2/4/8/16-Kb I²C CMOS Serial EEPROM

N24C02, N24C04, N24C08, N24C16

Description

The N24C02/04/08/16 are EEPROM Serial 2/4/8/16−Kb I²C devices organized internally as 16/32/64 and 128 pages respectively of 16 bytes each. All devices support the Standard (100 kHz), Fast (400 kHz) and Fast−Plus (1 MHz) I²C protocol.

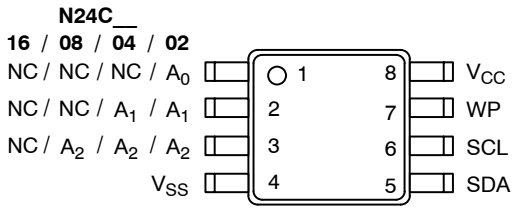
Data is written by providing a starting address, then loading 1 to 16 contiguous bytes into a Page Write Buffer, and then writing all data to non−volatile memory in one internal write cycle. Data is read by providing a starting address and then shifting out data serially while automatically incrementing the internal address count.

External address pins make it possible to address up to eight N24C02, four N24C04, two N24C08 and one N24C16 device on the same bus.

Features

- Automotive AEC−Q100 Grade 1 (−40°C to +125°C) Qualified
- Supports Standard, Fast and Fast−Plus I²C Protocol
- 1.7 V / 1.6 V to 5.5 V Supply Voltage Range
- 16−Byte Page Write Buffer
- Fast Write Time (4 ms max)
- Hardware Write Protection for Entire Memory
- Schmitt Triggers and Noise Suppression Filters on I²C Bus Inputs (SCL and SDA)
- Low Power CMOS Technology
- More than 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 are RoHS Compliant

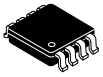
PIN CONFIGURATION



US8 (U) (Top View)

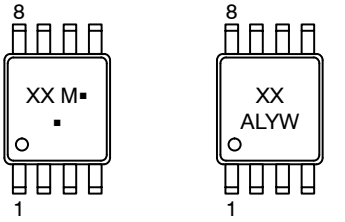
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US8
U SUFFIX
CASE 493

MARKING DIAGRAM



N24C02UVTG
N24C08UVTG
N24C16UVTG
N24C04UDTG
N24C04UVTG

N24C02UDTG
N24C08UDTG
N24C16UDTG

XX = Specific Device Code
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.

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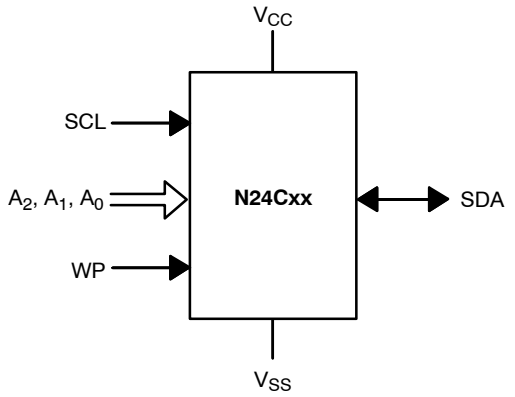


Figure 1. Functional Symbol

Table 1. PIN FUNCTION

Pin Name	Function
A0, A1, A2	Device Address Input
SDA	Serial Data Input/Output
SCL	Serial Clock Input
WP	Write Protect Input
V_{CC}	Power Supply
V_{SS}	Ground
NC	No Connect

Table 2. 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. During input transitions, voltage undershoot on any pin should not exceed −1 V for more than 20 ns. Voltage overshoot on pins A_0, A_1, A_2 and WP should not exceed V_{CC} + 1 V for more than 20 ns, while voltage on the I^2C bus pins, SCL and SDA, should not exceed the absolute maximum ratings, irrespective of V_{CC}.

Table 3. RELIABILITY CHARACTERISTICS

Symbol	Parameter	Min	Units
N_{END} (Note 2)	Endurance	1,000,000	Write Cycles (Note 3)
T_{DR} (Note 2)	Data Retention	100	Years

2. T_A = 25°C
3. A Write Cycle refers to writing a Byte or a Page.

Table 4. D.C. OPERATING CHARACTERISTICS

(V_{CC} = 1.7 V / 1.6 V* to 5.5 V, T_A = −40°C to +85°C and V_{CC} = 1.8 V to 5.5 V, T_A = −40°C to +125°C, unless otherwise specified.)

