

# HEF4093B

## Quad 2-input NAND Schmitt trigger

Rev. 11 — 5 September 2024

Product data sheet

### 1. General description

The HEF4093B is a quad 2-input NAND gate with Schmitt-trigger inputs. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of  $V_{DD}$ . Schmitt trigger inputs transform slowly changing input signals into sharply defined jitter-free output signals.

### 2. Features and benefits

- Schmitt trigger input discrimination
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Wide supply voltage range from 3.0 V to 15.0 V
- CMOS low power dissipation
- High noise immunity
- Standardized symmetrical output characteristics
- Complies with JEDEC standard JESD 13-B
- ESD protection:
  - HBM: ANSI/ESDA/JEDEC JS-001 class 2 exceeds 2000 V
  - CDM: ANSI/ESDA/JEDEC JS-002 class C3 exceeds 1000 V
- Specified from -40 °C to +85 °C and -40 °C to +125 °C

### 3. Applications

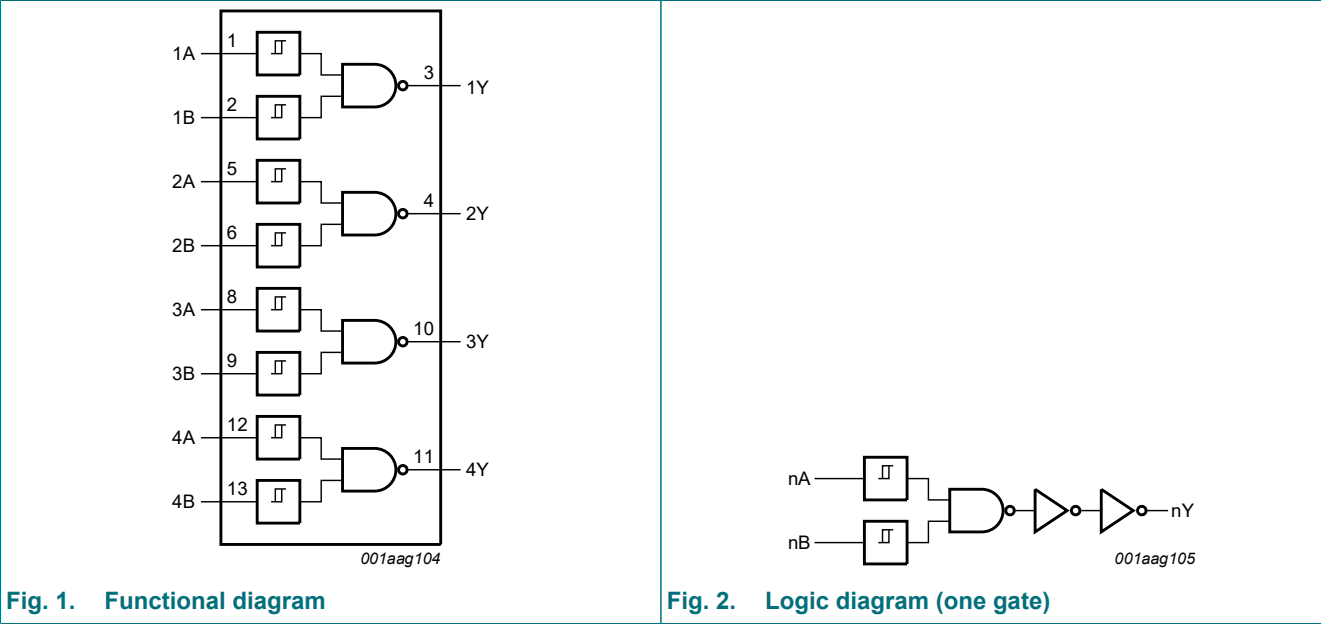
- Wave and pulse shapers
- Astable multivibrators
- Monostable multivibrators

