**N** *National Semiconductor*

# CD4047BM/CD4047BC Low Power Monostable/Astable Multivibrator

## General Description

CD4047B is capable of operating in either the monostable or astable mode. It requires an external capacitor (between pins 1 and 3) and an external resistor (between pins 2 and 3) to determine the output pulse width in the monostable mode, and the output frequency in the astable mode.

Astable operation is enabled by a high level on the astable input or low level on the astable input. The output frequency (at 50% duty cycle) at Q and $\overline{Q}$ outputs is determined by the timing components. A frequency twice that of Q is available at the Oscillator Output; a 50% duty cycle is not guaranteed.

Monostable operation is obtained when the device is triggered by low-to-high transition at $+$ trigger input or high-to-low transition at $-$ trigger input. The device can be retriggered by applying a simultaneous low-to-high transition to both the $+$ trigger and retrigger inputs.

A high level on Reset input resets the outputs Q to low, $\overline{Q}$ to high.

## Features

- Wide supply voltage range     3.0V to 15V
- High noise immunity     0.45 $V_{DD}$ (typ.)
- Low power TTL     Fan out of 2 driving 74L
  compatibility     or 1 driving 74LS

### SPECIAL FEATURES

- Low power consumption: special CMOS oscillator configuration
- Monostable (one-shot) or astable (free-running) operation
- True and complemented buffered outputs
- Only one external R and C required

## MONOSTABLE MULTIVIBRATOR FEATURES

- Positive- or negative-edge trigger
- Output pulse width independent of trigger pulse duration
- Retriggerable option for pulse width expansion
- Long pulse widths possible using small RC components by means of external counter provision
- Fast recovery time essentially independent of pulse width
- Pulse-width accuracy maintained at duty cycles approaching 100%

## ASTABLE MULTIVIBRATOR FEATURES

- Free-running or gatable operating modes
- 50% duty cycle
- Oscillator output available
- Good astable frequency stability
  typical     $= \pm 2\% + 0.03\%/°C$ @ 100 kHz
  frequency     $= \pm 0.5\% + 0.015\%/°C$ @ 10 kHz
  deviation     (circuits trimmed to frequency
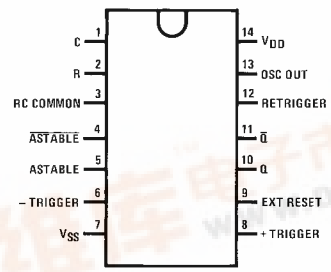      $V_{DD} = 10V \pm 10\%$)

## Applications

- Frequency discriminators
- Timing circuits
- Time-delay applications
- Envelope detection
- Frequency multiplication
- Frequency division

## Block and Connection Diagrams
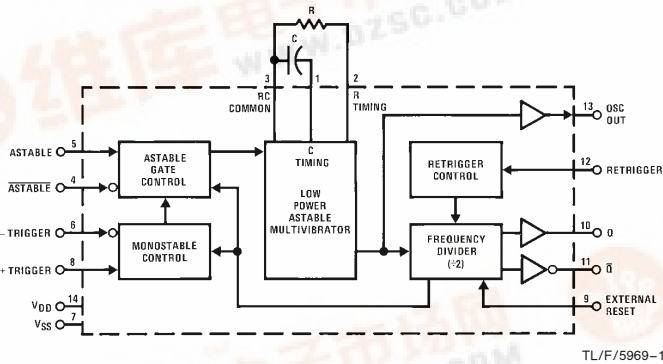


TL/F/5969–1

**Dual-In-Line Package**



TL/F/5969–2

**Top View**

**Order Number CD4047B**

## Absolute Maximum Ratings (Notes 1 and 2)

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

| | |
|---|---|
| DC Supply Voltage ($V_{DD}$) | $-0.5V$ to $+18V_{DC}$ |
| Input Voltage ($V_{IN}$) | $-0.5V$ to $V_{DD} +0.5V_{DC}$ |
| 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) | 260°C |

## Recommended Operating Conditions (Note 2)

| | |
|---|---|
| DC Supply Voltage ($V_{DD}$) | 3V to 15$V_{DC}$ |
| Input Voltage ($V_{IN}$) | 0 to $V_{DD}$ $V_{DC}$ |
| Operating Temperature Range ($T_A$) | |
| CD4047BM | $-55°C$ to $+125°C$ |
| CD4047BC | $-40°C$ to $+85°C$ |

