

NM24C32

32,768-Bit Standard 2-Wire Bus Interface Serial EEPROM with Write Protect

General Description:

The NM24C32/C32L/C32LZ devices are 32,768 bits of CMOS nonvolatile electrically erasable memory. These devices offer the designer different low voltage and low power options, and they conform to all specifications in the Extended I²C 2-wire protocol. Furthermore, they are designed to minimize device pin count and simplify PC board layout requirements.

The upper half of the memory can be disabled (Write Protection) by connecting the WP pin to V_{CC} . This section of memory then becomes ROM.

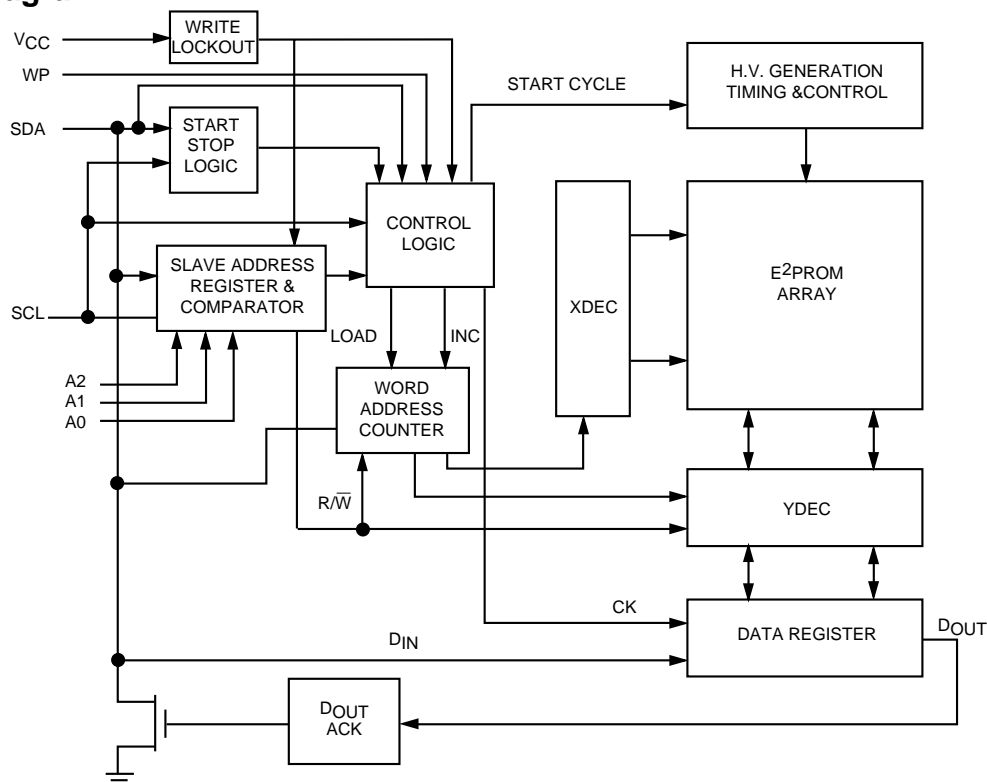
This communication protocol uses CLOCK (SCL) and DATA I/O (SDA) lines to synchronously clock data between the master (for example a microprocessor) and the slave EEPROM device(s).

Fairchild EEPROMs are designed and tested for applications requiring high endurance, high reliability, and low power consumption.

Features:

- Extended Operating Voltages
 - C32: 4.5V - 5.5V
 - C32L: 2.7V - 5.5V
 - C32LZ: 2.7V - 5.5V
- Low Power CMOS
 - 2mA active current typical
 - C32/C32L: 60μA standby current typical
 - C32LZ: less than 1μA standby current
- 2-wire I²C serial interface
- 32 byte page write mode
- Max write cycle time of 10ms byte/page
- 40 years data retention
- Endurance: 1,000,000 data changes
- Packages available: 8-pin SO, 8-pin DIP
- Internal ERASE/WRITE logic is disabled if V_{CC} is below 3.8V ($V_{CC} = 5 \pm 10\%$). Available on the 5V version NM24C32 (only).

