

# CD4093BM/CD4093BC Quad 2-Input NAND Schmitt Trigger

#### **General Description**

The CD4093B consists of four Schmitt-trigger circuits. Each circuit functions as a 2-input NAND gate with Schmitt-trigger action on both inputs. The gate switches at different points for positive and negative-going signals. The difference between the positive  $(V_T^{\,+})$  and the negative voltage  $(V_T^{\,-})$  is defined as hysteresis voltage  $(V_H)$ .

All outputs have equal source and sink currents and conform to standard B-series output drive (see Static Electrical Characteristics).

#### **Features**

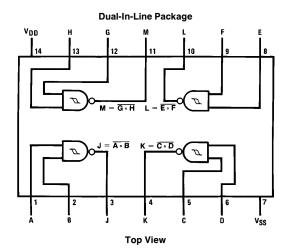
- Wide supply voltage range
- Schmitt-trigger on each input with no external components
- Noise immunity greater than 50%

- Equal source and sink currents
- No limit on input rise and fall time
- Standard B-series output drive
- Hysteresis voltage (any input) T<sub>A</sub> = 25°C

#### **Applications**

- Wave and pulse shapers
- High-noise-environment systems
- Monostable multivibrators
- Astable multivibrators
- NAND logic

#### **Connection Diagram**



3.0V to 15V

Order Number CD4093B

TL/F/5982-1

#### 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.

DC Supply Voltage (V<sub>DD</sub>)  $-0.5 \text{ to } +18 \text{ V}_{DC}$  Input Voltage (V<sub>IN</sub>)  $-0.5 \text{ to V}_{DD} +0.5 \text{ V}_{DC}$  Storage Temperature Range (T<sub>S</sub>)  $-65^{\circ}\text{C to } +150^{\circ}\text{C}$ 

Power Dissipation (PD)

Dual-In-Line 700 mW Small Outline 500 mW

Lead Temperature (T<sub>L</sub>) (Soldering, 10 seconds)

260°C

### **Recommended Operating Conditions** (Note 2)

DC Supply Voltage (V<sub>DD</sub>)  $3 \text{ to } 15 \text{ V}_{DC}$  Input Voltage (V<sub>IN</sub>)  $0 \text{ to } \text{V}_{DD} \text{ V}_{DC}$ 

