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CAT24AA04, CAT24AA08

4-Kb and 8-Kb I²C CMOS Serial EEPROM

Description

The CAT24AA04/24AA08 are 4-Kb and 8-Kb CMOS Serial EEPROM devices internally organized as 512x8/1024x8 bits.

They feature a 16-byte page write buffer and support 100 kHz, 400 kHz and 1 MHz I²C protocols.

In contrast to the CAT24C04/24C08, the CAT24AA04/24AA08 have no external address pins, and are therefore suitable in applications that require a single CAT24AA04/08 on the I²C bus.

Features

- Standard and Fast I²C Protocol Compatible
- Supports 1 MHz Clock Frequency
- 1.7 V to 5.5 V Supply Voltage Range
- 16-Byte Page Write Buffer
- Hardware Write Protection for Entire Memory
- Schmitt Triggers and Noise Suppression Filters on I²C Bus Inputs (SCL and SDA)
- Low Power CMOS Technology
- 1,000,000 Program/Erase Cycles
- 100 Year Data Retention
- Industrial Temperature Range
- TSOT-23 5-lead and SOIC 8-lead Packages
- These Devices are Pb-Free, Halogen Free/BFR Free, and RoHS Compliant

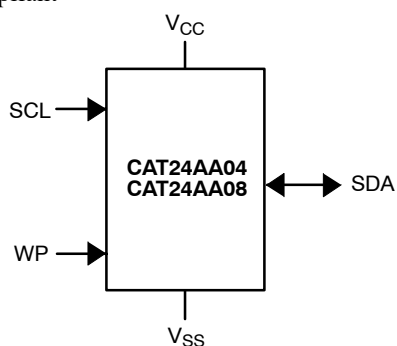


Figure 1. Functional Symbol



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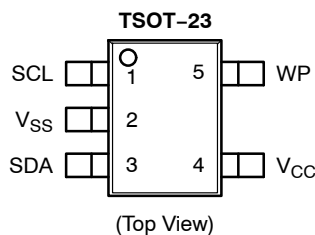
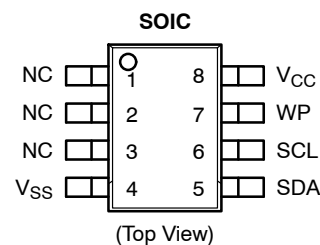


SOIC-8
W SUFFIX
CASE 751BD



TSOT-23
TB SUFFIX
CASE 419AE

PIN CONFIGURATIONS



PIN FUNCTION

| Pin Name | Function |
|-----------------|---------------------|
| SDA | Serial Data/Address |
| SCL | Clock Input |
| WP | Write Protect |
| V _{CC} | Power Supply |
| V _{SS} | Ground |
| NC | No Connect |

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

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Table 1. ABSOLUTE MAXIMUM RATINGS

| Parameters | Ratings | Units |
|--|--------------|-------|
| Storage Temperature | -65 to +150 | °C |
| Voltage on any Pin with Respect to Ground (Note 1) | -0.5 to +6.5 | V |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

- The DC input voltage on any pin should not be lower than -0.5 V or higher than $V_{CC} + 0.5$ V. During transitions, the voltage on any pin may undershoot to no less than -1.5 V or overshoot to no more than $V_{CC} + 1.5$ V, for periods of less than 20 ns.

Table 2. RELIABILITY CHARACTERISTICS (Note 2)

| Symbol | Parameter | Min | Units |
|--------------------|----------------|-----------|----------------------|
| N_{END} (Note 3) | Endurance | 1,000,000 | Program/Erase Cycles |
| T_{DR} | Data Retention | 100 | Years |

- These parameters are tested initially and after a design or process change that affects the parameter according to appropriate AEC-Q100 and JEDEC test methods.
- Page Mode @ 25°C

Table 3. D.C. OPERATING CHARACTERISTICS ($V_{CC} = 1.7$ V to 5.5 V, $T_A = -40$ °C to 85°C, unless otherwise specified.)

