# COS/MOS Quad Bilateral Switch

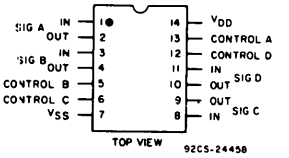
For Transmission or Multiplexing of Analog or Digital Signals

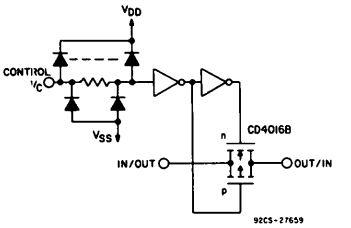
High-Voltage Types (20-Volt Rating)

The RCA-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.

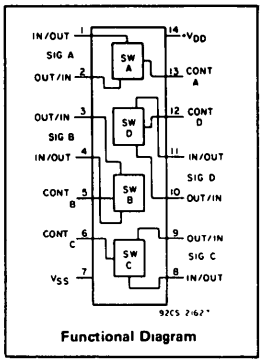
The CD4016 "B" Series types are supplied in 14-lead hermetic dual-in-line ceramic packages (D and F suffixes), 14-lead dual-in-line plastic packages (E suffix), 14-lead ceramic flat packages (K suffix), and in chip form (H suffix).

**Terminal Assignment**




*Schematic diagram - 1 of 4 identical sections.*




**Functional Diagram**

## *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 (contr l 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**
- **COS/MOS logic implementation**
- **Analog-to-digital & digital-to-analog conversi n**
- **Digital control f frequency, impedance, phase, and anal g-signal gain**

## 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) | -0.5 to +20 V |
| INPUT VOLTAGE RANGE, ALL INPUTS | -0.5 to $V_{DD}$ +0.5 V |
| DC INPUT CURRENT, ANY ONE INPUT (INCLUDING TRANSMISSION GATE) | ±10 mA |
| POWER DISSIPATION PER PACKAGE ($P_D$) | |
| For $T_A$ = –40 to +60°C (PACKAGE TYPE E) | 500 mW |
| For $T_A$ = +60 to +85°C (PACKAGE TYPE E) | Derate Linearly at 12 mW/°C to 200 mW |
| For $T_A$ = –55 to +100°C (PACKAGE TYPES D, F) | 500 mW |
| For $T_A$ = +100 to +125°C (PACKAGE TYPES D, F) | Derate Linearly at 12 mW/°C to 200 mW |
| DEVICE DISSIPATION PER TRANSMISSION GATE | |
| FOR $T_A$ = FULL PACKAGE-TEMPERATURE RANGE (All Package Types) | 100 mW |
| OPERATING-TEMPERATURE RANGE ($T_A$) | |
| PACKAGE TYPES D, F, H | -55 to +125°C |
| PACKAGE TYPE E | -40 to +85°C |
| STORAGE TEMPERATURE RANGE ($T_{stg}$) | 65 to +150°C |
| LEAD TEMPERATURE (DURING SOLDERING) | |
| At distance 1/16 ± 1/32 inch (1.59 ± 0.79 mm) from case for 10 s max | +265°C |

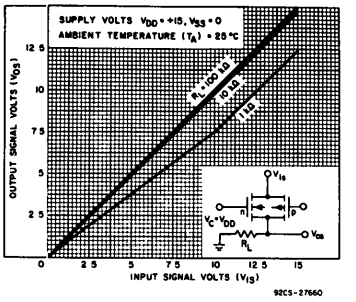



*Fig. 1– Typ. on-state characteristics for 1 of 4 switches with $V_{DD}$ = +15 V, $V_{SS}$ = 0 V.*

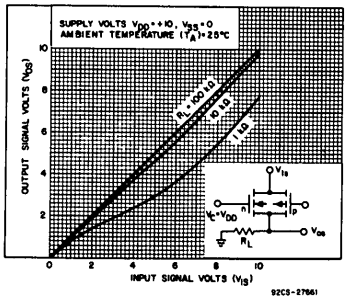



*Fig. 2– Typ. on-state characteristics for 1 of 4 switches with $V_{DD}$ = +10 V, $V_{SS}$ = 0 V.*

