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 3.0V to 15V
- Schmitt-trigger on each input with no external components
- Noise immunity greater than 50%

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

Connection Diagram
### 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.

<table>
<thead>
<tr>
<th>DC Supply Voltage (V&lt;sub&gt;DD&lt;/sub&gt;)</th>
<th>–0.5 to +18 V&lt;sub&gt;DC&lt;/sub&gt;</th>
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</thead>
<tbody>
<tr>
<td>Input Voltage (V&lt;sub&gt;I&lt;/sub&gt;)</td>
<td>–0.5 to V&lt;sub&gt;DD&lt;/sub&gt; + 0.5 V&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Storage Temperature Range (T&lt;sub&gt;S&lt;/sub&gt;)</td>
<td>–65°C to +150°C</td>
</tr>
<tr>
<td>Power Dissipation (P&lt;sub&gt;D&lt;/sub&gt;)</td>
<td>Dual-Line 700 mW</td>
</tr>
<tr>
<td>Lead Temperature (T&lt;sub&gt;L&lt;/sub&gt;) (Soldering, 10 seconds)</td>
<td>260°C</td>
</tr>
</tbody>
</table>

### DC Electrical Characteristics CD4093BM (Note 2)

#### Symbol | Parameter | Conditions | –55°C | +25°C | +125°C | Units |
<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>I&lt;sub&gt;DD&lt;/sub&gt;</td>
<td>Quiescent Device Current</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 5V</td>
<td>0.25</td>
<td>0.25</td>
<td>7.5</td>
<td>μA</td>
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<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 10V</td>
<td>0.5</td>
<td>0.5</td>
<td>15.0</td>
<td>μA</td>
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<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15V</td>
<td>1.0</td>
<td>1.0</td>
<td>30.0</td>
<td>μA</td>
</tr>
<tr>
<td>V&lt;sub&gt;OL&lt;/sub&gt;</td>
<td>Low Level Output Voltage</td>
<td>V&lt;sub&gt;I&lt;/sub&gt;</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5V</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10V</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15V</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;OH&lt;/sub&gt;</td>
<td>High Level Output Voltage</td>
<td>V&lt;sub&gt;I&lt;/sub&gt;</td>
<td>4.95</td>
<td>4.95</td>
<td>5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5V</td>
<td>4.95</td>
<td>4.95</td>
<td>5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10V</td>
<td>9.95</td>
<td>9.95</td>
<td>10</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15V</td>
<td>14.95</td>
<td>14.95</td>
<td>15</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;T&lt;/sub&gt;−</td>
<td>Negative-Going Threshold Voltage (Any Input)</td>
<td></td>
<td>1.3</td>
<td>1.5</td>
<td>2.25</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 5V, V&lt;sub&gt;DD&lt;/sub&gt; = 4.5V</td>
<td>2.85</td>
<td>3.0</td>
<td>4.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 10V, V&lt;sub&gt;DD&lt;/sub&gt; = 9V</td>
<td>4.35</td>
<td>4.5</td>
<td>6.75</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15V, V&lt;sub&gt;DD&lt;/sub&gt; = 13.5V</td>
<td>10</td>
<td>10.65</td>
<td>14.95</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;T&lt;/sub&gt;+&lt;/sub&gt;</td>
<td>Positive-Going Threshold Voltage (Any Input)</td>
<td></td>
<td>2.75</td>
<td>3.25</td>
<td>3.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 5V, V&lt;sub&gt;DD&lt;/sub&gt; = 0.5V</td>
<td>5.5</td>
<td>5.5</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 10V, V&lt;sub&gt;DD&lt;/sub&gt; = 1V</td>
<td>8.25</td>
<td>9.0</td>
<td>10.5</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;H&lt;/sub&gt;</td>
<td>Hysteresis (V&lt;sub&gt;T&lt;/sub&gt;− – V&lt;sub&gt;T&lt;/sub&gt;+) (Any Input)</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 5V</td>
<td>0.5</td>
<td>0.5</td>
<td>1.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 10V</td>
<td>1.0</td>
<td>1.0</td>
<td>2.2</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15V</td>
<td>1.5</td>
<td>1.5</td>
<td>2.7</td>
<td>V</td>
</tr>
<tr>
<td>I&lt;sub&gt;OL&lt;/sub&gt;</td>
<td>Low Level Output Current (Note 3)</td>
<td>V&lt;sub&gt;I&lt;/sub&gt;</td>
<td>0.64</td>
<td>0.51</td>
<td>0.88</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.4V</td>
<td>1.3</td>
<td>2.25</td>
<td>0.9</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5V</td>
<td>4.2</td>
<td>3.4</td>
<td>8.8</td>
<td>mA</td>
</tr>
<tr>
<td>I&lt;sub&gt;OH&lt;/sub&gt;</td>
<td>High Level Output Current (Note 3)</td>
<td>V&lt;sub&gt;I&lt;/sub&gt;</td>
<td>–0.64</td>
<td>–0.51</td>
<td>–0.88</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.4V</td>
<td>–1.3</td>
<td>–2.25</td>
<td>–0.9</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5V</td>
<td>–4.2</td>
<td>–3.4</td>
<td>–8.8</td>
<td>mA</td>
</tr>
<tr>
<td>I&lt;sub&gt;IN&lt;/sub&gt;</td>
<td>Input Current</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15V, V&lt;sub&gt;IN&lt;/sub&gt; = 0V</td>
<td>–0.1</td>
<td>–10&lt;sup&gt;−5&lt;/sup&gt;</td>
<td>–0.1</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 15V, V&lt;sub&gt;IN&lt;/sub&gt; = 15V</td>
<td>0.1</td>
<td>10&lt;sup&gt;−5&lt;/sup&gt;</td>
<td>0.1</td>
<td>μA</td>
</tr>
</tbody>
</table>

**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 those limits. The table of “Recommended Operating Conditions” and “Electrical Characteristics” provides conditions for actual device operation.

