National Semiconductor

August 1989

CD4016BM/CD4016BC Quad Bilateral Switch

General Description

The CD4016BM/CD4016BC is a quad bilateral switch intended for the transmission or multiplexing of analog or digital signals. It is pin-for-pin compatible with CD4066BM/CD4066BC.

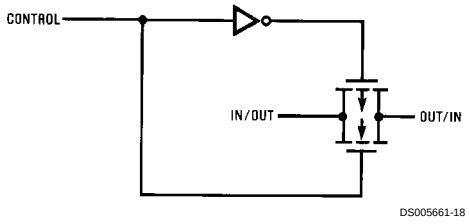
Features

- Wide supply voltage range: 3V to 15V
- Wide range of digital and analog switching: ±7.5 V_{PEAK}
- "ON" resistance for 15V operation: 400Ω (typ.)
- Matched "ON" resistance over 15V signal input: ΔR_{ON}=10Ω (typ.)
- High degree of linearity:
  - 0.4% distortion (typ.)
  - @ f_{IS} = 1 kHz, V_{IS}=5 V_{p-p},
  - V_{DD}–V_{SS}=10V, R_L=10 kΩ
- Extremely low "OFF" switch leakage:
  - 0.1 nA (typ.)
  - @ V_{DD} − V_{SS}=10V
  - T_A=25˚C
- Extremely high control input impedance: 10^{12}Ω (typ.)
- Low crosstalk between switches:
  - −50 dB (typ.)
  - @ f_{IS}=0.9 MHz, R_L= 1 kΩ
- Frequency response, switch "ON": 40 MHz (typ.)

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



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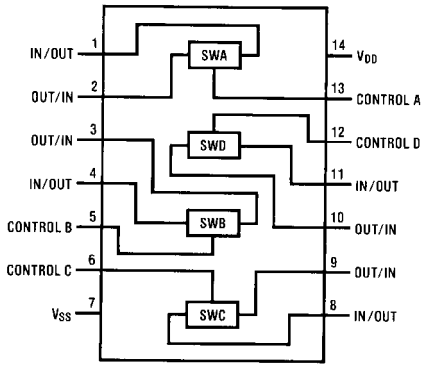
Dual-In-Line Package



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Order Number CD4016B

PrintDate=1997/06/27 PrintTime=11:31:00 12511 ds005661 Rev. No. 1 **Proof**

Absolute Maximum Ratings (Notes 1, 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

V_{DD} Supply Voltage	−0.5V to +18V
V_{IN} Input Voltage	−0.5V to V_{DD} + 0.5V
T_S Storage Temperature Range	−65˚C to + 150˚C
Power Dissipation (P_D)	
Dual-In-Line	700 mW
Small Outline	500 mW
Lead Temperature (Soldering, 10 seconds)	260˚C

Recommended Operating Conditions (Note 2)

V_{DD} Supply Voltage	3V to 15V
V_{IN} Input Voltage	0V to V_{DD}
T_A Operating Temperature Range	
CD4016BM	−55˚C to +125˚C
CD4016BC	−40˚C to +85˚C

DC Electrical Characteristics (Note 2)

CD4016BM

Symbol	Parameter	Conditions	−55˚C		25˚C			125˚C		Units
			Min	Max	Min	Typ	Max	Min	Max	
I_{DD}	Quiescent Device	V_{DD}=5V, V_{IN}=V_{DD} or V_{SS}		0.25		0.01	0.25		7.5	µA
	Current	V_{DD}=10V, V_{IN}=V_{DD} or V_{SS}		0.5		0.01	0.5		15	µA
		V_{DD}=15V, V_{IN}=V_{DD} or V_{SS}		1.0		0.01	1.0		30	µA
Signal Inputs and Outputs										
R_{ON}	"ON" Resistance	R_L=10kΩ to $\frac{V_{DD}-V_{SS}}{2}$								
		V_C=V_{DD}, V_{IS}=V_{SS} or V_{DD}								
		V_{DD}=10V		600		250	660		960	Ω
		V_{DD}=15V		360		200	400		600	Ω
		R_L=10kΩ to $\frac{V_{DD}-V_{SS}}{2}$								
		V_C=V_{DD}								
		V_{DD}=10V, V_{IS}=4.75 to 5.25V		1870		850	2000		2600	Ω
		V_{DD}=15V, V_{IS}=7.25 to 7.75V		775		400	850		1230	Ω
ΔR_{ON}	Δ"ON" Resistance	R_L=10kΩ to $\frac{V_{DD}-V_{SS}}{2}$								
	Between any 2 of	V_C=V_{DD}, V_{IS}=V_{SS} to V_{DD}								
	4 Switches	V_{DD}=10V				15				Ω
	(In Same Package)	V_{DD}=15V				10				Ω
I_{IS}	Input or Output	V_C=0, V_{DD}=15V		±50		±0.1	±50		±500	nA
	Leakage	V_{IS}=15V and 0V,								
	Switch "OFF"	V_{OS}=0V and 15V								
Control Inputs										
V_{ILC}	Low Level Input	V_{IS}=V_{SS} and V_{DD}								
	Voltage	V_{OS}=V_{DD} and V_{SS}								
		I_{IS}=±10 µA								
		V_{DD}=5V		0.9			0.7		0.5	V
		V_{DD}=10V		0.9			0.7		0.5	V
		V_{DD}=15V		0.9			0.7		0.5	V
V_{IHC}	High Level Input	V_{DD}=5V	3.5		3.5			3.5		V
	Voltage	V_{DD}=10V	7.0		7.0			7.0		V
		V_{DD}=15V	11.0		11.0			11.0		V
		(Note 6) and *Figure 8*								

