

# 32 Kb I<sup>2</sup>C CMOS Serial EEPROM

## N24C32

### Description

The N24C32 is a 32 Kb CMOS Serial EEPROM device, organized internally as 128 pages of 32 bytes each. This device supports the Standard (100 kHz), Fast (400 kHz) and Fast-Plus (1 MHz) I<sup>2</sup>C protocol.

Data is written by providing a starting address, then loading 1 to 32 contiguous bytes into a Page Write Buffer, and then writing all data to non-volatile memory in one internal write cycle. Data is read by providing a starting address and then shifting out data serially while automatically incrementing the internal address count.

External address pins make it possible to address up to eight N24C32 devices on the same bus.

### Features

- Automotive AEC-Q100 Grade 1 (–40°C to +125°C) Qualified
- Supports Standard, Fast and Fast-Plus I<sup>2</sup>C Protocol
- 1.7 V / 1.6 V to 5.5 V Supply Voltage Range
- 32-Byte Page Write Buffer
- Fast Write Time (4 ms max)
- Hardware Write Protection for Entire Memory
- Schmitt Triggers and Noise Suppression Filters on I<sup>2</sup>C Bus Inputs (SCL and SDA)
- Low Power CMOS Technology
- 1,000,000 Program/Erase Cycles
- 100 Year Data Retention
- Industrial and Automotive Grade 1 Temperature Range
- US 8-lead Package
- These Devices are Pb-Free, Halogen Free/BFR Free, and RoHS Compliant



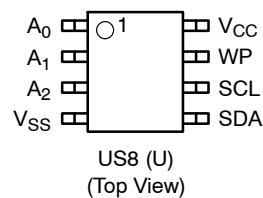
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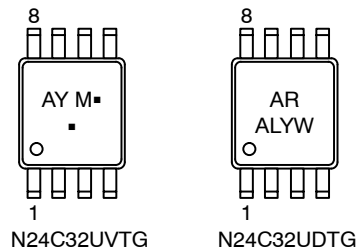


**US8  
U SUFFIX  
CASE 493**

### PIN CONFIGURATIONS



### MARKING DIAGRAM

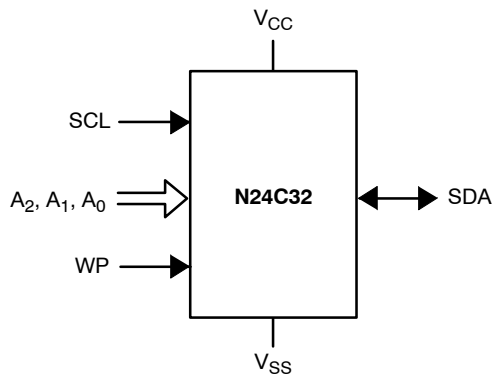


M = Date Code  
▪ = Pb-Free Package  
A = Assembly Location  
L = Wafer Lot Traceability  
YW = Date Code  
(Note: Microdot may be in either location)

### ORDERING INFORMATION

See detailed ordering, marking and shipping information in the package dimensions section on page 9 of this data sheet.

## N24C32



**PIN FUNCTION**

| Pin Name                                         | Function       |
|--------------------------------------------------|----------------|
| A <sub>0</sub> , A <sub>1</sub> , A <sub>2</sub> | Device Address |
| SDA                                              | Serial Data    |
| SCL                                              | Serial Clock   |
| WP                                               | Write Protect  |
| V <sub>CC</sub>                                  | Power Supply   |
| V <sub>SS</sub>                                  | Ground         |

**Figure 1. Functional Symbol**

**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 those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. The DC input voltage on any pin should not be lower than –0.5 V or higher than V<sub>CC</sub> + 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<sub>CC</sub> + 1.5 V, for periods of less than 20 ns.