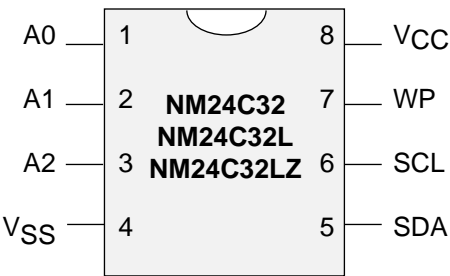
Block Diagram



DS500073-1

Connection Diagram

Dual-In-Line Package (N)
and 8-Pin SO Package (M8)



DS500073-2

Pin Names

A0, A1, A2	Device Address Input
V _{SS}	Ground
SDA	Data I/O
SCL	Clock Input
WP	Write Protect
V _{CC}	Power Supply

Ordering Information

Letter	Description
NM	Fairchild Non-Volatile Memory
24	IIC - 2 Wire
C	CMOS
XX	32K with write protect
F	400KHz
LZ	2.7V to 5.5V and <1μA Standby Current
E	-40 to +85°C
XX	8-Pin SOIC
Package	8-Pin DIP
Temp. Range	0 to 70°C
Voltage Operating Range	4.5V to 5.5V
SCL Clock Frequency	100KHz
Density	32K with write protect
Interface	IIC - 2 Wire

Product Specifications

Absolute Maximum Ratings

Ambient Storage Temperature	-65°C to +150°C
All Input or Output Voltages with Respect to Ground	6.5V to -0.3V
Lead Temperature (Soldering, 10 seconds)	+300°C
ESD Rating	2000V min.

Operating Conditions

Ambient Operating Temperature	0°C to +70°C
NM24C32	-40°C to +85°C
NM24C32E	-40°C to +125°C
NM24C32V	
Positive Power Supply	4.5V to 5.5V
NM24C32	2.7V to 5.5V
NM24C32L	2.7V to 5.5V
NM24C32LZ	2.7V to 5.5V

Standard V_{CC} (4.5V to 5.5V) DC Electrical Characteristics

Symbol	Parameter	Test Conditions	Limits			Units
			Min	Typ	Max	
I_{CCA}	Active Power Supply Current	$f_{SCL} = 100 \text{ kHz}$		0.5	1.0	mA
I_{SB}	Standby Current	$V_{IN} = \text{GND or } V_{CC}$		10	50	μA
I_{LI}	Input Leakage Current	$V_{IN} = \text{GND to } V_{CC}$		0.1	1	μA
I_{LO}	Output Leakage Current	$V_{OUT} = \text{GND to } V_{CC}$		0.1	1	μA
V_{IL}	Input Low Voltage		-0.3		$V_{CC} \times 0.3$	V
V_{IH}	Input High Voltage		$V_{CC} \times 0.7$		$V_{CC} + 0.5$	V
V_{OL}	Output Low Voltage	$I_{OL} = 3 \text{ mA}$			0.4	V

Low V_{CC} (2.7V to 5.5V) DC Electrical Characteristics

Symbol	Parameter	Test Conditions	Limits			Units
			Min	Typ	Max	
I_{CCA}	Active Power Supply Current	$f_{SCL} = 100 \text{ kHz}$		0.5	1.0	mA
I_{SB} (Note 1)	Standby Current for L Standby Current for LZ	$V_{IN} = \text{GND or } V_{CC}$ $V_{IN} = \text{GND or } V_{CC}$		1 0.1	10 1	μA μA
I_{LI}	Input Leakage Current	$V_{IN} = \text{GND to } V_{CC}$		0.1	1	μA
I_{LO}	Output Leakage Current	$V_{OUT} = \text{GND to } V_{CC}$		0.1	1	μA
V_{IL}	Input Low Voltage		-0.3		$V_{CC} \times 0.3$	V
V_{IH}	Input High Voltage		$V_{CC} \times 0.7$		$V_{CC} + 0.5$	V
V_{OL}	Output Low Voltage	$I_{OL} = 3 \text{ mA}$			0.4	V

Capacitance $T_A = +25^\circ\text{C}$, $f = 100/400 \text{ KHz}$, $V_{CC} = 5\text{V}$ (Note 1)

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

Note 1: Typical values are for $T_A = 25^\circ\text{C}$ and nominal supply voltage (5V).

