

# NV24C128

## Product Preview

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

### Description

The NV24C128 is a 128-Kb Serial CMOS EEPROM, internally organized as 16,384 words of 8 bits each.

It features a 64-byte page write buffer and supports both the Standard (100 kHz), Fast (400 kHz) and Fast-Plus (1 MHz) I<sup>2</sup>C protocol.

Write operations can be inhibited by taking the WP pin High (this protects the entire memory).

On-Chip ECC (Error Correction Code) makes the device suitable for high reliability applications.

### Features

- Automotive Temperature Grade 1 (–40°C to +125°C)
- Supports Standard, Fast and Fast-Plus I<sup>2</sup>C Protocol
- 2.5 V to 5.5 V Supply Voltage Range
- 64-Byte Page Write Buffer
- 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
- UDFN–8 2 x 3 mm Wettable Flank Package
- This Device is Pb-Free, Halogen Free/BFR Free and RoHS Compliant\*

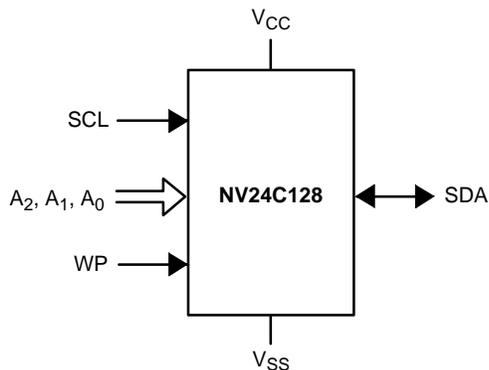


Figure 1. Functional Symbol

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

This document contains information on a product under development. ON Semiconductor reserves the right to change or discontinue this product without notice.



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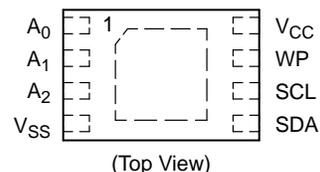


UDFN–8  
MUW3 SUFFIX  
CASE 517DH



XXXXX = Specific Device Code  
A = Assembly Location  
WL = Wafer Lot  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

### PIN CONFIGURATION



For the location of Pin 1, please consult the corresponding package drawing.

### PIN FUNCTION

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

### ORDERING INFORMATION

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

**Table 1. ABSOLUTE MAXIMUM RATINGS**

Parameter	Rating	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.

- 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
$N_{END}$ (Notes 3, 4)	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,  $V_{CC} = 5$  V, 25°C
- This device uses ECC (Error Correction Code) logic with 6 ECC bits to correct one bit error in 4 data bytes. Therefore, when a single byte has to be written, 4 bytes (including the ECC bits) are re-programmed. It is recommended to write by multiple of 4 bytes in order to benefit from the maximum number of write cycles.

**Table 3. D.C. OPERATING CHARACTERISTICS ( $V_{CC} = 2.5$  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, $f_{SCL} = 400$ kHz/1 MHz		1	mA
$I_{CCW}$	Write Current			3	mA
$I_{SB}$	Standby Current	All I/O Pins at GND or $V_{CC}$	$T_A = -40$ °C to +125°C	5	µA
$I_L$	I/O Pin Leakage	Pin at GND or $V_{CC}$	$T_A = -40$ °C to +125°C	2	µA
$V_{IL}$	Input Low Voltage		-0.5	$0.3 V_{CC}$	V
$V_{IH}$	Input High Voltage		$0.7 V_{CC}$	$V_{CC} + 0.5$	V
$V_{OL}$	Output Low Voltage	$I_{OL} = 3.0$ mA		0.4	V

**Table 4. PIN IMPEDANCE CHARACTERISTICS ( $V_{CC} = 2.5$  V to 5.5 V,  $T_A = -40$ °C to +125°C, unless otherwise specified.)**

Symbol	Parameter	Conditions	Max	Units
$C_{IN}$ (Note 5)	SDA I/O Pin Capacitance	$V_{IN} = 0$ V	8	pF
$C_{IN}$ (Note 5)	Input Capacitance (other pins)	$V_{IN} = 0$ V	6	pF
$I_{WP}, I_A$ (Note 6)	WP Input Current, Address Input Current ( $A_0, A_1, A_2$ )	$V_{IN} < V_{IH}, V_{CC} = 5.5$ V	75	µA
		$V_{IN} < V_{IH}, V_{CC} = 3.3$ V	50	
		$V_{IN} > V_{IH}$	2	

