 will release the SDA line so the master can then generate a Stop condition.

The transmitting device, which can be the bus master or the Serial EEPROM, must release the SDA line at the falling edge of the eighth clock cycle to allow the receiving device to drive the SDA line to a logic '0' to ACK the previous 8-bit word. The receiving device must release the SDA line at the end of the ninth clock cycle to allow the transmitter to continue sending new data. A timing diagram has been provided in Figure 5-1 to better illustrate these requirements.

**Figure 5-1. Start Condition, Data Transitions, Stop Condition and Acknowledge**




## 5.4 Standby Mode

The AT24CS64 features a low-power Standby mode that is enabled when any one of the following occurs:

- A valid power-up sequence is performed (see Power-Up Requirements and Reset Behavior).
- A Stop condition is received by the device unless it initiates an internal write cycle (see Write Operations).
- At the completion of an internal write cycle (see Write Operations).

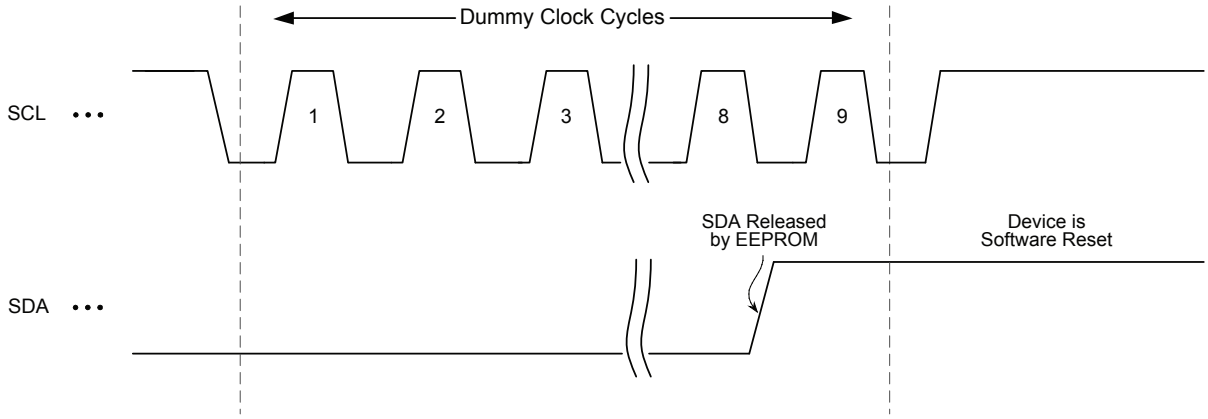
## 5.5 Software Reset

After an interruption in protocol, power loss or system Reset, any two-wire device can be protocol reset by clocking SCL until SDA is released by the EEPROM and goes high. The number of clock cycles until SDA is released by the EEPROM will vary. The software Reset sequence should not take more than nine dummy clock cycles. Once the software Reset sequence is complete, new protocol can be sent to the device by sending a Start condition followed by the protocol. Refer to Figure 5-2 for an illustration.

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**Figure 5-2. Software Reset**




In the event that the device is still non-responsive or remains active on the SDA bus, a power cycle must be used to reset the device (see Power-Up Requirements and Reset Behavior).

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# 6. Memory Organization

The AT24CS64 is internally organized as 256 pages of 32 bytes each.

## 6.1 Device Addressing

Accessing the device requires an 8-bit device address byte following a Start condition to enable the device for a read or write operation. Since multiple slave devices can reside on the serial bus, each slave device must have its own unique address so the master can access each device independently.

The Most Significant four bits of the device address byte is referred to as the device type identifier. The device type identifier '1010' (Ah) is required in bits 7 through 4 of the device address byte (see Table 6-1).

The AT24CS64 utilizes a separate memory block containing a factory programmed 128-bit serial number. Access to this memory location is similar to the EERPOM region with the exception that the device type identifier is set to '1011' (Bh) in bits 7 through 4 of the device address byte (see Table 6-1).

Following the 4-bit device type identifier are the hardware slave address bits, A2, A1 and A0. These bits can be used to expand the address space by allowing up to eight Serial EEPROM devices on the same bus. These hardware slave address bits must correlate with the voltage level on the corresponding hardwired device address input pins A0, A1 and A2. The A0, A1 and A2 pins use an internal proprietary circuit that automatically biases the pin to a logic '0' state if the pin is allowed to float. In order to operate in a wide variety of application environments, the pull-down mechanism is intentionally designed to be somewhat strong. Once the pin is biased above the CMOS input buffer's trip point (~0.5 x $V_{CC}$), the pull-down mechanism disengages. Microchip recommends connecting the A0, A1 and A2 pins to a known state whenever possible.

The eighth bit (bit 0) of the device address byte is the Read/Write Select bit. A read operation is initiated if this bit is high and a write operation is initiated if this bit is low.

Upon the successful comparison of the device address byte, the AT24CS64 will return an ACK. If a valid comparison is not made, the device will NACK.

**Table 6-1. Device Addressing**

| Access Area | Device Type Identifier | | | | Hardware Slave Address Bits | | | R/$\overline{W}$ Select |
|---|---|---|---|---|---|---|---|---|
| | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| EEPROM | 1 | 0 | 1 | 0 | A2 | A1 | A0 | R/$\overline{W}$ |
| Serial Number | 1 | 0 | 1 | 1 | A2 | A1 | A0 | R/$\overline{W}$ |

For all operations except the current address read, two 8-bit word address bytes must be transmitted to the device immediately following the device address byte. The word address bytes consist of the 13-bit memory array word address, and are used to specify which byte location in the EEPROM to start reading or writing.

The first word address byte contains the five Most Significant bits of the word address (A12 through A8) in bit positions four through zero, as seen in Table 6-2. The remainder of the first word address byte are "don't care" bits (in bit positions seven through five) as they are outside of the addressable 64-Kbit range. Upon completion of the first word address byte, the AT24CS64 will return an ACK.

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**Table 6-2. First Word Address Byte**

| Access Area | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---|---|---|---|---|---|---|---|---|
| EEPROM | X | X | X | A12 | A11 | A10 | A9 | A8 |
| Serial Number | X | X | X | X | 1 | 0 | X | X |

Next, the second word address byte is sent to the device which provides the remaining eight bits of the word address (A7 through A0). Upon completion of the second word address byte, the AT24CS64 will return an ACK. See Table 6-3 to review these bit positions.