Symbol	Parameter	Test Conditions		Min	Max	Units
I_{CCR}	Read Current	Read, f_{SCL} = 1 MHz			0.3	mA
I_{CCW}	Write Current	Write			0.5	mA
I_{SB}	Standby Current	All I/O Pins at GND or V_{CC}	T_A = −40°C to +85°C		1	μA
			T_A = −40°C to +125°C		2	
I_L	I/O Pin Leakage	Pin at GND or V_{CC}			2	μA
V_{IL1}	Input Low Voltage	2.2 V ≤ V_{CC} ≤ 5.5 V		−0.5	0.3 V_{CC}	V
V_{IL2}	Input Low Voltage	1.6 V ≤ V_{CC} < 2.2 V		−0.5	0.2 V_{CC}	V
V_{IH1}	Input High Voltage	2.2 V ≤ V_{CC} ≤ 5.5 V		0.7 V_{CC}	V_{CC} + 0.5	V
V_{IH2}	Input High Voltage	1.6 V ≤ V_{CC} < 2.2 V		0.8 V_{CC}	V_{CC} + 0.5	V
V_{OL1}	Output Low Voltage	V_{CC} ≥ 2.2 V, I_{OL} = 6.0 mA			0.4	V
V_{OL2}	Output Low Voltage	V_{CC} < 2.2 V, I_{OL} = 2.0 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.

*$V_{CC(min)}$ = 1.6 V for Read operations, T_A = −20°C to +85°C.

Table 5. PIN IMPEDANCE CHARACTERISTICS
(V_{CC} = 1.7 V / 1.6 V* to 5.5 V, T_A = −40°C to +85°C and V_{CC} = 1.8 V to 5.5 V, T_A = −40°C to +125°C, unless otherwise specified.)

Symbol	Parameter	Conditions	Max	Units
C_{IN} (Note 4)	SDA I/O Pin Capacitance	V_{IN} = 0 V	8	pF
C_{IN} (Note 4)	Input Capacitance (other pins)	V_{IN} = 0 V	6	pF
I_{WP}, I_A (Note 5)	WP Input Current, Address Input Current (A0, A1, A2)	$V_{IN} < V_{IH}$, V_{CC} = 5.5 V	50	μA
		$V_{IN} < V_{IH}$, V_{CC} = 3.3 V	35	
		$V_{IN} < V_{IH}$, V_{CC} = 1.7 V	25	
		$V_{IN} > V_{IH}$	2	

4. 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.
5. 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 (~ 0.5 x V_{CC}), the strong pull−down reverts to a weak current source.

*$V_{CC(min)}$ = 1.6 V for Read operations, T_A = −20°C to +85°C.

Table 6. A.C. CHARACTERISTICS
(V_{CC} = 1.7 V / 1.6 V* to 5.5 V, T_A = −40°C to +85°C and V_{CC} = 1.8 V to 5.5 V, T_A = −40°C to +125°C, unless otherwise specified.) (Note 6)

		Standard		Fast		Fast−Plus		
Symbol	Parameter	Min	Max	Min	Max	Min	Max	Units
F_{SCL}	Clock Frequency		100		400		1,000	kHz
$t_{HD:STA}$	START Condition Hold Time	4		0.6		0.26		μs
t_{LOW}	Low Period of SCL Clock	4.7		1.3		0.50		μs
t_{HIGH}	High Period of SCL Clock	4		0.6		0.26		μs
$t_{SU:STA}$	START Condition Setup Time	4.7		0.6		0.26		μs
$t_{HD:DAT}$	Data In Hold Time	0		0		0		μs
$t_{SU:DAT}$	Data In Setup Time	250		100		50		ns
t_R (Note 7)	SDA and SCL Rise Time		1,000		300		120	ns
t_F (Note 7)	SDA and SCL Fall Time		300		300		120	ns
$t_{SU:STO}$	STOP Condition Setup Time	4		0.6		0.26		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		0.45	μs
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		μs
$t_{HD:WP}$	WP Hold Time	2.5		2.5		1		μs
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

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.

*$V_{CC(min)}$ = 1.6 V for Read operations, T_A = −20°C to +85°C.