| Symbol | Parameter | Test Conditions | Min | Max | Units |
|-----------|--------------------|--|---------------------|---------------------|-------|
| I_{CCR} | Read Current | Read, $f_{SCL} = 400$ kHz | | 0.5 | mA |
| I_{CCW} | Write Current | Write, $f_{SCL} = 400$ kHz | | 1 | mA |
| I_{SB} | Standby Current | All I/O Pins at GND or V_{CC} | | 1 | μA |
| I_L | I/O Pin Leakage | Pin at GND or V_{CC} | | 1 | μA |
| V_{IL} | Input Low Voltage | | -0.5 | $V_{CC} \times 0.3$ | V |
| V_{IH} | Input High Voltage | | $V_{CC} \times 0.7$ | $V_{CC} + 0.5$ | V |
| V_{OL1} | Output Low Voltage | $V_{CC} \geq 2.5$ V, $I_{OL} = 3.0$ mA | | 0.4 | V |
| V_{OL2} | Output Low Voltage | $V_{CC} < 2.5$ V, $I_{OL} = 1.0$ mA | | 0.2 | V |

Table 4. PIN IMPEDANCE CHARACTERISTICS ($V_{CC} = 1.7$ V to 5.5 V, $T_A = -40$ °C to 85°C, unless otherwise specified.)

| Symbol | Parameter | Conditions | Max | Units |
|-------------------|--------------------------------|---|-----|-------|
| C_{IN} (Note 2) | SDA I/O Pin Capacitance | $V_{IN} = 0$ V | 8 | pF |
| C_{IN} (Note 2) | Input Capacitance (other pins) | $V_{IN} = 0$ V | 6 | pF |
| I_{WP} (Note 4) | WP Input Current | $V_{IN} < 0.5 \times V_{CC}$, $V_{CC} = 5.5$ V | 200 | μA |
| | | $V_{IN} < 0.5 \times V_{CC}$, $V_{CC} = 3.3$ V | 150 | |
| | | $V_{IN} < 0.5 \times V_{CC}$, $V_{CC} = 1.8$ V | 100 | |
| | | $V_{IN} > 0.5 \times V_{CC}$ | 1 | |

- When not driven, the WP pin is pulled down to GND internally. For improved noise immunity, the internal pull-down is relatively strong; therefore the external driver must be able to supply the pull-down current when attempting to drive the input HIGH. To conserve power, as the input level exceeds the trip point of the CMOS input buffer ($\sim 0.5 \times V_{CC}$), the strong pull-down reverts to a weak current source.

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Table 5. A.C. CHARACTERISTICS (Note 5) ($V_{CC} = 1.7\text{ V to }5.5\text{ V}$, $T_A = -40^\circ\text{C to }85^\circ\text{C}$, unless otherwise specified.)

| Symbol | Parameter | Standard $V_{CC} = 1.7\text{ V} - 5.5\text{ V}$ | | Fast $V_{CC} = 1.7\text{ V} - 5.5\text{ V}$ | | 1 MHz $V_{CC} = 2.5\text{ V} - 5.5\text{ V}$ | | Units |
|--------------------------|--|--|-----------------|--|-----|---|-----|---------------|
| | | Min | Max | Min | Max | Min | Max | |
| | | f_{SCL} | Clock Frequency | | 100 | | 400 | |
| $t_{HD:STA}$ | START Condition Hold Time | 4 | | 0.6 | | 0.25 | | μs |
| t_{LOW} | Low Period of SCL Clock | 4.7 | | 1.3 | | 0.5 | | μs |
| t_{HIGH} | High Period of SCL Clock | 4 | | 0.6 | | 0.5 | | μs |
| $t_{SU:STA}$ | START Condition Setup Time | 4.7 | | 0.6 | | 0.25 | | μs |
| $t_{HD:DAT}$ | Data In Hold Time | 0 | | 0 | | 0 | | ns |
| $t_{SU:DAT}$ | Data In Setup Time | 250 | | 100 | | 100 | | ns |
| t_R (Note 6) | SDA and SCL Rise Time | | 1000 | | 300 | | 300 | ns |
| t_F (Note 6) | SDA and SCL Fall Time | | 300 | | 300 | | 100 | ns |
| $t_{SU:STO}$ | STOP Condition Setup Time | 4 | | 0.6 | | 0.25 | | μs |
| t_{BUF} | Bus Free Time Between STOP and START | 4.7 | | 1.3 | | 0.5 | | μs |
| t_{AA} | SCL Low to Data Out Valid | | 3.5 | | 0.9 | | 0.4 | μs |
| t_{DH} | Data Out Hold Time | 100 | | 50 | | 50 | | ns |
| T_i (Note 6) | Noise Pulse Filtered at SCL and SDA Inputs | | 100 | | 100 | | 100 | ns |
| $t_{SU:WP}$ | WP Setup Time | 0 | | 0 | | 0 | | μs |
| $t_{HD:WP}$ | WP Hold Time | 2.5 | | 2.5 | | 1 | | μs |
| t_{WR} | Write Cycle Time | | 5 | | 5 | | 5 | ms |
| t_{PU} (Notes 6, 7) | Power-up to Ready Mode | | 1 | | 1 | | 1 | ms |

