CD4016B Types

CMOS Quad Bilateral Switch

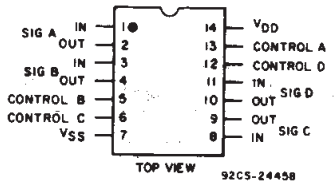
For Transmission or Multiplexing of Analog or Digital Signals

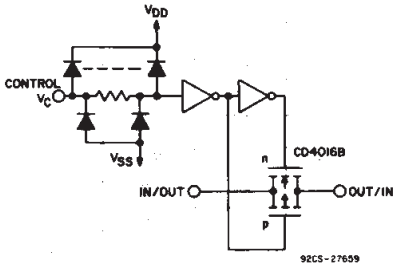
High-Voltage Types (20-Volt Rating)

■ 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.

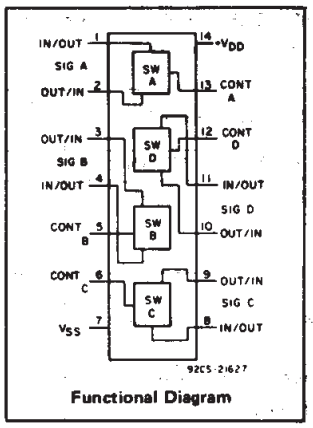
The CD4016 "B" Series types are supplied in 14-lead hermetic dual-in-line ceramic packages (D and F suffixes), 14-lead dual-in-line plastic packages (E suffix), and in chip form (H suffix).

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

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 kΩ**
- **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 kΩ**
- **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°C**
- **Extremely high control input impedance (control circuit isolated from signal circuit: 10^{12} Ω typ.**
- **Low crosstalk between switches: –50 dB typ. @ f_{is} = 0.9 MHz, R_L = 1 kΩ**
- **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°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**

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} +0.5V
DC INPUT CURRENT, ANY ONE INPUT ..... ±10mA
POWER DISSIPATION PER PACKAGE (P_D):
For T_A = -55°C to +100°C 500mW
For T_A = +100°C to +125°C ..... Derate Linearity at 12mW/°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°C to +125°C
STORAGE TEMPERATURE RANGE (T_{stg}) ..... -65°C to +150°C
LEAD TEMPERATURE (DURING SOLDERING):
At distance 1/16 ± 1/32 inch (1.59 ± 0.79mm) from case for 10s max ..... +265°C

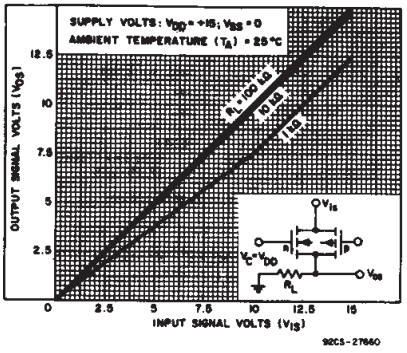


Fig. 1– Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +15 V, V_{SS} = 0 V.

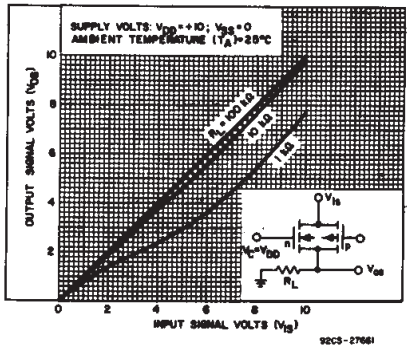


Fig. 2– Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +10 V, V_{SS} = 0 V.

ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	TEST CONDITIONS		V_{IN} (V)	V_{DD} (V)	LIMITS AT INDICATED TEMPERATURES (°C) −55	−40	+85	+125	+25 Typ.	+25 Max.	UNITS
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.	$V_C = V_{DD}$, $R_L = 10k\Omega$ Returned to $\frac{V_{DD}-V_{SS}}{2}$	$V_{is}=V_{DD}$ 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}	V_{DD} = +5 V $V_C = V_{SS}$ = −5 V				–	–	–	–	4	–	pF
Output, C_{os}					–	–	–	–	4	–	
Feedthrough, C_{ios}					–	–	–	–	0.2	–	

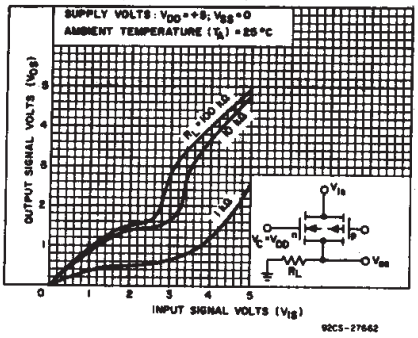


Fig. 3—Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = 0 V.

