National Semiconductor

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# DS1651/DS3651
# Quad High Speed MOS Sense Amplifiers

## General Description

The DS1651/DS3651 is TTL compatible high speed circuits intended for sensing in a broad range of MOS memory system applications. Switching speeds have been enhanced over conventional sense amplifiers by application of Schottky technology, and TRI-STATE® strobing is incorporated, offering a high impedance output state for bused organization.

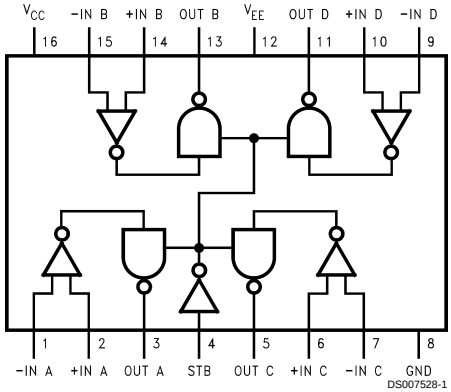
The DS1651/DS3651 has active pull-up outputs and offers open collector outputs providing implied "AND" operations.

## Features

- High speed
- TTL compatible
- Input sensitivity — ±7 mV
- TRI-STATE outputs for high speed buses
- Standard supply voltages — ±5V
- Pin and function compatible with MC3430

## Connection Diagram

**Dual-in-Line Package**




**Top View**
**Order Number DS1651J, DS3651J or DS3651N**
**See NS Package Number J16A or N16A**

## Truth Table

| Input | Strobe | Output |
|---|---|---|
| | | DS3651 |
| $V_{ID} \geq 7$ mW<br>$T_A = 0^\circ C$ to $+70^\circ C$ | L<br>H | H<br>Open |
| $-7$ mV $\leq V_{ID} \leq +7$ mV<br>$T_A = 0^\circ C$ to $+70^\circ C$ | L<br>H | X<br>Open |
| $V_{ID} \leq -7$ mV<br>$T_A = 0^\circ C$ to $+70^\circ C$ | L<br>H | L<br>Open |

L = Low logic state
H = High logic state
Open = TRI-STATE
X = Indeterminate state

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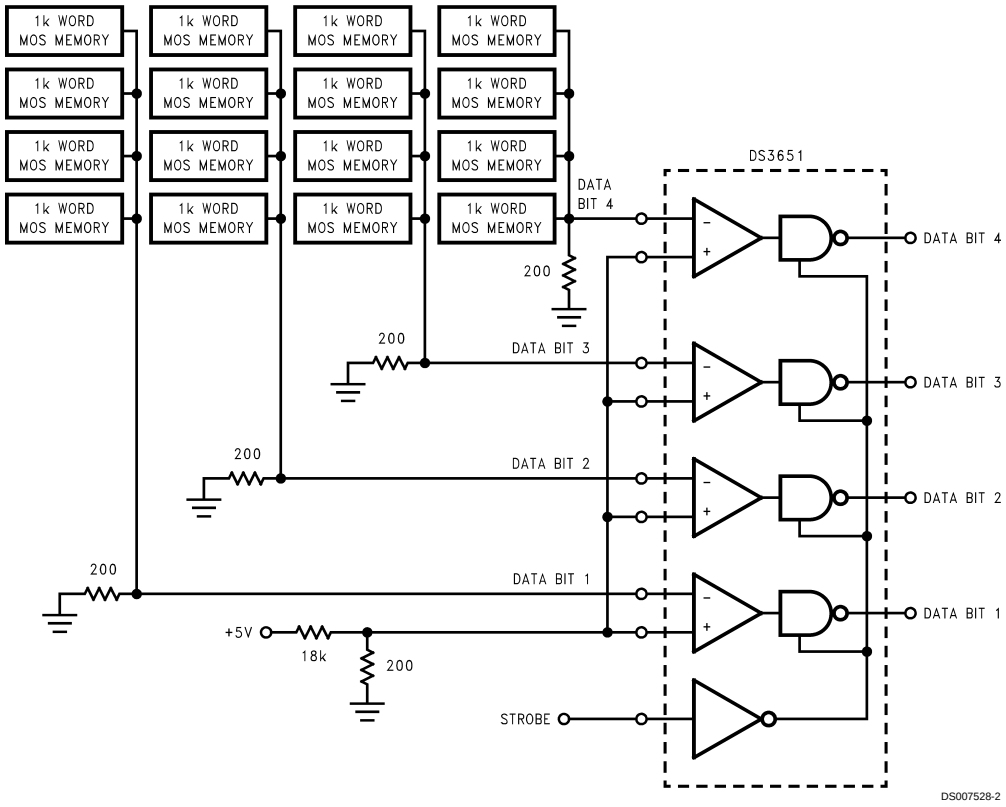
## Typical Applications

