

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).

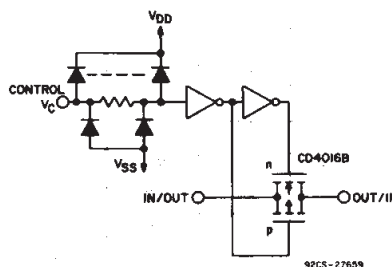
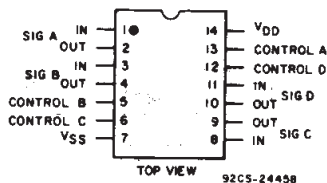
Features:

- 20-V digital or ± 10 -V peak-to-peak switching
- 280- Ω typical on-state resistance for 15-V operation
- Switch on-state resistance matched to within 10 Ω typ. over 15-V signal-input range
- High on/off output-voltage ratio: 65 dB typ. @ $f_{is} = 10$ kHz, $R_L = 10$ k Ω
- High degree of linearity: <0.5% distortion typ. @ $f_{is} = 1$ kHz, $V_{is} = 5$ V_{p-p}, $V_{DD} - V_{SS} \geq 10$ V, $R_L = 10$ k Ω
- 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: 1012 Ω typ.)
- Low crosstalk between switches: -50 dB typ. @ $f_{is} = 0.9$ MHz, $R_L = 1$ k Ω
- 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 μA 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

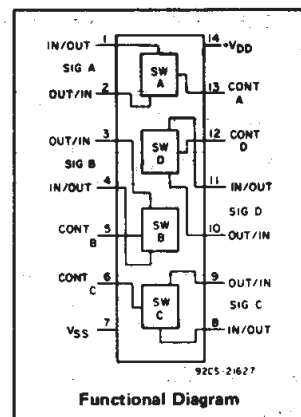
Applications:

- 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

Terminal Assignment



Schematic diagram - 1 of 4 identical sections.



Functional Diagram

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})	-0.5V to +20V
INPUT VOLTAGE RANGE, ALL INPUTS	-0.5V to $V_{DD} + 0.5$ V
DC INPUT CURRENT, ANY ONE INPUT	± 10 mA
POWER DISSIPATION PER PACKAGE (P_D):	
For $T_A = -55^\circ\text{C}$ to $+100^\circ\text{C}$	500 mW
For $T_A = +100^\circ\text{C}$ to $+125^\circ\text{C}$	Derate Linearity at 12 mW/ $^\circ\text{C}$ to 200 mW
DEVICE DISSIPATION PER OUTPUT TRANSISTOR	
FOR T_A = FULL PACKAGE-TEMPERATURE RANGE (All Package Types)	100 mW
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 $\pm$ 0.79 mm) from case for 10s max	$+265^\circ\text{C}$

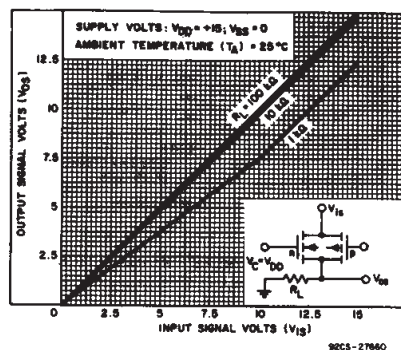


Fig. 1— Typ. on-state characteristics for 1 of 4 switches with $V_{DD} = +15$ V, $V_{SS} = 0$ V.

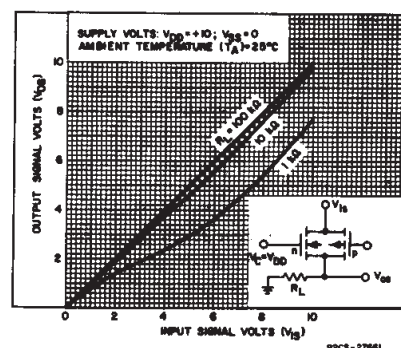


Fig. 2— Typ. on-state characteristics for 1 of 4 switches with $V_{DD} = +10$ V, $V_{SS} = 0$ V.

