

## 1. General Description

The HEF4093 is a quad two-input NAND gate. Each input has a Schmitt trigger circuit. The gate switches at different points for positive-going and negative-going signals. The difference between the positive voltage ( $V_{T+}$ ) and the negative voltage ( $V_{T-}$ ) is defined as hysteresis voltage ( $V_H$ ). It operates over a recommended  $V_{DD}$  power supply range of 3V to 15V referenced to  $V_{SS}$  (usually ground). Unused inputs must be connected to  $V_{DD}$ ,  $V_{SS}$ , or another input.

## 2. Features and Benefits

- Wide supply voltage range from 3V to 15V
- Schmitt trigger input discrimination
- Fully static operation
- 5V, 10V, and 15V parametric ratings
- Standardized symmetrical output characteristics
- Specified from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Packaging information: SOP14 / TSSOP14

## 3. Ordering Information

Table 1. Ordering information

| Type number | Package  |                                                                        |          |
|-------------|----------|------------------------------------------------------------------------|----------|
|             | Name     | Description                                                            | Quantity |
| HEF4093BT   | SOP-14   | plastic small outline package; 16 leads; body width 3.9 mm             | 2500     |
| HEF4093BTT  | TSSOP-14 | plastic thin shrink small outline package; 16 leads; body width 4.4 mm | 2500     |

## 4. Function Diagram

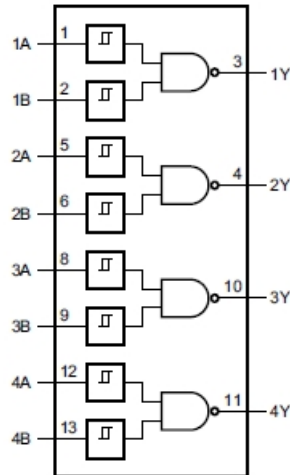


Fig. 1. Functional diagram

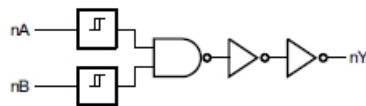
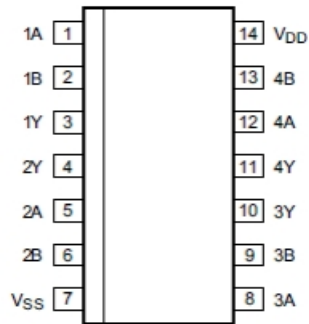


Fig. 2. Logic diagram (one gate)

## 5. Pinning Information

### Pinning



### Pin description

Table 2. Pin description

| Symbol          | Pin | Description    |
|-----------------|-----|----------------|
| 1A              | 1   | data input     |
| 1B              | 2   | data input     |
| 1Y              | 3   | data output    |
| 2Y              | 4   | data output    |
| 2A              | 5   | data input     |
| 2B              | 6   | data input     |
| V <sub>SS</sub> | 7   | ground (0V)    |
| 3A              | 8   | data input     |
| 3B              | 9   | data input     |
| 3Y              | 10  | data output    |
| 4Y              | 11  | data output    |
| 4A              | 12  | data input     |
| 4B              | 13  | data input     |
| V <sub>DD</sub> | 14  | supply voltage |

## 6. Functional Description

### Function table

Table 3. Function table

H = HIGH voltage level; L = LOW voltage level.

| Input |    | Output |
|-------|----|--------|
| nA    | nB | nY     |
| L     | L  | H      |
| L     | H  | H      |
| H     | L  | H      |
| H     | H  | L      |

## 7. Absolute Maximum Ratings

Table 4. Absolute Maximum Ratings

(Voltages are referenced to  $V_{SS}$  (ground = 0 V), unless otherwise specified.)