AC Conditions of Test

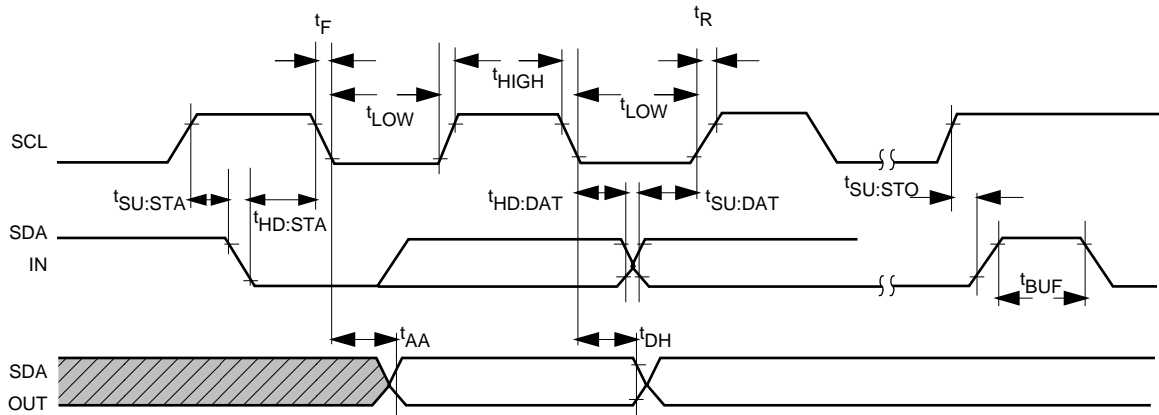
Input Pulse Levels	$V_{CC} \times 0.1$ to $V_{CC} \times 0.9$
Input Rise and Fall Times	10 ns
Input & Output Timing Levels	$V_{CC} \times 0.5$
Output Load	1 TTL Gate and $C_L = 100 \text{ pF}$

Read and Write Cycle Limits (Standard and Low V_{CC} Range - 2.7V-5.5V)

Symbol	Parameter	100 kHz		400 kHz		Units
		Min	Max	Min	Max	
f_{SCL}	SCL Clock Frequency		100		400	kHz
T_I	Noise Suppression Time Constant at SCL, SDA Inputs (Minimum V_{IN} Pulse width)		100		50	ns
t_{AA}	SCL Low to SDA Data Out Valid	0.3	3.5	0.1	0.9	μ s
t_{BUF}	Time the Bus Must Be Free before a New Transmission Can Start	4.7		1.3		μ s
$t_{HD:STA}$	Start Condition Hold Time	4.0		0.6		μ s
t_{LOW}	Clock Low Period	4.7		1.5		μ s
t_{HIGH}	Clock High Period	4.0		0.6		μ s
$t_{SU:STA}$	Start Condition Setup Time (for a Repeated Start Condition)	4.7		0.6		μ s
$t_{HD:DAT}$	Data in Hold Time	0		0		μ s
$t_{SU:DAT}$	Data in Setup Time	250		100		ns
t_R	SDA and SCL Rise Time		1		0.3	μ s
t_F	SDA and SCL Fall Time		300		300	ns
$t_{SU:STO}$	Stop Condition Setup Time	4.7		0.6		μ s
t_{DH}	Data Out Hold Time	300		50		ns
t_{WR}	Write Cycle Time - NM24C32		10		10	ms
(Note 2)	- NM24C32L, NM24C32LZ		15		15	

Note 2: The write cycle time (t_{WR}) is the time from a valid stop condition of a write sequence to the end of the internal erase/program cycle. During the write cycle, the NM24C32 bus interface circuits are disabled, SDA is allowed to remain high per the bus-level pull-up resistor, and the device does not respond to its slave address

Bus Timing



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Note 3: SCL = Serial Clock Data
SDA = Serial Data I/O

BACKGROUND INFORMATION (I²C Bus)

As mentioned, the I²C bus allows synchronous bidirectional communication between Transmitter/Receiver using the SCL (clock) and SDA (Data I/O) lines. All communication must be started with a valid START condition, concluded with a STOP condition and acknowledged by the Receiver with an ACKNOWLEDGE condition.

In addition, since the I²C bus is designed to support other devices such as RAM, EPROM, etc., the device type identifier string, or control byte, must follow the START condition. For EEPROMs, the first 4-bit of the control byte is 1010 binary for READ and WRITE operations. This is then followed by the device selection bits A2, A1 and A0, and acts as the three most significant bits of the word address. The final bit in the control byte determines the type of operation performed (READ/WRITE). A "1" signifies a READ while a "0" signifies a WRITE. The control byte is then followed by two bytes that define the word address, which is then followed by the data byte.

The EEPROMs on the I²C bus may be configured in any manner required, providing the total memory addressed does not exceed 512K bits (64K bytes). EEPROM memory addressing is controlled by hardware configuring the A2, A1, and A0 pins (Device Address pins) with pull-up or pull-down resistors. ALL UNUSED PINS MUST BE GROUNDED (tied to V_{SS}).