CD4016B Types

ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	TEST CONDITIONS	LIMITS AT INDICATED TEMPERATURES (°C)								UNITS
		V _{IN} (V)	V _{DD} (V)					+25		
				-55	-40	+85	+125	Typ.	Max.	
Quiescent Device Current, I _{DD}		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 _{is}) and Output (V _{os})										
On-State Resistance, r _{on} Max.	V _C = V _{DD} R _L = 10kΩ Returned to V _{DD} -V _{SS} 2	V _{is} =V _{DD} or V _{SS}	10	600	610	840	960	—	660	Ω
		V _{is} =4.75 to 5.75 V	10	1870	1900	2380	2600	—	2000	
		V _{is} =V _{DD} or V _{SS}	15	360	370	520	600	—	400	
		V _{is} =7.25 to 7.75 V	15	775	790	1080	1230	—	850	
ΔOn-State Resistance Between Any 2 Switches, Δr _{on}	R _L = 10 kΩ, V _C = V _{DD}		5	—	—	—	—	15	—	Ω
			10	—	—	—	—	10	—	
			15	—	—	—	—	5	—	
Total Harmonic Distortion, THD	V _C =V _{DD} = 5 V, V _{SS} = -5 V, V _{is} (p-p) = 5 V (Sine wave centered on 0 V) R _L =10 kΩ, f _{is} =1 kHz sine wave			—	—	—	—	0.4	—	%
-3dB Cutoff Frequency (Switch on)	V _C =V _{DD} =5 V, V _{SS} = -5 V, V _{is} (p-p) = 5 V (Sine wave centered on 0 V) R _L = 1 kΩ.			—	—	—	—	40	—	MHz
-50dB Feed-through Frequency (Switch off)	V _C =V _{SS} = -5 V, V _{is} (p-p)=5 V (Sine wave centered on 0 V) R _L = 1 kΩ			—	—	—	—	1.25	—	MHz
Input/Output Leakage Current (Switch off) I _{is} Max.	V _C = 0 V V _{is} = 18 V, V _{os} = 0 V; V _{is} = 0 V, V _{os} = 18 V	18		±0.1	±0.1	±1	±1	10 ⁻⁴	±0.1	μA
-50 dB Crosstalk Frequency	V _C (A) = V _{DD} = +5 V, V _C (B) = V _{SS} = -5 V, V _{is} (A) = 5 V p-p, 50 Ω source R _L = 1 kΩ			—	—	—	—	0.9	—	MHz
Propagation Delay (Signal Input to Signal Output) t _{pd}	R _L = 200 kΩ V _C = V _{DD} , V _{SS} = GND, C _L = 50 pF V _{is} = Square Wave 0 to V _{DD} t _r , t _f = 20 ns	5		—	—	—	—	40	100	ns
		10		—	—	—	—	20	40	
		15		—	—	—	—	15	30	
Capacitance: Input, C _{is} Output, C _{os} Feedthrough, C _{ios}	V _{DD} = +5 V V _C = V _{SS} = -5 V			—	—	—	—	4	—	pF
				—	—	—	—	4	—	
				—	—	—	—	0.2	—	

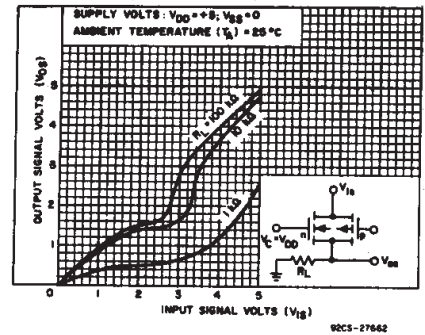


Fig. 3—Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = 0 V.

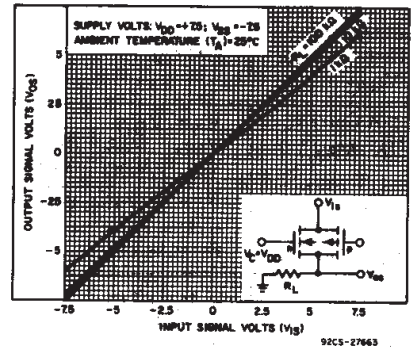


Fig. 4—Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +7.5 V, V_{SS} = -7.5 V.

