

# CMOS Quad Bilateral Switch

For Transmission or Multiplexing of Analog or Digital Signals

The RCA-CD4016A 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.

These 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).

**Features:**

- 15-V digital or ± 7.5-V peak-to-peak switching
- 280-Ω typical ON resistance for 15-V operation
- Switch ON resistance matched to within 10 Ω typ. over 15-V signal-input range
- High ON/OFF output-voltage ratio: 65 dB typ. @  $f_{is} = 10 \text{ kHz}$ ,  $R_L = 10 \text{ k}\Omega$

**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 $T_A = \text{Full Package Temperature Range}$ )	3	12	V

**TYPICAL "ON" RESISTANCE CHARACTERISTICS**

CHARACTERISTIC*	SUPPLY CONDITIONS		LOAD CONDITIONS					
	$V_{DD}$ (V)	$V_{SS}$ (V)	$R_L = 1\text{k}\Omega$		$R_L = 10\text{k}\Omega$		$R_L = 100\text{k}\Omega$	
			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
$R_{ON(max)}$	+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	500	+7.4	560	+5.6	610	+5.5
$R_{ON}$	+5	0	860	+5	470	+5	450	+5
$R_{ON(max)}$	+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
$R_{ON(max)}$	+7.5	-7.5	290	+0.25	280	+25	400	+0.25
$R_{ON}$	+5	-5	260	+5	250	+5	240	+5
$R_{ON(max)}$	+5	-5	310	+5	250	-5	240	-5
$R_{ON}$	+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
$R_{ON(max)}$	+2.5	-2.5	720	+2.5	520	-2.5	520	-2.5
$R_{ON}$	+2.5	-2.5	232k	+0.25	300k	+0.25	870k	+0.25

\* Variation from a perfect switch,  $R_{ON} = 0\Omega$ .

- High degree of linearity: <0.5% distortion typ. @  $f_{is} = 1 \text{ kHz}$ ,  $V_{is} = 5 \text{ V}_{p-p}$ ,  $V_{DD} - V_{SS} \geq 10 \text{ V}$ ,  $R_L = 10 \text{ k}\Omega$
- Extremely low OFF switch leakage resulting in very low offset current and high effective OFF resistance: 100 pA typ. @  $V_{DD} - V_{SS} = 10 \text{ V}$ ,  $T_A = 25^\circ\text{C}$
- Extremely high control input impedance (control circuit isolated from signal circuit): 1012 Ω typ.
- Low crosstalk between switches: -50 dB typ. @  $f_{is} = 0.9 \text{ MHz}$ ,  $R_L = 1 \text{ k}\Omega$
- Matched control-input to signal-output capacitance: Reduces output signal transients
- Frequency response, switch ON = 40 MHz (typ.)
- Quiescent current specified to 15 V
- Maximum input leakage current of 1 μA at 15 V (full package-temperature range)

**Applications:**

- Analog signal switching/multiplexing
- Signal gating
- Squelch control
- Chopper
- Modulator
- Demodulator
- Commutating switch

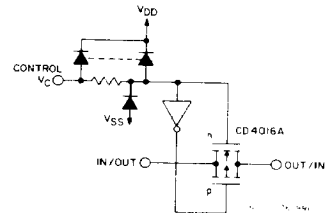
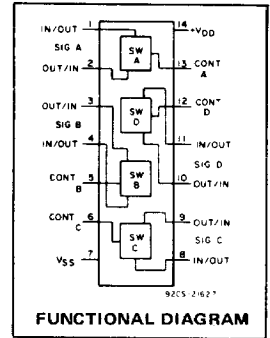


Fig. 1 - Schematic diagram - 1 of 4 identical sections.

- Digital signal switching/multiplexing
- CMOS logic implementation
- Analog-to-digital & digital-to-analog conversion
- Digital control of frequency, impedance, phase, and analog-signal gain

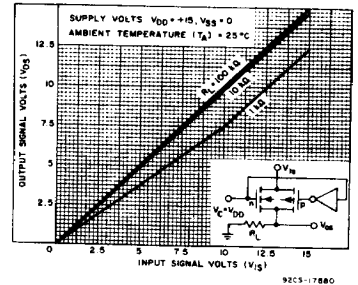


Fig. 2 - Typ. "ON" characteristics for 1 of 4 switches with  $V_{DD} = +15 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ .

