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.

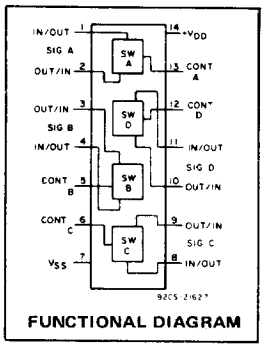
These types are supplied in 14-lead hermetic dual-in-line ceramic packages (D and F suffixes), 14-lead dual-in-line plastic packages (E suffix), 14-lead ceramic flat packages (K suffix), and in chip form (H suffix).

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 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 switch leakage resulting in very low offset current and high effective OFF resistance: 100 pA typ. @ $V_{DD}-V_{SS}$ = 10 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.)**
- **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**
- **Digital signal switching/multiplexing**
- **CMOS logic implementation**
- **Analog-to-digital & digital-to-analog conversion**
- **Digital control of frequency, impedance, phase, and analog-signal gain**



FUNCTIONAL DIAGRAM

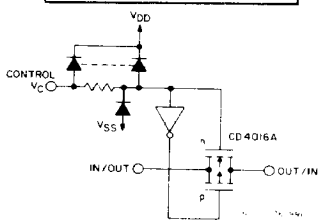


Fig. 1—Schematic diagram — 1 of 4 identical sections.

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	12	V

TYPICAL "ON" RESISTANCE CHARACTERISTICS

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 a perfect switch, R_{ON} = 0Ω.

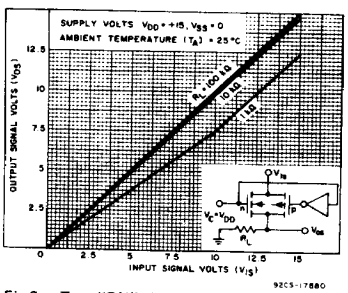


Fig.2 — Typ. "ON" characteristics for 1 of 4 switches with V_{DD} = +15 V, V_{SS} = 0 V.

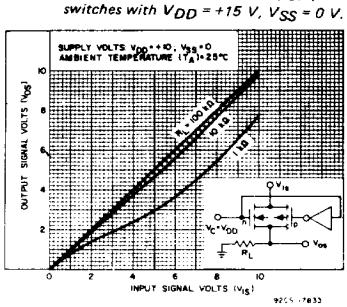


Fig.3 — Typ. "ON" characteristics for 1 of 4 switches with V_{DD} = +10 V, V_{SS} = 0 V.

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 *All Voltage Values are in Volts*			Limits *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*						Unit
			V_{DD} (V)	−55°	−40°	+85°	+125°	+25°C Typ.	+25°C Max.	
Quiescent Device Current, I_L max (All switches ON or all Switches OFF) D,F,H Pkgs.			5	0.25	–	–	10	0.01	0.25	μA
			10	0.5	–	–	20	0.01	0.5	
			15	2	–	–	40	0.01	2	
E,Y Pkgs.			5	–	0.25	5	–	–	0.25	μA
			10	–	0.5	10	–	–	0.5	
			15	–	2	20	–	–	2	
Signal Inputs (V_{is}) and Outputs (V_{os})										
ON Resistance, R_{ON}	V_C=V_{DD}	V_{SS}	V_{is}	Typ/Max	Typ/Max	Typ/Max	Typ/Max			Ω
	R_L = 10 kΩ●									
	+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	
			±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	
			±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	
ΔON Resistance Between Any 2 of 4 Switches ΔR_{ON}	R_L = 10 kΩ●									Ω
	+7.5	−7.5	±7.5	–	–	–	–	10	–	
	+5	−5	±5	–	–	–	–	15	–	
Sine Wave Response (Distortion)	+5	−5	5 p-p▲							%
	R_L = 10 kΩ, f_{is} = 1 kHz			–	–	–	–	0.4	–	
Frequency Response Switch ON (Sine-Wave Input)	V_{DD}=+5, V_C=V_{SS}=−5		−5 p-p							MHz
	R_L = 1 kΩ, 20 $\log_{10}\frac{V_{os}}{V_{is}}$ = −3 dB			–	–	–	–	40	–	
Feedthrough Switch OFF	+5	−5	−5 p-p							MHz
	R_L = 1 kΩ, 20 $\log_{10}\frac{V_{os}}{V_{is}}$ = −50 dB			–	–	–	–	1.25	–	
Input or Output Leakage Current Switch OFF (Effective OFF Resistance)	V_{DD}	V_C=V_{SS}	±7.5	–	–	–	–	±100	–	pA
	+7.5	−7.5								
	+5	−5	±5	–	–	–	–	$\pm 10 \times 10^{-3}$	±125*	nA