### 4. Ordering information

Table 1. Ordering information

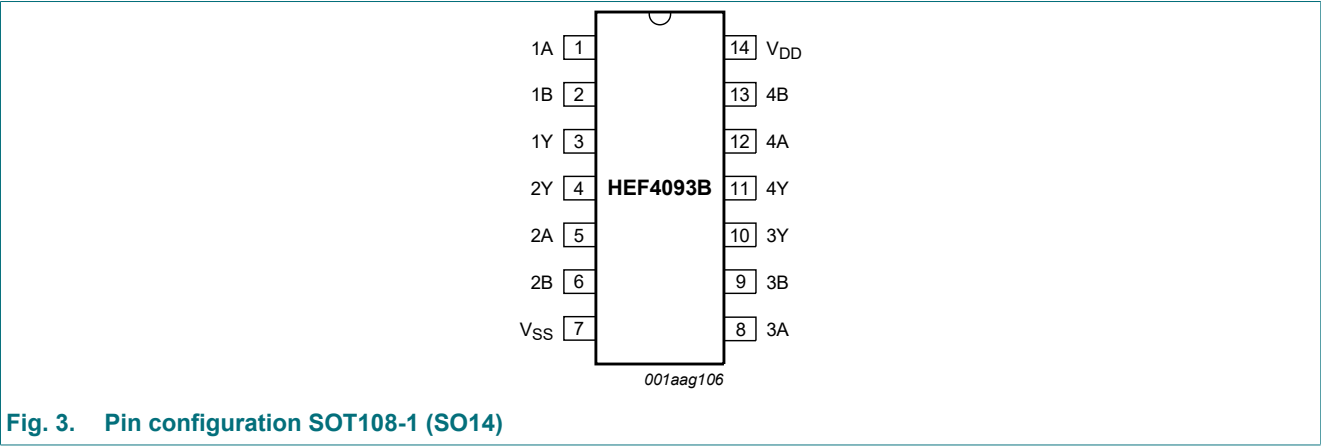
| Type number               | Package           |      |                                                               |                          |
|---------------------------|-------------------|------|---------------------------------------------------------------|--------------------------|
|                           | Temperature range | Name | Description                                                   | Version                  |
| <a href="#">HEF4093BT</a> | -40 °C to +125 °C | SO14 | plastic small outline package; 14 leads;<br>body width 3.9 mm | <a href="#">SOT108-1</a> |

5. Functional diagram



6. Pinning information

6.1. Pinning



6.2. Pin description

Table 2. Pin description

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

7. Functional description

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      |

8. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to  $V_{SS} = 0\text{ V}$  (ground).

| Symbol    | Parameter               | Conditions                                             | Min  | Max            | Unit |
|-----------|-------------------------|--------------------------------------------------------|------|----------------|------|
| $V_{DD}$  | supply voltage          |                                                        | -0.5 | +18            | V    |
| $I_{IK}$  | input clamping current  | $V_I < -0.5\text{ V}$ or $V_I > V_{DD} + 0.5\text{ V}$ | -    | $\pm 10$       | mA   |
| $V_I$     | input voltage           |                                                        | -0.5 | $V_{DD} + 0.5$ | V    |
| $I_{OK}$  | output clamping current | $V_O < -0.5\text{ V}$ or $V_O > V_{DD} + 0.5\text{ V}$ | -    | $\pm 10$       | mA   |
| $I_{I/O}$ | input/output current    |                                                        | -    | $\pm 10$       | mA   |
| $I_{DD}$  | supply current          |                                                        | -    | 50             | mA   |
| $T_{stg}$ | storage temperature     |                                                        | -65  | +150           | °C   |
| $T_{amb}$ | ambient temperature     |                                                        | -40  | +125           | °C   |
| $P_{tot}$ | total power dissipation | $T_{amb} = -40\text{ °C}$ to $+125\text{ °C}$ [1]      | -    | 500            | mW   |
| P         | power dissipation       | per output                                             | -    | 100            | mW   |

[1] For SOT108-1 (SO14) package:  $P_{tot}$  derates linearly with 10.1 mW/K above 100 °C.