**A Typical MOS Memory Sensing Application for a 4k work by 4-bit Memory Arrangement Employing 1103 Type Memory Devices**




**Note:** Only 4 devices are required for a 4k word by 16-bit memory system.

## Absolute Maximum Ratings (Note 2)

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

| | |
|---|---|
| Power Supply Voltages | |
| $V_{CC}$ | +7 $V_{DC}$ |
| $V_{EE}$ | −7 $V_{DC}$ |
| Differential-Mode Input Signal Voltage Range, $V_{IDR}$ | ±6 $V_{DC}$ |
| Common-Mode Input Voltage Range, $V_{ICR}$ | ±5 $V_{DC}$ |
| Strobe Input Voltage, $V_{I(S)}$ | 5.5 $V_{DC}$ |
| Strobe Temperature Range | −65˚C to +150˚C |
| Maximum Power Dissipation (Note 1) at 25˚C | |
| Cavity Package | 1509 mW |
| Molded Package | 1476 mW |
| Lead Temp. (Soldering, 10 seconds) | 300˚C |

## Operating Conditions

| | Min | Max | Unit |
|---|---|---|---|
| Supply Voltage ($V_{CC}$) | | | |
| DS1651 | 4.5 | 5.5 | V |
| DS3651 | 4.75 | 5.25 | V |
| Supply Voltage ($V_{EE}$) | | | |
| DS1651 | −4.5 | −5.5 | V |
| DS3651 | −4.75 | −5.25 | V |
| Operating Temperature ($T_A$) | | | |
| DS1651 | −55 | +125 | ˚C |
| DS3651 | 0 | +70 | ˚C |
| Output Load Current, ($I_{OL}$) | | 16 | mA |
| Differential Mode Input Voltage Range, ($V_{IDR}$) | −5.0 | +5.0 | V |
| Common-Mode Input Voltage Range, ($V_{ICR}$) | −3.0 | +3.0 | V |
| Input Voltage Range (Any Input to GND), ($V_{IR}$) | −5.0 | +3.0 | V |

## Electrical Characteristics

$V_{CC}$ = 5 $V_{DC}$, $V_{EE}$ = −5 $V_{DC}$, Min ≤ $T_A$ ≤ Max, unless otherwise noted (Notes 3, 4)

| Symbol | Parameter | Conditions | | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|---|
| $V_{IS}$ | Input Sensitivity (Note 6) (Common-Mode Voltage Range) $V_{ICR}$ = −3V ≤ $V_{IN}$ ≤ +3V | Min ≤ $V_{CC}$ ≤ Max<br>Min ≥ $V_{EE}$ ≥ Max | | | | | ±7.0 | mV |
| $V_{IO}$ | Input Offset Voltage | | | | | 2 | | mV |
| $I_{IB}$ | Input Bias Current | $V_{CC}$ = Max, $V_{EE}$ = Max | | | | | 20 | µA |
| $I_{IO}$ | Input Offset Current | | | | | 0.5 | | µA |
| $V_{IL(S)}$ | Strobe Input Voltage (Low State) | | | | | | 0.8 | V |
| $V_{IH(S)}$ | Strobe Input Voltage (High State) | | | | 2 | | | V |
| $I_{IL(S)}$ | Strobe Current (Low State) | $V_{CC}$ = Max, $V_{EE}$ = Max, $V_{IN}$ = 0.4V | | | | | −1.6 | mA |
| $I_{IL(S)}$ | Strobe Current (High State) | $V_{CC}$ = Max, $V_{EE}$ = Max | $V_{IN}$ = 2.4V | DS3651 | | | 40 | µA |
| | | | $V_{IN}$ = $V_{CC}$ | | | | 1 | mA |
| | | | $V_{IN}$ = 2.4V | DS1651 | | | 100 | µA |
| | | | $V_{IN}$ = $V_{CC}$ | | | | 1 | mA |
| $V_{OH}$ | Output Voltage (High States) | $V_{CC}$ = Min, $V_{EE}$ = Min | $I_O$ = −400 µA | DS1651/DS3651 | 2.4 | | | V |
| $V_{OL}$ | Output Voltage (Low State) | $V_{CC}$ = Min, $V_{EE}$ = Min | $I_O$ = 16 mA | DS3651 | | | 0.45 | V |
| | | | | DS1651 | | | 0.50 | |
| $I_{OS}$ | Output Current Short Circuit | $V_{CC}$ = Max, $V_{EE}$ = Max, (Note 5) | | DS1651/DS3651 | −18 | | −70 | mA |
| $I_{OFF}$ | Output Disable Leakage Current | $V_{CC}$ = Max, $V_{EE}$ = Max | | DS3651 | | | 40 | µA |
| | | | | DS1651 | | | 100 | µA |
| $I_{CC}$ | High Logic Level Supply Current | $V_{CC}$ = Max, $V_{EE}$ = Max | | | | 45 | 60 | mA |
| $I_{EE}$ | High Logic Level Supply Current | $V_{CC}$ = Max, $V_{EE}$ = Max | | | | −17 | −30 | mA |

