National Semiconductor

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NM93C86AL
16,384-Bit Serial Interface, Low Voltage CMOS EEPROM (MICROWIRE™ Synchronous Bus)

NM93C86AL 16,384-Bit Serial Interface, Low Voltage CMOS EEPROM (MICROWIRE Synchronous Bus)

General Description

The NM93C86AL is 16,384 bits of CMOS nonvolatile, electrically erasable memory available user organized as either 1024 16-bit registers or 2048 8-bit registers. The user organization is determined by the status of the ORG input. The memory device is fabricated using National Semiconductor's floating gate CMOS process for high reliability, high endurance, and low power consumption. The NM93C86AL is available in an 8-pin SO package for space considerations.

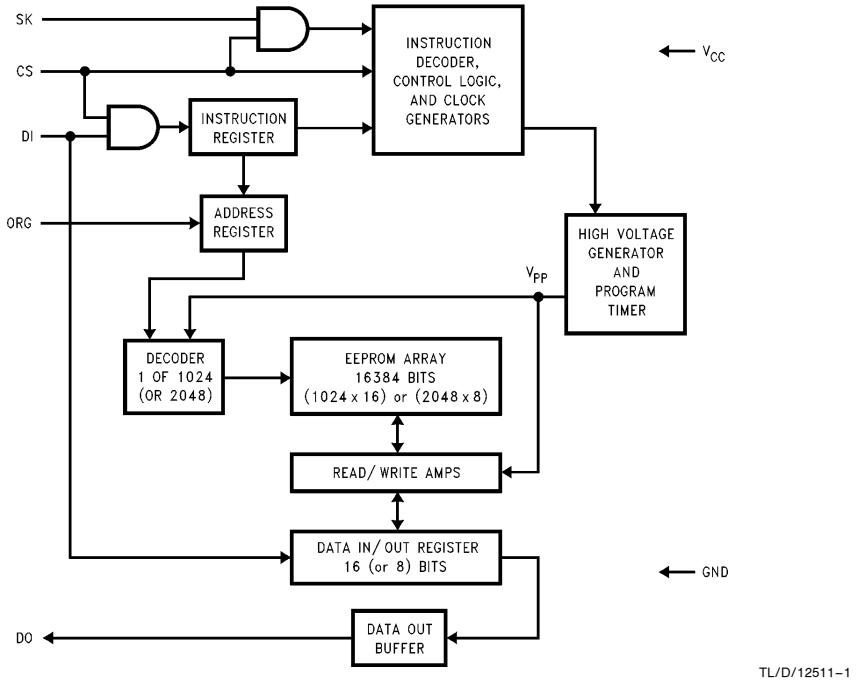
The EEPROM is MICROWIRE compatible for simple interfacing to a wide variety of microcontrollers and microprocessors. There are 7 instructions that operate the NM93C86AL: Read, Erase/Write Enable, Erase, Write, Erase/Write Disable, Write All, and Erase All.

The NM93C86AL defaults to the 1024 x 16 configuration if the ORG pin (Pin 6) is left floating, as it is internally pulled up to V_{CC}.

Features

- 2.7V to 5.5V operation in all modes
- Typical active current of 100 μA; Typical standby current of 1 μA
- Device status indication during programming mode
- No erase required before write
- Reliable CMOS floating gate technology
- MICROWIRE compatible serial I/O
- Self-timed programming cycle
- 40 years data retention
- Endurance: 10^6 data changes
- Packages available: 8-pin SO, 8-pin DIP

Block Diagram



TL/D/12511–1

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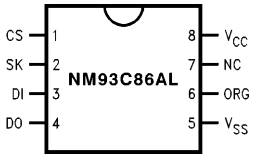
Connection Diagram

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



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Top View

See NS Package Number
N08E and M08A

Pin Names

CS	Chip Select
SK	Serial Data Clock
DI	Serial Data Input
DO	Serial Data Output
V_{SS}	Ground
ORG	Memory Organizational Select
NC	No Connect
V_{CC}	Positive Power Supply

Ordering Information

Commercial Temp. Range (0°C to + 70°C)

Order Number
NM93C86ALN NM93C86ALM8

Extended Temp. Range (−40°C to + 85°C)

Order Number
NM93C86ALEN NM93C86ALEM8

Automotive Temp. Range (−40°C to + 125°C)

