

# 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.

- Extremely low leakage
- Transmits frequencies up to 10 MHz

$V_{is} = 5 V_{p-p}$   
 $V_{DD} - V_{SS} = 10V$   
 $R_L = 10 k\Omega$

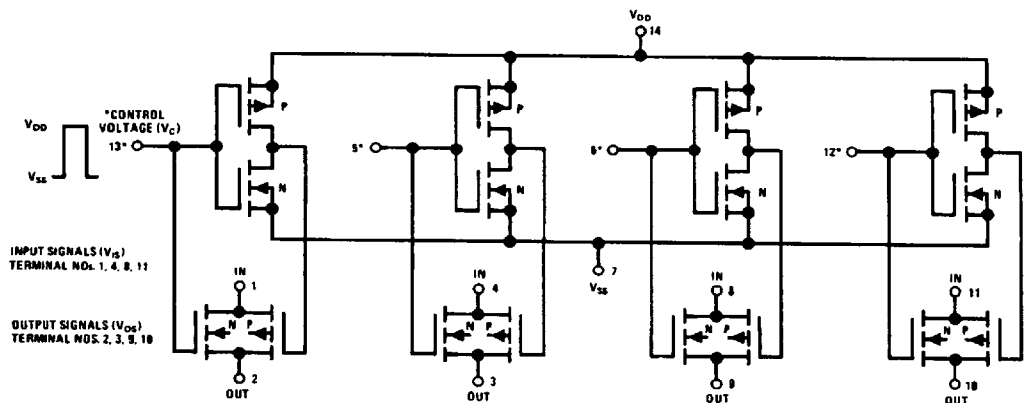
### Features

- Wide supply voltage range  
3V to 15V
- High noise immunity  
0.45  $V_{CC}$  typ.
- Wide range of digital and analog levels  
 $\pm 7.5 V_{PEAK}$
- Low "ON" resistance  
300  $\Omega$  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

### 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

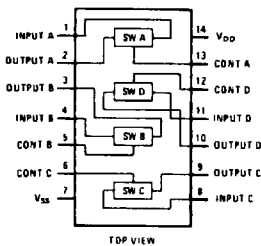
### Schematic and Connection Diagrams



**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:  $V_{SS} < V_{is} < V_{DD}$

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



TL/H/6104-2

**Order Number CD4016MJ or CD4016CJ**  
 See NS Package J14A

**Order Number CD4016CN**  
 See NS Package N14A

**Order Number CD4016MW**  
 See NS Package W14B

### Absolute Maximum Ratings

Voltage at Any Pin (Note 1)  $V_{SS} - 0.3V$  to  $V_{SS} + 15.5V$   
 Operating Temperature Range CD4016M  $-55^{\circ}C$  to  $+125^{\circ}C$   
 CD4016C  $-40^{\circ}C$  to  $+85^{\circ}C$

Storage Temperature Range  $-65^{\circ}C$  to  $+150^{\circ}C$   
 Package Dissipation  $500$  mW  
 Lead Temp. (Soldering, 10 seconds)  $300^{\circ}C$   
 Operating  $V_{DD}$  Range  $V_{SS} + 3V$  to  $V_{SS} + 15V$

