# CD4016M/CD4016C Quad Bilateral Switch

## General Description

The CD4016M/CD4016C is a quad bilateral switch which utilizes P-channel and N-channel complementary MOS (CMOS) circuits to provide an extremely high "OFF" resistance and low "ON" resistance switch. The switch will pass signals in either direction and is extremely useful in digital switching.

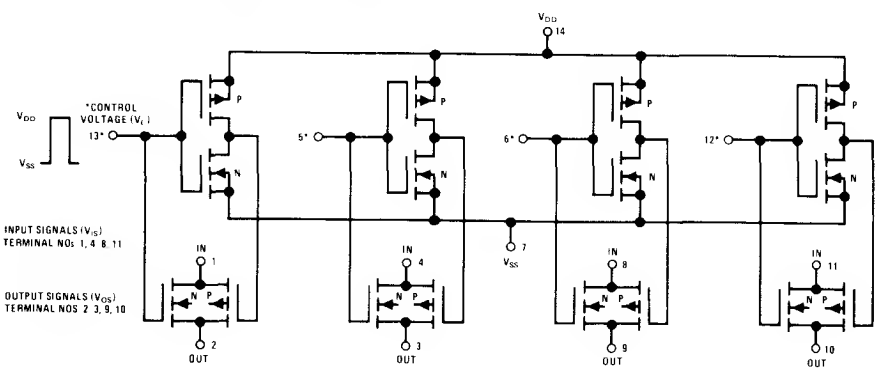
## Features

| | |
|---|---|
| ■ Wide supply voltage range | 3V to 15V |
| ■ High noise immunity | 0.45 $V_{CC}$ typ. |
| ■ Wide range of digital and analog levels | ±7.5 $V_{PEAK}$ |
| ■ Low "ON" resistance | 300Ω typ. $V_{DD} - V_{SS} = 15V$ |
| ■ Matched switch characteristics | $\Delta R_{ON} = 40\Omega$ typ. |
| ■ High "ON/OFF" output voltage ratio | 65 dB typ. @ $f_{IS} = 10$ kHz $R_L = 10k$ |
| ■ High degree of linearity | .5% distortion typ. @ $f_{IS} = 1$ kHz |
| ■ Extremely low leakage | $V_{IS} = 5\ V_{p-p}$ $V_{DD} - V_{SS} = 10V$ $R_L = 10\ k\Omega$ |
| ■ Transmits frequencies up to 10 MHz | |

## 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

## Schematic and Connection Diagrams

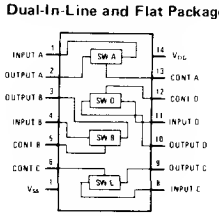



Note 1: All switch P-channel substrates are internally connected to terminal No. 14
Note 2: All switch N-channel substrates are internally connected to terminal No. 7

Signal-level range $V_{SS} \leq V_{IS} \leq V_{DD}$

Normal operation: Control line biasing, switch ON $V_C$ "1" = $V_{DD}$, switch OFF $V_C$ "0" = $V_{SS}$

**Dual-In-Line and Flat Package**




**Order Number CD4016MD**
**See Package 14**
**Order Number CD4016MF**
**See Package 23**
**Order Number CD4016CJ or CD4016MJ**
**See Package 18**
**Order Number CD4016CN**
**See Package 21**

## Absolute Maximum Ratings

Voltage at Any Pin (Note 1) $V_{SS}$ −0.3V to $V_{SS}$ +15 5V
Operating Temperature Range CD4016M −55°C to +125°C
CD4016C −40°C to +85°C
Storage Temperature Range −65°C to +150°C
Package Dissipation 500 mW
Lead Temperature (Soldering, 10 sec) 300°C
Operating $V_{DD}$ Range $V_{SS}$ +3V to $V_{SS}$ +15V