9. Recommended operating conditions

Table 5. Recommended operating conditions

| Symbol    | Parameter           | Conditions  | Min | Max      | Unit |
|-----------|---------------------|-------------|-----|----------|------|
| $V_{DD}$  | supply voltage      |             | 3   | 15       | V    |
| $V_I$     | input voltage       |             | 0   | $V_{DD}$ | V    |
| $T_{amb}$ | ambient temperature | in free air | -40 | +125     | °C   |

10. Static characteristics

Table 6. Static characteristics

$V_{SS} = 0\text{ V}$ ;  $V_I = V_{SS}$  or  $V_{DD}$ ; unless otherwise specified.

| Symbol   | Parameter                 | Conditions                     | $V_{DD}$ | $T_{amb} = -40\text{ °C}$ |     | $T_{amb} = +25\text{ °C}$ |     | $T_{amb} = +85\text{ °C}$ |     | $T_{amb} = +125\text{ °C}$ |     | Unit |
|----------|---------------------------|--------------------------------|----------|---------------------------|-----|---------------------------|-----|---------------------------|-----|----------------------------|-----|------|
|          |                           |                                |          | Min                       | Max | Min                       | Max | Min                       | Max | Min                        | Max |      |
| $V_{OH}$ | HIGH-level output voltage | $ I_O  < 1\text{ }\mu\text{A}$ | 5 V      | 4.95                      | -   | 4.95                      | -   | 4.95                      | -   | 4.95                       | -   | V    |
|          |                           |                                | 10 V     | 9.95                      | -   | 9.95                      | -   | 9.95                      | -   | 9.95                       | -   | V    |
|          |                           |                                | 15 V     | 14.95                     | -   | 14.95                     | -   | 14.95                     | -   | 14.95                      | -   | V    |

| Symbol          | Parameter                 | Conditions                                            | V <sub>DD</sub> | T <sub>amb</sub> = -40 °C |       | T <sub>amb</sub> = +25 °C |      | T <sub>amb</sub> = +85 °C |       | T <sub>amb</sub> = +125 °C |       | Unit |
|-----------------|---------------------------|-------------------------------------------------------|-----------------|---------------------------|-------|---------------------------|------|---------------------------|-------|----------------------------|-------|------|
|                 |                           |                                                       |                 | Min                       | Max   | Min                       | Max  | Min                       | Max   | Min                        | Max   |      |
| V <sub>OL</sub> | LOW-level output voltage  | I <sub>O</sub>   < 1 µA                               | 5 V             | -                         | 0.05  | -                         | 0.05 | -                         | 0.05  | -                          | 0.05  | V    |
|                 |                           |                                                       | 10 V            | -                         | 0.05  | -                         | 0.05 | -                         | 0.05  | -                          | 0.05  | V    |
|                 |                           |                                                       | 15 V            | -                         | 0.05  | -                         | 0.05 | -                         | 0.05  | -                          | 0.05  | V    |
| I <sub>OH</sub> | HIGH-level output current | V <sub>O</sub> = 2.5 V                                | 5 V             | -                         | -1.7  | -                         | -1.4 | -                         | -1.1  | -                          | -1.1  | mA   |
|                 |                           | V <sub>O</sub> = 4.6 V                                | 5 V             | -                         | -0.64 | -                         | -0.5 | -                         | -0.36 | -                          | -0.36 | mA   |
|                 |                           | V <sub>O</sub> = 9.5 V                                | 10 V            | -                         | -1.6  | -                         | -1.3 | -                         | -0.9  | -                          | -0.9  | mA   |
|                 |                           | V <sub>O</sub> = 13.5 V                               | 15 V            | -                         | -4.2  | -                         | -3.4 | -                         | -2.4  | -                          | -2.4  | mA   |
| I <sub>OL</sub> | LOW-level output current  | V <sub>O</sub> = 0.4 V                                | 5 V             | 0.64                      | -     | 0.5                       | -    | 0.36                      | -     | 0.36                       | -     | mA   |
|                 |                           | V <sub>O</sub> = 0.5 V                                | 10 V            | 1.6                       | -     | 1.3                       | -    | 0.9                       | -     | 0.9                        | -     | mA   |
|                 |                           | V <sub>O</sub> = 1.5 V                                | 15 V            | 4.2                       | -     | 3.4                       | -    | 2.4                       | -     | 2.4                        | -     | mA   |
| I <sub>I</sub>  | input leakage current     |                                                       | 15 V            | -                         | ±0.1  | -                         | ±0.1 | -                         | ±1.0  | -                          | ±1.0  | µA   |
| I <sub>DD</sub> | supply current            | all valid input combinations;<br>I <sub>O</sub> = 0 A | 5 V             | -                         | 0.25  | -                         | 0.25 | -                         | 7.5   | -                          | 7.5   | µA   |
|                 |                           |                                                       | 10 V            | -                         | 0.5   | -                         | 0.5  | -                         | 15.0  | -                          | 15.0  | µA   |
|                 |                           |                                                       | 15 V            | -                         | 1.0   | -                         | 1.0  | -                         | 30.0  | -                          | 30.0  | µA   |
| C <sub>I</sub>  | input capacitance         |                                                       |                 | -                         | -     | -                         | 7.5  | -                         | -     | -                          | -     | pF   |

