



## 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.

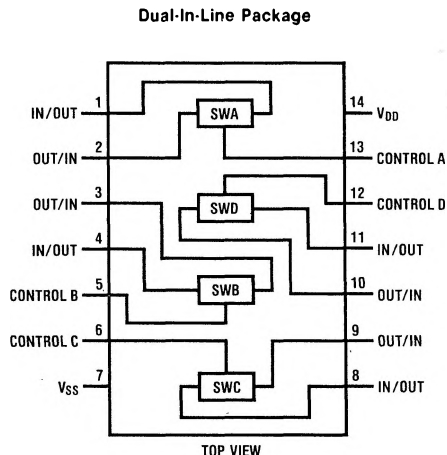
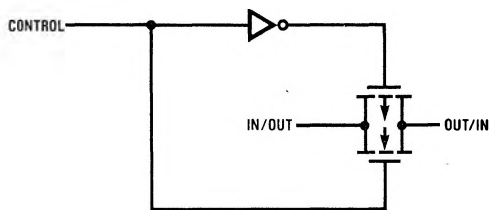
### Features

- 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 $\Omega$  (typ.)
- Matched "ON" resistance over 15V signal input  $\Delta R_{ON} = 10\Omega$  (typ.)
- High degree of linearity 0.4% distortion (typ.)  
@  $f_{IS} = 1 \text{ kHz}$ ,  $V_{IS} = 5 \text{ Vp-p}$ ,  
 $V_{DD} - V_{SS} = 10 \text{ V}$ ,  $R_L = 10 \text{ k}\Omega$
- Extremely low "OFF" switch leakage 0.1 nA (typ.)  
@  $V_{DD} - V_{SS} = 10 \text{ V}$   
 $T_A = 25^\circ \text{C}$
- Extremely high control input impedance  $10^{12}\Omega$  (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



**Absolute Maximum Ratings** (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          |
| $P_D$ Package Dissipation                | 500mW                    |
| Lead Temperature (Soldering, 10 seconds) | 300°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 | -55°C to +125°C |
| CD4016BM                          | -55°C to +125°C |
| CD4016BC                          | -40°C to +85°C  |