**Table 2. RELIABILITY CHARACTERISTICS**

| Symbol                    | Parameter      | Max       | Units                 |
|---------------------------|----------------|-----------|-----------------------|
| N <sub>END</sub> (Note 2) | Endurance      | 1,000,000 | Write Cycles (Note 3) |
| T <sub>DR</sub> (Note 2)  | Data Retention | 100       | Years                 |

2. T<sub>A</sub> = 25°C

3. A Write Cycle refers to writing a Byte or a Page.

**Table 3. D.C. OPERATING CHARACTERISTICS**

( $V_{CC} = 1.7\text{ V} / 1.6\text{ V}^*$  to  $5.5\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  and  $V_{CC} = 1.8\text{ V}$  to  $5.5\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ , unless otherwise specified.)

| Symbol    | Parameter          | Test Conditions                                       |                                                   | Min          | Max            | Units         |
|-----------|--------------------|-------------------------------------------------------|---------------------------------------------------|--------------|----------------|---------------|
| $I_{CCR}$ | Read Current       | Read, $f_{SCL} = 1\text{ MHz}$                        |                                                   |              | 0.4            | mA            |
| $I_{CCW}$ | Write Current      | Write                                                 |                                                   |              | 0.6            | mA            |
| $I_{SB}$  | Standby Current    | All I/O Pins at GND or $V_{CC}$                       | $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$  |              | 1              | $\mu\text{A}$ |
|           |                    |                                                       | $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$ |              | 2              |               |
| $I_L$     | I/O Pin Leakage    | Pin at GND or $V_{CC}$                                |                                                   |              | 2              | $\mu\text{A}$ |
| $V_{IL1}$ | Input Low Voltage  | $2.2\text{ V} \leq V_{CC} \leq 5.5\text{ V}$          |                                                   | -0.5         | $0.3 V_{CC}$   | V             |
| $V_{IL2}$ | Input Low Voltage  | $1.6\text{ V} \leq V_{CC} < 2.2\text{ V}$             |                                                   | -0.5         | $0.2 V_{CC}$   | V             |
| $V_{IH1}$ | Input High Voltage | $2.2\text{ V} \leq V_{CC} \leq 5.5\text{ V}$          |                                                   | $0.7 V_{CC}$ | $V_{CC} + 0.5$ | V             |
| $V_{IH2}$ | Input High Voltage | $1.6\text{ V} \leq V_{CC} < 2.2\text{ V}$             |                                                   | $0.8 V_{CC}$ | $V_{CC} + 0.5$ | V             |
| $V_{OL1}$ | Output Low Voltage | $V_{CC} \geq 2.2\text{ V}$ , $I_{OL} = 6.0\text{ mA}$ |                                                   |              | 0.4            | V             |
| $V_{OL2}$ | Output Low Voltage | $V_{CC} < 2.2\text{ V}$ , $I_{OL} = 2.0\text{ mA}$    |                                                   |              | 0.2            | V             |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

**Table 4. PIN IMPEDANCE CHARACTERISTICS**

( $V_{CC} = 1.7\text{ V} / 1.6\text{ V}^*$  to  $5.5\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  and  $V_{CC} = 1.8\text{ V}$  to  $5.5\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ , unless otherwise specified.)

| Symbol                       | Parameter                                            | Conditions                                  | Max | Units         |
|------------------------------|------------------------------------------------------|---------------------------------------------|-----|---------------|
| $C_{IN}$ (Note 4)            | SDA I/O Pin Capacitance                              | $V_{IN} = 0\text{ V}$                       | 8   | pF            |
| $C_{IN}$ (Note 4)            | Input Capacitance (other pins)                       | $V_{IN} = 0\text{ V}$                       | 6   | pF            |
| $I_{WP}$ , $I_A$<br>(Note 5) | WP Input Current, Address Input Current (A0, A1, A2) | $V_{IN} < V_{IH}$ , $V_{CC} = 5.5\text{ V}$ | 50  | $\mu\text{A}$ |
|                              |                                                      | $V_{IN} < V_{IH}$ , $V_{CC} = 3.3\text{ V}$ | 35  |               |
|                              |                                                      | $V_{IN} < V_{IH}$ , $V_{CC} = 1.8\text{ V}$ | 25  |               |
|                              |                                                      | $V_{IN} > V_{IH}$                           | 2   |               |

