National Semiconductor

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.

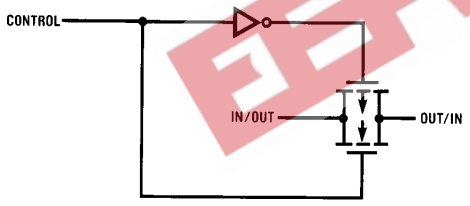
Features

- Wide supply voltage range — 3V to 15V
- Wide range of digital and analog switching — ± 7.5 V_{PEAK}
- "ON" resistance for 15V operation — 400Ω (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 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 — $10^{12}\Omega$ (typ.)
- Low crosstalk between switches — −50 dB (typ.) @ $f_{IS} = 0.9$ MHz, $R_L = 1$ kΩ
- Frequency response, switch "ON" — 40 MHz (typ.)

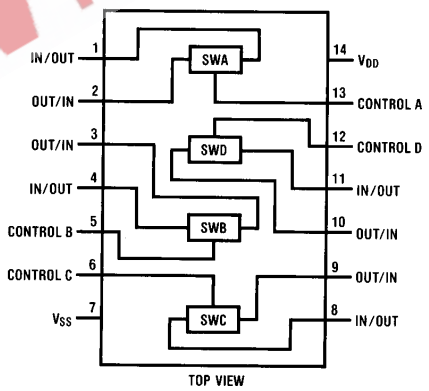
Applications

- 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

Schematic and Connection Diagrams



Dual-In-Line Package



TL/F/5661–1

Order Number CD4016B

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	$R_L=10\ k\Omega$ 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	Ω
		$V_{DD}=15V$		360		200	400		600	Ω
		$R_L=10\ k\Omega$ 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	Ω
		$V_{DD}=15V$, $V_{IS}=7.25$ to $7.75V$		775		400	850		1230	Ω
ΔR_{ON}	Δ"ON" Resistance Between any 2 of 4 Switches (In Same Package)	$R_L=10\ k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$								
		$V_C=V_{DD}$, $V_{IS}=V_{SS}$ to V_{DD}								
		$V_{DD}=10V$				15				Ω
		$V_{DD}=15V$				10				Ω
I_{IS}	Input or Output Leakage Switch "OFF"	$V_C=0$, $V_{DD}=15V$		±50		±0.1	±50		±500	nA
		$V_{IS}=15V$ and 0V,								
		$V_{OS}=0V$ and 15V								
Control Inputs										
V_{ILC}	Low Level Input Voltage	$V_{IS}=V_{SS}$ and V_{DD}								
		$V_{OS}=V_{DD}$ and V_{SS}								
		$I_{IS}=\pm10\ \mu A$								
		$V_{DD}=5V$		0.9			0.7		0.5	V
		$V_{DD}=10V$		0.9			0.7		0.5	V
		$V_{DD}=15V$		0.9			0.7		0.5	V
V_{IHC}	High Level Input Voltage	$V_{DD}=5V$	3.5		3.5			3.5		V
		$V_{DD}=10V$ (see Note 6 and	7.0		7.0			7.0		V
		$V_{DD}=15V$ *Figure 8*)	11.0		11.0			11.0		V
I_{IN}	Input Current	$V_{DD}-V_{SS}=15V$		±0.1		$\pm10^{-5}$	±0.1		±1.0	μA
		$V_{DD}\geq V_{IS}\geq V_{SS}$								
		$V_{DD}\geq V_C\geq V_{SS}$								