**Table 6-3. Second Word Address Byte**

| Access Area | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---|---|---|---|---|---|---|---|---|
| EEPROM | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 |
| Serial Number | X | X | X | A4 | A3 | A2 | A1 | A0 |

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# 7. Write Operations

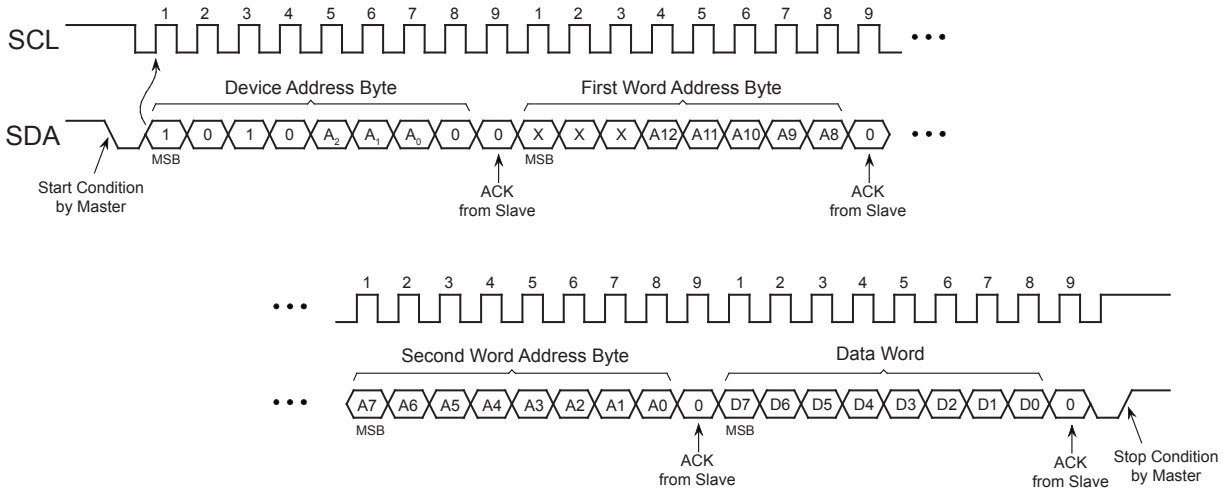
All write operations for the AT24CS64 begin with the master sending a Start condition, followed by a device address byte with the R/$\overline{W}$ bit set to logic '0', and then by the word address bytes. The data value(s) to be written to the device immediately follow the word address bytes.

## 7.1 Byte Write

The AT24CS64 supports the writing of a single 8-bit byte. Selecting a data word in the AT24CS64 requires 13-bit word address.

Upon receipt of the proper device address and the word address bytes, the EEPROM will send an Acknowledge. The device will then be ready to receive the 8-bit data word. Following receipt of the 8-bit data word, the EEPROM will respond with an ACK. The addressing device, such as a bus master, must then terminate the write operation with a Stop condition. At that time, the EEPROM will enter an internally self-timed write cycle, which will be completed within $t_{WR}$, while the data word is being programmed into the nonvolatile EEPROM. All inputs are disabled during this write cycle, and the EEPROM will not respond until the write is complete.

**Figure 7-1. Byte Write**




## 7.2 Page Write

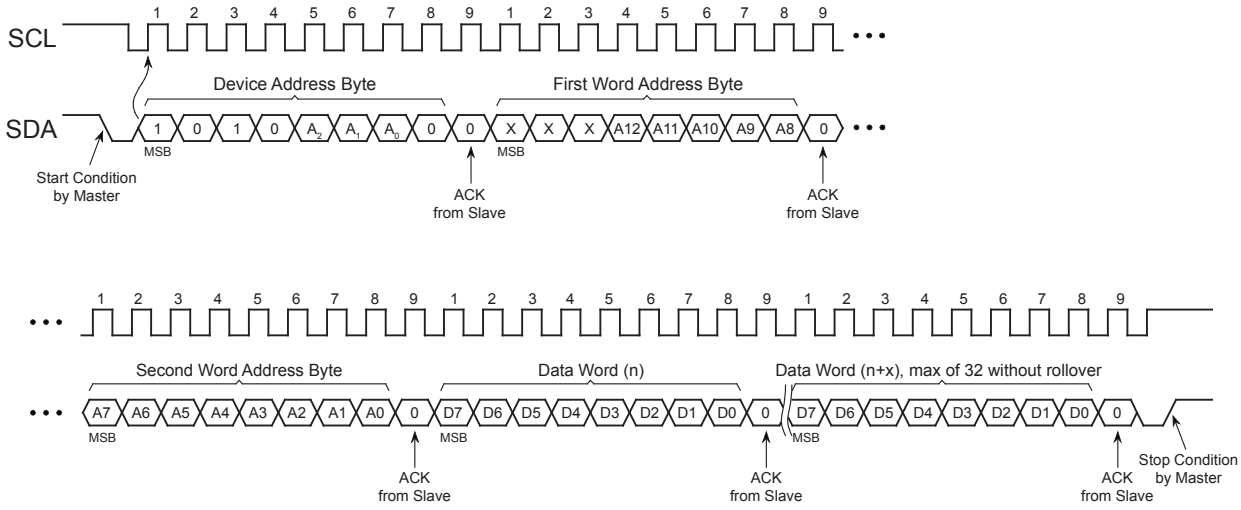
A page write operation allows up to 32 bytes to be written in the same write cycle, provided all bytes are in the same row of the memory array (where address bits A12 through A5 are the same). Partial page writes of less than 32 bytes are also allowed.

A page write is initiated the same way as a byte write, but the bus master 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 bus master can transmit up to thirty one additional data words. The EEPROM will respond with an ACK after each data word is received. Once all data to be written has been sent to the device, the bus master must issue a Stop condition (see Figure 7-2) at which time the internally self-timed write cycle will begin.

The lower five bits of the word address are internally incremented following the receipt of each data word. The higher order address bits are not incremented and retain the memory page row location. Page write operations are limited to writing bytes within a single physical page, regardless of the number of bytes actually being written. When the incremented word address reaches the page boundary, the address counter will rollover to the beginning of the same page. Nevertheless, creating a rollover event should be avoided as previously loaded data in the page could become unintentionally altered.


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**Figure 7-2. Page Write**

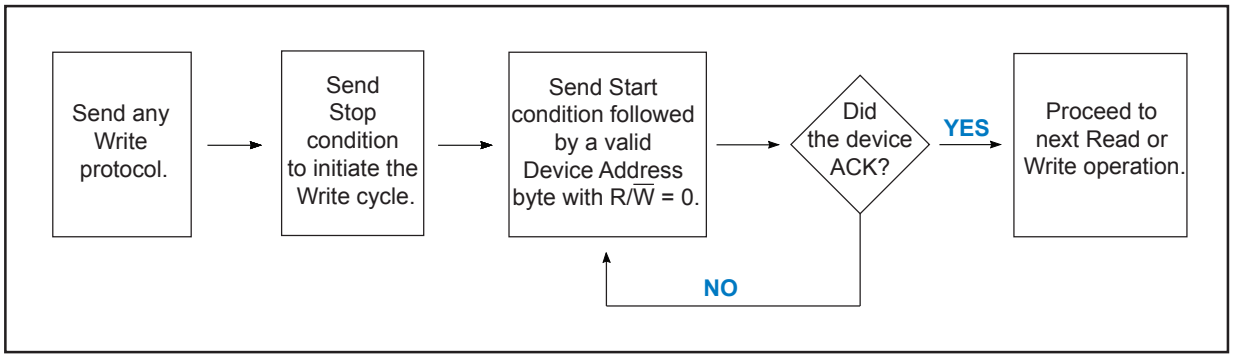



## 7.3 Acknowledge Polling

An Acknowledge Polling routine can be implemented to optimize time-sensitive applications that would prefer not to wait the fixed maximum write cycle time ($t_{WR}$). This method allows the application to know immediately when the Serial EEPROM write cycle has completed, so a subsequent operation can be started.