## ELECTRICAL CHARACTERISTICS

| Characteristic | Test Conditions | | $V_{IN}$ (V) | $V_{DD}$ (V) | LIMITS AT INDICATED TEMPERATURE (°C) Values at −55, +25, +125 Apply to D, F, H Packages Values at −40, +25, +85 Apply to E Package | | | | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | +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. | $V_C = V_{DD}$, $R_L = 10k\Omega$ 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, $\Delta r_{on}$ | $R_L$=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 $V_{is}$ = 10 V (Square wave centered on 5 V $t_r$, $t_f$ = 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 | – | |

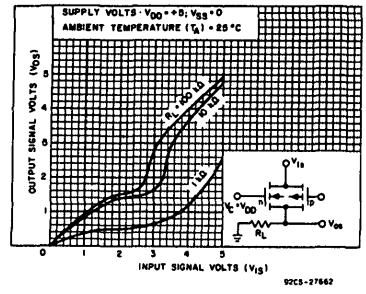



*Fig. 3—Typ. on-state characteristics for 1 of 4 switches with $V_{DD}$ = +5 V, $V_{SS}$ = 0 V.*

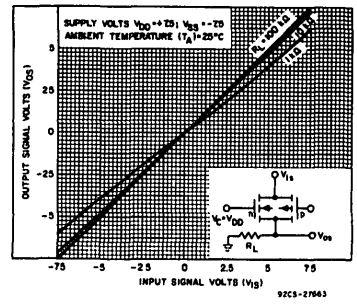



*Fig. 4—Typ. on-state characteristics for 1 of 4 switches with $V_{DD}$ = +7.5 V, $V_{SS}$ = −7.5 V.*

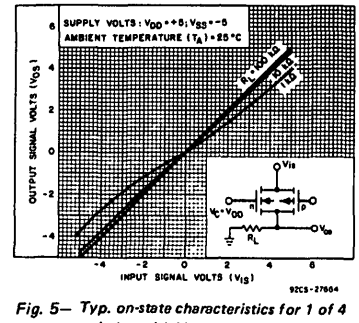



*Fig. 5— Typ. on-state characteristics for 1 of 4 switches with $V_{DD}$ = +5 V, $V_{SS}$ = −5 V.*

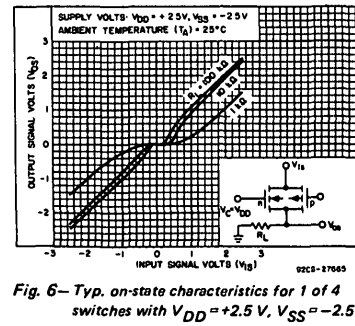



*Fig. 6— Typ. on-state characteristics for 1 of 4 switches with $V_{DD}$ = +2.5 V, $V_{SS}$ = −2.5 V.*

**ELECTRICAL CHARACTERISTICS (cont'd)**

| Characteristic | Test Conditions | $V_{DD}$ (V) | LIMITS AT INDICATED TEMPERATURE (°C) Values at −55, +25, +125 Apply to D, F, H Packages Values at −40, +25, +85 Apply to E Package | | | | | | 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. 1 | 5 | 3.5 (Min.) | | | | | | V |
| | | 10 | 7 (Min.) | | | | | | |
| | | 15 | 11 (Min.) | | | | | | |
| 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 | – | – | – | – | 35 | 70 | ns |
| | | 10 | – | – | – | – | 20 | 40 | |
| | | 15 | – | – | – | – | 15 | 30 | |
| 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, $V_{OS} = \frac{1}{2} V_{OS}$ @ 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