## Electrical Characteristics CD4016M

| CHARACTERISTIC | SYMBOL | TEST CONDITIONS | LIMITS −55°C MIN | −55°C TYP | −55°C MAX | 25°C MIN | 25°C TYP | 25°C MAX | 125°C MIN | 125°C TYP | 125°C MAX | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quiescent Dissipation per Package | | TERMINALS / VOLTS APPLIED: $V_{DD}$ 14 +10; $V_{SS}$ 7 GND; $V_C$ 5 6 12 13 GND; $V_{is}$ 1 4 8 11 ≤ +10; $V_{os}$ 2 3 9 10 ≤ +10 | | | | | | | | | | |
| All Switches "OFF" | $P_T$ | | | | 5 | | 0 1 | 5 | | | 300 | µW |
| | | TERMINALS / VOLTS APPLIED: $V_{DD}$ 14 +10; $V_{SS}$ 7 GND; $V_C$ 5 6 12 13 +10; $V_{is} = V_{OS}$ 1-4 8-11 < +10 | | | | | | | | | | |
| All Switches "ON" | | | | | 5 | | 0 1 | 5 | | | 300 | µW |
| Threshold Voltage N Channel | $V_{TH}N$ | $I_{DS}$ = 10 µA, $V_{DD}$ = 5V, 10V or 15V | | 1 7 | | | 1 5 | | | 1 3 | | V |
| P Channel | $V_{TH}P$ | $I_{DS}$ = 10 µA, $V_{DD}$ = 5V, 10V or 15V | | −1 7 | | | −1 5 | | | −1.3 | | V |
| **SIGNAL INPUTS ($V_{is}$) AND OUTPUTS ($V_{os}$)** | | | | | | | | | | | | |
| "ON" Resistance | $R_{ON}$ | $R_L$ = 10kΩ; $V_C = V_{DD}$, $V_{SS}$, $V_{is}$: +7 5V | | 120 | 360 | | 200 | 400 | | 300 | 600 | |
| | | +7 5V, −7 5V, −7 5V | | 120 | 360 | | 200 | 400 | | 300 | 600 | Ω |
| | | ±0 25V | | 130 | 775 | | 280 | 850 | | 470 | 1230 | |
| | | +5V | | 130 | 600 | | 250 | 660 | | 400 | 960 | |
| | | +5V, −5V, −5V | | 130 | 600 | | 250 | 660 | | 400 | 960 | Ω |
| | | ±0 25V | | 325 | 1870 | | 580 | 2000 | | 900 | 2600 | |
| | | +15V | | 120 | 360 | | 200 | 400 | | 300 | 600 | |
| | | +15V, 0V, +0 25V | | 120 | 360 | | 200 | 400 | | 300 | 600 | Ω |
| | | 9 3V | | 150 | 775 | | 300 | 850 | | 490 | 1230 | |
| | | +10V | | 130 | 600 | | 250 | 660 | | 400 | 960 | |
| | | +10V, 0V, +0 25V | | 130 | 600 | | 250 | 660 | | 400 | 960 | Ω |
| | | 5 6V | | 300 | 1870 | | 560 | 2000 | | 880 | 2600 | |
| Δ "ON" Resistance Between Any 2 of 4 Switches | $\Delta R_{ON}$ | +7 5V, −7 5V, ±7 5V | | | | | 10 | | | | | Ω |
| | | +5V, −5V, ±5V | | | | | 15 | | | | | |
| Sine Wave Response (Distortion) | | $R_L$ = 10 kΩ, $f_{is}$ = 1 kHz; +5V, −5V, 5V(p-p) (Note 3) | | | | | 0 4 | | | | | % |
