# 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.

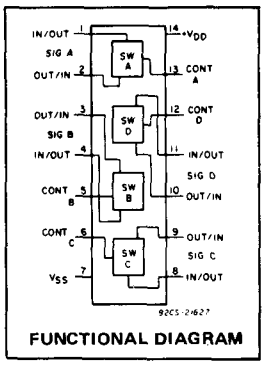
These types are supplied in 14-lead hermetic dual-in-line ceramic packages (D and F suffixes), 14-lead dual-in-line plastic packages (E suffix), 14-lead ceramic flat packages (K suffix), and in chip form (H suffix).

*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

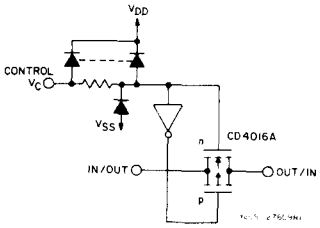



*Fig. 1—Schematic diagram — 1 of 4 identical sections.*

## 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.

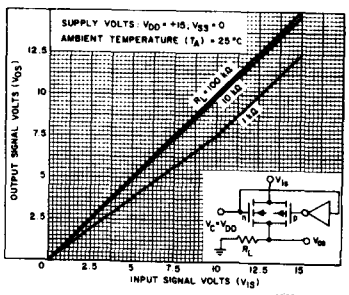



*Fig.2 — Typ. "ON" characteristics for 1 of 4 switches with $V_{DD}$ = +15 V, $V_{SS}$ = 0 V.*

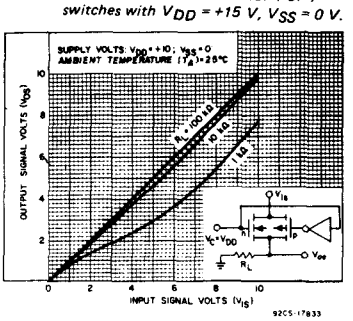



*Fig.3 — Typ. "ON" characteristics for 1 of 4 switches with $V_{DD}$ = +10 V, $V_{SS}$ = 0 V.*

# 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 *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 $\Delta R_{ON}$ | $R_L$ = 10 kΩ● | | | | | | | | | Ω |
| | +7.5 | -7.5 | ±7.5 | – | – | – | – | 10 | – | |
| | +5 | -5 | ±5 | – | – | – | – | 15 | – | |
| Sine Wave Response (Distortion) | +5 | -5 | 5 p-p▲ | – | – | – | – | 0.4 | – | % |
| | $R_L$ = 10 kΩ, $f_{is}$ = 1 kHz | | | | | | | | | |
| Frequency Response Switch ON (Sine-Wave Input) | $V_{DD}$=+5, $V_C=V_{SS}$=-5 | | -5 p-p | – | – | – | – | 40 | – | MHz |
| | $R_L$ = 1 kΩ, $20\log_{10}\frac{V_{os}}{V_{is}}$ = -3 dB | | | | | | | | | |
| Feedthrough Switch OFF | +5 | -5 | -5 p-p | – | – | – | – | 1.25 | – | MHz |
| | $R_L$ = 1 kΩ, $20\log_{10}\frac{V_{os}}{V_{is}}$ = -50 dB | | | | | | | | | |
| 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 | – | – | – | – | $\pm 10\times10^{-3}$ | ±125* | nA |

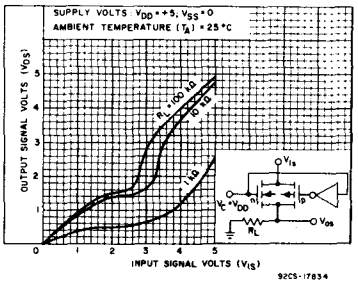



*Fig. 4 – Typ. "ON" characteristics for 1 of 4 switches with $V_{DD}$ = +5 V, $V_{SS}$ = 0 V.*

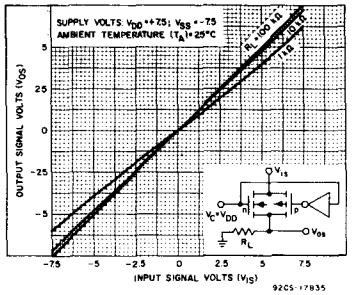



*Fig.5 – Typ. "ON" characteristics for 1 of 4 switches with $V_{DD}$ = +7.5 V, $V_{SS}$ = -7.5 V.*