**DC Electrical Characteristics** CD4016BM (Note 2)

| Parameter                                                                                       | Conditions                                       | -55°C |           | 25°C |               |           | 125°C |           | Units    |
|-------------------------------------------------------------------------------------------------|--------------------------------------------------|-------|-----------|------|---------------|-----------|-------|-----------|----------|
|                                                                                                 |                                                  | Min.  | Max.      | Min. | Typ.          | Max.      | Min.  | Max.      |          |
| $I_{DD}$ Quiescent Device Current                                                               | $V_{DD} = 5V$                                    |       | 0.25      |      | 0.01          | 0.25      |       | 7.5       | $\mu A$  |
|                                                                                                 | $V_{DD} = 10V$                                   |       | 0.5       |      | 0.01          | 0.5       |       | 15        | $\mu A$  |
|                                                                                                 | $V_{DD} = 15V$                                   |       | 1.0       |      | 0.01          | 1.0       |       | 30        | $\mu A$  |
| <b>Signal Inputs and Outputs</b>                                                                |                                                  |       |           |      |               |           |       |           |          |
| $R_{ON}$ "ON" Resistance                                                                        | $R_L = 10k\Omega$ to $\frac{V_{DD} - V_{SS}}{2}$ |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_C = V_{DD}$ , $V_{IS} = V_{SS}$ or $V_{DD}$   |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_{DD} = 10V$                                   |       | 600       |      | 250           | 660       |       | 960       | $\Omega$ |
|                                                                                                 | $V_{DD} = 15V$                                   |       | 360       |      | 200           | 400       |       | 600       | $\Omega$ |
| $\Delta R_{ON}$ $\Delta$ "ON" Resistance<br>Between any 2 of<br>4 Switches<br>(In Same Package) | $R_L = 10k\Omega$ to $\frac{V_{DD} - V_{SS}}{2}$ |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_C = V_{DD}$                                   |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_{DD} = 10V$ , $V_{IS} = 4.75$ to $5.25V$      |       | 1870      |      | 850           | 2000      |       | 2600      | $\Omega$ |
|                                                                                                 | $V_{DD} = 15V$ , $V_{IS} = 7.25$ to $7.75V$      |       | 775       |      | 400           | 850       |       | 1230      | $\Omega$ |
| $\Delta R_{ON}$ $\Delta$ "ON" Resistance<br>Between any 2 of<br>4 Switches<br>(In Same Package) | $R_L = 10k\Omega$ to $\frac{V_{DD} - V_{SS}}{2}$ |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_C = V_{DD}$ , $V_{IS} = V_{SS}$ to $V_{DD}$   |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_{DD} = 10V$                                   |       |           |      | 15            |           |       |           | $\Omega$ |
| $I_{IS}$ Input or Output Leakage<br>Switch "OFF"                                                | $V_C = 0$ , $V_{DD} = 15V$                       |       | $\pm 50$  |      | $\pm 0.1$     | $\pm 50$  |       | $\pm 500$ | nA       |
|                                                                                                 | $V_{IS} = 15V$ and $0V$ ,                        |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_{OS} = 0V$ and $15V$                          |       |           |      |               |           |       |           |          |
| <b>Control Inputs</b>                                                                           |                                                  |       |           |      |               |           |       |           |          |
| $V_{ILC}$ Low Level Input Voltage                                                               | $V_{IS} = V_{SS}$ and $V_{DD}$                   |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_{OS} = V_{DD}$ and $V_{SS}$                   |       |           |      |               |           |       |           |          |
|                                                                                                 | $I_{IS} = \pm 10\mu A$                           |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_{DD} = 5V$                                    |       | 0.9       |      |               | 0.7       |       | 0.5       | V        |
|                                                                                                 | $V_{DD} = 10V$                                   |       | 0.9       |      |               | 0.7       |       | 0.5       | V        |
| $V_{IHC}$ High Level Input Voltage                                                              | $V_{DD} = 15V$                                   |       | 0.9       |      |               | 0.7       |       | 0.5       | V        |
|                                                                                                 | $V_{DD} = 5V$                                    | 3.5   |           | 3.5  |               |           | 3.5   |           | V        |
|                                                                                                 | $V_{DD} = 10V$ (see Note 6 and Figure 8)         | 7.0   |           | 7.0  |               |           | 7.0   |           | V        |
| $I_{IN}$ Input Current                                                                          | $V_{DD} = 15V$                                   | 11.0  |           | 11.0 |               |           | 11.0  |           | V        |
|                                                                                                 | $V_{DD} - V_{SS} = 15V$                          |       | $\pm 0.1$ |      | $\pm 10^{-5}$ | $\pm 0.1$ |       | $\pm 1.0$ | $\mu A$  |
|                                                                                                 | $V_{DD} \geq V_{IS} \geq V_{SS}$                 |       |           |      |               |           |       |           |          |
|                                                                                                 | $V_{DD} \geq V_C \geq V_{SS}$                    |       |           |      |               |           |       |           |          |

