National Semiconductor

June 1992

# CD4066BM/CD4066BC Quad Bilateral Switch

## General Description

The CD4066BM/CD4066BC is a quad bilateral switch intended for the transmission or multiplexing of analog or digital signals. It is pin-for-pin compatible with CD4016BM/CD4016BC, but has a much lower "ON" resistance, and "ON" resistance is relatively constant over the input-signal range.

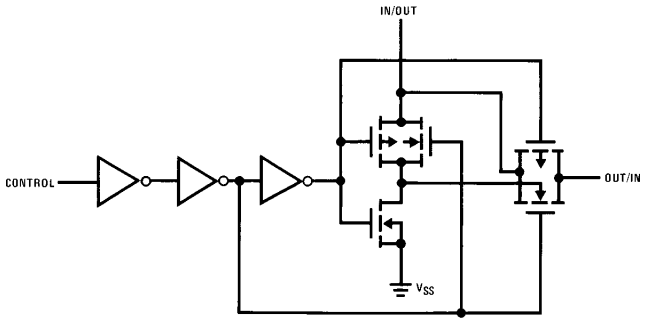
## Features

- Wide supply voltage range — 3V to 15V
- High noise immunity — 0.45 $V_{DD}$ (typ.)
- Wide range of digital and analog switching — $\pm 7.5$ $V_{PEAK}$
- "ON" resistance for 15V operation — 80Ω
- Matched "ON" resistance over 15V signal input — $\Delta R_{ON} = 5\Omega$ (typ.)
- "ON" resistance flat over peak-to-peak signal range
- High "ON"/"OFF" output voltage ratio — 65 dB (typ.) @ $f_{is} = 10$ kHz, $R_L = 10$ kΩ
- High degree linearity — 0.1% distortion (typ.) @ $f_{is} = 1$ kHz, $V_{is} = 5V_{p-p}$, $V_{DD} - V_{SS} = 10V$, $R_L = 10$ kΩ
- Extremely low "OFF" switch leakage — 0.1 nA (typ.) @ $V_{DD} - V_{SS} = 10V$, $T_A = 25°C$
- Extremely high control input impedance — $10^{12}\Omega$ (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

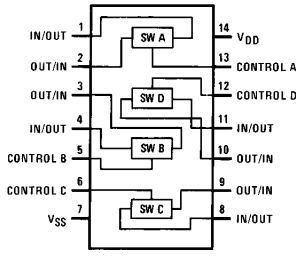
- Analog signal switching/multiplexing
  - Signal gating
  - Squelch control
  - Chopper
  - Modulator/Demodulator
  - Commutating switch
- Digital signal switching/multiplexing
- CMOS logic implementation
- Analog-to-digital/digital-to-analog conversion
- Digital control of frequency, impedance, phase, and analog-signal-gain

## Schematic and Connection Diagrams




**Order Number CD4066B**

**Dual-In-Line Package**

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**Top View**

 

RRD-B30M105/Printed in U. S. A.

## 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.**

| | |
|---|---|
| Supply Voltage ($V_{DD}$) | −0.5V to +18V |
| Input Voltage ($V_{IN}$) | −0.5V to $V_{DD}$ +0.5V |
| Storage Temperature Range ($T_S$) | −65°C to +150°C |
| Power Dissipation ($P_D$) | |
| Dual-In-Line | 700 mW |
| Small Outline | 500 mW |
| Lead Temperature ($T_L$) (Soldering, 10 seconds) | 300°C |

## Recommended Operating Conditions (Note 2)

| | |
|---|---|
| Supply Voltage ($V_{DD}$) | 3V to 15V |
| Input Voltage ($V_{IN}$) | 0V to $V_{DD}$ |
| Operating Temperature Range ($T_A$) | |
| CD4066BM | −55°C to +125°C |
| CD4066BC | −40°C to +85°C |

