



MMC 4093

## QUAD 2-INPUT NAND SCHMITT TRIGGERS

### GENERAL DESCRIPTION

The MMC 4093 consists of four Schmitt-trigger circuits. Each circuit functions as a two-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 voltage ( $V_P$ ) and negative voltage ( $V_N$ ) is defined as hysteresis voltage ( $V_H$ ). The MMC 4093 types are supplied in 14-lead hermetic dual-in-line ceramic or plastic packages.

### FEATURES

- Schmitt-trigger action on each input with no external components
- Hysteresis voltage typically 0.9 V at  $V_{DD} = 5$  V and 2.3 V at  $V_{DD} = 10$  V
- No limit on input rise and fall times

### APPLICATIONS

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

### ABSOLUTE MAXIMUM RATINGS

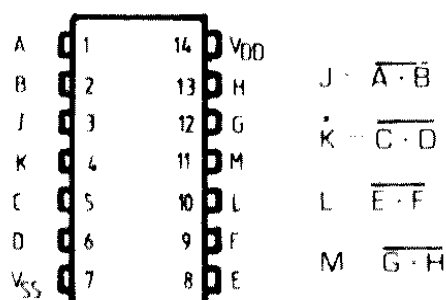
|            |                                                                              |         |                |    |
|------------|------------------------------------------------------------------------------|---------|----------------|----|
| $V_{DD}^*$ | Supply voltage: G and H types                                                | -0.5 to | 20             | V  |
|            | E and F types                                                                | -0.5 to | 18             | V  |
| $V_i$      | Input voltage                                                                | -0.5 to | $V_{DD} + 0.5$ | V  |
| $I_i$      | DC input current (any one input)                                             |         | $\pm 10$       | mA |
| $P_{tot}$  | Total power dissipation (per package)                                        |         | 200            | mW |
|            | Dissipation per output transistor for $T_A$ = full package-temperature range |         | 100            | mW |
| $T_A$      | Operating temperature: G and H types                                         | -55 to  | 125            | °C |
|            | E and F types                                                                | -40 to  | 85             | °C |
| $T_{stg}$  | Storage temperature                                                          | -65 to  | 150            | °C |

\* All voltage values are referred to  $V_{SS}$  pin voltage

### RECOMMENDED OPERATING CONDITIONS

|            |                                      |        |          |    |
|------------|--------------------------------------|--------|----------|----|
| $V_{DD}^*$ | Supply voltage: G and H types        | 3 to   | 18       | V  |
|            | E and F types                        | 3 to   | 15       | V  |
| $V_i$      | Input voltage                        | 0 to   | $V_{DD}$ | V  |
| $T_A$      | Operating temperature: G and H types | -55 to | 125      | °C |
|            | E and F types                        | -40 to | 85       | °C |

### CONNECTION DIAGRAM



### FUNCTIONAL DIAGRAM



# **STATIC ELECTRICAL CHARACTERISTICS**

(over recommended operating conditions)

