FAIRCHILD SEMICONDUCTOR™

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# CD4016BC
# Quad Bilateral Switch

## General Description

The CD4016BC is a quad bilateral switch intended for the transmission or multiplexing of analog or digital signals. It is pin-for-pin compatible with CD4066BC.

## Features

- Wide supply voltage range: 3V to 15V
- Wide range of digital and analog switching: ±7.5 $V_{PEAK}$
- "ON" resistance for 15V operation: 400Ω (typ.)
- Matched "ON" resistance over 15V signal input: $\Delta R_{ON}$ = 10Ω (typ.)
- High degree of linearity:
  - 0.4% distortion (typ.)
  - @ $f_{IS}$ = 1 kHz, $V_{IS}$ = 5 $V_{p-p}$,
  - $V_{DD}$–$V_{SS}$ = 10V, $R_L$ = 10 kΩ
- Extremely low "OFF" switch leakage:
  - 0.1 nA (typ.)
  - @ $V_{DD}$ − $V_{SS}$ = 10V
  - $T_A$ = 25°C
- Extremely high control input impedance: $10^{12}$Ω (typ.)
- Low crosstalk between switches:
  - –50 dB (typ.)
  - @ $f_{IS}$ = 0.9 MHz, $R_L$ = 1 kΩ
- Frequency response, switch "ON": 40 MHz (typ.)

## Applications

- Analog signal switching/multiplexing
  - Signal gating
  - Squelch control
  - Chopper
  - Modulator/Demodulator
  - Commutating switch
- Digital signal switching/multiplexing
- CMOS logic implementation
- Analog-to-digital/digital-to-analog conversion
- Digital control of frequency, impedance, phase, and analog-signal gain

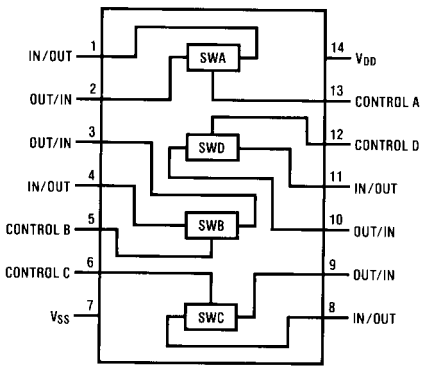
## Ordering Code:

| Order Number | Package Number | Package Description |
|---|---|---|
| CD4016BCM | M14A | 14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-120, 0.150" Narrow |
| CD4016BCN | N14A | 14-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide |

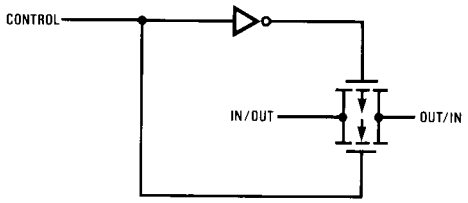
Devices also available in Tape and Reel. Specify by appending the letter suffix "X" to the ordering code.

## Connection Diagram

**Pin Assignments for DIP and SOIC**




## Schematic Diagram



## Absolute Maximum Ratings (Note 1)

(Note 2)

| | |
|---|---|
| $V_{DD}$ Supply Voltage | −0.5V to +18V |
| $V_{IN}$ Input Voltage | −0.5V to $V_{DD}$ + 0.5V |
| $T_S$ Storage Temperature Range | −65°C to + 150°C |
| Power Dissipation ($P_D$) | |
| Dual-In-Line | 700 mW |
| Small Outline | 500 mW |
| Lead Temperature | |
| (Soldering, 10 seconds) | 260°C |

## Recommended Operating Conditions (Note 2)

| | |
|---|---|
| $V_{DD}$ Supply Voltage | 3V to 15V |
| $V_{IN}$ Input Voltage | 0V to $V_{DD}$ |
| $T_A$ Operating Temperature Range | −40°C to +85°C |

**Note 1:** "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The tables of "Recommended Operating Conditions" and "Electrical Characteristics" provide conditions for actual device operation.

