CMOS Quad Bilateral Switch

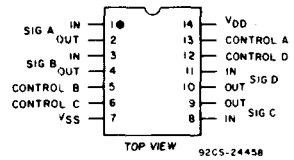
For Transmission or Multiplexing of Analog or Digital Signals

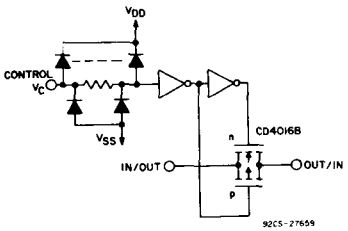
High-Voltage Types (20-Volt Rating)

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.

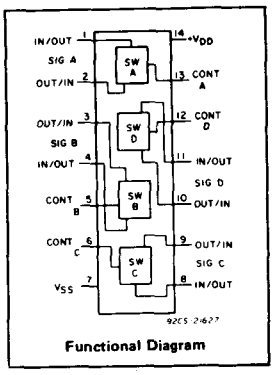
The CD4016 "B" Series types are supplied in 14-lead hermetic dual-in-line ceramic packages (D and F suffixes), 14-lead dual-in-line plastic packages (E suffix), 14-lead ceramic flat packages (K suffix), and in chip form (H suffix).

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 (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**

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, K)	500 mW
For T_A = +100 to +125°C (PACKAGE TYPES D, F, K)	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, K, 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

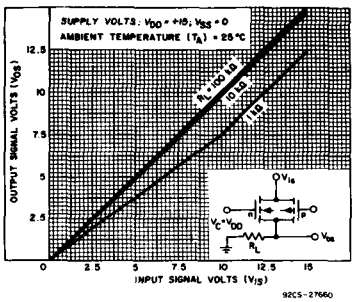


Fig. 1– Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +15 V, V_{SS} = 0 V.

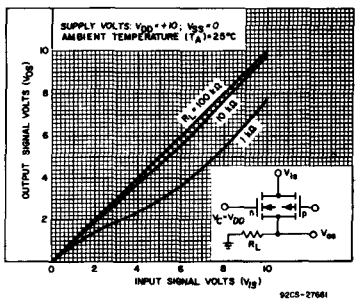


Fig. 2– Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +10 V, V_{SS} = 0 V.

CD4016B Types

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, K, H Packages Values at −40, +25, +85 Apply to E Package −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	–	

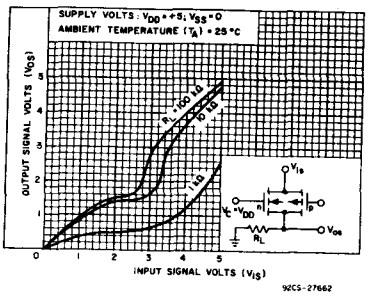


Fig. 3—Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = 0 V.

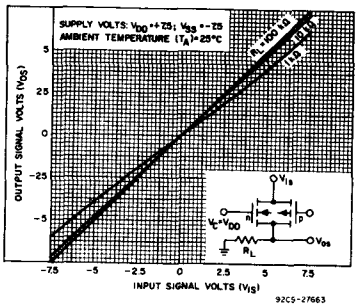


Fig. 4—Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +7.5 V, V_{SS} = −7.5 V.

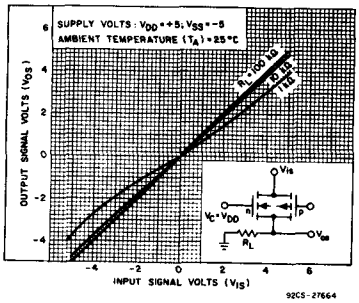


Fig. 5— Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = −5 V.

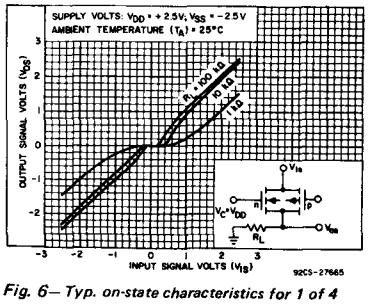


Fig. 6— Typ. on-state characteristics for 1 of 4 switches with V_{DD} = +2.5 V, V_{SS} = −2.5 V.

