

## 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

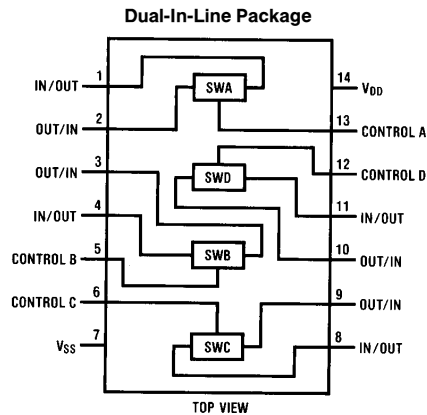
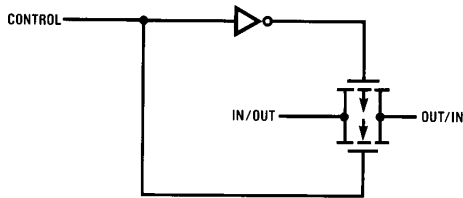
- Wide supply voltage range 3V to 15V
- Wide range of digital and analog switching  $\pm 7.5 V_{PEAK}$
- "ON" resistance for 15V operation 400 $\Omega$  (typ.)
- Matched "ON" resistance over 15V signal input  $\Delta R_{ON} = 10\Omega$  (typ.)
- High degree of linearity 0.4% distortion (typ.)  
@  $f_{IS} = 1 \text{ kHz}$ ,  $V_{IS} = 5 V_{p-p}$ ,  
 $V_{DD} - V_{SS} = 10V$ ,  $R_L = 10 \text{ k}\Omega$
- 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 10<sup>12</sup> $\Omega$  (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



Order Number CD4016B

TL/F/5661-1

## 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 <sub>DD</sub> Supply Voltage	−0.5V to +18V
V <sub>IN</sub> Input Voltage	−0.5V to V <sub>DD</sub> + 0.5V
T <sub>S</sub> Storage Temperature Range	−65°C to +150°C
Power Dissipation (P <sub>D</sub> )	
Dual-In-Line	700 mW
Small Outline	500 mW
Lead Temperature (Soldering, 10 seconds)	260°C