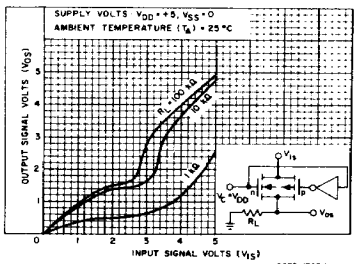


Fig. 4 — Typ. "ON" characteristics for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = 0 V.

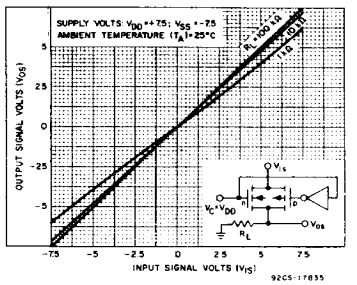


Fig.5 — Typ. "ON" characteristics for 1 of 4 switches with V_{DD} = +7.5 V, V_{SS} = -7.5 V.

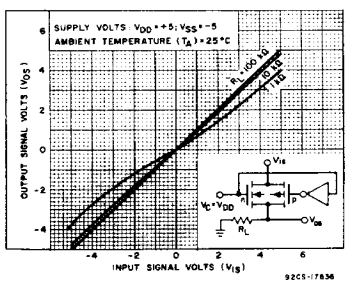


Fig.6 — Typ. "ON" characteristics for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = -5 V.

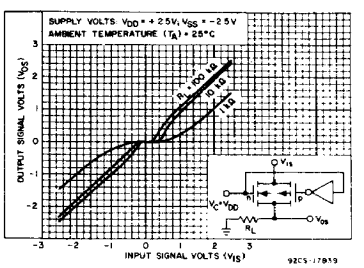


Fig.7 — Typ. "ON" characteristics for 1 of 4 switches with V_{DD} = +2.5 V, V_{SS} = -2.5 V.

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*	V_{DD} (V)	Limits *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* −55°	−40°	+85°	+125°	+25°C Typ.	+25°C Max.	Unit
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 kΩ $20\log_{10}\frac{V_{OS}(B)}{V_{is}(A)}$ = −50 dB		–	–	–	–	0.9	–	MHz
Propagation Delay (Signal Input to Signal Output) t_{pd}	$V_C = V_{DD}$ = 10 V_{SS} = GND C_L = 50 pF V_{is} = 10 Sq. Wave t_r, t_f = 20 ns	5					20	50	ns
		10					10	25	
Capacitance: Input, C_{is}	V_{DD} = +5		–	–	–	–	4	–	pF
Output, C_{os}	$V_{CC}=V_{SS}$ = −5		–	–	–	–	4	–	
Feedthrough, C_{ios}			–	–	–	–	0.2	–	
Control (V_C)†									
Switch Threshold Voltage, V_{TH}	$V_{is} \leq V_{DD}$, I_{is} = 10 μA $V_{DD}-V_{SS}$ = 15, 10, 5		0.7min 2.9max	– –	– –	0.2min 2.4max	0.5min 1.5	2.7	V
Input Leakage Current, I_{IL} max	$V_{is} \leq V_{DD}$	15	±10⁻⁵ typ; ±1 max.						μA
Crosstalk (Control Input to Signal Output)	V_C = 10 (Sq. Wave) t_r, t_f = 20 ns R_L = 10 kΩ	V_{DD} = 10	–	–	–	–	50	–	mV
Turn-On Propagation Delay, t_{pd}	$V_{DD}-V_{SS}$ = 10 V_C = 10 (See Fig. 25) t_r, t_f = 20 ns C_L = 15 pF R_L = 1 kΩ	5	–	–	–	–	20	40	ns
		10	–	–	–	–	10	20	
Maximum Allowable Control Input Repetition Rate	V_{DD} = 10, V_{SS} = GND R_L = 1 kΩ, 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.