Addressing an EEPROM memory location involves sending a command string with the following information:

[DEVICE TYPE]-[DEVICE ADDRESS]-[PAGE BLOCK ADDRESS]-[BYTE ADDRESS]

Pin Description

SERIAL CLOCK (SCL)

	Definitions
Word	8 bits (byte) of data
Page	32 sequential addresses (one byte each) that may be programmed during a "Page Write" programming cycle.
Master	Any I ² C device CONTROLLING the transfer of data (such as a microcontroller).
Slave	Device being controlled (EEPROMS are always considered Slaves).
Transmitter	Device currently SENDING data on the bus (may be either a Master or Slave).
Receiver	Device currently receiving data on the bus (Master or Slave).

The SCL input is used to clock all data into and out of the device.

SERIAL DATA (SDA)

SDA is a bidirectional pin used to transfer data into and out of the device. It is an open drain output and may be wire-ORed with any number of open drain or open collector outputs.

Device Address Inputs (A0, A1, A2)

Device address pins A0, A1, and A2 are connected to V_{CC} or V_{SS} to configure the EEPROM address for multiple device configuration. A total of eight different devices can be attached to the same SDA bus.

Write Protection (WP)

If WP is tied to V_{CC} , program WRITE operations onto the upper half of the memory (32K bits) will not be executed. READ operations are always available.

If WP is tied to V_{SS} , normal memory operation is enabled, READ/ WRITE over the entire 64K bit memory array.

This feature allows the user to assign the upper half of the memory as ROM which can be protected against accidental programming writes. When WRITE is disabled, slave address and word address will be acknowledged but data will not be acknowledged.

Device Operation

The NM24C32xxx supports a bidirectional bus oriented protocol. The protocol defines any device that sends data onto the bus as a transmitter and the receiving devices as the receiver. The device controlling the transfer is the master and the device that is controlled is the slave. The master will always initiate data transfers and provide the clock for both transmit and receive operations. Therefore, the NM24C32xxx is considered a slave in all applications.

CLOCK AND DATA CONVENTIONS

Data states on the SDA line can change only during SCL LOW. SDA state changes during SCL HIGH and reserved for indication start and stop conditions. Refer to Figures 2 and 3.

START CONDITION

All commands are preceded by the start condition, which is a HIGH to LOW transition of SDA when SCL is HIGH. The NM24C32xxx continuously monitors the SDA and SCL lines for the start condition and will not respond to any command until this condition has been met.

STOP CONDITION

All communications are terminated by a stop condition, which is a LOW to HIGH transition of SDA when SCL is HIGH. The stop condition is also used by the NM24C32xxx to place the device in the standby power mode.

Write Cycle Timing

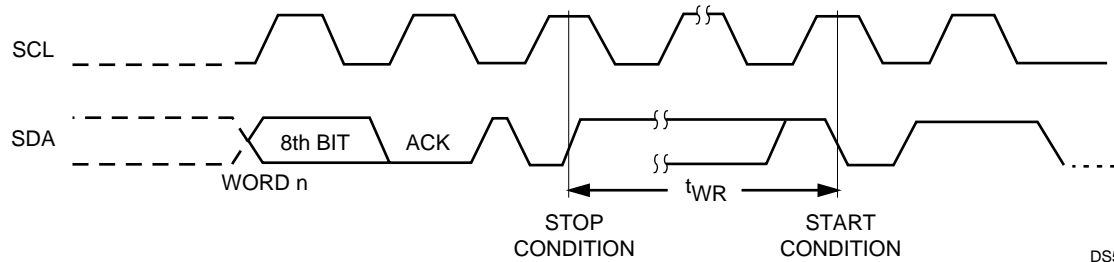
ACKNOWLEDGE

Acknowledge is a software convention used to indicate successful data transfers. The transmitting device, either master or slave, will release the bus after transmitting eight bits. During the ninth clock cycle the receiver will pull the SDA line LOW to acknowledge that it received the eight bits of data. Refer to Figure 4.

The NM24C32xxx device will always respond with an acknowledge after recognition of a start condition and its slave address. If both the device and a WRITE operation have been selected, the NM24C32xxx will respond with an acknowledge after the receipt of each subsequent eight bit word.