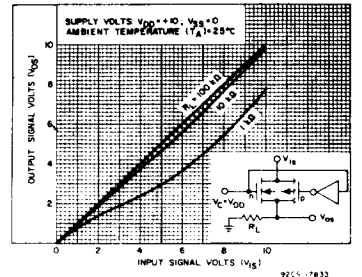


Fig. 3 - Typ. "ON" characteristics for 1 of 4 switches with  $V_{DD} = +10 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ .

# CD4016A Types

**ELECTRICAL CHARACTERISTICS (All inputs. . . . .  $V_{SS} \leq V_I \leq V_{DD}$ )**  
**Recommended DC Supply Voltage ( $V_{DD}-V_{SS}$ ). . . 3 to 15 V)**

Characteristic	Test Conditions <i>All Voltage Values are in Volts</i>	Limits						Unit
		Values at -55°C, +25°C, +125°C Apply to D, F, K, H Packages Values at -40°C, +25°C, +85°C Apply to E Package						
		$V_{DD}$ (V)	-55°	-40°	+85°	+125°	+25°C	
					Typ.	Max.		
Quiescent Device Current, $I_Q$ max (All switches ON or all Switches OFF) D, F, H Pkgs.		5	0.25	-	-	10	0.01	0.25
		10	0.5	-	-	20	0.01	0.5
		15	2	-	-	40	0.01	2
E, V Pkgs.		5	-	0.25	5	-	-	0.25
		10	-	0.5	10	-	-	0.5
		15	-	2	20	-	-	2

Signal Inputs ( $V_{IS}$ ) and Outputs ( $V_{OS}$ )										
Characteristic	$V_C = V_{DD}$	$V_{SS}$	$V_{IS}$	Typ/Max				Typ	Max	
				$R_L = 10\text{ k}\Omega$						
ON Resistance, $R_{ON}$	+7.5	-7.5	+7.5	120/360	130/370	260/520	300/600	200	400	
			-7.5	120/360	130/370	260/520	300/600	200	400	
			$\pm 0.25$	130/775	160/790	400/1080	470/1230	280	850	
		+5	-5	+5	130/600	150/610	340/840	400/960	250	660
				-5	130/600	150/610	340/840	400/960	250	660
				$\pm 0.25$	325/1870	370/1900	770/2380	900/2600	580	2000
	+15	0	+15	120/360	130/370	260/520	300/600	200	400	
			-0.25	120/360	130/370	260/520	300/600	200	400	
			+9.3	150/775	180/790	400/1080	490/1230	300	850	
	+10	0	+10	130/600	150/610	340/840	400/960	250	660	
			-0.25	130/600	150/610	340/840	400/960	250	660	
			+5.6	300/1870	350/1900	750/2380	880/2600	560	2000	
$\Delta R_{ON}$ Resistance Between Any 2 of 4 Switches	$R_L = 10\text{ k}\Omega$									
	+7.5	-7.5	$\pm 7.5$	-	-	-	-	10	-	
Sine Wave Response (Distortion)	+5	-5	5					0.4	%	
				$R_L = 10\text{ k}\Omega$		$f_{IS} = 1\text{ kHz}$				
Frequency Response (Sine-Wave Input)	$V_{DD} = +5$	$V_C = V_{SS} = -5$	-5					40	MHz	
				$R_L = 1\text{ k}\Omega$		$20 \log_{10} \frac{V_{OS}}{V_{IS}} = -3\text{ dB}$				
Feedthrough Switch OFF	+5	-5	-5					1.25	MHz	
				$R_L = 1\text{ k}\Omega$		$20 \log_{10} \frac{V_{OS}}{V_{IS}} = -50\text{ dB}$				
Input or Output Leakage Current (Effective OFF Resistance)	$V_{DD}$	$V_C = V_{SS}$						$\pm 100$	$\mu\text{A}$	
				+7.5	-7.5	$\pm 7.5$	-			-
	+5	-5	$\pm 5$	-	-	-	$\pm 10 \times 10^{-3}$	$\pm 125^*$	nA	