Operating Temperature Range (T<sub>A</sub>) CD4093BM

#### DC Electrical Characteristics CD4093BM (Note 2)

| Symbol           | Parameter  | Conditions   | −55°C                 |                       | + <b>25°C</b>         |                        |                      | + 125°C               |                      | Units          |
|------------------|--|--|-----------------------|-----------------------|-----------------------|------------------------|----------------------|-----------------------|----------------------|----------------|
|                  |  |  | Min                   | Max                   | Min                   | Тур                    | Max                  | Min                   | Max                  | Jillis         |
| I <sub>DD</sub>  | Quiescent Device<br>Current  | $V_{DD} = 5V$ $V_{DD} = 10V$ $V_{DD} = 15V$  |                       | 0.25<br>0.5<br>1.0    |                       |                        | 0.25<br>0.5<br>1.0   |                       | 7.5<br>15.0<br>30.0  | μΑ<br>μΑ<br>μΑ |
| V <sub>OL</sub>  | Low Level<br>Output Voltage  | $V_{IN} = V_{DD},  I_{O}  < 1 \mu A$ $V_{DD} = 5V$ $V_{DD} = 10V$ $V_{DD} = 15V$                                 |                       | 0.05<br>0.05<br>0.05  |                       | 0<br>0<br>0            | 0.05<br>0.05<br>0.05 |                       | 0.05<br>0.05<br>0.05 | V<br>V         |
| V <sub>OH</sub>  | High Level<br>Output Voltage   | $V_{IN} = V_{SS},  I_{O}  < 1 \mu A$ $V_{DD} = 5V$ $V_{DD} = 10V$ $V_{DD} = 15V$                                 | 4.95<br>9.95<br>14.95 |                       | 4.95<br>9.95<br>14.95 | 5<br>10<br>15          |                      | 4.95<br>9.95<br>14.95 |                      | V<br>V<br>V    |
| V <sub>T</sub> - | Negative-Going Threshold<br>Voltage (Any Input)  | $ I_O  < 1 \mu A$<br>$V_{DD} = 5V, V_O = 4.5V$<br>$V_{DD} = 10V, V_O = 9V$<br>$V_{DD} = 15V, V_O = 13.5V$        | 1.3<br>2.85<br>4.35   | 2.25<br>4.5<br>6.75   | 1.5<br>3.0<br>4.5     | 1.8<br>4.1<br>6.3      | 2.25<br>4.5<br>6.75  | 1.5<br>3.0<br>4.5     | 2.3<br>4.65<br>6.9   | V<br>V         |
| V <sub>T</sub> + | Positive-Going Threshold<br>Voltage (Any Input)  | $ I_O  < 1 \mu A$<br>$V_{DD} = 5V, V_O = 0.5V$<br>$V_{DD} = 10V, V_O = 1V$<br>$V_{DD} = 15V, V_O = 1.5V$         | 2.75<br>5.5<br>8.25   | 3.65<br>7.15<br>10.65 | 2.75<br>5.5<br>8.25   | 3.3<br>6.2<br>9.0      | 3.5<br>7.0<br>10.5   | 2.65<br>5.35<br>8.1   | 3.5<br>7.0<br>10.5   | V<br>V         |
| V <sub>H</sub>   | Hysteresis (V <sub>T</sub> <sup>+</sup> - V <sub>T</sub> <sup>-</sup> )<br>(Any Input) | $V_{DD} = 5V$ $V_{DD} = 10V$ $V_{DD} = 15V$  | 0.5<br>1.0<br>1.5     | 2.35<br>4.30<br>6.30  | 0.5<br>1.0<br>1.5     | 1.5<br>2.2<br>2.7      | 2.0<br>4.0<br>6.0    | 0.35<br>0.70<br>1.20  | 2.0<br>4.0<br>6.0    | V<br>V<br>V    |
| l <sub>OL</sub>  | Low Level Output<br>Current (Note 3)   | $V_{IN} = V_{DD}$<br>$V_{DD} = 5V, V_{O} = 0.4V$<br>$V_{DD} = 10V, V_{O} = 0.5V$<br>$V_{DD} = 15V, V_{O} = 1.5V$ | 0.64<br>1.6<br>4.2    |                       | 0.51<br>1.3<br>3.4    | 0.88<br>2.25<br>8.8    |                      | 0.36<br>0.9<br>2.4    |                      | mA<br>mA<br>mA |
| ГОН              | High Level Output<br>Current (Note 3)  | $V_{IN} = V_{SS}$<br>$V_{DD} = 5V, V_O = 4.6V$<br>$V_{DD} = 10V, V_O = 9.5V$<br>$V_{DD} = 15V, V_O = 13.5V$      | -0.64<br>-1.6<br>-4.2 |                       | 0.51<br>-1.3<br>-3.4  | -0.88<br>-2.25<br>-8.8 |                      | -0.36<br>-0.9<br>-2.4 |                      | mA<br>mA<br>mA |
| I <sub>IN</sub>  | Input Current  | $V_{DD} = 15V, V_{IN} = 0V$<br>$V_{DD} = 15V, V_{IN} = 15V$  |                       | -0.1<br>0.1           |                       | -10 <sup>-5</sup>      | -0.1<br>0.1          |                       | -1.0<br>1.0          | μA<br>μA       |

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 operation.

