

August 1989

CD4016BM/CD4016BC Quad Bilateral Switch

General Description

The CD4016BM/CD4016BC is a quad bilateral switch intended for the transmission or multiplexing of analog or digital signals. It is pin-for-pin compatible with CD4066BM/CD4066BC.

Features

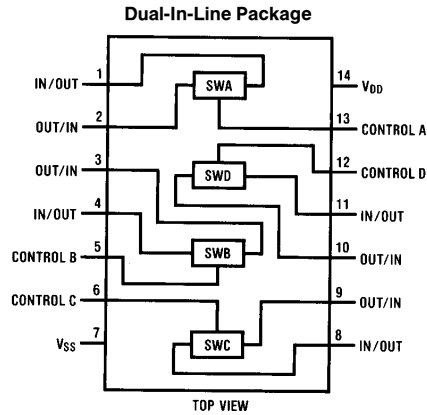
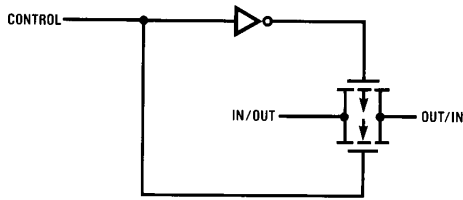
- Wide supply voltage range 3V to 15V
- Wide range of digital and analog switching $\pm 7.5 V_{PEAK}$
- "ON" resistance for 15V operation 400 Ω (typ.)
- Matched "ON" resistance over 15V signal input $\Delta R_{ON} = 10\Omega$ (typ.)
- High degree of linearity 0.4% distortion (typ.)
@ $f_{IS} = 1 \text{ kHz}$, $V_{IS} = 5 V_{p-p}$,
 $V_{DD} - V_{SS} = 10V$, $R_L = 10 \text{ k}\Omega$
- Extremely low "OFF" switch leakage 0.1 nA (typ.)
@ $V_{DD} - V_{SS} = 10V$
 $T_A = 25^\circ\text{C}$

- Extremely high control input impedance 10¹² Ω (typ.)
- Low crosstalk between switches -50 dB (typ.)
@ $f_{IS} = 0.9 \text{ MHz}$, $R_L = 1 \text{ k}\Omega$
- 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

Schematic and Connection Diagrams



Order Number CD4016B

TL/F/5661-1

CD4016BM/CD4016BC Quad Bilateral Switch

Absolute Maximum Ratings

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

(Notes 1 and 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 | |
| CD4016BM | −55°C to +125°C |
| CD4016BC | −40°C to +85°C |

DC Electrical Characteristics CD4016BM (Note 2)

| Symbol | Parameter | Conditions | −55°C | | 25°C | | | 125°C | | Units | |
|----------------------------------|---|--|------------------|--------------------------|--|-------------------|-------------------|-------|-------------------|-------------|---|
| | | | Min | Max | Min | Typ | Max | Min | Max | | |
| I _{DD} | Quiescent Device Current | V _{DD} =5V, V _{IN} =V _{DD} or V _{SS} | | 0.25 | | 0.01 | 0.25 | | 7.5 | μA | |
| | | V _{DD} =10V, V _{IN} =V _{DD} or V _{SS} | | 0.5 | | 0.01 | 0.5 | | 15 | μA | |
| | | V _{DD} =15V, V _{IN} =V _{DD} or V _{SS} | | 1.0 | | 0.01 | 1.0 | | 30 | μA | |
| Signal Inputs and Outputs | | | | | | | | | | | |
| R _{ON} | “ON” Resistance | R _L = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V _C = V _{DD} , V _{IS} = V _{SS} or V _{DD} V _{DD} = 10V V _{DD} = 15V | | 600 360 | | 250 200 | 660 400 | | 960 600 | Ω Ω | |
| | | R _L = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V _C = V _{DD} V _{DD} = 10V, V _{IS} = 4.75 to 5.25V V _{DD} = 15V, V _{IS} = 7.25 to 7.75V | | 1870 775 | | 850 400 | 2000 850 | | 2600 1230 | Ω Ω | |
| ΔR _{ON} | Δ“ON” Resistance Between any 2 of 4 Switches (In Same Package) | R _L = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V _C = V _{DD} , V _{IS} = V _{SS} to V _{DD} V _{DD} = 10V V _{DD} = 15V | | | | 15 10 | | | Ω Ω | | |
| I _{IS} | Input or Output Leakage Switch “OFF” | V _C = 0, V _{DD} = 15V V _{IS} = 15V and 0V, V _{OS} = 0V and 15V | | ±50 | | ±0.1 | ±50 | | ±500 | nA | |
| Control Inputs | | | | | | | | | | | |
| V _{ILC} | Low Level Input Voltage | V _{IS} = V _{SS} and V _{DD} V _{OS} = V _{DD} and V _{SS} I _{IS} = ±10 μA V _{DD} = 5V V _{DD} = 10V V _{DD} = 15V | | 0.9 0.9 0.9 | | | 0.7 0.7 0.7 | | 0.5 0.5 0.5 | V V V | |
| | | | V _{IHC} | High Level Input Voltage | V _{DD} = 5V | 3.5 | | 3.5 | | 3.5 | V |
| | | | | | V _{DD} = 10V (see Note 6 and Figure 8) | 7.0 | | 7.0 | | 7.0 | V |
| | | V _{DD} = 15V | 11.0 | | 11.0 | | 11.0 | V | | | |
| I _{IN} | Input Current | V _{DD} − V _{SS} = 15V V _{DD} ≥ V _{IS} ≥ V _{SS} V _{DD} ≥ V _C ≥ V _{SS} | | ±0.1 | | ±10 ^{−5} | ±0.1 | | ±1.0 | μA | |