## Switching Characteristics

$V_{CC}$ = 5 $V_{DC}$, $V_{EE}$ = −5 $V_{DC}$, $T_A$ = 25˚C unless otherwise noted.

| Symbol | Parameter | Conditions | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| $t_{PHL(D)}$ | High-to-Low Logic Level Propagation Delay Time (Differential Inputs) | 5 mV + $V_{IS}$, (*Figure 2*) | DS1651/ DS3651 | | 23 | 45 | ns |
| $t_{PLH(D)}$ | Low-to-High Logic Level Propagation Delay Time (Differential Inputs) | 5 mV + $V_{IS}$, (*Figure 2*) | DS1651/ DS3651 | | 22 | 55 | ns |
| $t_{POH(S)}$ | TRI-STATE to High Logic Level Propagation Delay Time (Strobe) | (*Figure 1*) | DS1651/ DS3651 | | 16 | 21 | ns |
| $t_{PHO(S)}$ | High Logic Level to TRI-STATE Propagation Delay Time (Strobe) | (*Figure 1*) | DS1651/ DS3651 | | 7 | 18 | ns |
| $t_{POL(S)}$ | TRI-STATE to Low Logic Level Propagation Delay Time (Strobe) | (*Figure 1*) | DS1651/ DS3651 | | 19 | 27 | ns |
| $t_{PLO(S)}$ | Low Logic Level to TRI-STATE Propagation Delay Time (Strobe) | (*Figure 1*) | DS1651/ DS3651 | | 14 | 29 | ns |

**Note 1:** Derate cavity package 10.1 mW/˚C above 25˚C; derate molded package 11.8 mW/˚C above 25˚C.

**Note 2:** "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. Except for "Operating Temperature Range" they are not meant to imply that the device should be operated at these limits. The table of "Electrical Characteristics" provides conditions for actual device operation.

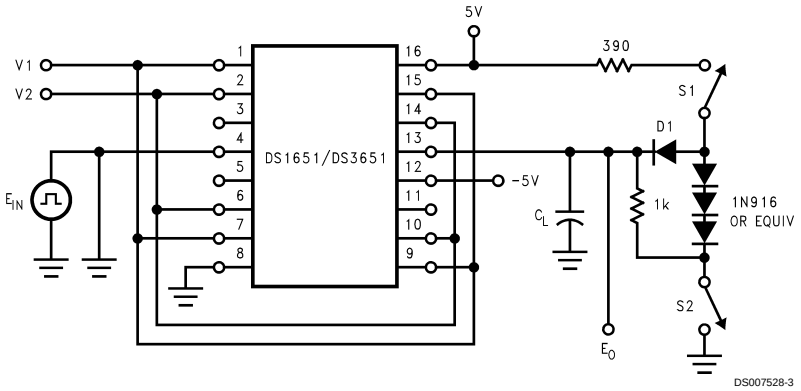
**Note 3:** Unless otherwise specified min/max limits apply across the 0˚C to +70˚C range for the DS3651 and across the −55˚C to +125˚C range for the DS1651. All typical values are for $T_A$ = 25˚C, $V_{CC}$ = 5V and $V_{EE}$ = −5V.