| PARAMETER       |                                    |            | TEST CONDITIONS       |                       |                          |                        | VALUES             |      |       |      |      |                     |      | UNIT |
|-----------------|------------------------------------|------------|-----------------------|-----------------------|--------------------------|------------------------|--------------------|------|-------|------|------|---------------------|------|------|
|                 |                                    |            | V <sub>I</sub><br>(V) | V <sub>O</sub><br>(V) | I <sub>O</sub>  <br>(μA) | V <sub>DD</sub><br>(V) | T <sub>LOW</sub> * |      | 25°C  |      |      | T <sub>HIGH</sub> * |      |      |
|                 |                                    |            |                       |                       |                          |                        | min.               | max. | min.  | typ  | max. | min.                | max. |      |
| I <sub>L</sub>  | Quiescent current                  | G, H types | 0/ 5                  |                       |                          | 5                      |                    | 1    |       | 0.02 | 1    |                     | 30   | μA   |
|                 |                                    |            | 0/10                  |                       |                          | 10                     |                    | 2    |       | 0.02 | 2    |                     | 60   |      |
|                 |                                    |            | 0/15                  |                       |                          | 15                     |                    | 4    |       | 0.02 | 4    |                     | 120  |      |
|                 |                                    |            | 0/20                  |                       |                          | 20                     |                    | 20   |       | 0.04 | 20   |                     | 600  |      |
|                 | E, F types                         | 0/ 5       |                       |                       | 5                        |                        | 4                  |      | 0.02  | 4    |      | 30                  |      |      |
|                 |                                    | 0/10       |                       |                       | 10                       |                        | 8                  |      | 0.02  | 8    |      | 60                  |      |      |
| 0/15            |                                    |            |                       | 15                    |                          | 16                     |                    | 0.02 | 16    |      | 120  |                     |      |      |
| V <sub>P</sub>  | Positive trigger threshold voltage | a          |                       |                       | 5                        | 2.2                    | 3.6                | 2.2  | 2.9   | 3.6  | 2.2  | 3.6                 | V    |      |
|                 |                                    |            |                       |                       | 10                       | 4.6                    | 7.1                | 4.6  | 5.9   | 7.1  | 4.6  | 7.1                 |      |      |
|                 |                                    |            |                       |                       | 15                       | 6.8                    | 10.8               | 6.8  | 8.8   | 10.8 | 6.8  | 10.8                |      |      |
|                 |                                    | b          |                       |                       | 5                        | 2.6                    | 4                  | 2.6  | 3.3   | 4    | 2.6  | 4                   |      |      |
|                 |                                    |            |                       |                       | 10                       | 5.6                    | 8.2                | 5.6  | 7     | 8.2  | 5.6  | 8.2                 |      |      |
|                 |                                    |            |                       |                       | 15                       | 6.3                    | 12.7               | 6.3  | 9.4   | 12.7 | 6.3  | 12.7                |      |      |
| V <sub>N</sub>  | Negative trigger threshold voltage | a          |                       |                       | 5                        | 0.9                    | 2.8                | 0.9  | 1.9   | 2.8  | 0.9  | 2.8                 | V    |      |
|                 |                                    |            |                       |                       | 10                       | 2.5                    | 5.2                | 2.5  | 3.9   | 5.2  | 2.5  | 5.2                 |      |      |
|                 |                                    |            |                       |                       | 15                       | 4                      | 7.4                | 4    | 5.8   | 7.4  | 4    | 7.4                 |      |      |
|                 |                                    | b          |                       |                       | 5                        | 1.4                    | 3.2                | 1.4  | 2.3   | 3.2  | 1.4  | 3.2                 |      |      |
|                 |                                    |            |                       |                       | 10                       | 3.4                    | 6.6                | 3.4  | 5.1   | 6.6  | 3.4  | 6.6                 |      |      |
|                 |                                    |            |                       |                       | 15                       | 4.8                    | 9.6                | 4.8  | 7.3   | 9.6  | 4.8  | 9.6                 |      |      |
| V <sub>H</sub>  | Hysteresis voltage                 | a          |                       |                       | 5                        | 0.3                    | 1.6                | 0.3  | 0.9   | 1.6  | 0.3  | 1.6                 | V    |      |
|                 |                                    |            |                       |                       | 10                       | 1.2                    | 3.4                | 1.2  | 2.3   | 3.4  | 1.2  | 3.4                 |      |      |
|                 |                                    |            |                       |                       | 15                       | 1.6                    | 5                  | 1.6  | 3.5   | 5    | 1.6  | 5                   |      |      |
|                 |                                    | b          |                       |                       | 5                        | 0.3                    | 1.6                | 0.3  | 0.9   | 1.6  | 0.3  | 1.6                 |      |      |
|                 |                                    |            |                       |                       | 10                       | 1.2                    | 3.4                | 1.2  | 2.3   | 3.4  | 1.2  | 3.4                 |      |      |
|                 |                                    |            |                       |                       | 15                       | 1.6                    | 5                  | 1.6  | 3.5   | 5    | 1.6  | 5                   |      |      |
| I <sub>OH</sub> | Output drive current               | G, H types | 0/ 5                  | 2.5                   |                          | 5                      | -2                 |      | -1.6  | -3.2 |      | -1.15               | mA   |      |
|                 |                                    |            | 0/ 5                  | 4.6                   |                          | 5                      | -0.64              |      | -0.51 | -1   |      | -0.36               |      |      |
|                 |                                    |            | 0/10                  | 9.5                   |                          | 10                     | -1.6               |      | -1.3  | -2.6 |      | -0.9                |      |      |
|                 |                                    |            | 0/15                  | 13.5                  |                          | 15                     | -4.2               |      | -3.4  | -6.8 |      | -2.4                |      |      |
|                 |                                    | E, F types | 0/ 5                  | 2.5                   |                          | 5                      | -1.53              |      | -1.36 | -3.2 |      | -1.1                |      |      |
|                 |                                    |            | 0/ 5                  | 4.6                   |                          | 5                      | -0.52              |      | -0.44 | -1   |      | -0.36               |      |      |
|                 |                                    |            | 0/10                  | 9.5                   |                          | 10                     | -1.3               |      | -1.1  | -2.6 |      | -0.9                |      |      |
|                 |                                    |            | 0/15                  | 13.5                  |                          | 15                     | -3.6               |      | -3.0  | -6.8 |      | -2.4                |      |      |
| V <sub>OH</sub> | Output high voltage                |            | 0/ 5                  |                       | < 1                      | 5                      | 4.95               |      | 4.95  |      |      | 4.95                | V    |      |
|                 |                                    |            | 0/10                  |                       | < 1                      | 10                     | 9.95               |      | 9.95  |      |      | 9.95                |      |      |
|                 |                                    |            | 0/15                  |                       | < 1                      | 15                     | 14.95              |      | 14.95 |      |      | 14.95               |      |      |