### Electrical Characteristics CD4016M

Symbol	Characteristic	Test Conditions	Limits									Units
			$-55^{\circ}C$			$25^{\circ}C$			$125^{\circ}C$			
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
	Quiescent Dissipation per Package	Terminals	Volts Applied									
$P_T$	All Switches "OFF"	$V_{DD}$ 14 $V_{SS}$ 7 $V_C$ 5, 6, 12, 13 $V_{is}$ 1, 4, 8, 11 $V_{os}$ 2, 3, 9, 10	+10 GND GND $\leq +10$ $\leq +10$			5	0.1	5			300	$\mu W$
	All Switches "ON"	Terminals $V_{DD}$ 14 $V_{SS}$ 7 $V_C$ 5, 6, 12, 13 $V_{is} = V_{os}$ 1-4, 8-11	+10 GND +10 $\leq +10$			5	0.1	5			300	$\mu W$
$V_{THN}$	Threshold Voltage N-Channel	$I_{DS} = 10 \mu A$ $V_{DD} = 5V, 10V, \text{ or } 15V$			1.7		1.5			1.3		V
$V_{THP}$	P-Channel	$I_{DS} = 10 \mu A$ $V_{DD} = 5V, 10V, \text{ or } 15V$			-1.7		-1.5			-1.3		V
<b>SIGNAL INPUTS (<math>V_{is}</math>) AND OUTPUTS (<math>V_{os}</math>)</b>												
$R_{ON}$	"ON" Resistance	$R_L = 10 \text{ k}\Omega$	$V_C = V_{DD}$ $V_{SS}$ $V_{is}$									
			+7.5V -7.5V +7.5V	120	360	200	400	300	600			$\Omega$
			$\pm 0.25V$	120	360	200	400	300	600			
			+5V -5V +5V	130	775	280	850	470	1230			
			$\pm 0.25V$	130	600	250	660	400	960			$\Omega$
			+15V 0V +0.25V	130	600	250	660	400	960			
			+10V 0V +0.25V	325	1870	580	2000	900	2600			$\Omega$
$\Delta R_{ON}$	$\Delta$ "ON" Resistance Between Any 2 of 4 Switches		+7.5V -7.5V $\pm 7.5V$				10					$\Omega$
		+5V -5V $\pm 5V$					15					
	Sine Wave Response (Distortion)	$R_L = 10 \text{ k}\Omega$ $f_{is} = 1 \text{ kHz}$ $V_C = V_{SS}$ $V_{DD}$	+5V -V 5V(p-p)				0.4					%
	Input or Output Leakage-Switch "OFF" (Effective "OFF" Resistance)	+7.5V -7.5V +7.5V					$\pm 100$					pA
		+5V -5V +5V					$\pm 100$	125				nA
	Frequency Response-Switch "ON" (Sine Wave Input)	$V_C = V_{DD} = +5V, V_{SS} = -5V$ $R_L = 1 \text{ k}\Omega$ $20 \text{ Log}_{10} \frac{V_{os}}{V_{is}} = -3 \text{ dB}$ $V_{is} = 5V(p-p)$ $V_{DD} = +5V, V_C = V_{SS} = -5V$					40					MHz
	Feedthrough Switch "OFF"		$20 \text{ Log}_{10} \frac{V_{os}}{V_{is}} = -50 \text{ dB}$				1.25					MHz
	Crosstalk Between any 2 of the 4 switches (Frequency at -50 dB)	$R_L = 1 \text{ k}\Omega$ $V_{is}(A) = 5V(p-p)$	$V_C(A) = V_{DD} = +5V$ $V_C(B) = V_{SS} = 5V$ $20 \text{ Log}_{10} \frac{V_{os}(B)}{V_{is}(A)} = -50 \text{ dB}$				0.9					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.

Electrical Characteristics CD4016M (Continued)												
Symbol	Characteristic	Test Conditions	Limits									Units
			-55°C			25°C			125°C			
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
<b>SIGNAL INPUTS (<math>V_{is}</math>) AND OUTPUTS (<math>V_{os}</math>) (Continued)</b>												
$C_{is}$ $C_{os}$ $C_{ios}$	Capacitance Input Output Feedthrough	$V_{DD} = -5V, V_C = V_{SS} = -5V$						4 4 0.2				pF
$t_{pd}$	Propagation Delay Signal Input to Signal Output	$V_C = V_{DD} = -10V, V_{SS} = GND, C_L = 15 pF$ $V_{is} = 10V$ (square wave) $t_r = t_f = 20 ns$ (input Signal)						10				ns
<b>CONTROL (<math>V_C</math>)</b>												
$V_{THC}$	Switch Threshold Voltage	$V_{is} \leq V_{DD}$ $V_{DD} - V_{SS} = 15V, 10V, 5V$ $I_{is} = 10 \mu A$	0.7		2.9	0.5	1.5	2.7	0.2		2.4	V
$I_C$	Input Current	$V_{DD} - V_{SS} = 10V$ $V_C \leq V_{DD} - V_{SS}$					$\pm 10$					pA
$C_C$	Average Input Capacitance						5					pF
	Crosstalk – Control Input to Signal Output	$V_{DD} - V_{SS} = 10V$ $V_C = 10V$ $R_L = 10 k\Omega$ (square wave)					50					mV
$t_{pdC}$	Turn "ON" Propagation Delay	$t_{rc} = t_{fc} = 20 ns$ $V_{is} < 10V, C_L = 15 pF$					20					ns
	Maximum Allowable Control Input Repetition Rate	$V_{DD} = 10V, V_{SS} = GND, R_L = 1 \Omega$ $C_L = 15 pF$ $V_C = 10V$ (square wave) $t_r = t_f = 20 ns$					10					MHz