## DC Electrical Characteristics CD4047BM (Note 2)

| Symbol | Parameter | Conditions | −55°C Min | −55°C Max | 25°C Min | 25°C Typ | 25°C Max | 125°C Min | 125°C Max | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| $I_{DD}$ | Quiescent Device Current | $V_{DD} = 5V$ | | 5 | | | 5 | | 150 | $\mu$A |
| | | $V_{DD} = 10V$ | | 10 | | | 10 | | 300 | $\mu$A |
| | | $V_{DD} = 15V$ | | 20 | | | 20 | | 600 | $\mu$A |
| $V_{OL}$ | Low Level Output Voltage | $\|I_O\| < 1\ \mu$A | | | | | | | | |
| | | $V_{DD} = 5V$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| | | $V_{DD} = 10V$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| | | $V_{DD} = 15V$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| $V_{OH}$ | High Level Output Voltage | $\|I_O\| < 1\ \mu$A | | | | | | | | |
| | | $V_{DD} = 5V$ | 4.95 | | 4.95 | 5 | | 4.95 | | V |
| | | $V_{DD} = 10V$ | 9.95 | | 9.95 | 10 | | 9.95 | | V |
| | | $V_{DD} = 15V$ | 14.95 | | 14.95 | 15 | | 14.95 | | V |
| $V_{IL}$ | Low Level Input Voltage | $V_{DD} = 5V, V_O = 0.5V$ or $4.5V$ | | 1.5 | | 2.25 | 1.5 | | 1.5 | V |
| | | $V_{DD} = 10V, V_O = 1V$ or $9V$ | | 3.0 | | 4.5 | 3.0 | | 3.0 | V |
| | | $V_{DD} = 15V, V_O = 1.5V$ or $13.5V$ | | 4.0 | | 6.75 | 4.0 | | 4.0 | V |
| $V_{IH}$ | High Level Input Voltage | $V_{DD} = 5V, V_O = 0.5V$ or $4.5V$ | 3.5 | | 3.5 | 2.75 | | 3.5 | | V |
| | | $V_{DD} = 10V, V_O = 1V$ or $9V$ | 7.0 | | 7.0 | 5.5 | | 7.0 | | V |
| | | $V_{DD} = 15V, V_O = 1.5V$ or $13.5V$ | 11.0 | | 11.0 | 8.25 | | 11.0 | | V |
| $I_{OL}$ | Low Level Output Current (Note 3) | $V_{DD} = 5V, V_O = 0.4V$ | 0.64 | | 0.51 | 0.88 | | 0.36 | | mA |
| | | $V_{DD} = 10V, V_O = 0.5V$ | 1.6 | | 1.3 | 2.25 | | 0.9 | | mA |
| | | $V_{DD} = 15V, V_O = 1.5V$ | 4.2 | | 3.4 | 8.8 | | 2.4 | | mA |
| $I_{OH}$ | High Level Output Current (Note 3) | $V_{DD} = 5V, V_O = 4.6V$ | $-0.64$ | | $-0.51$ | $-0.88$ | | $-0.36$ | | mA |
| | | $V_{DD} = 10V, V_O = 9.5V$ | $-1.6$ | | $-1.3$ | $-2.25$ | | $-0.9$ | | mA |
| | | $V_{DD} = 15V, V_O = 13.5V$ | $-4.2$ | | $-3.4$ | $-8.8$ | | $-2.4$ | | mA |
| $I_{IN}$ | Input Current | $V_{DD} = 15V, V_{IN} = 0V$ | | $-0.1$ | | $-10^{-5}$ | $-0.1$ | | $-1.0$ | $\mu$A |
| | | $V_{DD} = 15V, V_{IN} = 15V$ | | 0.1 | | $10^{-5}$ | 0.1 | | 1.0 | $\mu$A |