| Symbol    | Parameter               | Conditions            |           | Min. | Max.         | Unit |
|-----------|-------------------------|-----------------------|-----------|------|--------------|------|
| $V_{DD}$  | supply voltage          | -                     |           | -0.5 | +18          | V    |
| $I_{IK}$  | DC input current        | any one input         |           | -    | $\pm 10$     | mA   |
| $V_I$     | input voltage           | all inputs            |           | -0.5 | $V_{DD}+0.5$ | V    |
| $T_{stg}$ | storage temperature     | -                     |           | -65  | +150         | °C   |
| $P_{tot}$ | total power dissipation | -                     |           | -    | 500          | mW   |
| P         | device dissipation      | per output transistor |           | -    | 100          | mW   |
| $T_L$     | Soldering temperature   | 10s                   | SOP/TSSOP | 260  |              | °C   |

## 8. Recommended Operating Conditions

Table 5. Recommended Operating Conditions

| Symbol    | Parameter           | Conditions  | Min. | Typ. | Max. | Unit |
|-----------|---------------------|-------------|------|------|------|------|
| $V_{DD}$  | supply voltage      | -           | 3    | -    | 15   | V    |
| $T_{amb}$ | ambient temperature | in free air | -40  | -    | +125 | °C   |

## 9. Electrical Characteristics

Table 6. DC Characteristics 1

$T_{amb} = 25\text{ }^{\circ}\text{C}$ , voltages are referenced to  $V_{SS}$  (ground = 0 V), unless otherwise specified.

| Symbol   | Parameter                 | Conditions (V) |          |          | $T_{amb}=25\text{ }^{\circ}\text{C}$ |      |         | Unit          |
|----------|---------------------------|----------------|----------|----------|--------------------------------------|------|---------|---------------|
|          |                           | $V_O$          | $V_{IN}$ | $V_{DD}$ | Min.                                 | Typ. | Max.    |               |
| $I_{DD}$ | supply current            | -              | 0, 5     | 5        | -                                    | -    | 1       | $\mu\text{A}$ |
|          |                           | -              | 0, 10    | 10       | -                                    | -    | 2       | $\mu\text{A}$ |
|          |                           | -              | 0, 15    | 15       | -                                    | -    | 4       | $\mu\text{A}$ |
| $I_{OL}$ | LOW-level output current  | 0.4            | 0, 5     | 5        | 0.51                                 | 1    | -       | mA            |
|          |                           | 0.5            | 0, 10    | 10       | 1.3                                  | 2.6  | -       | mA            |
|          |                           | 1.5            | 0, 15    | 15       | 3.4                                  | 6.8  | -       | mA            |
| $I_{OH}$ | HIGH-level output current | 4.6            | 0, 5     | 5        | -0.51                                | -1   | -       | mA            |
|          |                           | 2.5            | 0, 5     | 5        | -1.6                                 | -3.2 | -       | mA            |
|          |                           | 9.5            | 0, 10    | 10       | -1.3                                 | -2.6 | -       | mA            |
|          |                           | 13.5           | 0, 15    | 15       | -3.4                                 | -6.8 | -       | mA            |
| $V_{OL}$ | LOW-level output voltage  | -              | 0, 5     | 5        | -                                    | 0    | 0.05    | V             |
|          |                           | -              | 0, 10    | 10       | -                                    | 0    | 0.05    | V             |
|          |                           | -              | 0, 15    | 15       | -                                    | 0    | 0.05    | V             |
| $V_{OH}$ | HIGH-level output voltage | -              | 0, 5     | 5        | 4.95                                 | 5    | -       | V             |
|          |                           | -              | 0, 10    | 10       | 9.95                                 | 10   | -       | V             |
|          |                           | -              | 0, 15    | 15       | 14.95                                | 15   | -       | V             |
| $I_I$    | input leakage current     | -              | 0, 15    | 15       | -                                    | -    | $\pm 1$ | $\mu\text{A}$ |

Table 7. DC Characteristics 2

$T_{amb} = -40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ , voltages are referenced to  $V_{SS}$  (ground = 0 V), unless otherwise specified.