- 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,  $A_0, A_1, A_2$  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** ( $V_{CC} = 2.5\text{ V to }5.5\text{ V}$ ,  $T_A = -40^\circ\text{C to }+125^\circ\text{C}$ ) (Note 7)

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 8)	SDA and SCL Rise Time		1,000		300		100	ns
$t_F$ (Note 8)	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	$\mu\text{s}$
$t_{DH}$	Data Out Hold Time	100		100		50		ns
$T_i$ (Note 8)	Noise Pulse Filtered at SCL and SDA Inputs		100		100		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		5		5		5	ms
$t_{PU}$ (Notes 8, 9)	Power-up to Ready Mode		1		1	0.1	1	ms

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.

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

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

9.  $t_{PU}$  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: $I_{OL} = 3\text{ mA}$ ; $C_L = 100\text{ pF}$

## Power-On Reset (POR)

The NV24C128 incorporates Power-On Reset (POR) circuitry which protects the device against powering up in the wrong state.

The NV24C128 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.

## 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.

**A<sub>0</sub>, A<sub>1</sub> and A<sub>2</sub>:** The Address pins accept the device address. 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 NV24C128 supports the Inter-Integrated Circuit (I<sup>2</sup>C) 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 NV24C128 acts as a Slave device. Master and Slave alternate as either transmitter or receiver. Up to 8 devices may be connected to the bus as determined by the device address inputs A<sub>0</sub>, A<sub>1</sub>, and A<sub>2</sub>.

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

The I<sup>2</sup>C 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 A.C. 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 STOP 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.

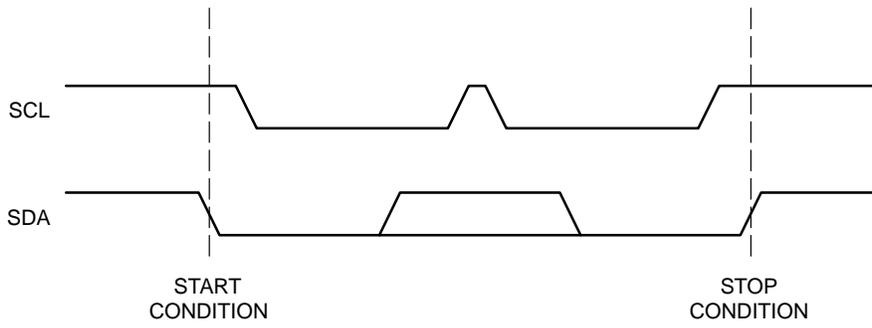
## Device Addressing

The Master initiates data transfer by creating a START condition on the bus. The Master then broadcasts an 8-bit serial Slave address. The first 4 bits of the Slave address are set to 1010, for normal Read/Write operations (Figure 3). The next 3 bits, A<sub>2</sub>, A<sub>1</sub> and A<sub>0</sub>, select one of 8 possible Slave devices and must match the state of the external address pins. The last bit, R/ $\bar{W}$ , specifies whether a Read (1) or Write (0) operation is to be performed.

## Acknowledge

After processing the Slave address, the Slave responds with an acknowledge (ACK) by pulling down the SDA line during the 9<sup>th</sup> clock cycle (Figure 4). The Slave will also acknowledge all address bytes 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<sup>th</sup> 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.