## Recommended Operating Conditions (Note 2)

V <sub>DD</sub> Supply Voltage	3V to 15V
V <sub>IN</sub> Input Voltage	0V to V <sub>DD</sub>
T <sub>A</sub> 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 <sub>DD</sub>	Quiescent Device Current	V <sub>DD</sub> = 5V, V <sub>IN</sub> = V <sub>DD</sub> or V <sub>SS</sub>		0.25		0.01	0.25		7.5	μA
		V <sub>DD</sub> = 10V, V <sub>IN</sub> = V <sub>DD</sub> or V <sub>SS</sub>		0.5		0.01	0.5		15	μA
		V <sub>DD</sub> = 15V, V <sub>IN</sub> = V <sub>DD</sub> or V <sub>SS</sub>		1.0		0.01	1.0		30	μA
<b>Signal Inputs and Outputs</b>										
R <sub>ON</sub>	“ON” Resistance	R <sub>L</sub> = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V <sub>C</sub> = V <sub>DD</sub> , V <sub>IS</sub> = V <sub>SS</sub> or V <sub>DD</sub> V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V		600 360		250 200	660 400		960 600	Ω Ω
		R <sub>L</sub> = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V <sub>C</sub> = V <sub>DD</sub> V <sub>DD</sub> = 10V, V <sub>IS</sub> = 4.75 to 5.25V V <sub>DD</sub> = 15V, V <sub>IS</sub> = 7.25 to 7.75V		1870 775		850 400	2000 850		2600 1230	Ω Ω
ΔR <sub>ON</sub>	Δ“ON” Resistance Between any 2 of 4 Switches (In Same Package)	R <sub>L</sub> = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V <sub>C</sub> = V <sub>DD</sub> , V <sub>IS</sub> = V <sub>SS</sub> to V <sub>DD</sub> V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V				15 10			Ω Ω	
I <sub>IS</sub>	Input or Output Leakage Switch “OFF”	V <sub>C</sub> = 0, V <sub>DD</sub> = 15V V <sub>IS</sub> = 15V and 0V, V <sub>OS</sub> = 0V and 15V		±50		±0.1	±50		±500	nA
<b>Control Inputs</b>										
V <sub>ILC</sub>	Low Level Input Voltage	V <sub>IS</sub> = V <sub>SS</sub> and V <sub>DD</sub> V <sub>OS</sub> = V <sub>DD</sub> and V <sub>SS</sub> I <sub>IS</sub> = ±10 μA V <sub>DD</sub> = 5V		0.9			0.7		0.5	V
		V <sub>DD</sub> = 10V		0.9			0.7		0.5	V
		V <sub>DD</sub> = 15V		0.9			0.7		0.5	V
V <sub>IHC</sub>	High Level Input Voltage	V <sub>DD</sub> = 5V	3.5		3.5			3.5		V
		V <sub>DD</sub> = 10V (see Note 6 and Figure 8)	7.0		7.0			7.0		V
		V <sub>DD</sub> = 15V	11.0		11.0			11.0		V
I <sub>IN</sub>	Input Current	V <sub>DD</sub> − V <sub>SS</sub> = 15V V <sub>DD</sub> ≥ V <sub>IS</sub> ≥ V <sub>SS</sub> V <sub>DD</sub> ≥ V <sub>C</sub> ≥ V <sub>SS</sub>		±0.1		±10 <sup>−5</sup>	±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 <sub>DD</sub>	Quiescent Device Current	V <sub>DD</sub> = 5V, V <sub>IN</sub> = V <sub>DD</sub> or V <sub>SS</sub>		1.0		0.01	1.0		7.5	μA
		V <sub>DD</sub> = 10V, V <sub>IN</sub> = V <sub>DD</sub> or V <sub>SS</sub>		2.0		0.01	2.0		15	μA
		V <sub>DD</sub> = 15V, V <sub>IN</sub> = V <sub>DD</sub> or V <sub>SS</sub>		4.0		0.01	4.0		30	μA
<b>Signal Inputs and Outputs</b>										
R <sub>ON</sub>	"ON" Resistance	R <sub>L</sub> = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V <sub>C</sub> = V <sub>DD</sub> , V <sub>IS</sub> = V <sub>SS</sub> or V <sub>DD</sub> V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V		610 370		275 200	660 400		840 520	Ω Ω
		R <sub>L</sub> = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V <sub>C</sub> = V <sub>DD</sub> V <sub>DD</sub> = 10V, V <sub>IS</sub> = 4.75 to 5.25V V <sub>DD</sub> = 15V, V <sub>IS</sub> = 7.25 to 7.75V		1900 790		850 400	2000 850		2380 1080	Ω Ω
ΔR <sub>ON</sub>	Δ"ON" Resistance Between any 2 of 4 Switches (In Same Package)	R <sub>L</sub> = 10 kΩ to $\frac{V_{DD}-V_{SS}}{2}$ V <sub>C</sub> = V <sub>DD</sub> , V <sub>IS</sub> = V <sub>SS</sub> to V <sub>DD</sub> V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V				15 10			Ω Ω	
I <sub>IS</sub>	Input or Output Leakage Switch "OFF"	V <sub>C</sub> = 0, V <sub>DD</sub> = 15V V <sub>IS</sub> = 0V or 15V, V <sub>OS</sub> = 15V or 0V		±50		±0.1	±50		±200	nA
<b>Control Inputs</b>										
V <sub>ILC</sub>	Low Level Input Voltage	V <sub>IS</sub> = V <sub>SS</sub> and V <sub>DD</sub> V <sub>OS</sub> = V <sub>DD</sub> and V <sub>SS</sub> I <sub>IS</sub> = ±10 μA V <sub>DD</sub> = 5V V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V		0.9 0.9 0.9			0.7 0.7 0.7		0.4 0.4 0.4	V V V
			V <sub>IHC</sub>	High Level Input Voltage	V <sub>DD</sub> = 5V	3.5	3.5	3.5	V	
					V <sub>DD</sub> = 10V (see Note 6 and Figure 8)	7.0	7.0	7.0	V	
					V <sub>DD</sub> = 15V	11.0	11.0	11.0	V	
I <sub>IN</sub>	Input Current	V <sub>CC</sub> - V <sub>SS</sub> = 15V V <sub>DD</sub> ≥ V <sub>IS</sub> ≥ V <sub>SS</sub> V <sub>DD</sub> ≥ V <sub>C</sub> ≥ V <sub>SS</sub>		±0.3		±10 <sup>-5</sup>	±0.3		±1.0	μA