## DC Electrical Characteristics CD4066BM (Note 2)

| Symbol | Parameter | Conditions | −55°C | | +25°C | | | +125°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Typ | Max | Min | Max | |
| $I_{DD}$ | Quiescent Device Current | $V_{DD}=5V$ | | 0.25 | | 0.01 | 0.25 | | 7.5 | μA |
| | | $V_{DD}=10V$ | | 0.5 | | 0.01 | 0.5 | | 15 | μA |
| | | $V_{DD}=15V$ | | 1.0 | | 0.01 | 1.0 | | 30 | μA |
| **SIGNAL INPUTS AND OUTPUTS** | | | | | | | | | | |
| $R_{ON}$ | "ON" Resistance | $R_L=10\ k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$ | | | | | | | | |
| | | $V_C=V_{DD}$, $V_{IS}=V_{SS}$ to $V_{DD}$ | | | | | | | | |
| | | $V_{DD}=5V$ | | 800 | | 270 | 1050 | | 1300 | Ω |
| | | $V_{DD}=10V$ | | 310 | | 120 | 400 | | 550 | Ω |
| | | $V_{DD}=15V$ | | 200 | | 80 | 240 | | 320 | Ω |
| $\Delta R_{ON}$ | Δ"ON" Resistance Between any 2 of 4 Switches | $R_L=10\ k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$ | | | | | | | | |
| | | $V_C=V_{DD}$, $V_{IS}=V_{SS}$ to $V_{DD}$ | | | | | | | | |
| | | $V_{DD}=10V$ | | | | 10 | | | | Ω |
| | | $V_{DD}=15V$ | | | | 5 | | | | Ω |
| $I_{IS}$ | Input or Output Leakage Switch "OFF" | $V_C=0$ | | ±50 | | ±0.1 | ±50 | | ±500 | nA |
| | | $V_{IS}=15V$ and 0V, | | | | | | | | |
| | | $V_{OS}=0V$ and 15V | | | | | | | | |
| **CONTROL INPUTS** | | | | | | | | | | |
| $V_{ILC}$ | Low Level Input Voltage | $V_{IS}=V_{SS}$ and $V_{DD}$ | | | | | | | | |
| | | $V_{OS}=V_{DD}$ and $V_{SS}$ | | | | | | | | |
| | | $I_{IS}=\pm 10\ \mu A$ | | | | | | | | |
| | | $V_{DD}=5V$ | | 1.5 | | 2.25 | 1.5 | | 1.5 | V |
| | | $V_{DD}=10V$ | | 3.0 | | 4.5 | 3.0 | | 3.0 | V |
| | | $V_{DD}=15V$ | | 4.0 | | 6.75 | 4.0 | | 4.0 | V |
| $V_{IHC}$ | High Level Input Voltage | $V_{DD}=5V$ | 3.5 | | 3.5 | 2.75 | | 3.5 | | V |
| | | $V_{DD}=10V$ (see note 6) | 7.0 | | 7.0 | 5.5 | | 7.0 | | V |
| | | $V_{DD}=15V$ | 11.0 | | 11.0 | 8.25 | | 11.0 | | V |
| $I_{IN}$ | Input Current | $V_{DD}-V_{SS}=15V$ | | ±0.1 | | $\pm 10^{-5}$ | ±0.1 | | ±1.0 | μA |
| | | $V_{DD} \geq V_{IS} \geq V_{SS}$ | | | | | | | | |
| | | $V_{DD} \geq V_C \geq V_{SS}$ | | | | | | | | |

## DC Electrical Characteristics CD4066BC (Note 2)

| Symbol | Parameter | Conditions | −40°C | | +25°C | | | +85°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Typ | Max | Min | Max | |
| $I_{DD}$ | Quiescent Device Current | $V_{DD}=5V$ | | 1.0 | | 0.01 | 1.0 | | 7.5 | μA |
| | | $V_{DD}=10V$ | | 2.0 | | 0.01 | 2.0 | | 15 | μA |
| | | $V_{DD}=15V$ | | 4.0 | | 0.01 | 4.0 | | 30 | μA |

