

# CMOS Quad Bilateral Switch

For Transmission or Multiplexing of Analog or Digital Signals

High-Voltage Types (20-Volt Rating)

■ CD4016B Series types are quad bilateral switches intended for the transmission or multiplexing of analog or digital signals. Each of the four independent bilateral switches has a single control signal input which simultaneously biases both the p and n device in a given switch on or off.

The CD4016 "B" Series types are supplied in 14-lead hermetic dual-in-line ceramic packages (D and F suffixes), 14-lead dual-in-line plastic packages (E suffix), and in chip form (H suffix).

### Features:

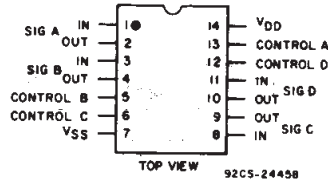
- 20-V digital or  $\pm 10$ -V peak-to-peak switching
- 280- $\Omega$  typical on-state resistance for 15-V operation
- Switch on-state resistance matched to within 10  $\Omega$  typ. over 15-V signal-input range
- High on/off output-voltage ratio: 65 dB typ. @  $f_{is} = 10$  kHz,  $R_L = 10$  k $\Omega$
- High degree of linearity: <0.5% distortion typ. @  $f_{is} = 1$  kHz,  $V_{is} = 5$  V<sub>p-p</sub>,  $V_{DD} - V_{SS} \geq 10$  V,  $R_L = 10$  k $\Omega$
- Extremely low off-state switch leakage resulting in very low offset current and high effective off-state resistance: 100 pA typ. @  $V_{DD} - V_{SS} = 18$  V,  $T_A = 25^\circ\text{C}$
- Extremely high control input impedance (control circuit isolated from signal circuit): 10<sup>12</sup>  $\Omega$  typ.
- Low crosstalk between switches: -50 dB typ. @  $f_{is} = 0.9$  MHz,  $R_L = 1$  k $\Omega$
- Matched control-input to signal-output capacitance: Reduces output signal transients
- Frequency response, switch on = 40 MHz (typ.)
- 100% tested for quiescent current at 20 V
- Maximum control input current of 1  $\mu\text{A}$  at 18 V over full package temperature range; 100 nA at 18 V at 25 $^\circ\text{C}$
- 5-V, 10-V, and 15-V parametric ratings

### Applications:

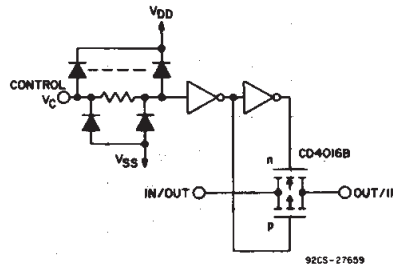
- Analog signal switching/multiplexing
  - Signal gating
  - Squelch control
  - Chopper
  - Modulator
  - Demodulator
  - Commutating switch
- Digital signal switching/multiplexing
- CMOS logic implementation
- Analog-to-digital & digital-to-analog conversion
- Digital control of frequency, impedance, phase, and analog-signal gain

# CD4016B Types

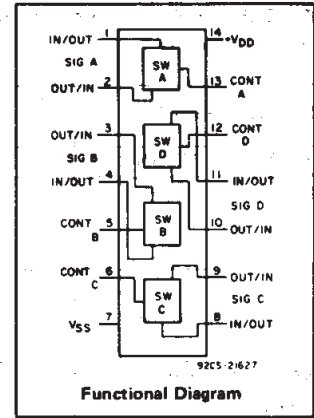
### Terminal Assignment



TOP VIEW 92CS-2445B



Schematic diagram - 1 of 4 identical sections.