DC Electrical Characteristics (Note 2) (Continued)

CD4016BM

Symbol	Parameter	Conditions	−55˚C		25˚C			125˚C		Units
			Min	Max	Min	Typ	Max	Min	Max	
Control Inputs										
I_{IN}	Input Current	$V_{DD}-V_{SS}=15V$ $V_{DD}\geq V_{IS}\geq V_{SS}$ $V_{DD}\geq V_C\geq V_{SS}$		±0.1		$\pm10^{-5}$	±0.1		±1.0	µA
I_{DD}	Quiescent Device Current	$V_{DD}=5V$, $V_{IN}=V_{DD}$ or V_{SS}		1.0		0.01	1.0		7.5	µA
		$V_{DD}=10V$, $V_{IN}=V_{DD}$ or V_{SS}		2.0		0.01	2.0		15	µA
		$V_{DD}=15V$, $V_{IN}=V_{DD}$ or V_{SS}		4.0		0.01	4.0		30	µA
Signal Inputs and Outputs										
R_{ON}	"ON" Resistance	$R_L=10k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$ $V_C=V_{DD}$, $V_{IS}=V_{SS}$ or V_{DD}								
		$V_{DD}=10V$		610		275	660		840	Ω
		$V_{DD}=15V$		370		200	400		520	Ω
		$R_L=10k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$ $V_C=V_{DD}$								
		$V_{DD}=10V$, $V_{IS}=4.75$ to $5.25V$		1900		850	2000		2380	Ω
		$V_{DD}=15V$, $V_{IS}=7.25$ to $7.75V$		790		400	850		1080	Ω
ΔR_{ON}	Δ"ON" Resistance	$R_L=10k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$								
	Between any 2 of 4 Switches (In Same Package)	$V_C=V_{DD}$, $V_{IS}=V_{SS}$ to V_{DD}								
		$V_{DD}=10V$				15				Ω
		$V_{DD}=15V$				10				Ω
I_{IS}	Input or Output Leakage Switch "OFF"	$V_C=0$, $V_{DD}=15V$ $V_{IS}=0V$ or $15V$, $V_{OS}=15V$ or $0V$		±50		±0.1	±50		±200	nA
Control Inputs										
V_{ILC}	Low Level Input Voltage	$V_{IS}=V_{SS}$ and V_{DD} $V_{OS}=V_{DD}$ and V_{SS} $I_{IS}=\pm10$ µA								
		$V_{DD}=5V$		0.9			0.7		0.4	V
		$V_{DD}=10V$		0.9			0.7		0.4	V
		$V_{DD}=15V$		0.9			0.7		0.4	V
V_{IHC}	High Level Input Voltage	$V_{DD}=5V$	3.5		3.5			3.5		V
		$V_{DD}=10V$	7.0		7.0			7.0		V
		$V_{DD}=15V$	11.0		11.0			11.0		V
		(Note 6) and *Figure 8*								
I_{IN}	Input Current	$V_{CC}-V_{SS}=15V$ $V_{DD}\geq V_{IS}\geq V_{SS}$ $V_{DD}\geq V_C\geq V_{SS}$		±0.3		$\pm10^{-5}$	±0.3		±1.0	µA

AC Electrical Characteristics (Note 7)