## DC Electrical Characteristics (Continued) CD4066BC (Note 2)

| Symbol | Parameter | Conditions | −40°C | | +25°C | | | +85°C | | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Min | Typ | Max | Min | Max | |
| **SIGNAL INPUTS AND OUTPUTS** | | | | | | | | | | |
| $R_{ON}$ | "ON" Resistance | $R_L = 10\ k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$<br>$V_C = V_{DD}$, $V_{SS}$ to $V_{DD}$ | | | | | | | | |
| | | $V_{DD} = 5V$ | | 850 | | 270 | 1050 | | 1200 | Ω |
| | | $V_{DD} = 10V$ | | 330 | | 120 | 400 | | 520 | Ω |
| | | $V_{DD} = 15V$ | | 210 | | 80 | 240 | | 300 | Ω |
| $\Delta R_{ON}$ | Δ"ON" Resistance Between Any 2 of 4 Switches | $R_L = 10\ k\Omega$ to $\frac{V_{DD}-V_{SS}}{2}$<br>$V_{CC} = V_{DD}$, $V_{IS} = V_{SS}$ to $V_{DD}$ | | | | | | | | |
| | | $V_{DD} = 10V$ | | | | 10 | | | | Ω |
| | | $V_{DD} = 15V$ | | | | 5 | | | | Ω |
| $I_{IS}$ | Input or Output Leakage Switch "OFF" | $V_C = 0$ | | ±50 | | ±0.1 | ±50 | | ±200 | nA |
| **CONTROL INPUTS** | | | | | | | | | | |
| $V_{ILC}$ | Low Level Input Voltage | $V_{IS} = V_{SS}$ and $V_{DD}$<br>$V_{OS} = V_{DD}$ and $V_{SS}$<br>$I_{IS} = \pm 10\mu A$ | | | | | | | | |
| | | $V_{DD} = 5V$ | | 1.5 | | 2.25 | 1.5 | | 1.5 | V |
| | | $V_{DD} = 10V$ | | 3.0 | | 4.5 | 3.0 | | 3.0 | V |
| | | $V_{DD} = 15V$ | | 4.0 | | 6.75 | 4.0 | | 4.0 | V |
| $V_{IHC}$ | High Level Input Voltage | $V_{DD} = 5V$ | 3.5 | | 3.5 | 2.75 | | 3.5 | | V |
| | | $V_{DD} = 10V$ (See note 6) | 7.0 | | 7.0 | 5.5 | | 7.0 | | V |
| | | $V_{DD} = 15V$ | 11.0 | | 11.0 | 8.25 | | 11.0 | | V |
| $I_{IN}$ | Input Current | $V_{DD} - V_{SS} = 15V$<br>$V_{DD} \geq V_{IS} \geq V_{SS}$<br>$V_{DD} \geq V_C \geq V_{SS}$ | | ±0.3 | | $\pm 10^{-5}$ | ±0.3 | | ±1.0 | μA |

## AC Electrical Characteristics* $T_A = 25°C$, $t_r = t_f = 20$ ns and $V_{SS} = 0V$ unless otherwise noted

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $t_{PHL}$, $t_{PLH}$ | Propagation Delay Time Signal Input to Signal Output | $V_C = V_{DD}$, $C_L = 50$ pF, (*Figure 1*)<br>$R_L = 200k$ | | | | |
| | | $V_{DD} = 5V$ | | 25 | 55 | ns |
| | | $V_{DD} = 10V$ | | 15 | 35 | ns |
| | | $V_{DD} = 15V$ | | 10 | 25 | ns |
| $t_{PZH}$, $t_{PZL}$ | Propagation Delay Time Control Input to Signal Output High Impedance to Logical Level | $R_L = 1.0\ k\Omega$, $C_L = 50$ pF, (*Figures 2* and *3*) | | | | |
| | | $V_{DD} = 5V$ | | | 125 | ns |
| | | $V_{DD} = 10V$ | | | 60 | ns |
| | | $V_{DD} = 15V$ | | | 50 | ns |
| $t_{PHZ}$, $t_{PLZ}$ | Propagation Delay Time Control Input to Signal Output Logical Level to High Impedance | $R_L = 1.0\ k\Omega$, $C_L = 50$ pF, (*Figures 2* and *3*) | | | | |
| | | $V_{DD} = 5V$ | | | 125 | ns |
| | | $V_{DD} = 10V$ | | | 60 | ns |
| | | $V_{DD} = 15V$ | | | 50 | ns |
| | Sine Wave Distortion | $V_C = V_{DD} = 5V$, $V_{SS} = -5V$<br>$R_L = 10\ k\Omega$, $V_{IS} = 5V_{p\text{-}p}$, f = 1 kHz, (*Figure 4*) | | 0.1 | | % |
| | Frequency Response-Switch "ON" (Frequency at −3 dB) | $V_C = V_{DD} = 5V$, $V_{SS} = -5V$,<br>$R_L = 1\ k\Omega$, $V_{IS} = 5V_{p\text{-}p}$,<br>20 $\text{Log}_{10}\ V_{OS}/V_{OS}$ (1 kHz) − dB,<br>(*Figure 4*) | | 40 | | MHz |

