National Semiconductor

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.

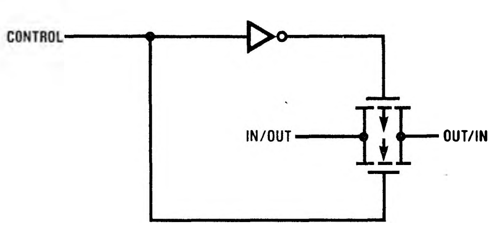
Features

- 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 ΔR_{ON} = 10Ω (typ.)
- High degree of linearity 0.4% distortion (typ.) @ f_{IS} = 1 kHz, V_{IS} = 5 Vp-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}Ω (typ.)
- Low crosstalk between switches −50 dB (typ.) @ f_{IS} = 0.9 MHz, R_L = 1 kΩ
- Frequency response, switch "ON" 40 MHz (typ.)

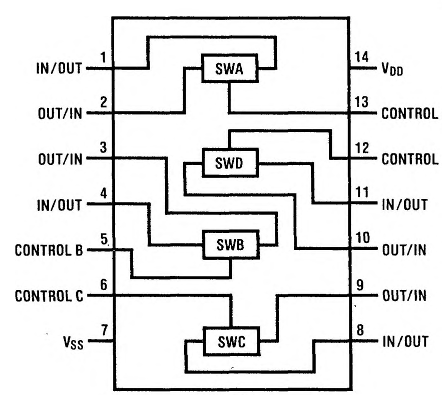
Applications

- 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



TOP VIEW

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	500 mW
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	
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 V_{DD} = 10V V_{DD} = 15V		0.25 0.5 1.0		0.01 0.01 0.01	0.25 0.5 1.0		7.5 15 30	μA μA μA
Signal Inputs and Outputs										
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 V_{DD} = 15V		600 360		250 200	660 400		960 600	Ω Ω
		$R_L = 10k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$ $V_C = V_{DD}$ V_{DD} = 10V, V_{IS} = 4.75 to 5.25V V_{DD} = 15V, V_{IS} = 7.25 to 7.75V		1870 775		850 400	2000 850		2600 1230	Ω Ω
ΔR_{ON}	Δ "ON" Resistance Between any 2 of 4 Switches (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 V_{DD} = 15V				15 10				Ω Ω
I_{IS}	Input or Output Leakage Switch "OFF"	$V_C = 0$, V_{DD} = 15V V_{IS} = 15V and 0V, V_{OS} = 0V and 15V		±50		±0.1	±50		±500	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} = ±10μA V_{DD} = 5V V_{DD} = 10V V_{DD} = 15V		0.9 0.9 0.9			0.7 0.7 0.7		0.5 0.5 0.5	V V V
V_{IHC}	High Level Input Voltage	V_{DD} = 5V V_{DD} = 10V (see Note 6 and V_{DD} = 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_{IN}	Input Current	$V_{DD} - V_{SS}$ = 15V $V_{DD} \geq V_{IS} \geq V_{SS}$ $V_{DD} \geq V_C \geq V_{SS}$		±0.1		$\pm 10^{-5}$	±0.1		±1.0	μA

DC Electrical Characteristics CD4016BC (Note 2)

Parameter		Conditions	−40°C Min.	−40°C Max.	25°C Min.	25°C Typ.	25°C Max.	85°C Min.	85°C Max.	Units
I_{DD}	Quiescent Device Current	$V_{DD}=5V$		1.0		0.01	1.0		7.5	μA
		$V_{DD}=10V$		2.0		0.01	2.0		15	μA
		$V_{DD}=15V$		4.0		0.01	4.0		30	μA
Signal Inputs and Outputs										
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}								
		$V_{DD}=10V$		610		275	660		840	Ω
		$V_{DD}=15V$		370		200	400		520	Ω
		$R_L=10k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$ $V_C=V_{DD}$								
		$V_{DD}=10V$, $V_{IS}=4.75$ to $5.25V$		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)	$R_L=10k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$ $V_{CC}=V_{DD}$, $V_{IS}=V_{SS}$ 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	7.0		7.0			7.0		V
		$V_{DD}=15V$ *Figure 8*)	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 $T_A=25°C$, $t_r=t_f=20ns$ and $V_{SS}=0V$ unless otherwise specified