Order Number
NM93C86ALVN NM93C86ALVM8

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Ambient Storage Temperature	−65°C to +150°C
All Input or Output Voltage with Respect to Ground	V_{CC} + 1 to −0.3V
Lead Temperature (Soldering, 10 sec.)	+300°C
ESD Rating	2000V

Operating Conditions

Ambient Operating Temperature	
NM93C86AL	0°C to +70°C
NM93C86ALE	−40°C to +85°C
NM93C86ALV	−40°C to +125°C
Power Supply (V_{CC}) Range	2.7V to 5.5V

DC and AC Electrical Characteristics 2.7V ≤ V_{CC} < 4.5V

Symbol	Parameter	Part Number	Condition	Min	Max	Units
I_{CCA}	Operating Current		CS = V_{IH}, f_{SK} = 250 kHz		1	mA
I_{CCS}	Standby Current		CS = 0V, ORG = V_{CC} or NC		50	μA
I_{IL}	Input Leakage		V_{IN} = 0V to V_{CC} (Note 2)	−1	1	μA
I_{ILO}	Input Leakage ORG pin		ORG tied to V_{CC} ORG tied to V_{SS} (Note 3)	−1 −2.5	1 2.5	μA
I_{OL}	Output Leakage		V_{IN} = 0V to V_{CC}	−1	1	μA
V_{IL}	Input Low Voltage			−0.1	0.15 V_{CC}	V
V_{IH}	Input High Voltage			0.8 V_{CC}	V_{CC} +1	V
V_{OL}	Output Low Voltage		I_{OL} = 10 μA		0.2	V
V_{OH}	Output High Voltage		I_{OH} = −10 μA	0.9 V_{CC}		V
f_{SK}	SK Clock Frequency		(Note 4)	0	250	kHz
t_{SKH}	SK High Time			1		μs
t_{SKL}	SK Low Time			1		μs
t_{CS}	Minimum CS Low Time		(Note 5)	1		μs
t_{CSS}	CS Set-up Time			0.2		μs
t_{DH}	DO Hold Time			70		ns
t_{DIS}	DI Set-up Time			0.4		μs
t_{CSH}	CS Hold Time			0		μs
t_{DIH}	DI Hold Time			0.4		μs
t_{PD1}	Output Delay to "1"				2	μs
t_{PD0}	Output Delay to "0"				2	μs
t_{SV}	CS to Status Valid				1	μs
t_{DF}	CS to DO in TRI-STATE®				0.4	μs
t_{WP}	Write Cycle Time				15	ms

DC and AC Electrical Characteristics $4.5V \leq V_{CC} < 5.5V$

Symbol	Parameter	Part Number	Condition	Min	Max	Units
I_{CCA}	Operating Current		CS = V_{IH}, f_{SK} = 250 kHz		1	mA
I_{CCS}	Standby Current		CS = 0V, ORG = V_{CC} or NC		50	μA
I_{IL}	Input Leakage		V_{IN} = 0V to V_{CC} (Note 2)	−1	1	μA
I_{ILO}	Input Leakage ORG pin		ORG tied to V_{CC} ORG tied to V_{SS} (Note 3)	−1 −2.5	1 2.5	μA
I_{OL}	Output Leakage		V_{IN} = 0V to V_{CC}	−1	1	μA
V_{IL}	Input Low Voltage			−0.1	0.8	V
V_{IH}	Input High Voltage			2	V_{CC} +1	V
V_{OL1}	Output Low Voltage		I_{OL} = 2.1 mA		0.4	V
V_{OH1}	Output High Voltage		I_{OH} = −400 μA	2.4		V
V_{OL2}	Output Low Voltage		I_{OL} = 10 μA		0.2	V
V_{OH2}	Output High Voltage		I_{OH} = −10 μA	V_{CC} − 0.2		V
f_{SK}	SK Clock Frequency		(Note 4)	0	1	MHz
t_{SKH}	SK High Time	NM93C86AL NM93C86ALE/V		250 300		ns
t_{SKL}	SK Low Time			250		ns
t_{CS}	Minimum CS Low Time		(Note 5)	250		ns
t_{CSS}	CS Set-up Time			50		ns
t_{DH}	DO Hold Time			70		ns
t_{DIS}	DI Set-up Time			100		ns
t_{CSH}	CS Hold Time			0		ns
t_{DIH}	DI Hold Time			20		ns
t_{PD1}	Output Delay to "1"				500	ns
t_{PD0}	Output Delay to "0"				500	ns
t_{SV}	CS to Status Valid				500	ns
t_{DF}	CS to DO in TRI-STATE				100	ns
t_{WP}	Write Cycle Time				10	ms