**Note 2:** V<sub>SS</sub> = 5V unless otherwise specified.

**Note 3:** I<sub>OH</sub> and I<sub>OL</sub> are tested one output at a time.
### DC Electrical Characteristics

**Symbol** | **Parameter** | **Conditions** | **−40°C** | **25°C** | **85°C** | Units
--- | --- | --- | --- | --- | --- | ---
| | | | Min | Max | Min | Max | | Min | Max | Min | Max | Min | Max |

**IDQ**  
Quiescent Device Current  
- $V_{DD} = 5V$: 1.0  
- $V_{DD} = 10V$: 2.0  
- $V_{DD} = 15V$: 4.0  

**VOL**  
Low Level Output Voltage  
- $V_{OL} = V_{DD}, I_{OL} < 1 \mu A$: 0.05  
- $V_{OL} = 5V$: 4.95  
- $V_{OL} = 10V$: 9.95  
- $V_{OL} = 15V$: 14.95  

**VOL**  
High Level Output Voltage  
- $V_{OH} = V_{SS}, I_{OH} < 1 \mu A$: 4.95  
- $V_{OH} = 5V$: 9.95  
- $V_{OH} = 10V$: 14.95  

**VT−**  
Negative-Going Threshold Voltage (Any Input)  
- $|V_{THL}| < 1 \mu A$: 1.3  
- $V_{DD} = 5V, V_O = 4.5V$: 3.6  
- $V_{DD} = 10V, V_O = 9V$: 4.35  
- $V_{DD} = 15V, V_O = 13.5V$: 6.75  

**VT+**  
Positive-Going Threshold Voltage (Any Input)  
- $|V_{THL}| < 1 \mu A$: 2.75  
- $V_{DD} = 5V, V_O = 0.5V$: 3.6  
- $V_{DD} = 10V, V_O = 1V$: 5.5  
- $V_{DD} = 15V, V_O = 1.5V$: 8.25  

**VH**  
Hysteresis ($V_{THL} + V_{TH}^−$) (Any Input)  
- $V_{DD} = 5V$: 0.5  
- $V_{DD} = 10V$: 1.0  
- $V_{DD} = 15V$: 1.5  

**IOL**  
Low Level Output Current (Note 3)  
- $V_{DD} = 5V, V_O = 0.4V$: 0.52  
- $V_{DD} = 10V, V_O = 0.5V$: 1.3  
- $V_{DD} = 15V, V_O = 1.5V$: 3.6  

**IOH**  
High Level Output Current (Note 3)  
- $V_{DD} = 5V, V_O = 4.6V$: −0.52  
- $V_{DD} = 10V, V_O = 9.5V$: −1.3  
- $V_{DD} = 15V, V_O = 15V$: −3.6  

## AC Electrical Characteristics

**Symbol** | **Parameter** | **Conditions** | **Min** | **Typ** | **Max** | Units
--- | --- | --- | --- | --- | --- | ---
| | | | | | | |

**IPHL, IPHL**  
Propagation Delay Time  
- $V_{DD} = 5V$: 300  
- $V_{DD} = 10V$: 120  
- $V_{DD} = 15V$: 80  

**ITHL, ITLH**  
Transition Time  
- $V_{DD} = 5V$: 90  
- $V_{DD} = 10V$: 50  
- $V_{DD} = 15V$: 40  

**CIN**  
Input Capacitance (Any Input)  
- $V_{DD} = 15V, V_{IN} = 0V$: 0.3  
- $V_{DD} = 15V, V_{IN} = 15V$: 0.3  

**CDD**  
Power Dissipation Capacitance (Per Gate)  
- $V_{DD} = 5V$: 5.0  
- $V_{DD} = 10V$: 5.0  
- $V_{DD} = 15V$: 5.0  

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*AC Parameters are guaranteed by DC correlated testing.

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

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

Assume $t_1 + t_2 > > t_{PHL} + t_{PLH}$ then:

$$t_0 = RC \times \frac{1}{V_{DD}/V_{T+}}$$

$$t_1 = RC \times \frac{1}{V_{DD} - V_T^-}$$

$$t_2 = RC \times \frac{1}{V_T^+ - V_{DD}}$$

$$t = \frac{t_1 + t_2}{R C \times \frac{1}{V_{T+}} \frac{V_{DD} - V_T^-}{V_T^- - V_{DD} - V_T^+}}$$

Gated Oscillator

Gated One-Shot

(a) Negative-Edge Triggered

(b) Positive-Edge Triggered
Typical Performance Characteristics

Guaranteed Trigger Threshold Voltage vs VDD

Guaranteed Hysteresis vs VDD

Input and Output Characteristics

Output Characteristic Input Characteristic

AC Test Circuits and Switching Time Waveforms
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