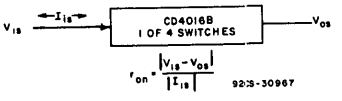



*Fig. 10— Determination of $r_{on}$ as a test condition for control input high voltage ($V_{IHC}$) specification.*

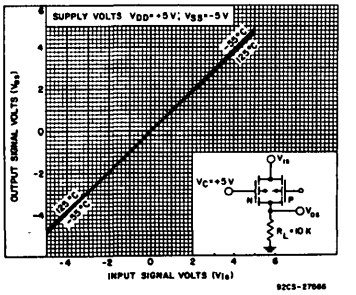



*Fig. 7— Typ. on-state characteristics as a function of temp. for 1 of 4 switches with $V_{DD}$ = +5 V, $V_{SS}$ = −5 V.*

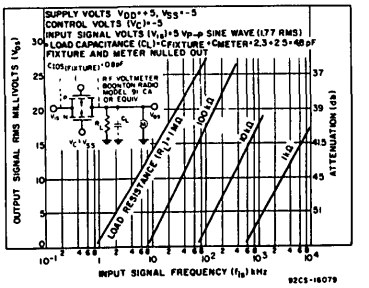



*Fig. 8 — Typ. feedthru vs. frequency — switch off.*

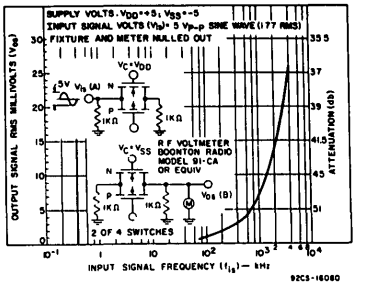



*Fig. 9— Typical crosstalk between switch circuits in the same package.*

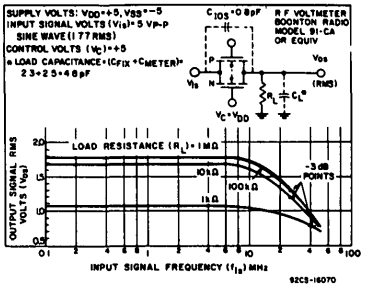



*Fig. 11 — Typical frequency response — switch on.*

## 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.

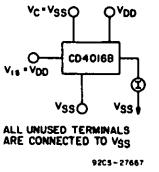



*Fig. 12 – Off-state switch input or output leakage current test circuit.*

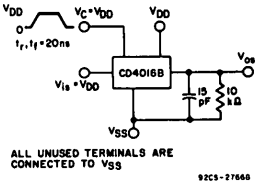
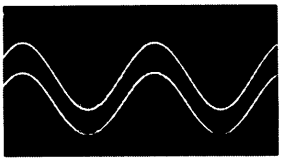


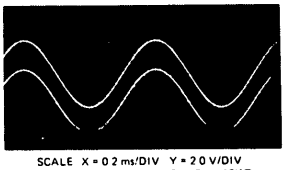

*Fig.13 – Test circuit for square-wave response.*



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

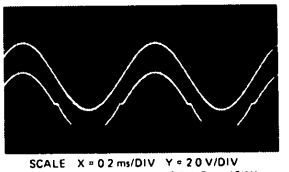
*Fig 14 – Typical sine wave response of $V_{DD}$ = +7.5 V, $V_{SS}$ = −7.5 V.*



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

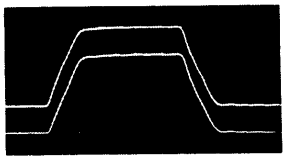
*Fig.15 – Typical sine wave response of $V_{DD}$ = +5 V, $V_{SS}$ = −5 V.*



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

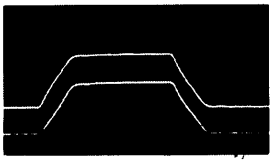
*Fig.16 – Typical sine wave response of $V_{DD}$ = +2.5 V, $V_{SS}$ = −2.5 V.*