\* $V_{CC(min)} = 1.6\text{ V}$  for Read operations,  $T_A = -20^\circ\text{C}$  to  $+85^\circ\text{C}$

- 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.
- When not driven, the WP, A0, A1 and A2 pins are 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**

( $V_{CC} = 1.7\text{ V} / 1.6\text{ V}^*$  to  $5.5\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  and  $V_{CC} = 1.8\text{ V}$  to  $5.5\text{ V}$ ,  $T_A = -40^\circ\text{C}$  to  $+125^\circ\text{C}$  unless otherwise noted.) (Note 6)

| Symbol                | Parameter                                  | Standard |       | Fast |      | Fast-Plus |       | Units         |
|-----------------------|--------------------------------------------|----------|-------|------|------|-----------|-------|---------------|
|                       |                                            | Min      | Max   | Min  | Max  | Min       | Max   |               |
| $F_{SCL}$             | Clock Frequency                            |          | 100   |      | 400  |           | 1,000 | kHz           |
| $t_{HD:STA}$          | START Condition Hold Time                  | 4        |       | 0.6  |      | 0.25      |       | $\mu\text{s}$ |
| $t_{LOW}$             | Low Period of SCL Clock                    | 4.7      |       | 1.3  |      | 0.45      |       | $\mu\text{s}$ |
| $t_{HIGH}$            | High Period of SCL Clock                   | 4        |       | 0.6  |      | 0.40      |       | $\mu\text{s}$ |
| $t_{SU:STA}$          | START Condition Setup Time                 | 4.7      |       | 0.6  |      | 0.25      |       | $\mu\text{s}$ |
| $t_{HD:DAT}$          | Data In Hold Time                          | 0        |       | 0    |      | 0         |       | $\mu\text{s}$ |
| $t_{SU:DAT}$          | Data In Setup Time                         | 250      |       | 100  |      | 50        |       | ns            |
| $t_R$ (Note 7)        | SDA and SCL Rise Time                      |          | 1,000 |      | 300  |           | 100   | ns            |
| $t_F$ (Note 7)        | SDA and SCL Fall Time                      |          | 300   |      | 300  |           | 100   | ns            |
| $t_{SU:STO}$          | STOP Condition Setup Time                  | 4        |       | 0.6  |      | 0.25      |       | $\mu\text{s}$ |
| $t_{BUF}$             | Bus Free Time Between STOP and START       | 4.7      |       | 1.3  |      | 0.5       |       | $\mu\text{s}$ |
| $t_{AA}$              | SCL Low to Data Out Valid                  |          | 3.5   |      | 0.9  |           | 0.40  | $\mu\text{s}$ |
| $t_{DH}$ (Note 7)     | Data Out Hold Time                         | 100      |       | 100  |      | 50        |       | ns            |
| $T_i$ (Note 7)        | Noise Pulse Filtered at SCL and SDA Inputs |          | 50    |      | 50   |           | 50    | ns            |
| $t_{SU:WP}$           | WP Setup Time                              | 0        |       | 0    |      | 0         |       | $\mu\text{s}$ |
| $t_{HD:WP}$           | WP Hold Time                               | 2.5      |       | 2.5  |      | 1         |       | $\mu\text{s}$ |
| $t_{WR}$              | Write Cycle Time                           |          | 4     |      | 4    |           | 4     | ms            |
| $t_{PU}$ (Notes 7, 8) | Power-up to Ready Mode                     |          | 0.35  |      | 0.35 |           | 0.35  | ms            |

\* $V_{CC(\min)} = 1.6\text{ V}$  for Read operations,  $T_A = -20^\circ\text{C}$  to  $+85^\circ\text{C}$