**Note 4:** All currents into device pins shown as positive, out of device pins as negative, all voltages referenced to ground unless otherwise noted. All values shown as max or min on absolute value basis.

**Note 5:** Only one output at a time should be shorted.

**Note 6:** A parameter which is of primary concern when designing with sense amplifiers is, what is the minimum differential input voltage required at the sense amplifier input terminals to guarantee a given output logic state. This parameter is commonly referred to as threshold voltage. It is well known that design considerations of threshold voltage are plagued by input offset currents, bias currents, network source resistances, and voltage gain. As a design convenience, the DS1651 and DS3651 are specified to a parameter called input sensitivity ($V_{IS}$). This parameter takes into consideration input offset currents and bias currents, and guarantees a minimum input differential voltage to cause a given output logic state with respect to a maximum source impedance of 200Ω at each input.

## Switching Time Waveform




**Note:** Output of channel B shown under test, other channels are tested similarly.

| Delay | V1 | V2 | S1 | S2 | $C_L$ |
|---|---|---|---|---|---|
| $t_{PLO(S)}$) | 100 mV | GND | Closed | Closed | 15 pF |
| $t_{POL(S)}$ | 100 mV | GND | Closed | Open | 50 pF |
| $t_{PHO(S)}$ | GND | 100 mV | Closed | Closed | 15 pF |
| $t_{POH(S)}$ | GND | 100 mV | Open | Closed | 50 pF |

$C_L$ includes jig and probe capacitance.
$E_{IN}$ waveform characteristics: $t_{TLH}$ and $t_{THL} \leq$ 10 ns measured 10% to 90%
PRR = 1 MHz
Duty cycle = 50%

## AC Test Circuits

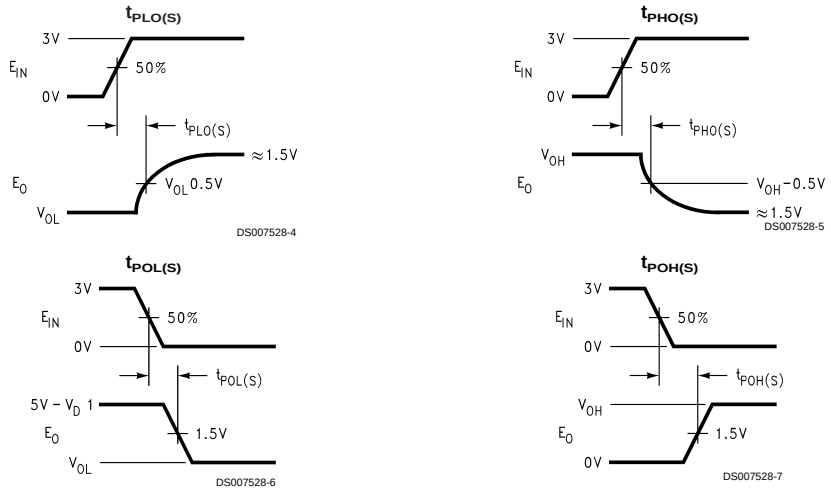
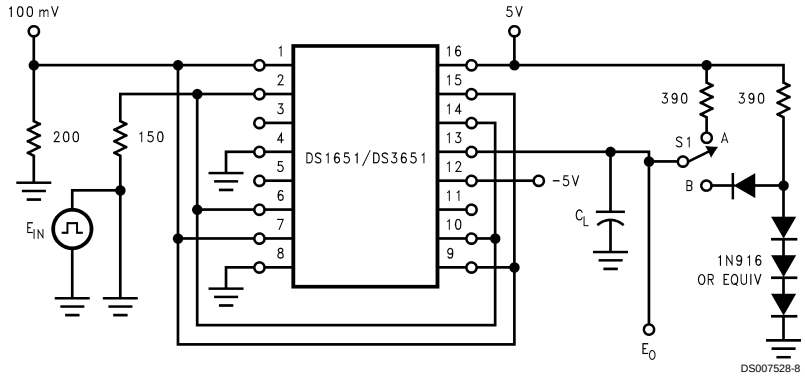
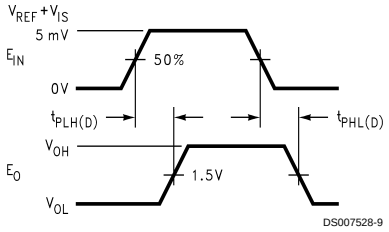



**FIGURE 1. Strobe Propagation Delay $t_{PLO(S)}$, $t_{POL(S)}$, $t_{PHL(S)}$ and $t_{POH(S)}$**




**Note:** Output of channel B shown under test, other channels are tested similarly.
S1 at "B" for DS1651/DS3651, $C_L$ = 50 pF total for DS1651/DS3651.