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	$R_L=10\ k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$, $V_C=V_{DD}$, $V_{IS}=V_{SS}$ or V_{DD}								
		$V_{DD}=10V$		610		275	660		840	Ω
		$V_{DD}=15V$		370		200	400		520	Ω
		$R_L=10\ k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$, $V_C=V_{DD}$								
		$V_{DD}=10V$, $V_{IS}=4.75$ to $5.25V$		1900		850	2000		2380	Ω
		$V_{DD}=15V$, $V_{IS}=7.25$ to $7.75V$		790		400	850		1080	Ω
ΔR_{ON}	Δ"ON" Resistance Between any 2 of 4 Switches (In Same Package)	$R_L=10\ k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$, $V_C=V_{DD}$, $V_{IS}=V_{SS}$ to V_{DD}								
		$V_{DD}=10V$				15				Ω
		$V_{DD}=15V$				10				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}, $I_{IS}=\pm10\ \mu A$								
		$V_{DD}=5V$		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 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	$V_{CC}-V_{SS}=15V$, $V_{DD}\geq V_{IS}\geq V_{SS}$, $V_{DD}\geq V_C\geq V_{SS}$		±0.3		$\pm10^{-5}$	±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*) $R_L=200k$				
		$V_{DD}=5V$		58	100	ns
		$V_{DD}=10V$		27	50	ns
		$V_{DD}=15V$		20	40	ns
t_{PZH}, t_{PZL}	Propagation Delay Time Control Input to Signal Output High Impedance to Logical Level	$R_L=1.0\ k\Omega$, $C_L=50$ pF, (*Figures 2* and *3*)				
		$V_{DD}=5V$		20	50	ns
		$V_{DD}=10V$		18	40	ns
		$V_{DD}=15V$		17	35	ns
t_{PHZ}, t_{PLZ}	Propagation Delay Time *Control Input to Signal* Output Logical Level to High Impedance	$R_L=1.0\ k\Omega$, $C_L=50$ pF, (*Figures 2* and *3*)				
		$V_{DD}=5V$		15	40	ns
		$V_{DD}=10V$		11	25	ns
		$V_{DD}=15V$		10	22	ns
	Sine Wave Distortion	$V_C=V_{DD}=5V$, $V_{SS}=-5$, $R_L=10\ k\Omega$, $V_{IS}=5\ V_{P-P}$, $f=1$ kHz, (*Figure 4*)		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)	$V_C = V_{DD} = 5V$, $V_{SS} = -5V$, $R_L = 1\ k\Omega$, $V_{IS} = 5\ V_{P-P}$, $20\ \text{Log}_{10}\ V_{OS}/V_{OS}$ (1 kHz) −dB, (*Figure 4*)		40		MHz
	Feedthrough — Switch "OFF" (Frequency at −50 dB)	$V_{DD} = 5V$, $V_C = V_{SS} = -5V$, $R_L = 1\ k\Omega$, $V_{IS} = 5\ V_{P-P}$, $20\ \text{Log}_{10}\ (V_{OS}/V_{IS}) = -50$ dB, (*Figure 4*)		1.25		MHz
	Crosstalk Between Any Two Switches (Frequency at −50 dB)	$V_{DD} = V_{C(A)} = 5V$; $V_{SS} = V_{C(B)} = -5V$, $R_L = 1\ k\Omega V_{IS(A)} = 5\ V_{P-P}$, $20\ \text{Log}_{10}\ (V_{OS(B)}/V_{OS(A)}) = -50$ dB, (*Figure 5*)		0.9		MHz
	Crosstalk; Control Input to Signal Output	$V_{DD} = 10V$, $R_L = 10\ k\Omega$ $R_{IN} = 1\ k\Omega$, $V_{CC} = 10V$ Square Wave, $C_L = 50$ pF (*Figure 6*)		150		mV_{P-P}
	Maximum Control Input	$R_L = 1\ k\Omega$, $C_L = 50$ 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

*AC Paramters 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 $V_{OL} \leq$ "B" series. These currents are shown in *Figure 8*.

AC Test Circuits and Switching Time Waveforms

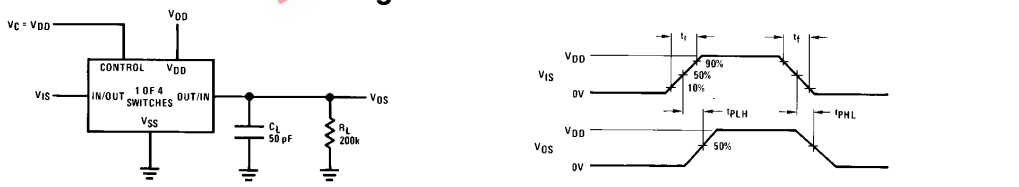
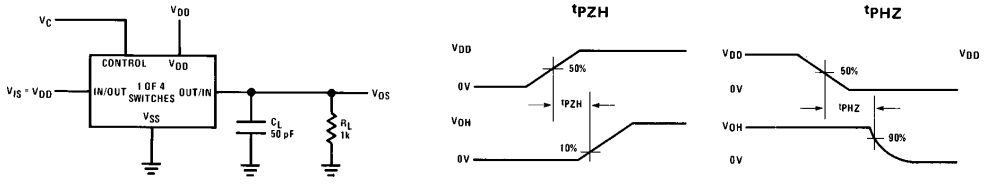


Figure 1. t_{PLH}, t_{PLH} Propagation Delay Time Signal Input to Signal Output



TL/F/5661–2

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

AC Test Circuits and Switching Time Waveforms (Continued)