## AC Electrical Characteristics\* T<sub>A</sub> = 25°C, t<sub>r</sub> = t<sub>f</sub> = 20 ns and V<sub>SS</sub> = 0V unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t <sub>PHL</sub> , t <sub>PLH</sub>	Propagation Delay Time Signal Input to Signal Output	V <sub>C</sub> = V <sub>DD</sub> , C <sub>L</sub> = 50 pF, (Figure 1) R <sub>L</sub> = 200k				
		V <sub>DD</sub> = 5V		58	100	ns
		V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V		27 20	50 40	ns ns
t <sub>PZH</sub> , t <sub>PZL</sub>	Propagation Delay Time Control Input to Signal Output High Impedance to Logical Level	R <sub>L</sub> = 1.0 kΩ, C <sub>L</sub> = 50 pF, (Figures 2 and 3)				
		V <sub>DD</sub> = 5V		20	50	ns
		V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V		18 17	40 35	ns ns
t <sub>PHZ</sub> , t <sub>PLZ</sub>	Propagation Delay Time Control Input to Signal Output Logical Level to High Impedance	R <sub>L</sub> = 1.0 kΩ, C <sub>L</sub> = 50 pF, (Figures 2 and 3)				
		V <sub>DD</sub> = 5V		15	40	ns
		V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V		11 10	25 22	ns ns
		Sine Wave Distortion V <sub>C</sub> = V <sub>DD</sub> = 5V, V <sub>SS</sub> = -5 R <sub>L</sub> = 10 kΩ, V <sub>IS</sub> = 5 V <sub>P-P</sub> , f = 1 kHz, (Figure 4)		0.4		%

## AC Electrical Characteristics\* (Continued)

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

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

\*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:**  $V_{SS} = 0\text{V}$  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 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  $V_{OL} \leq “B”$  series. These currents are shown in Figure 8.

## AC Test Circuits and Switching Time Waveforms

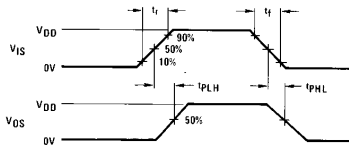
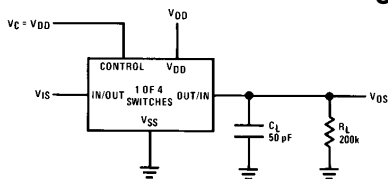


Figure 1.  $t_{PLH}$ ,  $t_{PHL}$  Propagation Delay Time Signal Input to Signal Output

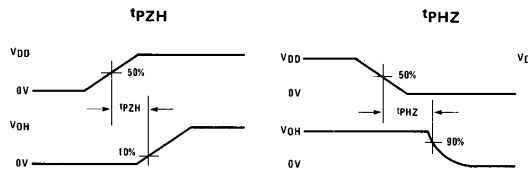
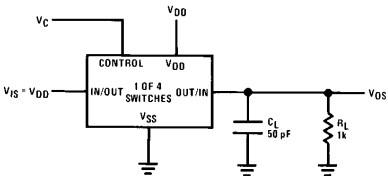


FIGURE 2.  $t_{PZH}$ ,  $t_{PHZ}$  Propagation Delay Time Control to Signal Output

TL/F/5661-2

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

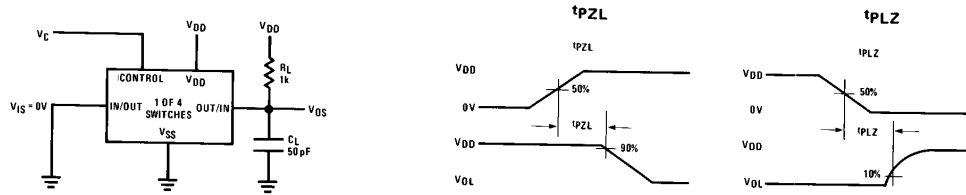


FIGURE 3.  $t_{PZH}$ ,  $t_{PHZ}$  Propagation Delay Time Control to Signal Output