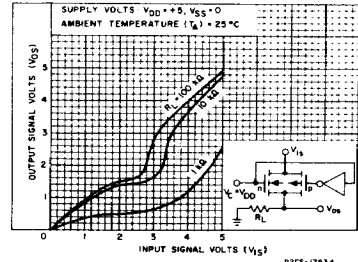


Fig. 4 — Typ. "ON" characteristics for 1 of 4 switches with  $V_{DD} = +5\text{ V}$ ,  $V_{SS} = 0\text{ V}$ .

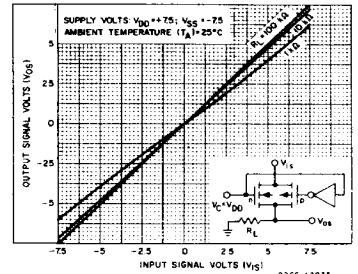


Fig. 5 — Typ. "ON" characteristics for 1 of 4 switches with  $V_{DD} = +7.5\text{ V}$ ,  $V_{SS} = -7.5\text{ V}$ .

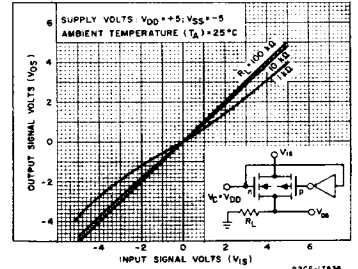


Fig. 6 — Typ. "ON" characteristics for 1 of 4 switches with  $V_{DD} = +5\text{ V}$ ,  $V_{SS} = -5\text{ V}$ .

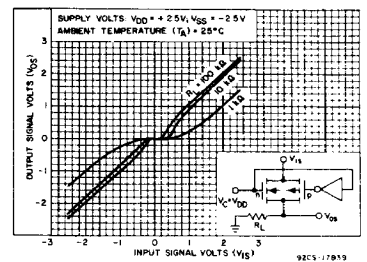


Fig. 7 — Typ. "ON" characteristics for 1 of 4 switches with  $V_{DD} = +2.5\text{ V}$ ,  $V_{SS} = -2.5\text{ V}$ .

# CD4016A Types

## ELECTRICAL CHARACTERISTICS (Cont'd) $V_{SS} \leq V_I \leq V_{DD}$ Recommended DC Supply Voltage ( $V_{DD}-V_{SS}$ ) .3 to 15 V