| DC Electrical Characteristics CD4016BC (Note 2) (Continued) | | | | | | | | | | | | |
|--|--|--|------------------|--------------------------|---|-------------------|-------------------|------|-------------------|-------------|--|---|
| Symbol | Parameter | Conditions | -40°C | | 25°C | | | 85°C | | Units | | |
| | | | Min | Max | Min | Typ | Max | Min | Max | | | |
| I _{DD} | Quiescent Device Current | V _{DD} = 5V, V _{IN} = V _{DD} or V _{SS} | | 1.0 | | 0.01 | 1.0 | | 7.5 | μA | | |
| | | 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 = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V _C = V _{DD} , V _{IS} = V _{SS} or V _{DD} V _{DD} = 10V V _{DD} = 15V | | 610 370 | | 275 200 | 660 400 | | 840 520 | Ω Ω | | |
| | | R _L = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V _C = V _{DD} V _{DD} = 10V, V _{IS} = 4.75 to 5.25V V _{DD} = 15V, V _{IS} = 7.25 to 7.75V | | 1900 790 | | 850 400 | 2000 850 | | 2380 1080 | Ω Ω | | |
| ΔR _{ON} | Δ"ON" Resistance Between any 2 of 4 Switches (In Same Package) | R _L = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V _C = V _{DD} , V _{IS} = V _{SS} to V _{DD} V _{DD} = 10V V _{DD} = 15V | | | | 15 10 | | | Ω Ω | | | |
| I _{IS} | Input or Output Leakage Switch "OFF" | V _C = 0, V _{DD} = 15V V _{IS} = 0V or 15V, V _{OS} = 15V or 0V | | ±50 | | ±0.1 | ±50 | | ±200 | nA | | |
| Control Inputs | | | | | | | | | | | | |
| V _{ILC} | Low Level Input Voltage | V _{IS} = V _{SS} and V _{DD} V _{OS} = V _{DD} and V _{SS} I _{IS} = ±10 μA V _{DD} = 5V V _{DD} = 10V V _{DD} = 15V | | 0.9 0.9 0.9 | | | 0.7 0.7 0.7 | | 0.4 0.4 0.4 | V V V | | |
| | | | V _{IHC} | High Level Input Voltage | V _{DD} = 5V V _{DD} = 10V (see Note 6 and Figure 8) V _{DD} = 15V | 3.5 | | 3.5 | | 3.5 | | V |
| | | | | | | 7.0 | | 7.0 | | 7.0 | | V |
| | | | | | | 11.0 | | 11.0 | | 11.0 | | V |
| I _{IN} | Input Current | V _{CC} - V _{SS} = 15V V _{DD} ≥ V _{IS} ≥ V _{SS} V _{DD} ≥ V _C ≥ V _{SS} | | ±0.3 | | ±10 ⁻⁵ | ±0.3 | | ±1.0 | μA | | |
| AC Electrical Characteristics* 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 Signal Input to Signal Output | V _C = V _{DD} , C _L = 50 pF, (Figure 1) R _L = 200k V _{DD} = 5V V _{DD} = 10V V _{DD} = 15V | | | | | | | | | | |
| | | | 58 | 100 | ns | | | | | | | |
| | | | 27 | 50 | ns | | | | | | | |
| t _{PZH} , t _{PZL} | Propagation Delay Time Control Input to Signal Output High Impedance to Logical Level | R _L = 1.0 kΩ, C _L = 50 pF, (Figures 2 and 3) V _{DD} = 5V V _{DD} = 10V V _{DD} = 15V | | | | | | | | | | |
| | | | 20 | 50 | ns | | | | | | | |
| | | | 18 | 40 | ns | | | | | | | |
| t _{PHZ} , t _{PLZ} | Propagation Delay Time Control Input to Signal Output Logical Level to High Impedance | R _L = 1.0 kΩ, C _L = 50 pF, (Figures 2 and 3) V _{DD} = 5V V _{DD} = 10V V _{DD} = 15V | | | | | | | | | | |
| | | | 15 | 40 | ns | | | | | | | |
| | | | 11 | 25 | ns | | | | | | | |
| | Sine Wave Distortion | V _C = V _{DD} = 5V, V _{SS} = -5 R _L = 10 kΩ, V _{IS} = 5 V _{P-P} , f = 1 kHz, (Figure 4) | | | | | | | | | | |
| 10 | | | 22 | ns | | | | | | | | |
| | | | 0.4 | | | % | | | | | | |

