

## 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

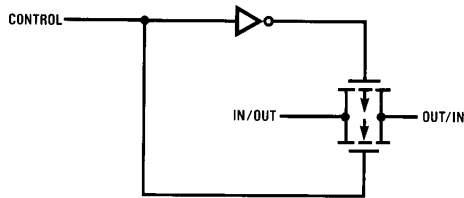
- Wide supply voltage range 3V to 15V
- Wide range of digital and analog switching  $\pm 7.5 V_{PEAK}$
- "ON" resistance for 15V operation 400 $\Omega$  (typ.)
- Matched "ON" resistance over 15V signal input  $\Delta R_{ON} = 10\Omega$  (typ.)
- High degree of linearity 0.4% distortion (typ.)  
@  $f_{IS}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

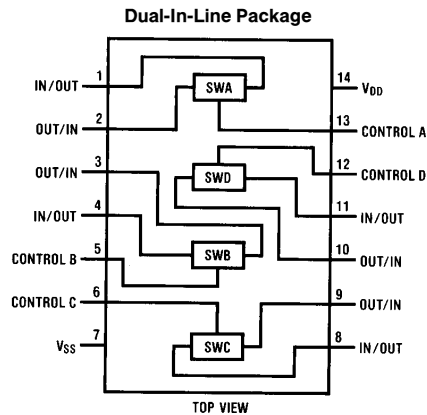
### Applications

- 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

### Signal Inputs and Outputs

R <sub>ON</sub>	“ON” Resistance	$R_L = 10\text{ k}\Omega$ 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
ΔR <sub>ON</sub>	Δ“ON” Resistance Between any 2 of 4 Switches (In Same Package)	$R_L = 10\text{ k}\Omega$ 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
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

### Control Inputs

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		0.5 0.5 0.5	V V V
V <sub>IHC</sub>	High Level Input Voltage	V <sub>DD</sub> = 5V V <sub>DD</sub> = 10V (see Note 6 and Figure 8) V <sub>DD</sub> = 15V	3.5 7.0 11.0		3.5 7.0 11.0			3.5 7.0 11.0		V V 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> V <sub>DD</sub> = 10V, V <sub>IN</sub> = V <sub>DD</sub> or V <sub>SS</sub> V <sub>DD</sub> = 15V, V <sub>IN</sub> = V <sub>DD</sub> or V <sub>SS</sub>		1.0 2.0 4.0		0.01 0.01 0.01	1.0 2.0 4.0		7.5 15 30	μA μA μA
Signal Inputs and Outputs										
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 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		610 370		275 200	660 400		840 520	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		1900 790		850 400	2000 850		2380 1080	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
Control Inputs										
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 V <sub>DD</sub> = 10V (see Note 6 and V <sub>DD</sub> = 15V Figure 8)	3.5 7.0 11.0		3.5 7.0 11.0			3.5 7.0 11.0		V V 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 V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V		58 27 20	100 50 40	ns 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 V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V		20 18 17	50 40 35	ns ns ns				
t <sub>PHZ</sub> , t <sub>PLZ</sub>	Propagation Delay Time Control Input to Signal Output Logical Level to High Impedance  Sine Wave Distortion	R <sub>L</sub> = 1.0 kΩ, C <sub>L</sub> = 50 pF, (Figures 2 and 3) V <sub>DD</sub> = 5V V <sub>DD</sub> = 10V V <sub>DD</sub> = 15V 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)		15 11 10 0.4	40 25 22	ns ns ns %				

## 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 $-3\text{ dB}$ )	$V_C = V_{DD} = 5\text{V}$ , $V_{SS} = -5\text{V}$ , $R_L = 1\text{ k}\Omega$ , $V_{IS} = 5\text{ V}_{P-P}$ , $20\text{ Log}_{10} V_{OS}/V_{OS}(1\text{ kHz}) - \text{dB}$ , (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  $5\text{ pF}$  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

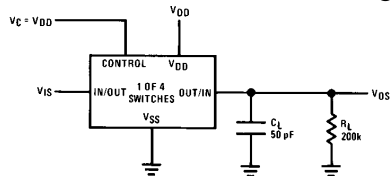


Figure 1.  $t_{PLH}$ ,  $t_{PLH}$  Propagation Delay Time Signal Input to Signal Output

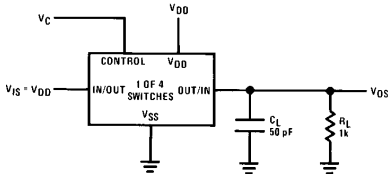
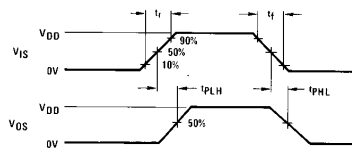
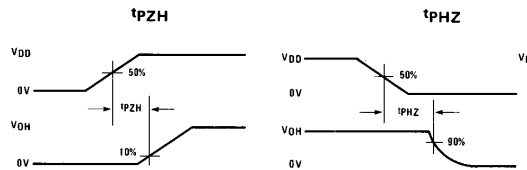