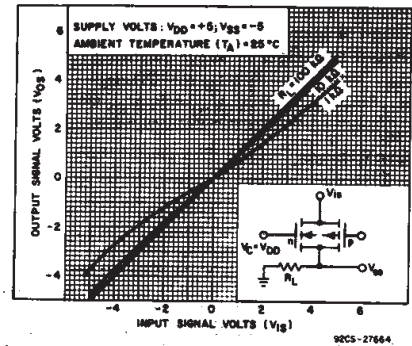


Fig. 5—Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = -5 V.

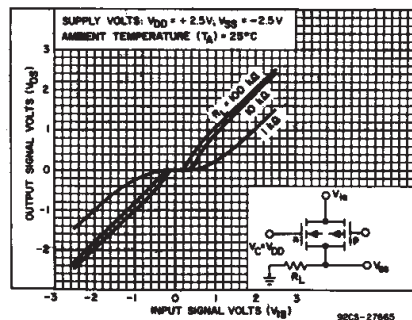


Fig. 6—Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +2.5 V, V_{SS} = -2.5 V.

CD4016B Types

ELECTRICAL CHARACTERISTICS (cont'd)

CHARACTERISTIC	TEST CONDITIONS	LIMITS AT INDICATED TEMPERATURES (°C)						UNITS	
		V _{DD} (V)	-55	-40	+85	+125	+25		
							Typ.		Max.
Control (V _C)									
Control Input Low Voltage, V _{ILC} (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 _{IHC}	See Fig. 10	5 10 15	3.5 (Min.) 7 (Min.) 11 (Min.)						V
Input Current, I _{IN} (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 _C = 10 V (Sq. Wave) t _r , t _f = 20 ns R _L = 10 kΩ	10	—	—	—	—	50	—	mV
Turn-On Propagation Delay	t _r , t _f = 20 ns C _L = 50 pF R _L = 1 kΩ	5 10 15	—	—	—	—	35 20 15	70 40 30	ns
Maximum Control Input Repetition Rate	V _{is} = V _{DD} , V _{SS} = GND, R _L = 1 kΩ to gnd, C _L = 50 pF, V _C = 10 V (Square wave centered on 5 V) t _r , t _f = 20 ns, V _{os} = ½ V _{os} @ 1 kHz	10	—	—	—	—	10	—	MHz
Input Capacitance, C _{IN}			—	—	—	—	5	7.5	μF

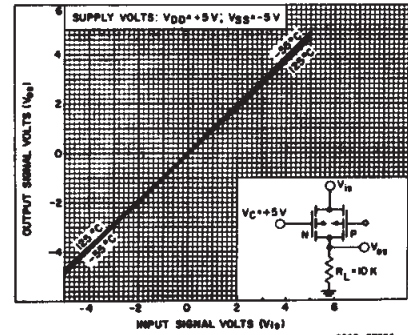


Fig. 7—Typ. on-state characteristics as a function of temp. for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = -5 V.

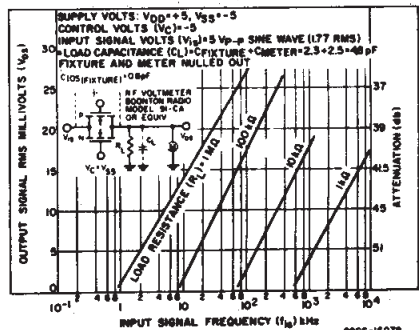


Fig. 8—Typ. feedthru vs. frequency—switch off.

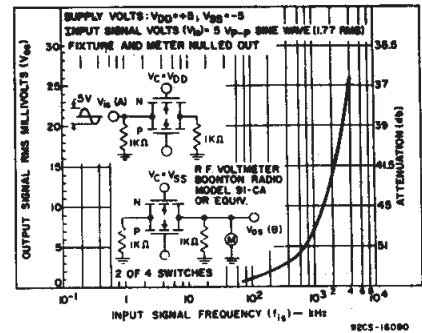


Fig. 9—Typical crosstalk between switch circuits in the same package.

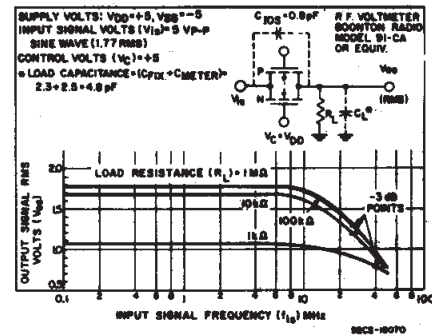


Fig. 11—Typical frequency response—switch on.