5. Test conditions according to "A.C. Test Conditions" table.

6. Tested initially and after a design or process change that affects this parameter.

7. t_{PU} is the delay between the time V_{CC} is stable and the device is ready to accept commands.

Table 6. A.C. TEST CONDITIONS

| | |
|---------------------------|--|
| Input Levels | $0.2 \times V_{CC}$ to $0.8 \times V_{CC}$ |
| Input Rise and Fall Times | $\leq 50\text{ ns}$ |
| Input Reference Levels | $0.3 \times V_{CC}$, $0.7 \times V_{CC}$ |
| Output Reference Levels | $0.5 \times V_{CC}$ |
| Output Load | Current Source: $I_{OL} = 3\text{ mA}$ ($V_{CC} \geq 2.5\text{ V}$); $I_{OL} = 1\text{ mA}$ ($V_{CC} < 2.5\text{ V}$); $C_L = 100\text{ pF}$ |

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Power-On Reset (POR)

Each CAT24AA04/08 incorporates Power-On Reset (POR) circuitry which protects the internal logic against powering up in the wrong state. The device will power up into Standby mode after V_{CC} exceeds the POR trigger level and will power down into Reset mode when V_{CC} drops below the POR trigger level.

This bi-directional POR behavior protects the device against brown-out failure, following a temporary loss of power.

Pin Description

SCL: The Serial Clock input pin accepts the clock signal generated by the Master.

SDA: The Serial Data I/O pin accepts input data and delivers output data. In transmit mode, this pin is open drain. Data is acquired on the positive edge, and delivered on the negative edge of SCL.

WP: When the Write Protect input pin is forced HIGH by an external source, all write operations are inhibited. When the pin is not driven by an external source, it is pulled LOW internally.

Functional Description

The CAT24AA04/08 supports the Inter-Integrated Circuit (I²C) Bus protocol. The protocol relies on the use of a Master device, which provides the clock and directs bus traffic, and Slave devices which execute requests. The CAT24AA04/08 operates as a Slave device. Both Master and Slave can transmit or receive, but only the Master can assign those roles.

I²C Bus Protocol

The 2-wire I²C bus consists of two lines, SCL and SDA, connected to the V_{CC} supply via pull-up resistors. The Master provides the clock to the SCL line, and the Master and Slaves drive the SDA line. A '0' is transmitted by pulling a line LOW and a '1' by releasing it HIGH. Data transfer may be initiated only when the bus is not busy (see A.C. Characteristics). During data transfer, SDA must remain stable while SCL is HIGH.

START/STOP Condition

An SDA transition while SCL is HIGH creates a START or STOP condition (Figure 2). A START is generated by a HIGH to LOW transition, while a STOP is generated by a LOW to HIGH transition. The START acts like a wake-up call. Absent a START, no Slave will respond to the Master. The STOP completes all commands.

Device Addressing

The Master addresses a Slave by creating a START condition and then broadcasting an 8-bit Slave address (Figure 3). The four most significant bits of the Slave address are 1010 (Ah). The next three bits from the Slave address byte are assigned as shown in Figure 3, where a_9 and a_8 are internal address bits. The last bit, R/\overline{W} , instructs the Slave to either provide (1) or accept (0) data, i.e. it specifies a Read (1) or a Write (0) operation.

Acknowledge

During the 9th clock cycle following every byte sent onto the bus, the transmitter releases the SDA line, allowing the receiver to respond. The receiver then either acknowledges (ACK) by pulling SDA LOW, or does not acknowledge (NoACK) by letting SDA stay HIGH (Figure 4). Bus timing is illustrated in Figure 5.