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

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

8.  $t_{PU}$  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 $0.8 \times V_{CC}$ for $V_{CC} \geq 2.2\text{ V}$<br>$0.15 \times V_{CC}$ to $0.85 \times V_{CC}$ for $V_{CC} < 2.2\text{ V}$ |
| 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   | $0.3 \times V_{CC}$ , $0.7 \times V_{CC}$                                                                                                             |
| Output Load               | Current Source: $I_{OL} = 6\text{ mA}$ ( $V_{CC} \geq 2.5\text{ V}$ ); $I_{OL} = 2\text{ mA}$ ( $V_{CC} < 2.5\text{ V}$ ); $C_L = 100\text{ pF}$      |

## Power-On Reset (POR)

Each N24C32 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 is delivered on the negative edge of SCL.

**A<sub>0</sub>, A<sub>1</sub> and A<sub>2</sub>:** The Address inputs set the device address that must be matched by the corresponding Slave address bits. The Address inputs are hard-wired HIGH or LOW allowing for up to eight devices to be used (cascaded) on the same bus. When left floating, these inputs are pulled LOW internally.

**WP:** When pulled HIGH, the Write Protect input pin inhibits all write operations. When left floating, this pin is pulled LOW internally.

## Functional Description

The N24C32 supports the Inter-Integrated Circuit (I<sup>2</sup>C) 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 N24C32 operates as a Slave device. Both Master and Slave can transmit or receive, but only the Master can assign those roles.

## I<sup>2</sup>C Bus Protocol

The 2-wire I<sup>2</sup>C 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 either the Master or the Slaves drive the SDA line. A '0' is transmitted by pulling a line LOW and a '1' by letting it stay 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). The START consists of a HIGH to LOW SDA transition, while SCL is HIGH. Absent the START, a Slave will not respond to the Master. The STOP completes all commands, and consists of a LOW to HIGH SDA transition, while SCL is HIGH.

## Device Addressing

The Master addresses a Slave by creating a START condition and then broadcasting an 8-bit Slave address. For the N24C32, the first four bits of the Slave address are set to 1010 (Ah); the next three bits, A<sub>2</sub>, A<sub>1</sub> and A<sub>0</sub>, must match the logic state of the similarly named input pins. The R/ $\overline{W}$  bit tells the Slave whether the Master intends to read (1) or write (0) data (Figure 3).

## Acknowledge

During the 9<sup>th</sup> clock cycle following every byte sent to 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.