V _{DD} (V)	V _{is} (V)	Switch Input I _{is} (mA)						Switch Output V _{os} (V)	
		-55°C	-40°C	25°C*	25°C▲	+85°C	+125°C	Min.	Max.
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

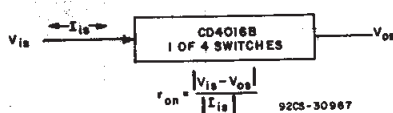


Fig. 10—Determination of r_{on} as a test condition for control input high voltage (V_{IHC}) specification.

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 (Ω)	V_{IS} (V)	VALUE (Ω)	V_{IS} (V)	VALUE (Ω)	V_{IS} (V)
r_{on}	+15	0	200	+15	200	+15	180	+15
$r_{on} \text{ (max.)}$	+15	0	200	0	200	0	200	0
r_{on}	+10	0	290	+10	250	+10	240	+10
$r_{on} \text{ (max.)}$	+10	0	290	0	250	0	300	0
r_{on}	+5	0	860	+5	470	+5	450	+5
$r_{on} \text{ (max.)}$	+5	0	600	0	580	0	800	0
r_{on}	+7.5	-7.5	200	+7.5	200	+7.5	180	+7.5
$r_{on} \text{ (max.)}$	+7.5	-7.5	290	± 0.25	280	± 25	400	± 0.25
r_{on}	+5	-5	260	+5	250	+5	240	+5
$r_{on} \text{ (max.)}$	+5	-5	310	-5	250	-5	240	-5
r_{on}	+2.5	-2.5	590	+2.5	450	+2.5	490	+2.5
$r_{on} \text{ (max.)}$	+2.5	-2.5	720	-2.5	520	-2.5	520	-2.5
$r_{on} \text{ (max.)}$	+2.5	-2.5	232k	± 0.25	300k	± 0.25	870k	± 0.25

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

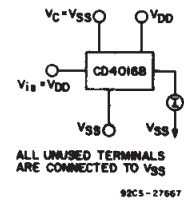


Fig. 12 — Off-state switch input or output leakage current test circuit.

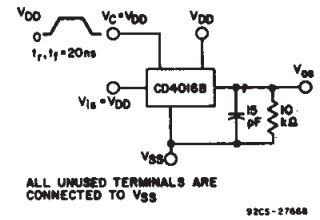
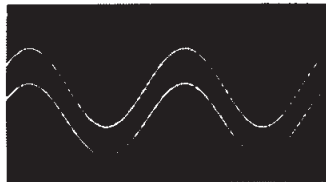


Fig. 13 — Test circuit for square-wave response.



SCALE: X = 0.2 ms/DIV Y = 2.0 V/DIV
VDD = VC = +7.5V, VSS = -7.5V, RL = 10K Ω
CL = 15 pF
fIS = 1 KHz VIS = 5V p-p
DISTORTION = 0.2 %

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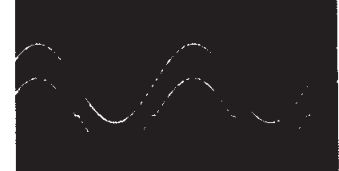
Fig. 14 — Typical sine wave response of $V_{DD} = +7.5 \text{ V}$, $V_{SS} = -7.5 \text{ V}$.



SCALE: X = 0.2 ms/DIV Y = 2.0 V/DIV
VDD = VC = +5 V, VSS = -5 V, RL = 10K Ω
CL = 15 pF
fIS = 1 KHz VIS = 5V 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
VDD = VC = +2.5V, VSS = -2.5V, RL = 10K Ω
CL = 15 pF
fIS = 1 KHz VIS = 5V 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 $V_{DD} = V_C = +5 \text{ V}$, $V_{SS} = \text{Gnd.}$