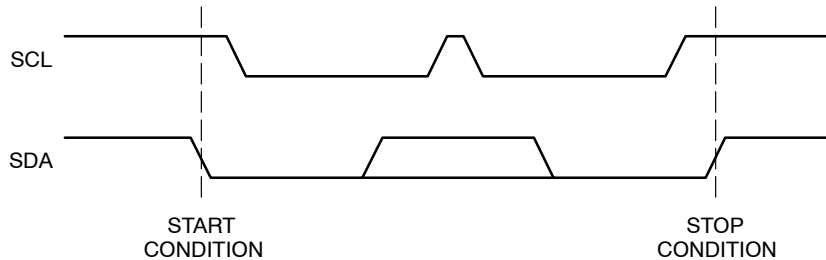


Figure 2. Start/Stop Timing

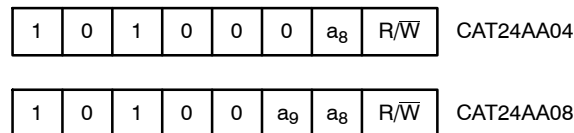


Figure 3. Slave Address Bits

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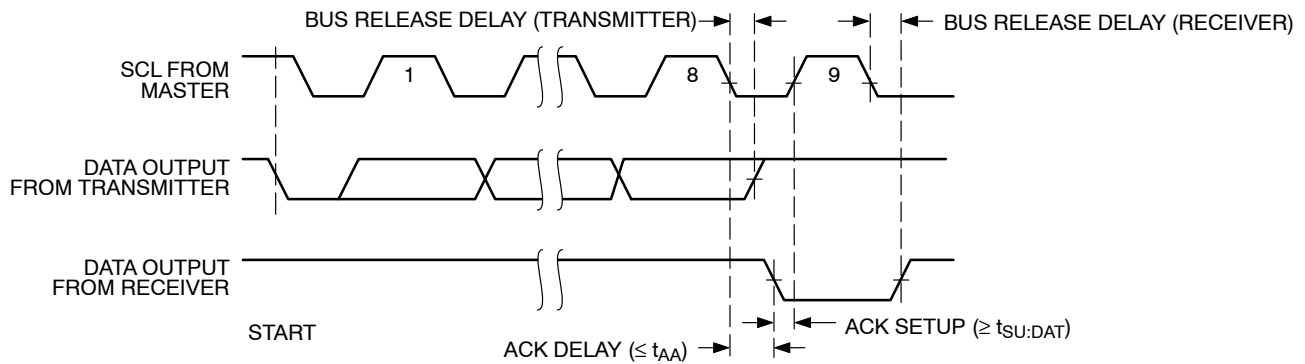


Figure 4. Acknowledge Timing

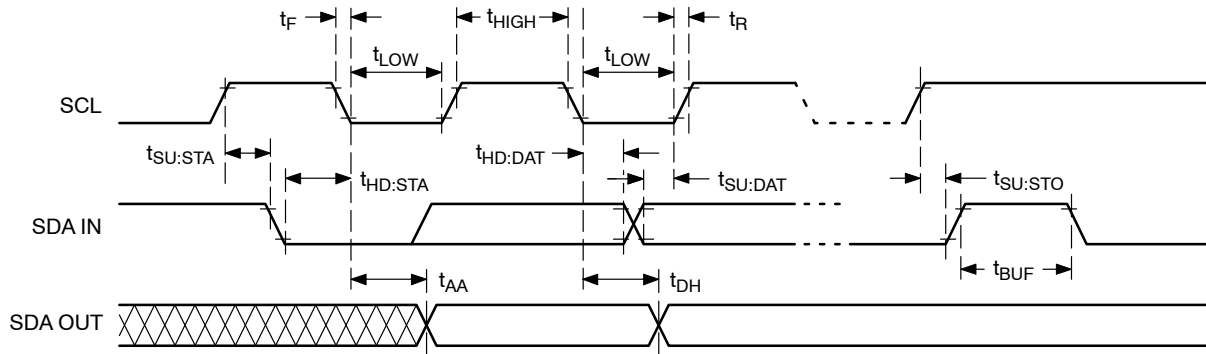


Figure 5. Bus Timing

WRITE OPERATIONS

Byte Write

To write data to memory, the Master creates a START condition on the bus and then broadcasts a Slave address with the R/\overline{W} bit set to '0'. The Master then sends an address byte and a data byte and concludes the session by creating a STOP condition on the bus. The Slave responds with ACK after every byte sent by the Master (Figure 6). The STOP starts the internal Write cycle, and while this operation is in progress (t_{WR}), the SDA output is tri-stated and the Slave does not acknowledge the Master (Figure 7).