Table 7. A.C. TEST CONDITIONS

Input Levels	0.2 x V_{CC} to 0.8 x V_{CC} for $V_{CC} \geq$ 2.2 V 0.15 x V_{CC} to 0.85 x V_{CC} for V_{CC} < 2.2 V
Input Rise and Fall Times	≤ 50 ns
Input Reference Levels	0.3 x V_{CC}, 0.7 x V_{CC}
Output Reference Levels	0.3 x V_{CC}, 0.7 x V_{CC}
Output Load	Current Source: I_{OL} = 6 mA ($V_{CC} \geq$ 2.2 V); I_{OL} = 2 mA (V_{CC} < 2.2 V); C_L = 100 pF

Power−On Reset (POR)

Each N24Cxx* incorporates Power−On Reset (POR) circuitry which protects the internal logic against powering up in the wrong state.

A N24Cxx 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 feature protects the device against ‘brown−out’ failure following a temporary loss of power.

**For common features, the N24C02/04/08/16 will be referred to as N24Cxx.*

Pin Description

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

SDA: The Serial Data I/O pin receives input data and transmits data stored in EEPROM. In transmit mode, this pin is open drain. Data is acquired on the positive edge, and is delivered on the negative edge of SCL.

A0, A1 and A2: The Address inputs set the device address when cascading multiple devices. When not driven, these pins are pulled LOW internally.

WP: The Write Protect input pin inhibits all write operations, when pulled HIGH. When not driven, this pin is pulled LOW internally.

Functional Description

The N24Cxx supports the Inter−Integrated Circuit (I^2C) Bus data transmission protocol, which defines a device that sends data to the bus as a transmitter and a device receiving data as a receiver. Data flow is controlled by a Master device, which generates the serial clock and all START and STOP conditions. The N24Cxx acts as a Slave device. Master and Slave alternate as either transmitter or receiver.

I^2C Bus Protocol

The I^2C bus consists of two ‘wires’, SCL and SDA. The two wires are connected to the V_{CC} supply via pull−up resistors. Master and Slave devices connect to the 2−wire bus via their respective SCL and SDA pins. The transmitting device pulls down the SDA line to ‘transmit’ a ‘0’ and releases it to ‘transmit’ a ‘1’.

Data transfer may be initiated only when the bus is not busy (see AC Characteristics).

During data transfer, the SDA line must remain stable while the SCL line is high. An SDA transition while SCL is high will be interpreted as a START or STOP condition (Figure 2). The START condition precedes all commands. It consists of a HIGH to LOW transition on SDA while SCL is HIGH. The START acts as a ‘wake−up’ call to all receivers. Absent a START, a Slave will not respond to commands. The STOP condition completes all commands. It consists of a LOW to HIGH transition on SDA while SCL is HIGH.

NOTE: *The I/O pins of N24Cxx do not obstruct the SCL and SDA lines if the VCC supply is switched off. During power−up, the SCL and SDA pins (connected with pull−up resistors to VCC) will follow the VCC monotonically from VSS (0 V) to nominal VCC value, regardless of pull−up resistor value. The delta between the VCC and the instantaneous voltage levels during power ramping will be determined by the relation between bus time constant (determined by pull−up resistance and bus capacitance) and actual VCC ramp rate.*

Device Addressing

The Master initiates data transfer by creating a START condition on the bus. The Master then broadcasts an 8−bit serial Slave address. For normal Read/Write operations, the first 4 bits of the Slave address are fixed at 1010 (Ah). The next 3 bits are used as programmable address bits when cascading multiple devices and/or as internal address bits. The last bit of the slave address, R/W, specifies whether a Read (1) or Write (0) operation is to be performed. The 3 address space extension bits are assigned as illustrated in Figure 3. A_2, A_1 and A_0 must match the state of the external address pins, and a_{10}, a_9 and a_8 are internal address bits.

Acknowledge

After processing the Slave address, the Slave responds with an acknowledge (ACK) by pulling down the SDA line during the 9th clock cycle (Figure 4). The Slave will also acknowledge the address byte and every data byte presented in Write mode. In Read mode the Slave shifts out a data byte, and then releases the SDA line during the 9^{th} clock cycle. As long as the Master acknowledges the data, the Slave will continue transmitting. The Master terminates the session by not acknowledging the last data byte (NoACK) and by issuing a STOP condition. Bus timing is illustrated in Figure 5.