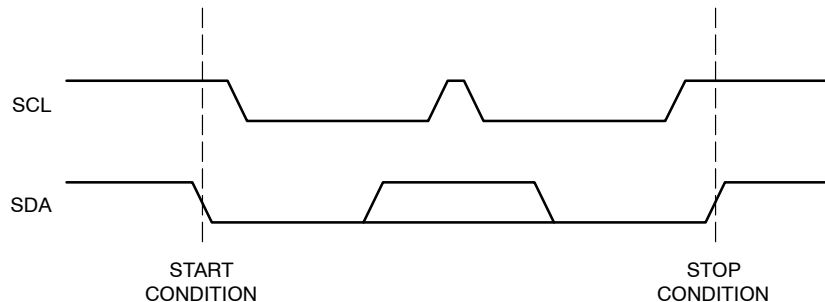


Figure 2. Start/Stop Timing

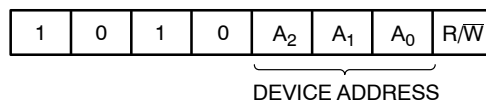


Figure 3. Slave Address Bits

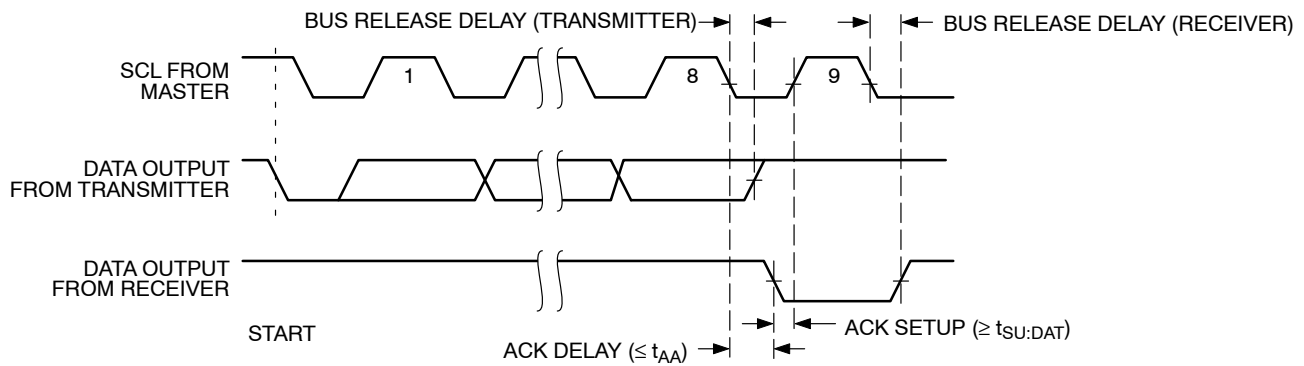


Figure 4. Acknowledge Timing

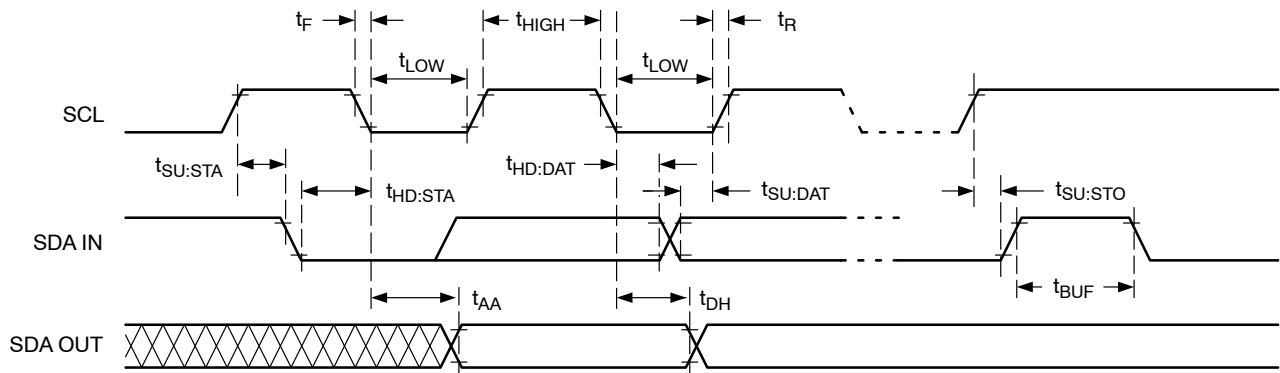


Figure 5. Bus Timing

## 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/W bit set to '0'. The Master then sends two address bytes 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 32 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

As soon (and as long) as internal Write is in progress, the Slave will not acknowledge the Master. This feature enables the Master to immediately follow-up with a new Read or Write request, rather than wait for the maximum specified Write time ( $t_{WR}$ ) to elapse. Upon receiving a NoACK response from the Slave, the Master simply repeats the request until the Slave responds with ACK.

### 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 1<sup>st</sup> 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 N24C32 is shipped erased, i.e., all bytes are FFh.