## DC Electrical Characteristics CD4047BC (Note 2)

| Symbol | Parameter | Conditions | −40°C Min | −40°C Max | 25°C Min | 25°C Typ | 25°C Max | 85°C Min | 85°C Max | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| $I_{DD}$ | Quiescent Device Current | $V_{DD} = 5V$ | | 20 | | | 20 | | 150 | $\mu$A |
| | | $V_{DD} = 10V$ | | 40 | | | 40 | | 300 | $\mu$A |
| | | $V_{DD} = 15V$ | | 80 | | | 80 | | 600 | $\mu$A |
| $V_{OL}$ | Low Level Output Voltage | $\|I_O\| < 1\ \mu$A | | | | | | | | |
| | | $V_{DD} = 5V$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| | | $V_{DD} = 10V$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| | | $V_{DD} = 15V$ | | 0.05 | | 0 | 0.05 | | 0.05 | V |
| $V_{OH}$ | High Level Output Voltage | $\|I_O\| < 1\ \mu$A | | | | | | | | |
| | | $V_{DD} = 5V$ | 4.95 | | 4.95 | 5 | | 4.95 | | V |
| | | $V_{DD} = 10V$ | 9.95 | | 9.95 | 10 | | 9.95 | | V |
| | | $V_{DD} = 15V$ | 14.95 | | 14.95 | 15 | | 14.95 | | V |

## DC Electrical Characteristics CD4047BC (Note 2) (Continued)

| Symbol | Parameter | Conditions | −40°C Min | −40°C Max | 25°C Min | 25°C Typ | 25°C Max | 85°C Min | 85°C Max | Units |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{IL}$ | Low Level Input Voltage | $V_{DD} = 5V$, $V_O = 0.5V$ or $4.5V$<br>$V_{DD} = 10V$, $V_O = 1V$ or $9V$<br>$V_{DD} = 15V$, $V_O = 1.5V$ or $13.5V$ | | 1.5<br>3.0<br>4.0 | | 2.25<br>4.5<br>6.75 | 1.5<br>3.0<br>4.0 | | 1.5<br>3.0<br>4.0 | V<br>V<br>V |
| $V_{IH}$ | High Level Input Voltage | $V_{DD} = 5V$, $V_O = 0.5V$ or $4.5V$<br>$V_{DD} = 10V$, $V_O = 1V$ or $9V$<br>$V_{DD} = 15V$, $V_O = 1.5V$ or $13.5V$ | 3.5<br>7.0<br>11.0 | | 3.5<br>7.0<br>11.0 | 2.75<br>5.5<br>8.25 | | 3.5<br>7.0<br>11.0 | | V<br>V<br>V |
| $I_{OL}$ | Low Level Output Current (Note 3) | $V_{DD} = 5V$, $V_O = 0.4V$<br>$V_{DD} = 10V$, $V_O = 0.5V$<br>$V_{DD} = 15V$, $V_O = 1.5V$ | 0.52<br>1.3<br>3.6 | | 0.44<br>1.1<br>3.0 | 0.88<br>2.25<br>8.8 | | 0.36<br>0.9<br>2.4 | | mA<br>mA<br>mA |
| $I_{OH}$ | High Level Output Current (Note 3) | $V_{DD} = 5V$, $V_O = 4.6V$<br>$V_{DD} = 10V$, $V_O = 9.5V$<br>$V_{DD} = 15V$, $V_O = 13.5V$ | −0.52<br>−1.3<br>−3.6 | | −0.44<br>−1.1<br>−3.0 | −0.88<br>−2.25<br>−8.8 | | −0.36<br>−0.9<br>−2.4 | | mA<br>mA<br>mA |
| $I_{IN}$ | Input Current | $V_{DD} = 15V$, $V_{IN} = 0V$<br>$V_{DD} = 15V$, $V_{IN} = 15V$ | | −0.3<br>0.3 | | $-10^{-5}$<br>$10^{-5}$ | −0.3<br>0.3 | | −1.0<br>1.0 | $\mu$A<br>$\mu$A |

**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 table of "Recommended Operating Conditions" and "Electrical Characteristics" provides conditions for actual device oepration.