T_A=25˚C, t_r=t_f=20 ns and V_{SS}=0V unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{PHL}, t_{PLH}	Propagation Delay Time	V_C=V_{DD}, C_L=50 pF, (*Figure 1*)				
	Signal Input to Signal Output	R_L=200k				
		V_{DD}=5V		58	100	ns
		V_{DD}=10V		27	50	ns
		V_{DD}=15V		20	40	ns
t_{PZH}, t_{PZL}	Propagation Delay Time	R_L=1.0 kΩ, C_L=50 pF, (*Figures 2, 3*)				
	Control Input to Signal	V_{DD}=5V		20	50	ns
	Output High Impedance to	V_{DD}=10V		18	40	ns
	Logical Level	V_{DD}=15V		17	35	ns
t_{PHZ}, t_{PLZ}	Propagation Delay Time	R_L=1.0 kΩ, C_L=50 pF, (*Figures 2, 3*)				
	Control Input to Signal	V_{DD}=5V		15	40	ns
	Output Logical Level to	V_{DD}=10V		11	25	ns
	High Impedance	V_{DD}=15V		10	22	ns
	Sine Wave Distortion	V_C=V_{DD}=5V, V_{SS}=−5		0.4		%
		R_L=10 kΩ, V_{IS}=5 V_{P-P}, f=1 kHz, (*Figure 4*)				
	Frequency Response — Switch	V_C=V_{DD}=5V, V_{SS}=−5V,		40		MHz
	"ON" (Frequency at −3 dB)	R_L=1 kΩ, V_{IS}=5 V_{P-P}, 20 Log_{10} V_{OS}/V_{OS} (1 kHz) −dB, (*Figure 4*)				
	Feedthrough — Switch "OFF"	V_{DD}=5V, V_C=V_{SS}=−5V,		1.25		MHz
	(Frequency at −50 dB)	R_L=1 kΩ, V_{IS}=5 V_{P-P}, 20 Log_{10} (V_{OS}/V_{IS})=−50 dB, (*Figure 4*)				
	Crosstalk Between Any Two	V_{DD}=$V_{C(A)}$=5V; V_{SS}=$V_{C(B)}$=−5V,		0.9		MHz
	Switches (Frequency at −50 dB)	R_L=1 kΩ$V_{IS(A)}$=5 V_{P-P}, 20 Log_{10} ($V_{OS(B)}/V_{OS(A)}$)=−50 dB, (*Figure 5*)				
	Crosstalk; Control Input to	V_{DD}=10V, R_L=10 kΩ		150		mV_{P-P}
	Signal Output	R_{IN}=1 kΩ, V_{CC}=10V Square Wave, C_L=50 pF (*Figure 6*)				
	Maximum Control Input	R_L= 1 kΩ, C_L=50 pF, (*Figure 7*) $V_{OS(f)}$=½ V_{OS}(1 kHz)				
		V_{DD}=5V		6.5		MHz
		V_{DD}=10V		8.0		MHz
		V_{DD}=15V		9.0		MHz
C_{IS}	Signal Input Capacitance			4		pF
C_{OS}	Signal Output Capacitance	V_{DD}=10V		4		pF
C_{IOS}	Feedthrough Capacitance	V_C=0V		0.2		pF
C_{IN}	Control Input Capacitance			5	7.5	pF

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The tables of "Recommended Operating Conditions" and "Electrical Characteristics" provide conditions for actual device operation.

Note 2: V_{SS}=0V unless otherwise specified.

Note 3: These devices should not be connected to circuits with the power "ON".

Note 4: In all cases, there is approximately 5 pF of probe and jig capacitance on the output; however, this capacitance is included in C_L wherever it is specified.

Note 5: V_{IS} is the voltage at the in/out pin and V_{OS} is the voltage at the out/in pin. V_C is the voltage at the control input.

Note 6: If the switch input is held at V_{DD}, V_{IHC} is the control input level that will cause the switch output to meet the standard "B" series V_{OH} and I_{OH} output levels. If the analog switch input is connected to V_{SS}, V_{IHC} is the control input level — which allows the switch to sink standard "B" series $|I_{OH}|$, high level current, and still maintain a $V_{OL} \leq$ "B" series. These currents are shown in *Figure 8* .

Note 7: AC Paramters are guaranteed by DC correlated testing.