## N24C32

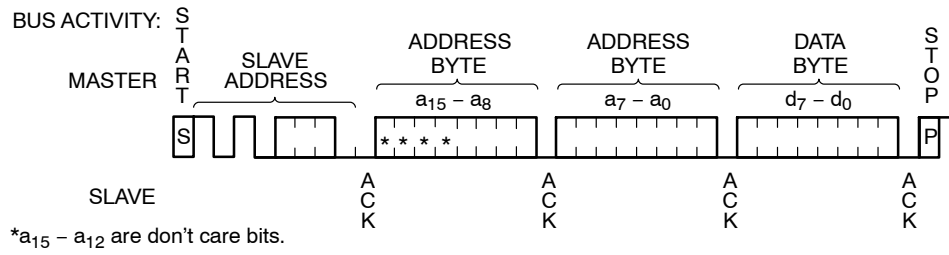


Figure 6. Byte Write Sequence



Figure 7. Write Cycle Timing

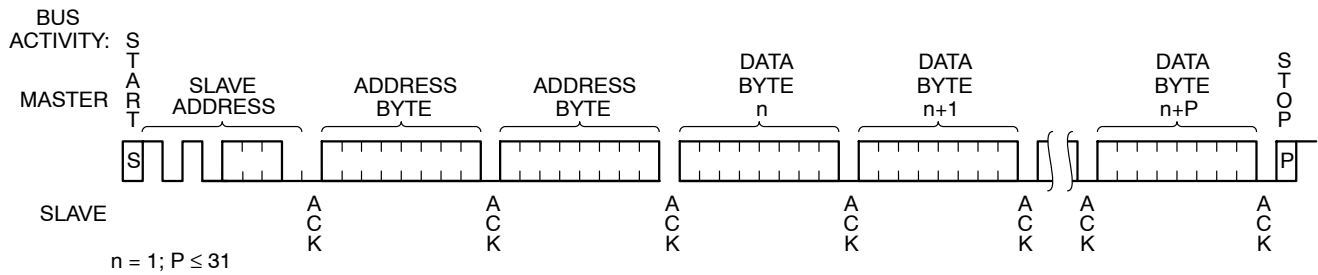


Figure 8. Page Write Sequence

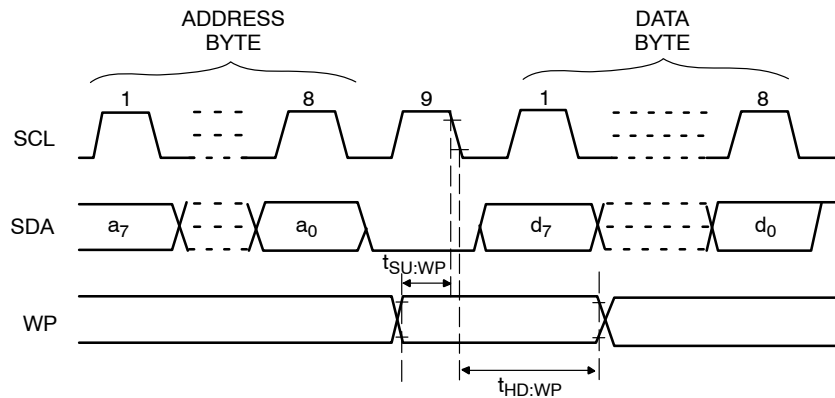


Figure 9. WP Timing

## 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 two address bytes 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.