Once the internally self-timed write cycle has started, an Acknowledge Polling routine can be initiated. This involves repeatedly sending a Start condition followed by a valid device address byte with the R/$\overline{W}$ bit set at logic '0'. The device will not respond with an ACK while the write cycle is ongoing. Once the internal write cycle has completed, the EEPROM will respond with an ACK, allowing a new read or write operation to be immediately initiated. A flowchart has been included below in Figure 7-3 to better illustrate this technique.

**Figure 7-3. Acknowledge Polling Flowchart**

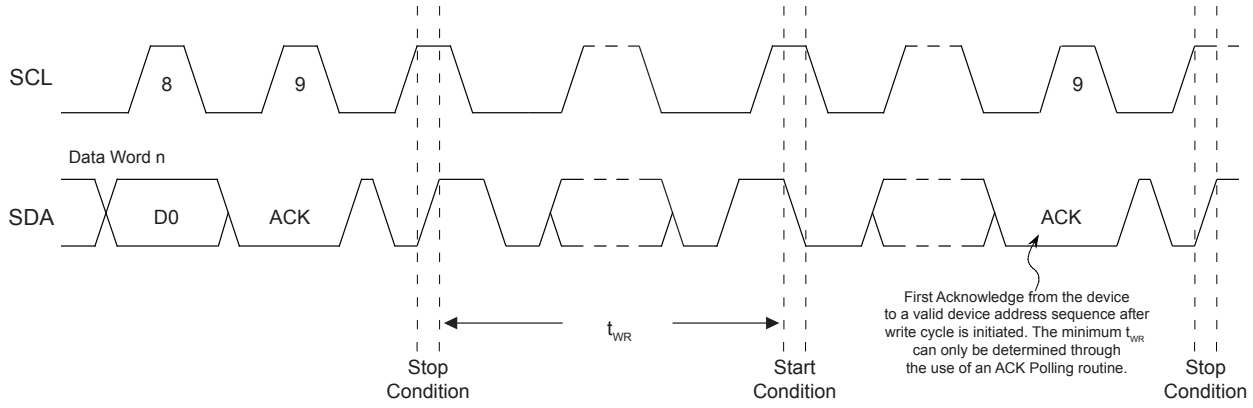



## 7.4 Write Cycle Timing

The length of the self-timed write cycle ($t_{WR}$) is defined as the amount of time from the Stop condition that begins the internal write cycle to the Start condition of the first device address byte sent to the AT24CS64 that it subsequently responds to with an ACK. Figure 7-4 has been included to show this measurement. During the internally self-timed write cycle, any attempts to read from or write to the memory array will not be processed.


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**Figure 7-4. Write Cycle Timing**




## 7.5 Write Protection

The AT24CS64 utilizes a hardware data protection scheme that allows the user to write-protect the entire memory contents when the WP pin is at $V_{CC}$ (or a valid $V_{IH}$). No write protection will be set if the WP pin is at GND or left floating.

**Table 7-1. AT24CS64 Write-Protect Behavior**

| WP Pin Voltage | Part of the Array Protected |
|---|---|
| $V_{CC}$ | Full Array |
| GND | None – Write Protection Not Enabled |

The status of the WP pin is sampled at the Stop condition for every byte write or page write operation prior to the start of an internally self-timed write cycle. Changing the WP pin state after the Stop condition has been sent will not alter or interrupt the execution of the write cycle.

If an attempt is made to write to the device while the WP pin has been asserted, the device will acknowledge the device address, word address and data bytes, but no write cycle will occur when the Stop condition is issued. The device will immediately be ready to accept a new read or write command.

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# 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 byte must be a logic '1'. There are four read operations:

- Current Address Read
- Random Address Read
- Sequential Read
- Serial Number Read

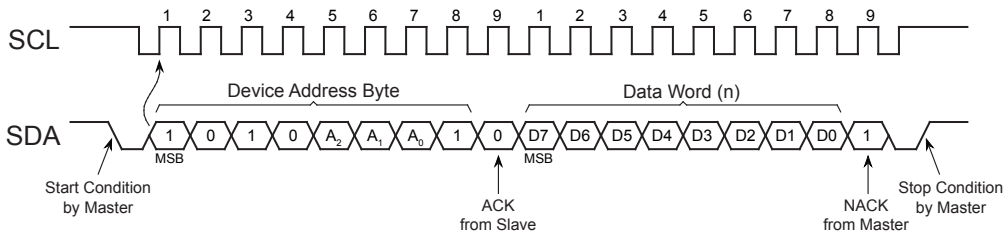
**Note:** The AT24CS64 contains a single Address Pointer register, which is shared by both the EEPROM and the serial number. As such, when changing from one region to the other, the first read operation in the new region should begin with a dummy write sequence (i.e., a random read operation with the new region's device address and word address bytes) in order to ensure the Address Pointer is set to a known value. See Serial Number Read for additional requirements on the serial number read.

## 8.1 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 $V_{CC}$ is maintained to the part. The address roll-over during a read is from the last byte of the last page to the first byte of the first page of the memory.

A current address read operation will output data according to the location of the internal data word address counter. This is initiated with a Start condition, followed by a valid device address byte with the R/$\overline{W}$ bit set to logic '1'. The device will ACK this sequence and the current address data word is serially clocked out on the SDA line. All types of read operations will be terminated if the bus master does not respond with an ACK (it NACKs) during the ninth clock cycle. After the NACK response, the master may send a Stop condition to complete the protocol, or it can send a Start condition to begin the next sequence.