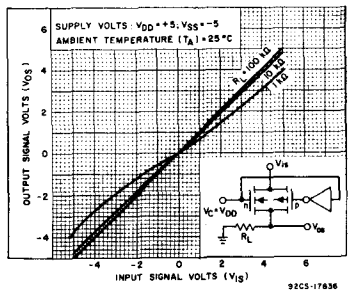



*Fig.6 – Typ. "ON" characteristics for 1 of 4 switches with $V_{DD}$ = +5 V, $V_{SS}$ = -5 V.*

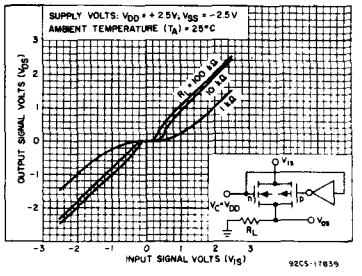



*Fig.7 – Typ. "ON" characteristics for 1 of 4 switches with $V_{DD}$ = +2.5 V, $V_{SS}$ = -2.5 V.*

**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* | | | | | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| | | | −55° | −40° | +85° | +125° | +25°C Typ. | +25°C Max. | |
| Crosstalk Between Any 2 of 4 Switches (f = −50 dB) | $V_C(A)=V_{DD}=+5$<br>$V_C(B)=V_{SS}=-5$<br>$V_{is}(A)$ = 5 p-p<br>$R_L$=1 kΩ<br>$20\log_{10}\frac{V_{os}(B)}{V_{is}(A)}$ = −50 dB | | – | – | – | – | 0.9 | – | MHz |
| Propagation Delay (Signal Input to Signal Output) $t_{pd}$ | $V_C = V_{DD}$ = 10<br>$V_{SS}$ = GND<br>$C_L$ = 50 pF<br>$V_{is}$ = 10 Sq. Wave<br>$t_r, t_f$ = 20 ns | $V_{DD}$<br>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, $V_{TH}$ | $V_{is}\leq V_{DD}$, $I_{is}$=10μA<br>$V_{DD}-V_{SS}$=15,10,5 | | 0.7min<br>2.9max | – | – | 0.2min<br>2.4max | 0.5min<br>1.5 | 2.7 | V |
| Input Leakage Current, $I_{IL}$ max | $V_{is}\leq V_{DD}$ | $V_{DD}$ =15 | ±$10^{-5}$ typ; ±1 max. | | | | | | μA |
| Crosstalk (Control Input to Signal Output) | $V_C$=10 (Sq.Wave)<br>$t_r, t_f$=20 ns<br>$R_L$=10 kΩ | $V_{DD}$ =10 | – | – | – | – | 50 | – | mV |
| Turn-On Propagation Delay, $t_{pd}$ | $V_{DD}-V_{SS}$=10<br>$V_C$ =10<br>(See Fig.25)<br>$t_r, t_f$=20 ns<br>$C_L$=15 pF<br>$R_L$= 1 kΩ | $V_{DD}$<br>5 | – | – | – | – | 20 | 40 | ns |
| | | 10 | – | – | – | – | 10 | 20 | |
| Maximum Allowable Control Input Repetition Rate | $V_{DD}$=10,<br>$V_{SS}$=GND<br>$R_L$=1 kΩ,<br>$C_L$=15 pF<br>$V_{CC}$=10(Sq.Wave)<br>$t_r, t_f$ 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.

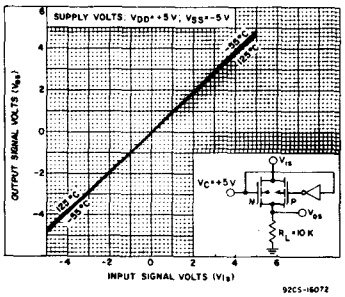



*Fig.8 – Typ. "ON" characteristics as a function of temp. for 1 of 4 switches with $V_{DD}$ = +5 V, $V_{SS}$ = -5 V.*