| Symbol   | Parameter                | Conditions (V) |          |          | $T_{amb}=-40\text{ }^{\circ}\text{C}$ |      | $T_{amb}=+85\text{ }^{\circ}\text{C}$ |      | $T_{amb}=+125\text{ }^{\circ}\text{C}$ |      | Unit          |
|----------|--------------------------|----------------|----------|----------|---------------------------------------|------|---------------------------------------|------|----------------------------------------|------|---------------|
|          |                          | $V_O$          | $V_{IN}$ | $V_{DD}$ | Min.                                  | Max. | Min.                                  | Max. | Min.                                   | Max. |               |
| $I_{DD}$ | supply current           | -              | 0, 5     | 5        | -                                     | 1    | -                                     | 30   | -                                      | 30   | $\mu\text{A}$ |
|          |                          | -              | 0, 10    | 10       | -                                     | 2    | -                                     | 60   | -                                      | 60   | $\mu\text{A}$ |
|          |                          | -              | 0, 15    | 15       | -                                     | 4    | -                                     | 120  | -                                      | 120  | $\mu\text{A}$ |
| $I_{OL}$ | LOW-level output current | 0.4            | 0, 5     | 5        | 0.61                                  | -    | 0.42                                  | -    | 0.36                                   | -    | mA            |
|          |                          | 0.5            | 0, 10    | 10       | 1.5                                   | -    | 1.1                                   | -    | 0.9                                    | -    | mA            |
|          |                          | 1.5            | 0, 15    | 15       | 4                                     | -    | 2.8                                   | -    | 2.4                                    | -    | mA            |

## Quad 2-input Nand Schmitt Gate

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|          |                           |      |       |    |       |         |       |         |       |         |         |
|----------|---------------------------|------|-------|----|-------|---------|-------|---------|-------|---------|---------|
| $I_{OH}$ | HIGH-level output current | 4.6  | 0, 5  | 5  | -0.61 | -       | -0.42 | -       | -0.36 | -       | mA      |
|          |                           | 2.5  | 0, 5  | 5  | -1.8  | -       | -1.3  | -       | -1.15 | -       | mA      |
|          |                           | 9.5  | 0, 10 | 10 | -1.5  | -       | -1.1  | -       | -0.9  | -       | mA      |
|          |                           | 13.5 | 0, 15 | 15 | -4    | -       | -2.8  | -       | -2.4  | -       | mA      |
| $V_{OL}$ | LOW-level output voltage  | -    | 0, 5  | 5  | -     | 0.05    | -     | 0.05    | -     | 0.05    | V       |
|          |                           | -    | 0, 10 | 10 | -     | 0.05    | -     | 0.05    | -     | 0.05    | V       |
|          |                           | -    | 0, 15 | 15 | -     | 0.05    | -     | 0.05    | -     | 0.05    | V       |
| $V_{OH}$ | HIGH-level output voltage | -    | 0, 5  | 5  | 4.95  | -       | 4.95  | -       | 4.95  | -       | V       |
|          |                           | -    | 0, 10 | 10 | 9.95  | -       | 9.95  | -       | 9.95  | -       | V       |
|          |                           | -    | 0, 15 | 15 | 14.95 | -       | 14.95 | -       | 14.95 | -       | V       |
| $I_I$    | input leakage current     | -    | 0, 15 | 15 | -     | $\pm 1$ | -     | $\pm 1$ | -     | $\pm 1$ | $\mu A$ |

Table 8. AC Characteristics

 $T_{amb}=25^{\circ}C$ ,  $V_{SS}=0V$ ,  $t_r$ ,  $t_f=20ns$ ,  $C_L=50pF$ ,  $R_L=200k\Omega$ , unless otherwise.

| Symbol             | Parameter              | Conditions   |              | Min. | Typ. | Max. | Unit |
|--------------------|------------------------|--------------|--------------|------|------|------|------|
| $t_{PHL}, t_{PLH}$ | propagation delay time | see Figure 4 | $V_{DD}=5V$  | -    | 45   | 100  | ns   |
|                    |                        |              | $V_{DD}=10V$ | -    | 25   | 60   | ns   |
|                    |                        |              | $V_{DD}=15V$ | -    | 20   | 50   | ns   |
| $t_{THL}, t_{TLH}$ | transition time        | see Figure 4 | $V_{DD}=5V$  | -    | 30   | 70   | ns   |
|                    |                        |              | $V_{DD}=10V$ | -    | 25   | 60   | ns   |
|                    |                        |              | $V_{DD}=15V$ | -    | 20   | 50   | ns   |
| $C_i$              | input capacitance      | any input    |              | -    | 5    | 7.5  | pF   |