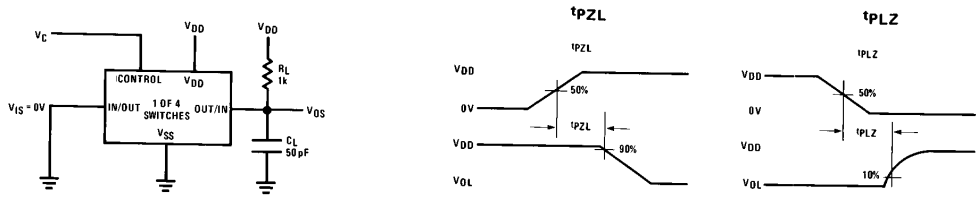
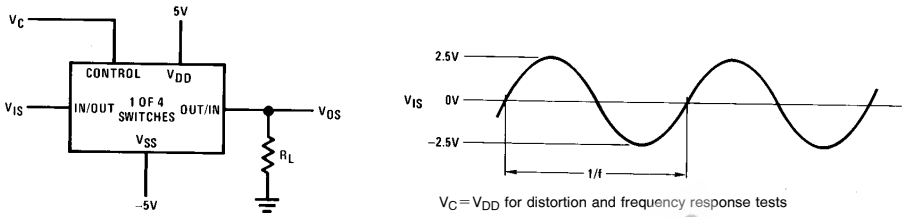


FIGURE 3. t_{PZH}, t_{PHZ} Propagation Delay Time Control to Signal Output



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

FIGURE 4. Sine Wave Distortion, Frequency Response and Feedthrough

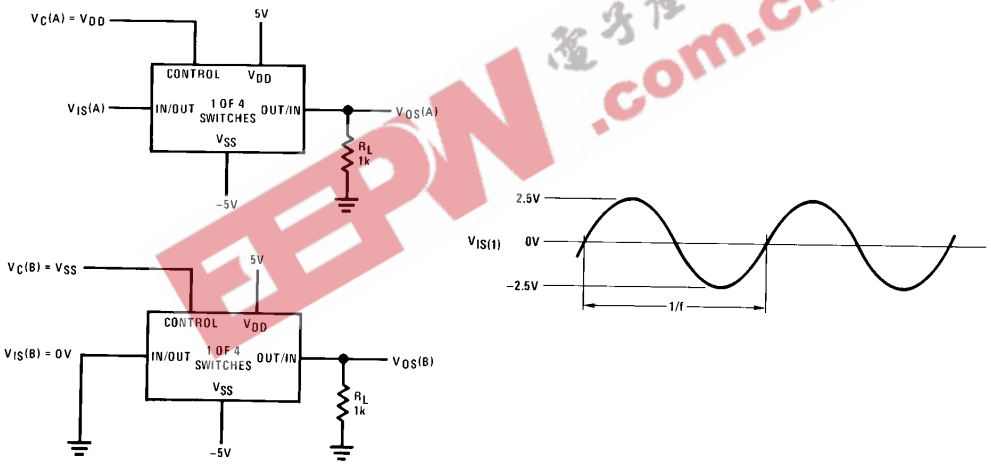


FIGURE 5. Crosstalk Between Any Two Switches

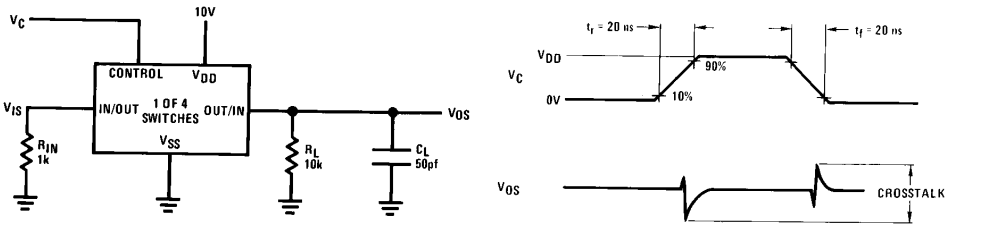


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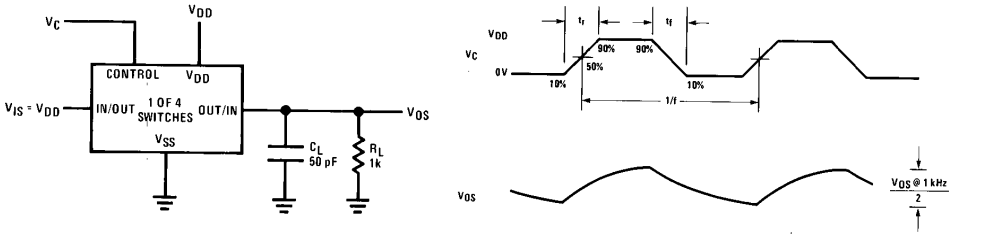
FIGURE 6. Crosstalk — Control to Input Signal Output

AC Test Circuits and Switching Time Waveforms (Continued)