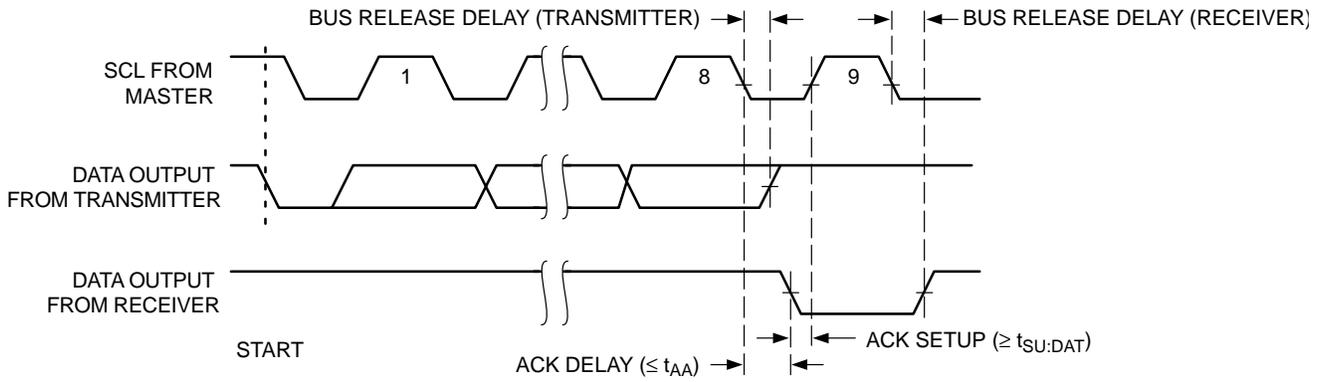
# NV24C128



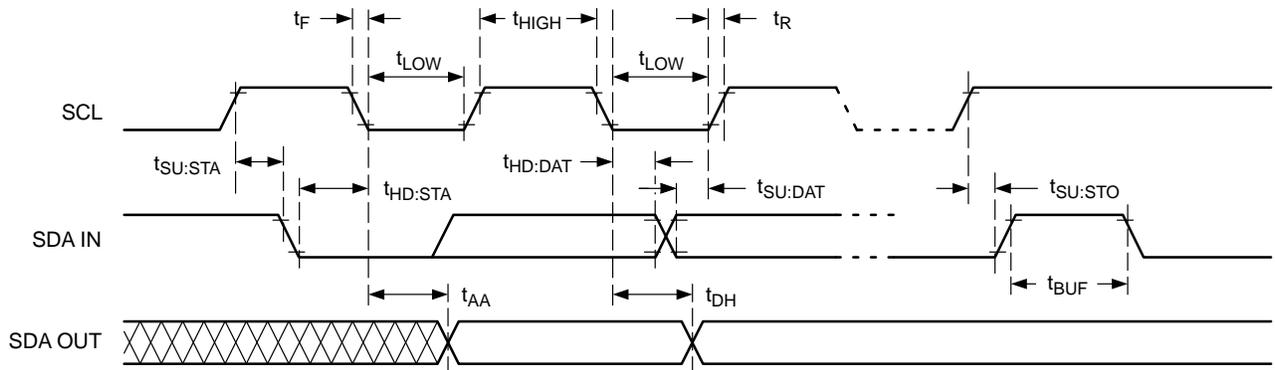
**Figure 2. START/STOP Conditions**



**Figure 3. Slave Address Bits**



**Figure 4. Acknowledge Timing**



**Figure 5. Bus Timing**

**Write Operations**

**Byte Write**

Upon receiving a Slave address with the  $R/\overline{W}$  bit set to '0', the NV24C128 will interpret the next two bytes as address bytes. These bytes are used to initialize the internal address counter; the 2 most significant bits are 'don't care', the next 8 point to one of 256 available pages and the last 6 point to a location within a 64 byte page. A byte following the address bytes will be interpreted as data. The data will be loaded into the Page Write Buffer and will eventually be written to memory at the address specified by the 14 active address bits provided earlier. The NV24C128 will acknowledge the Slave address, address bytes and data byte. The Master then starts the internal Write cycle by issuing a STOP condition (Figure 6). During the internal Write cycle ( $t_{WR}$ ), the SDA output will be tri-stated and additional Read or Write requests will be ignored (Figure 7).

**Page Write**

By continuing to load data into the Page Write Buffer after the 1<sup>st</sup> data byte and before issuing the STOP condition, up to 64 bytes can be written simultaneously during one internal Write cycle (Figure 8). If more data bytes are loaded than locations available to the end of page, then loading will continue from the beginning of page, i.e. the page address is

latched and the address count automatically increments to and then wraps-around at the page boundary. Previously loaded data can thus be overwritten by new data. What is eventually written to memory reflects the latest Page Write Buffer contents. Only data loaded within the most recent Page Write sequence will be written to memory.

**Acknowledge Polling**

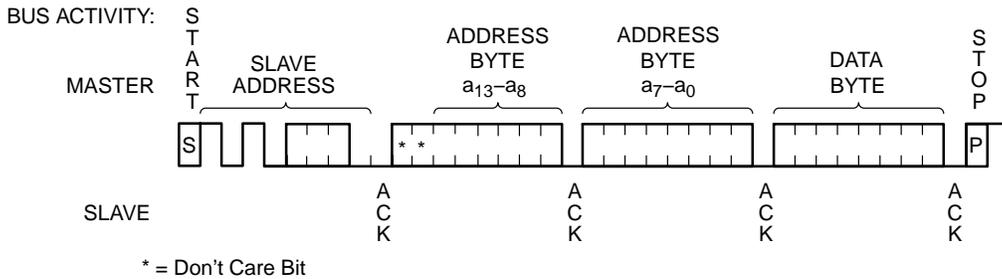
The ready/busy status of the NV24C128 can be ascertained by sending Read or Write requests immediately following the STOP condition that initiated the internal Write cycle. As long as internal Write is in progress, the NV24C128 will not acknowledge the Slave address.