Page Write

The Byte Write operation can be expanded to Page Write, by sending more than one data byte to the Slave before issuing the STOP condition (Figure 8). Up to 16 distinct data bytes can be loaded into the internal Page Write Buffer starting at the address provided by the Master. The page address is latched, and as long as the Master keeps sending data, the internal byte address is incremented up to the end of page, where it then wraps around (within the page). New data can therefore replace data loaded earlier. Following the STOP, data loaded during the Page Write session will be written to memory in a single internal Write cycle (t_{WR}).

Acknowledge Polling

The acknowledge (ACK) polling routine can be used to take advantage of the typical write cycle time. Once the stop condition is issued to indicate the end of the host's write operation, the CAT24AA04/08 initiates the internal write cycle. The ACK polling can be initiated immediately. This involves issuing the start condition followed by the slave address for a write operation. If the CAT24AA04/08 is still busy with the write operation, NoACK will be returned. If the CAT24AA04/08 device has completed the internal write operation, an ACK will be returned and the host can then proceed with the next read or write operation.

Hardware Write Protection

With the WP pin held HIGH, the entire memory is protected against Write operations. If the WP pin is left floating or is grounded, it has no impact on the Write operation. The state of the WP pin is strobed on the last falling edge of SCL immediately preceding the 1st data byte (Figure 9). If the WP pin is HIGH during the strobe interval, the Slave will not acknowledge the data byte and the Write request will be rejected.

Delivery State

The CAT24AA04/08 is shipped erased, i.e., all bytes are FFh.

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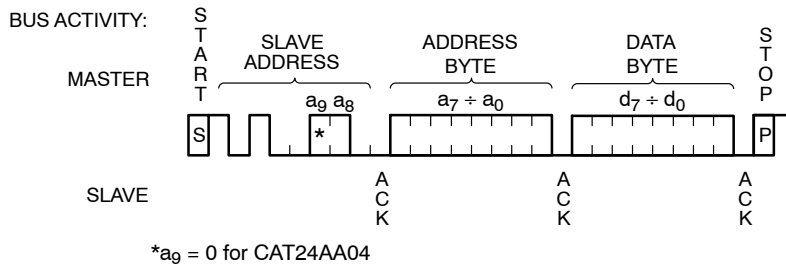