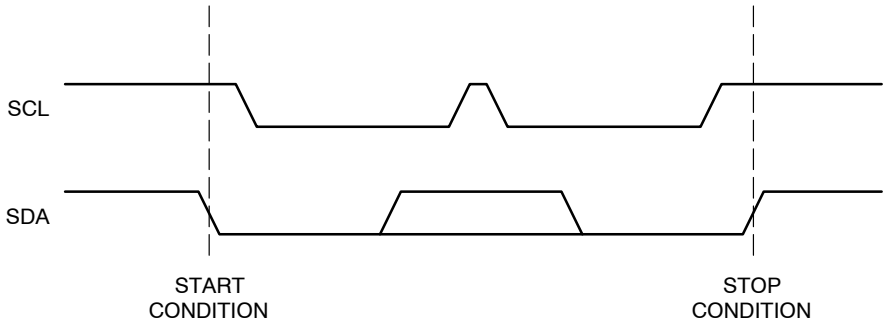


Figure 2. Start/Stop Timing

1	0	1	0	A_2	A_1	A_0	R/$\overline{W}$	N24C02
1	0	1	0	A_2	A_1	a_8	R/$\overline{W}$	N24C04
1	0	1	0	A_2	a_9	a_8	R/$\overline{W}$	N24C08
1	0	1	0	a_{10}	a_9	a_8	R/$\overline{W}$	N24C16