**Note 2:** $V_{SS}$ = 0V unless otherwise specified.

## DC Electrical Characteristics (Note 2)

| Symbol | Parameter | Conditions | −40°C | | 25°C | | | +85°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Typ | Max | Min | Max | |
| $I_{DD}$ | Quiescent Device | $V_{DD}$ = 5V, $V_{IN}$ = $V_{DD}$ or $V_{SS}$ | | 1.0 | | 0.01 | 1.0 | | 7.5 | µA |
| | Current | $V_{DD}$ = 10V, $V_{IN}$ = $V_{DD}$ or $V_{SS}$ | | 2.0 | | 0.01 | 2.0 | | 15 | µA |
| | | $V_{DD}$ = 15V, $V_{IN}$ = $V_{DD}$ or $V_{SS}$ | | 4.0 | | 0.01 | 4.0 | | 30 | µA |
| **Signal Inputs and Outputs** | | | | | | | | | | |
| $R_{ON}$ | "ON" Resistance | $R_L$ = 10kΩ to ($V_{DD}$ − $V_{SS}$)/2 | | | | | | | | |
| | | $V_C$ = $V_{DD}$, $V_{IS}$ = $V_{SS}$ or $V_{DD}$ | | | | | | | | |
| | | $V_{DD}$ = 10V | | 610 | | 275 | 660 | | 840 | Ω |
| | | $V_{DD}$ = 15V | | 370 | | 200 | 400 | | 520 | Ω |
| | | $R_L$ = 10kΩ to ($V_{DD}$ − $V_{SS}$)/2 | | | | | | | | |
| | | $V_C$ = $V_{DD}$ | | | | | | | | |
| | | $V_{DD}$ = 10V, $V_{IS}$ = 4.75 to 5.25V | | 1900 | | 850 | 2000 | | 2380 | Ω |
| | | $V_{DD}$ = 15V, $V_{IS}$ = 7.25 to 7.75V | | 790 | | 400 | 850 | | 1080 | Ω |
| $\Delta R_{ON}$ | Δ"ON" Resistance | $R_L$ = 10kΩ to ($V_{DD}$ − $V_{SS}$)/2 | | | | | | | | |
| | Between any 2 of | $V_C$ = $V_{DD}$, $V_{IS}$ = $V_{SS}$ to $V_{DD}$ | | | | | | | | |
| | 4 Switches | $V_{DD}$ = 10V | | | | 15 | | | | Ω |
| | (In Same Package) | $V_{DD}$ = 15V | | | | 10 | | | | Ω |
| $I_{IS}$ | Input or Output | $V_C$ = 0, $V_{DD}$ = 15V | | ±50 | | ±0.1 | ±50 | | ±200 | nA |
| | Leakage | $V_{IS}$ = 0V or 15V, | | | | | | | | |
| | Switch "OFF" | $V_{OS}$ = 15V or 0V | | | | | | | | |
| **Control Inputs** | | | | | | | | | | |
| $V_{ILC}$ | LOW Level Input | $V_{IS}$ = $V_{SS}$ and $V_{DD}$ | | | | | | | | |
| | Voltage | $V_{OS}$ = $V_{DD}$ and $V_{SS}$ | | | | | | | | |
| | | $I_{IS}$ = ±10 µA | | | | | | | | |
| | | $V_{DD}$ = 5V | | 0.9 | | | 0.7 | | 0.4 | V |
| | | $V_{DD}$ = 10V | | 0.9 | | | 0.7 | | 0.4 | V |
| | | $V_{DD}$ = 15V | | 0.9 | | | 0.7 | | 0.4 | V |
| $V_{IHC}$ | HIGH Level Input | $V_{DD}$ = 5V | 3.5 | | 3.5 | | | 3.5 | | V |
| | Voltage | $V_{DD}$ = 10V | 7.0 | | 7.0 | | | 7.0 | | V |
| | | $V_{DD}$ = 15V | 11.0 | | 11.0 | | | 11.0 | | V |
| | | (Note 3) and Figure 8 | | | | | | | | |
| $I_{IN}$ | Input Current | $V_{CC}$ − $V_{SS}$ = 15V | | ±0.3 | | $\pm 10^{-5}$ | ±0.3 | | ±1.0 | µA |
| | | $V_{DD} \geq V_{IS} \geq V_{SS}$ | | | | | | | | |
| | | $V_{DD} \geq V_C \geq V_{SS}$ | | | | | | | | |