Capacitance $T_A = +25°C$, f = 1 MHz

Symbol	Test	Max	Units
C_{OUT}	Output Capacitance	5	pF
C_{IN}	Input Capacitance	5	pF

AC Test Conditions

Output Load	1 TTL Gate and $C_L = 100$ pF
Input Pulse Levels	0.4V and 2.4V
Timing Measurement Reference Level	
Input	1V and 2V
Output	0.8V and 2.0V

Note 1: Stress ratings above those listed under ''Absolute Maximum Ratings'' may cause permanent damage to the device. This is a stress rating only and operation of the device at these or any other conditions above those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: Typical leakage values are in the 20 nA range.

Note 3: The ORG pin may draw >1 μA when in the x8 mode due to an internal pull-up transistor.

Note 4: The shortest allowable SK clock period = $1/f_{SK}$ (as shown under the f_{SK} parameter). Maximum SK clock speed (minimum SK period) is determined by the interaction of several AC parameters stated in the datasheet. Within this SK period, both t_{SKH} and t_{SKL} limits must be observed. Therefore, it is not allowable to set $1/t_{SK} = t_{SKH(minimum)} + t_{SKL(minimum)}$ for shorter SK cycle time operation.

Note 5: CS (Chip Select) must be brought low (to V_{IL}) for an interval of t_{CS} in order to reset all internal device registers (device reset) prior to beginning another opcode cycle. (This is shown in the opcode diagrams in the following pages.)

Interface Pin Description

Chip Select (CS):

Chip Select performs several functions. It is used to differentiate between various devices on the same MICROWIRE bus. The rising edge resets the internal circuitry of the device, a function necessary prior to initiating a new cycle. Chip Select (as shown on Block Diagram) also gates the Data Input (DI) and Serial Clock (SK) Input, to disable these functions. In the case of these EEPROMs, Chip Select cannot be tied HIGH even if it is the only device on the bus.

Chip Select must be held HIGH continuously during the course of clocking in the start bit, op-code address, and data-in or data-out. Otherwise the internal circuits will reset and the cycle will have to be started again with a new start bit.

Chip Select initiates the internal programming cycle. The falling edge of Chip Select will start the internal asynchronous programming cycle after a programming op-code has been entered (Erase, Write, Erase All, or Write All). In conjunction with Chip Select, Data-Out (DO) will indicate when programming is complete. If the internal programming is incomplete, then Data-Out pin will be LOW. Then when the internal programming is complete, the Data-Out pin will be HIGH (see Timing Diagrams).

Serial Clock (SK):

The Serial Clock input is used to clock all start bits, op-codes, data, addresses, and data bits into or out of the EEPROMs. The clock's rising edge controls the input and output of bits. The falling edge has no effect on the device. The Serial Clock is not necessary for the asynchronous Ready/Busy polling function.

The Serial Clock is in a ''Don't Care'' at any time Chip Select is LOW. It is also in a ''Don't Care'' state prior to clocking in a start bit, or during Ready/Busy polling. During either of these last two conditions, Data-In (DI) must be held at a LOW level, otherwise a new start bit will be interpreted.

Data-In (DI):

The Data-In pin receives the start bit, address, and input data synchronously. Each bit is clocked in on the rising edge of SK. DI is gated by Chip Select to provide a high degree of noise immunity. Data-In is routed to both the instruction shift register and the data shift register. After the start bit is clocked into the last bit of the instruction register, the clock is switched to the data register to receive input data. To avoid false reading of a start bit, it is safer to keep the Data-In pin at LOW level when not in use.

Data-Out (DO):

The Data-Out pin sends Read data onto the MICROWIRE bus and it is clocked out on the rising edge of the Serial Clock. During the Read cycle, the DO output begins to drive actively after the last address bit (A0) is clocked in.

Data-Out also carries the device's status during the asynchronous programming cycle. The Data-Out pin drives LOW while the device is still in its internal programming cycle. After the EEPROM has completed this internal programming, Data-Out will drive HIGH. This is accomplished while Chip Select is held HIGH.

Finally, if Chip Select is pulsed LOW to HIGH, Data-Out pin will again produce a pulse HIGH. Thus indicating the completion of the programming cycle.