**Figure 8-1. Current Address Read**

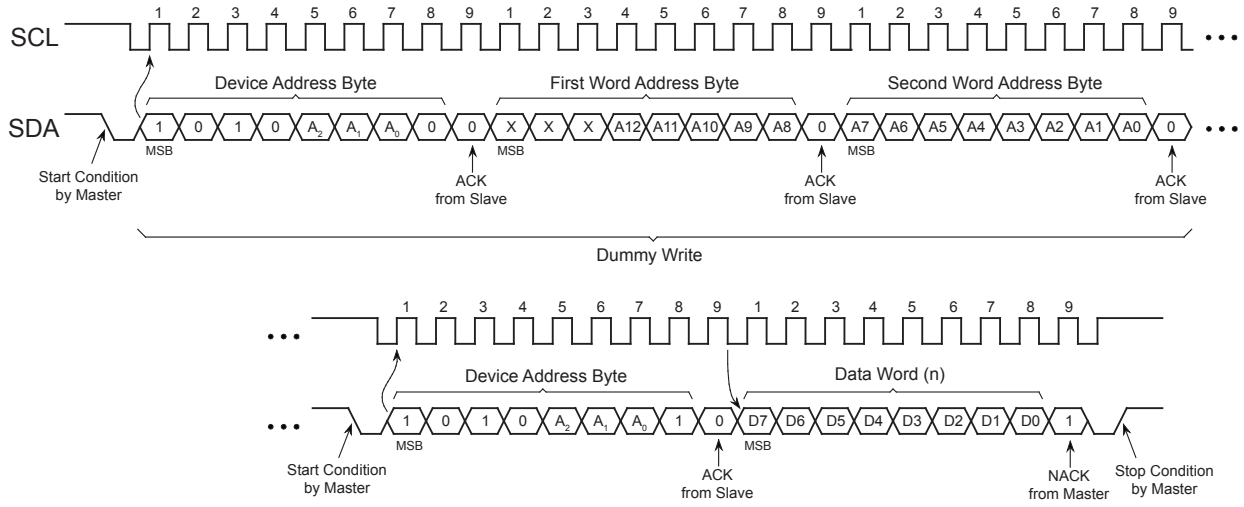



## 8.2 Random Read

A random read begins in the same way as a byte write operation does to load in a new data word address. This is known as a "dummy write" sequence; however, the data byte and the Stop condition of the byte write must be omitted to prevent the part from entering an internal write cycle. Once the device address and word address are clocked in and acknowledged by the EEPROM, the bus master must generate another Start condition. The bus master now initiates a current address read by sending a Start condition, followed by a valid device address byte with the R/$\overline{W}$ bit set to logic '1'. The EEPROM will ACK the device address and serially clock out the data word on the SDA line. All types of read operations will be terminated if the bus master does not respond with an ACK (it NACKs) during the ninth clock cycle. After the NACK response, the master may send a Stop condition to complete the protocol, or it can send a Start condition to begin the next sequence.


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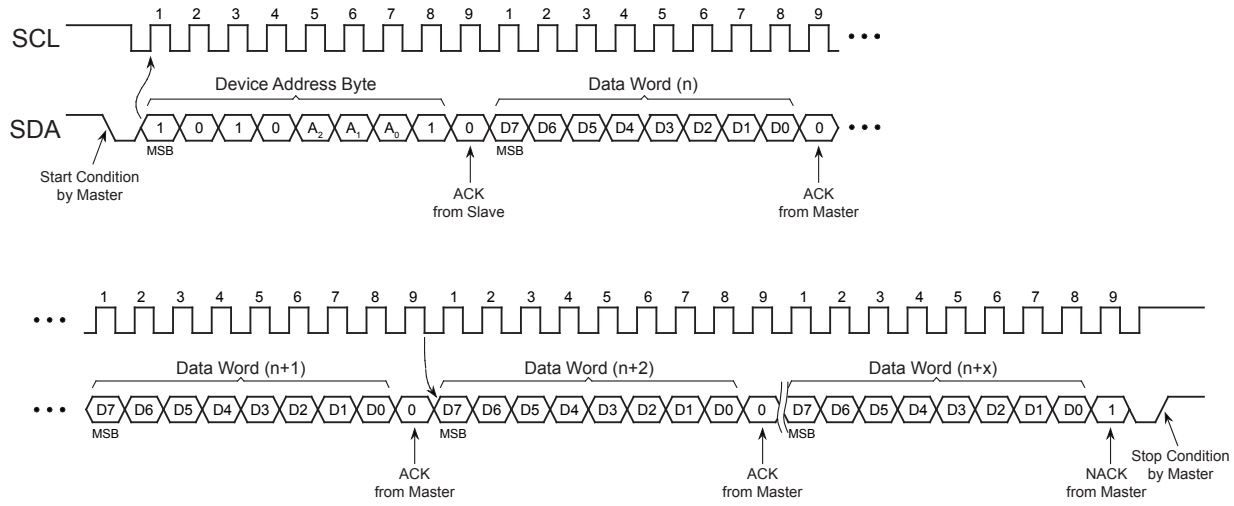
**Figure 8-2. Random Read**




## 8.3 Sequential Read

Sequential reads are initiated by either a current address read or a random read. After the bus master receives a data word, it responds with an Acknowledge. As long as the EEPROM receives an ACK, it will continue to increment the word address and serially clock out sequential data words. When the maximum memory address is reached, the data word address will roll-over and the sequential read will continue from the beginning of the memory array. All types of read operations will be terminated if the bus master does not respond with an ACK (it NACKs) during the ninth clock cycle. After the NACK response, the master may send a Stop condition to complete the protocol, or it can send a Start condition to begin the next sequence.

**Figure 8-3. Sequential Read**




## 8.4 Serial Number Read

Reading the serial number is similar to the sequential read sequence but requires use of the specific Device Address and Word Address bytes as specified in Table 6-1 and Table 6-2.

**Note:** The entire 128-bit value must be read from the starting address of the serial number block to ensure a unique number.


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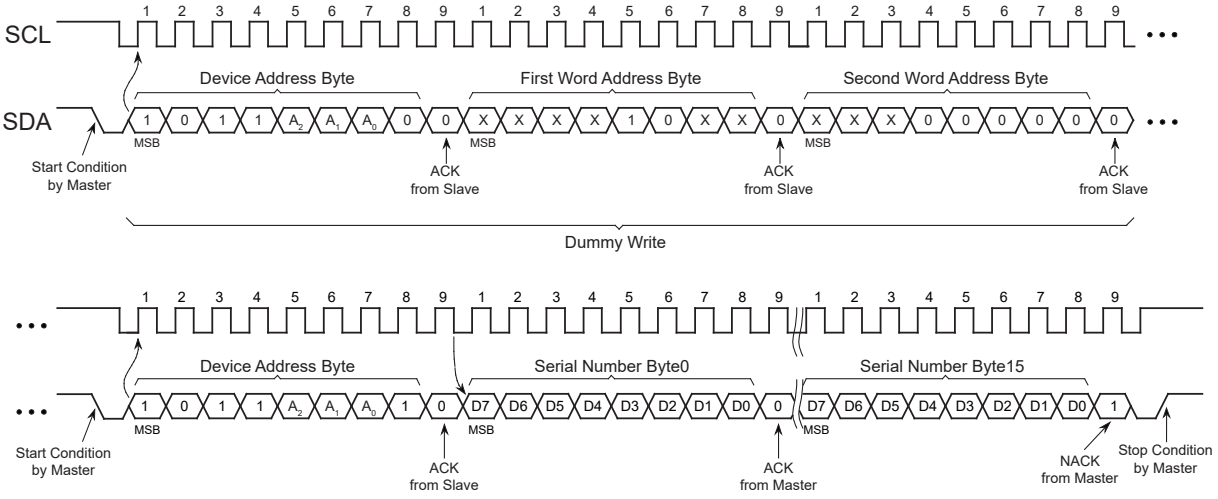
Since the Address Pointer of the device is shared between the regular EEPROM array and the serial number block, a dummy write sequence, as part of a random read or sequential read protocol, should be performed to ensure the Address Pointer is set to a known value. Reading the serial number from a location other than the first address of the block will not result in a unique serial number.