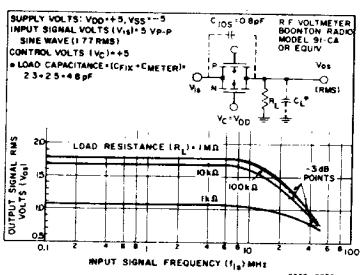


Fig.11 – Typical switch frequency response – switch "ON".

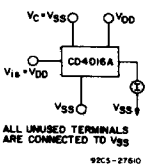


Fig.12 – "OFF" switch input or output leakage current test circuit.

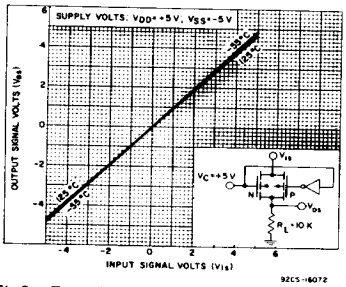


Fig.8 – Typ. "ON" characteristics as a function of temp. for 1 of 4 switches with V_{DD} = +5 V, V_{SS} = −5 V.

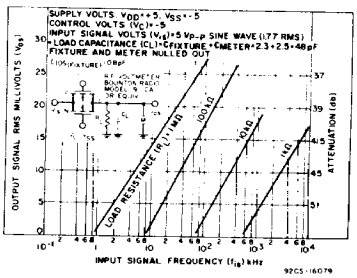


Fig.9 – Typ. feedthru vs. frequency – switch "OFF".

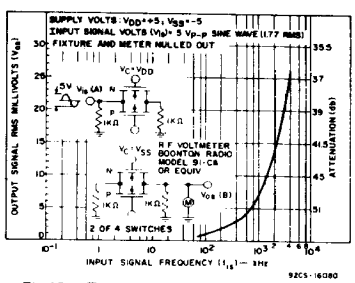


Fig.10 – Typical crosstalk between switch circuits in the same package.

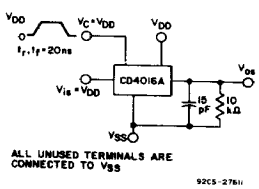


Fig.13 – Test circuit for square-wave response.

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} = +2.5 V, V_{SS} = –2.5 V.

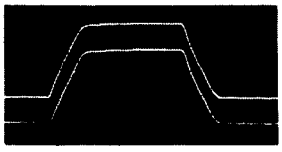


Fig. 16 – Typical square wave response at $V_{DD} = V_C$ = +15 V, V_{SS} = Gnd.

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

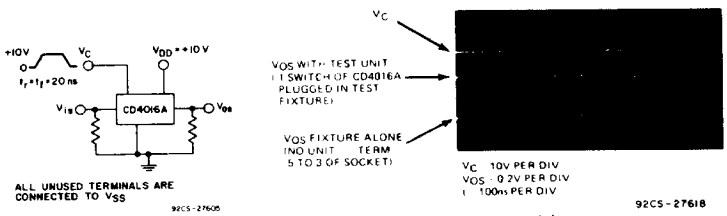


Fig. 18 – Crosstalk-control input to signal output.

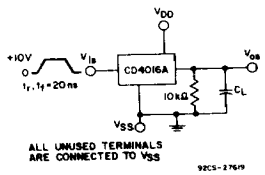


Fig. 19 – Propagation delay time signal input (V_{IS}) to signal output (V_{OS}).

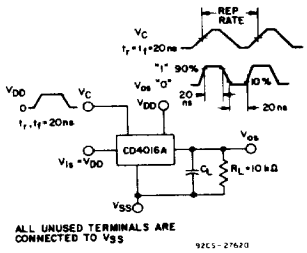


Fig. 20 – Max. allowable control-input repetition rate.

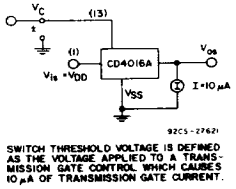


Fig. 21 – Switch threshold voltage.

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

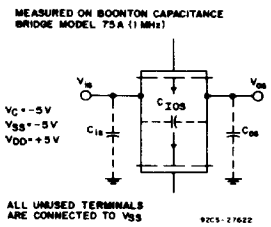


Fig. 22 – Capacitance C_{IOS} and C_{OS}.