$10^{12}\Omega$  (typ.)

-50 dB (typ.)

40 MHz (typ.)

@ f $_{IS}\!=\!0.9$  MHz,  $R_L\!=\,1~k\Omega$ 



### 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<sub>PEAK</sub> ■ "ON" resistance for 15V operation  $400\Omega$  (typ.)

■ Matched "ON" resistance over 15V

 $\Delta R_{ON} = 10\Omega$  (typ.) signal input ■ High degree of linearity

> @  $f_{IS} = 1 \text{ kHz}, V_{IS} = 5 V_{p-p},$  $V_{DD}\!-\!V_{SS}\!=\!10V,\,R_L\!=\!10\,k\Omega$

■ Extremely low "OFF" switch leakage 0.1 nA (typ.)  $V_{DD} - V_{SS} = 10V$ 

0.4% distortion (typ.)

T<sub>A</sub> = 25°C

· Commutating switch ■ Digital signal switching/multiplexing ■ CMOS logic implementation

■ Analog-to-digital/digital-to-analog conversion

■ Extremely high control input impedance

■ Low crosstalk between switches

■ Frequency response, switch "ON"

■ Analog signal switching/multiplexing

**Applications** 

Signal gating

Chopper

Squelch control

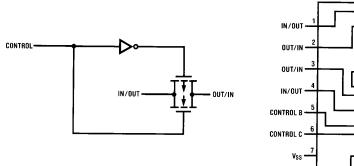
Modulator/Demodulator

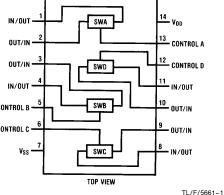
■ Digital control of frequency, impedance, phase, and an-

alog-signal gain

**Dual-In-Line Package** 

## **Schematic and Connection Diagrams**





**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)

 $\begin{array}{lll} V_{DD} \, \text{Supply Voltage} & -0.5 \text{V to} \, + 18 \text{V} \\ V_{IN} \, \text{Input Voltage} & -0.5 \text{V to} \, V_{DD} \, + \, 0.5 \text{V} \end{array}$ 

Ts Storage Temperature Range -65°C to + 150°C

Power Dissipation (PD)

Dual-In-Line 700 mW 5mall 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<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
Syllibol	raiailietei	Conditions	Min	Max	Min	Тур	Max	Min	Max	Jilles
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	μΑ
		$V_{DD} = 10V$ , $V_{IN} = V_{DD}$ 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	μΑ
Signal In	puts and Outputs				•					
R <sub>ON</sub>	"ON" Resistance	$R_L = 10 \text{ k}\Omega \text{ to } \frac{V_{DD} - V_{SS}}{2}$								
		$V_C = V_{DD}$ , $V_{IS} = V_{SS}$ or $V_{DD}$								
		V <sub>DD</sub> =10V		600		250	660		960	Ω
		V <sub>DD</sub> =15V		360		200	400		600	Ω
		$R_L = 10 \text{ k}\Omega \text{ to } \frac{V_{DD} - V_{SS}}{2}$								
		$V_C = V_{DD}$								
		$V_{DD} = 10V, V_{IS} = 4.75 \text{ to } 5.25V$		1870		850	2000		2600	Ω
		$V_{DD} = 15V, V_{IS} = 7.25 \text{ to } 7.75V$		775		400	850		1230	Ω
ΔR <sub>ON</sub>	Δ"ON" Resistance	$R_L = 10 \text{ k}\Omega \text{ to } \frac{V_{DD} - V_{SS}}{2}$								
	Between any 2 of	$V_C = V_{DD}$ , $V_{IS} = V_{SS}$ to $V_{DD}$								
	4 Switches	V <sub>DD</sub> =10V				15				Ω
	(In Same Package)	V <sub>DD</sub> =15V				10				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,		±50		± 0.1	±50		±500	nA
		V <sub>OS</sub> =0V and 15V								
Control	Inputs				•					
V <sub>ILC</sub>	Low Level Input Voltage	V <sub>IS</sub> =V <sub>SS</sub> and V <sub>DD</sub>								
		$V_{OS} = V_{DD}$ and $V_{SS}$								
		$I_{IS} = \pm 10 \mu A$								١.,
		V <sub>DD</sub> =5V		0.9			0.7		0.5	V
		V <sub>DD</sub> =10V		0.9 0.9			0.7 0.7		0.5 0.5	V V
		V <sub>DD</sub> =15V		0.9			0.7		0.5	
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	7.0		7.0			7.0		V
		V <sub>DD</sub> =15V Figure 8)	11.0		11.0			11.0		V
I <sub>IN</sub>	Input Current	$V_{DD} - V_{SS} = 15V$		±0.1		±10 <sup>-5</sup>	±0.1		±1.0	μΑ
		$V_{DD} \ge V_{IS} \ge V_{SS}$								
		$V_{DD} \ge V_C \ge V_{SS}$			l			1		