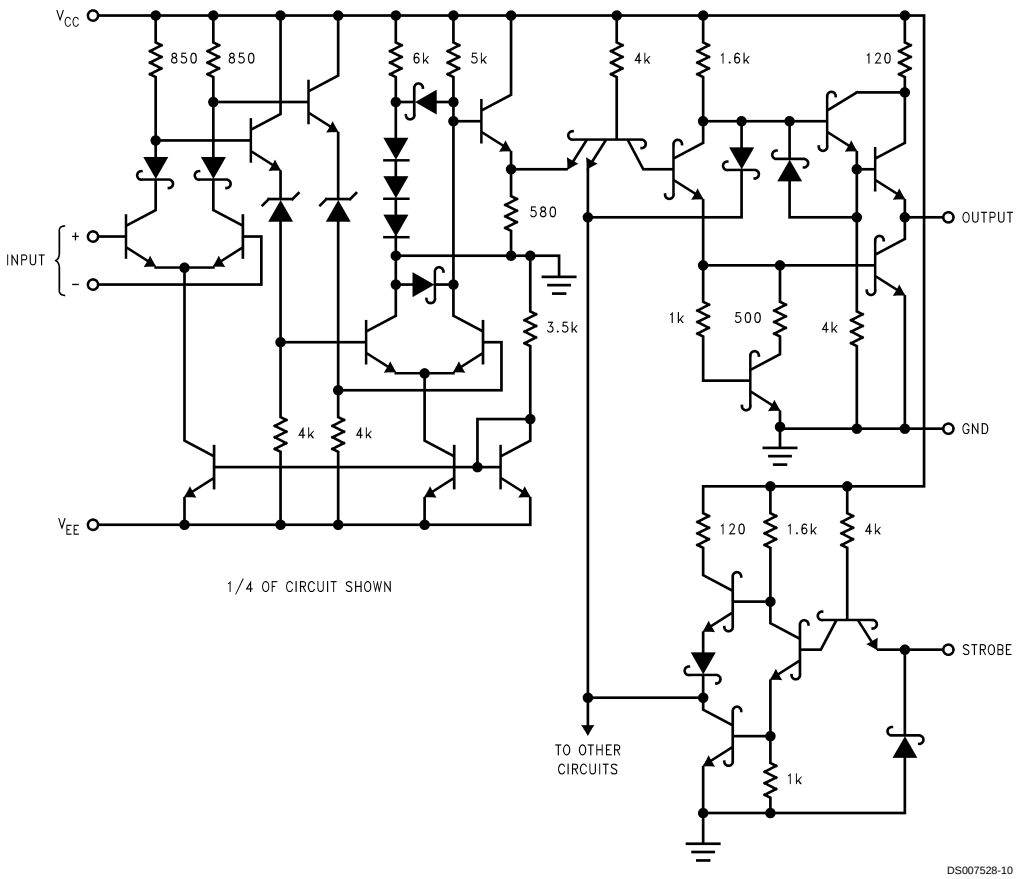



$E_{IN}$ waveform characteristics:
$t_{TLH}$ and $t_{THL} \leq$ 10 ns measured 10% to 90%
PRR = 1 MHz, duty cycle = 500 ns