Electrical Characteristics CD4016C												
Symbol	Characteristic	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										
$P_T$	All Switches "OFF"	$V_{DD}$ 14    +10 $V_{SS}$ 7    GND $V_C$ 5, 6, 12, 13    GND $V_{is}$ 1, 4, 8, 11 $\leq +10$ $V_{os}$ 2, 3, 9, 10 $\leq +10$			5		0.1		5		80	$\mu W$
	All Switches "ON"	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 $\leq +10$			5		0.1		5		80	$\mu W$
$V_{THN}$	Threshold Voltage N-Channel	$I_{DS} = 10 \mu A$ $V_{DD} = 5V, 10V, \text{ or } 15V$		1.7			1.5			1.3		V
$V_{THP}$	P-Channel	$I_{DS} = 10 \mu A$ $V_{DD} = 5V, 10V, \text{ or } 15V$		-1.7			-1.5			-1.3		V

**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.

### Electrical Characteristics CD4016C (Continued)

Sym.	Characteristic	Test Conditions	Limits									Units
			-40°C			25°C			85°C			
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
<b>SIGNAL INPUTS (<math>V_{is}</math>) AND OUTPUTS (<math>V_{os}</math>)</b>												
$R_{ON}$	"ON" Resistance	$R_L = 10\text{ k}\Omega$	$V_C = V_{DD}$ $V_{SS}$ $V_{is}$									
			+7.5V -7.5V +7.5V	130	370		200	400		260	520	$\Omega$
			+7.5V -7.5V -7.5V	130	370		200	400		260	520	$\Omega$
			$\pm 0.25V$	160	790		280	850		400	1080	$\Omega$
			+5V -5V +5V	150	610		250	660		340	840	$\Omega$
			+5V -5V -5V	150	610		250	660		340	840	$\Omega$
$\Delta R_{ON}$	$\Delta$ "ON" Resistance Between Any 2 of 4 Switches	$R_L = 10\text{ k}\Omega$	+7.5V -7.5V $\pm 7.5V$				10				$\Omega$	
			+5V -5V $\pm 5V$				15				$\Omega$	
			+15V 0V +0.25V	130	370		200	400		260	520	$\Omega$
			+15V 0V +0.25V	130	370		200	400		260	520	$\Omega$
			+10V 0V +0.25V	150	610		250	660		340	840	$\Omega$
			+10V 0V +0.25V	150	610		250	660		340	840	$\Omega$
	Sine Wave Response (Distortion)	$R_L = 10\text{ k}\Omega$ $f_{is} = 1\text{ kHz}$ $V_C = V_{SS}$ $V_{DD}$	+5V -5V 5V(p-p)				0.4				%	
			$V_{is}$ (Note 3)									
	Input or Output Leakage-Switch "OFF" (Effective "OFF" Resistance)	$R_L = 1\text{ k}\Omega$ $V_{is} = 5V(p-p)$ $V_{DD} = +5V, V_C = V_{SS} = -5V$	+7.5V -7.5V +7.5V				$\pm 100$				pA	
			+5V -5V +5V				$\pm 100$ (Note 2)	125			nA	
	Frequency Response-Switch "ON" (Sine Wave Input)	$R_L = 1\text{ k}\Omega$ $V_{is} = 5V(p-p)$ $V_{DD} = +5V, V_C = V_{SS} = -5V$	$V_C = V_{DD} = +5V, V_{SS} = -5V$ $20\text{ Log}_{10} \frac{V_{os}}{V_{is}} = -3\text{ dB}$				40				MHz	
	Feedthrough Switch "OFF"		$20\text{ Log}_{10} \frac{V_{os}}{V_{is}} = -50\text{ dB}$				1.25				MHz	
	Crosstalk Between any 2 of the 4 switches (Frequency at -50 dB)	$R_L = 1\text{ k}\Omega$ $V_{is(A)} = 5V(p-p)$ $V_{is(B)} = 5V(p-p)$	$V_C(A) = V_{DD} = +5V$ $V_C(B) = V_{SS} = -5V$ $20\text{ Log}_{10} \frac{V_{os(B)}}{V_{is(A)}} = -50\text{ dB}$				0.9				MHz	
$C_{is}$ $C_{os}$ $C_{ios}$	Capacitance Input Output Feedthrough	$V_{DD} = -5V, V_C = V_{SS} = -5V$					4 4 0.2				pF	
$t_{pd}$	Propagation Delay Signal Input to Signal Output	$V_C = V_{DD} = +10V, V_{SS} = GND, C_L = 15\text{ pF}$ $V_{is} = 10V$ (square wave) $t_r = t_f = 20\text{ ns}$ (input Signal)					10				ns	
<b>CONTROL (<math>V_C</math>)</b>												
$V_{THC}$	Switch Threshold Voltage	$V_{is} \leq V_{CD}$	$V_{DD} - V_{SS} = 15V, 10V, 5V$ $I_{IS} = 10\text{ }\mu\text{A}$				0.5	1.5	2.7		V	
$I_C$	Input Current		$V_{DD} - V_{SS} = 10V$ $V_C \leq V_{DD} - V_{SS}$				$\pm 10$				pA	
$C_C$	Average Input Capacitance						5				pF	
	Crosstalk - Control Input to Signal Output	$V_{DD} - V_{SS} = 10V$ $V_C = 10V$ (square wave)	$R_L = 10\text{ k}\Omega$				50				mV	
$t_{pdC}$	Turn "ON" Propagation Delay	$t_{rc} = t_{fc} = 20\text{ ns}$	$V_{is} < 10V, C_L = 15\text{ pF}$				20				ns	