11. Dynamic characteristics

Table 7. Dynamic characteristics

T<sub>amb</sub> = 25 °C; C<sub>L</sub> = 50 pF; t<sub>r</sub> = t<sub>f</sub> ≤ 20 ns; unless otherwise specified. For waveforms see Fig. 4; for test circuit see Fig. 5.

| Symbol           | Parameter                          | Conditions       | V <sub>DD</sub> | Extrapolation formula [1]          | Min | Typ | Max | Unit |
|------------------|------------------------------------|------------------|-----------------|------------------------------------|-----|-----|-----|------|
| t <sub>PHL</sub> | HIGH to LOW propagation delay      | nA or nB to nY   | 5 V             | 63 ns + (0.55 ns/pF)C <sub>L</sub> | -   | 90  | 185 | ns   |
|                  |                                    |                  | 10 V            | 29 ns + (0.23 ns/pF)C <sub>L</sub> | -   | 40  | 80  | ns   |
|                  |                                    |                  | 15 V            | 22 ns + (0.16 ns/pF)C <sub>L</sub> | -   | 30  | 60  | ns   |
| t <sub>PLH</sub> | LOW to HIGH propagation delay      | nA or nB to nY   | 5 V             | 58 ns + (0.55 ns/pF)C <sub>L</sub> | -   | 85  | 170 | ns   |
|                  |                                    |                  | 10 V            | 29 ns + (0.23 ns/pF)C <sub>L</sub> | -   | 40  | 80  | ns   |
|                  |                                    |                  | 15 V            | 22 ns + (0.16 ns/pF)C <sub>L</sub> | -   | 30  | 60  | ns   |
| t <sub>THL</sub> | HIGH to LOW output transition time | nY to LOW        | 5 V             | 10 ns + (1.00 ns/pF)C <sub>L</sub> | -   | 60  | 120 | ns   |
|                  |                                    |                  | 10 V            | 9 ns + (0.42 ns/pF)C <sub>L</sub>  | -   | 30  | 60  | ns   |
|                  |                                    |                  | 15 V            | 6 ns + (0.28 ns/pF)C <sub>L</sub>  | -   | 20  | 40  | ns   |
| t <sub>TLH</sub> | LOW to HIGH output transition time | nA or nB to HIGH | 5 V             | 10 ns + (1.00 ns/pF)C <sub>L</sub> | -   | 60  | 120 | ns   |
|                  |                                    |                  | 10 V            | 9 ns + (0.42 ns/pF)C <sub>L</sub>  | -   | 30  | 60  | ns   |
|                  |                                    |                  | 15 V            | 6 ns + (0.28 ns/pF)C <sub>L</sub>  | -   | 20  | 40  | ns   |

[1] Typical value of the propagation delay and output transition time can be calculated with the extrapolation formula (C<sub>L</sub> in pF).

Table 8. Dynamic power dissipation

V<sub>SS</sub> = 0 V; t<sub>r</sub> = t<sub>f</sub> ≤ 20 ns; T<sub>amb</sub> = 25 °C.