Additionally, the word address contains a '10' sequence in bit A11 and A10 of the word address, regardless of the intended address as depicted in Table 6-2. If a word address other than '10' is used, then the device will output undefined data.

**Note:** If the application desires to read the first byte of the serial number, the word address input would need to be 0800h.

When the end of the 128-bit serial number is reached (16 bytes of data), continued reading of the extended memory region will result in an additional 16 bytes of 00h data. Upon reaching the end of the 32-byte extended memory region, the data word address will roll-over back to the beginning of the 128-bit serial number. The serial number read operation is terminated when the bus master does not respond with an ACK (it NACKs) during the ninth clock cycle. After the NACK response, the master may send a Stop condition to complete the protocol, or it can send a Start condition to begin the next sequence (see Figure 8-4).

**Figure 8-4. Serial Number Read**





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# 9. Device Default Condition from Microchip

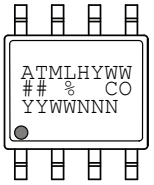
The AT24CS64 is delivered with the EEPROM array set to logic '1', resulting in FFh data in all locations.


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# 10. Packaging Information

## 10.1 Package Marking Information

### AT24CS64: Package Marking Information

| 8-lead SOIC | 8-lead TSSOP | 8-pad UDFN |
|---|---|---|
|  |  | 2.0 x 3.0 mm Body<br> |

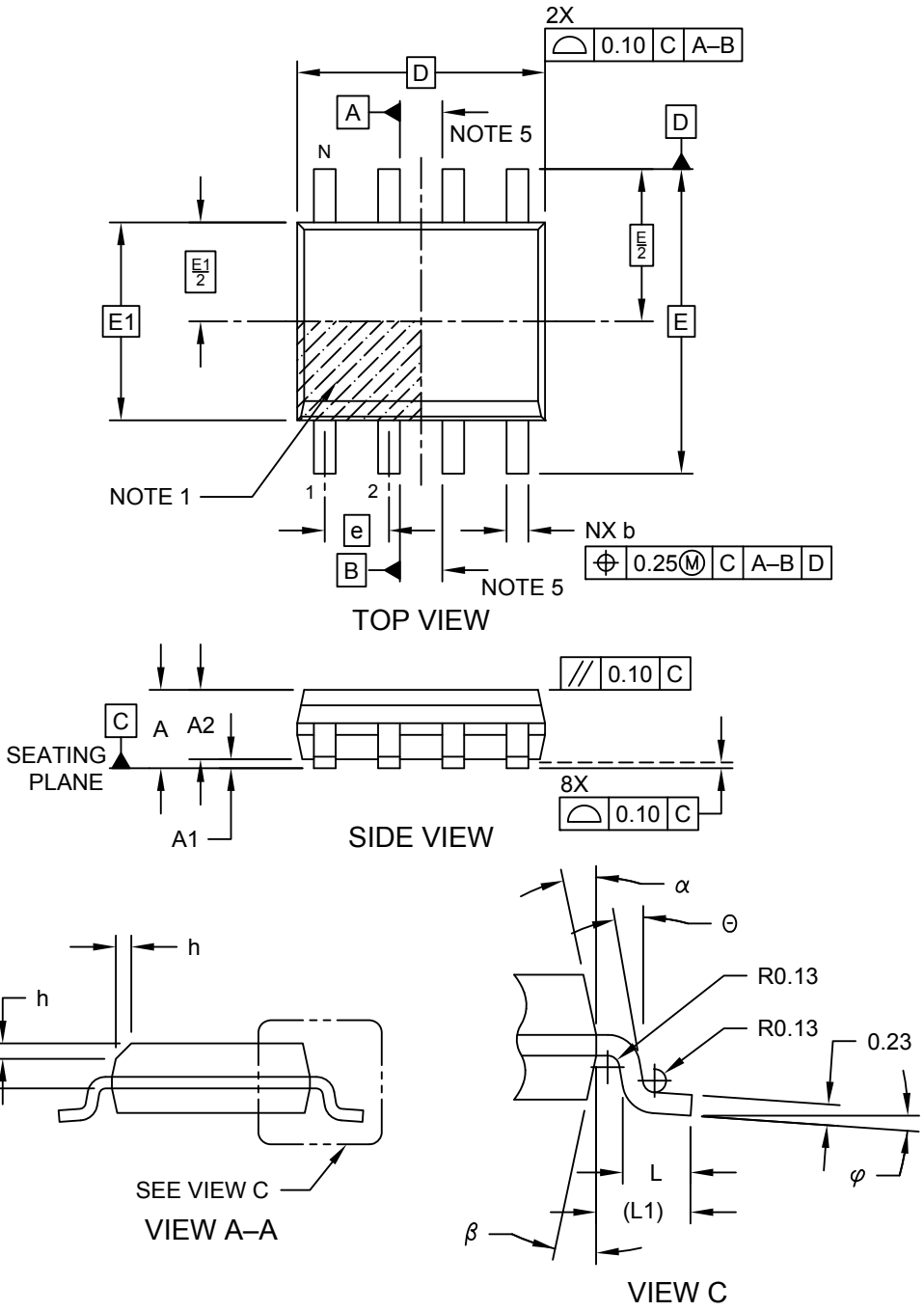
Note 1: ● designates pin 1
Note 2: Package drawings are not to scale

| **Catalog Number Truncation** | | | | | |
|---|---|---|---|---|---|
| AT24CS64 | | Truncation Code ##: NC | | | |
| **Date Codes** | | | | | **Voltages** |
| YY = Year | | Y = Year | | WW = Work Week of Assembly | % = Minimum Voltage |
| 16: 2016 | 20: 2020 | 6: 2016 | 0: 2020 | 02: Week 2 | M: 1.7V min |
| 17: 2017 | 21: 2021 | 7: 2017 | 1: 2021 | 04: Week 4 | |
| 18: 2018 | 22: 2022 | 8: 2018 | 2: 2022 | ... | |
| 19: 2019 | 23: 2023 | 9: 2019 | 3: 2023 | 52: Week 52 | |
| **Country of Origin** | | **Device Grade** | | | **Atmel Truncation** |
| CO = Country of Origin | | H or U: Industrial Grade | | | AT: Atmel<br>ATM: Atmel<br>ATML: Atmel |
| **Lot Number or Trace Code** | | | | | |
| NNN = Alphanumeric Trace Code (2 Characters for Small Packages) | | | | | |


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### 8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