AC Test Circuits and Switching Time Waveforms

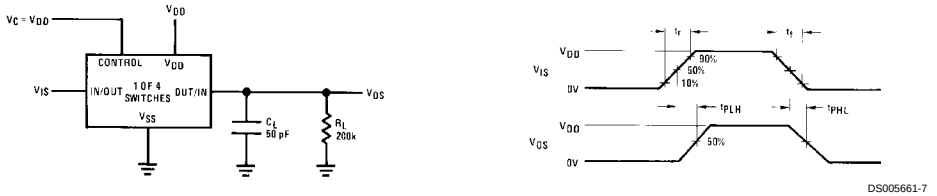

FIGURE 1. t_{PLH}, t_{PLH} Propagation Delay Time Control to Signal Output

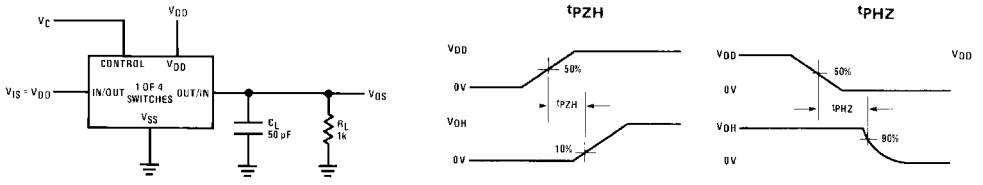

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FIGURE 2. t_{PZH}, t_{PHZ} Propagation Delay Time Control to Signal Output

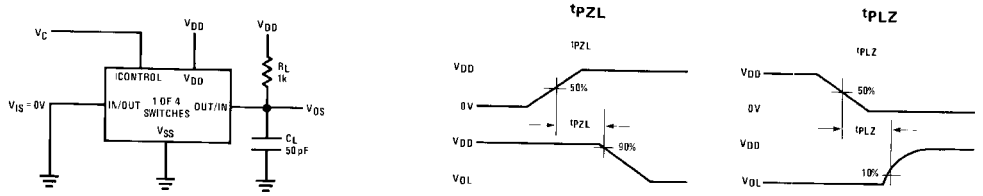

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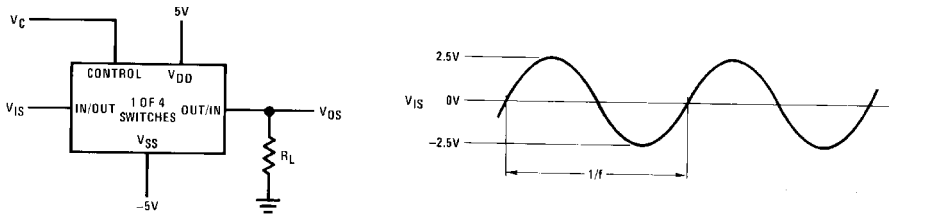
FIGURE 3. t_{PZH}, t_{PHZ} Propagation Delay Time Control to Signal Output



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V_C=V_{DD} for distortion and frequency response tests
V_C=V_{SS} for feedthrough test

FIGURE 4. Sine Wave Distortion, Frequency Response and Feedthrough

AC Test Circuits and Switching Time Waveforms (Continued)