Functional Diagram 92CS-21627

### RECOMMENDED OPERATING CONDITIONS

For maximum reliability, nominal operating conditions should be selected so that operation is always within the following range:

CHARACTERISTIC	LIMITS		UNITS
	Min.	Max.	
Supply Voltage Range (For $T_A =$ Full Package Temperature Range)	3	18	V

### MAXIMUM RATINGS, Absolute-Maximum Values:

- DC SUPPLY-VOLTAGE RANGE, ( $V_{DD}$ ) Voltages referenced to  $V_{SS}$  Terminal: -0.5V to +20V
- INPUT VOLTAGE RANGE, ALL INPUTS: -0.5V to  $V_{DD} + 0.5$ V
- DC INPUT CURRENT, ANY ONE INPUT:  $\pm 10$  mA
- POWER DISSIPATION PER PACKAGE ( $P_D$ ):
  - For  $T_A = -55^\circ\text{C}$  to  $+100^\circ\text{C}$ : 500mW
  - For  $T_A = +100^\circ\text{C}$  to  $+125^\circ\text{C}$ : Derate Linearly at 12mW/ $^\circ\text{C}$  to 200mW
- DEVICE DISSIPATION PER OUTPUT TRANSISTOR
  - FOR  $T_A =$  FULL PACKAGE-TEMPERATURE RANGE (All Package Types): 100mW
- OPERATING-TEMPERATURE RANGE ( $T_A$ ): -55 $^\circ\text{C}$  to +125 $^\circ\text{C}$
- STORAGE TEMPERATURE RANGE ( $T_{stg}$ ): -65 $^\circ\text{C}$  to +150 $^\circ\text{C}$
- LEAD TEMPERATURE (DURING SOLDERING):
  - At distance 1/16  $\pm$  1/32 inch (1.59  $\pm$  0.79mm) from case for 10s max: +265 $^\circ\text{C}$

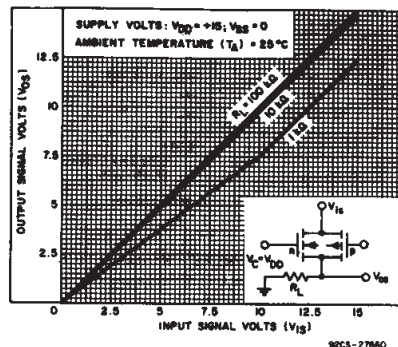


Fig. 1—Typ. on-state characteristics for 1 of 4 switches with  $V_{DD} = +15$  V,  $V_{SS} = 0$  V.

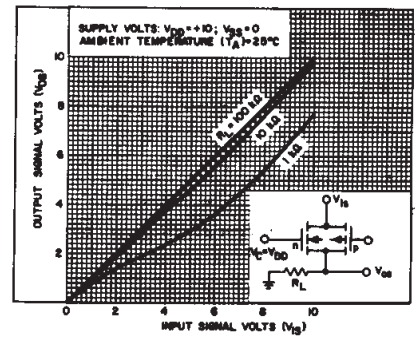


Fig. 2—Typ. on-state characteristics for 1 of 4 switches with  $V_{DD} = +10$  V,  $V_{SS} = 0$  V.