AC Electrical Characteristics* (Continued)

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

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|------------------|--|---|-----|------|-----|-------------------|
| | Frequency Response — Switch “ON” (Frequency at -3 dB) | V _C = V _{DD} = 5V, V _{SS} = -5V, R _L = 1 kΩ, V _{IS} = 5 V _{P-P} , 20 Log ₁₀ V _{OS} /V _{IS} (1 kHz) - dB, (Figure 4) | | 40 | | MHz |
| | Feedthrough — Switch “OFF” (Frequency at -50 dB) | V _{DD} = 5V, V _C = V _{SS} = -5V, R _L = 1 kΩ, V _{IS} = 5 V _{P-P} , 20 Log ₁₀ (V _{OS} /V _{IS}) = -50 dB, (Figure 4) | | 1.25 | | MHz |
| | Crosstalk Between Any Two Switches (Frequency at -50 dB) | V _{DD} = V _{C(A)} = 5V; V _{SS} = V _{C(B)} = -5V, R _L = 1 kΩ, V _{IS(A)} = 5 V _{P-P} , 20 Log ₁₀ (V _{OS(B)} /V _{OS(A)}) = -50 dB, (Figure 5) | | 0.9 | | MHz |
| | Crosstalk; Control Input to Signal Output | V _{DD} = 10V, R _L = 10 kΩ, R _{IN} = 1 kΩ, V _{CC} = 10V Square Wave, C _L = 50 pF (Figure 6) | | 150 | | mV _{P-P} |
| | Maximum Control Input | R _L = 1 kΩ, C _L = 50 pF, (Figure 7) | | | | |
| | | V _{OS(f)} = 1/2 V _{OS} (1 kHz) | | 6.5 | | MHz |
| | | V _{DD} = 5V | | 8.0 | | MHz |
| | | V _{DD} = 10V | | 9.0 | | MHz |
| | | V _{DD} = 15V | | | | |
| 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 |

*AC Parameters are guaranteed by DC correlated testing.

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.

Note 3: These devices should not be connected to circuits with the power “ON”.

Note 4: 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 5: 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.

Note 6: 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} ≤ “B” series. These currents are shown in Figure 8.