## AC Electrical Characteristics* (Continued) $T_A = 25°C$, $t_r = t_f = 20$ ns and $V_{SS} = 0V$ unless otherwise noted

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| | Feedthrough — Switch "OFF" (Frequency at −50 dB) | $V_{DD} = 5.0V$, $V_{CC} = V_{SS} = -5.0V$, $R_L = 1\ k\Omega$, $V_{IS} = 5.0V_{p-p}$, 20 $Log_{10}$, $V_{OS}/V_{IS} = -50$ dB, *(Figure 4)* | | 1.25 | | |
| | Crosstalk Between Any Two Switches (Frequency at −50 dB) | $V_{DD} = V_{C(A)} = 5.0V$; $V_{SS} = V_{C(B)} = 5.0V$, $R_L 1\ k\Omega$, $V_{IS(A)} = 5.0\ V_{p-p}$, 20 $Log_{10}$, $V_{OS(B)}/V_{IS(A)} = -50$ dB *(Figure 5)* | | 0.9 | | MHz |
| | Crosstalk; Control Input to Signal Output | $V_{DD} = 10V$, $R_L = 10\ k\Omega$, $R_{IN} = 1.0\ k\Omega$, $V_{CC} = 10V$ Square Wave, $C_L = 50$ pF *(Figure 6)* | | 150 | | $mV_{p-p}$ |
| | Maximum Control Input | $R_L = 1.0\ k\Omega$, $C_L = 50$ pF, *(Figure 7)* $V_{OS(f)} = ½\ V_{OS}$(1.0 kHz) | | | | |
| | | $V_{DD} = 5.0V$ | | 6.0 | | MHz |
| | | $V_{DD} = 10V$ | | 8.0 | | MHz |
| | | $V_{DD} = 15V$ | | 8.5 | | MHz |
| $C_{IS}$ | Signal Input Capacitance | | | 8.0 | | pF |
| $C_{OS}$ | Signal Output Capacitance | $V_{DD} = 10V$ | | 8.0 | | pF |
| $C_{IOS}$ | Feedthrough Capacitance | $V_C = 0V$ | | 0.5 | | pF |
| $C_{IN}$ | Control Input Capacitance | | | 5.0 | 7.5 | pF |

*AC Parameters are guaranteed by DC correlated testing.

**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 in 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:** Conditions for $V_{IHC}$: a) $V_{IS} = V_{DD}$, $I_{OS}$ = standard B series $I_{OH}$ b) $V_{IS} = 0V$, $I_{OL}$ = standard B series $I_{OL}$.