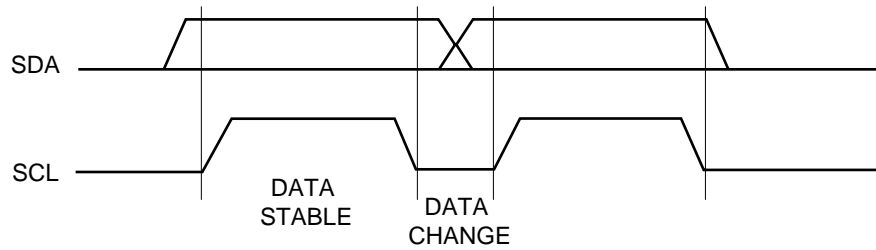
In the READ mode the NM24C32xxx slave will transmit eight bits of data, release the SDA line and monitor the line for an acknowledge. If an acknowledge is detected and no stop condition is generated by the master, the slave will continue to transmit data. If an acknowledge is not detected, the slave will terminate further data transmissions and await the stop condition to return to the standby power mode.

Write Cycle Timing (Figure 1)



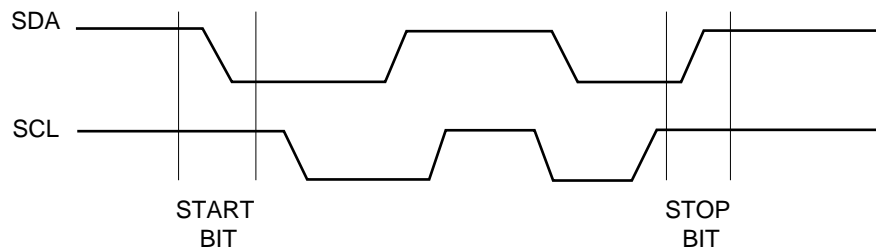
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Data Validity (Figure 2)



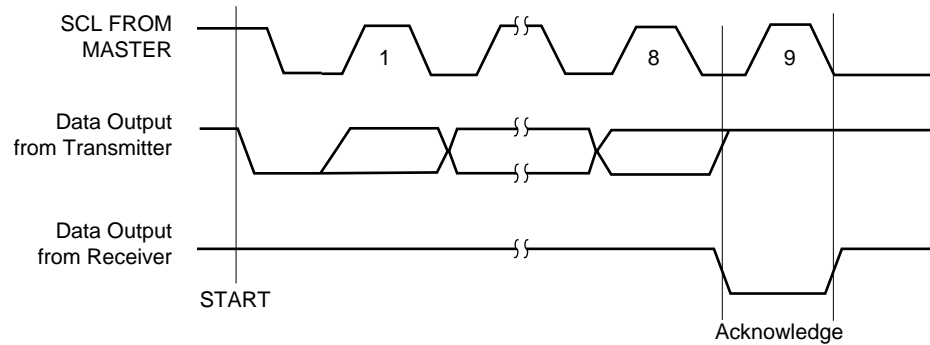
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Definition of Start and Stop (Figure 3)



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Acknowledge Response from Receiver (Figure 4)



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DEVICE ADDRESSING

Following a start condition the master must output the address of the slave it is accessing. The most significant four bits of the slave address are those of the device type identifier. This is fixed as 1010 for all four devices: NM24C32, NM24C32L and NM24C32LZ.

The next three bits identifies the device address. Address from 000 to 111 are acceptable thus allowing up to eight devices to be connected to the I²C bus.

The last bit of the slave address defines whether a write or read condition is requested by the master. A "1" indicates that a READ operation is to be executed and a "0" initiates the WRITE mode.

A simple review: After the NM24C32xxx recognizes the start condition, the devices interfaced to the I²C bus waits for a slave address to be transmitted over the SDA line. If the transitted slave address matches an address of one of the devices, the designated slave pulls the line LOW with an acknowledge. signal and awaits further transmissions.

Write Operations

BYTE WRITE

For a WRITE operation, two additional address fields are required after the control byte acknowledge which is the word address and is comprised of thirteen bits to provide access to any one of the 8K words in the selected page of memory. The first byte indicates the high-order byte of the word address. Only the five least significant bits can be changed, the three most significant bits are pre-assigned the value "0". Following the acknowledgement from the first word address, the next byte indicates the low-order byte of the word address. Upon receipt of the word address, the NM24C32xxx responds with another acknowledge and waits for the next eight bits of data, again, responding with an acknowledge. The master

then terminates the transfer by generating a stop condition, at which time the NM24C32xxx begins the internal write cycle to the nonvolatile memory. While the internal write cycle is in progress, the device's inputs are disabled and the device will not respond to any requests from the master. Refer to *Figure 5* for the address, acknowledge and data transfer sequence.