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

**Note 3:** $I_{OH}$ and $I_{OL}$ are tested one output at a time.

## AC Electrical Characteristics* CD4047B

$T_A = 25°C$, $C_L = 50$ pF, $R_L = 200k$, input $t_r = t_f = 20$ ns, unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $t_{PHL}$, $t_{PLH}$ | Propagation Delay Time Astable, $\overline{Astable}$ to Osc Out | $V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$ | | 200<br>100<br>80 | 400<br>200<br>160 | ns<br>ns<br>ns |
| $t_{PHL}$, $t_{PLH}$ | Astable, $\overline{Astable}$ to Q, $\overline{Q}$ | $V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$ | | 550<br>250<br>200 | 900<br>500<br>400 | ns<br>ns<br>ns |
| $t_{PHL}$, $t_{PLH}$ | + Trigger, − Trigger to $\overline{Q}$ | $V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$ | | 700<br>300<br>240 | 1200<br>600<br>480 | ns<br>ns<br>ns |
| $t_{PHL}$, $t_{PLH}$ | + Trigger, Retrigger to $\overline{Q}$ | $V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$ | | 300<br>175<br>150 | 600<br>300<br>250 | ns<br>ns<br>ns |
| $t_{PHL}$, $t_{PLH}$ | Reset to Q, $\overline{Q}$ | $V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$ | | 300<br>125<br>100 | 600<br>250<br>200 | ns<br>ns<br>ns |
| $t_{THL}$, $t_{TLH}$ | Transition Time Q, $\overline{Q}$, Osc Out | $V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$ | | 100<br>50<br>40 | 200<br>100<br>80 | ns<br>ns<br>ns |
| $t_{WL}$, $t_{WH}$ | Minimum Input Pulse Duration | Any Input<br>$V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$ | | <br>500<br>200<br>160 | <br>1000<br>400<br>320 | <br>ns<br>ns<br>ns |
| $t_{RCL}$, $t_{FCL}$ | + Trigger, Retrigger, Rise and Fall Time | $V_{DD} = 5V$<br>$V_{DD} = 10V$<br>$V_{DD} = 15V$ | | | 15<br>5<br>5 | $\mu$s<br>$\mu$s<br>$\mu$s |
| $C_{IN}$ | Average Input Capacitance | Any Input | | 5 | 7.5 | pF |

*AC Parameters are guaranteed by DC correlated testing.

## Logic Diagram
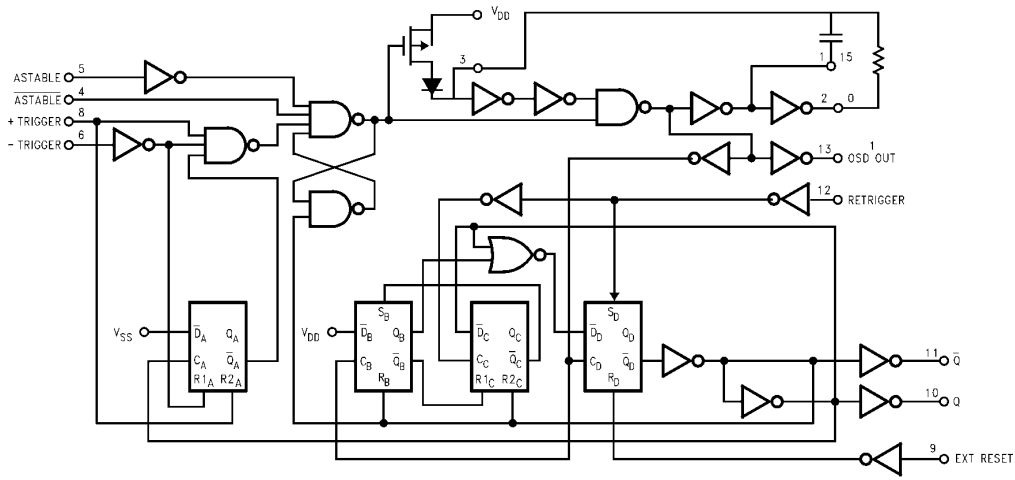


*Special input protection circuit to permit larger input-voltage swings.

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## Truth Table

| Function | Terminal Connections | | | Output Pulse From | Typical Output Period or Pulse Width |
|---|---|---|---|---|---|
| | To $V_{DD}$ | To $V_{SS}$ | Input Pulse To | | |
| Astable Multivibrator | | | | | |
|   Free-Running | 4, 5, 6, 14 | 7, 8, 9, 12 | | 10, 11, 13 | $t_A$ (10, 11) $=$ 4.40 RC |
|   True Gating | 4, 6, 14 | 7, 8, 9, 12 | 5 | 10, 11, 13 | $t_A$ (13) $=$ 2.20 RC |
|   Complement Gating | 6, 14 | 5, 7, 8, 9, 12 | 4 | 10, 11, 13 | |
| Monostable Multivibrator | | | | | |
|   Positive-Edge Trigger | 4, 14 | 5, 6, 7, 9, 12 | 8 | 10, 11 | |
|   Negative-Edge Trigger | 4, 8, 14 | 5, 7, 9, 12 | 6 | 10, 11 | $t_M$ (10, 11) $=$ 2.48 RC |
|   Retriggerable | 4, 14 | 5, 6, 7, 9 | 8, 12 | 10, 11 | |
|   External Countdown* | 14 | 5, 6, 7, 8, 9, 12 | (See Figure) | (See Figure) | (See Figure) |