FIGURE 2.  $t_{PZH}$ ,  $t_{PHZ}$  Propagation Delay Time Control to Signal Output



TL/F/5661-2

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

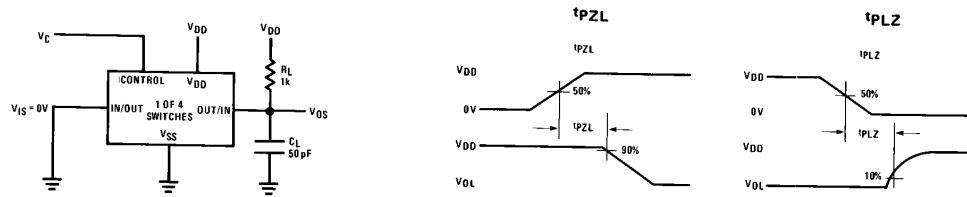


FIGURE 3.  $t_{PZH}$ ,  $t_{PHZ}$  Propagation Delay Time Control to Signal Output

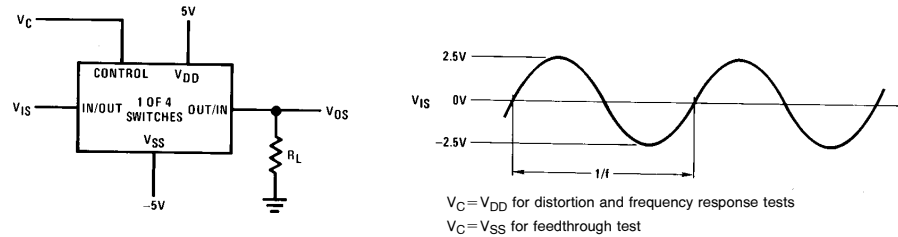


FIGURE 4. Sine Wave Distortion, Frequency Response and Feedthrough

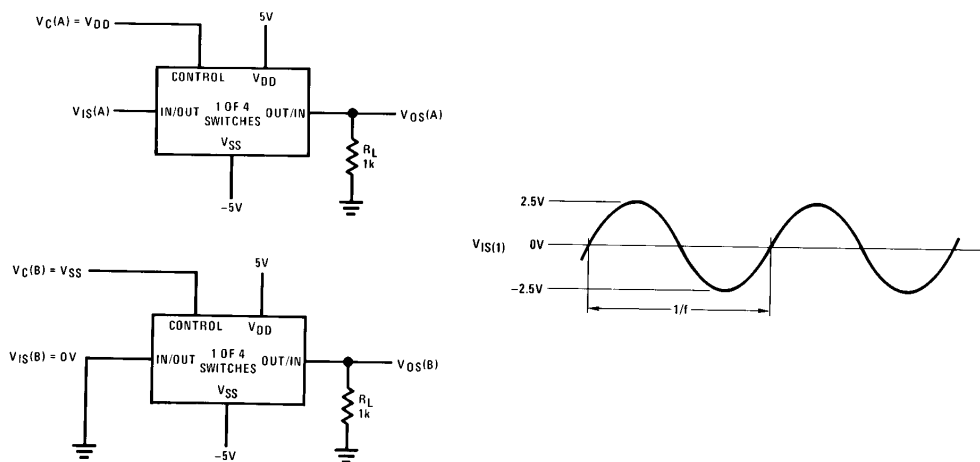


FIGURE 5. Crosstalk Between Any Two Switches

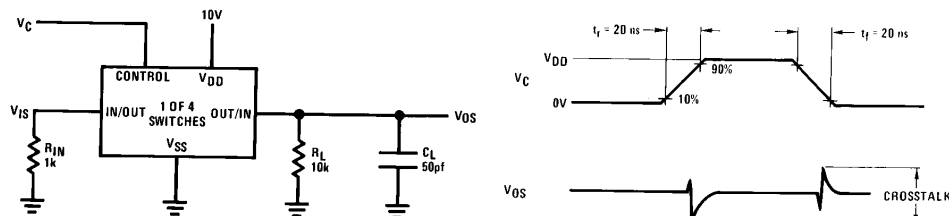


FIGURE 6. Crosstalk — Control to Input Signal Output

TL/F/5661-3

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

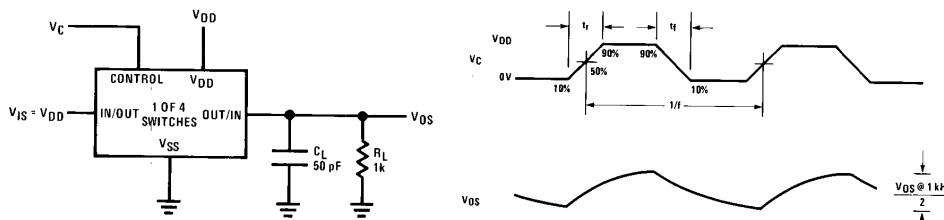


FIGURE 7. Maximum Control Input Frequency

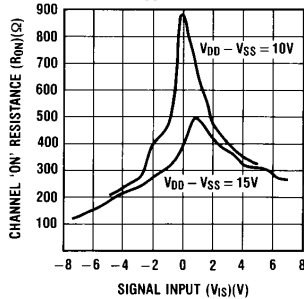
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Temperature Range	V <sub>DD</sub>	Switch Input				Switch Output V <sub>OS</sub> (V)	
		V <sub>IS</sub>	I <sub>IS</sub> (mA)			Min	Max
			T <sub>LOW</sub>	25°C	T <sub>HIGH</sub>		
MILITARY	5	0	0.25	0.2	0.14		0.4
	5	5	-0.25	-0.2	-0.14	4.6	
	10	0	0.62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