Figure 3. Slave Address Bits

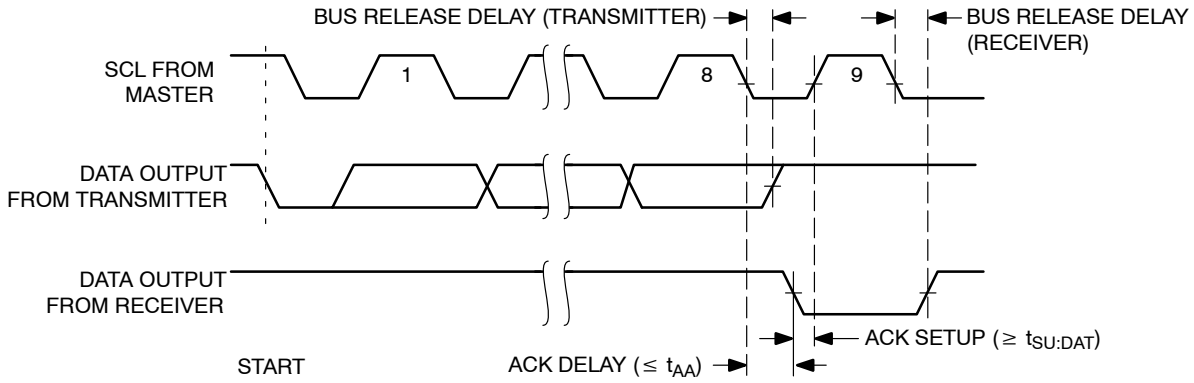


Figure 4. Acknowledge Timing

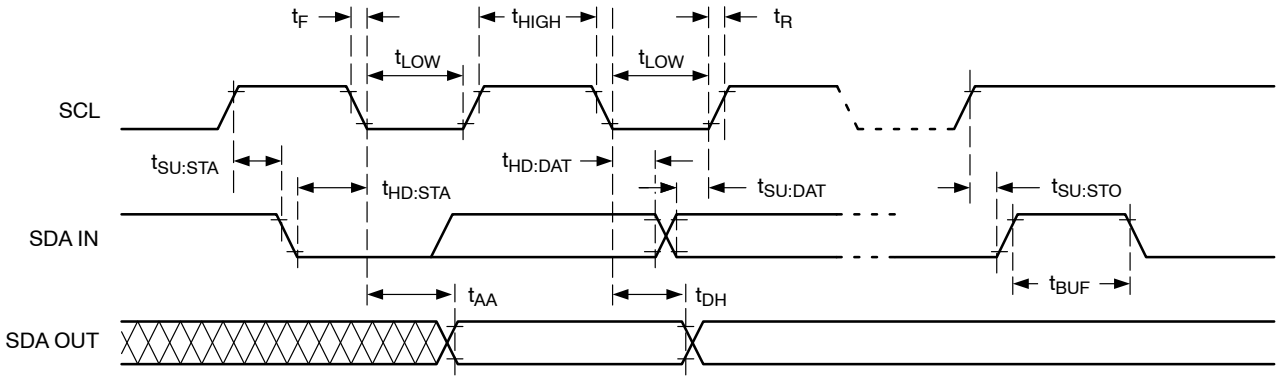


Figure 5. Bus Timing

WRITE OPERATIONS

Byte Write

In Byte Write mode, the Master sends the START condition and the Slave address with the R/W bit set to zero to the Slave. After the Slave generates an acknowledge, the Master sends the byte address that is to be written into the address pointer of the N24Cxx. After receiving another acknowledge from the Slave, the Master transmits the data byte to be written into the addressed memory location. The N24Cxx device will acknowledge the data byte and the Master generates the STOP condition, at which time the device begins its internal Write cycle to nonvolatile memory (Figure 6). While this internal cycle is in progress (t_{WR}), the SDA output will be tri−stated and the N24Cxx will not respond to any request from the Master device (Figure 7).

Page Write

The N24Cxx writes up to 16 bytes of data in a single write cycle, using the Page Write operation (Figure 8). The Page Write operation is initiated in the same manner as the Byte Write operation, however instead of terminating after the data byte is transmitted, the Master is allowed to send up to fifteen additional bytes. After each byte has been transmitted the N24Cxx will respond with an acknowledge and internally increments the four low order address bits. The high order bits that define the page address remain unchanged. If the Master transmits more than sixteen bytes prior to sending the STOP condition, the address counter ‘wraps around’ to the beginning of page and previously transmitted data will be overwritten. Once all sixteen bytes are received and the STOP condition has been sent by the Master, the internal Write cycle begins. At this point all received data is written to the N24Cxx in a single write cycle.

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 N24Cxx 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 N24Cxx is still busy with the write operation, NoACK will be returned. If the N24Cxx 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 operation of the N24Cxx. The state of the WP pin is strobed on the last falling edge of SCL immediately preceding the first data byte (Figure 9). If the WP pin is HIGH during the strobe interval, the N24Cxx will not acknowledge the data byte and the Write request will be rejected.

Delivery State

The N24Cxx is shipped erased, i.e., all bytes are FFh.