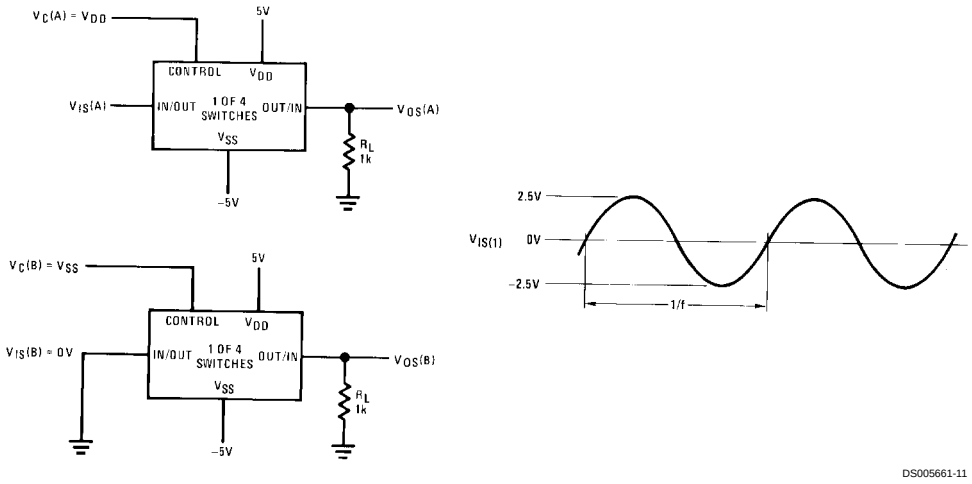


FIGURE 5. Crosstalk Between Any Two Switches

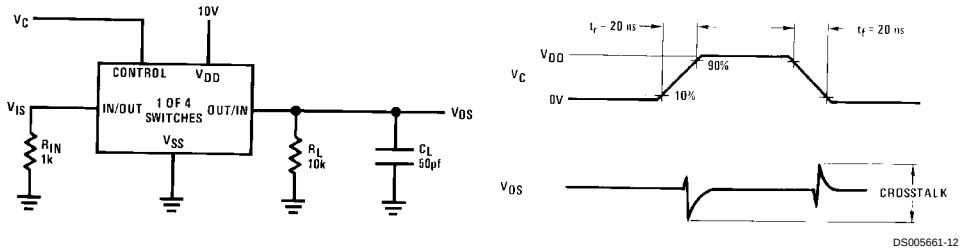


FIGURE 6. Crosstalk — Control to Input Signal Output

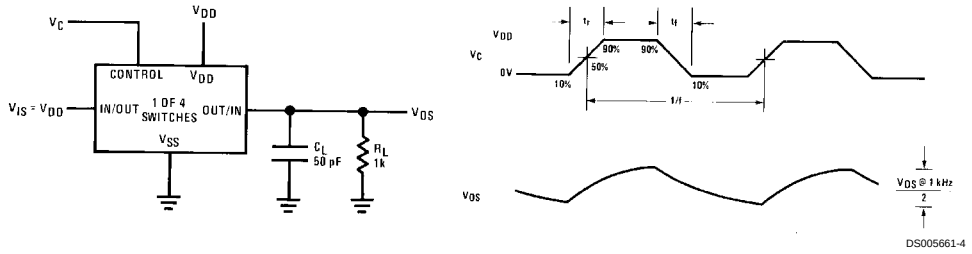


FIGURE 7. Maximum Control Input Frequency

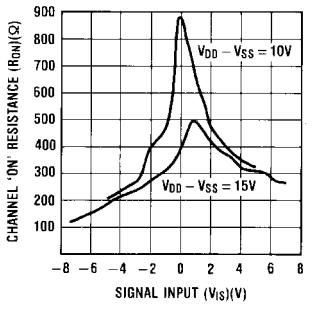
AC Test Circuits and Switching Time Waveforms (Continued)

Temperature Range	V_{DD}	Switch Input				Switch Output	
		V_{IS}	I_{IS} (mA)			V_{OS}(V)	
			T_{LOW}	25˚C	T_{HIGH}	Min	Max
MILITARY	5	0	0.25	0.2	0.14		0.4
	5	5	−0.25	−0.2	−0.14	4.6	
	10	0	0.62	0.5	0.35		0.5
	10	10	−0.62	−0.5	−0.35	9.5	
	15	0	1.8	1.5	1.1		1.5
	15	15	−1.8	−1.5	−1.1	13.5	
COMMERCIAL	5	0	0.2	0.16	0.12		0.4
	5	5	−0.2	−0.16	−0.12	4.6	
	10	0	0.5	0.4	0.3		0.5
	10	10	−0.5	−0.4	−0.3	9.5	
	15	0	1.4	1.2	1.0		1.5
	15	15	−1.4	−1.2	−1.0	13.5	

FIGURE 8. CD4016B Switch Test Conditions for V_{IHC}

Typical Performance Characteristics

"ON' Resistance vs. Signal Voltage T_A=25˚C



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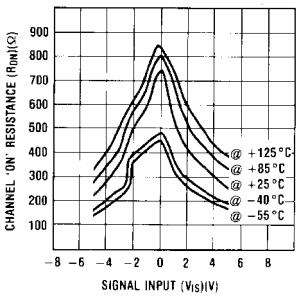
"ON' Resistance Temperature Variation for V_{DD}−V_{SS}=10V



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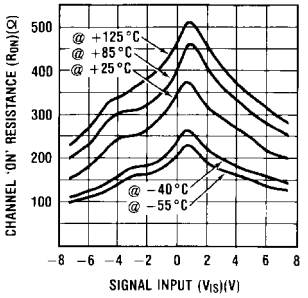
"ON' Resistance Temperature Variation for V_{DD}−V_{SS}=15V