Table 9. Transfer Characteristics 1

 $T_{amb}=25^{\circ}C$ , voltages are referenced to  $V_{SS}$ (ground=0V), unless otherwise specified.

| Symbol   | Parameter                        | Conditions (V) |          |          | $T_{amb}=25^{\circ}C$ |      |      | Unit |
|----------|----------------------------------|----------------|----------|----------|-----------------------|------|------|------|
|          |                                  | $V_O$          | $V_{IN}$ | $V_{DD}$ | Min.                  | Typ. | Max. |      |
| $V_{T+}$ | positive-going threshold voltage | -              | [1]      | 5        | 2.2                   | 2.9  | 3.6  | V    |
|          |                                  | -              | [1]      | 10       | 4.6                   | 5.9  | 7.1  | V    |
|          |                                  | -              | [1]      | 15       | 6.8                   | 8.8  | 10.8 | V    |
|          |                                  | -              | [2]      | 5        | 2.6                   | 3.3  | 4    | V    |
|          |                                  | -              | [2]      | 10       | 5.6                   | 7    | 8.2  | V    |
|          |                                  | -              | [2]      | 15       | 6.3                   | 9.4  | 12.7 | V    |

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|          |                                  |   |     |    |     |     |     |   |
|----------|----------------------------------|---|-----|----|-----|-----|-----|---|
| $V_{T-}$ | negative-going threshold voltage | - | [1] | 5  | 0.9 | 1.9 | 2.8 | V |
|          |                                  | - | [1] | 10 | 2.5 | 3.9 | 5.2 | V |
|          |                                  | - | [1] | 15 | 4   | 5.8 | 7.4 | V |
|          |                                  | - | [2] | 5  | 1.4 | 2.3 | 3.2 | V |
|          |                                  | - | [2] | 10 | 3.4 | 5.1 | 6.6 | V |
|          |                                  | - | [2] | 15 | 4.8 | 7.3 | 9.6 | V |
| $V_H$    | hysteresis voltage               | - | [1] | 5  | 0.3 | 0.9 | 1.6 | V |
|          |                                  | - | [1] | 10 | 1.2 | 2.3 | 3.4 | V |
|          |                                  | - | [1] | 15 | 1.6 | 3.5 | 5   | V |
|          |                                  | - | [2] | 5  | 0.3 | 0.9 | 1.6 | V |
|          |                                  | - | [2] | 10 | 1.2 | 2.3 | 3.4 | V |
|          |                                  | - | [2] | 15 | 1.6 | 3.5 | 5   | V |

[1] Input on terminals 1, 5, 8, 12 or 2, 6, 9, 13; other inputs to  $V_{DD}$ .[2] Input on terminals 1 and 2, 5 and 6, 8 and 9 or 12 and 13; other inputs to  $V_{DD}$ .

[3] See Figure 5 and Figure 6.

**Table 10. Transfer Characteristics 2**

$T_{amb} = -40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ , voltages are referenced to GND (ground = 0 V), unless otherwise specified.