To clear the Ready/Busy polling, it is necessary to raise Chip Select and clock in another start bit. Once the start bit is clocked in, Data-Out will return to the HIGH impedance state. It is not necessary to continue with a cycle after this start bit has been clocked in, although it is permissible to start a new cycle with this start bit. This clearing of Ready/Busy status may be necessary if a bidirectional data bus is used (Data-In tied to Data-Out) as the Data-Out output will interfere with the new data being presented on the Data-In pin. This connecting of the two Data pins is used for three-wire interface schemes.

Organization (ORG):

The Organization input (ORG) is available on the NM93C86AL device and it is used to control the internal organization of the memory. The two selectable organizations are 16-bit words and 8-bit words. By connecting the ORG pin to V_{CC}, 16-bit words are selected. In contrast, by connecting the ORG pin to GND, 8-bit words are selected. If the ORG pin is left floating, then default setting is the 16-bit word. When in the 8-bit mode, one additional address bit is required in the instruction sequence since the depth of the memory is doubled.

Instruction Set for the NM93C86AL

The NM93C86AL has 7 instructions as described below. Note that the MSB of any instruction is a ''1'' and is viewed as a start bit in the interface sequence. The next 2 bits carry the op code, the next 10 (or 11) bits carry the address for selection of 1 of 1024 16-bit registers or 1 of 2048 8-bit registers, depending on memory array organization.

1024 by 16-Bit Organization (NM93C86AL when ORG = V_{CC} or NC)

Instruction	SB	OP-Code 2 Bits	Address 10 Bits	Data 16 Bits	Function
READ	1	10	A9–A0		Read data stored in selected register.
EWEN	1	00	11XXXXXXXX		Enables programming modes.
EWDS	1	00	00XXXXXXXX		Disables all programming modes.
ERASE	1	11	A9–A0		Erases selected register.
WRITE	1	01	A9–A0	D15–D0	Writes data pattern D15–D0 into selected register.
ERAL	1	00	10XXXXXXXX		Erases all registers.
WRAL	1	00	01XXXXXXXX	D15–D0	Writes data pattern D15–D0 into all registers.

2048 by 8-Bit Organization (NM93C86AL when ORG = GND)

Instruction	SB	OP-Code 2 Bits	Address 11 Bits	Data 18 Bits	Function
READ	1	10	A10–A0		Read data stored in selected register.
EWEN	1	00	11XXXXXXXXX		Enables programming modes.
EWDS	1	00	00XXXXXXXXX		Disables all programming modes.
ERASE	1	11	A10–A0		Erases selected register.
WRITE	1	01	A10–A0	D7–D0	Writes data pattern D7–D0 into selected register.
ERAL	1	00	10XXXXXXXXX		Erases all registers.
WRAL	1	00	01XXXXXXXXX	D7–D0	Writes data pattern D7–D0 into all registers.

Functional Description

Device	ORG Pin Logic	Memory	
		Configuration	# of Address Bits
NM93C86AL	0	2048 x 8	11 Bits
	1	1024 x 16	10 Bits

Programming

The programming cycle for both devices is automatically started after entering the D0 data bit; independent of the status of the CS input pin. This feature allows a programming instruction (ERASE/WRITE/ERAL/WRAL) to be cancelled at any time before entering the last data bit (D0). This is accomplished by forcing the CS input pin low (for t_{CS}) at any time before the DO data bit is clocked in. Note that the CS input pin can be brought low after the D0 bit is clocked in, to maintain compatibility with the other family members, but is not necessary to start a programming cycle.

In all programming modes the READY/BUSY status of the device can be determined by polling the DO pin. After clocking in the last bit of the instruction sequence and with the CS held ''high'', the DO pin will exit the high impedance state and indicate the READY/BUSY status of the device. DO = logical ''0'' indicates that programming is still in progress and no other instruction can be executed. DO = logical ''1'' indicates that the device is READY for another instruction. If CS is forced ''low'' the DO pin will return to the high impedance state. After the programming cycle has been completed and DO = logical ''1'', the DO pin can be reset back to the high impedance state by clocking a logical ''1'' into the DI pin. (This is also performed with the start bit on all op codes, thus clocking an instruction has the same effect.)

Read (READ)

The READ instruction outputs serial data on the DO pin. After a READ instruction is received, the instruction and address are decoded, followed by data transfer from the selected memory register into a serial-out shift register. A dummy bit (logical 0) precedes the serial data output string. Output data changes are initiated by a low to high transition of the SK clock after the last address bit (A0) is clocked in.