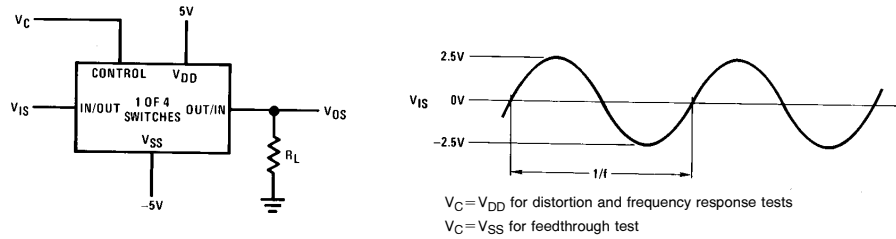


FIGURE 4. Sine Wave Distortion, Frequency Response and Feedthrough

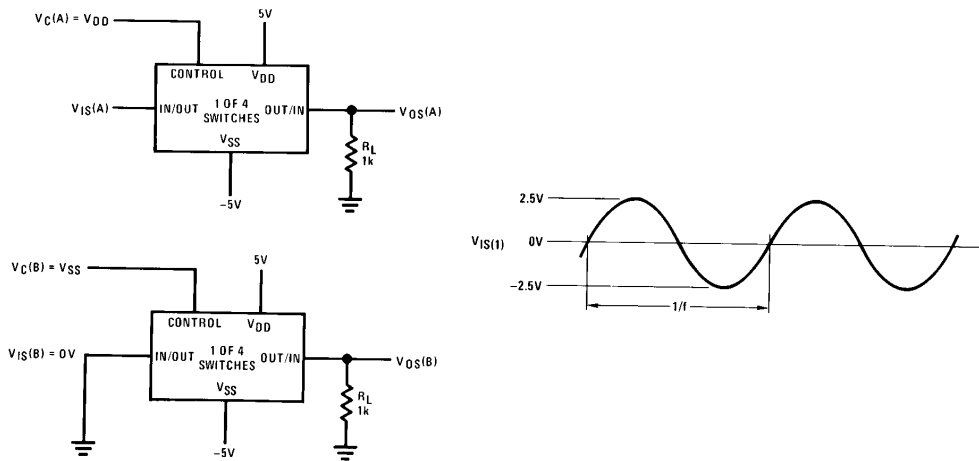


FIGURE 5. Crosstalk Between Any Two Switches

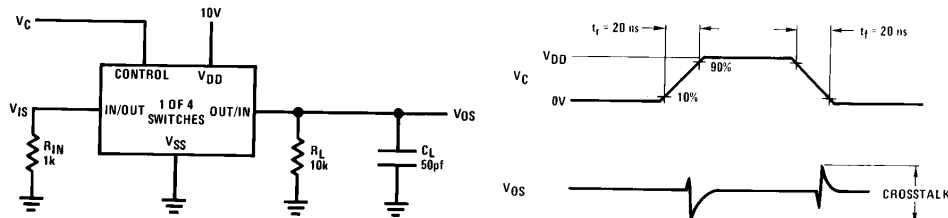


FIGURE 6. Crosstalk — Control to Input Signal Output

TL/F/5661-3

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

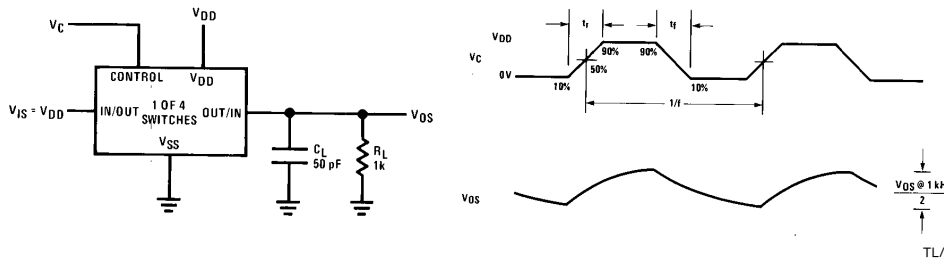


FIGURE 7. Maximum Control Input Frequency

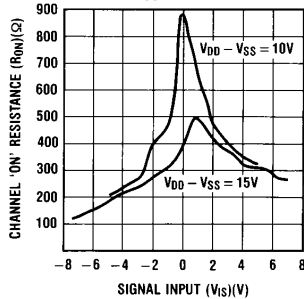
TL/F/5661-4

Temperature Range	V <sub>DD</sub>	Switch Input				Switch Output V <sub>OS</sub> (V)	
		V <sub>IS</sub>	I <sub>S</sub> (mA)			Min	Max
			T <sub>LOW</sub>	25°C	T <sub>HIGH</sub>		
MILITARY	5	0	0.25	0.2	0.14	4.6	0.4
	5	5	-0.25	-0.2	-0.14	9.5	0.5
	10	0	0.62	0.5	0.35	13.5	1.5
	10	10	-0.62	-0.5	-0.35		
	15	0	1.8	1.5	1.1		
COMMERCIAL	5	0	0.2	0.16	0.12	4.6	0.4
	5	5	-0.2	-0.16	-0.12	9.5	0.5
	10	0	0.5	0.4	0.3	13.5	1.5
	10	10	-0.5	-0.4	-0.3		
	15	0	1.4	1.2	1.0		
	15	15	-1.4	-1.2	-1.0		

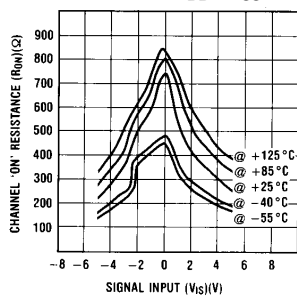
FIGURE 8. CD4016B Switch Test Conditions for V<sub>IHC</sub>