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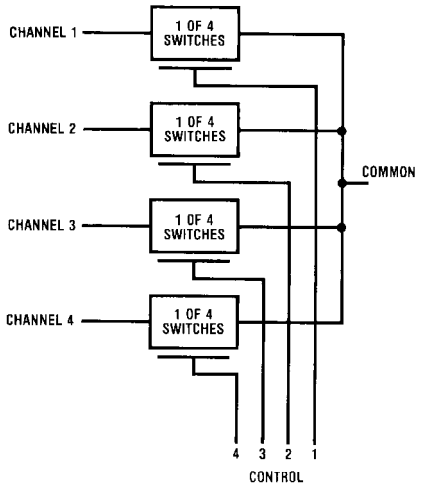
Typical Applications

4 Input Multiplexer



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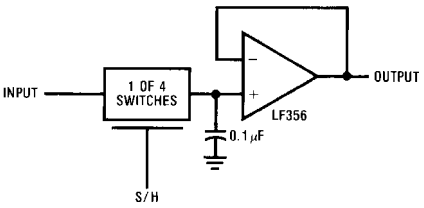
Sample/Hold Amplifier



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Special Considerations

The CD4016B is composed of 4, two-transistor analog switches. These switches do not have any linearization or compensation circuitry for "R_{ON}" as do the CD4066B's. Because of this, the special operating considerations for the CD4066B do not apply to the CD4016B, but at low supply voltages, ≤5V, the CD4016B's on resistance becomes non-linear. It is recommended that at 5V, voltages on the in/out pins be maintained within about 1V of either V_{DD} or V_{SS}; and that at 3V the voltages on the in/out pins should be at V_{DD} or V_{SS} for reliable operation.

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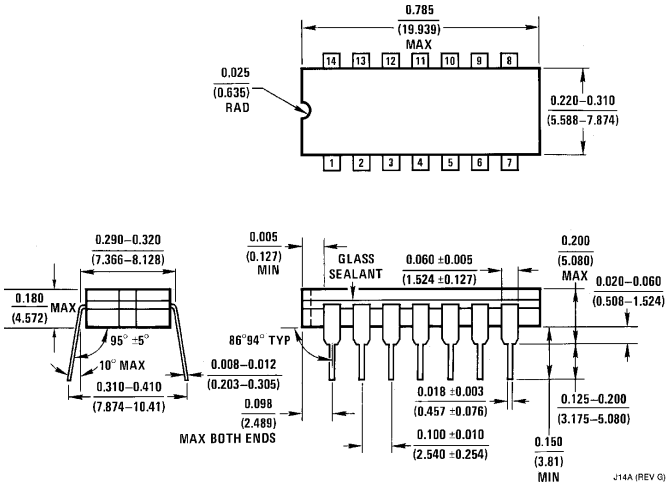
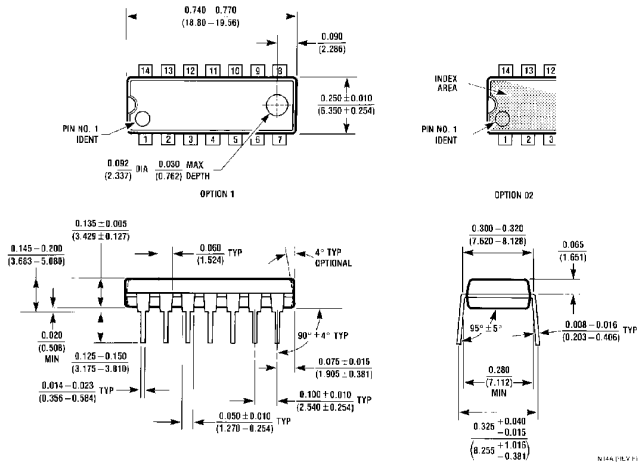
Physical Dimensions inches (millimeters) unless otherwise noted



Dual-In-Line Package
Order Number CD4016CJ or CD4016MJ
NS Package J14A



Dual-In-Line Package
Order Number CD4016CN
NS Package N14A

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National Semiconductor Corporation
Americas
Tel: 1-800-272-9959
Fax: 1-800-737-7018
Email: support@nsc.com

www.national.com

National Semiconductor Europe
Fax: +49 (0) 1 80-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 1 80-530 85 85
English Tel: +49 (0) 1 80-532 78 32
Français Tel: +49 (0) 1 80-532 93 58
Italiano Tel: +49 (0) 1 80-534 16 80

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductor Japan Ltd.
Tel: 81-3-5620-6175
Fax: 81-3-5620-6179

PrintDate=1997/06/27 PrintTime=11:31:11 12511 ds005661 Rev. No. 1 **Proof**

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