# CD4016B Types

## ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	TEST CONDITIONS	LIMITS AT INDICATED TEMPERATURES (°C)							UNITS	
		V <sub>IN</sub> (V)	V <sub>DD</sub> (V)					+25		
				-55	-40	+85	+125	Typ.		Max.
Quiescent Device Current, I <sub>DD</sub>		0,5	5	0,25	0,25	7,5	7,5	0,01	0,25	μA
		0,10	10	0,5	0,5	15	15	0,01	0,5	
		0,15	15	1	1	30	30	0,01	1	
		0,20	20	5	5	150	150	0,02	5	
Signal Inputs (V <sub>is</sub> ) and Output (V <sub>os</sub> )										
On-State Resistance, r <sub>on</sub> Max.	V <sub>C</sub> = V <sub>DD</sub> R <sub>L</sub> = 10kΩ Returned to V <sub>DD</sub> -V <sub>SS</sub> 2	V <sub>is</sub> = V <sub>DD</sub> or V <sub>SS</sub>	10	600	610	840	960	-	660	Ω
			V <sub>is</sub> = 4.75 to 5.75 V	10	1870	1900	2380	2600	-	
		V <sub>is</sub> = V <sub>DD</sub> or V <sub>SS</sub>	15	360	370	520	600	-	400	
			V <sub>is</sub> = 7.25 to 7.75 V	15	775	790	1080	1230	-	
ΔOn-State Resistance Between Any 2 Switches, Δr <sub>on</sub>	R <sub>L</sub> = 10kΩ, V <sub>C</sub> = V <sub>DD</sub>		5	-	-	-	-	15	-	Ω
		10	-	-	-	-	-	10	-	
		15	-	-	-	-	-	5	-	
Total Harmonic Distortion, THD	V <sub>C</sub> = V <sub>DD</sub> = 5 V, V <sub>SS</sub> = -5 V, V <sub>is</sub> (p-p) = 5 V (Sine wave centered on 0 V) R <sub>L</sub> = 10 kΩ, f <sub>is</sub> = 1 kHz sine wave		-	-	-	-	-	0.4	-	%
-3dB Cutoff Frequency (Switch on)	V <sub>C</sub> = V <sub>DD</sub> = 5 V, V <sub>SS</sub> = -5 V, V <sub>is</sub> (p-p) = 5 V (Sine wave centered on 0 V) R <sub>L</sub> = 1 kΩ.		-	-	-	-	-	40	-	MHz
-50dB Feedthrough Frequency (Switch off)	V <sub>C</sub> = V <sub>SS</sub> = -5 V, V <sub>is</sub> (p-p) = 5 V (Sine wave centered on 0 V) R <sub>L</sub> = 1 kΩ.		-	-	-	-	-	1.25	-	MHz
Input/Output Leakage Current (Switch off) I <sub>is</sub> Max.	V <sub>C</sub> = 0 V V <sub>is</sub> = 18 V, V <sub>os</sub> = 0 V; V <sub>is</sub> = 0 V, V <sub>os</sub> = 18 V	18	±0.1	±0.1	±1	±1	10 <sup>-4</sup>	±0.1	μA	
-50 dB Crosstalk Frequency	V <sub>C</sub> (A) = V <sub>DD</sub> = +5 V, V <sub>C</sub> (B) = V <sub>SS</sub> = -5 V, V <sub>is</sub> (A) = 5 V p-p, 50 Ω source R <sub>L</sub> = 1 kΩ.		-	-	-	-	-	0.9	-	MHz
Propagation Delay (Signal Input to Signal Output) t <sub>pd</sub>	R <sub>L</sub> = 200 kΩ V <sub>C</sub> = V <sub>DD</sub> , V <sub>SS</sub> = GND, C <sub>L</sub> = 50 pF V <sub>is</sub> = Square Wave 0 to V <sub>DD</sub> t <sub>r</sub> , t <sub>f</sub> = 20 ns	5	-	-	-	-	40	100	ns	
		10	-	-	-	-	20	40		
		15	-	-	-	-	15	30		
Capacitance: Input, C <sub>is</sub> Output, C <sub>os</sub> Feedthrough, C <sub>ios</sub>	V <sub>DD</sub> = +5 V V <sub>C</sub> = V <sub>SS</sub> = -5 V		-	-	-	-	4	-	pF	
			-	-	-	-	4	-		
			-	-	-	-	0.2	-		

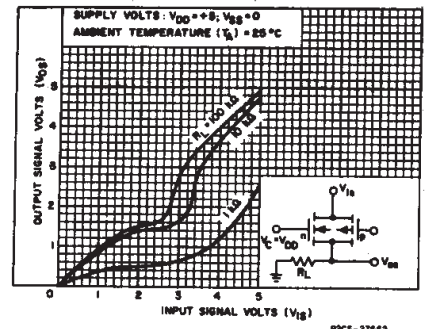


Fig. 3—Typ. on-state characteristics for 1 of 4 switches with V<sub>DD</sub> = +5 V, V<sub>SS</sub> = 0 V.

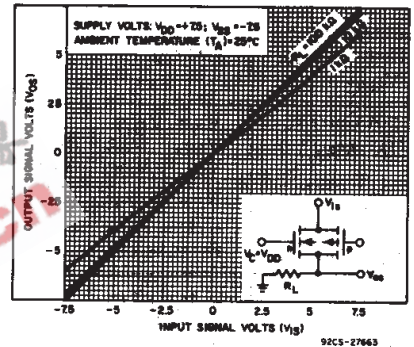


Fig. 4—Typ. on-state characteristics for 1 of 4 switches with V<sub>DD</sub> = +7.5 V, V<sub>SS</sub> = -7.5 V.