PAGE WRITE

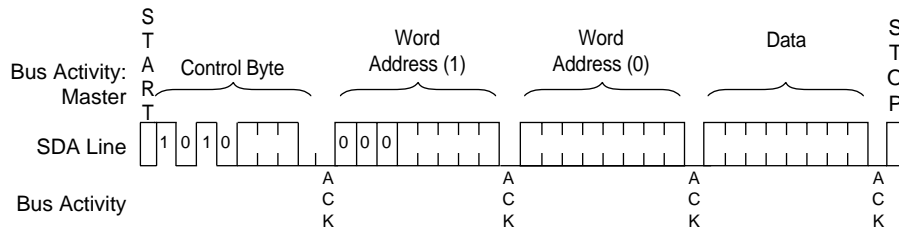
The NM24C32xxx is capable of thirty-two byte page write operation. It is initiated in the same manner as the byte write operation; but instead of termination the write cycle after the first data word is transfered, the master can transmit up to thirty-one more words. After the receipt of each word, the device responds with an acknowledge.

After the receipt of each word, the internal address counter increments to the next address and the next SDA data is accepted. If the master should transmit more than thirty-two words prior to generating the stop condition, the address counter will "roll over" and the previous written data will be overwritten. As with the byte write operation, all inputs are disabled until completion of the internal write cycle. Refer to *Figure 6* for the address, acknowledge and data transfer sequence.

Acknowledge Polling

Once the stop condition is issued to indicate the end of the host's write operation, the NM24C32xxx initiates the internal write cycle. ACK polling can be initiated immediately. This involves issuing the start condition followed by the slave address for a write operation. If the NM24C32xxx is still busy with the write operation, no ACK will be returned. If the device has completed the write operation, an ACK will be returned and the host can then proceed with the next read or write operation.

Byte Write (Figure 5)



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Write Protection

Programming of the upper half of memory will not take place if the WP pin is connected to V_{CC} (+5V). The device will accept control and word addresses; but if the memory accessed is write protected by the WP pin, the NM24C32xxx will not generate an acknowledge after the first byte of data has been received, and thus the program cycle will not be started when the stop condition is asserted.

Low V_{CC} Lockout

NM24C32xxx provides data security against inadvertent writes that could potentially happen during the time the device is being powered on, powered down and brown out conditions by monitoring the V_{CC} voltage during a write cycle. Whenever a write cycle is started, the built-in circuitry starts to monitor the V_{CC} level throughout the duration of the write command sequence until the master issues the required STOP condition to start the actual internal write operation. If the sensed V_{CC} voltage is below 3.8V at any point during this monitoring period, the device prohibits the write operation and does not generate the ACK pulse. This low V_{CC} lockout feature is only available for standard 5V device.

Read Operation

Read operations are initiated in the same manner as write operations, with the exception that the R/W bit of the slave address is set to "1". There are three basic read operations: current address read, random read and sequential read.

CURRENT ADDRESS READ

Internally the NM24C32xxx contains an address counter that maintains the address of the last word accessed, incremented by one. Therefore, if the last access (either a read or write) was to address n , the next read operation would access data from address $n+1$. Upon receipt of the slave address with R/W set to one, the NM24C32xxx issues an acknowledge and transmits the eight bit word. The master will not acknowledge acknowledge the

transfer but does generate a stop condition, and therefore discontinues transmission. Refer to *Figure 7* for the sequence of address, acknowledge and data transfer.

RANDOM READ

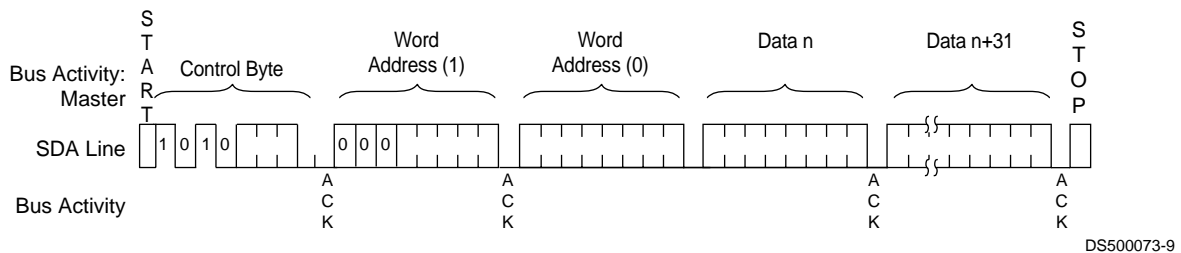
Random read operations allow the master to access any memory location in a random manner. Prior to issuing the slave address with the R/W bit set to "1", the master must first perform a "dummy" write operation. The master issues a start condition, slave address and then the word address it is to read. After the word address acknowledge, the master immediately reissues the start condition and the slave address with the R/W bit set to "1". This will be followed by an acknowledge from the NM24C32xxx and then by the eight bit word. The master will not acknowledge the transfer but does generate the stop condition, and therefore the NM24C32xxx discontinues transmission. Refer to *Figure 8* for the address, acknowledge and data transfer sequence.