**Hardware Write Protection**

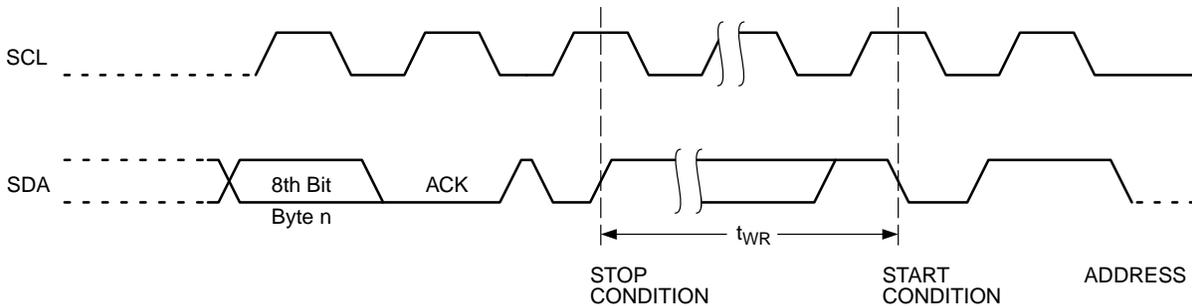
With the WP pin held HIGH, the entire memory is protected against Write operations. If the WP pin is left floating or is grounded, it has no impact on the operation of the NV24C128. The state of the WP pin is strobed on the last falling edge of SCL immediately preceding the first data byte (Figure 9). If the WP pin is HIGH during the strobe interval, the NV24C128 will not acknowledge the data byte and the Write request will be rejected.

**Delivery State**

The NV24C128 is shipped erased, i.e., all bytes are FFh.



**Figure 6. Byte Write Sequence**



**Figure 7. Write Cycle Timing**

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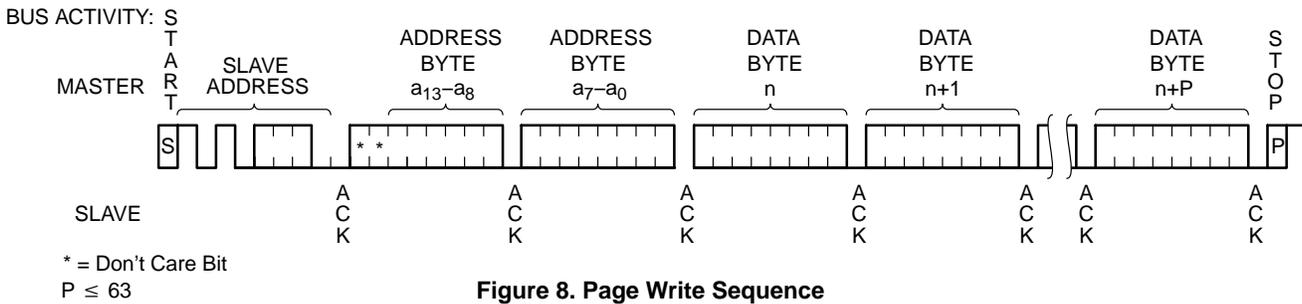


Figure 8. Page Write Sequence

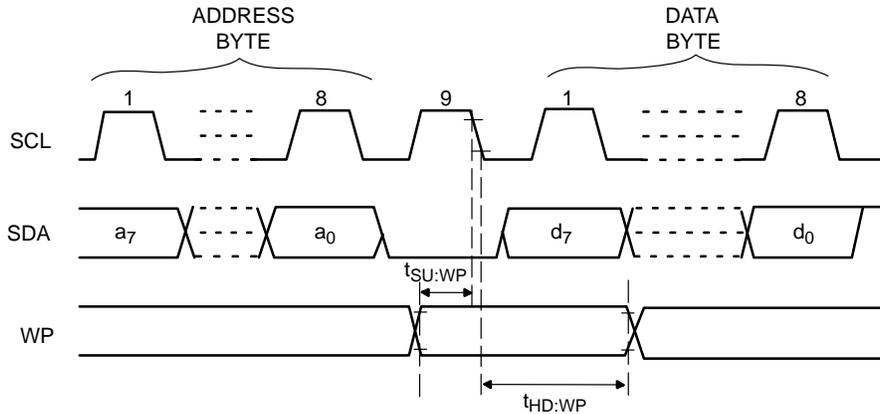


Figure 9. WP Timing

## Read Operations

### Immediate Read

Upon receiving a Slave address with the  $R/\overline{W}$  bit set to '1', the NV24C128 will interpret this as a request for data residing at the current byte address in memory. The NV24C128 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 NV24C128 returns to Standby mode.