ELECTRICAL CHARACTERISTICS (cont'd)

Characteristic	Test Conditions	V_{DD} (V)	LIMITS AT INDICATED TEMPERATURE (°C) Values at −55, +25, +125 Apply to D, F, K, H Packages Values at −40, +25, +85 Apply to E Package −55	−40	+85	+125	+25 Typ.	+25 Max.	UNITS
Control (V_C)									
Control Input Low Voltage, V_{ILC} (Max.)	$\lvert I_{is}\rvert < 10\,\mu A$ $V_{is} = V_{SS}$, $V_{OS} = V_{DD}$ 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	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

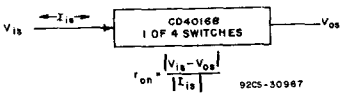


Fig. 10– Determination of r_{on} as a test condition for control input high voltage (V_{IHC}) specification.

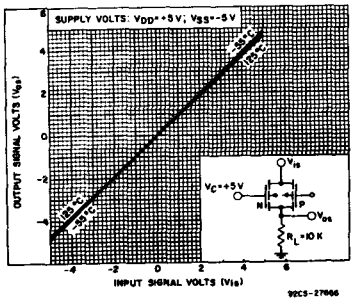


Fig. 7– Typ. on-state characteristics as a function of temp. for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = −5 V.

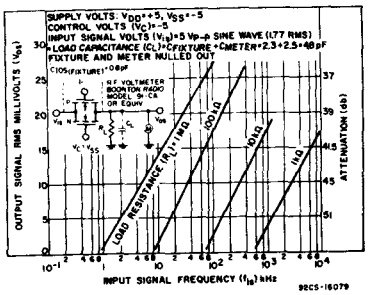


Fig. 8 – Typ. feedthru vs. frequency – switch off.

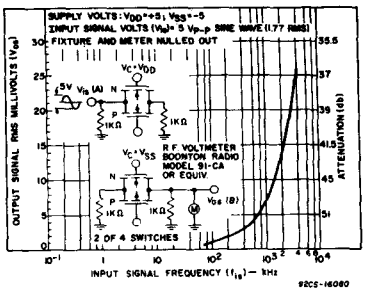


Fig. 9– Typical crosstalk between switch circuits in the same package.

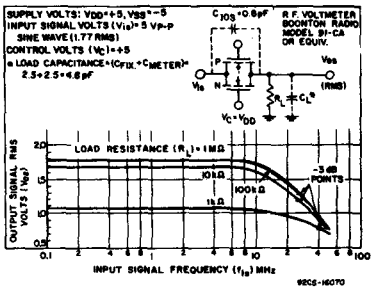


Fig. 11 – Typical frequency response – switch on.

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.

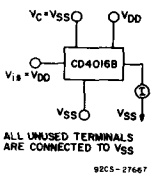


Fig. 12 – Off-state switch input or output leakage current test circuit.

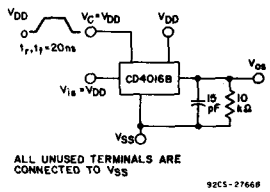


Fig. 13 – Test circuit for square-wave response.

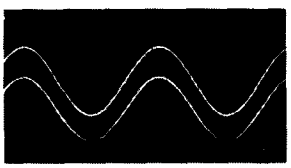


Fig. 14 – Typical sine wave response of V_{DD} = +7.5 V, V_{SS} = −7.5 V.

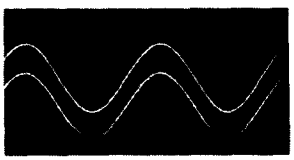


Fig. 15 – Typical sine wave response of V_{DD} = +5 V, V_{SS} = −5 V.

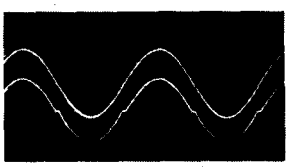


Fig. 16 – Typical sine wave response of V_{DD} = +2.5 V, V_{SS} = −2.5 V.

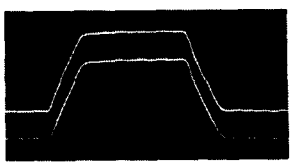


Fig. 17 – Typical square wave response at V_{DD} = V_C = +15 V, V_{SS} = Gnd.