## AC Test Circuits and Switching Time Waveforms

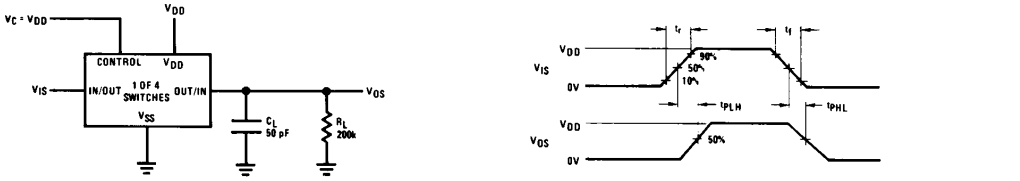


**FIGURE 1. $t_{PHL}$, $t_{PLH}$ Propagation Delay Time Signal Input to Signal Output**

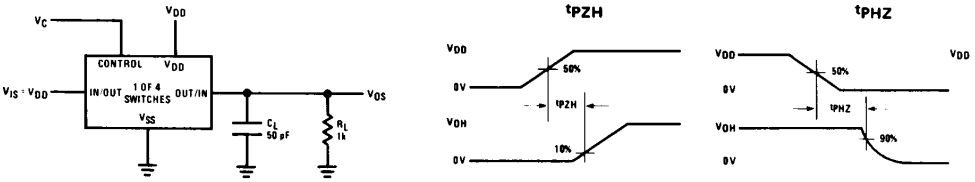


**FIGURE 2. $t_{PZH}$, $t_{PHZ}$ Propagation Delay Time Control to Signal Output**

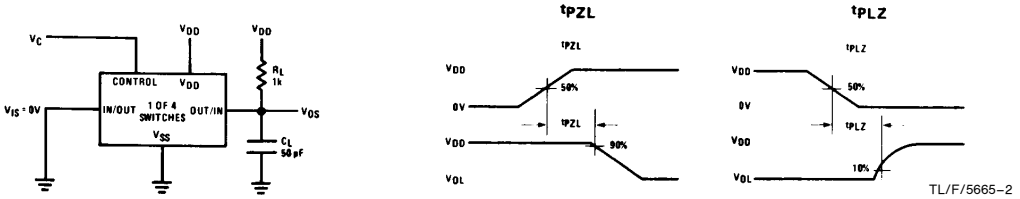


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**FIGURE 3. $t_{PZL}$, $t_{PLZ}$ Propagtion Delay Time Control to Signal Output**