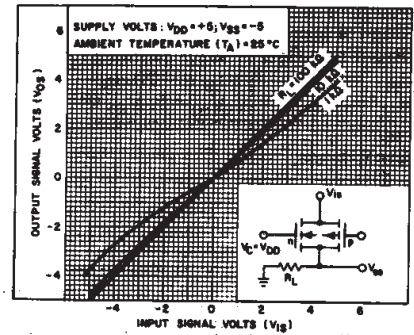


Fig. 5—Typ. on-state characteristics for 1 of 4 switches with V<sub>DD</sub> = +5 V, V<sub>SS</sub> = -5 V.

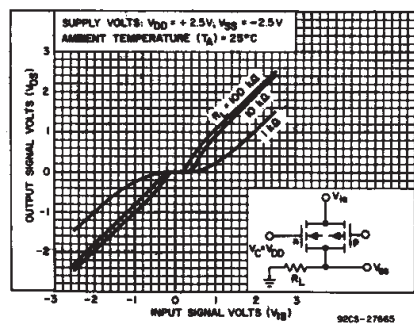


Fig. 6—Typ. on-state characteristics for 1 of 4 switches with V<sub>DD</sub> = +2.5 V, V<sub>SS</sub> = -2.5 V.

# CD4016B Types

## ELECTRICAL CHARACTERISTICS (cont'd)

CHARACTERISTIC	TEST CONDITIONS	LIMITS AT INDICATED TEMPERATURES (°C)						UNITS	
		V <sub>DD</sub> (V)					+25		
			-55	-40	+85	+125	Typ.		Max.
<b>Control (V<sub>C</sub>)</b>									
Control Input Low Voltage, V <sub>ILC</sub> (Max.)	$ I_{is}  < 10 \mu A$ $V_{is} = V_{SS}, V_{OS} = V_{DD}$ and $V_{is} = V_{DD}, V_{OS} = V_{SS}$	5, 10, 15	0.9	0.9	0.4	0.4	-	0.7	V
Control Input High Voltage, V <sub>IHC</sub>	See Fig. 10	5, 10, 15	3.5 (Min.) 7 (Min.) 11 (Min.)				-	-	V
Input Current, I <sub>IN</sub> (Max.)	$V_{is} \leq V_{DD}$ $V_{DD} - V_{SS} = 18 V$ $V_{CC} \leq V_{DD} - V_{SS}$	18	±0.1	±0.1	±1	±1	±10-5	±0.1	μA
Crosstalk (Control Input to Signal Output)	V <sub>C</sub> = 10 V (Sq. Wave) t <sub>r</sub> , t <sub>f</sub> = 20 ns R <sub>L</sub> = 10 kΩ	10	-	-	-	-	50	-	mV
Turn-On Propagation Delay	t <sub>r</sub> , t <sub>f</sub> = 20 ns C <sub>L</sub> = 50 pF R <sub>L</sub> = 1 kΩ	5	-	-	-	-	35	70	ns
		10	-	-	-	-	20	40	
		15	-	-	-	-	15	30	
Maximum Control Input Repetition Rate	V <sub>is</sub> = V <sub>DD</sub> , V <sub>SS</sub> = GND, R <sub>L</sub> = 1 kΩ to gnd, C <sub>L</sub> = 50 pF, V <sub>C</sub> = 10 V (Square wave centered on 5 V) t <sub>r</sub> , t <sub>f</sub> = 20 ns, V <sub>OS</sub> = ½ V <sub>OS</sub> @ 1 kHz	10	-	-	-	-	10	-	MHz
Input Capacitance, C <sub>IN</sub>			-	-	-	-	5	7.5	μF

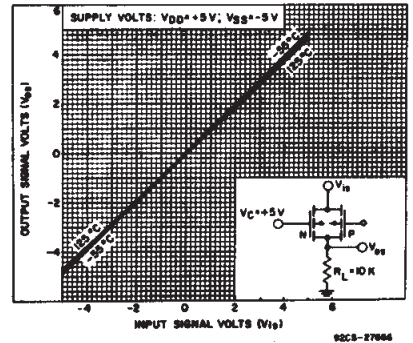


Fig. 7—Typ. on-state characteristics as a function of temp. for 1 of 4 switches with V<sub>DD</sub> = +5 V, V<sub>SS</sub> = -5 V.