| Input or Output Leakage—Switch "OFF" (Effective "OFF" Resistance) | | $V_{DD}$ / $V_C = V_{SS}$ / $V_{is}$: +7 5V, +7 5V | | | | | ±100 | | | | | pA |
| | | +7 5V, −7 5V, +5V, −5V | | | | | ±100 (Note 2) | 125 | | | | nA |
| | | +5V, −5V, −5V | | | | | (Note 2) | 125 | | | | |
| Frequency Response—Switch "ON" (Sine Wave Input) | | $V_C = V_{DD}$ = +5V, $V_{SS}$ = −5V; $R_L$ = 1 kΩ, $V_{is}$ = 5V(p-p); $20 \log_{10} \frac{V_o}{V_{is}} = -3$ dB | | | | | 40 | | | | | MHz |
| Feedthrough Switch "OFF" | | $V_{DD}$ = +5V, $V_C$, $V_{SS}$ = −5V; $20 \log_{10} \frac{V_o}{V_{is}} = -50$ dB | | | | | 1 25 | | | | | MHz |
| Crosstalk Between any 2 of the 4 switches (Frequency at −50 dB) | | $V_C(A) = V_{DC}$ = +5V, $V_C(B) = V_{SS}$ = −5V; $R_L$ = 1 kΩ, $V_{is}(A)$ = 5V(p-p); $20 \log_{10} \frac{V_o(B)}{V_{is}(A)} = -50$ dB | | | | | 0 9 | | | | | MHz |
| Capacitance Input | $C_{IS}$ | $V_{DD}$ = +5V, $V_C$, $V_{SS}$ = −5V | | | | | 4 | | | | | pF |
| Output | $C_{OS}$ | | | | | | 4 | | | | | |
| Feedthrough | $C_{IOS}$ | | | | | | 0.2 | | | | | |
| Propagation Delay Signal Input to Signal Output | $t_{pd}$ | $V_C = V_{DD}$ = +10V, $V_{SS}$ = GND, $C_L$ = 15 pF; $V_{is}$ = 10V (square wave); $t_r = t_f$ = 20 ns (input signal) | | | | | 10 | | | | | ns |
| **CONTROL ($V_C$)** | | | | | | | | | | | | |
| Switch Threshold Voltage | $V_{TH}C$ | $V_{is} < V_{DD}$; $V_{DD}$, $V_{SS}$ = 15V, 10V, 5V; $I_{IS}$ = 10 µA | 0 7 | | 2 9 | 0 5 | 1 5 | 2 7 | 0 2 | | 2 4 | V |
| Input Current | $I_C$ | $V_{DD} - V_{SS}$ = 10V, $V_C \leq V_{DD} - V_{SS}$ | | | | | ±10 | | | | | pA |
| Average Input Capacitance | $C_C$ | | | | | | 5 | | | | | pF |
| Crosstalk — Control Input to Signal Output | | $V_{DD} - V_{SS}$ = 10V, $V_C$ = 10V (square wave); $R_L$ = 10 kΩ | | | | | 50 | | | | | mV |
| Turn "ON" Propagation Delay | $t_{pd}C$ | $t_{rc} = t_{fc}$ = 20 ns; $V_{is}$ < 10V, $C_L$ = 15 pF | | | | | 20 | | | | | ns |
| Maximum Allowable Control Input Repetition Rate | | $V_{DD}$ = 10V, $V_{SS}$ = GND, $R_L$ = 1 kΩ, $C_L$ 15 pF, $V_C$ = 10V (square wave); $t_r = t_f$ = 20 ns | | | | | 10 | | | | | MHz |