Symbol	Parameter	Conditions	-4	10°C		25°C		8	5°C	Units
	raidilletei	Conditions	Min	Max	Min	Тур	Max	Min	Max	Jints
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	μΑ μΑ μΑ
Signal In	puts and Outputs									
$\begin{array}{c c} R_{ON} & \text{"ON" Resistance} & R_L = 10 \text{ k}\Omega \text{ to} \frac{V_{DD} - V_{SS}}{2} \\ V_C = V_{DD}, V_{IS} = V_{SS} \text{ or } V_{DD} \\ V_{DD} = 10V \\ V_{DD} = 15V \\ R_L = 10 \text{ k}\Omega \text{ to} \frac{V_{DD} - V_{SS}}{2} \\ V_C = V_{DD} \\ V_{DD} = 10V, V_{IS} = 4.75 \text{ to } 5.25V \\ V_{DD} = 15V, V_{IS} = 7.25 \text{ to } 7.75V \\ \end{array}$			610 370 1900 790		275 200 850 400	660 400 2000 850		840 520 2380 1080	$\Omega$ $\Omega$ $\Omega$	
ΔR <sub>ON</sub>	Δ"ON" Resistance Between any 2 of 4 Switches (In Same Package)	$\begin{array}{c} R_L = 10 \text{ k}\Omega \text{ to} \frac{V_{DD} - V_{SS}}{2} \\ V_C = V_{DD}, V_{IS} = V_{SS} \text{ to } V_{DD} \\ V_{DD} = 10V \\ V_{DD} = 15V \end{array}$				15 10				ΩΩ
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	$ \begin{array}{c} V_{IS}\!=\!V_{SS} \text{ and } V_{DD} \\ V_{OS}\!=\!V_{DD} \text{ and } V_{SS} \\ I_{IS}\!=\!\pm 10 \ \mu\text{A} \\ V_{DD}\!=\!5V \\ V_{DD}\!=\!10V \\ V_{DD}\!=\!15V \end{array} $		0.9 0.9 0.9			0.7 0.7 0.7		0.4 0.4 0.4	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 <i>Figure 8</i> )	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	$V_{CC}-V_{SS}=15V$ $V_{DD}\geq V_{IS}\geq V_{SS}$ $V_{DD}\geq V_{C}\geq V_{SS}$		±0.3		±10 <sup>-5</sup>	±0.3		±1.0	μΑ

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

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

#### **AC Electrical Characteristics\*** (Continued)

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

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

<sup>\*</sup>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<sub>SS</sub>=0V unless otherwise specified.

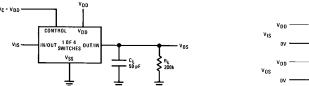
Note 3: These devices should not be connected to circuits with the power "ON".

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<sub>L</sub> 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  $V_{OL} \le$  "B" series. These currents are shown in  $Figure \ 8$ .

#### **AC Test Circuits and Switching Time Waveforms**



V<sub>1S</sub> V<sub>DD</sub> V<sub>DD</sub>

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

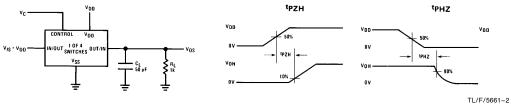
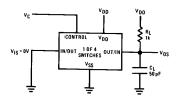
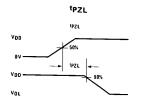


FIGURE 2.  $t_{\mbox{\scriptsize PZH}}, t_{\mbox{\scriptsize PHZ}}$  Propagation Delay Time Control to Signal Output

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





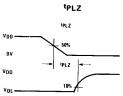
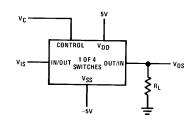
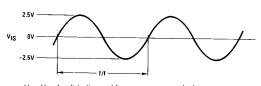


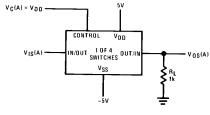
FIGURE 3.  $t_{\mbox{\scriptsize PZH}}, t_{\mbox{\scriptsize PHZ}}$  Propagation Delay Time Control to Signal Output