TL/F/5661–4

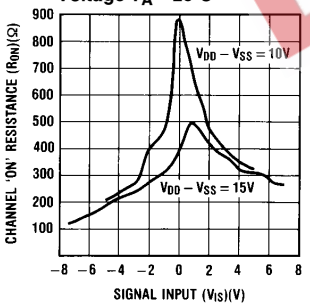
FIGURE 7. Maximum Control Input Frequency

Temperature Range	V_{DD}	Switch Input				Switch Output $V_{OS(V)}$	
		V_{IS}	I_{IS} (mA)				
			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	

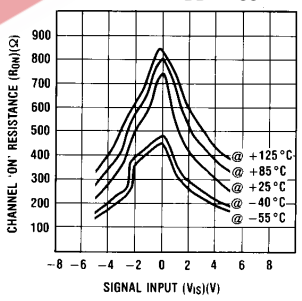
FIGURE 8. CD4016B Switch Test Conditions for V_{IHC}

Typical Performance Characteristics

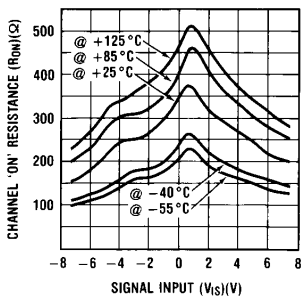
'ON' Resistance vs. Signal Voltage $T_A = 25°C$



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



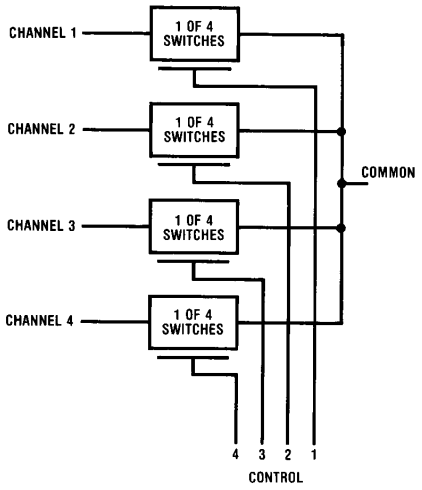
'ON' Resistance Temperature Variation for $V_{DD} - V_{SS} = 15V$



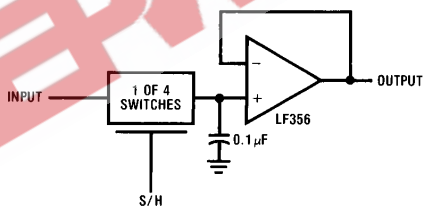
TL/F/5661–5

Typical Applications

4 Input Multiplexer



Sample/Hold Amplifier

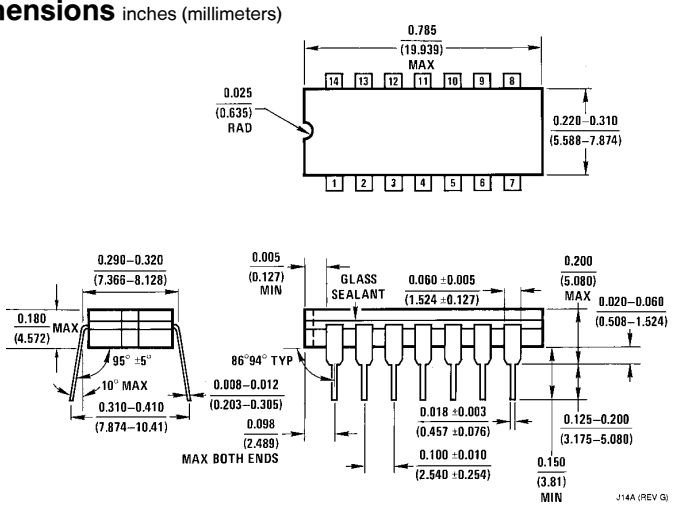


TL/F/5661–6

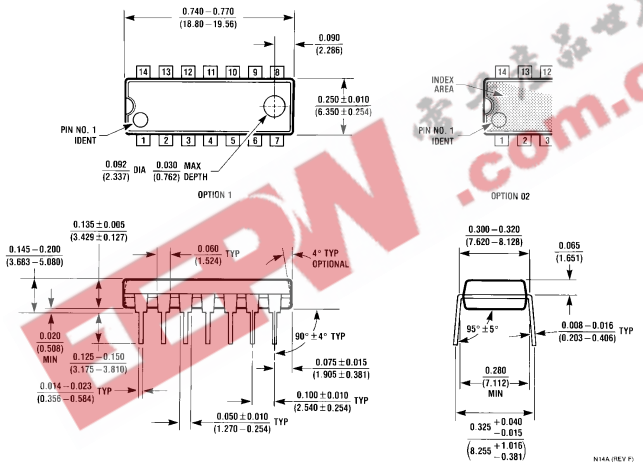
Special Considerations

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.

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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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.
13th 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