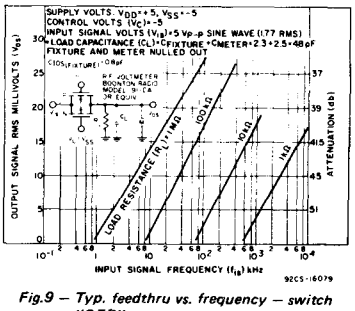



*Fig.9 – Typ. feedthru vs. frequency – switch "OFF".*

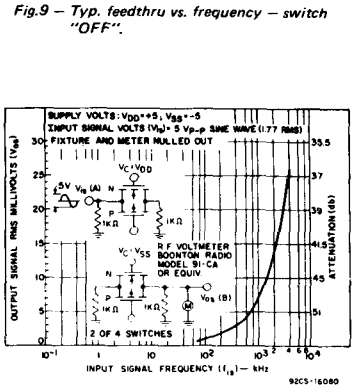



*Fig.10 – Typical crosstalk between switch circuits in the same package.*

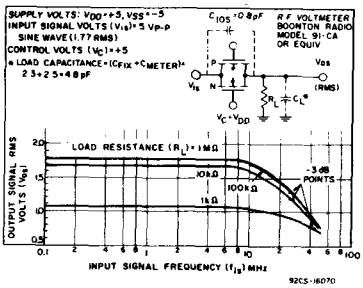



*Fig.11 – Typical switch frequency response – switch "ON".*

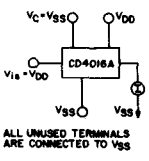



*Fig.12 – "OFF" switch input or output leakage current test circuit.*

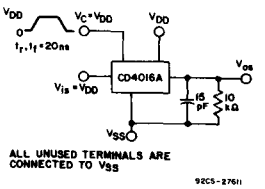



*Fig.13 – Test circuit for square-wave response.*

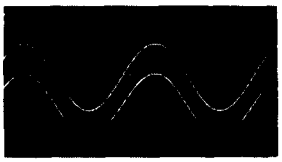



*Fig.14 – Typical sine wave response of $V_{DD}$ = +7.5 V, $V_{SS}$ = –7.5 V.*

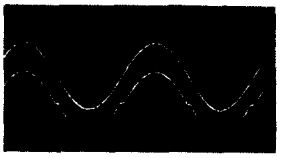



*Fig.15 – Typical sine wave response of $V_{DD}$ = +2.5 V, $V_{SS}$ = –2.5 V.*

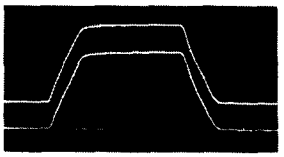



*Fig.16 – Typical square wave response at $V_{DD}$ = $V_C$ = +15 V, $V_{SS}$ = Gnd.*


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

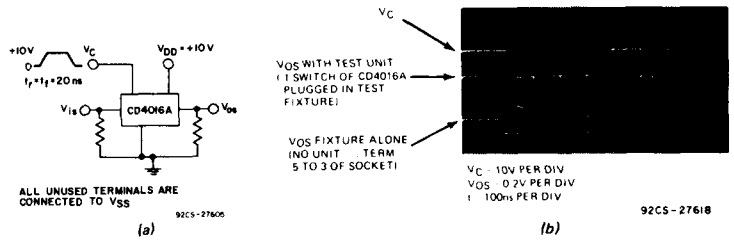



*Fig.18 – Crosstalk-control input to signal output.*

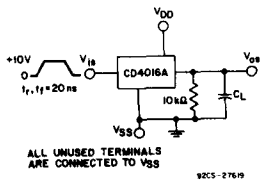



*Fig.19 – Propagation delay time signal input ($V_{IS}$) to signal output ($V_{OS}$).*

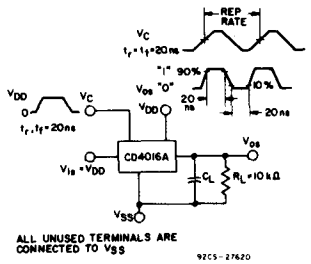



*Fig.20 – Max. allowable control-input repetition rate.*

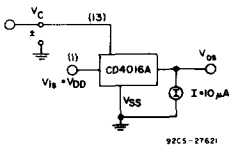



*Fig.21 – Switch threshold voltage.*

**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 |

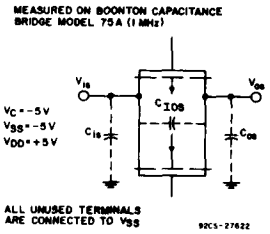



*Fig.22 – Capacitance $C_{IOS}$ and $C_{OS}$.*