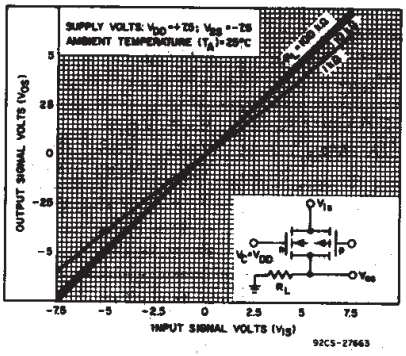


Fig. 4—Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +7.5 V, V_{SS} = −7.5 V.

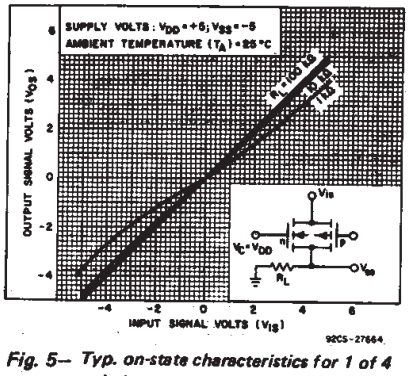


Fig. 5— Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = −5 V.

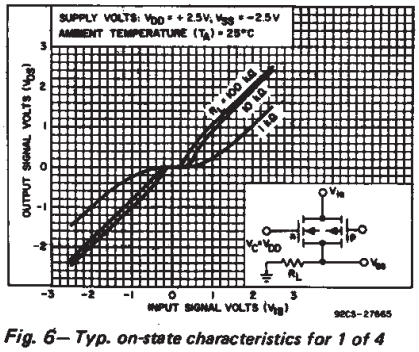


Fig. 6— Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +2.5 V, V_{SS} = −2.5 V.

ELECTRICAL CHARACTERISTICS (cont'd)

CHARACTERISTIC	TEST CONDITIONS	V_{DD} (V)	LIMITS AT INDICATED TEMPERATURES (°C)						UNITS
			−55	−40	+85	+125	+25 Typ.	+25 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	$\pm 10^{-5}$	±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

V_{DD} (V)	V_{is} (V)	Switch Input I_{is} (mA) −55°C	−40°C	25°C*	25°C▲	+85°C	+125°C	Switch Output V_{os} (V) 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

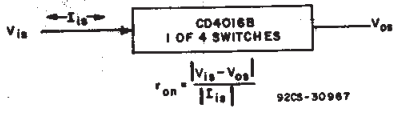


Fig. 10— Determination of r_{on} as a test condition for control input high voltage (V_{IHC}) specification.

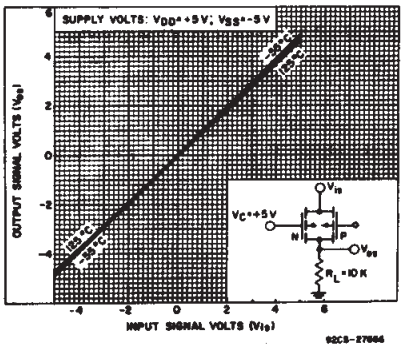


Fig. 7— Typ. on-state characteristics as a function of temp. for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = −5 V.

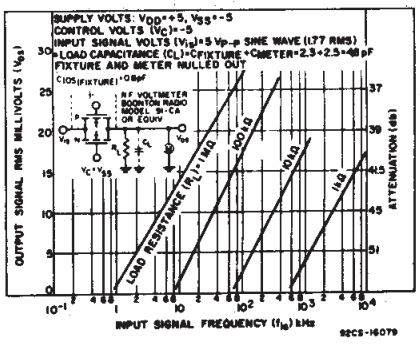


Fig. 8 — Typ. feedthru vs. frequency — switch off.