## AC Test Circuits and Switching Time Waveforms (Continued)

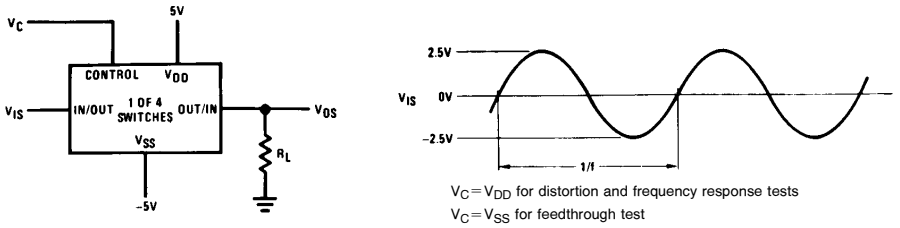


**FIGURE 4. Sine Wave Distortion, Frequency Response and Feedthrough**

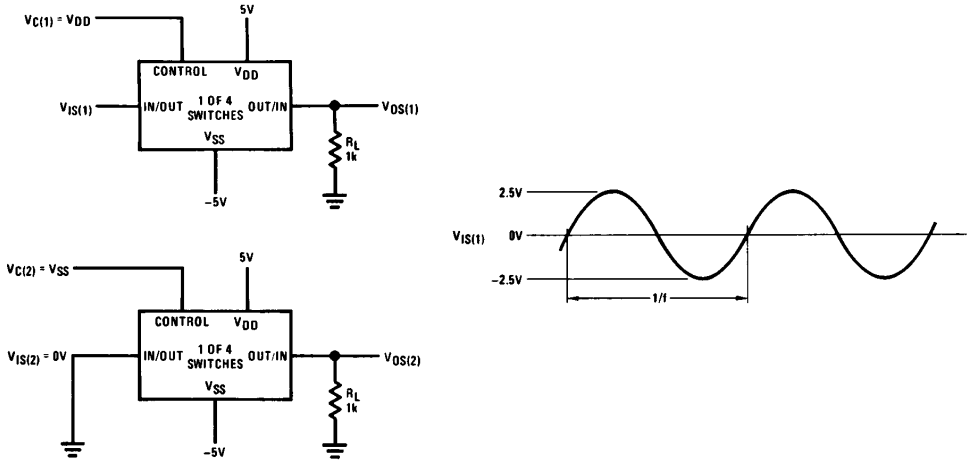


**FIGURE 5. Crosstalk Between Any Two Switches**

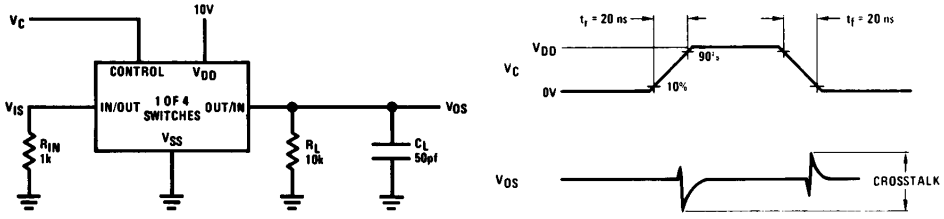


**FIGURE 6. Crosstalk: Control Input to Signal Output**

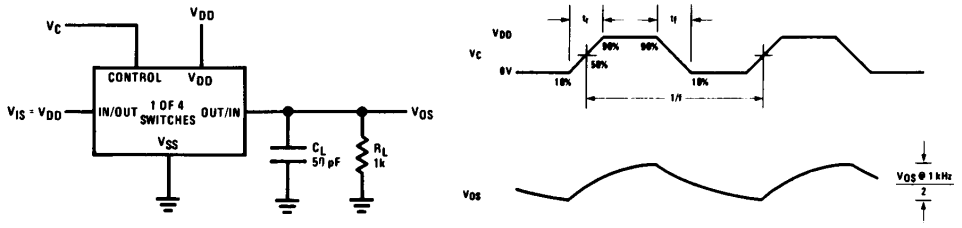


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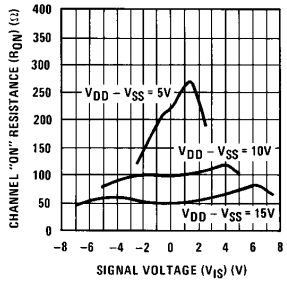
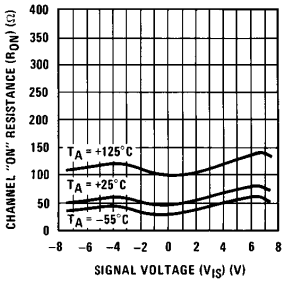
**FIGURE 7. Maximum Control Input Frequency**

## Typical Performance Characteristics

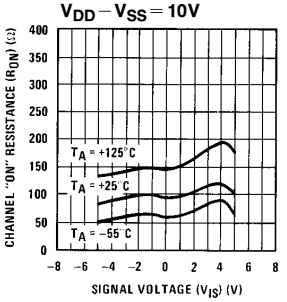
**"ON" Resistance vs Signal Voltage for $T_A = 25°C$**



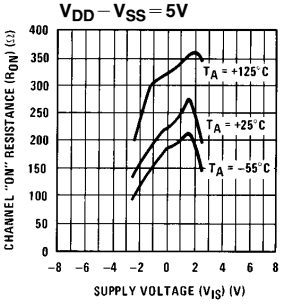

**"ON" Resistance as a Function of Temperature for $V_{DD} - V_{SS} = 15V$**




**"ON" Resistance as a Function of Temperature for $V_{DD} - V_{SS} = 10V$**




**"ON" Resistance as a Function of Temperature for $V_{DD} - V_{SS} = 5V$**

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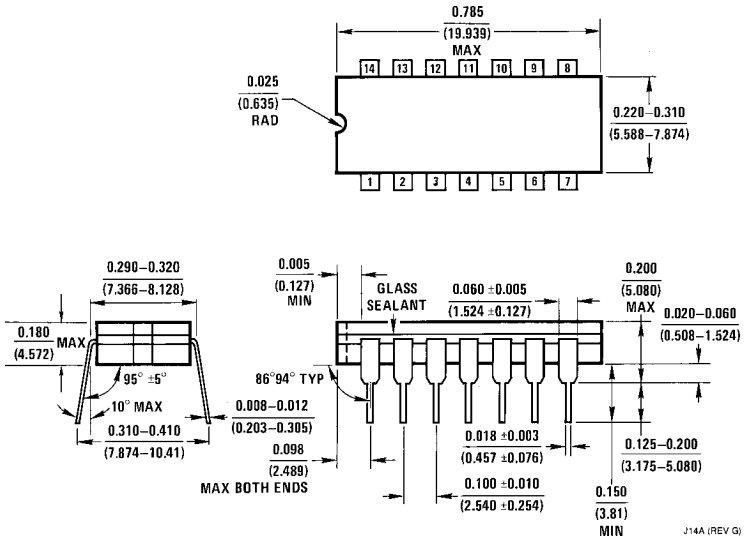
## Special Considerations