AC Test Circuits and Switching Time Waveforms

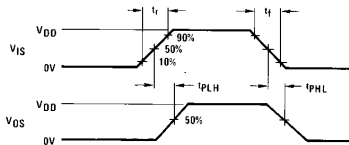
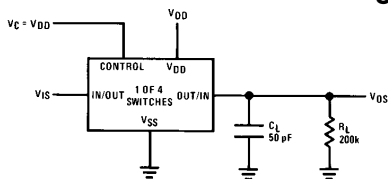


Figure 1. t_{PLH}, t_{PHL} Propagation Delay Time Signal Input to Signal Output

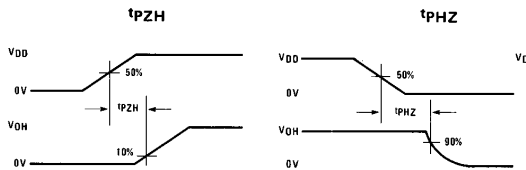
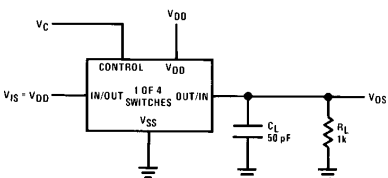


FIGURE 2. t_{PZH}, t_{PHZ} Propagation Delay Time Control to Signal Output

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AC Test Circuits and Switching Time Waveforms (Continued)