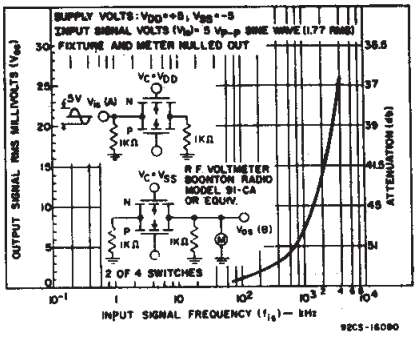


Fig. 9— Typical crosstalk between switch circuits in the same package.

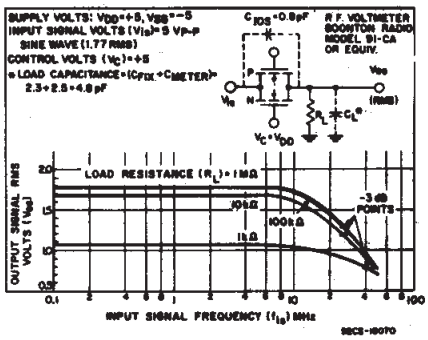


Fig. 11 — Typical frequency response — switch on.

TYPICAL ON-STATE RESISTANCE CHARACTERISTICS, T_A = 25°C

CHARACTERISTIC*	SUPPLY CONDITIONS		LOAD CONDITIONS					
			R_L = 1kΩ		R_L = 10kΩ		R_L = 100kΩ	
	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
			200	0	200	0	200	0
r_{on} (max.)	+15	0	300	+11	300	+9.3	320	+9.2
r_{on}	+10	0	290	+10	250	+10	240	+10
			290	0	250	0	300	0
r_{on} (max.)	+10	0	500	+7.4	560	+5.6	610	+5.5
r_{on}	+ 5	0	860	+ 5	470	+ 5	450	+ 5
			600	0	580	0	800	0
r_{on} (max.)	+ 5	0	1.7k	+4.2	7k	+2.9	33k	+2.7
r_{on}	+7.5	−7.5	200	+7.5	200	+7.5	180	+7.5
			200	−7.5	200	−7.5	180	−7.5
r_{on} (max.)	+7.5	−7.5	290	±0.25	280	±25	400	±0.25
r_{on}	+ 5	− 5	260	+ 5	250	+ 5	240	+ 5
			310	− 5	250	− 5	240	− 5
r_{on} (max.)	+ 5	− 5	600	±0.25	580	±0.25	760	±0.25
r_{on}	+2.5	−2.5	590	+2.5	450	+2.5	490	+2.5
			720	−2.5	520	−2.5	520	−2.5
r_{on} (max.)	+2.5	−2.5	232k	±0.25	300k	±0.25	870k	±0.25

* Variation from aperfect switch, r_{on} = 0 Ω.

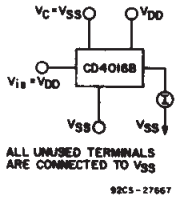


Fig. 12 – Off-state switch input or output leakage current test circuit.

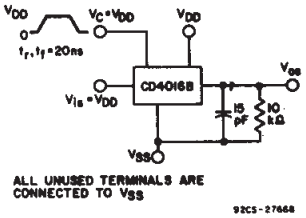
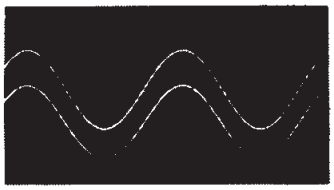


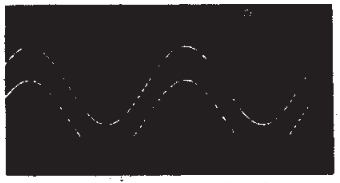
Fig.13 – Test circuit for square-wave response.



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

92CS-27612

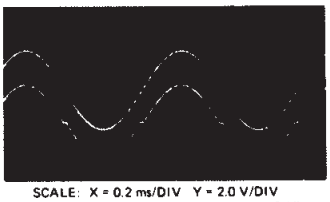
Fig.14 – Typical sine wave response of V_{DD} = +7.5 V, V_{SS} = −7.5 V.



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

92CS-27613

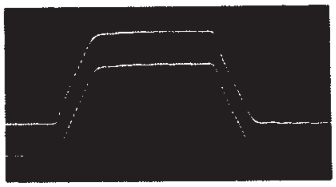
Fig.15 – Typical sine wave response of V_{DD} = +5 V, V_{SS} = −5 V.