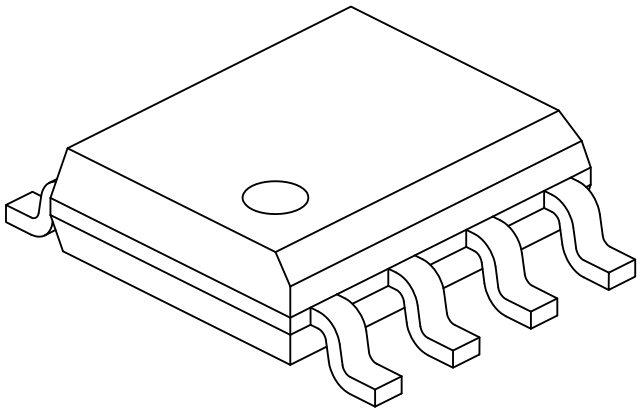



Microchip Technology Drawing No. C04-057-SN Rev E Sheet 1 of 2


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**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Number of Pins | N | | 8 | |
| Pitch | e | | 1.27 BSC | |
| Overall Height | A | - | - | 1.75 |
| Molded Package Thickness | A2 | 1.25 | - | - |
| Standoff § | A1 | 0.10 | - | 0.25 |
| Overall Width | E | | 6.00 BSC | |
| Molded Package Width | E1 | | 3.90 BSC | |
| Overall Length | D | | 4.90 BSC | |
| Chamfer (Optional) | h | 0.25 | - | 0.50 |
| Foot Length | L | 0.40 | - | 1.27 |
| Footprint | L1 | | 1.04 REF | |
| Foot Angle | φ | 0° | - | 8° |
| Lead Thickness | c | 0.17 | - | 0.25 |
| Lead Width | b | 0.31 | - | 0.51 |
| Mold Draft Angle Top | α | 5° | - | 15° |
| Mold Draft Angle Bottom | β | 5° | - | 15° |

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.
5. Datums A & B to be determined at Datum H.

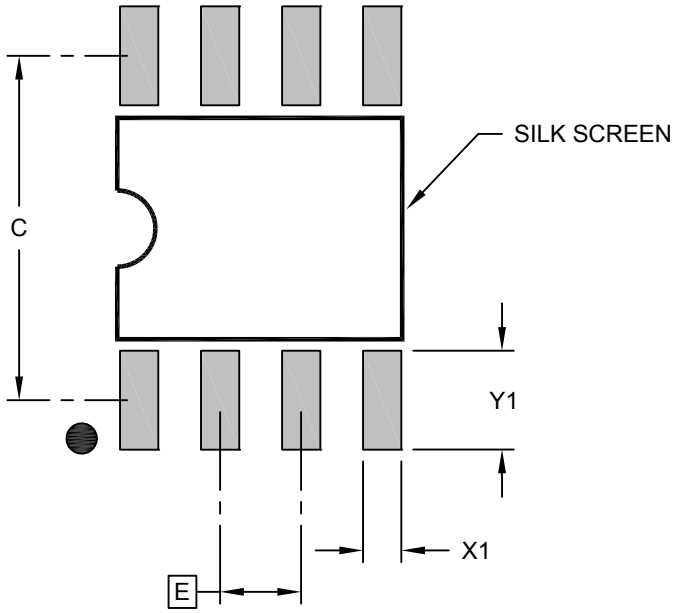
Microchip Technology Drawing No. C04-057-SN Rev E Sheet 2 of 2

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## 8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm Body [SOIC]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging




RECOMMENDED LAND PATTERN

| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Contact Pitch | E | | 1.27 BSC | |
| Contact Pad Spacing | C | | 5.40 | |
| Contact Pad Width (X8) | X1 | | | 0.60 |
| Contact Pad Length (X8) | Y1 | | | 1.55 |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

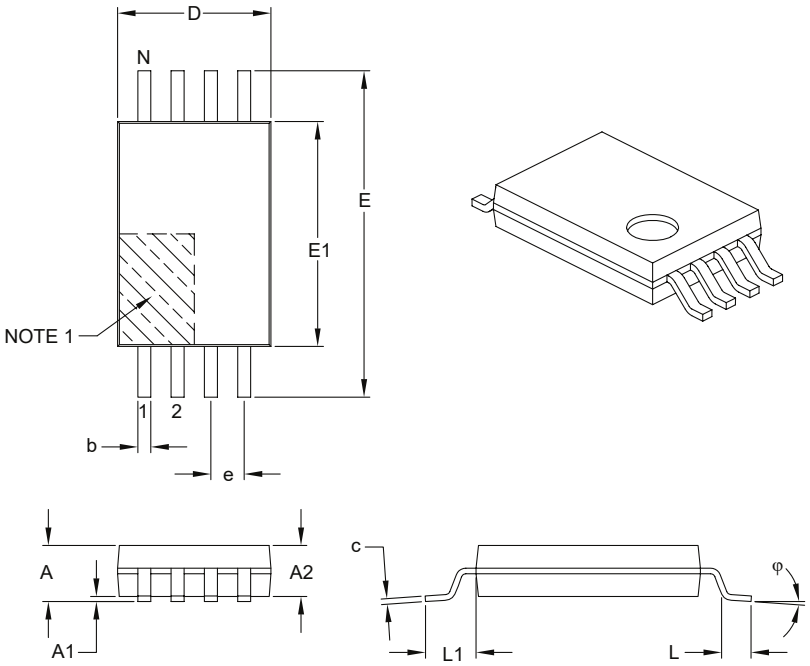
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-2057-SN Rev E


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### 8-Lead Plastic Thin Shrink Small Outline (ST) – 4.4 mm Body [TSSOP]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging




| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Number of Pins | N | | 8 | |
| Pitch | e | | 0.65 BSC | |
| Overall Height | A | – | – | 1.20 |
| Molded Package Thickness | A2 | 0.80 | 1.00 | 1.05 |
| Standoff | A1 | 0.05 | – | 0.15 |
| Overall Width | E | | 6.40 BSC | |
| Molded Package Width | E1 | 4.30 | 4.40 | 4.50 |
| Molded Package Length | D | 2.90 | 3.00 | 3.10 |
| Foot Length | L | 0.45 | 0.60 | 0.75 |
| Footprint | L1 | | 1.00 REF | |
| Foot Angle | φ | 0° | – | 8° |
| Lead Thickness | c | 0.09 | – | 0.20 |
| Lead Width | b | 0.19 | – | 0.30 |

**Notes:**

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15 mm per side.
3. Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information purposes only.