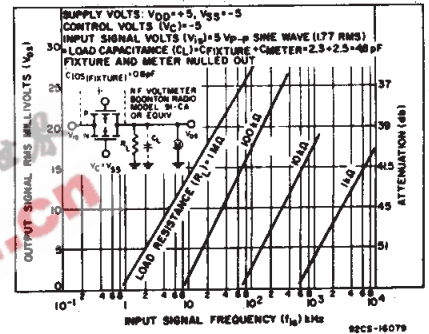


Fig. 8—Typ. feedthrough vs. frequency - switch off.

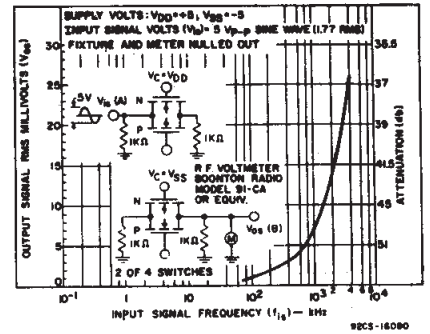


Fig. 9—Typical crosstalk between switch circuits in the same package.

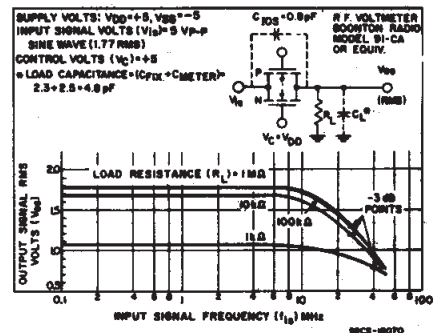


Fig. 11—Typical frequency response - switch on.

V <sub>DD</sub> (V)	V <sub>is</sub> (V)	Switch Input I <sub>is</sub> (mA)						Switch Output V <sub>OS</sub> (V)	
		I <sub>is</sub> (mA)						Min.	Max.
		-55°C	-40°C	25°C*	25°C▲	+85°C	+125°C		
5	0	0.25	0.2	0.2	0.16	0.12	0.14	-	0.4
5	5	-0.25	-0.2	-0.2	-0.16	-0.12	-0.14	4.6	-
10	0	0.62	0.5	0.5	0.4	0.3	0.35	-	0.5
10	10	-0.62	-0.5	-0.5	-0.4	-0.3	-0.35	9.5	-
15	0	1.8	1.4	1.5	1.2	1	1.1	-	1.5
15	15	-1.8	-1.4	-1.5	-1.2	-1	-1.1	13.5	-

\* Plastic package

▲ Ceramic package

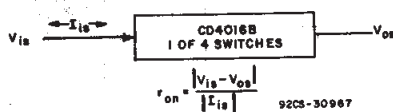


Fig. 10—Determination of r<sub>on</sub> as a test condition for control input high voltage (V<sub>IHC</sub>) specification.

# CD4016B Types

TYPICAL ON-STATE RESISTANCE CHARACTERISTICS,  $T_A = 25^\circ\text{C}$

CHARACTERISTIC*	SUPPLY CONDITIONS		LOAD CONDITIONS					
			$R_L = 1\text{k}\Omega$		$R_L = 10\text{k}\Omega$		$R_L = 100\text{k}\Omega$	
	$V_{DD}$ (V)	$V_{SS}$ (V)	VALUE ( $\Omega$ )	$V_{is}$ (V)	VALUE ( $\Omega$ )	$V_{is}$ (V)	VALUE ( $\Omega$ )	$V_{is}$ (V)
$r_{on}$	+15	0	200	+15	200	+15	180	+15
$r_{on}$ (max.)	+15	0	300	+11	300	+9.3	320	+9.2
$r_{on}$	+10	0	290	+10	250	+10	240	+10
$r_{on}$ (max.)	+10	0	290	0	250	0	300	0
$r_{on}$	+5	0	860	+5	470	+5	450	+5
$r_{on}$ (max.)	+5	0	600	0	580	0	800	0
$r_{on}$	+7.5	-7.5	200	+7.5	200	+7.5	180	+7.5
$r_{on}$ (max.)	+7.5	-7.5	290	$\pm 0.25$	280	$\pm 25$	400	$\pm 0.25$
$r_{on}$	+5	-5	260	+5	250	+5	240	+5
$r_{on}$ (max.)	+5	-5	310	-5	250	-5	240	-5
$r_{on}$	+2.5	-2.5	590	+2.5	450	+2.5	490	+2.5
$r_{on}$ (max.)	+2.5	-2.5	720	-2.5	520	-2.5	520	-2.5
$r_{on}$	+2.5	-2.5	232k	$\pm 0.25$	300k	$\pm 0.25$	870k	$\pm 0.25$

\* Variation from perfect switch,  $r_{on} = 0 \Omega$ .