**Note 3:** If the switch input is held at $V_{DD}$, $V_{IHC}$ is the control input level that will cause the switch output to meet the standard "B" series $V_{OH}$ and $I_{OH}$ output levels. If the analog switch input is connected to $V_{SS}$, $V_{IHC}$ is the control input level — which allows the switch to sink standard "B" series $|I_{OH}|$, high level current, and still maintain a $V_{OL} \leq$ "B" series. These currents are shown in Figure 8.

## AC Electrical Characteristics (Note 4)

$T_A = 25°C$, $t_r = t_f = 20$ ns and $V_{SS} = 0V$ unless otherwise specified

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $t_{PHL}$, $t_{PLH}$ | Propagation Delay Time | $V_C = V_{DD}$, $C_L = 50$ pF, (Figure 1) | | | | |
| | Signal Input to Signal Output | $R_L = 200k$ | | | | |
| | | $V_{DD} = 5V$ | | 58 | 100 | ns |
| | | $V_{DD} = 10V$ | | 27 | 50 | ns |
| | | $V_{DD} = 15V$ | | 20 | 40 | ns |
| $t_{PZH}$, $t_{PZL}$ | Propagation Delay Time | $R_L = 1.0$ kΩ, $C_L = 50$ pF, (Figure 2, Figure 3) | | | | |
| | Control Input to Signal | $V_{DD} = 5V$ | | 20 | 50 | ns |
| | Output HIGH Impedance to | $V_{DD} = 10V$ | | 18 | 40 | ns |
| | Logical Level | $V_{DD} = 15V$ | | 17 | 35 | ns |
| $t_{PHZ}$, $t_{PLZ}$ | Propagation Delay Time | $R_L = 1.0$ kΩ, $C_L = 50$ pF, (Figure 2, Figure 3) | | | | |
| | Control Input to Signal | $V_{DD} = 5V$ | | 15 | 40 | ns |
| | Output Logical Level to | $V_{DD} = 10V$ | | 11 | 25 | ns |
| | HIGH Impedance | $V_{DD} = 15V$ | | 10 | 22 | ns |
| | Sine Wave Distortion | $V_C = V_{DD} = 5V$, $V_{SS} = -5$ | | 0.4 | | % |
| | | $R_L = 10$ kΩ, $V_{IS} = 5\ V_{P-P}$, f = 1 kHz, | | | | |
| | | (Figure 4) | | | | |
| | Frequency Response — Switch | $V_C = V_{DD} = 5V$, $V_{SS} = -5V$, | | 40 | | MHz |
| | "ON" (Frequency at −3 dB) | $R_L = 1$ kΩ, $V_{IS} = 5\ V_{P-P}$, | | | | |
| | | 20 $\text{Log}_{10}$ $V_{OS}/V_{OS}$ (1 kHz) −dB, | | | | |
| | | (Figure 4) | | | | |
| | Feedthrough — Switch "OFF" | $V_{DD} = 5V$, $V_C = V_{SS} = -5V$, | | 1.25 | | MHz |
| | (Frequency at −50 dB) | $R_L = 1$ kΩ, $V_{IS} = 5\ V_{P-P}$, | | | | |
| | | 20 $\text{Log}_{10}$ $(V_{OS}/V_{IS}) = -50$ dB, | | | | |
| | | (Figure 4) | | | | |
| | Crosstalk Between Any Two | $V_{DD} = V_{C(A)} = 5V$; $V_{SS} = V_{C(B)} = -5V$, | | 0.9 | | MHz |
| | Switches (Frequency at −50 dB) | $R_L = 1$ kΩ$V_{IS(A)} = 5\ V_{P-P}$, | | | | |
| | | 20 $\text{Log}_{10}$ $(V_{OS(B)}/V_{OS(A)}) = -50$ dB, | | | | |
| | | (Figure 5) | | | | |
| | Crosstalk; Control Input to | $V_{DD} = 10V$, $R_L = 10$ kΩ | | 150 | | $mV_{P-P}$ |
| | Signal Output | $R_{IN} = 1$ kΩ, $V_{CC} = 10V$ Square Wave, | | | | |
| | | $C_L = 50$ pF (Figure 6) | | | | |
| | Maximum Control Input | $R_L = 1$ kΩ, $C_L = 50$ pF, (Figure 7) | | | | |
| | | $V_{OS(f)} = ½\ V_{OS}$(1 kHz) | | | | |
| | | $V_{DD} = 5V$ | | 6.5 | | MHz |
| | | $V_{DD} = 10V$ | | 8.0 | | MHz |
| | | $V_{DD} = 15V$ | | 9.0 | | MHz |
| $C_{IS}$ | Signal Input Capacitance | | | 4 | | pF |
| $C_{OS}$ | Signal Output Capacitance | $V_{DD} = 10V$ | | 4 | | pF |
| $C_{IOS}$ | Feedthrough Capacitance | $V_C = 0V$ | | 0.2 | | pF |
| $C_{IN}$ | Control Input Capacitance | | | 5 | 7.5 | pF |