**FIGURE 2. Differential Input Propagation Delay $t_{PLH(D)}$ and $t_{PHL(D)}$**

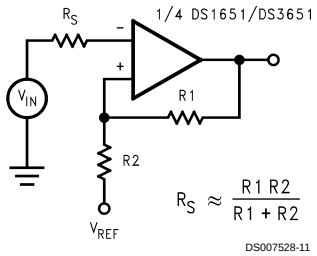
## Schematic Diagrams

**DS1651/DS3651**



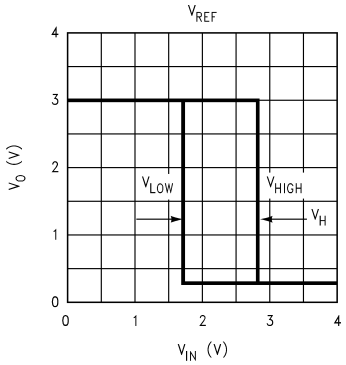
## Typical Applications

**Level Detector with Hysteresis**




DS007528-11

**Transfer Characteristics and Equations for Level Detector with Hysteresis**




DS007528-12

$$V_{HIGH} = V_{REF} + \frac{R2\,[V_{O(MAX)} - V_{REF}]}{R1 + R2}$$

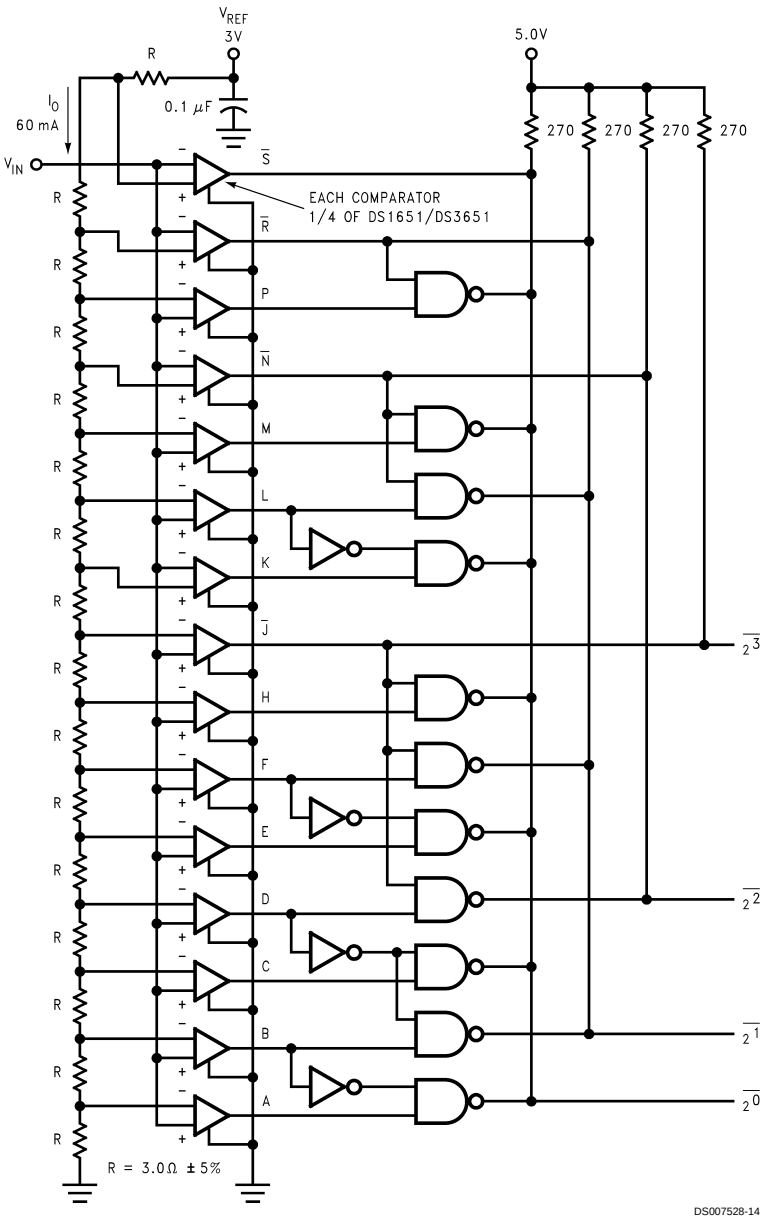
$$V_{LOW} = V_{REF} + \frac{R2\,[V_{O(MIN)} - V_{REF}]}{R1 + R2}$$