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

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

### DC Electrical Characteristics CD4093BC (Note 2)

| Symbol           | Parameter  | Conditions  | −40°C                 |                      | + 25°C                |                        |                      | +85°C                 |                      | Units          |
|------------------|--|---|-----------------------|----------------------|-----------------------|------------------------|----------------------|-----------------------|----------------------|----------------|
|                  |  |   | Min                   | Max                  | Min                   | Тур                    | Max                  | Min                   | Max                  | Jillis         |
| I <sub>DD</sub>  | Quiescent Device<br>Current  | $V_{DD} = 5V$ $V_{DD} = 10V$ $V_{DD} = 15V$   |                       | 1.0<br>2.0<br>4.0    |                       |                        | 1.0<br>2.0<br>4.0    |                       | 7.5<br>15.0<br>30.0  | μΑ<br>μΑ<br>μΑ |
| V <sub>OL</sub>  | Low Level<br>Output Voltage  | $V_{IN} = V_{DD,}  I_{O}  < 1 \mu A$ $V_{DD} = 5V$ $V_{DD} = 10V$ $V_{DD} = 15V$  |                       | 0.05<br>0.05<br>0.05 |                       | 0<br>0<br>0            | 0.05<br>0.05<br>0.05 |                       | 0.05<br>0.05<br>0.05 | V<br>V         |
| V <sub>OH</sub>  | High Level<br>Output Voltage   | $V_{IN} = V_{SS},  I_O  < 1 \mu A$ $V_{DD} = 5V$ $V_{DD} = 10V$ $V_{DD} = 15V$  | 4.95<br>9.95<br>14.95 |                      | 4.95<br>9.95<br>14.95 | 5<br>10<br>15          |                      | 4.95<br>9.95<br>14.95 |                      | V<br>V         |
| V <sub>T</sub> - | Negative-Going Threshold<br>Voltage (Any Input)  | $ \begin{vmatrix}  I_O  < 1 \ \mu A \\ V_{DD} = 5V, V_O = 4.5V \\ V_{DD} = 10V, V_O = 9V \\ V_{DD} = 15V, V_O = 13.5V \end{vmatrix} $ | 1.3<br>2.85<br>4.35   | 2.25<br>4.5<br>6.75  | 1.5<br>3.0<br>4.5     | 1.8<br>4.1<br>6.3      | 2.25<br>4.5<br>6.75  | 1.5<br>3.0<br>4.5     | 2.3<br>4.65<br>6.9   | V<br>V<br>V    |
| V <sub>T</sub> + | Positive-Going Threshold<br>Voltage (Any Input)  | $ I_O  < 1 \mu A$<br>$V_{DD} = 5V, V_O = 0.5V$<br>$V_{DD} = 10V, V_O = 1V$<br>$V_{DD} = 15V, V_O = 1.5V$                              | 2.75<br>5.5<br>8.25   | 3.6<br>7.15<br>10.65 | 2.75<br>5.5<br>8.25   | 3.3<br>6.2<br>9.0      | 3.5<br>7.0<br>10.5   | 2.65<br>5.35<br>8.1   | 3.5<br>7.0<br>10.5   | V<br>V         |
| V <sub>H</sub>   | Hysteresis (V <sub>T</sub> <sup>+</sup> - V <sub>T</sub> <sup>-</sup> )<br>(Any Input) | $V_{DD} = 5V$ $V_{DD} = 10V$ $V_{DD} = 15V$   | 0.5<br>1.0<br>1.5     | 2.35<br>4.3<br>6.3   | 0.5<br>1.0<br>1.5     | 1.5<br>2.2<br>2.7      | 2.0<br>4.0<br>6.0    | 0.35<br>0.70<br>1.20  | 2.0<br>4.0<br>6.0    | V<br>V<br>V    |
| loL              | Low Level Output<br>Current (Note 3)   | $V_{IN} = V_{DD}$ $V_{DD} = 5V, V_{O} = 0.4V$ $V_{DD} = 10V, V_{O} = 0.5V$ $V_{DD} = 15V, V_{O} = 1.5V$                               | 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 |
| Гон              | High Level Output<br>Current (Note 3)  | $V_{IN} = V_{SS}$<br>$V_{DD} = 5V, V_O = 4.6V$<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 <sub>IN</sub>  | Input Current  | $V_{DD} = 15V, V_{IN} = 0V$<br>$V_{DD} = 15V, V_{IN} = 15V$   |                       | -0.3<br>0.3          |                       | -10 <sup>-5</sup>      | -0.3<br>0.3          |                       | -1.0<br>1.0          | μA<br>μA       |

AC Electrical Characteristics\*  $T_A=25^{\circ}\text{C, }C_L=50\text{ pF, }R_L=200\text{k, Input }t_f,\,t_f=20\text{ ns, unless otherwise specified}$ 

| Symbol                              | Parameter                     | Conditions     | Min | Тур | Max | Units |
|-------------------------------------|-------------------------------|----------------|-----|-----|-----|-------|
| t <sub>PHL</sub> , t <sub>PLH</sub> | Propagation Delay Time        | $V_{DD} = 5V$  |     | 300 | 450 | ns    |
|                                     |                               | $V_{DD} = 10V$ |     | 120 | 210 | ns    |
|                                     |                               | $V_{DD} = 15V$ |     | 80  | 160 | ns    |
| t <sub>THL</sub> , t <sub>TLH</sub> | Transition Time               | $V_{DD} = 5V$  |     | 90  | 145 | ns    |
|                                     |                               | $V_{DD} = 10V$ |     | 50  | 75  | ns    |
|                                     |                               | $V_{DD} = 15V$ |     | 40  | 60  | ns    |
| C <sub>IN</sub>                     | Input Capacitance             | (Any Input)    |     | 5.0 | 7.5 | pF    |
| C <sub>PD</sub>                     | Power Dissipation Capacitance | (Per Gate)     |     | 24  |     | pF    |

<sup>\*</sup>AC Parameters are guaranteed by DC correlated testing.

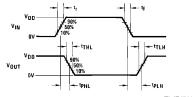
Note 2:  $V_{SS} = 0V$  unless otherwise specified.