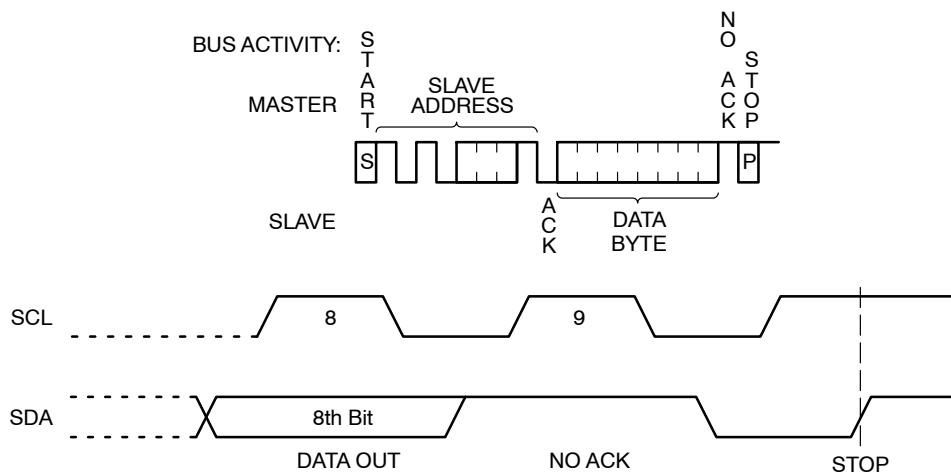


Figure 10. Immediate Read Sequence and Timing

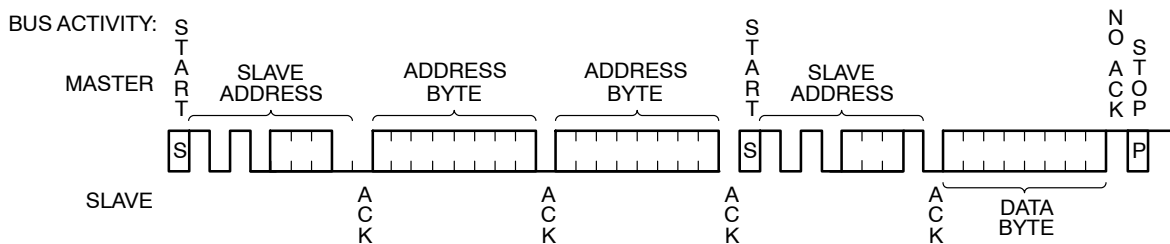


Figure 11. Selective Read Sequence

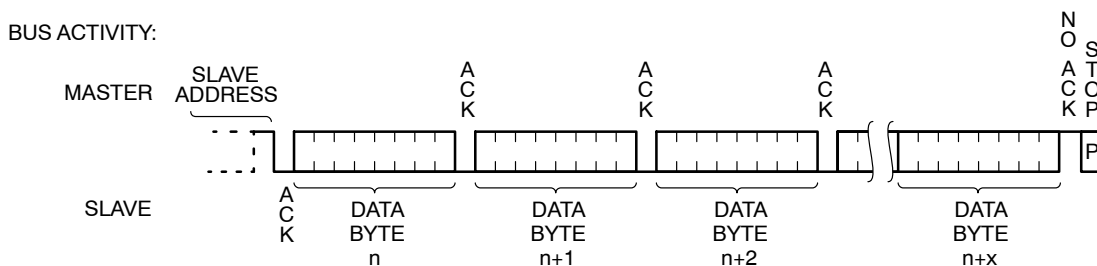


Figure 12. Sequential Read Sequence

## N24C32

### ORDERING INFORMATION

| Device Order Number | Specific Device Marking | Package Type | Temperature Range                           | Shipping                               |
|---------------------|-------------------------|--------------|---------------------------------------------|----------------------------------------|
| N24C32UDTG          | AR                      | U = US-8     | D = Industrial<br>(-40°C to +85°C)          | T = Tape & Reel,<br>3,000 Units / Reel |
| N24C32UVTG          | AY                      | U = US-8     | V = Automotive Grade 1<br>(-40°C to +125°C) | T = Tape & Reel,<br>3,000 Units / Reel |