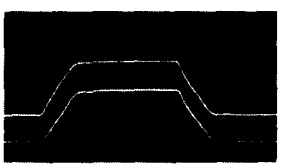


Fig. 18 – Typical square wave response at V_{DD} = V_C = +10 V, V_{SS} = Gnd.

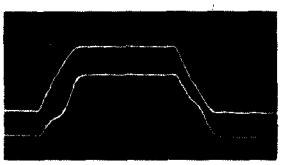
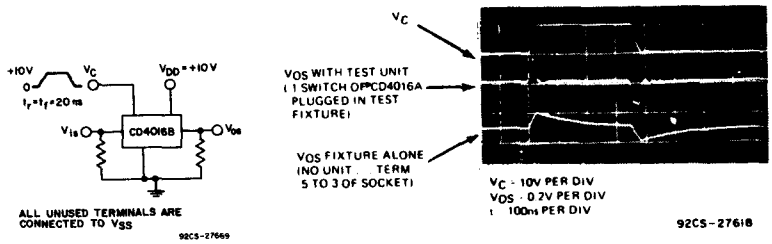


Fig. 19 – Typical square wave response at V_{DD} = V_C = +5 V, V_{SS} = Gnd.



(a) (b)

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

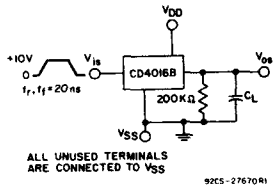


Fig.21 – Propagation delay time signal input (V_{IS}) to signal output (V_{OS}).

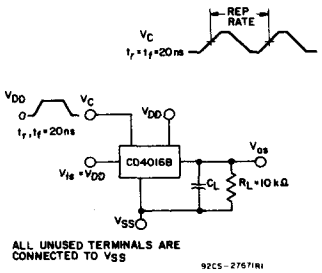


Fig. 22 – Max. control-input repetition rate.

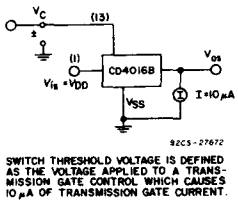


Fig.23 – Switch threshold voltage.

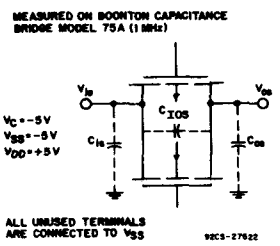


Fig.24 – Capacitance C_{IOS} and C_{OS}.

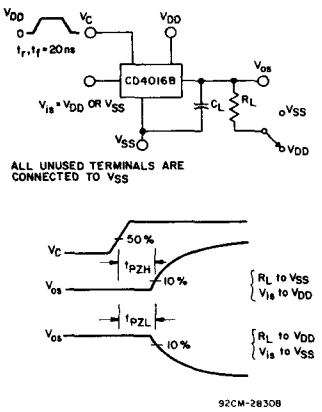
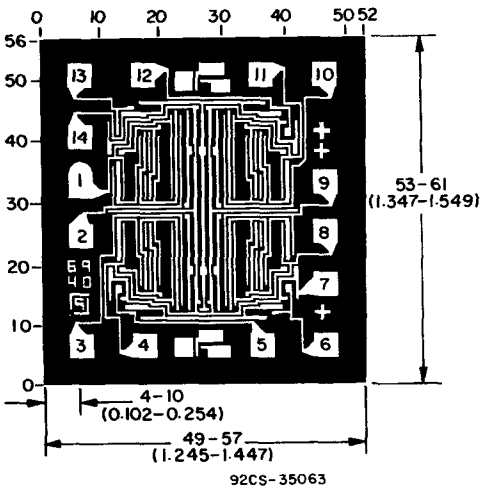


Fig.25 – Turn-On propagation delay-control input.

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).

The photographs and dimensions of each CMOS chip represent a chip when it is part of the wafer. When the wafer is separated into individual chips, the angle of cleavage may vary with respect to the chip face for different chips. The actual dimensions of the isolated chip, therefore, may differ slightly from the nominal dimensions shown. The user should consider a tolerance of −3 mils to +16 mils applicable to the nominal dimensions shown.