Note 3:  $\mathbf{I}_{OH}$  and  $\mathbf{I}_{OL}$  are tested one output at a time.

## **Typical Applications Gated Oscillator** CONTROL ٧<sub>DD</sub>. V<sub>T+</sub> TL/F/5982-2 Assume $t_1 \ + \ t_2 >> \ t_{PHL} \ + \ t_{PLH}$ then: $t_0 = RC \ \ell \ n \ [V_{DD}/V_T{}^-]$ $\begin{aligned} &t_1 = \text{RC } \ \ell \ \text{n} \ [(\text{V}_{DD} - \text{V}_{\text{T}}^-)/(\text{V}_{DD} - \text{V}_{\text{T}}^+)] \\ &t_2 = \text{RC } \ \ell \ \text{n} \ [\text{V}_{\text{T}}^+/\text{V}_{\text{T}}^-] \end{aligned}$ VOUT t<sub>1</sub> to -TL/F/5982-3 **Gated One-Shot** TL/F/5982-4 \_ t = RC ln [V<sub>DD</sub>/(V<sub>DD</sub> - V<sub>T+</sub>)] TL/F/5982-5 (a) Negative-Edge Triggered TL/F/5982-6 — t = RC ℓn (V<sub>DD</sub>/V<sub>T</sub>\_) TL/F/5982-7 (b) Positive-Edge Triggered

#### **Typical Performance Characteristics Typical Transfer** Characteristics Guaranteed Hysteresis vs V<sub>DD</sub> HYSTERESIS, $\frac{V_H}{V_{DD}}$ x 100 (%) 40 **GUARANTEED MAXIMUM** OUTPUT VOLTAGE (V) 30 20 Vnn = 51 TYPICAL 10 GUARANTEED MINIMUM 0 0 10 INPUT VOLTAGE (V) V<sub>DD</sub> (V) TL/F/5982-8 TL/F/5982-9 **Guaranteed Trigger Threshold** Voltage vs V<sub>DD</sub> Guaranteed Hysteresis vs V<sub>DD</sub> GUARANTEED TRIGGER THRESHOLD VOLTAGE (VT+, VT-), (V) 10 **GUARANTEED HYSTERESIS (V)** (0.4 V<sub>DD</sub>) 8 (0.1 V<sub>DD</sub>) 0 10 10 V<sub>DD</sub> (V) V<sub>DD</sub> (V) TL/F/5982-10 TL/F/5982-11 **Input and Output Characteristics** Input Characteristic Output Characteristic LOGIC "1" OUTPUT REGION VIH(MIN) = VT+(MIN) LOAD LOGIC "O" INPUT REGION TL/F/5982-12 VSS LOGIC "O" OUTPUT REGION TL/F/5982-13 $V_{NML} = V_{IH(MIN)} - V_{OL} \cong V_{IH(MIN)} = V_{T}{}^{+}{}_{(MIN)}$ $V_{NMH} = V_{OH} - V_{IL(MAX)} \cong V_{DD} - V_{IL(MAX)} = V_{DD} - V_{T} - {}_{(MAX)}$ **AC Test Circuits and Switching Time Waveforms**





TL/F/5982-15

#### Physical Dimensions inches (millimeters) (19.939) MAX 14 13 12 11 10 9 8 0.025 (0.635)0.220-D.310 RAD (5.588-7.874) 1 2 3 4 5 6 7 0.290-0.320 0.200 (5.080) MAX 0.020-0.060 (D.127) MIN (7.366-8.128) $0.060 \pm 0.005$ (1.524 ±0.127) 0.180 (0.508-1.524) -MA (4.572) 95° ±5 86°94° TYF 10° MAX 0.008-0.012 (0.203-D.305) 0.310-0.410 0.125-0.200 (7.874-10.41) 0.098 (0.457 ±0.076) (3.175-5.080) (2.489) 0.100 ±0.010 MAX BOTH ENDS (2 540 +0 254) (3.81) MIN J14A (REV G) Ceramic Dual-In-Line Package (J) Order Number CD4093BMJ or CD4093BCJ NS Package Number J14A 1 2 3 4 5 6 $\frac{0.092}{(2.337)}$ DIA $\frac{0.030}{(0.762)}$ MAX 0.145 - 0.200 (3.683 - 5.080) 0.125 - 0.150 (3.175 - 3.810) 0.050 ± 0.010 (1.270 - 0.254) TYP 0.325 +0 Molded Dual-In-Line Package (N)

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Order Number CD4093BM or CD4093BCN NS Package Number N14A

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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.



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