Functional Description (Continued)

Erase/Write Enable (EWEN)

When V_{CC} is applied to the part, it ''powers up'' in the Erase/Write Disable (EWDS) state. Therefore, all programming modes must be preceded by an Erase/Write Enable (EWEN) instruction. Once an Erase/Write Enable instruction is executed, programming remains enabled until an Erase/Write Disable (EWDS) instruction is executed or V_{CC} is removed from the part.

Erase/Write Disable (EWDS)

To protect against accidental data overwrites, the Erase/Write Disable (EWDS) instruction disables all programming modes and should follow all programming operations. Execution of a READ instruction is independent of both the EWEN and EWDS instructions.

Erase (ERASE)

The ERASE instruction will program all bits in the specified register to the logical ''1'' state. The self-timed programming cycle is initiated on the rising edge of the SK clock as the last address bit (A0) is clocked in. At this point CS, SK, and DI become don't care states. After starting an ERASE cycle the DO pin indicates the READY/BUSY status of the chip if CS is held ''high''. DO = logical ''0'' indicates that programming is still in progress. DO = logical ''1'' indicates that the register, at the address specified in the instruction, has been erased.

Write (WRITE)

The WRITE instruction is followed by 16 bits of data (or 8 bits of data when using the NM93C86AL in the x8 organization) to be written into the specified address. Note that if the CS is brought ''low'' before clocking in all of the data bits, then the WRITE instruction will be aborted. The self-timed programming cycle is initiated on the rising edge of the SK clock as the last data bit (D0) is clocked in. At this point, CS, SK and DI become don't care states. No separate ERASE cycle is required before a WRITE instruction.

As in the ERASE instruction, after starting a WRITE cycle, the DO pin indicates the READY/BUSY status of the chip if CS is held ''high''. DO = logical ''0'' indicates that programming is still in progress. DO = logical ''1'' indicates that the register, at the address specified in the instruction, has been written and that the part is ready for another instruction.

Erase All (ERAL)

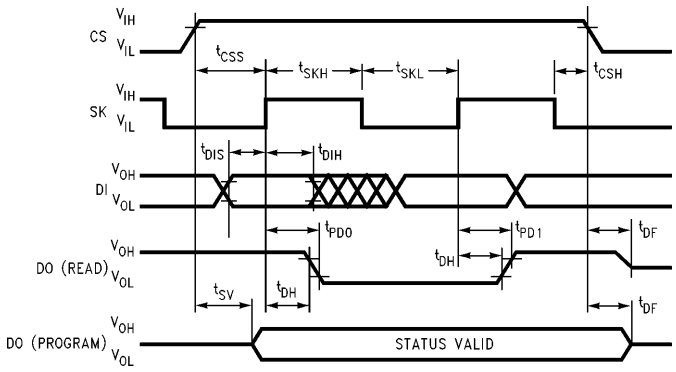
The ERAL instruction will simultaneously program all registers in the memory array to the logical ''1'' state.

Write All (WRAL)

The WRAL instruction will simultaneously program all registers with the data pattern specified in the instruction.

Timing Diagrams for the NM93C86AL

Synchronous Data Timing



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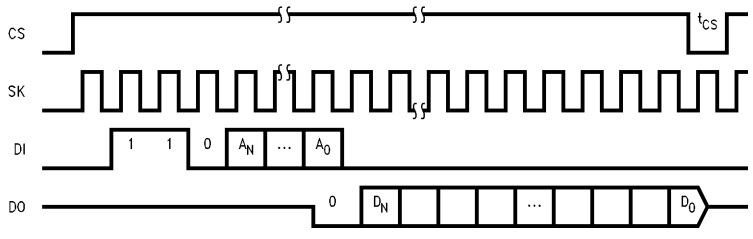
Timing Diagrams (Continued)

Organization of Address and Data Fields for the NM93C86AL

Org	Organization	A_N	D_N
V_{CC} or NC	1024 x 16	A9	D15
V_{SS}	2048 x 8	A10	D7

READ



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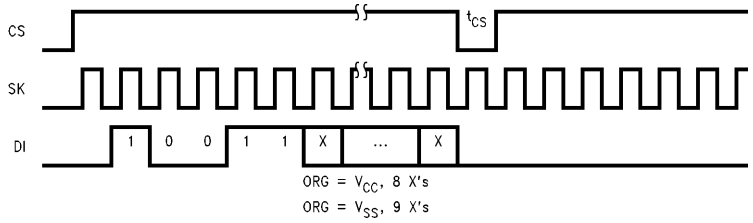
EWEN
DO = TRI-STATE