**Note 4:** AC Parameters are guaranteed by DC correlated testing.

**Note 5:** These devices should not be connected to circuits with the power "ON".

**Note 6:** In all cases, there is approximately 5 pF of probe and jig capacitance on the output; however, this capacitance is included in $C_L$ wherever it is specified.

**Note 7:** $V_{IS}$ is the voltage at the in/out pin and $V_{OS}$ is the voltage at the out/in pin. $V_C$ is the voltage at the control input.

## AC Test Circuits and Switching Time Waveforms


**FIGURE 1. $t_{PLH}$, $t_{PLH}$ Propagation Delay Time Control to Signal Output**

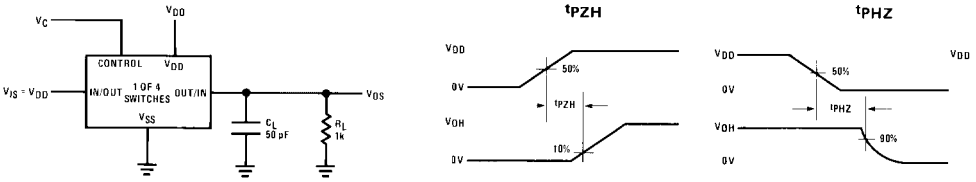



**FIGURE 2. $t_{PZH}$, $t_{PHZ}$ Propagation Delay Time Control to Signal Output**

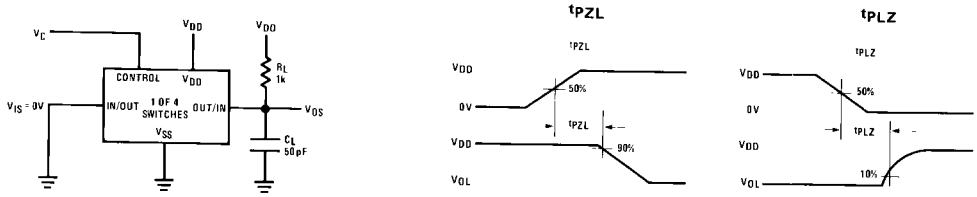
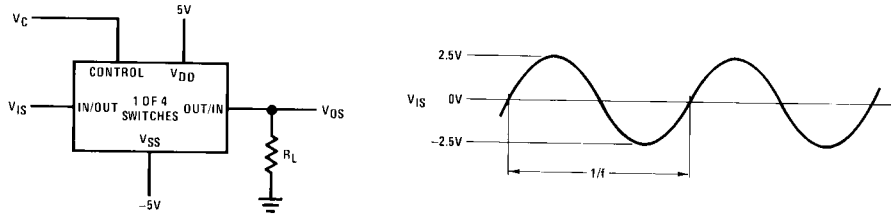