## Typical Performance Characteristics

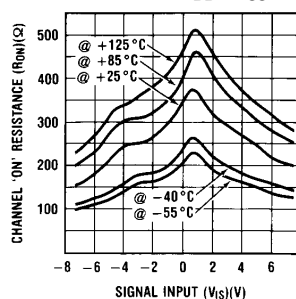
'ON' Resistance vs. Signal Voltage T<sub>A</sub> = 25°C



'ON' Resistance Temperature Variation for V<sub>DD</sub> - V<sub>SS</sub> = 10V

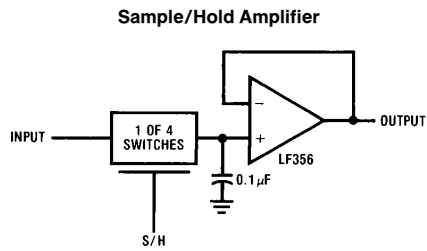
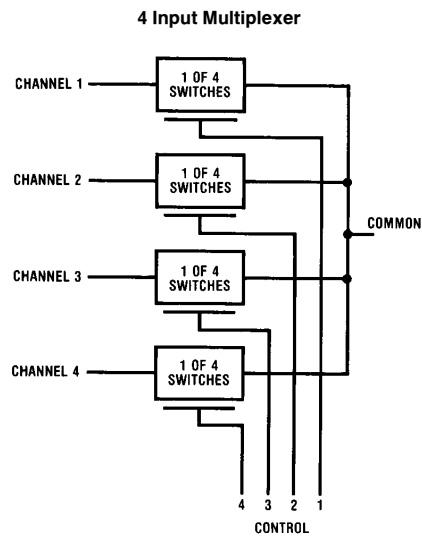


'ON' Resistance Temperature Variation for V<sub>DD</sub> - V<sub>SS</sub> = 15V



TL/F/5661-5

## Typical Applications



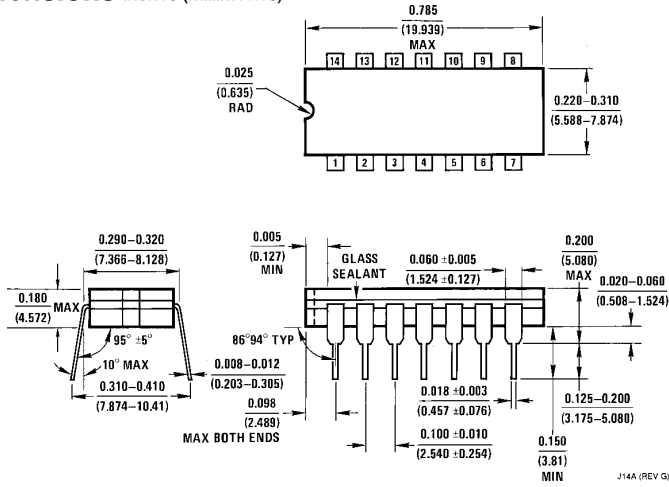
TL/F/5661-6

### Special Considerations

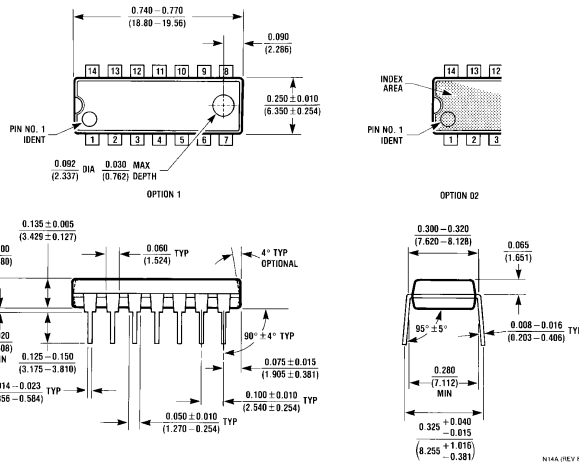
The CD4016B is composed of 4, two-transistor analog switches. These switches do not have any linearization or compensation circuitry for "R<sub>ON</sub>" as do the CD4066B's. Because of this, the special operating considerations for the CD4066B do not apply to the CD4016B, but at low

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<sub>DD</sub> or V<sub>SS</sub>; and that at 3V the voltages on the in/out pins should be at V<sub>DD</sub> or V<sub>SS</sub> for reliable operation.

**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**

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
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

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.