Figure 6. Byte Write Sequence

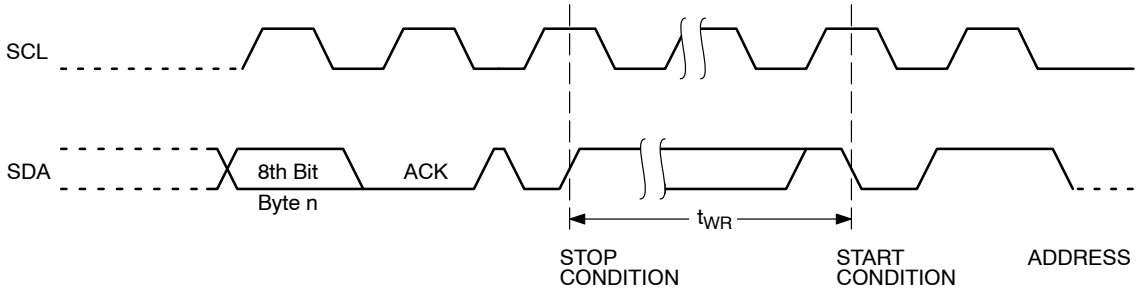


Figure 7. Write Cycle Timing

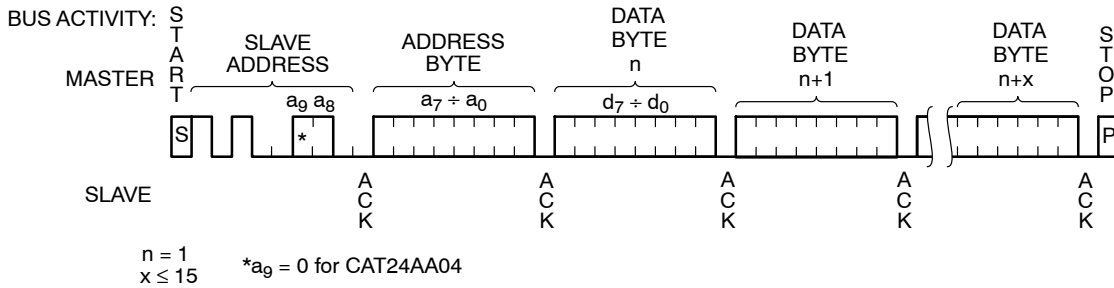


Figure 8. Page Write Sequence

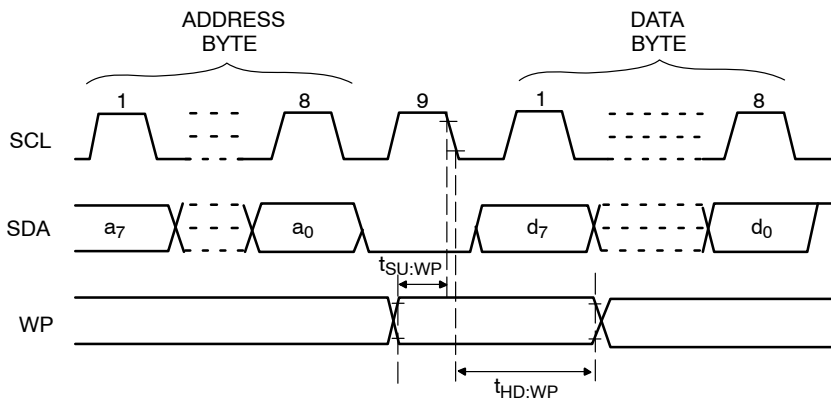


Figure 9. WP Timing

READ OPERATIONS

Immediate Read

To read data from memory, the Master creates a START condition on the bus and then broadcasts a Slave address with the R/\overline{W} bit set to '1'. The Slave responds with ACK and starts shifting out data residing at the current address. After receiving the data, the Master responds with NoACK and terminates the session by creating a STOP condition on the bus (Figure 10). The Slave then returns to Standby mode.

Selective Read

To read data residing at a specific address, the selected address must first be loaded into the internal address register. This is done by starting a Byte Write sequence, whereby the Master creates a START condition, then broadcasts a Slave address with the R/\overline{W} bit set to '0' and then sends an address byte to the Slave. Rather than completing the Byte Write

sequence by sending data, the Master then creates a START condition and broadcasts a Slave address with the R/\overline{W} bit set to '1'. The Slave responds with ACK after every byte sent by the Master and then sends out data residing at the selected address. After receiving the data, the Master responds with NoACK and then terminates the session by creating a STOP condition on the bus (Figure 11).

Sequential Read

If, after receiving data sent by the Slave, the Master responds with ACK, then the Slave will continue transmitting until the Master responds with NoACK followed by STOP (Figure 12). During Sequential Read the internal byte address is automatically incremented up to the end of memory, where it then wraps around to the beginning of memory.