**FIGURE 3. $t_{PZH}$, $t_{PHZ}$ Propagation Delay Time Control to Signal Output**




$V_C = V_{DD}$ for distortion and frequency response tests

$V_C = V_{SS}$ for feedthrough test

**FIGURE 4. Sine Wave Distortion, Frequency Response and Feedthrough**

## AC Test Circuits and Switching Time Waveforms (Continued)

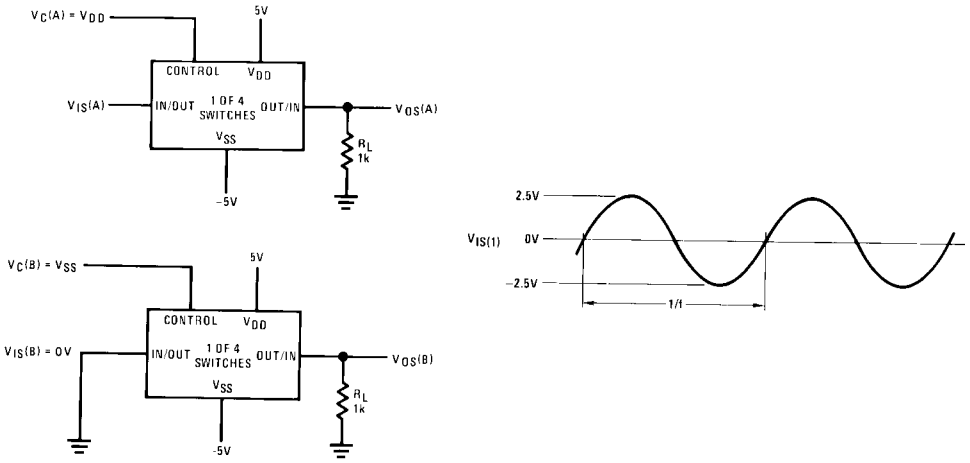



**FIGURE 5. Crosstalk Between Any Two Switches**

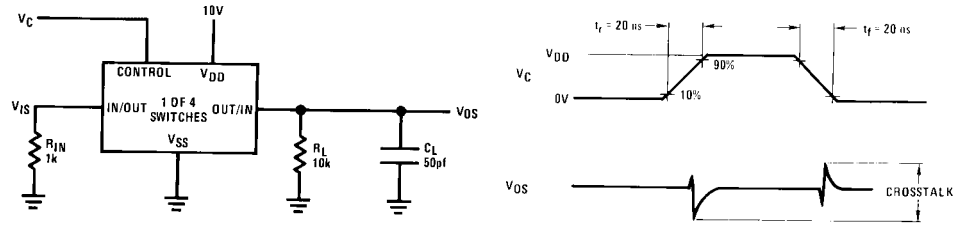



**FIGURE 6. Crosstalk — Control to Input Signal Output**

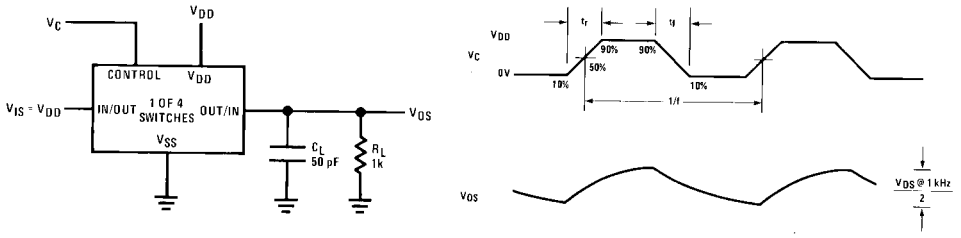



**FIGURE 7. Maximum Control Input Frequency**

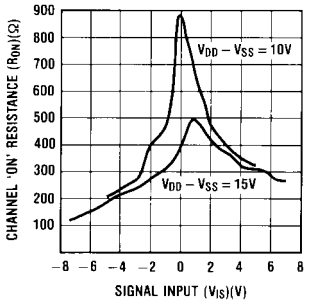
## AC Test Circuits and Switching Time Waveforms (Continued)