### Selective Read

To read data residing at a specific location, the internal address counter must first be initialized as described under Byte Write. If rather than following up the two address bytes

with data, the Master instead follows up with an Immediate Read sequence, then the NV24C128 will use the 14 active address bits to initialize the internal address counter and will shift out data residing at the corresponding location. If the Master does not acknowledge the data (NoACK) and then follows up with a STOP condition (Figure 11), the NV24C128 returns to Standby mode.

### Sequential Read

If during a Read session the Master acknowledges the 1<sup>st</sup> data byte, then the NV24C128 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).

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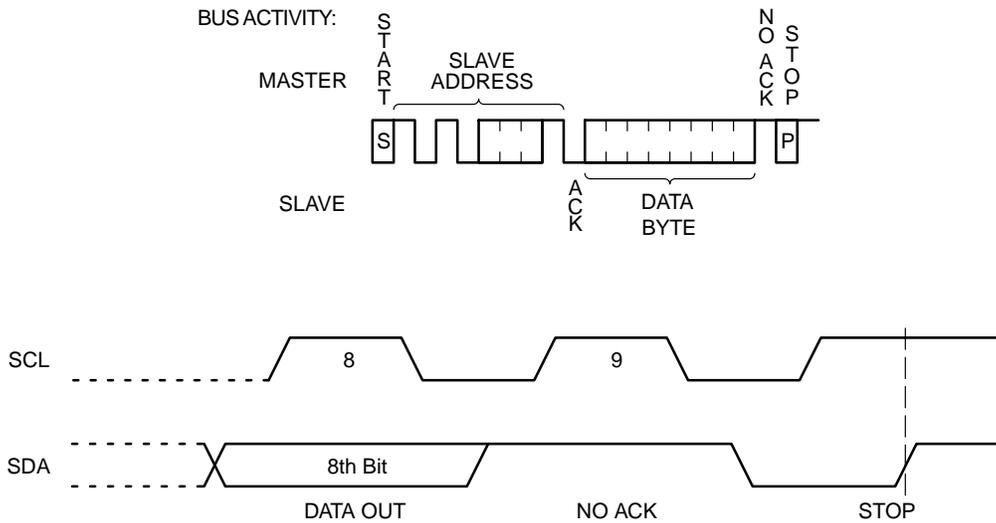