| Symbol         | Parameter                 | V <sub>DD</sub> | Typical formula                                                                                                   | where:                                                                                                                                                                                                                                          |
|----------------|---------------------------|-----------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| P <sub>D</sub> | dynamic power dissipation | 5 V             | P <sub>D</sub> = 1300 × f <sub>i</sub> + Σ(f <sub>o</sub> × C <sub>L</sub> ) × V <sub>DD</sub> <sup>2</sup> (µW)  | f <sub>i</sub> = input frequency in MHz;<br>f <sub>o</sub> = output frequency in MHz;<br>C <sub>L</sub> = output load capacitance in pF;<br>Σ(f <sub>o</sub> × C <sub>L</sub> ) = sum of the outputs;<br>V <sub>DD</sub> = supply voltage in V. |
|                |                           | 10 V            | P <sub>D</sub> = 6400 × f <sub>i</sub> + Σ(f <sub>o</sub> × C <sub>L</sub> ) × V <sub>DD</sub> <sup>2</sup> (µW)  |                                                                                                                                                                                                                                                 |
|                |                           | 15 V            | P <sub>D</sub> = 18700 × f <sub>i</sub> + Σ(f <sub>o</sub> × C <sub>L</sub> ) × V <sub>DD</sub> <sup>2</sup> (µW) |                                                                                                                                                                                                                                                 |