| Temperature Range | $V_{DD}$ | Switch Input | | | | Switch Output | |
|---|---|---|---|---|---|---|---|
| | | $V_{IS}$ | $I_{IS}$ (mA) | | | $V_{OS}$(V) | |
| | | | −40°C | 25°C | +85°C | Min | Max |
| | 5 | 0 | 0.2 | 0.16 | 0.12 | | 0.4 |
| | 5 | 5 | −0.2 | −0.16 | −0.12 | 4.6 | |
| COMMERCIAL | 10 | 0 | 0.5 | 0.4 | 0.3 | | 0.5 |
| | 10 | 10 | −0.5 | −0.4 | −0.3 | 9.5 | |
| | 15 | 0 | 1.4 | 1.2 | 1.0 | | 1.5 |
| | 15 | 15 | −1.4 | −1.2 | −1.0 | 13.5 | |

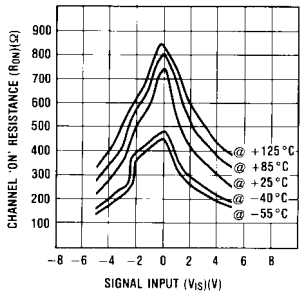
**FIGURE 8. CD4016B Switch Test Conditions for $V_{IHC}$**

## Typical Performance Characteristics

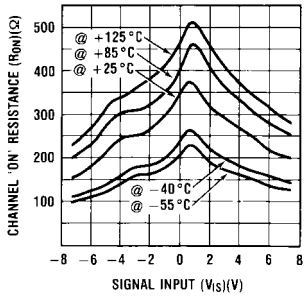
**'ON' Resistance vs. Signal Voltage $T_A = 25°C$**