Hysteresis Loop ($V_H$)

$$V_H = V_{HIGH} - V_{LOW} = \frac{R2}{R1 + R2}\,[V_{O(MAX)} - V_{O(MIN)}]$$

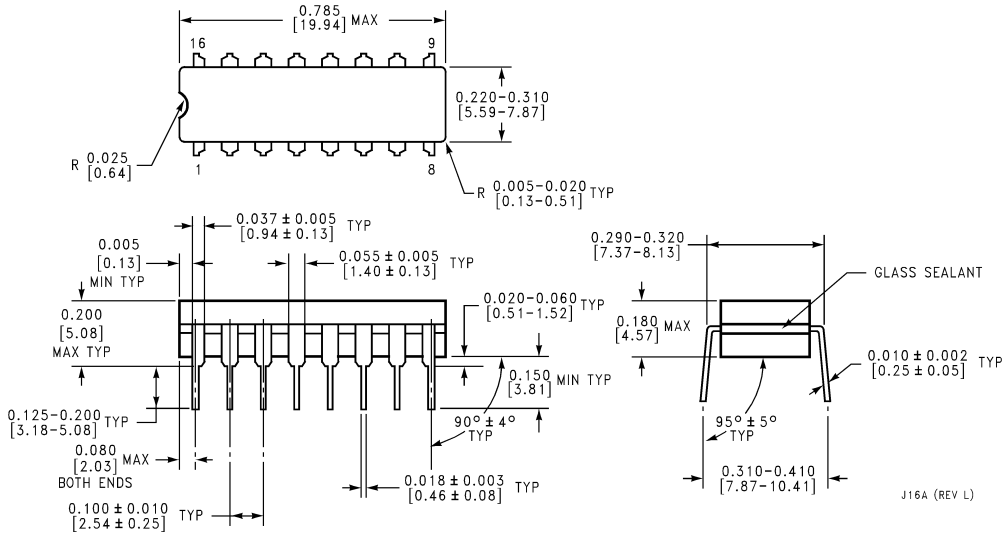
## Typical Applications (Continued)

**4-Bit Parallel A/D Converter**

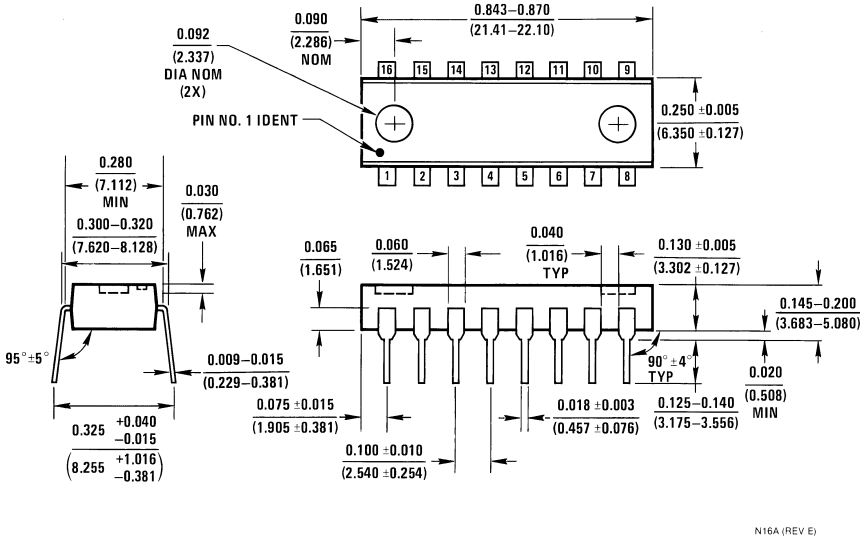



$2^{\overline{0}} = (\overline{A} + B)\ (\overline{C} + D)\ (\overline{E} + F)\ (\overline{H} + J)\ (\overline{K} + L)\ (\overline{M} + N)\ (\overline{P} + R)\ (\overline{S})$
$2^{\overline{1}} = (\overline{B} + D)\ (\overline{F} + J)\ (\overline{L} + N)\ (\overline{R})$
$2^{\overline{2}} = (\overline{D} + J)\ (\overline{N})$
$2^{\overline{3}} = \overline{J}$
Conversion time ≅ 50 ns

## Physical Dimensions inches (millimeters) unless otherwise noted




**Ceramic Dual-in-Line Package (J)**
**Order Number DS1651J, DS1653J, DS3651J or DS3653J**
**NS Package Number J16A**




**Molded Dual-in-Line Package (N)**
**Order Number DS3651N or DS3653N**
**NS Package Number N16A**

## Notes

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