**Note:** External resistor between terminals 2 and 3. External capacitor between terminals 1 and 3.
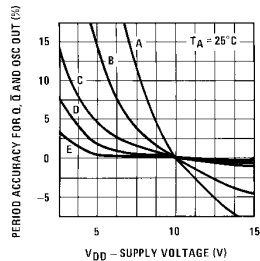
### *Typical Implementation of External Countdown Option
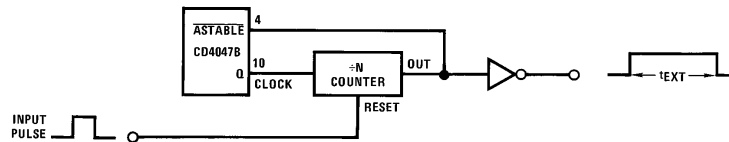


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$$t_{EXT} = (N - 1) t_A + (t_M + t_A/2)$$

4

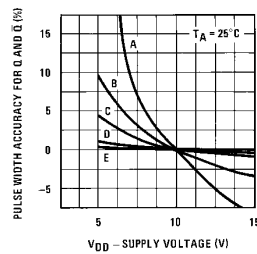# Typical Performance Characteristics

### Typical Q, Q̄, Osc Out Period Accuracy vs Supply Voltage (Astable Mode Operation)



TL/F/5969–5

| | $f_{Q, \overline{Q}}$ | R | C |
|---|---|---|---|
| **A** | 1000 kHz | 22k | 10 pF |
| **B** | 100 kHz | 22k | 100 pF |
| **C** | 10 kHz | 220k | 100 pF |
| **D** | 1 kHz | 220k | 1000 pF |
| **E** | 100 Hz | 2.2M | 1000 pF |

### Typical Q, Q̄, Pulse Width Accuracy vs Supply Voltage Monostable Mode Operation



TL/F/5969–6

| | $t_M$ | R | C |
|---|---|---|---|
| **A** | 2 μs | 22k | 10 pF |
| **B** | 7 μs | 22k | 100 pF |
| **C** | 60 μs | 220k | 100 pF |
| **D** | 550 μs | 220k | 1000 pF |
| **E** | 5.5 ms | 2.2M | 1000 pF |

### Typical Q, Q̄ and Osc Out Period Accuracy vs Temperature Astable Mode Operation
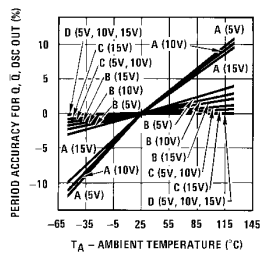


TL/F/5969–7

| | $f_{Q, \overline{Q}}$ | R | C |
|---|---|---|---|
| **A** | 1000 kHz | 22k | 10 pF |
| **B** | 100 kHz | 22k | 100 pF |
| **C** | 10 kHz | 220k | 100 pF |
| **D** | 1 kHz | 220k | 1000 pF |

### Typical Q and Q̄ Pulse Width Accuracy vs Temperature Monostable Mode Operation
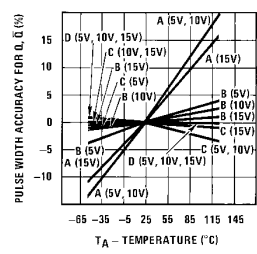


TL/F/5969–8

| | $t_M$ | R | C |
|---|---|---|---|
| **A** | 2 μs | 22k | 10 pF |
| **B** | 7 μs | 22k | 100 pF |
| **C** | 60 μs | 220k | 100 pF |
| **D** | 550 μs | 220k | 1000 pF |