Parameter		Conditions	Min.	Typ.	Max.	Units
t_{PHL}, t_{PLH}	Propagation Delay Time Signal Input to Signal Output	$V_C=V_{DD}$, $C_L=50pF$, *(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	$R_L=1.0k\Omega$, $C_L=50pF$, *(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	$R_L=1.0k\Omega$, $C_L=50pF$, *(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	$V_C=V_{DD}=5V$, $V_{SS}=-5V$ $R_L=10k\Omega$, $V_{IS}=5V_{P\text{-}P}$, $f=1kHz$, *(Figure 4)*		0.4		%

AC Electrical Characteristics (Cont'd)

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

	Parameter	Conditions	Min	Typ	Max	Units
	Frequency Response — Switch "ON" (Frequency at −3dB)	$V_C = V_{DD} = 5V$, $V_{SS} = -5V$, $R_L = 1k\Omega$, $V_{IS} = 5V_{P\text{-}P}$, 20 Log_{10} V_{OS}/V_{OS} (1 kHz) − dB, *(Figure 4)*		40		MHz
	Feedthrough — Switch "OFF" (Frequency at −50dB)	$V_{DD} = 5V$, $V_C = V_{SS} = -5V$, $R_L = 1k\Omega$, $V_{IS} = 5V_{P\text{-}P}$, 20 Log_{10} $(V_{OS}/V_{IS}) = -50dB$, *(Figure 4)*		1.25		MHz
	Crosstalk Between Any Two Switches (Frequency at −50dB)	$V_{DD} = V_{C(A)} = 5V$; $V_{SS} = V_{C(B)} = -5V$, $R_L = 1k\Omega$, $V_{IS(A)} = 5V_{P\text{-}P}$, 20 Log_{10} $(V_{OS(B)}/V_{OS(A)}) = -50dB$, *(Figure 5)*		0.9		MHz
	Crosstalk; Control Input to Signal Output	$V_{DD} = 10V$, $R_L = 10k\Omega$, $R_{IN} = 1k\Omega$, $V_{CC} = 10V$ Square Wave, $C_L = 50pF$ *(Figure 6)*		150		$mV_{P\text{-}P}$
	Maximum Control Input	$R_L = 1k\Omega$, $C_L = 50pF$, *(Figure 7)* $V_{OS(f)} = ½V_{OS}(1kHz)$				
		$V_{DD} = 5V$		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

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 conected 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

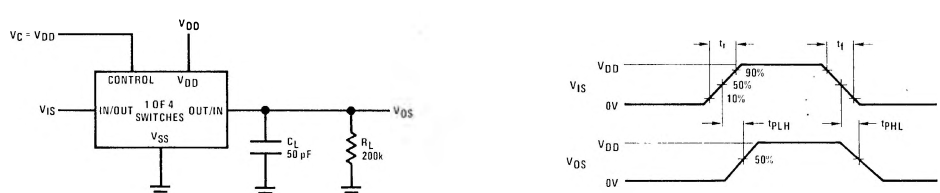


Figure 1. t_{PHL}, t_{PLH} **Propagation Delay Time Signal Input to Signal Output**