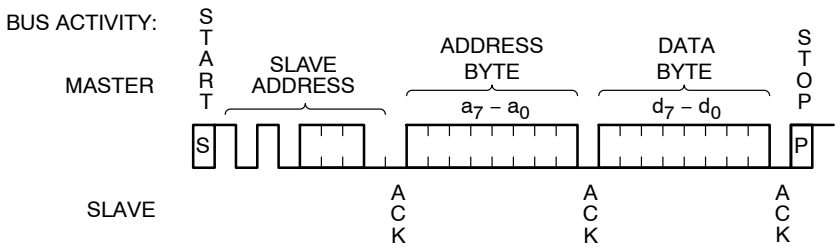


Figure 6. Byte Write Sequence

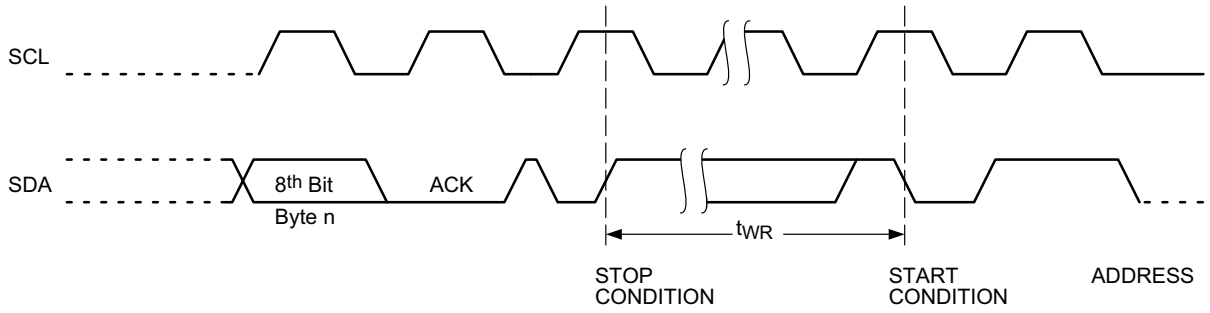


Figure 7. Write Cycle Timing

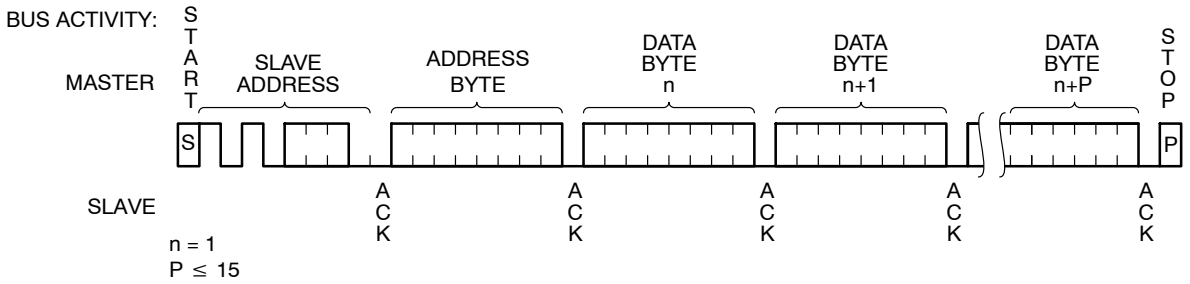


Figure 8. Page Write Sequence

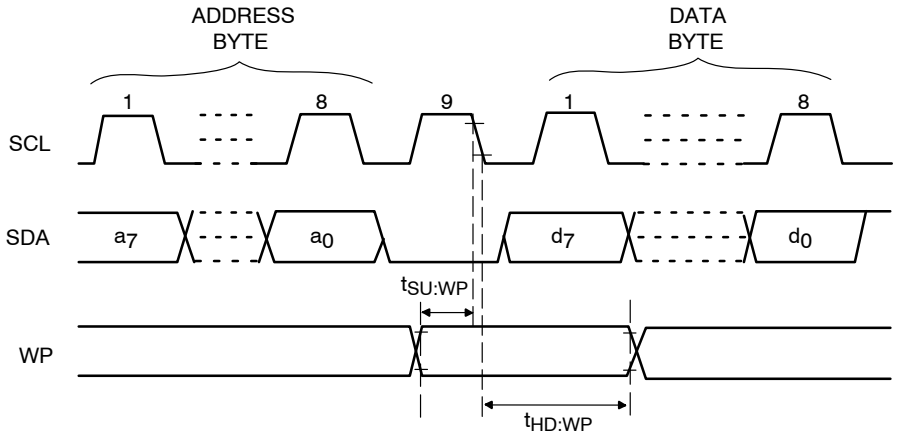


Figure 9. WP Timing

READ OPERATIONS

Immediate Read

Upon receiving a Slave address with the R/W bit set to ‘1’, the N24Cxx will interpret this as a request for data residing at the current byte address in memory. The N24Cxx will acknowledge the Slave address, will immediately shift out the data residing at the current address, and will then wait for the Master to respond. If the Master does not acknowledge the data (NoACK) and then follows up with a STOP condition (Figure 10), the N24Cxx returns to Standby mode.

Selective Read

Selective Read operations allow the Master device to select at random any memory location for a read operation. The Master device first performs a ‘dummy’ write operation by sending the START condition, slave address and byte address of the location it wishes to read. After the N24Cxx acknowledges the byte address, the Master device resends the START condition and the slave address, this time with the R/W bit set to one. The N24Cxx then responds with its acknowledge and sends the requested data byte. The Master device does not acknowledge the data (NoACK) but will generate a STOP condition (Figure 11).

Sequential Read

If during a Read session, the Master acknowledges the 1st data byte, then the N24Cxx will continue transmitting data residing at subsequent locations until the Master responds with a NoACK, followed by a STOP (Figure 12). In contrast to Page Write, during Sequential Read the address count will automatically increment to and then wrap−around at end of memory (rather than end of page).