a: input on terminals 1, 5, 8, 12 or 2, 6, 9, 13; other inputs to  $V_{DD}$ .  
b: input on terminals 1 and 2, 5 and 6, 8 and 9, or 12 and 13;  
other inputs to  $V_{DD}$ .

| PARAMETER                         |                       |            | TEST CONDITIONS           |                       |                          |                        | VALUES           |                      |                   |      |                      |                   | UNIT                 |      |
|-----------------------------------|-----------------------|------------|---------------------------|-----------------------|--------------------------|------------------------|------------------|----------------------|-------------------|------|----------------------|-------------------|----------------------|------|
|                                   |                       |            | V <sub>I</sub><br>(V)     | V <sub>O</sub><br>(V) | I <sub>O</sub>  <br>(μA) | V <sub>DD</sub><br>(V) | T <sub>LOW</sub> |                      | 25°C              |      |                      | T <sub>HIGH</sub> |                      |      |
|                                   |                       |            |                           |                       |                          |                        | min.             | max.                 | min.              | typ  | max.                 | min.              |                      | max. |
| V <sub>OL</sub>                   | Output low voltage    |            | 5 / 0<br>10 / 0<br>15 / 0 |                       | < 1<br>< 1<br>< 1        | 5<br>10<br>15          |                  | 0.05<br>0.05<br>0.05 |                   |      | 0.05<br>0.05<br>0.05 |                   | 0.05<br>0.05<br>0.05 | V    |
| I <sub>OL</sub>                   | Output sink current   | G, H types | 0 / 5                     | 0.4                   |                          | 5                      | 0.64             |                      | 0.51              | 1    |                      | 0.36              |                      | mA   |
|                                   |                       |            | 0 / 10                    | 0.5                   |                          | 10                     | 1.6              |                      | 1.3               | 2.6  |                      | 0.9               |                      |      |
|                                   |                       |            | 0 / 15                    | 1.5                   |                          | 15                     | 4.2              |                      | 3.4               | 6.8  |                      | 2.4               |                      |      |
|                                   |                       | E, F types | 0 / 5                     | 0.4                   |                          | 5                      | 0.52             |                      | 0.44              | 1    |                      | 0.36              |                      |      |
|                                   |                       |            | 0 / 10                    | 0.5                   |                          | 10                     | 1.3              |                      | 1.1               | 2.6  |                      | 0.9               |                      |      |
|                                   |                       |            | 0 / 15                    | 1.5                   |                          | 15                     | 3.6              |                      | 3.0               | 6.8  |                      | 2.4               |                      |      |
| I <sub>IH</sub> , I <sub>IL</sub> | Input leakage current | G, H types | 0 / 18                    | Any input             | 18                       |                        | ±0.1             |                      | ±10 <sup>-5</sup> | ±0.1 |                      | ±1                | μA                   |      |
|                                   |                       | E, F types | 0 / 15                    |                       | 15                       |                        | ±0.3             |                      | ±10 <sup>-5</sup> | ±0.3 |                      | ±1                |                      |      |
| C <sub>I</sub>                    | Input capacitance     |            |                           | Any input             |                          |                        |                  |                      | 5                 | 7.5  |                      |                   | pF                   |      |