| Symbol   | Parameter                        | Conditions (V) |          |          | $T_{amb}=-40\text{ }^{\circ}\text{C}$ |      | $T_{amb}=+85\text{ }^{\circ}\text{C}$ |      | $T_{amb}=+125\text{ }^{\circ}\text{C}$ |      | Unit |
|----------|----------------------------------|----------------|----------|----------|---------------------------------------|------|---------------------------------------|------|----------------------------------------|------|------|
|          |                                  | $V_O$          | $V_{IN}$ | $V_{DD}$ | Min.                                  | Max. | Min.                                  | Max. | Min.                                   | Max. |      |
| $V_{T+}$ | positive-going threshold voltage | -              | [1]      | 5        | 2.2                                   | 3.6  | 2.2                                   | 3.6  | 2.2                                    | 3.6  | V    |
|          |                                  | -              | [1]      | 10       | 4.6                                   | 7.1  | 4.6                                   | 7.1  | 4.6                                    | 7.1  | V    |
|          |                                  | -              | [1]      | 15       | 6.8                                   | 10.8 | 6.8                                   | 10.8 | 6.8                                    | 10.8 | V    |
|          |                                  | -              | [2]      | 5        | 2.6                                   | 4    | 2.6                                   | 4    | 2.6                                    | 4    | V    |
|          |                                  | -              | [2]      | 10       | 5.6                                   | 8.2  | 5.6                                   | 8.2  | 5.6                                    | 8.2  | V    |
|          |                                  | -              | [2]      | 15       | 6.3                                   | 12.7 | 6.3                                   | 12.7 | 6.3                                    | 12.7 | V    |
| $V_{T-}$ | negative-going threshold voltage | -              | [1]      | 5        | 0.9                                   | 2.8  | 0.9                                   | 2.8  | 0.9                                    | 2.8  | V    |
|          |                                  | -              | [1]      | 10       | 2.5                                   | 5.2  | 2.5                                   | 5.2  | 2.5                                    | 5.2  | V    |
|          |                                  | -              | [1]      | 15       | 4                                     | 7.4  | 4                                     | 7.4  | 4                                      | 7.4  | V    |
|          |                                  | -              | [2]      | 5        | 1.4                                   | 3.2  | 1.4                                   | 3.2  | 1.4                                    | 3.2  | V    |
|          |                                  | -              | [2]      | 10       | 3.4                                   | 6.6  | 3.4                                   | 6.6  | 3.4                                    | 6.6  | V    |
|          |                                  | -              | [2]      | 15       | 4.8                                   | 9.6  | 4.8                                   | 9.6  | 4.8                                    | 9.6  | V    |
| $V_H$    | hysteresis voltage               | -              | [1]      | 5        | 0.3                                   | 1.6  | 0.3                                   | 1.6  | 0.3                                    | 1.6  | V    |
|          |                                  | -              | [1]      | 10       | 1.2                                   | 3.4  | 1.2                                   | 3.4  | 1.2                                    | 3.4  | V    |
|          |                                  | -              | [1]      | 15       | 1.6                                   | 5    | 1.6                                   | 5    | 1.6                                    | 5    | V    |
|          |                                  | -              | [2]      | 5        | 0.3                                   | 1.6  | 0.3                                   | 1.6  | 0.3                                    | 1.6  | V    |
|          |                                  | -              | [2]      | 10       | 1.2                                   | 3.4  | 1.2                                   | 3.4  | 1.2                                    | 3.4  | V    |
|          |                                  | -              | [2]      | 15       | 1.6                                   | 5    | 1.6                                   | 5    | 1.6                                    | 5    | V    |

[1] Input on terminals 1, 5, 8, 12 or 2, 6, 9, 13; other inputs to  $V_{DD}$ .

[2] Input on terminals 1 and 2, 5 and 6, 8 and 9 or 12 and 13; other inputs to  $V_{DD}$ .

[3] See Figure 5 and Figure 6.

## 10. Waveforms and test circuit

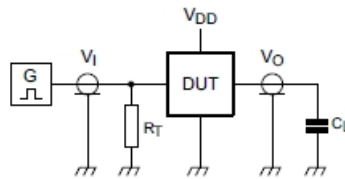


Fig. 3. Test circuit for switching times

Definitions for test circuit:

DUT=Device Under Test.

$C_L$ =Load capacitance including jig and probe capacitance.

$R_T$ =Termination resistance should be equal to the output impedance  $Z_o$  of the pulse generator.