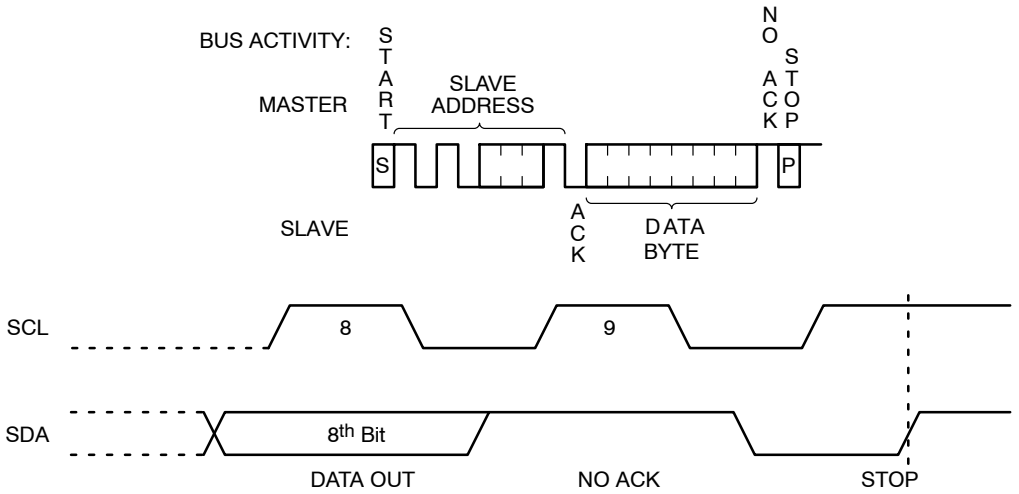


Figure 10. Immediate Read Sequence and Timing

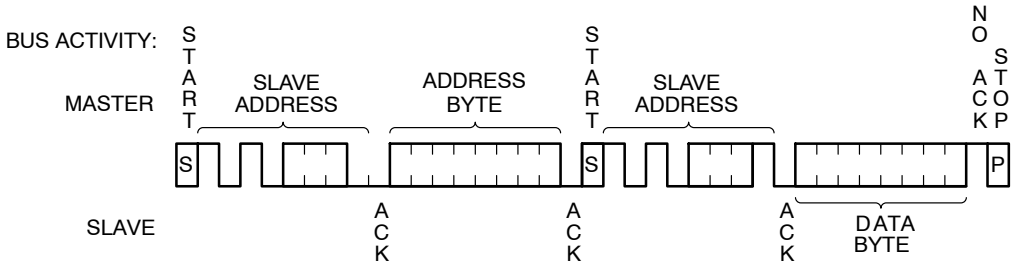


Figure 11. Selective Read Sequence

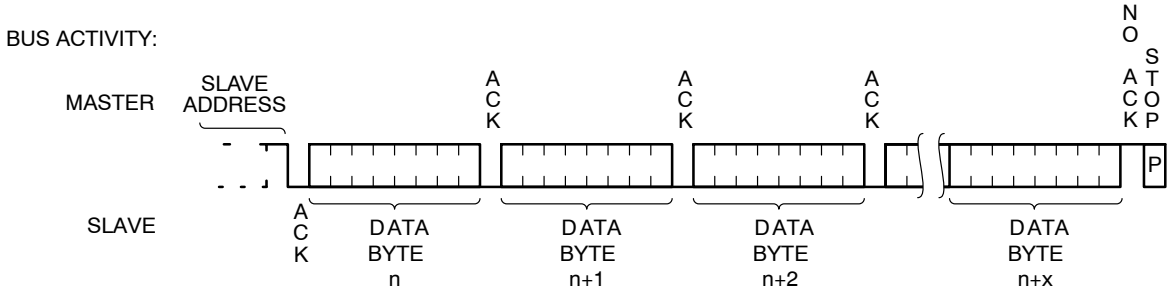


Figure 12. Sequential Read Sequence

ORDERING INFORMATION

N24C02 Ordering Information

Device Order Number	Specific Device Marking	Package Type	Temperature Range	Shipping†
N24C02UDTG	AV	U = US−8	D = Industrial (−40°C to +85°C)	T = Tape & Reel, 3,000 Units / Reel
N24C02UVTG	AM	U = US−8	V = Automotive Grade 1 (−40°C to +125°C)	T = Tape & Reel, 3,000 Units / Reel

N24C04 Ordering Information

Device Order Number	Specific Device Marking	Package Type	Temperature Range	Shipping†
N24C04UDTG	AN	U = US−8	D = Industrial (−40°C to +85°C)	T = Tape & Reel, 3,000 Units / Reel
N24C04UVTG	AW	U = US−8	V = Automotive Grade 1 (−40°C to +125°C)	T = Tape & Reel, 3,000 Units / Reel