**DC Electrical Characteristics** CD4016BC (Note 2)

| Parameter                                                                                         | Conditions                                                                                                                                                       | -40°C              |                   | 25°C               |                      |                   | 85°C               |                   | Units                         |
|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|--------------------|----------------------|-------------------|--------------------|-------------------|-------------------------------|
|                                                                                                   |                                                                                                                                                                  | Min.               | Max.              | Min.               | Typ.                 | Max.              | Min.               | Max.              |                               |
| $I_{DD}$ Quiescent Device Current                                                                 | $V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$                                                                                                                |                    | 1.0<br>2.0<br>4.0 |                    | 0.01<br>0.01<br>0.01 | 1.0<br>2.0<br>4.0 |                    | 7.5<br>15<br>30   | $\mu A$<br>$\mu A$<br>$\mu A$ |
| <b>Signal Inputs and Outputs</b>                                                                  |                                                                                                                                                                  |                    |                   |                    |                      |                   |                    |                   |                               |
| $R_{ON}$ "ON" Resistance                                                                          | $R_L = 10k\Omega$ to $\frac{V_{DD} - V_{SS}}{2}$<br>$V_C = V_{DD}$ , $V_{IS} = V_{SS}$ or $V_{DD}$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$                           |                    | 610<br>370        |                    | 275<br>200           | 660<br>400        |                    | 840<br>520        | $\Omega$<br>$\Omega$          |
|                                                                                                   | $R_L = 10k\Omega$ to $\frac{V_{DD} - V_{SS}}{2}$<br>$V_C = V_{DD}$<br>$V_{DD} = 10V$ , $V_{IS} = 4.75$ to $5.25V$<br>$V_{DD} = 15V$ , $V_{IS} = 7.25$ to $7.75V$ |                    | 1900<br>790       |                    | 850<br>400           | 2000<br>850       |                    | 2380<br>1080      | $\Omega$<br>$\Omega$          |
| $\Delta R_{ON}$ $\Delta$ "ON" Resistance<br>(Between any 2 of<br>4 Switches<br>(In Same Package)) | $R_L = 10k\Omega$ to $\frac{V_{DD} - V_{SS}}{2}$<br>$V_{CC} = V_{DD}$ , $V_{IS} = V_{SS}$ to $V_{DD}$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$                        |                    |                   |                    | 15<br>10             |                   |                    |                   | $\Omega$<br>$\Omega$          |
| $I_{IS}$ Input or Output Leakage<br>Switch "OFF"                                                  | $V_C = 0$ , $V_{DD} = 15V$<br>$V_{IS} = 0V$ or $15V$<br>$V_{OS} = 15V$ or $0V$                                                                                   |                    | $\pm 50$          |                    | $\pm 0.1$            | $\pm 50$          |                    | $\pm 200$         | nA                            |
| <b>Control Inputs</b>                                                                             |                                                                                                                                                                  |                    |                   |                    |                      |                   |                    |                   |                               |
| $V_{ILC}$ Low Level Input Voltage                                                                 | $V_{IS} = V_{SS}$ and $V_{DD}$<br>$V_{OS} = V_{DD}$ and $V_{SS}$<br>$I_{IS} = \pm 10\mu A$<br>$V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$                  |                    | 0.9<br>0.9<br>0.9 |                    |                      | 0.7<br>0.7<br>0.7 |                    | 0.4<br>0.4<br>0.4 | V<br>V<br>V                   |
| $V_{IHC}$ High Level Input Voltage                                                                | $V_{DD} = 5V$<br>$V_{DD} = 10V$ (see Note 6 and<br>$V_{DD} = 15V$ Figure 8)                                                                                      | 3.5<br>7.0<br>11.0 |                   | 3.5<br>7.0<br>11.0 |                      |                   | 3.5<br>7.0<br>11.0 |                   | V<br>V<br>V                   |
| $I_{IN}$ Input Current                                                                            | $V_{CC} - V_{SS} = 15V$<br>$V_{DD} \geq V_{IS} \geq V_{SS}$<br>$V_{DD} \geq V_C \geq V_{SS}$                                                                     |                    | $\pm 0.3$         |                    | $\pm 10^{-5}$        | $\pm 0.3$         |                    | $\pm 1.0$         | $\mu A$                       |

**AC Electrical Characteristics**  $T_A = 25^\circ C$ ,  $t_r = t_f = 20ns$  and  $V_{SS} = 0V$  unless otherwise specified

| Parameter                                                                                                            | Conditions                                                                                                      | Min. | Typ.           | Max.            | Units          |
|----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------|----------------|-----------------|----------------|
| $t_{PHL}$ , $t_{PLH}$ Propagation Delay Time<br>Signal Input to Signal Output                                        | $V_C = V_{DD}$ , $C_L = 50pF$ , (Figure 1)<br>$R_L = 200k$<br>$V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$ |      | 58<br>27<br>20 | 100<br>50<br>40 | ns<br>ns<br>ns |
| $t_{PZH}$ , $t_{PZL}$ Propagation Delay Time<br>Control Input to Signal<br>Output High Impedance to<br>Logical Level | $R_L = 1.0k\Omega$ , $C_L = 50pF$ , (Figures 2<br>and 3)<br>$V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$   |      | 20<br>18<br>17 | 50<br>40<br>35  | ns<br>ns<br>ns |
| $t_{PHZ}$ , $t_{PLZ}$ Propagation Delay Time<br>Control Input to Signal<br>Output Logical Level to<br>High Impedance | $R_L = 1.0k\Omega$ , $C_L = 50pF$ , (Figures 2<br>and 3)<br>$V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$   |      | 15<br>11<br>10 | 40<br>25<br>22  | ns<br>ns<br>ns |
| Sine Wave Distortion                                                                                                 | $V_C = V_{DD} = 5V$ , $V_{SS} = -5V$<br>$R_L = 10k\Omega$ , $V_{IS} = 5V_{P-P}$ , $f = 1kHz$ ,<br>(Figure 4)    |      | 0.4            |                 | %              |