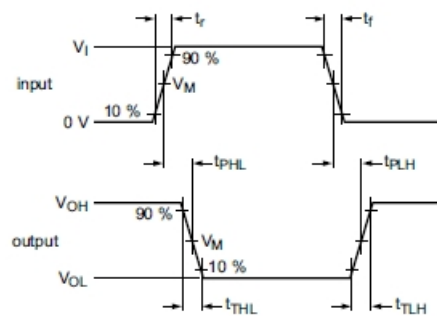


Fig. 4. Propagation delay and output transition time

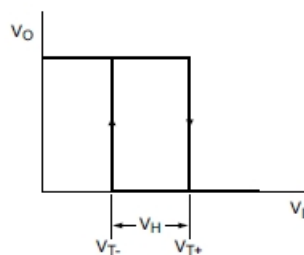


Fig. 5. Transfer characteristic

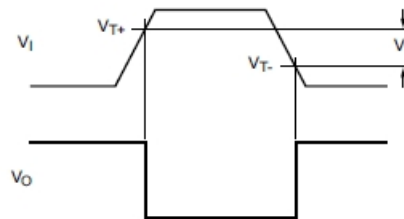
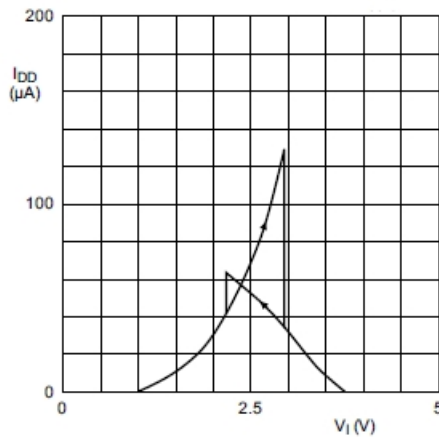
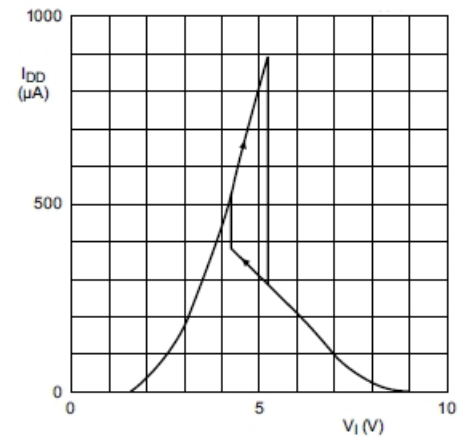


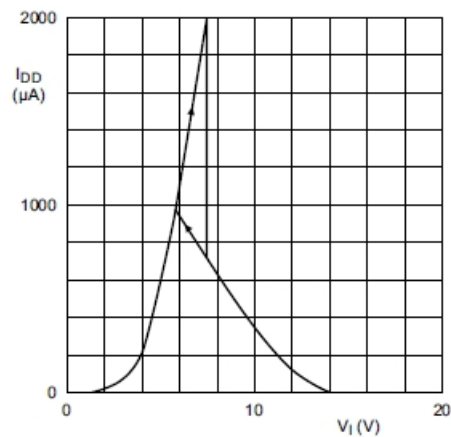
Fig. 6. Waveforms showing definition of  $V_{T+}$  and  $V_{T-}$  (between limits at 30% and 70%) and  $V_H$