CD4016B Types

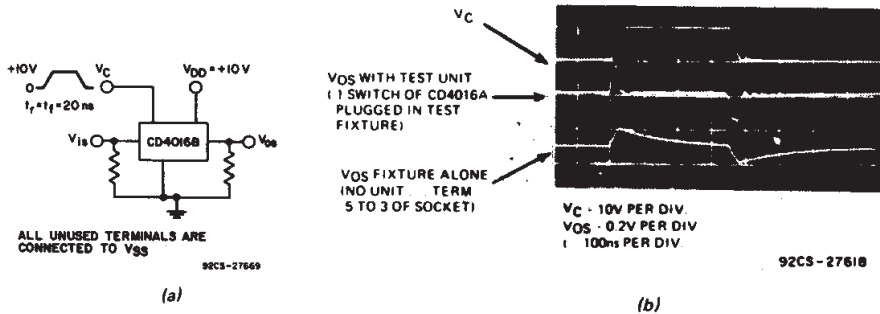


Fig. 20 - Crosstalk-control input to signal output.

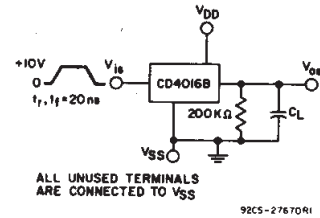


Fig. 21 - Propagation delay time signal input (V_{IS}) to signal output (V_{OS}).

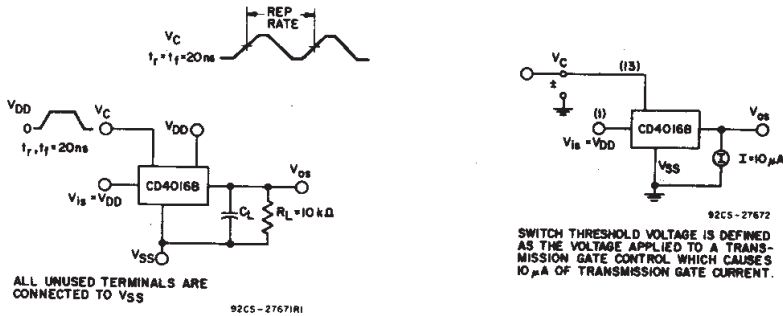


Fig. 22 - Max. control-input repetition rate.

Fig. 23 - Switch threshold voltage.

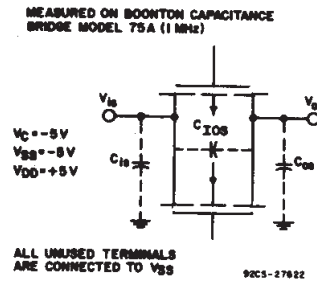


Fig. 24 - Capacitance C_{IOs} and C_{OS} .

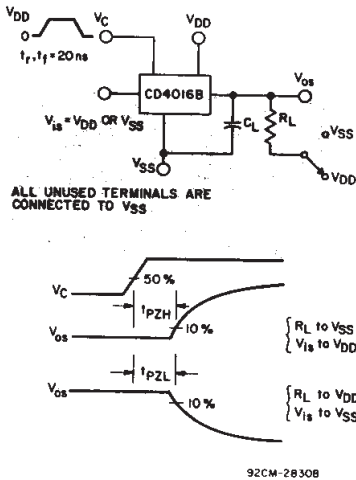
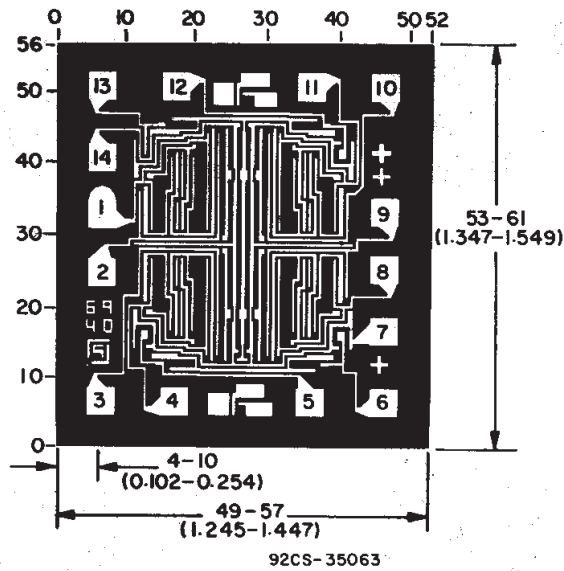


Fig. 25 - Turn-On propagation delay-control input.

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).

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