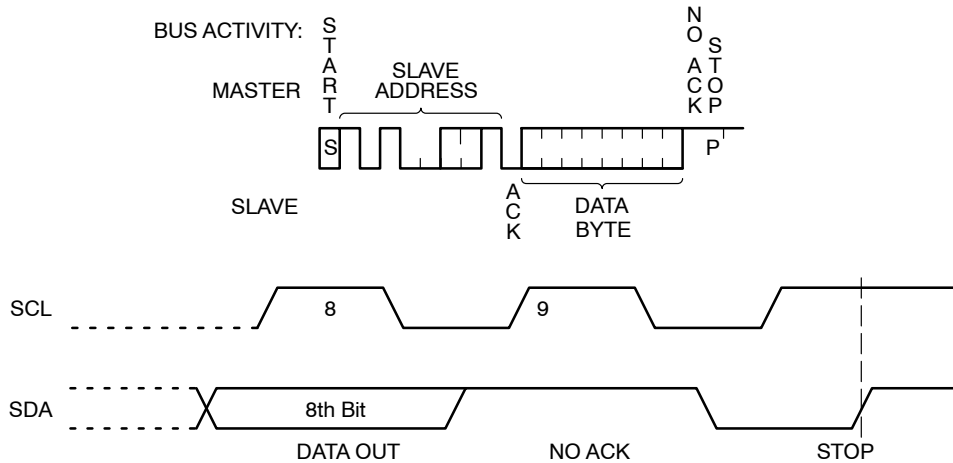


Figure 10. Immediate Read Sequence and Timing

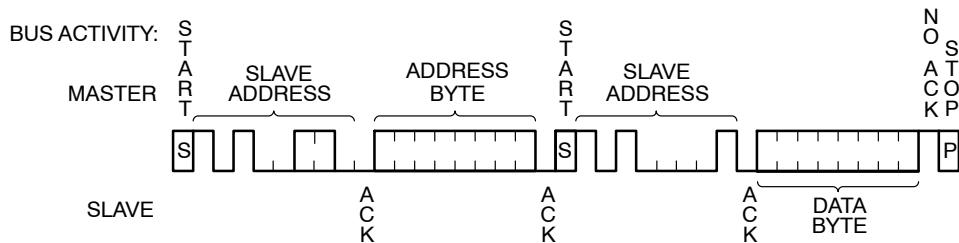


Figure 11. Selective Read Sequence

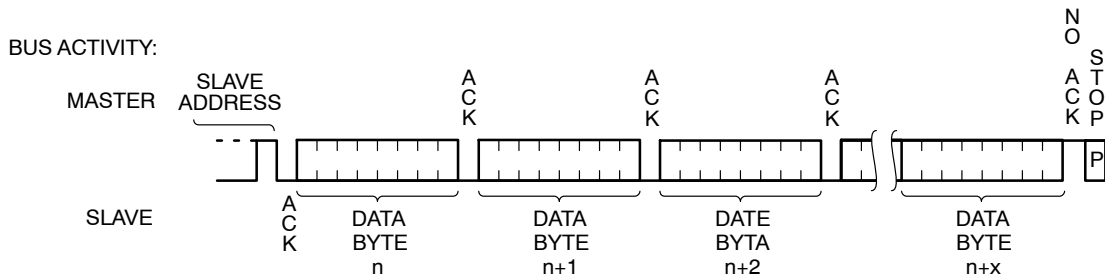
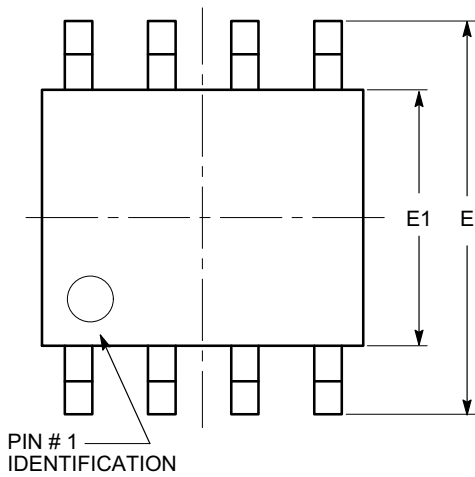


Figure 12. Sequential Read Sequence

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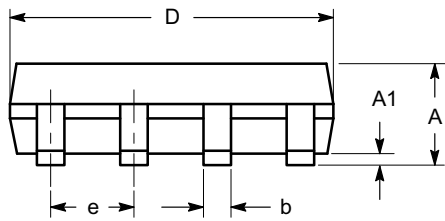
PACKAGE DIMENSIONS

SOIC 8, 150 mils
CASE 751BD-01
ISSUE O

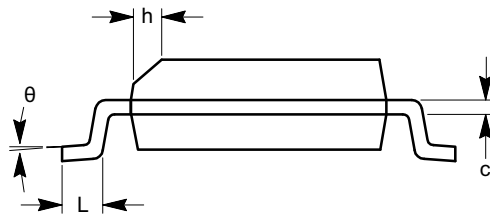


TOP VIEW

| SYMBOL | MIN | NOM | MAX |
|----------|----------|-----|------|
| A | 1.35 | | 1.75 |
| A1 | 0.10 | | 0.25 |
| b | 0.33 | | 0.51 |
| c | 0.19 | | 0.25 |
| D | 4.80 | | 5.00 |
| E | 5.80 | | 6.20 |
| E1 | 3.80 | | 4.00 |
| e | 1.27 BSC | | |
| h | 0.25 | | 0.50 |
| L | 0.40 | | 1.27 |
| θ | 0° | | 8° |



SIDE VIEW



END VIEW

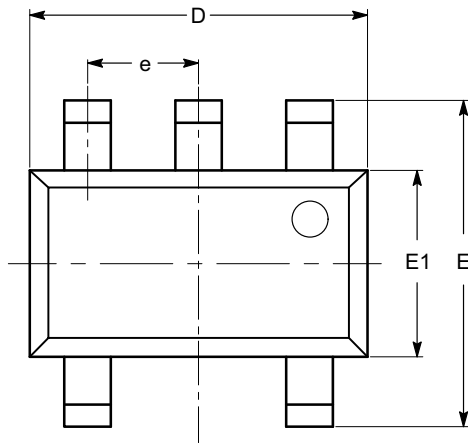
Notes:

- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MS-012.