**AC Electrical Characteristics** (Cont'd)

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

| Parameter                                                         | Conditions                                                                                                                                                                                                | Min | Typ  | Max | Units              |
|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------|-----|--------------------|
| Frequency Response — Switch "ON" (Frequency at $-3\text{dB}$ )    | $V_C = V_{DD} = 5\text{V}$ , $V_{SS} = -5\text{V}$ ,<br>$R_L = 1\text{k}\Omega$ , $V_{IS} = 5\text{V}_{P.P.}$ ,<br>$20 \log_{10} V_{OS}/V_{IS}$ (1 kHz) — dB,<br>(Figure 4)                               |     | 40   |     | MHz                |
| Feedthrough — Switch "OFF" (Frequency at $-50\text{dB}$ )         | $V_{DD} = 5\text{V}$ , $V_C = V_{SS} = -5\text{V}$ ,<br>$R_L = 1\text{k}\Omega$ , $V_{IS} = 5\text{V}_{P.P.}$ ,<br>$20 \log_{10} (V_{OS}/V_{IS}) = -50\text{dB}$ ,<br>(Figure 4)                          |     | 1.25 |     | MHz                |
| Crosstalk Between Any Two Switches (Frequency at $-50\text{dB}$ ) | $V_{DD} = V_{C(A)} = 5\text{V}$ ; $V_{SS} = V_{C(B)} = -5\text{V}$ ,<br>$R_L = 1\text{k}\Omega$ , $V_{IS(A)} = 5\text{V}_{P.P.}$ ,<br>$20 \log_{10} (V_{OS(B)}/V_{OS(A)}) = -50\text{dB}$ ,<br>(Figure 5) |     | 0.9  |     | MHz                |
| Crosstalk; Control Input to Signal Output                         | $V_{DD} = 10\text{V}$ , $R_L = 10\text{k}\Omega$<br>$R_{IN} = 1\text{k}\Omega$ , $V_{CC} = 10\text{V}$ Square Wave,<br>$C_L = 50\text{pF}$ (Figure 6)                                                     |     | 150  |     | mV <sub>P.P.</sub> |
| Maximum Control Input                                             | $R_L = 1\text{k}\Omega$ , $C_L = 50\text{pF}$ , (Figure 7)<br>$V_{OS(f)} = \frac{1}{2} V_{OS}(1\text{ kHz})$                                                                                              |     |      |     |                    |
|                                                                   | $V_{DD} = 5\text{V}$                                                                                                                                                                                      |     | 6.5  |     | MHz                |
|                                                                   | $V_{DD} = 10\text{V}$                                                                                                                                                                                     |     | 8.0  |     | MHz                |
|                                                                   | $V_{DD} = 15\text{V}$                                                                                                                                                                                     |     | 9.0  |     | MHz                |
| $C_{IS}$ Signal Input Capacitance                                 |                                                                                                                                                                                                           |     | 4    |     | pF                 |
| $C_{OS}$ Signal Output Capacitance                                | $V_{DD} = 10\text{V}$                                                                                                                                                                                     |     | 4    |     | pF                 |
| $C_{IOS}$ Feedthrough Capacitance                                 | $V_C = 0\text{V}$                                                                                                                                                                                         |     | 0.2  |     | pF                 |
| $C_{IN}$ Control Input Capacitance                                |                                                                                                                                                                                                           |     | 5    | 7.5 | pF                 |

**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:**  $V_{SS} = 0\text{V}$  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 5pF 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  $V_{OL} \leq$  standard "B" series. See Figure 8.

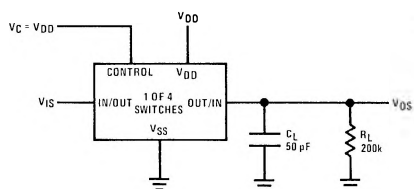
**AC Test Circuits and Switching Time Waveforms**

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

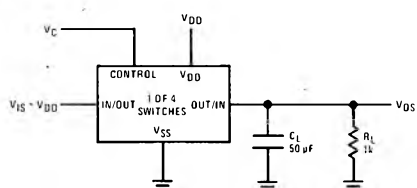
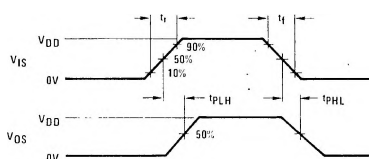
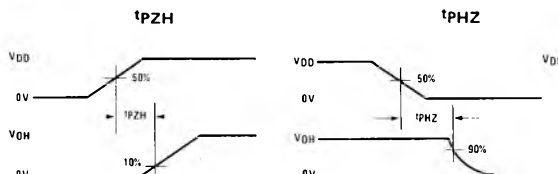