In applications where separate power sources are used to drive $V_{DD}$ and the signal input, the $V_{DD}$ current capability should exceed $V_{DD}/R_L$ ($R_L$ = effective external load of the 4 CD4066BM/CD4066BC bilateral switches). This provision avoids any permanent current flow or clamp action of the $V_{DD}$ supply when power is applied or removed from CD4066BM/CD4066BC.

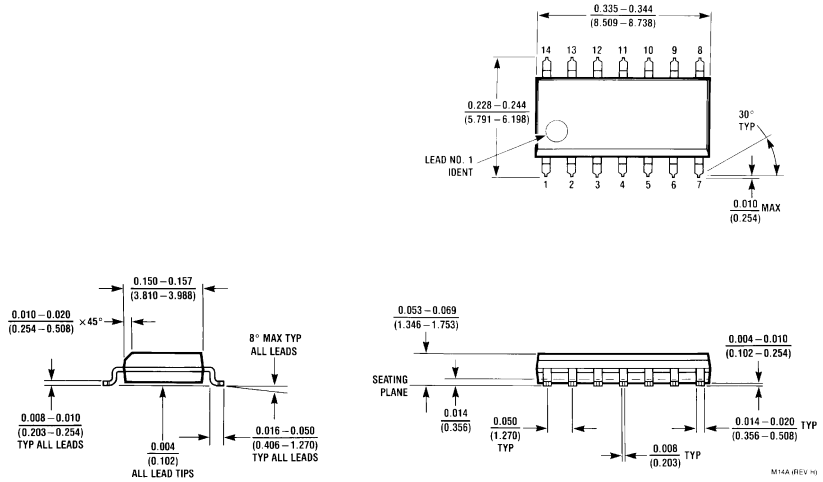
In certain applications, the external load-resistor current may include both $V_{DD}$ and signal-line components. To avoid drawing $V_{DD}$ current when switch current flows into terminals 1, 4, 8 or 11, the voltage drop across the bidirectional switch must not exceed 0.6V at $T_A \leq 25°C$, or 0.4V at $T_A > 25°C$ (calculated from $R_{ON}$ values shown).

No $V_{DD}$ current will flow through $R_L$ if the switch current flows into terminals 2, 3, 9 or 10.

## Physical Dimensions inches (millimeters)

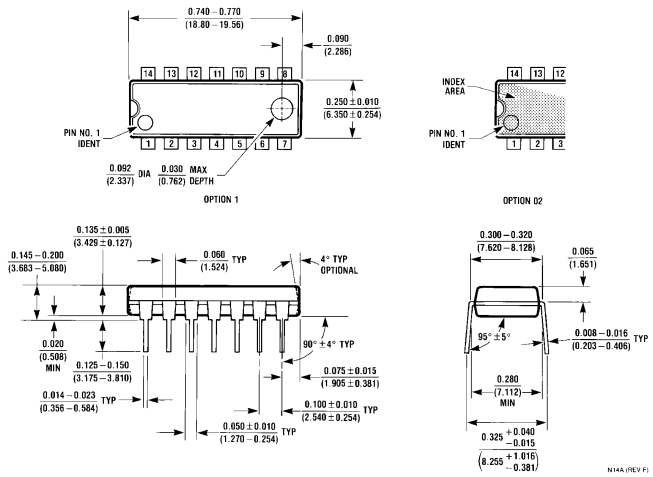



**Cerdip (J)**
**Order Number CD4066BMJ or CD4066BCJ**
**NS Package Number J14A**




**S.O. Package (M)**
**Order Number CD4066BCM**
**NS Package Number M14A**

## Physical Dimensions inches (millimeters) (Continued)




**Dual-In-Line Package (N)**
**Order Number CD4066BMN or CD4066BCN**
**NS Package Number N14A**

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