SEQUENTIAL READ

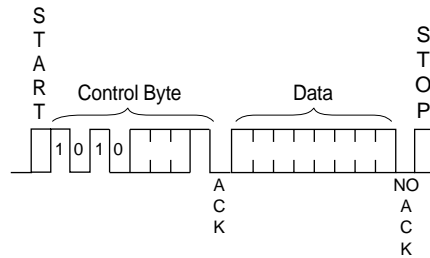
Sequential reads can be initiated as either a current address read or random access read. The first word is transmitted in the same manner as the other read modes; however, the master now responds with an acknowledge, indicating it requires additional data. The NM24C32xxx continues to output data for each acknowledge received. The read operation is terminated by the master not responding with an acknowledge or by generating a stop condition.

The data output is sequential, with the data from address n followed by the data $n+1$. The address counter for read operations increments all word address bits, allowing the entire memory contents to be serially read during one operation. After the entire memory has been read, the counter "rolls over" and the NM24C32xxx continues to output data for each acknowledge received. Refer to *Figure 9* for the address, acknowledge and data transfer sequence.

Page Write (Figure 6)

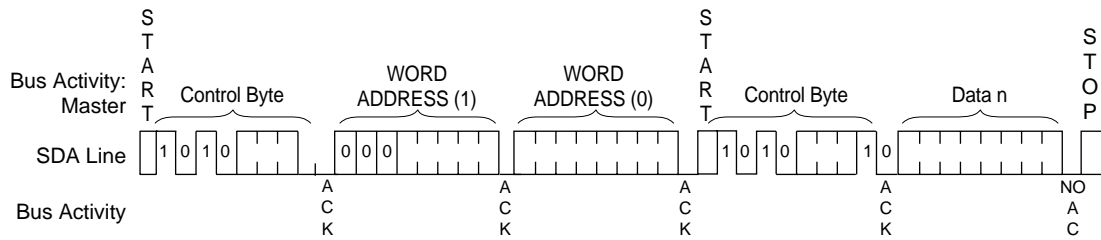


Current Address Read (Figure 7)



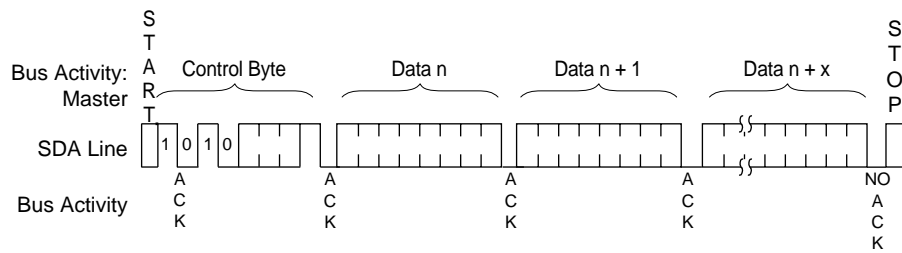
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Random Read (Figure 8)