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

92CS-27614

Fig.16 – Typical sine wave response of V_{DD} = +2.5 V, V_{SS} = −2.5 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 V, V_{SS} = Gnd.

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

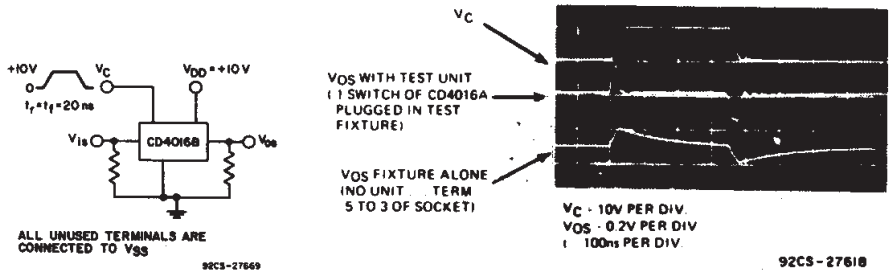
92CS-27616

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

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

92CS-27617

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



(a) (b)

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

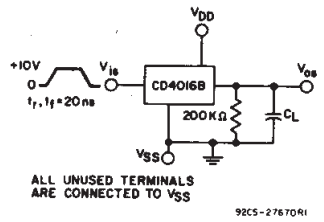


Fig.21 – Propagation delay time signal input (V_{IS}) to signal output (V_{OS}).

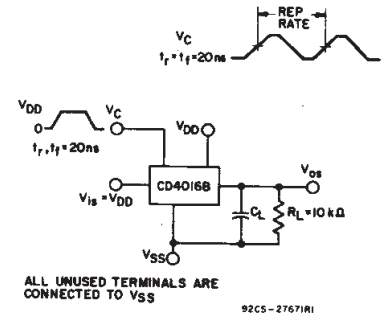


Fig. 22 – Max. control-input repetition rate.

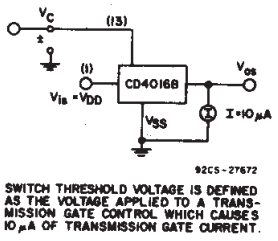


Fig.23 – Switch threshold voltage.

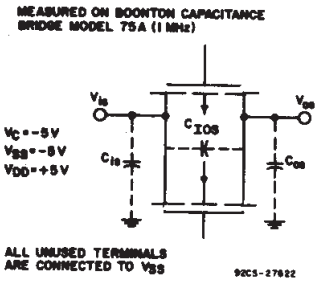


Fig.24 – Capacitance C_{IOS} and C_{OS}.

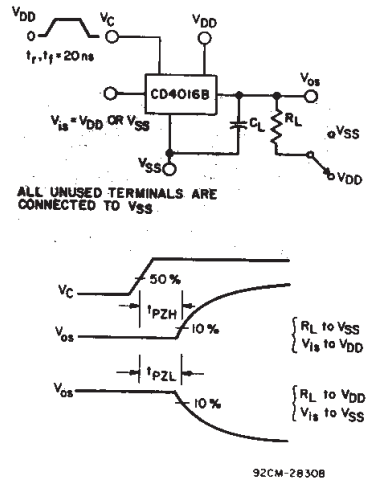
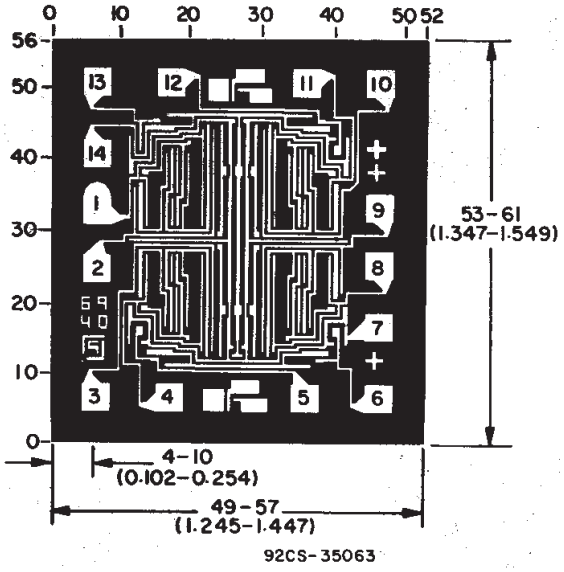


Fig.25 – Turn-On propagation delay-control input.

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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