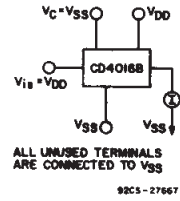


Fig. 12 - Off-state switch input or output leakage current test circuit.

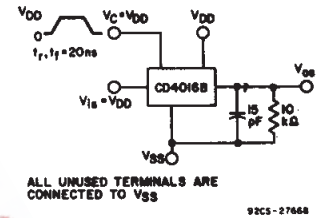
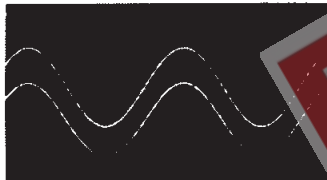


Fig. 13 - Test circuit for square-wave response.



SCALE: X = 0.2 ms/DIV Y = 2.0 V/DIV  
 $V_{DD} = V_C = +7.5\text{V}$ ,  $V_{SS} = -7.5\text{V}$ ,  $R_L = 10\text{k}\Omega$   
 $C_L = 15\text{pF}$   
 $f_{IS} = 1\text{KHz}$   $V_{IS} = 5\text{V p-p}$   
 DISTORTION = 0.2%

92CS-27612

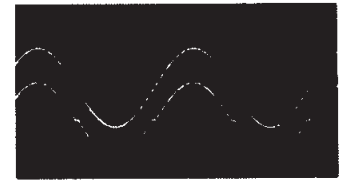
Fig. 14 - Typical sine wave response of  $V_{DD} = +7.5\text{V}$ ,  $V_{SS} = -7.5\text{V}$ .



SCALE: X = 0.2 ms/DIV Y = 2.0 V/DIV  
 $V_{DD} = V_C = +5\text{V}$ ,  $V_{SS} = -5\text{V}$ ,  $R_L = 10\text{k}\Omega$   
 $C_L = 15\text{pF}$   
 $f_{IS} = 1\text{KHz}$   $V_{IS} = 5\text{V p-p}$   
 DISTORTION = 0.4%

92CS-27613

Fig. 15 - Typical sine wave response of  $V_{DD} = +5\text{V}$ ,  $V_{SS} = -5\text{V}$ .



SCALE: X = 0.2 ms/DIV Y = 2.0 V/DIV  
 $V_{DD} = V_C = +2.5\text{V}$ ,  $V_{SS} = -2.5\text{V}$ ,  $R_L = 10\text{k}\Omega$   
 $C_L = 15\text{pF}$   
 $f_{IS} = 1\text{KHz}$   $V_{IS} = 5\text{V p-p}$   
 DISTORTION = 3%

92CS-27614

Fig. 16 - Typical sine wave response of  $V_{DD} = +2.5\text{V}$ ,  $V_{SS} = -2.5\text{V}$ .



SCALE: X = 100 ns/DIV  
 Y = 5.0 V/DIV

92CS-27615

Fig. 17 - Typical square wave response at  $V_{DD} = V_C = +15\text{V}$ ,  $V_{SS} = \text{Gnd}$ .



SCALE: X = 100 ns/DIV  
 Y = 5.0 V/DIV

92CS-27616

Fig. 18 - Typical square wave response at  $V_{DD} = V_C = +10\text{V}$ ,  $V_{SS} = \text{Gnd}$ .



SCALE: X = 100 ns/DIV  
 Y = 2 V/DIV

92CS-27617

Fig. 19 - Typical square wave response at  $V_{DD} = V_C = +5\text{V}$ ,  $V_{SS} = \text{Gnd}$ .