Figure 2.  $t_{PZH}$ ,  $t_{PHZ}$  Propagation Delay Time Control to Signal Output



## AC Test Circuits and Switching Time Waveforms (Cont'd)

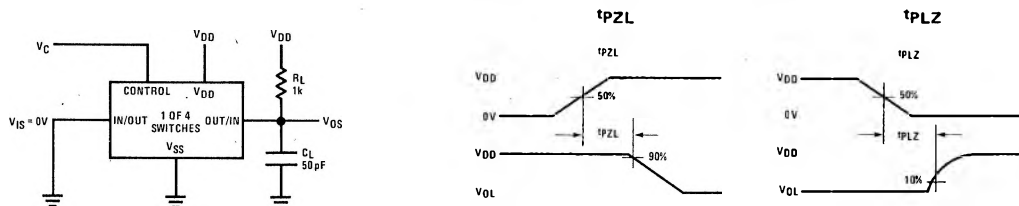
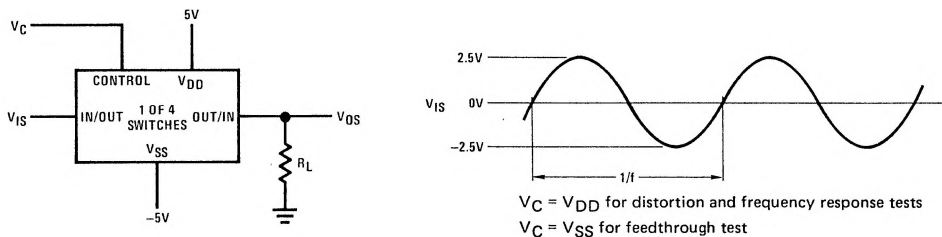
Figure 3.  $t_{PZH}$ ,  $t_{PHZ}$  Propagation Delay Time Control to Signal Output