Characteristic	Test Conditions All Voltage Values are in Volts	Limits						Unit		
		Values at $-55^{\circ}\text{C}$ , $+25^{\circ}\text{C}$ , $+125^{\circ}\text{C}$ Apply to D, F, K, H Packages Values at $-40^{\circ}\text{C}$ , $+25^{\circ}\text{C}$ , $+85^{\circ}\text{C}$ Apply to E Package								
		$V_{DD}$ (V)	$-55^{\circ}$	$-40^{\circ}$	$+85^{\circ}$	$+125^{\circ}$	$+25^{\circ}\text{C}$			
Typ.	Max.									
Crosstalk Between Any 2 of 4 Switches ( $f = -50$ dB)	$V_C(A) = V_{DD} + 5$ $V_C(B) = V_{SS} - 5$ $V_{is}(A) = 5$ p-p $R_L = 1$ k $\Omega$ $20 \log_{10} \frac{V_{os}(B)}{V_{is}(A)}$ -50 dB		-	-	-	-	0.9	-	MHz	
Propagation Delay (Signal Input to Signal Output) $t_{pd}$	$V_C = V_{DD}$ $V_{SS} = \text{GND}$ $C_L = 50$ pF $V_{is} = 10$ Sq. Wave $t_r, t_f = 20$ ns	$V_{DD}$ 5 10					20 10	50 25	ns	
Capacitance: Input, $C_{is}$ Output, $C_{os}$ Feedthrough, $C_{ios}$	$V_{DD} = +5$ $V_{CC} = V_{SS} = -5$		-	-	-	-	4 4 0.2	- - -	pF	
<b>Control (<math>V_C</math>)<sup>†</sup></b>										
Switch Threshold Voltage, $V_{TH}$	$V_{is} \leq V_{DD}$ , $I_{is} = 10$ $\mu\text{A}$ $V_{DD} = V_{SS} = 15, 10, 5$		0.7 min 2.9 max	-	-	-	0.2 min 2.4 max	0.5 min 1.5	2.7	V
Input Leakage Current, $I_{IL}$ max	$V_{is} \leq V_{DD}$ $V_{DD} = 15$								$\pm 10^{-5}$ typ; $\pm 1$ max.	$\mu\text{A}$
Crosstalk (Control Input to Signal Output)	$V_C = 10$ (Sq. Wave) $t_r, t_f = 20$ ns $V_{DD} = 10$ $R_L = 10$ k $\Omega$		-	-	-	-	50	-	-	mV
Turn-On Propagation Delay, $t_{pdc}$	$V_{DD} - V_{SS} = 10$ $V_C = 10$ (See Fig. 25) $t_r, t_f = 20$ ns $C_L = 15$ pF $R_L = 1$ k $\Omega$	$V_{DD}$ 5 10	-	-	-	-	20 10	40 20	20	ns
Maximum Allowable Control Input Repetition Rate	$V_{DD} = 10$ , $V_{SS} = \text{GND}$ $R_L = 1$ k $\Omega$ , $C_L = 15$ pF $V_{CC} = 10$ (Sq. Wave) $t_r, t_f = 20$ ns		-	-	-	-	10	-	-	MHz
Av. Input Capacitance, $C_I$			-	-	-	-	5	-	-	pF

- \* Limit determined by minimum feasible leakage current measurement for automatic testing.
- ▲ Symmetrical about 0 volts.
- For all test conditions.
- † All control inputs protected by COS/MOS protection network.

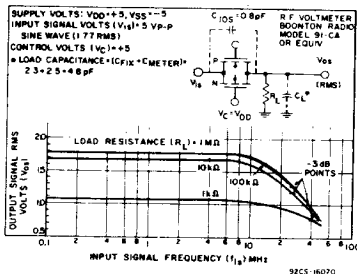


Fig. 11 - Typical switch frequency response - switch "ON".

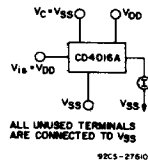


Fig. 12 - "OFF" switch input or output leakage current test circuit.

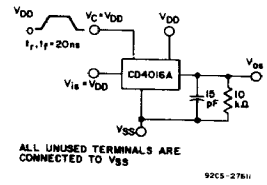


Fig. 13 - Test circuit for square-wave response.

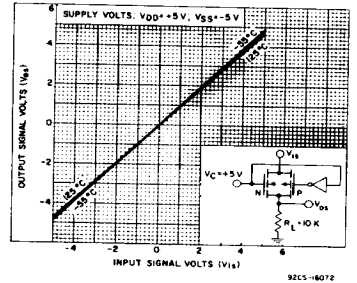


Fig. 8 - Typ. "ON" characteristics as a function of temp. for 1 of 4 switches with  $V_{DD} = +5$  V,  $V_{SS} = -5$  V.

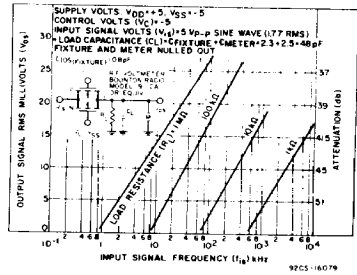


Fig. 9 - Typ. feedthru vs. frequency - switch "OFF".