CAT24AA04, CAT24AA08

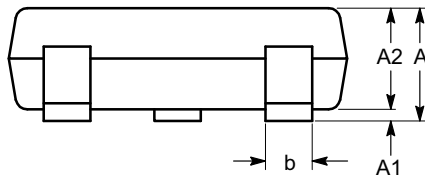
PACKAGE DIMENSIONS

TSOT-23, 5 LEAD
CASE 419AE-01
ISSUE O

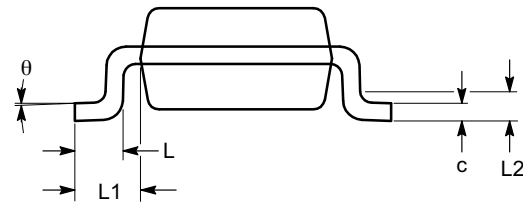


TOP VIEW

| SYMBOL | MIN | NOM | MAX |
|----------|----------|------|------|
| A | | | 1.00 |
| A1 | 0.01 | 0.05 | 0.10 |
| A2 | 0.80 | 0.87 | 0.90 |
| b | 0.30 | | 0.45 |
| c | 0.12 | 0.15 | 0.20 |
| D | 2.90 BSC | | |
| E | 2.80 BSC | | |
| E1 | 1.60 BSC | | |
| e | 0.95 TYP | | |
| L | 0.30 | 0.40 | 0.50 |
| L1 | 0.60 REF | | |
| L2 | 0.25 BSC | | |
| θ | 0° | | 8° |



SIDE VIEW



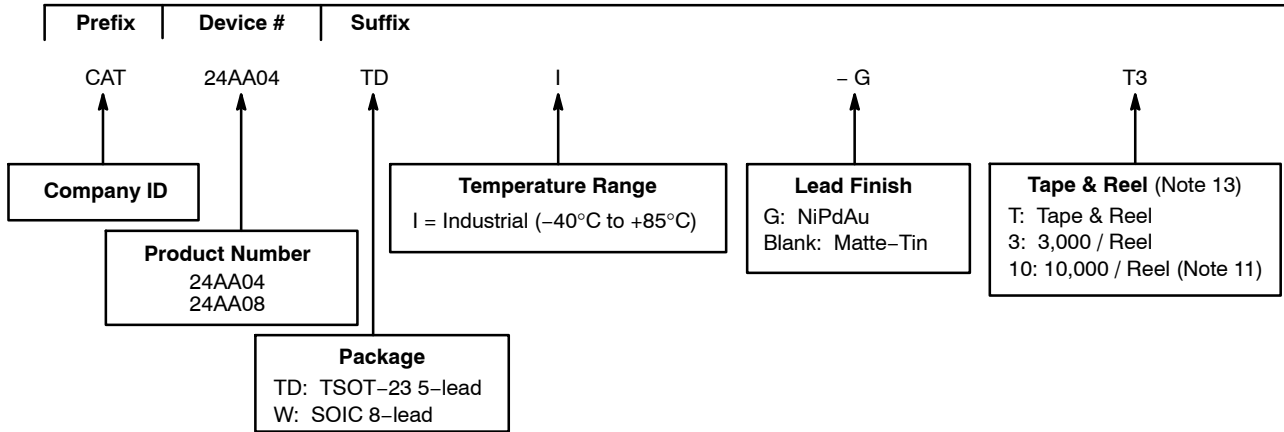
END VIEW

Notes:

- (1) All dimensions are in millimeters. Angles in degrees.
- (2) Complies with JEDEC MO-193.


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Example of Ordering Information



8. All packages are RoHS-compliant (Lead-free, Halogen-free).
9. The standard lead finish is NiPdAu.
10. The device used in the above example is a CAT24AA04TDI-GT3 (TSOT-23 5-lead, Industrial Temperature, NiPdAu, Tape & Reel, 3,000/Reel).
11. The 10,000/Reel option is only available for the TSOT-23 5-lead package.
12. For additional package and temperature options, please contact your nearest ON Semiconductor Sales office.
13. For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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