- \*  $T_{LOW} = -55^\circ\text{C}$  for G, H devices;  $-40^\circ\text{C}$  for E, F devices.
- \*  $T_{HIGH} = +125^\circ\text{C}$  for G, H devices;  $+85^\circ\text{C}$  for E, F devices.

The Noise Margin for both "1" and "0" level is:

1 V min. with  $V_{DD} = 5$  V  
 2 V min. with  $V_{DD} = 10$  V  
 2.5 V min. with  $V_{DD} = 15$  V

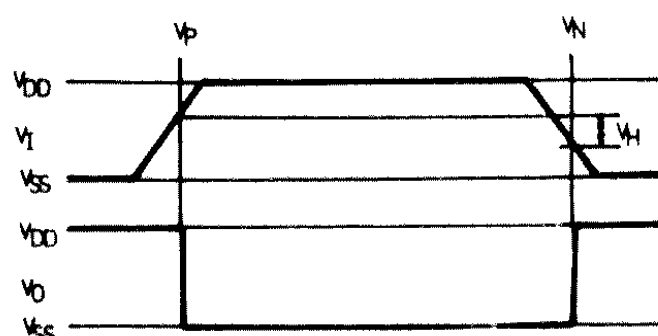
## DYNAMIC ELECTRICAL CHARACTERISTICS

( $T_A = 25^\circ\text{C}$ ; input  $t_r, t_f = 20$  ns,  $C_L = 50$  pF,  $R_L = 200$  kohm)

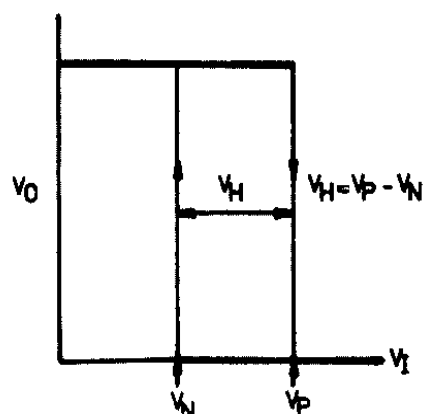
| PARAMETER        |                        | TEST CONDITIONS | VALUES              |      |      | UNIT |      |
|------------------|------------------------|-----------------|---------------------|------|------|------|------|
|                  |                        |                 | V <sub>DD</sub> (V) | min. | typ. |      | max. |
| t <sub>PHL</sub> | Propagation delay time |                 | 5                   |      | 190  | 380  | ns   |
| t <sub>PLH</sub> |                        |                 | 10                  |      | 90   | 180  |      |
|                  |                        |                 | 15                  |      | 65   | 90   |      |
| t <sub>THL</sub> | Transition time        |                 | 5                   |      | 100  | 200  | ns   |
|                  |                        |                 | 10                  |      | 50   | 100  |      |
| t <sub>THL</sub> |                        |                 | 15                  |      | 40   | 80   |      |