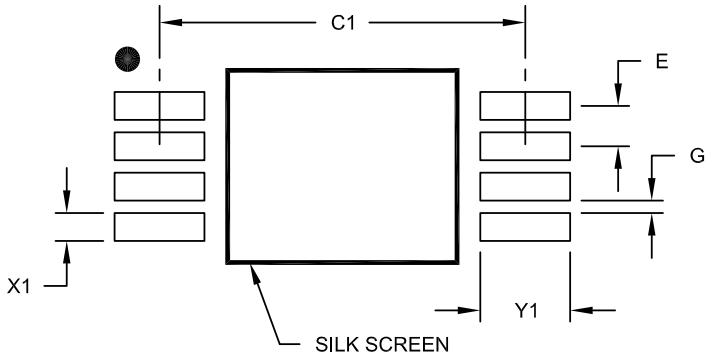
Microchip Technology Drawing C04-086B

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8-Lead Plastic Thin Shrink Small Outline (ST) - 4.4 mm Body [TSSOP]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging




RECOMMENDED LAND PATTERN

| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Contact Pitch | E | | 0.65 BSC | |
| Contact Pad Spacing | C1 | | 5.90 | |
| Contact Pad Width (X8) | X1 | | | 0.45 |
| Contact Pad Length (X8) | Y1 | | | 1.45 |
| Distance Between Pads | G | 0.20 | | |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

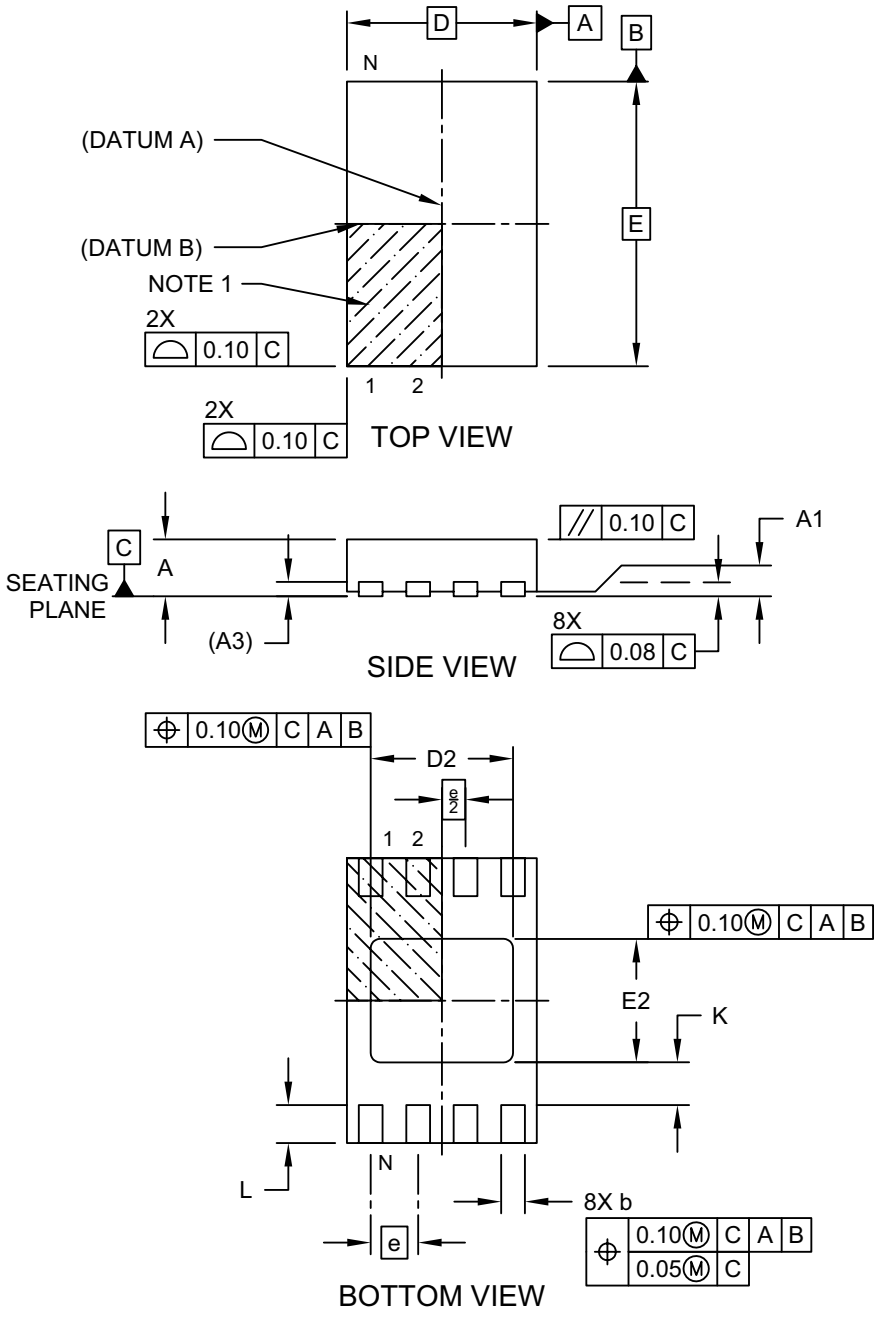
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2086A


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### 8-Lead Ultra Thin Plastic Dual Flat, No Lead Package (Q4B) - 2x3 mm Body [UDFN]
### Atmel Legacy YNZ Package

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

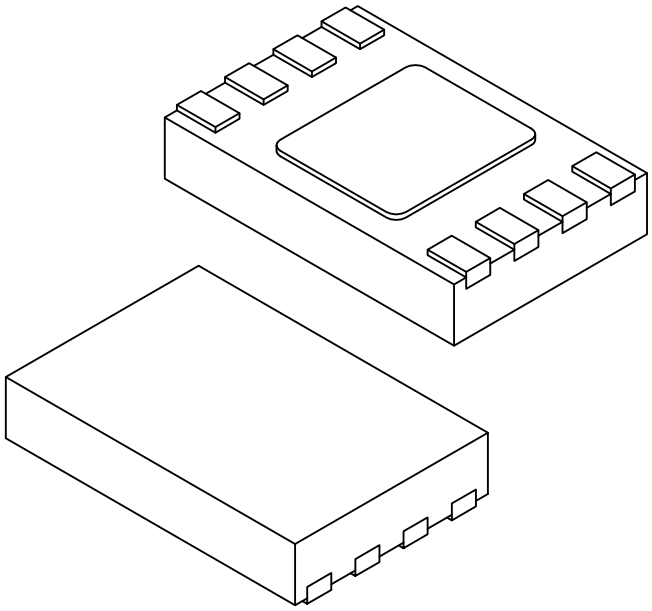



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| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Number of Terminals | N | | 8 | |
| Pitch | e | | 0.50 BSC | |
| Overall Height | A | 0.50 | 0.55 | 0.60 |
| Standoff | A1 | 0.00 | 0.02 | 0.05 |
| Terminal Thickness | A3 | | 0.152 REF | |
| Overall Length | D | | 2.00 BSC | |
| Exposed Pad Length | D2 | 1.40 | 1.50 | 1.60 |
| Overall Width | E | | 3.00 BSC | |
| Exposed Pad Width | E2 | 1.20 | 1.30 | 1.40 |
| Terminal Width | b | 0.18 | 0.25 | 0.30 |
| Terminal Length | L | 0.35 | 0.40 | 0.45 |
| Terminal-to-Exposed-Pad | K | 0.20 | - | - |