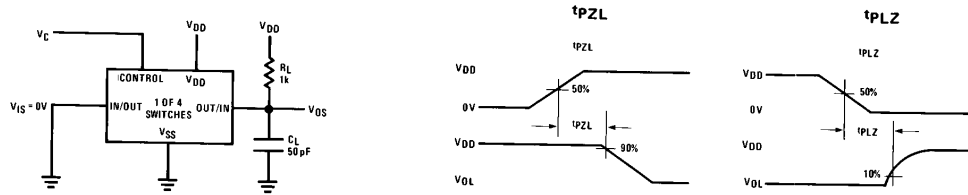


FIGURE 3. t_{PZH} , t_{PHZ} Propagation Delay Time Control to Signal Output

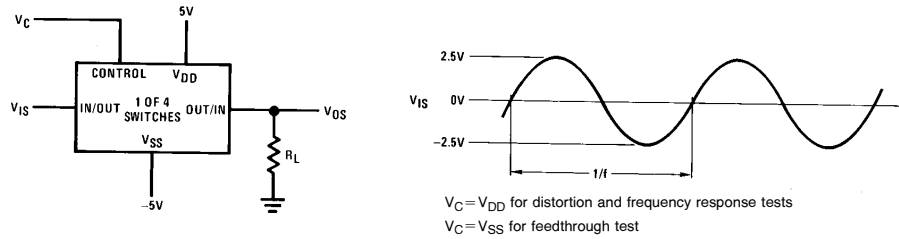


FIGURE 4. Sine Wave Distortion, Frequency Response and Feedthrough

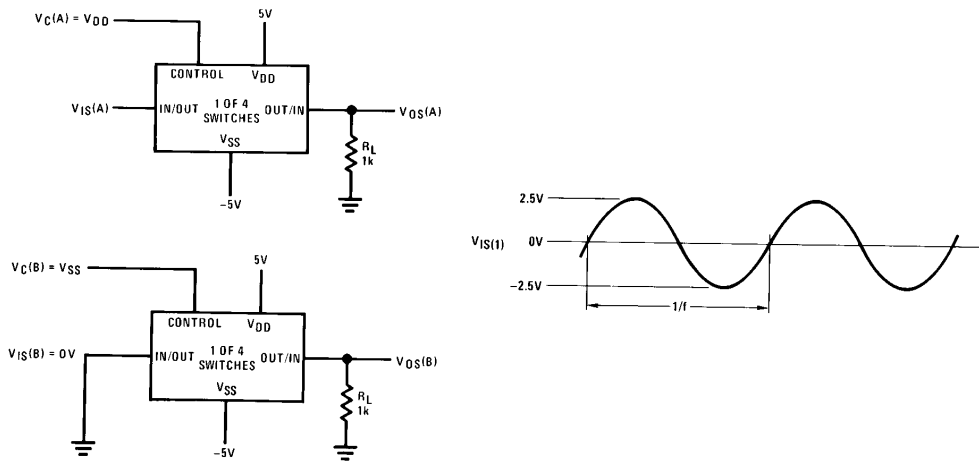


FIGURE 5. Crosstalk Between Any Two Switches

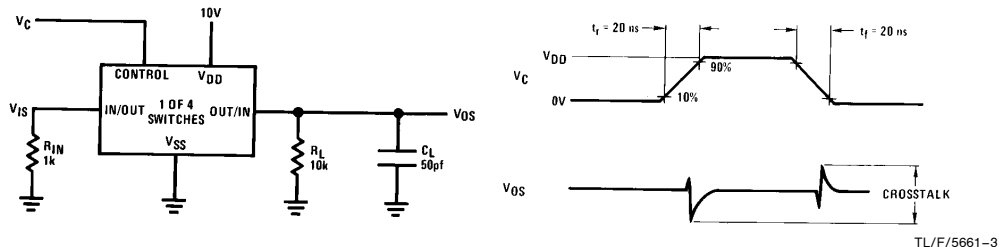


FIGURE 6. Crosstalk — Control to Input Signal Output

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AC Test Circuits and Switching Time Waveforms (Continued)

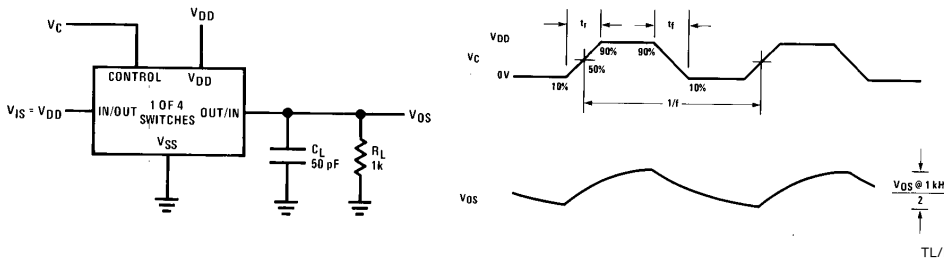


FIGURE 7. Maximum Control Input Frequency

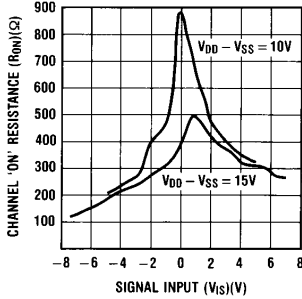
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| Temperature Range | V _{DD} | Switch Input | | | | Switch Output V _{OS} (V) | |
|-------------------|-----------------|-----------------|---------------------|-------|-------------------|-----------------------------------|-----|
| | | V _{IS} | I _S (mA) | | | Min | Max |
| | | | T _{LOW} | 25°C | T _{HIGH} | | |
| MILITARY | 5 | 0 | 0.25 | 0.2 | 0.14 | | 0.4 |
| | 5 | 5 | -0.25 | -0.2 | -0.14 | 4.6 | |
| | 10 | 0 | 0.62 | 0.5 | 0.35 | | 0.5 |
| | 10 | 10 | -0.62 | -0.5 | -0.35 | 9.5 | |
| | 15 | 0 | 1.8 | 1.5 | 1.1 | | 1.5 |
| | 15 | 15 | -1.8 | -1.5 | -1.1 | 13.5 | |
| COMMERCIAL | 5 | 0 | 0.2 | 0.16 | 0.12 | | 0.4 |
| | 5 | 5 | -0.2 | -0.16 | -0.12 | 4.6 | |
| | 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 | |

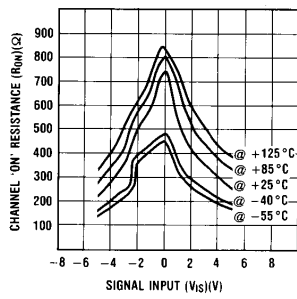
FIGURE 8. CD4016B Switch Test Conditions for V_{IHC}

Typical Performance Characteristics

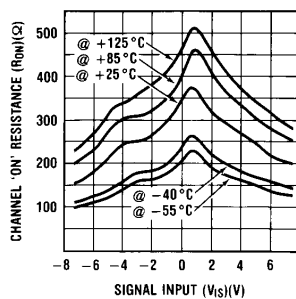
'ON' Resistance vs. Signal Voltage T_A = 25°C