a.  $V_{DD} = 5 \text{ V}$ ;  $T_{amb} = 25 \text{ °C}$



b.  $V_{DD} = 10 \text{ V}$ ;  $T_{amb} = 25 \text{ °C}$



c.  $V_{DD} = 15 \text{ V}$ ;  $T_{amb} = 25 \text{ °C}$

Fig. 7. Typical drain current as a function of input

**Table 13. Measurement points**

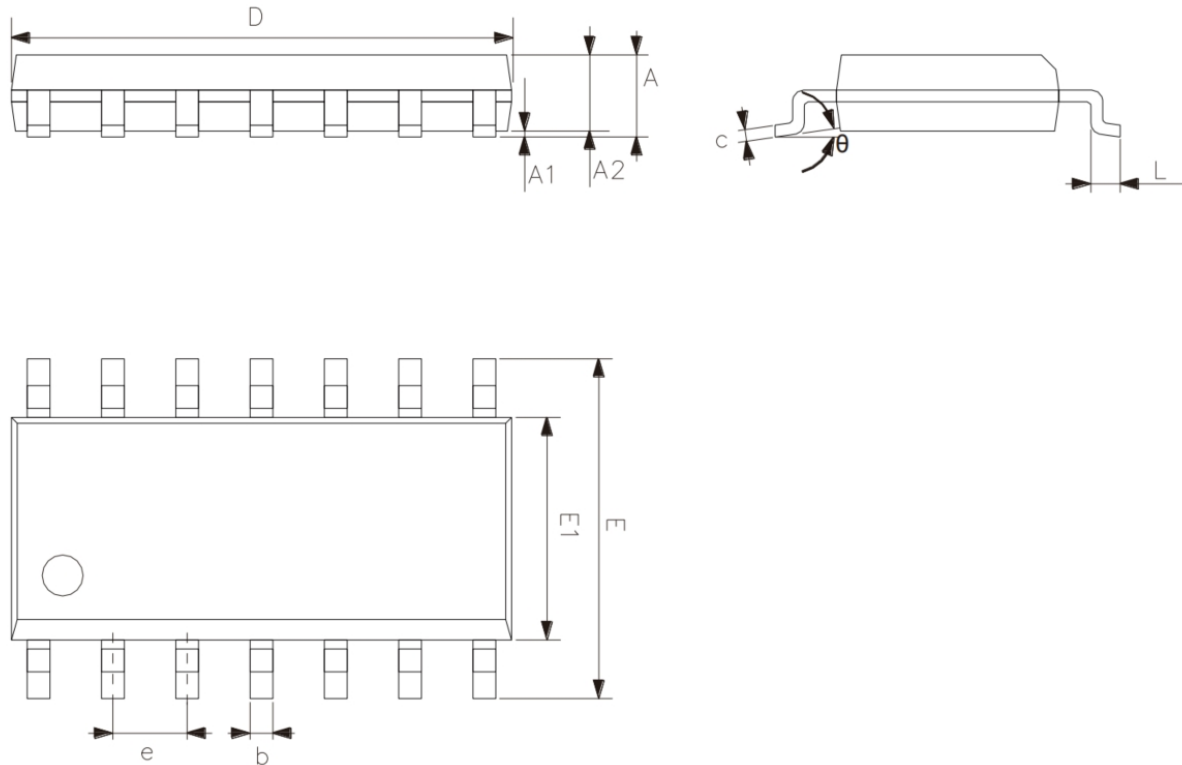
| Supply voltage | Input               | Output              |
|----------------|---------------------|---------------------|
| $V_{DD}$       | $V_M$               | $V_M$               |
| 5V to 15V      | $0.5 \times V_{DD}$ | $0.5 \times V_{DD}$ |

**Table 14. Test data**

| Supply voltage | Input                |                    | Load  |
|----------------|----------------------|--------------------|-------|
| $V_{DD}$       | $V_I$                | $t_r, t_f$         | $C_L$ |
| 5V to 15V      | $V_{SS}$ or $V_{DD}$ | $\leq 20\text{ns}$ | 50pF  |