Figure 10. Immediate Read Sequence and Timing

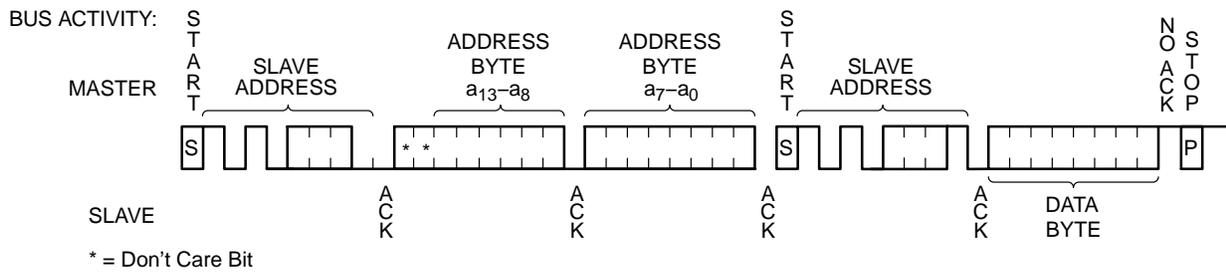


Figure 11. Selective Read Sequence

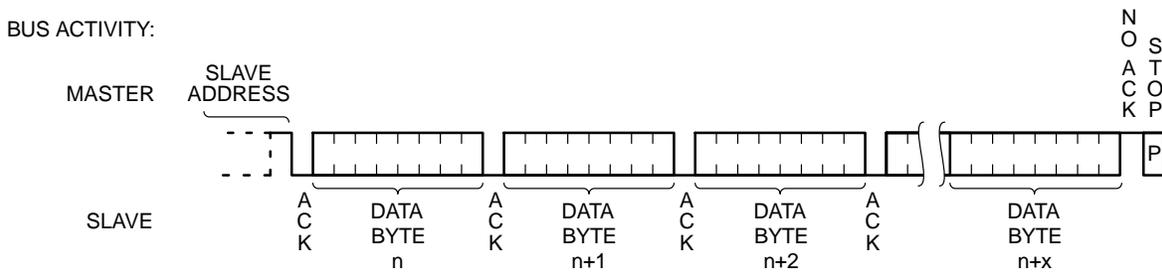
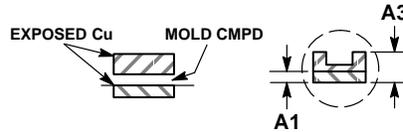
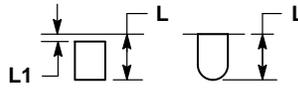
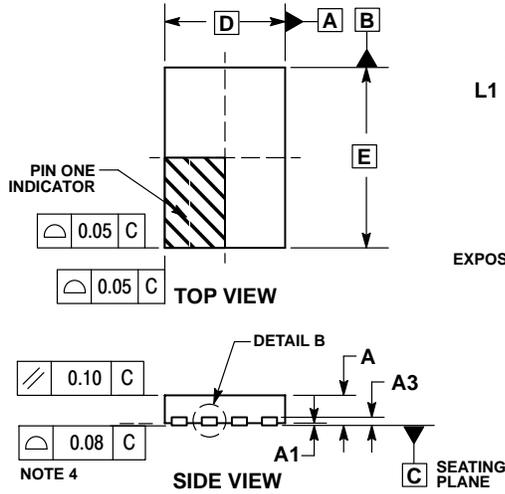


Figure 12. Sequential Read Sequence

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## PACKAGE DIMENSIONS

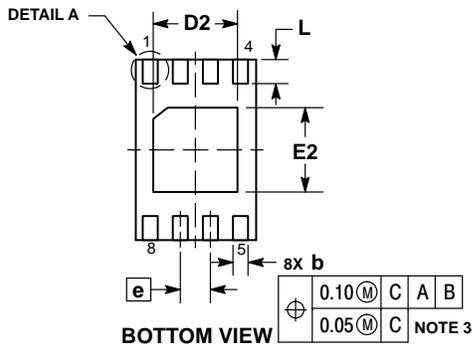
UDFN8 2x3, 0.5P  
CASE 517DH  
ISSUE O



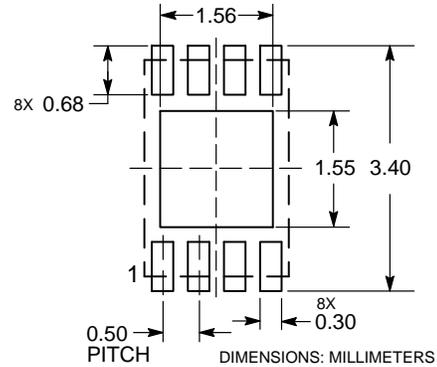
**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.25MM FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
5. FOR DEVICE OPN CONTAINING W OPTION, DETAIL B ALTERNATE CONSTRUCTION IS NOT APPLICABLE.

MILLIMETERS		
DIM	MIN	MAX
A	0.45	0.55
A1	0.00	0.05
A3	0.13	REF
b	0.20	0.30
D	2.00	BSC
D2	1.30	1.50
E	3.00	BSC
E2	1.30	1.50
e	0.50	BSC
L	0.30	0.50
L1	---	0.15



**RECOMMENDED SOLDERING FOOTPRINT\***



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

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## ORDERING INFORMATION (Notes 10 thru 14)

Device Order Number	Specific Device Marking	Package Type	Temperature Range	Lead Finish	Shipping
NV24C128MUW3VTBG	TBD	UDFN-8 (2x3 mm) Wettable Flank	V = Auto Grade 1 (-40°C to +125°C)	NiPdAu	Tape & Reel, 3,000 Units / Reel

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

11. **The standard lead finish is NiPdAu.**

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.

14. For detailed information and a breakdown of device nomenclature and numbering systems, please see the ON Semiconductor Device Nomenclature document, TND310/D, available at [www.onsemi.com](http://www.onsemi.com)

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