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

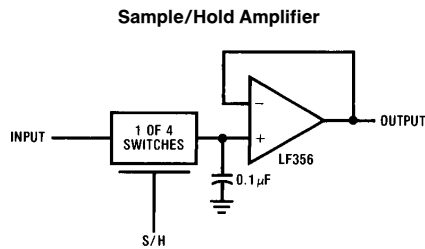
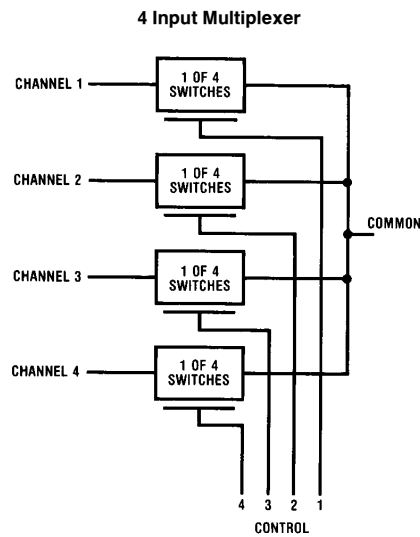


'ON' Resistance Temperature Variation for V_{DD} - V_{SS} = 15V



TL/F/5661-5

Typical Applications



TL/F/5661-6

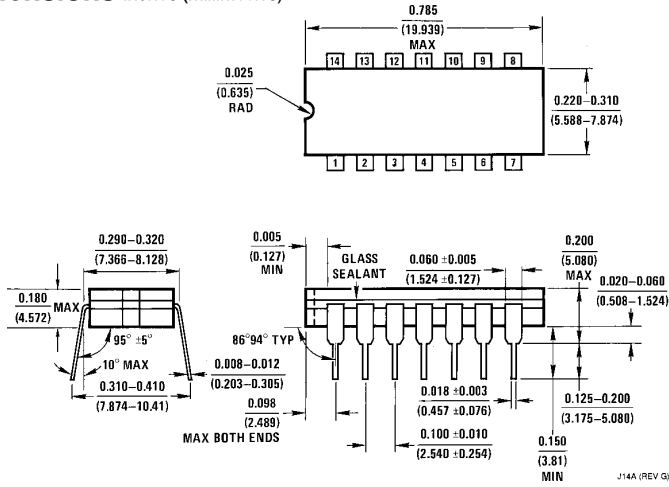
Special Considerations

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

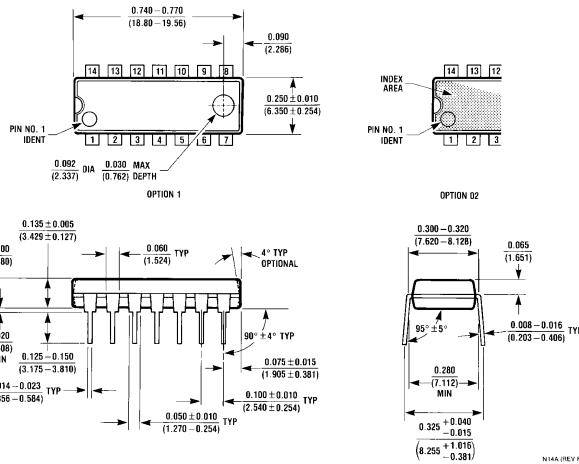
supply voltages, $\leq 5V$, the CD4016B's on resistance becomes non-linear. It is recommended that at 5V, voltages on the in/out pins be maintained within about 1V of either V_{DD} or V_{SS}; and that at 3V the voltages on the in/out pins should be at V_{DD} or V_{SS} for reliable operation.

CD4016BM/CD4016BC Quad Bilateral Switch

Physical Dimensions inches (millimeters)



Dual-In-Line Package
Order Number CD4016CJ or CD4016MJ
NS Package J14A



Dual-In-Line Package
Order Number CD4016CN
NS Package N14A

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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.



National Semiconductor Corporation
1111 West Bardin Road
Arlington, TX 76017
Tel: 1(800) 272-9959
Fax: 1(800) 737-7018

National Semiconductor Europe
Fax: (+49) 0-180-530 85 86
Email: cnjwge@tevm2.nsc.com
Deutsch Tel: (+49) 0-180-530 85 85
English Tel: (+49) 0-180-532 78 32
Français Tel: (+49) 0-180-532 93 58
Italiano Tel: (+49) 0-180-534 16 80

National Semiconductor Hong Kong Ltd.
19th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductor Japan Ltd.
Tel: 81-043-299-2309
Fax: 81-043-299-2408

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