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.

## Electrical Characteristics CD4016C (Continued)

Sym.	Characteristic	Test Conditions	Limits									Units
			-40°C			25°C			85°C			
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
<b>CONTROL (V<sub>C</sub>) Continued</b>												
	Maximum Allowable Control Input Repetition Rate	V <sub>DD</sub> = 10V, V <sub>SS</sub> = GND, R <sub>L</sub> = 1 Ω C <sub>L</sub> = 15 pF V <sub>C</sub> = 10V (square wave) t <sub>r</sub> = t <sub>f</sub> = 20 ns						10				MHz

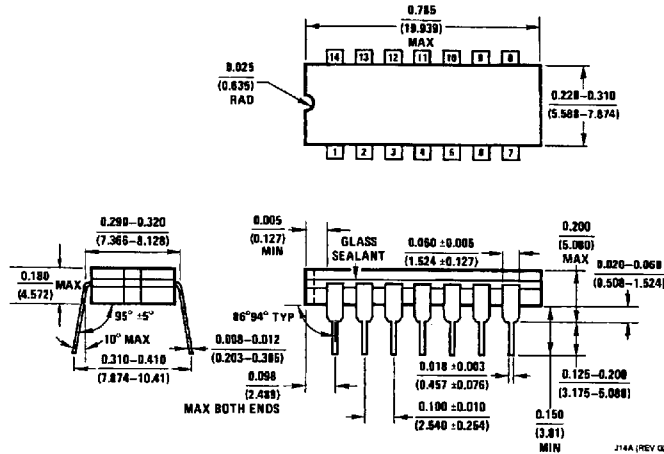
Note 1: The device should not be connected to circuits with the power on. Note 2:  $\pm 10 \times 10^{-3}$ . Note 3: Symmetrical about 0V.