SCALE X = 100 ns/DIV
Y = 5 0 V/DIV

92CS-27615

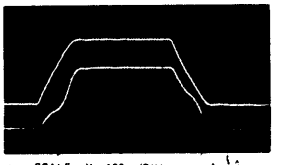
*Fig.17 – Typical square wave response at $V_{DD}$ = $V_C$ = +15 V, $V_{SS}$ = Gnd.*



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.*

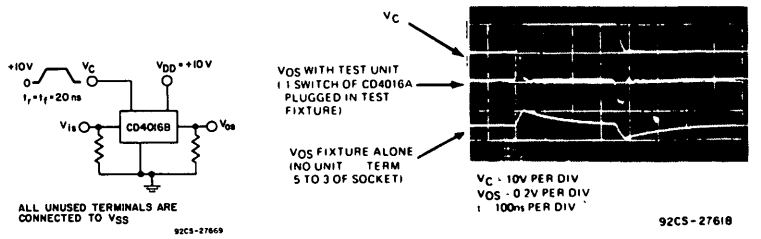



*Fig.20 – Crosstalk-control input to signal output.*

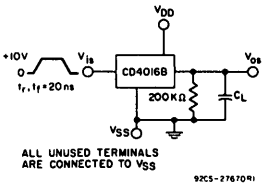



*Fig.21 – Propagation delay time signal input ($V_{IS}$) to signal output ($V_{OS}$).*

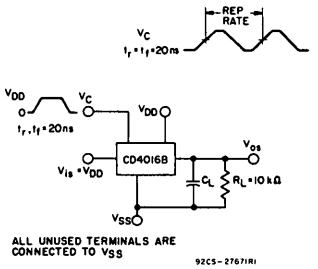



*Fig. 22 – Max. control-input repetition rate.*

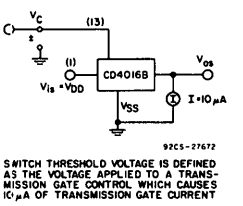



*Fig.23 – Switch threshold voltage.*

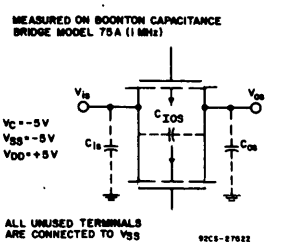



*Fig.24 – Capacitance $C_{IOS}$ and $C_{OS}$.*

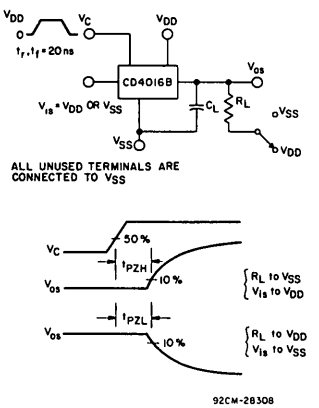
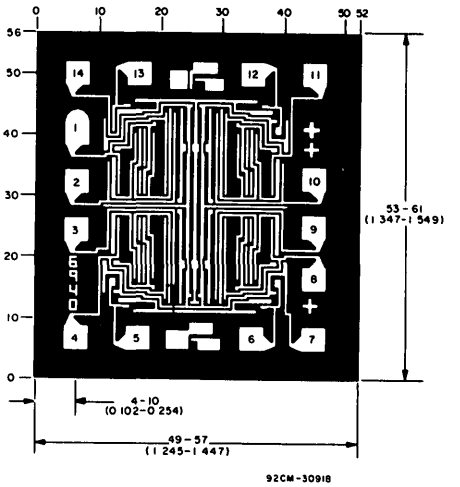



*Fig.25 – Turn-On propagation delay-control input.*

**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).*

*The photographs and dimensions of each COS/MOS chip represent a chip when it is part of the wafer. When the wafer is cut into chips, the cleavage angles are 57° instead of 90° with respect to the face of the chip. Therefore, the isolated chip is actually 7 mils (0.17 mm) larger in both dimensions.*