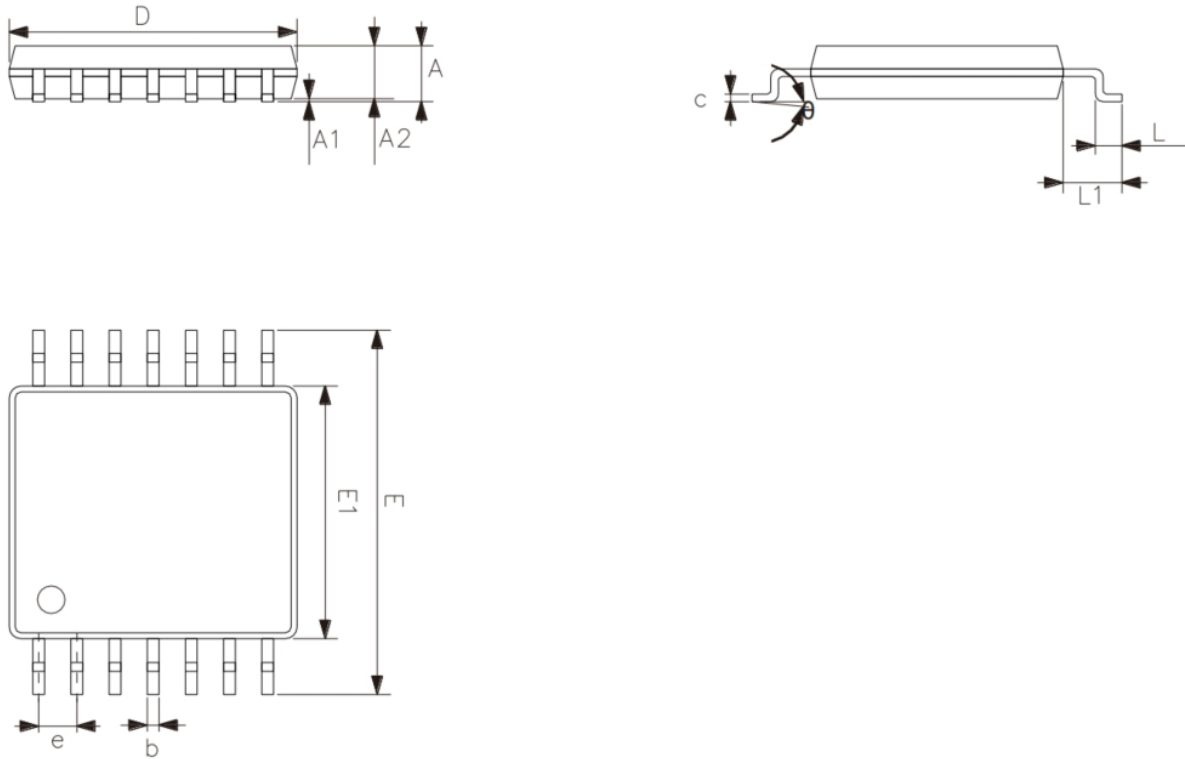
## 11. Package Outline

### SOP-14



| Symbol   | Dimensions In Millimeters |      |
|----------|---------------------------|------|
|          | Min.                      | Max. |
| A        | 1.50                      | 1.75 |
| A1       | 0.05                      | 0.25 |
| A2       | 1.30                      | -    |
| b        | 0.33                      | 0.50 |
| c        | 0.19                      | 0.25 |
| D        | 8.43                      | 8.76 |
| E        | 5.80                      | 6.25 |
| E1       | 3.75                      | 4.00 |
| e        | 1.27                      |      |
| L        | 0.40                      | 0.89 |
| $\theta$ | 0°                        | 8°   |

## TSSOP-14



| Symbol | Dimensions In Millimeters |      |
|--------|---------------------------|------|
|        | Min.                      | Max. |
| A      | —                         | 1.20 |
| A1     | 0.05                      | 0.15 |
| A2     | 0.80                      | 1.05 |
| b      | 0.19                      | 0.30 |
| c      | 0.09                      | 0.20 |
| D      | 4.90                      | 5.10 |
| E1     | 4.30                      | 4.50 |
| E      | 6.20                      | 6.60 |
| e      | 0.65                      |      |
| L      | 0.45                      | 0.75 |
| L1     | 1.00                      |      |
| θ      | 0°                        | 8°   |

## 12. Abbreviations

| Acronym | Description                             |
|---------|-----------------------------------------|
| CMOS    | Complementary Metal-Oxide Semiconductor |
| DUT     | Device Under Test                       |
| ESD     | ElectroStatic Discharge                 |
| HBM     | Human Body Model                        |
| CDM     | Charged Device Model                    |
| TTL     | Transistor-Transistor Logic             |

## 13. Revision History

| Document ID      | Release Date | Data sheet status | Change notice | Supersedes |
|------------------|--------------|-------------------|---------------|------------|
| HEF4093 Rev. 1.0 | Aug 08, 2024 | Product datasheet |               |            |