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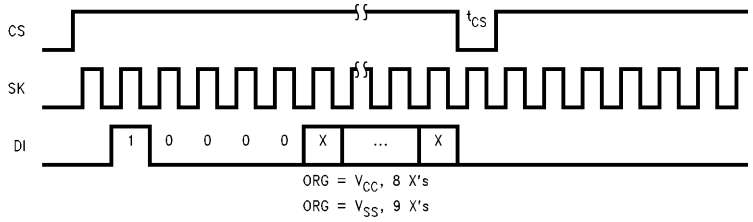
EWDS
DO = TRI-STATE



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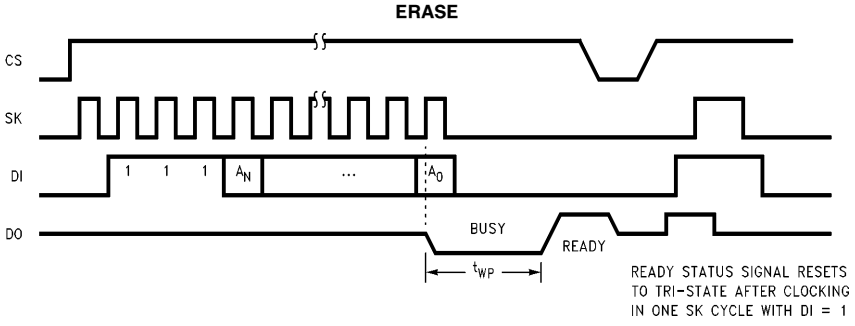
ERASE



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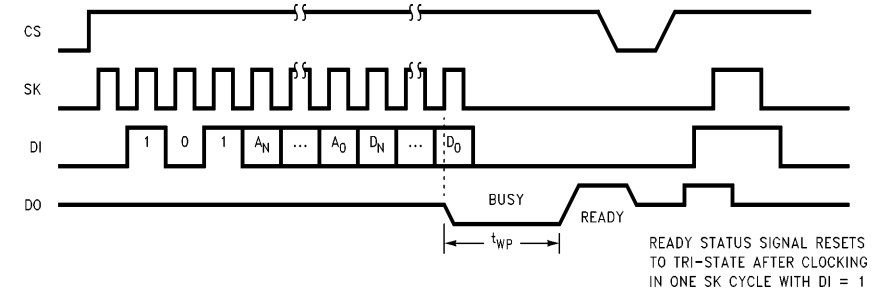
Timing Diagrams (Continued)

WRITE



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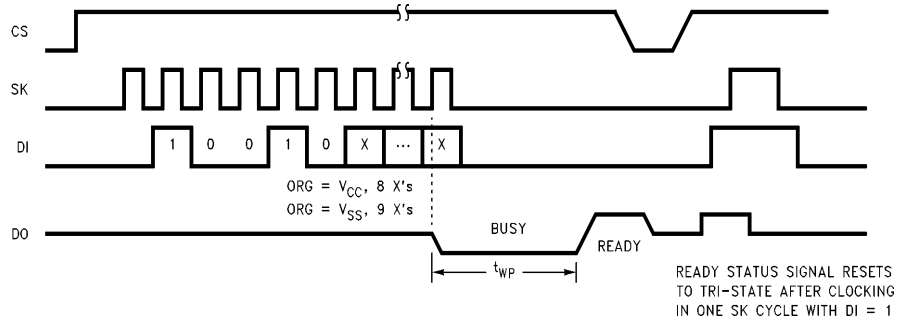
ERAL



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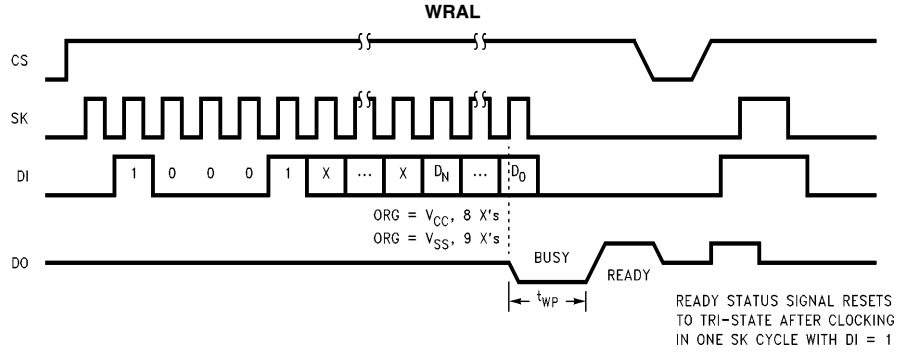
WRAL