Figure 4. Sine Wave Distortion, Frequency Response and Feedthrough

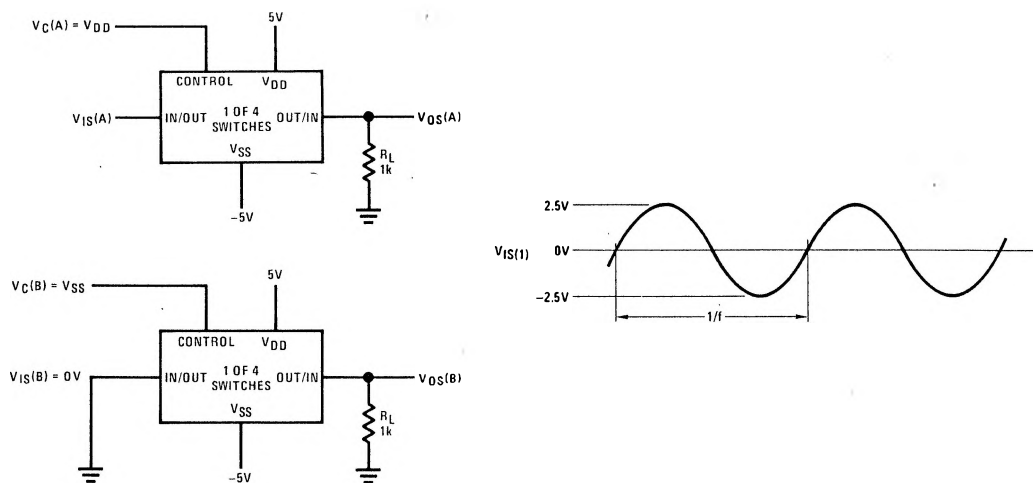


Figure 5. Crosstalk Between Any Two Switches

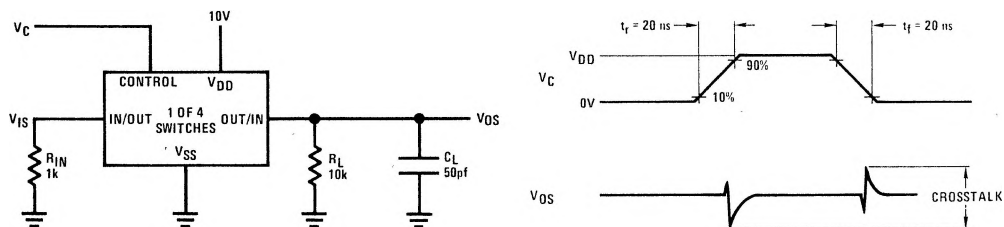


Figure 6. Crosstalk — Control to Input Signal Output

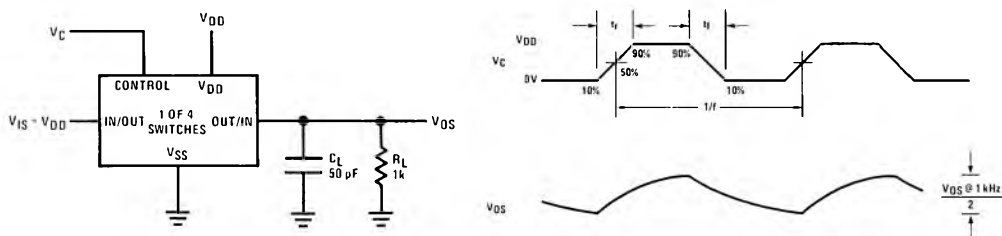


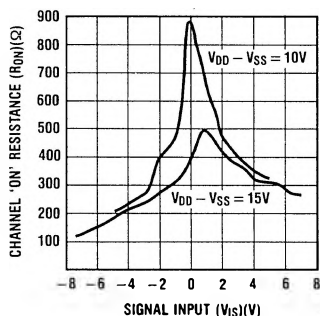
Figure 7. Maximum Control Input Frequency

| Temperature Range | $V_{DD}$ | Switch Input |               |       |            | Switch Output |      |
|-------------------|----------|--------------|---------------|-------|------------|---------------|------|
|                   |          | $V_{IS}$     | $I_{IS}$ (mA) |       |            | $V_{OS(V)}$   |      |
|                   |          |              | $T_{LOW}$     | 25°C  | $T_{HIGH}$ | Min.          | Max. |
| 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          |      |

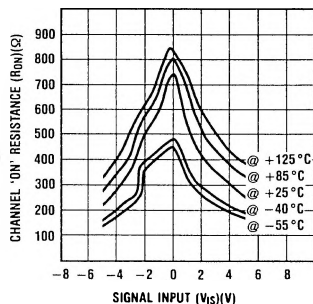
Figure 8. CD4016B Switch Test Conditions for  $V_{IHC}$ 

## Typical Performance Characteristics

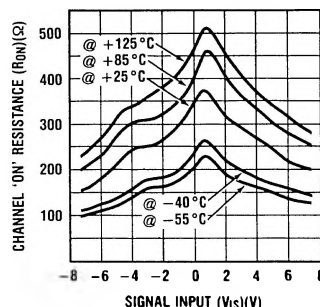
'ON' Resistance vs. Signal Voltage  
 $T_A = 25^\circ\text{C}$



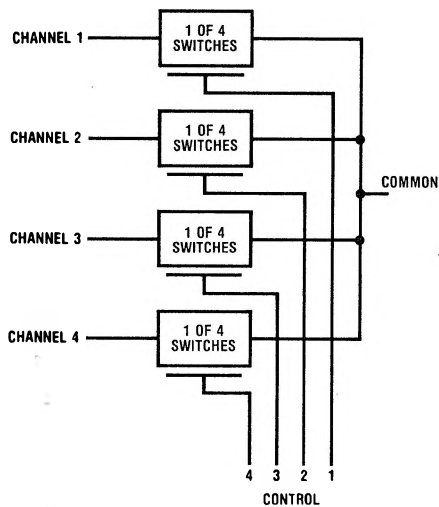
'ON' Resistance Temperature Variation for  $V_{DD} - V_{SS} = 10V$



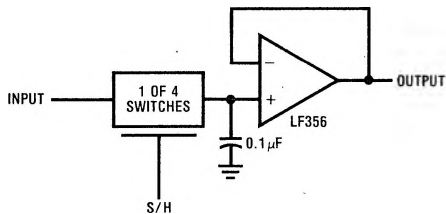
'ON' Resistance Temperature Variation for  $V_{DD} - V_{SS} = 15V$



## 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<sub>ON</sub>" 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.