## Typical ON Resistance Characteristics

Characteristic*	Supply Conditions		Load Conditions					
			R <sub>L</sub> = 1 kΩ		R <sub>L</sub> = 10 kΩ		R <sub>L</sub> = 100 kΩ	
			V <sub>DO</sub> (V)	V <sub>SS</sub> (V)	Value (Ω)	V <sub>IS</sub> (V)	Value (Ω)	V <sub>IS</sub> (V)
R <sub>ON</sub>	+15	0	200	+15	200	+15	180	+15
R <sub>ON(max)</sub>	+15	0	200	0	200	0	200	0
R <sub>ON</sub>	+15	0	300	+11	300	+9.3	320	+9.2
R <sub>ON(max)</sub>	+10	0	290	+10	250	+10	240	+10
R <sub>ON</sub>	+10	0	290	0	250	0	300	0
R <sub>ON(max)</sub>	+10	0	500	+7.4	560	+5.6	610	+5.5
R <sub>ON</sub>	+5	0	860	+5	470	+5	450	+5
R <sub>ON(max)</sub>	+5	0	600	0	580	0	800	0
R <sub>ON</sub>	+5	0	1.7k	+4.2	7k	+2.9	33k	+2.7
R <sub>ON</sub>	+7.5	-7.5	200	+7.5	200	+7.5	180	+7.5
R <sub>ON(max)</sub>	+7.5	-7.5	200	-7.5	200	-7.5	180	-7.5
R <sub>ON</sub>	+7.5	-7.5	290	±0.25	280	±25	400	±0.25
R <sub>ON</sub>	+5	-5	260	+5	250	+5	240	+5
R <sub>ON(max)</sub>	+5	-5	310	-5	250	-5	240	-5
R <sub>ON</sub>	+5	-5	600	±0.25	580	±0.25	760	±0.25
R <sub>ON</sub>	+2.5	-2.5	590	+2.5	450	+2.5	490	+2.5
R <sub>ON(max)</sub>	+2.5	-2.5	720	-2.5	520	-2.5	520	-2.5
R <sub>ON</sub>	+2.5	-2.5	232k	±0.25	300k	±0.25	870k	±0.25

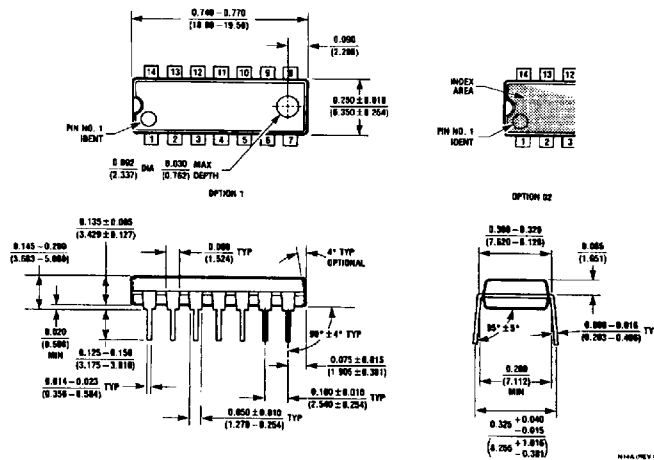
\*Variation from a perfect switch: R<sub>ON</sub> = 0Ω.

## Physical Dimensions inches (millimeters)

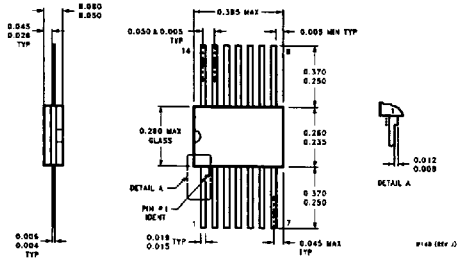


Dual-in-Line Package (J)  
Order Number CD4016MJ or CD4016CJ  
NS Package J14A

**Physical Dimensions** inches (millimeters) (Continued)



**Dual-In-Line Package (N)  
Order Number CD4016CN  
NS Package N14A**



**Dual-In-Line Package (W)  
Order Number CD4016MW  
NS Package W14B**

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