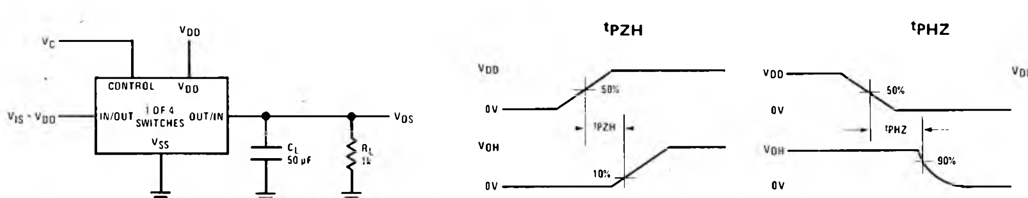


Figure 2. t_{PZH}, t_{PHZ} **Propagation Delay Time Control to Signal Output**

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

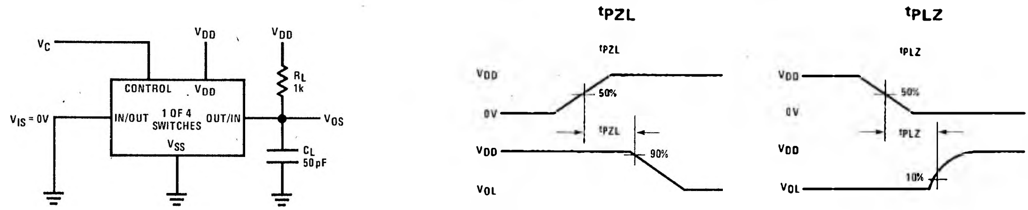


Figure 3. t_{PZH}, t_{PHZ} Propagation Delay Time Control to Signal Output

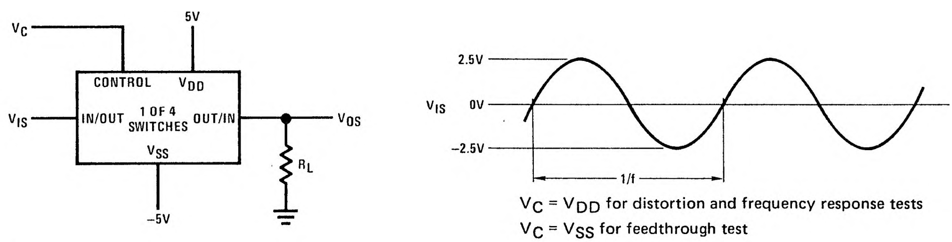


Figure 4. Sine Wave Distortion, Frequency Response and Feedthrough

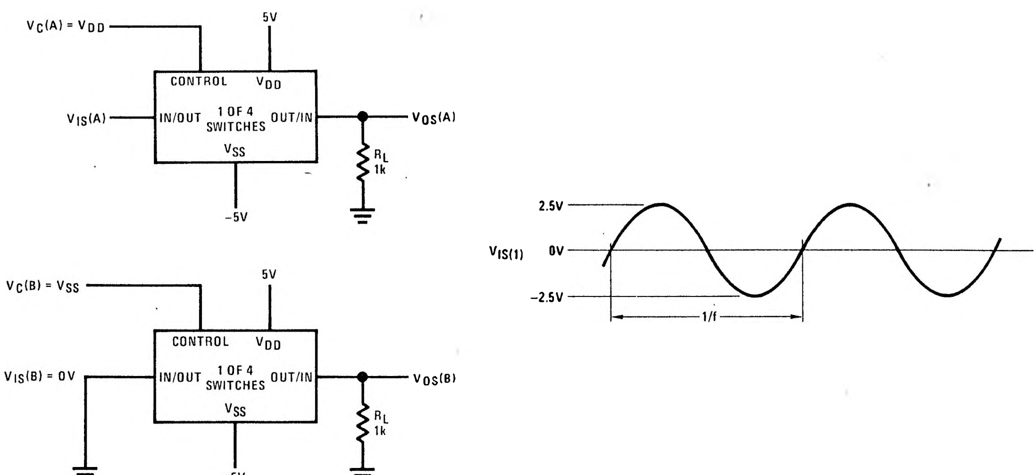


Figure 5. Crosstalk Between Any Two Switches

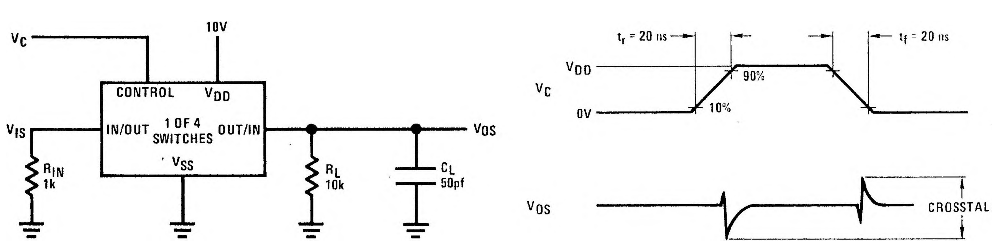


Figure 6. Crosstalk — Control to Input Signal Output

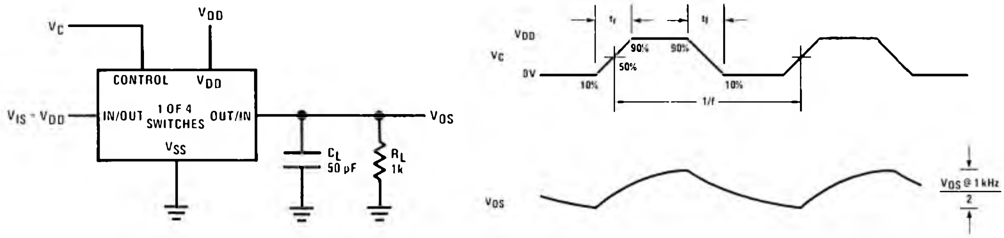


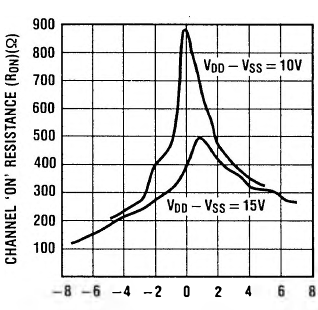
Figure 7. Maximum Control Input Frequency