# Timing Diagram

### Astable Mode



TL/F/5969–9

### Monostable Mode



TL/F/5969–10

### Retrigger Mode
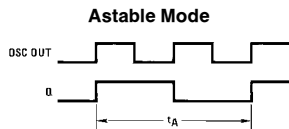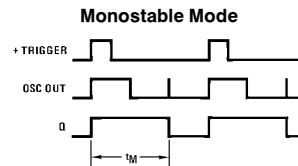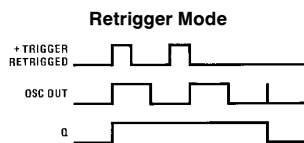


TL/F/5969–11

# Physical Dimensions inches (millimeters)

0.785
(19.939)
MAX

0.025
(0.635)
RAD

14 13 12 11 10 9 8

1 2 3 4 5 6 7

0.220—0.310
(5.588—7.874)

0.290—0.320
(7.366—8.128)

0.180
(4.572) MAX

95° ±5°

10° MAX

0.310—0.410
(7.874—10.41)

0.005
(0.127)
MIN

86°94° TYP

0.008—0.012
(0.203—0.305)

0.098
(2.489)
MAX BOTH ENDS

GLASS
SEALANT

0.060 ±0.005
(1.524 ±0.127)

0.018 ±0.003
(0.457 ±0.076)

0.100 ±0.010
(2.540 ±0.254)

0.200
(5.080)
MAX

0.020—0.060
(0.508—1.524)

0.125—0.200
(3.175—5.080)

0.150
(3.81)
MIN

J14A (REV G)
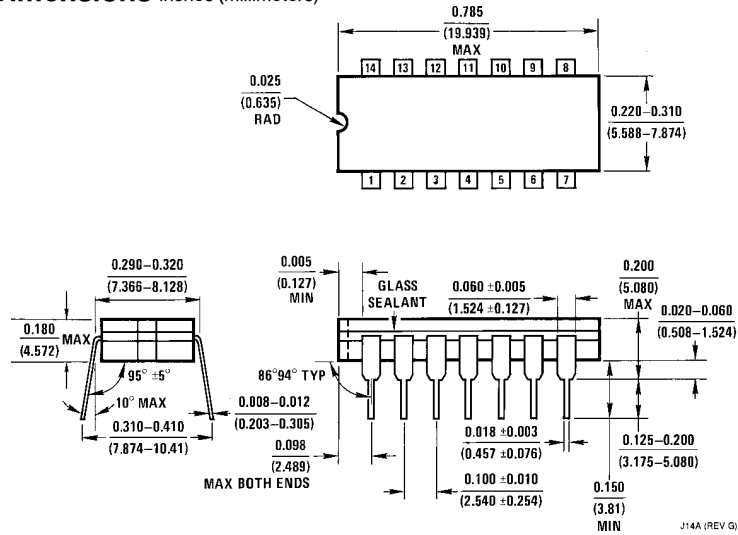
**Order Number CD4047BMJ or CD4047BCJ**
**NS Package Number J14A**

0.740—0.770
(18.80—19.56)

0.090
(2.286)

14 13 12 11 10 9 8

1 2 3 4 5 6 7

0.250 ±0.010
(6.350 ±0.254)

PIN NO. 1
IDENT

0.092
(2.337) DIA

0.030 MAX
(0.762) DEPTH

OPTION 1

INDEX
AREA

14 13 12

1 2 3

PIN NO. 1
IDENT

OPTION 02

0.135 ±0.005
(3.429 ±0.127)

0.145—0.200
(3.683—5.080)

0.060
(1.524) TYP

4° TYP
OPTIONAL

0.020
(0.508)
MIN

0.125—0.150
(3.175—3.810)

0.014—0.023
(0.356—0.584) TYP

0.075 ±0.015
(1.905 ±0.381)

90° ±4° TYP

0.100 ±0.010
(2.540 ±0.254) TYP

0.050 ±0.010
(1.270 ±0.254) TYP

0.300—0.325
(7.620—8.128)

0.065
(1.651)

95° ±5°

0.008—0.016
(0.203—0.406) TYP

0.280
(7.112)
MIN

0.325 +0.040
−0.015
(8.255 +1.016
−0.381)

N14A (REV F)

**Order Number CD4047BMN or CD4047BCN**
**NS Package Number N14A**

## LIFE SUPPORT POLICY

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.