COMMERCIAL CMOS  
 HIGH VOLTAGE ICs

# CD4016B Types

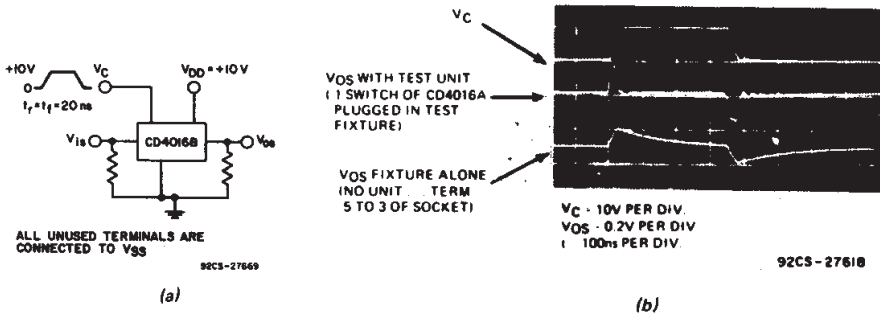


Fig. 20 - Crosstalk-control input to signal output.

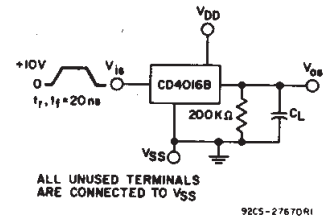


Fig. 21 - Propagation delay time signal input ( $V_{is}$ ) to signal output ( $V_{os}$ ).

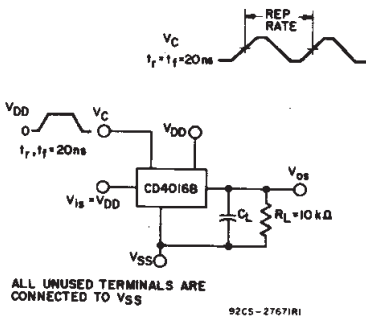


Fig. 22 - Max. control-input repetition rate.

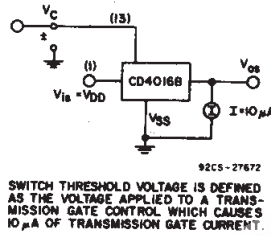


Fig. 23 - Switch threshold voltage.

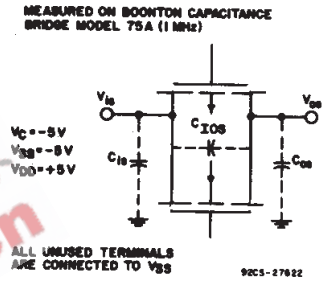


Fig. 24 - Capacitance  $C_{ios}$  and  $C_{os}$ .

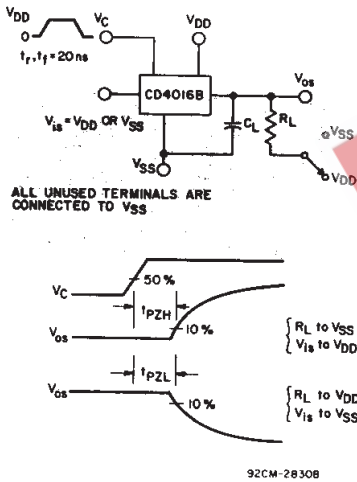
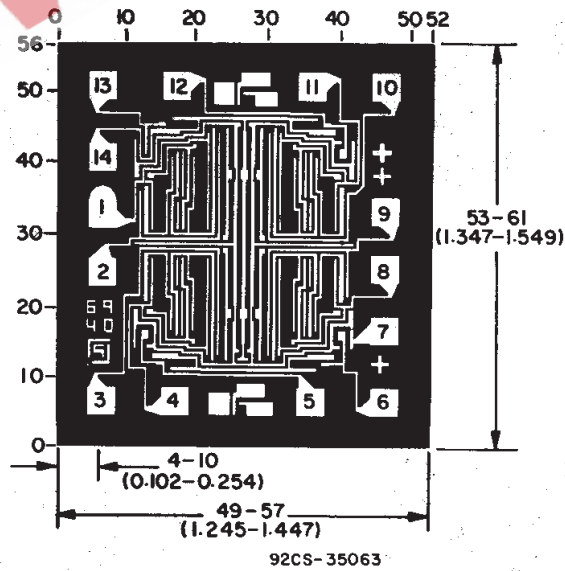


Fig. 25 - Turn-On propagation delay-control input.

## Dimensions and pad layout for CD4016BH



Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid graduations are in mils ( $10^{-3}$  inch).

## IMPORTANT NOTICE

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