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

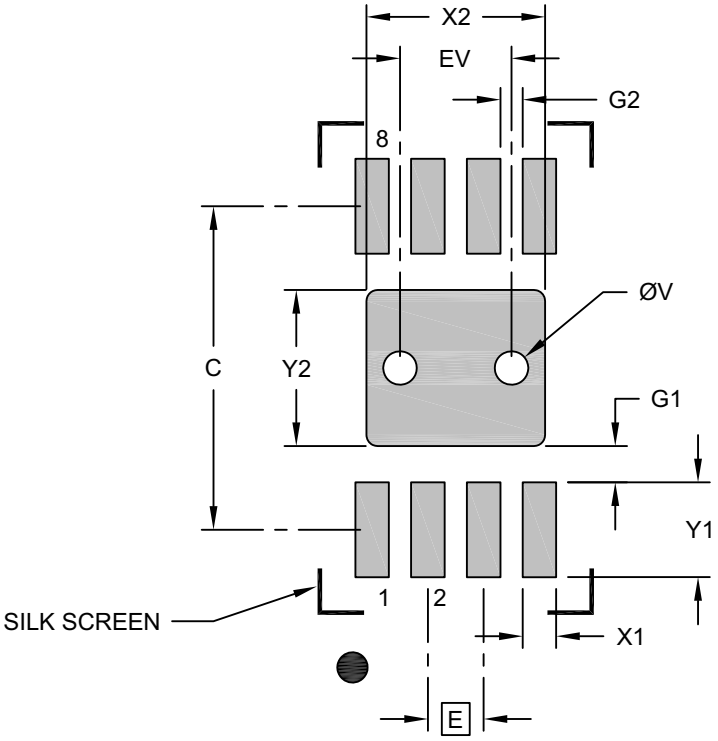
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RECOMMENDED LAND PATTERN

| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Contact Pitch | E | | 0.50 BSC | |
| Optional Center Pad Width | X2 | | | 1.60 |
| Optional Center Pad Length | Y2 | | | 1.40 |
| Contact Pad Spacing | C | | 2.90 | |
| Contact Pad Width (X8) | X1 | | | 0.30 |
| Contact Pad Length (X8) | Y1 | | | 0.85 |
| Contact Pad to Center Pad (X8) | G1 | 0.20 | | |
| Contact Pad to Contact Pad (X6) | G2 | 0.33 | | |
| Thermal Via Diameter | V | | 0.30 | |
| Thermal Via Pitch | EV | | 1.00 | |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

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# 11. Revision History

**Revision A (January 2020)**
Updated to Microchip template. Microchip DS20006296 replaces Atmel document 8870. Corrected $t_{LOW}$ typo from 400ns to 500ns. Corrected $t_{AA}$ typo from 550ns to 450ns. Updated Package Marking Information. Updated Product ID System. Updated the “Software Reset” section. Added ESD rating. Removed lead finish designation. Updated trace code format in package markings. Updated formatting throughout for clarification. Added a figure for “System Configuration Using 2-Wire Serial EEPROMs”. Added POR recommendations section.

**Atmel Document 8870 Revision D (January 2015)**
Add the UDFN Expanded Quantity Option an update the ordering information section.

**Atmel Document 8870 Revision C (August 2014)**
Add bulk SOIC and TSSOP ordering codes. Update ordering code table, 8X and 8MA2 package drawings, and update the disclaimer page.

**Atmel Document 8870 Revision B (May 2014)**
Update 8MA2 and 8X package drawings, disclaimer page, and data sheet status from preliminary to complete.

**Atmel Document 8870 Revision A (August 2013)**
Initial document release.

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- Technical Support

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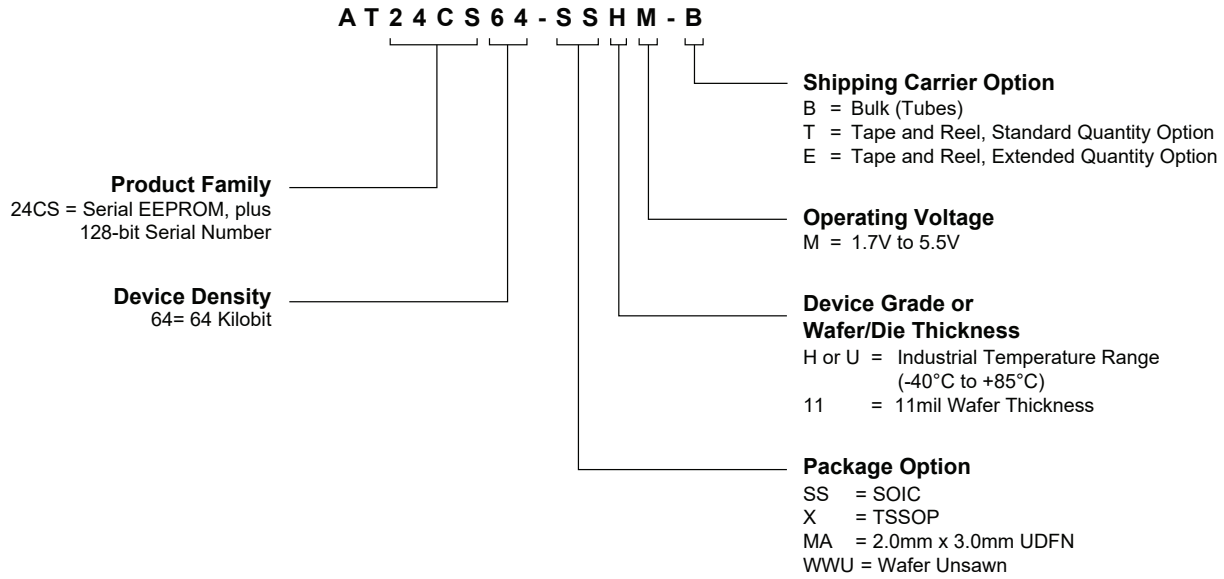
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## Product Identification System

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.




Examples

| Device | Package | Package Drawing Code | Package Option | Shipping Carrier Option | Device Grade |
|---|---|---|---|---|---|
| AT24CS64-SSHM-B | SOIC | SN | SS | Bulk (Tubes) | Industrial Temperature (-40°C to +85°C) |
| AT24CS64-SSHM-T | SOIC | SN | SS | Tape and Reel | |
| AT24CS64-XHM-B | TSSOP | ST | X | Bulk (Tubes) | |
| AT24CS64-XHM-T | TSSOP | ST | X | Tape and Reel | |
| AT24CS64-MAHM-T | UDFN | Q4B | MA | Tape and Reel | |
| AT24CS64-MAHM-E | UDFN | Q4B | MA | Extended Qty. Tape and Reel | |

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