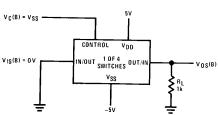




 $\rm V_C\!=\!V_{DD}$  for distortion and frequency response tests  $\rm V_C\!=\!V_{SS}$  for feedthrough test

FIGURE 4. Sine Wave Distortion, Frequency Response and Feedthrough





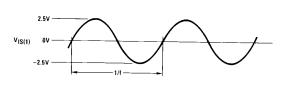
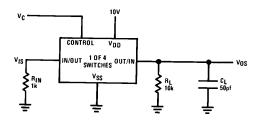


FIGURE 5. Crosstalk Between Any Two Switches



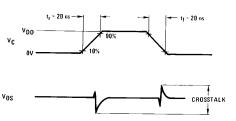


FIGURE 6. Crosstalk — Control to Input Signal Output

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

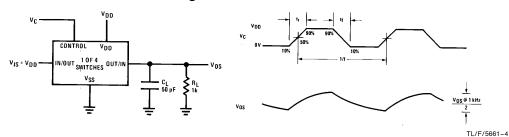


FIGURE 7. Maximum Control Input Frequency

Temperature **Switch Input Switch Output** Range Vos(v)  $v_{\text{DD}}$  $v_{\text{IS}}$ I<sub>IS</sub> (mA) 25°C Max Min  $\mathsf{T}_{\mathsf{LOW}}$ THIGH 5 0 0.25 0.2 0.14 0.4 5 5 -0.25-0.2-0.144.6 10 0 0.62 0.5 0.35 0.5 MILITARY 10 10 -0.62-0.5-0.359.5 15 0 1.8 1.5 1.1 1.5 15 15 -1.8-1.5-1.113.5 5 0 0.2 0.16 0.12 0.4 5 5 -0.2-0.16-0.1210 0 0.5 0.4 0.3 0.5 COMMERCIAL 10 10 -0.5-0.4-0.39.5 15 0 1.4 1.2 1.0 1.5

FIGURE 8. CD4016B Switch Test Conditions for VIHC

-1.2

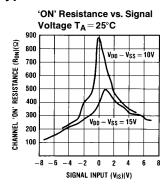
-1.0

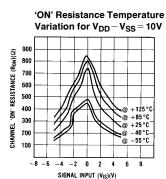
-1.4

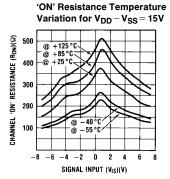
### **Typical Performance Characteristics**

15

15



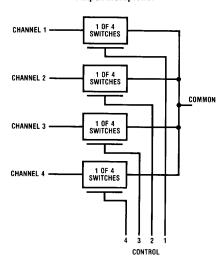




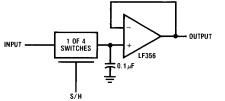
13.5

## **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) 0.785 (19.939) MAX [14] [13] [12] [11] [10] [9] [8] 0.025 (0.635) RAD 0.220-0.310 (5.588-7.874) 1 2 3 4 5 6 7 0.290-0.320 0.005 0.200 (D.127) MIN GLASS SEALANT (5.080) MAX 0.020-0.060 (7.366-8.128) 0.060 ±0.005 (1.524 ±0.127) 0.180 (0.508 - 1.524)MA 0.008-0.012 10° MAX (0.203-0.305) 0.310-0.410 D.018 ±0.003 0.125-0.200 0.098 (7.874 - 10.41)(0.457 ±0,076) (3.175-5.080) (2.489) MAX BOTH ENDS 0.100 ±0.010 0.150 (2.540 ±0.254) (3.81) J14A (REV G) MIN **Dual-In-Line Package** Order Number CD4016CJ or CD4016MJ NS Package J14A 14 13 12 11 10 9 8 14 13 12 0.250 ± 0.010 (6.350 ± 0.254) 1 2 3 4 5 6 7 $\frac{0.092}{(2.337)}$ DIA $\frac{0.030}{(0.762)}$ MAX DEPTH OPTION 1 OPTION 02 0.065 0.145 - 0.200 (3.683 - 5.080 0.020 (0.508) MIN 0.125 - 0.150 (3.175 - 3.810) 0.014 - 0.023 (0.356 - 0.584) TYP 0.100 ± 0.010 (2.540 ± 0.254) TYP 0.050 ± 0.010 (1.270 - 0.254) TYP 0.325

LIFE SUPPORT POLICY

#### **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.



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