**Note 1:** The device should not be connected to circuits with the power on.
**Note 2:** $+10 \times 10^{3}$
**Note 3:** Symmetrical about 0V

## Electrical Characteristics CD4016C

| CHARACTERISTIC | SYMBOL | TEST CONDITIONS | LIMITS | | | | | | | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | -40°C | | | 25°C | | | 85°C | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | |
| Quiescent Dissipation per Package | | | | | | | | | | | | |
| | | | TERMINALS | VOLTS APPLIED | | | | | | | | |
| | | $V_{DD}$ | 14 | +10 | | | | | | | | |
| | | $V_{SS}$ | 7 | GND | | | | | | | | |
| All Switches "OFF" | | $V_C$ | 5, 6, 12, 13 | GND | | | | | | | | |
| | | $V_{is}$ | 1, 4, 8, 11 | ≤ +10 | | | | | | | | |
| | $P_T$ | $V_{os}$ | 2, 3, 9, 10 | ≤ +10 | | | 5 | | | 0.1 | 5 | | | 80 | μW |
| | | | | VOLTS | | | | | | | | |
| | | | TERMINALS | APPLIED | | | | | | | | |
| | | $V_{DD}$ | 14 | +10 | | | | | | | | |
| All Switches "ON" | | $V_{SS}$ | 7 | GND | | | | | | | | |
| | | $V_C$ | 5, 6, 12, 13 | +10 | | | | | | | | |
| | | $V_{is} = V_{OS}$ | 1-4, 8, 11 | ≤ +10 | | | 5 | | | 0.1 | 5 | | | 80 | μW |
| Threshold Voltage N Channel | $V_{TH}N$ | $I_{DS} = 10\,\mu A$, $V_{DD}$ 5V, 10V, or 15V | | 1.7 | | | 1.5 | | | 1.3 | | | V |
| P Channel | $V_{TH}P$ | $I_{DS} = 10\,\mu A$, $V_{DD} = 5V$, 10V, or 15V | | 1.7 | | | -1.5 | | | 1.3 | | | V |
| **SIGNAL INPUTS ($V_{is}$) AND OUTPUTS ($V_{os}$)** | | | | | | | | | | | | |
| | | | $V_C = V_{DD}$ | $V_{SS}$ | $V_{is}$ | | | | | | | |
| | | | | | +7.5V | | 130 | 370 | | 200 | 400 | | 260 | 520 | |
| | | | +7.5V | 7.5V | -7.5V | | 130 | 370 | | 200 | 400 | | 260 | 520 | Ω |
| | | | | | 0.25V | | 160 | 790 | | 280 | 850 | | 400 | 1080 | |
| | | | | | +5V | | 150 | 610 | | 250 | 660 | | 340 | 840 | |
| | | | +5V | -5V | -5V | | 150 | 610 | | 250 | 660 | | 340 | 840 | Ω |
| "ON" Resistance | $R_{ON}$ | $R_L = 10k\Omega$ | | | +0.25V | | 370 | 1900 | | 580 | 2000 | | 770 | 2380 | |
| | | | | | +15V | | 130 | 370 | | 200 | 400 | | 260 | 520 | |
| | | | -15V | 0V | -0.25V | | 130 | 370 | | 200 | 400 | | 260 | 520 | Ω |
| | | | | | 9.3V | | 180 | 790 | | 300 | 850 | | 400 | 1080 | |
| | | | | | +10V | | 150 | 610 | | 250 | 660 | | 340 | 840 | |
| | | | +10V | 0V | +0.25V | | 150 | 610 | | 250 | 660 | | 340 | 840 | Ω |
| | | | | | 5.6V | | 350 | 1900 | | 560 | 2000 | | 750 | 2380 | |
| Δ "ON" Resistance Between Any 2 of 4 Switches | $\Delta R_{ON}$ | | +7.5V | 7.5V | +7.5V | | | | | 10 | | | | | Ω |
| | | | +5V | 5V | +5V | | | | | 15 | | | | | |
| Sine Wave Response (Distortion) | | $R_L = 10\,k\Omega$, $f_{is} = 1\,kHz$ | +5V | -5V | 5V(p-p) | | | | | 0.4 | | | | | % |
| | | | $V_{DD}$ | $V_C - V_{SS}$ | $V_{is}$ | | | | | | | | | | |