**'ON' Resistance Temperature Variation for $V_{DD} - V_{SS} = 10V$**

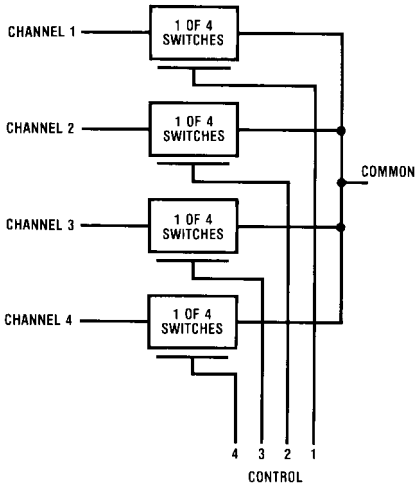



**'ON' Resistance Temperature Variation for $V_{DD} - V_{SS} = 15V$**

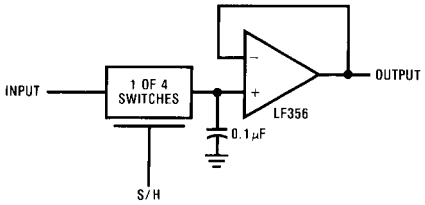


## Typical Applications

**4 Input Multiplexer**



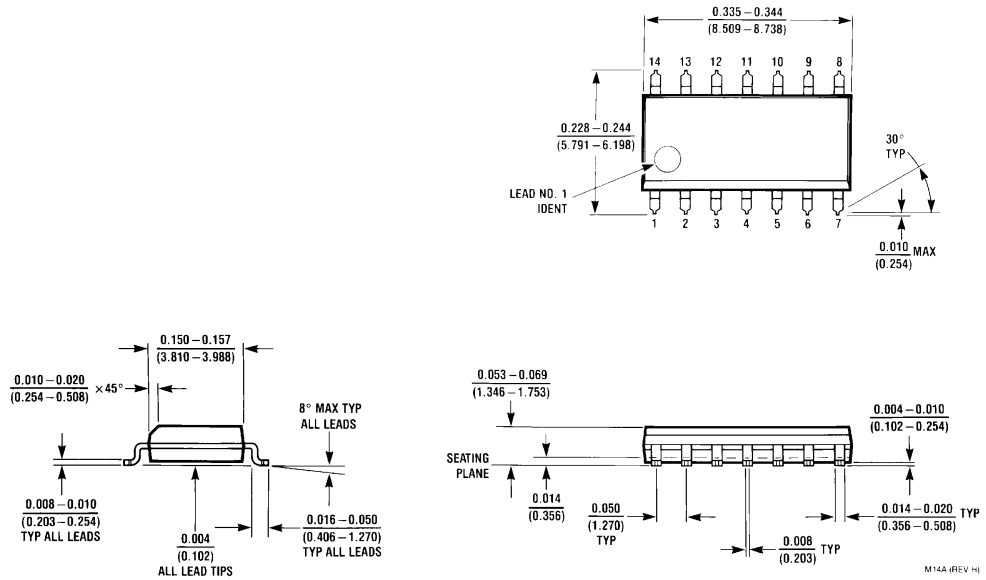

**Sample/Hold Amplifier**




**Special Considerations**

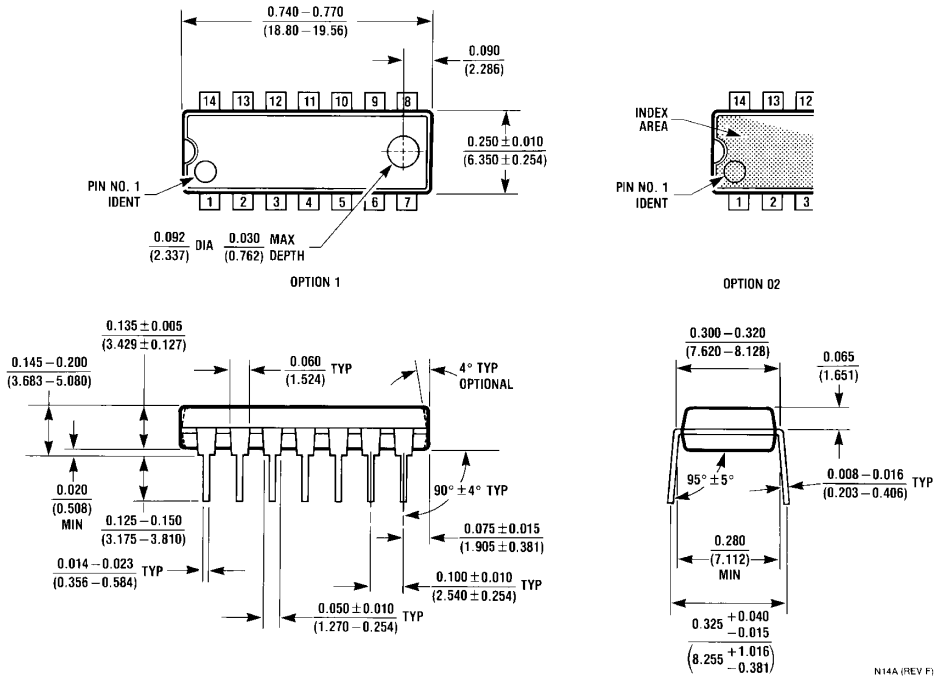
The CD4016B is composed of 4, two-transistor analog switches. These switches do not have any linearization or compensation circuitry for "$R_{ON}$" as do the CD4066B's. Because of this, the special operating considerations for the CD4066B do not apply to the CD4016B, but at low supply voltages, ≤5V, the CD4016B's on resistance becomes non-linear. It is recommended that at 5V, voltages on the in/out pins be maintained within about 1V of either $V_{DD}$ or $V_{SS}$; and that at 3V the voltages on the in/out pins should be at $V_{DD}$ or $V_{SS}$ for reliable operation.

## Physical Dimensions inches (millimeters) unless otherwise noted




**14-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-120, 0.150” Narrow**
**Package Number M14A**

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




**14-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide**
**Package Number N14A**