Temperature Range	V_{DD}	V_{IS}	I_{IS} (mA) T_{LOW}	I_{IS} (mA) 25°C	I_{IS} (mA) T_{HIGH}	$V_{OS(V)}$ Min.	$V_{OS(V)}$ 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	

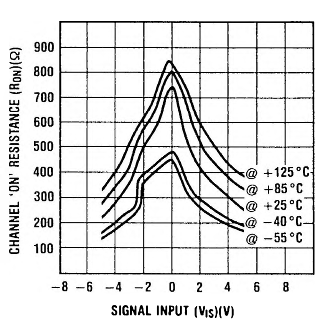
Figure 8. CD4016B Switch Test Conditions for V_{IHC}

Typical Performance Characteristics

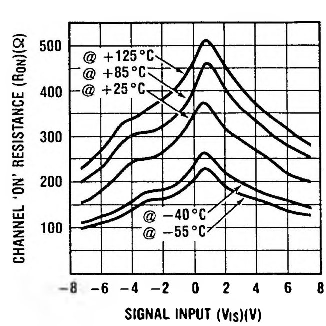
'ON' Resistance vs. Signal Voltage $T_A = 25°C$



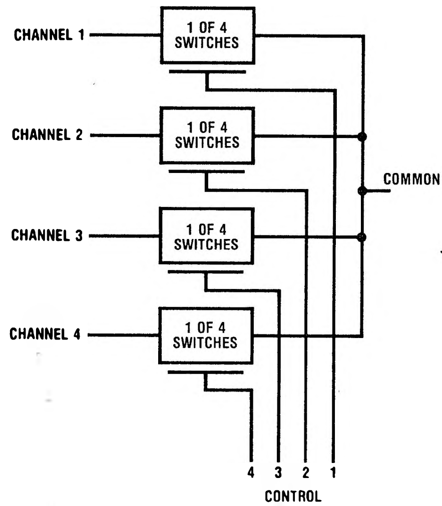
'ON' Resistance Temperature Variation for $V_{DD} - V_{SS} = 10V$



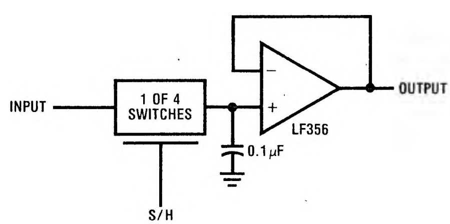
'ON' Resistance Temperature Variation for $V_{DD} - V_{SS} = 15V$



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_{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, ≤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.