9. All packages are RoHS-compliant (Lead-free, Halogen-free).

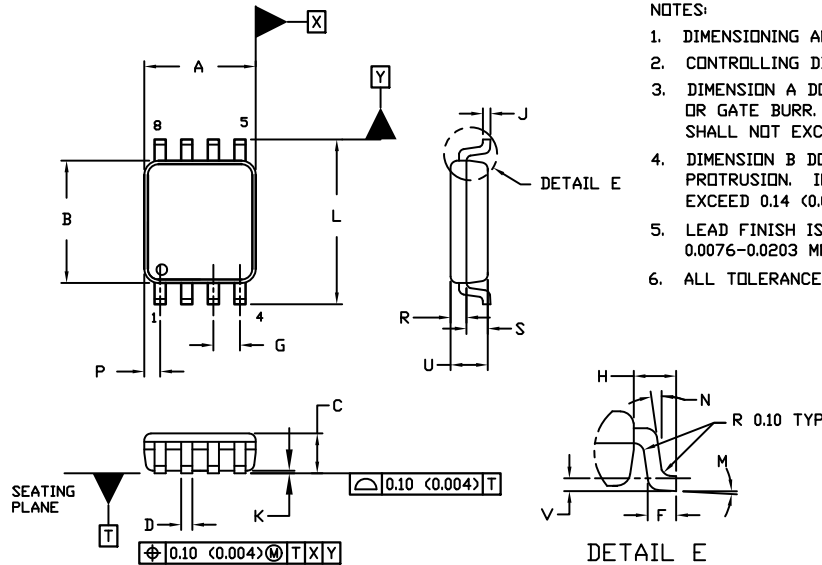
10. For additional package and temperature options, please contact your nearest ON Semiconductor Sales office.



SCALE 4:1

**US8**  
**CASE 493**  
**ISSUE F**

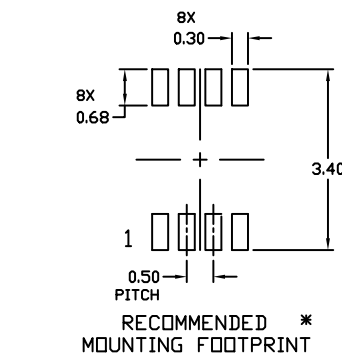
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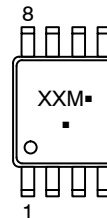
## NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSION, OR GATE BURR. MOLD FLASH, PROTRUSION, OR GATE BURR SHALL NOT EXCEED 0.14 (0.0055") PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH AND PROTRUSION SHALL NOT EXCEED 0.14 (0.0055") PER SIDE.
5. LEAD FINISH IS SOLDER PLATING WITH THICKNESS OF 0.0076-0.0203 MM (0.003-0.008").
6. ALL TOLERANCE UNLESS OTHERWISE SPECIFIED ±0.0508 MM (0.002").

| DIM | MILLIMETERS |      | INCHES    |       |
|-----|-------------|------|-----------|-------|
|     | MIN.        | MAX. | MIN.      | MAX.  |
| A   | 1.90        | 2.10 | 0.075     | 0.083 |
| B   | 2.20        | 2.40 | 0.087     | 0.094 |
| C   | 0.60        | 0.90 | 0.024     | 0.035 |
| D   | 0.17        | 0.25 | 0.007     | 0.010 |
| F   | 0.20        | 0.35 | 0.008     | 0.014 |
| G   | 0.50 BSC    |      | 0.020 BSC |       |
| H   | 0.40 REF    |      | 0.016 REF |       |
| J   | 0.10        | 0.18 | 0.004     | 0.007 |
| K   | 0.00        | 0.10 | 0.000     | 0.004 |
| L   | 3.00        | 3.25 | 0.118     | 0.128 |
| M   | 0°          | 6°   | 0°        | 6°    |
| N   | 0°          | 10°  | 0°        | 10°   |
| P   | 0.23        | 0.34 | 0.010     | 0.013 |
| R   | 0.23        | 0.33 | 0.009     | 0.013 |
| S   | 0.37        | 0.47 | 0.015     | 0.019 |
| U   | 0.60        | 0.80 | 0.024     | 0.031 |
| V   | 0.12 BSC    |      | 0.005 BSC |       |


**RECOMMENDED \***  
**MOUNTING FOOTPRINT**

\* For additional information on our Pb-Free strategy and soldering details, please download the DSI Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDER99/01.

**GENERIC**  
**MARKING DIAGRAM\***


XX = Specific Device Code  
M = Date Code  
• = Pb-Free Package

(Note: Microdot may be in either location)

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

|                         |                    |                                                                                                                                                                                  |
|-------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| <b>DESCRIPTION:</b>     | <b>US8</b>         | <b>PAGE 1 OF 1</b>                                                                                                                                                               |

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