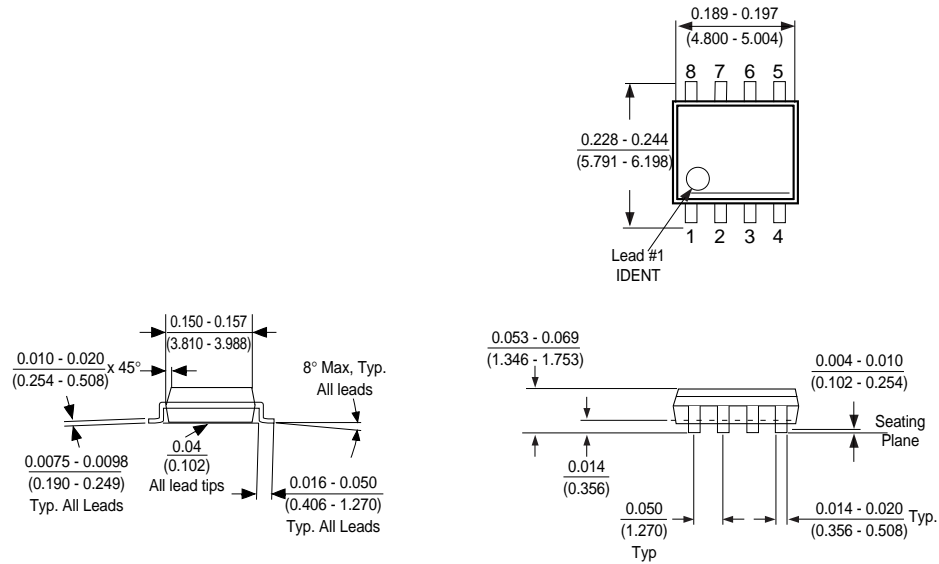
DS500073-11

Sequential Read (Figure 9)



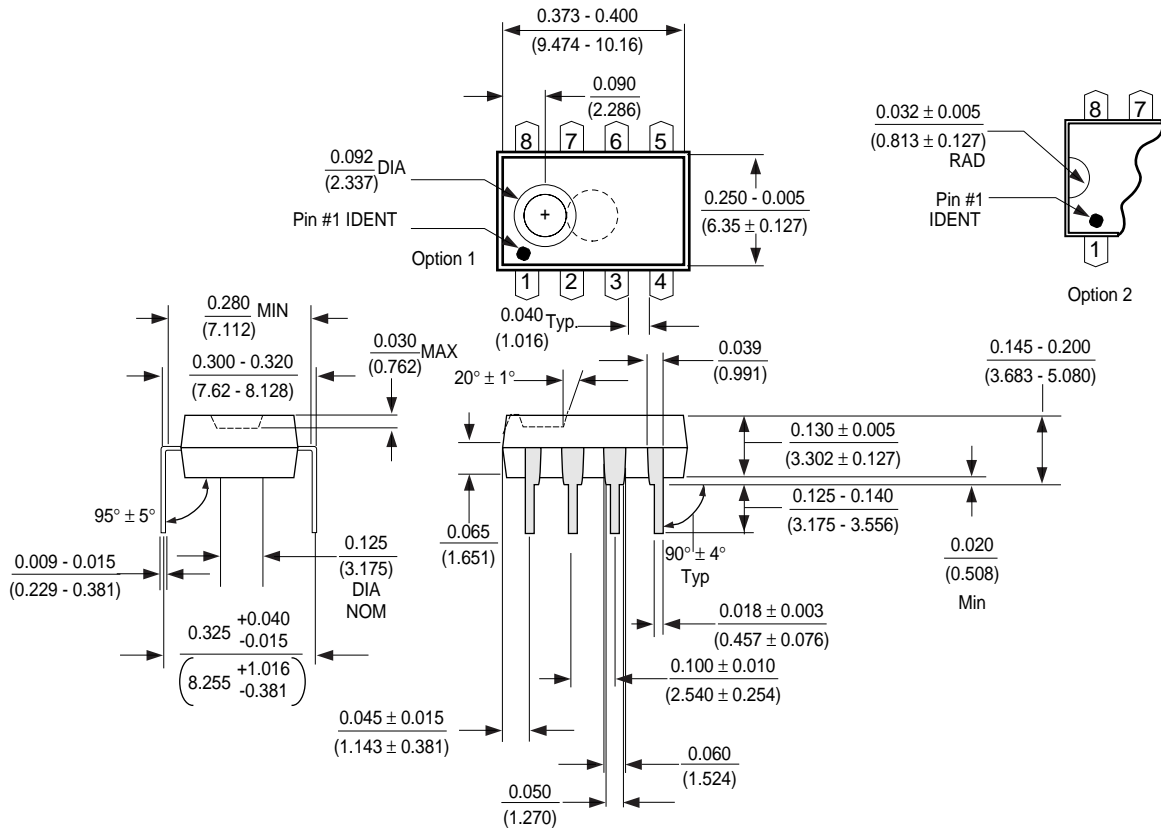
DS500073-12

Physical Dimensions inches (millimeters) unless otherwise noted



**Molded Small Out-Line Package (M8)
Order Number NM24C32xxxM8 or NM24C32xxxEM8
Package Number M08A**

Physical Dimensions inches (millimeters) unless otherwise noted



Molded Dual-In-Line Package (N)
Order Number NM24C32xxxN or NM24C32xxxEN
Package Number N08E

Life Support Policy

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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