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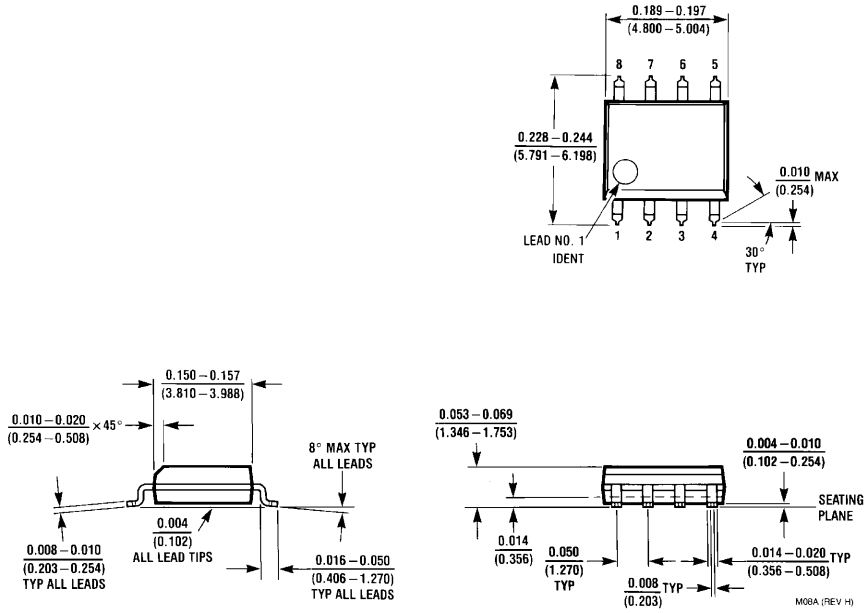
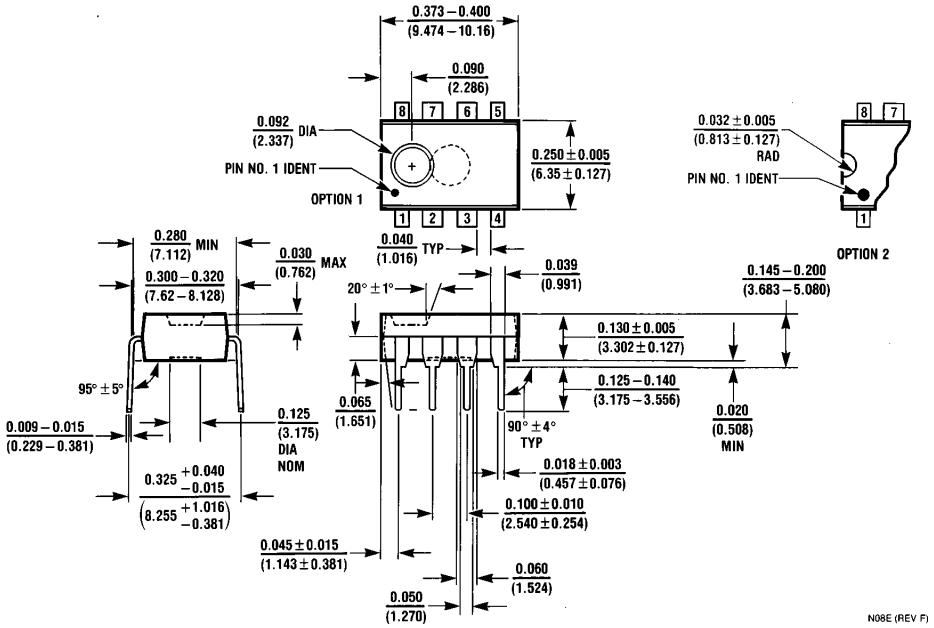
Physical Dimensions inches (millimeters) unless otherwise noted



Molded Small Out-Line Package (M8)
NS Package Number M08A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Molded Dual-In-Line Package (N)
NS Package Number N08E

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