| Input or Output Leakage (Switch "OFF") (Effective "OFF" Resistance) | | | +7.5V | -7.5V | +7.5V | | | | | ±100 | | | | | pA |
| | | | | | -7.5V | | | | | ±100 | | | | | |
| | | | +5V | -5V | +5V | | | | | (Note 2) 125 | | | | | nA |
| | | | | | -5V | | | | | (Note 2) 125 | | | | | |
| Frequency Response—Switch "ON" (Sine Wave Input) | | | $V_C = V_{DD}$ +5V, $V_{SS}$ -5V | | | | | | | 40 | | | | | MHz |
| | | $R_L$ 1 kΩ, $V_{is}$ 5V(p-p) | 20 $Log_{10} \frac{V_{os}}{V_{is}}$ -3 dB | | | | | | | | | | | | |
| Feedthrough Switch "OFF" | | | $V_{DD}$ +5V, $V_C$ $V_{SS}$ -5V | | | | | | | 1.25 | | | | | MHz |
| | | | 20 $Log_{10} \frac{V_{os}}{V_{is}}$ -50 dB | | | | | | | | | | | | |
| Crosstalk Between any 2 of the 4 switches (Frequency at -50 dB) | | $R_L$ 1 kΩ, $V_{is}$(A) 5V(p-p) | $V_C$(A) $V_{DD}$ +5V, $V_C$(B) $V_{SS}$ -5V | | | | | | | 0.9 | | | | | MHz |
| | | | 20 $Log_{10} \frac{V_{os}(B)}{V_{is}(A)}$ -50 dB | | | | | | | | | | | | |
| Capacitance Input | $C_{IS}$ | $V_{DD}$ = +5V, $V_C$, $V_{SS}$ = -5V | | | | | | | | 4 | | | | | |
| Output | $C_{OS}$ | | | | | | | | | 4 | | | | | pF |
| Feedthrough | $C_{IOS}$ | | | | | | | | | 0.2 | | | | | |
| Propagation Delay Signal Input to Signal Output | $t_{PHL}$, $t_{PLH}$ | $V_C = V_{DD}$ +10V, $V_{SS}$ GND, $C_L$ 15 pF, $V_{is}$ 10V (square wave), $t_r$, $t_f$ = 20 ns (input signal) | | | | | | | | 10 | | | | | ns |
| **CONTROL ($V_C$)** | | | | | | | | | | | | | | | |
| Switch Threshold Voltage | $V_{THC}$ | $V_{is} = V_{DD}$, $V_{DD} - V_{SS}$ 15V, 10V, 5V, $I_{is} = 10\,\mu A$ | | | | 0.5 | 1.5 | 2.7 | | | | | | | V |
| Input Current | $I_C$ | $V_{DD} - V_{SS}$ 10V, $V_C$ < $V_{DD} - V_{SS}$ | | | | | ±10 | | | | | | | | pA |
| Average Input Capacitance | $C_C$ | | | | | | 5 | | | | | | | | pF |
| Crosstalk Control Input to Signal Output | | $V_{DD} - V_{SS}$ 10V, $V_C$ 10V (square wave), $R_L$ 10 kΩ | | | | | 50 | | | | | | | | mV |
| Turn "ON" Propagation Delay | $t_{PHC}$, $t_{PLC}$ | $t_r = t_f$ 20 ns, $V_{is}$ < 10V, $C_L$ = 15 pF | | | | | 20 | | | | | | | | ns |
| Maximum Allowable Control Input Repetition Rate | | $V_{DD}$ 10V, $V_{SS}$ GND, $R_L$ = 1 kΩ, $C_L$ 15 pF, $V_C$ 10V (square wave), $t_r = t_f$ 20 ns | | | | | 10 | | | | | | | | MHz |

**Note 1**: The device should not be connected to circuits with the power on.

**Note 2**: $\pm 10 \times 10^{-3}$.

**Note 3**: Symmetrical about 0V.

## Typical ON Resistance Characteristics

| CHARACTERISTIC* | SUPPLY CONDITIONS | | LOAD CONDITIONS | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | $R_L$ = 1 kΩ | | $R_L$ = 10 kΩ | | $R_L$ = 100 kΩ | |
| | $V_{DD}$ (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 | -0.25 | 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: $R_{ON} = 0\Omega$.