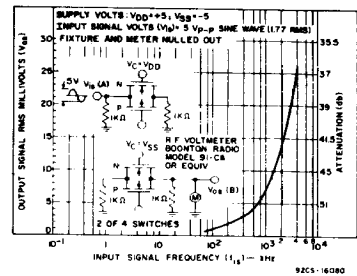


Fig. 10 - Typical crosstalk between switch circuits in the same package.

# CD4016A Types



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

92CS-27612

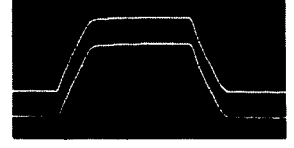
Fig. 14 - Typical sine wave response of  $V_{DD} = +7.5V, V_{SS} = -7.5V$ .



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

92CS-27614

Fig. 15 - Typical sine wave response of  $V_{DD} = +2.5V, V_{SS} = -2.5V$ .



SCALE X 100 ns DIV  
 Y 5.0 V DIV

92CS-27615

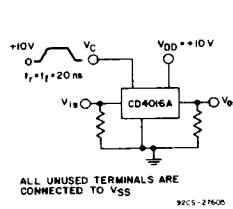
Fig. 16 - Typical square wave response at  $V_{DD} = V_C = +15V, V_{SS} = Gnd$ .



SCALE X 100 ns DIV  
 Y 2 V DIV

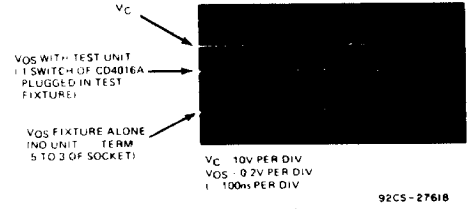
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Fig. 17 - Typical square wave response at  $V_{DD} = V_C = +5V, V_{SS} = Gnd$ .

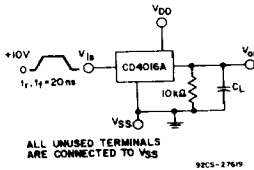


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Fig. 18 - Crosstalk-control input to signal output.

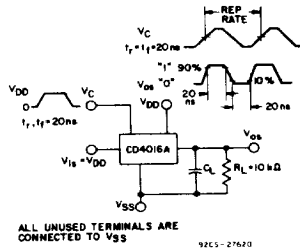


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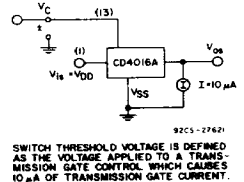
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Fig. 19 - Propagation delay time signal input ( $V_{IS}$ ) to signal output ( $V_{OS}$ ).



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Fig. 20 - Max. allowable control input repetition rate.



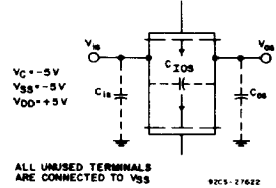
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Fig. 21 - Switch threshold voltage.

## MAXIMUM RATINGS, Absolute-Maximum Values:

STORAGE-TEMPERATURE RANGE ( $T_{stg}$ )	-65 to +150°C
OPERATING-TEMPERATURE RANGE ( $T_A$ )	
PACKAGE TYPES D, F, K, H	-55 to +125°C
PACKAGE TYPE E	-40 to +85°C
DC SUPPLY-VOLTAGE RANGE, ( $V_{DD}$ )	
(Voltages referenced to $V_{SS}$ Terminal)	-0.5 to +15 V
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 OUTPUT TRANSISTOR	
FOR $T_A =$ FULL PACKAGE-TEMPERATURE RANGE (ALL PACKAGE TYPES)	100 mW
INPUT VOLTAGE RANGE, ALL INPUTS	-0.5 to $V_{DD} + 0.5 V$
LEAD TEMPERATURE (DURING SOLDERING)	
At distance 1/16 ± 1/32 inch (1.59 ± 0.79 mm) from case for 10 s max.	+265°C

MEASURED ON BOONTON CAPACITANCE BRIDGE MODEL 75A (1 MHz)



92CS-27622

Fig. 22 - Capacitance  $C_{IO5}$  and  $C_{O5}$ .