Fig. 1 Hysteresis definition, characteristic and test setup

(a) Definition of  $V_P$ ,  $V_N$  and  $V_H$



(b) Transfer characteristic of 1 of 4 gates



(c) Test setup

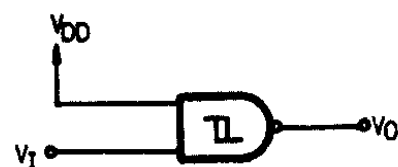
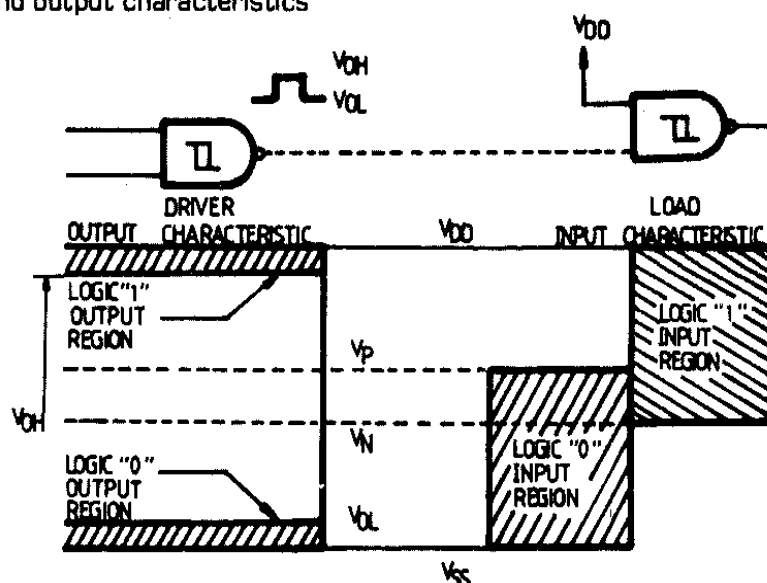


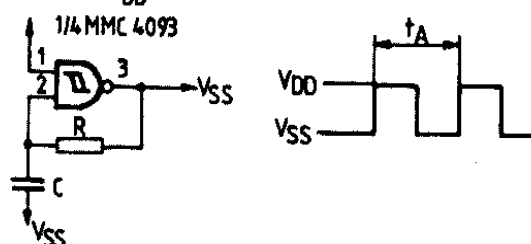
Fig. 2 Input and output characteristics



## APPLICATION

### Astable multivibrator

TO CONTROL  
SIGNAL OR TO  $V_{DD}$



$$t_A = 2RC \ln \left[ \left( \frac{V_P}{V_N} \right) \left( \frac{V_{DD} - V_N}{V_{DD} - V_P} \right) \right]$$

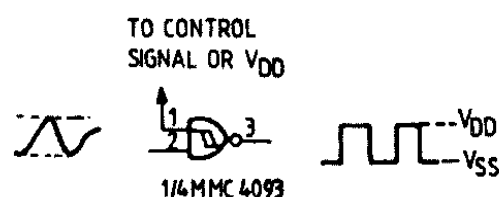
$$50k \leq R \leq 1M\Omega$$

$$100pF \leq C \leq 1\mu F$$

For the range of F and C given  $2\mu s < t_A < 0.4s$

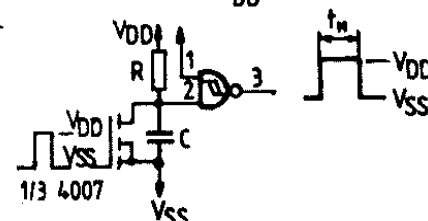
### Wave shaper

Frequency range of wave shaper is from DC to 1MHz



### Monostable multivibrator

TO CONTROL  
SIGNAL OR  $V_{DD}$



$$t_M = RC \ln \frac{V_{DD}}{V_{DD} - V_P}$$

$$50k \leq R \leq 1M\Omega$$

$$100pF \leq C \leq 1\mu F$$

For the range of R and C given  $5\mu s \leq t_M \leq 1s$