N24C08 Ordering Information

Device Order Number	Specific Device Marking	Package Type	Temperature Range	Shipping†
N24C08UDTG	AP	U = US−8	D = Industrial (−40°C to +85°C)	T = Tape & Reel, 3,000 Units / Reel
N24C08UVTG	AX	U = US−8	V = Automotive Grade 1 (−40°C to +125°C)	T = Tape & Reel, 3,000 Units / Reel

N24C16 Ordering Information

Device Order Number	Specific Device Marking	Package Type	Temperature Range	Shipping†
N24C16UDTG	AQ	U = US−8	D = Industrial (−40°C to +85°C)	T = Tape & Reel, 3,000 Units / Reel
N24C16UVTG	AZ	U = US−8	V = Automotive Grade 1 (−40°C to +125°C)	T = Tape & Reel, 3,000 Units / Reel

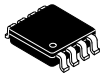
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

9. All packages are RoHS−compliant (Lead−free, Halogen−free).
10. 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.

ON Semiconductor is licensed by the Philips Corporation to carry the I^2C bus protocol.

MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS

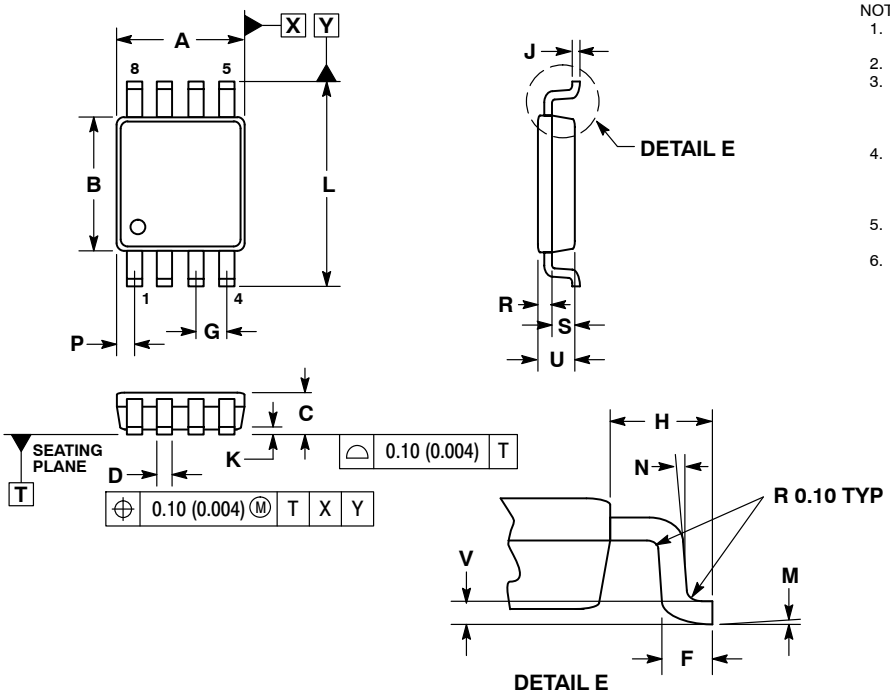
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SCALE 4 :1

US8
CASE 493
ISSUE D

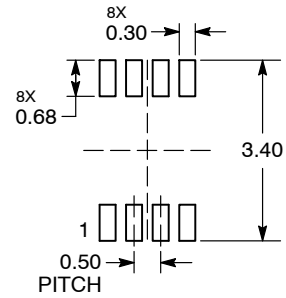
DATE 15 JUL 2015



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 AND GATE BURR SHALL NOT EXCEED 0.14MM (0.0055") PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH AND PROTRUSION SHALL NOT EXCEED 0.14MM (0.0055") PER SIDE.
5. LEAD FINISH IS SOLDER PLATING WITH THICKNESS OF 0.0076–0.0203MM (0.003–0.008").
6. ALL TOLERANCE UNLESS OTHERWISE SPECIFIED ±0.0508MM (0.0002").

	MILLIMETERS		INCHES	
DIM	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	3.20	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	

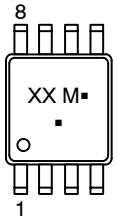
RECOMMENDED SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

*For additional information on our Pb–Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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.

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