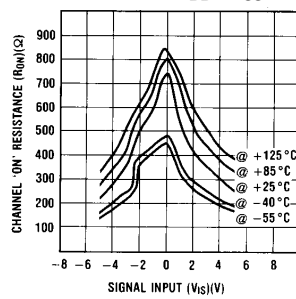
FIGURE 8. CD4016B Switch Test Conditions for V<sub>IHC</sub>

## Typical Performance Characteristics

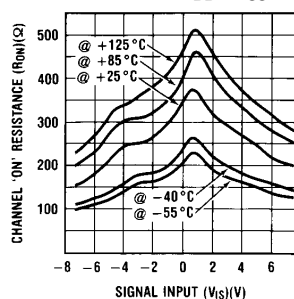
'ON' Resistance vs. Signal Voltage T<sub>A</sub> = 25°C



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

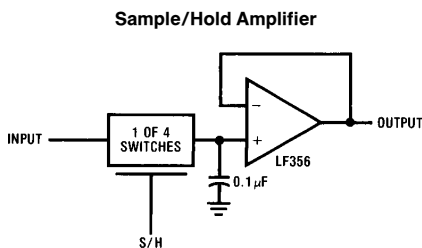
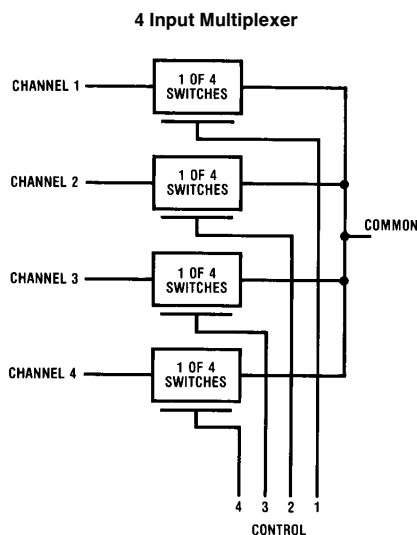


'ON' Resistance Temperature Variation for V<sub>DD</sub> - V<sub>SS</sub> = 15V



TL/F/5661-5

## Typical Applications



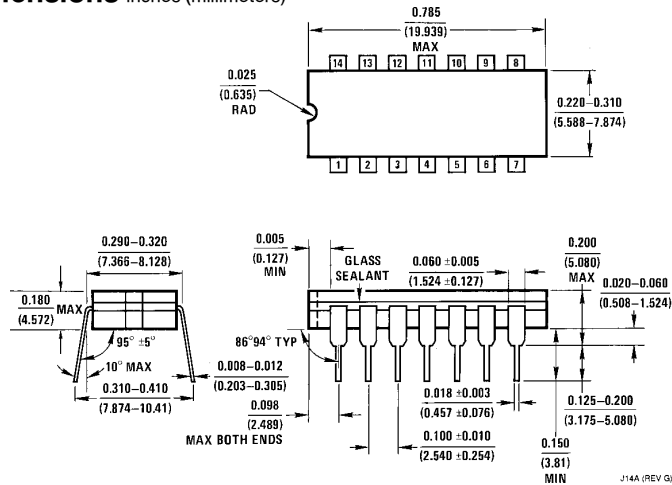
TL/F/5661-6

### Special Considerations

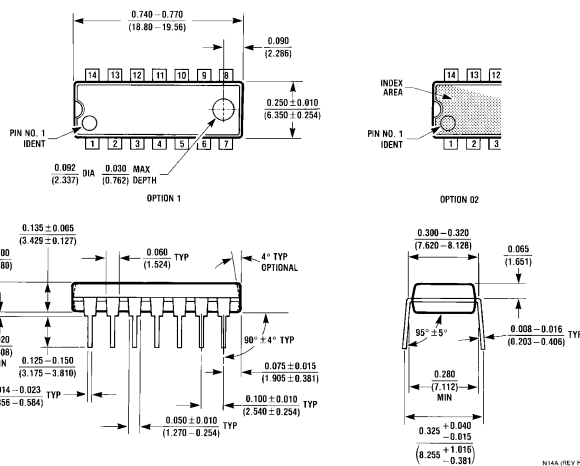
The CD4016B is composed of 4, two-transistor analog switches. These switches do not have any linearization or compensation circuitry for "R<sub>ON</sub>" as do the CD4066B's. Because of this, the special operating considerations for the CD4066B do not apply to the CD4016B, but at low

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

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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.



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