11.1. Waveforms and test circuit

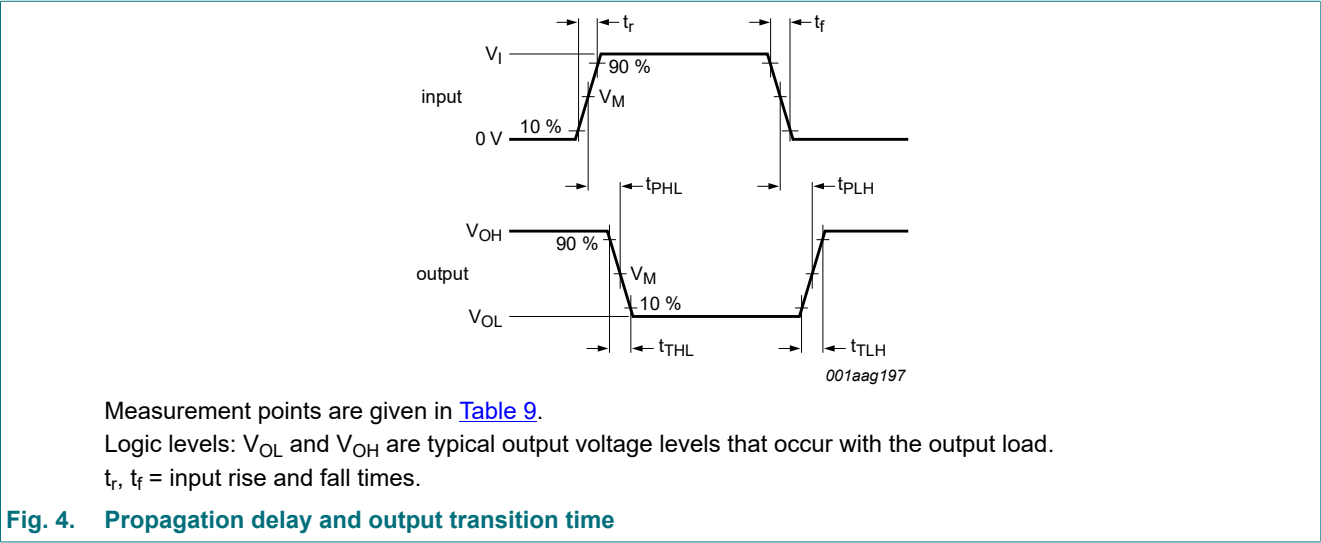


Table 9. Measurement points

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

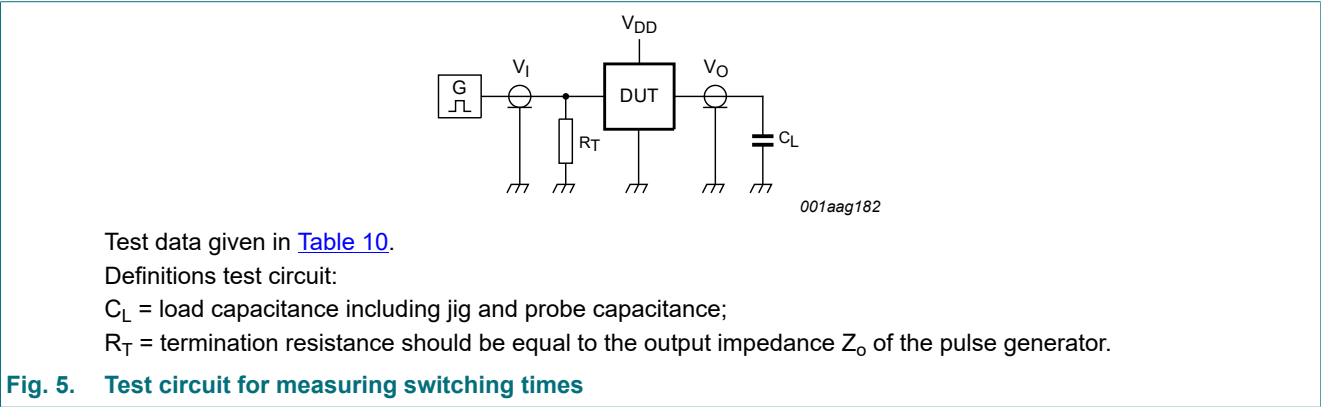


Table 10. Test data

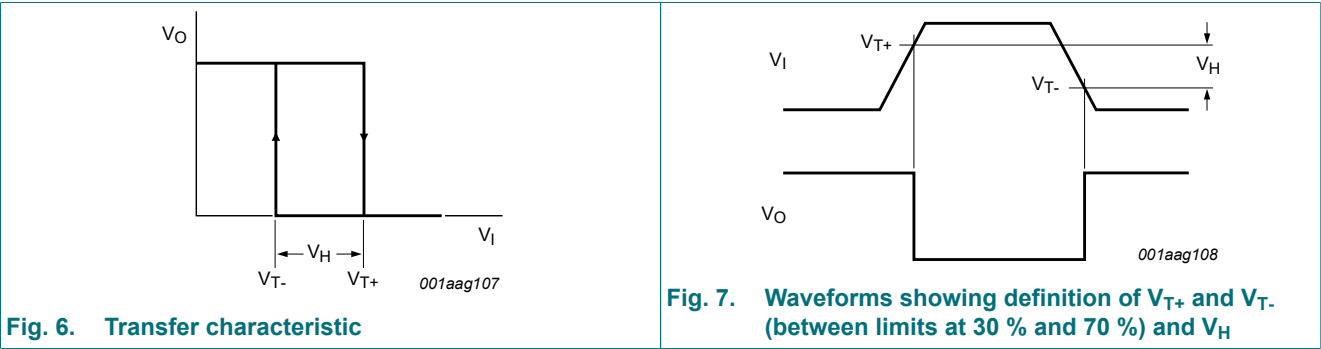
| Supply voltage | Input                |               | Load  |
|----------------|----------------------|---------------|-------|
| $V_{DD}$       | $V_I$                | $t_r$ , $t_f$ | $C_L$ |
| 5 V to 15 V    | $V_{SS}$ or $V_{DD}$ | $\leq 20$ ns  | 50 pF |

12. Transfer characteristics

Table 11. Transfer characteristics

$V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ; see Fig. 6 and Fig. 7.

| Symbol   | Parameter                        | Conditions | $V_{DD}$ | Min | Typ | Max  | Unit |
|----------|----------------------------------|------------|----------|-----|-----|------|------|
| $V_{T+}$ | positive-going threshold voltage |            | 5 V      | 1.9 | 2.9 | 3.5  | V    |
|          |                                  |            | 10 V     | 3.6 | 5.2 | 7    | V    |
|          |                                  |            | 15 V     | 4.7 | 7.3 | 11   | V    |
| $V_{T-}$ | negative-going threshold voltage |            | 5 V      | 1.5 | 2.2 | 3.1  | V    |
|          |                                  |            | 10 V     | 3   | 4.2 | 6.4  | V    |
|          |                                  |            | 15 V     | 4   | 6.0 | 10.3 | V    |
| $V_H$    | hysteresis voltage               |            | 5 V      | 0.4 | 0.7 | -    | V    |
|          |                                  |            | 10 V     | 0.6 | 1.0 | -    | V    |
|          |                                  |            | 15 V     | 0.7 | 1.3 | -    | V    |



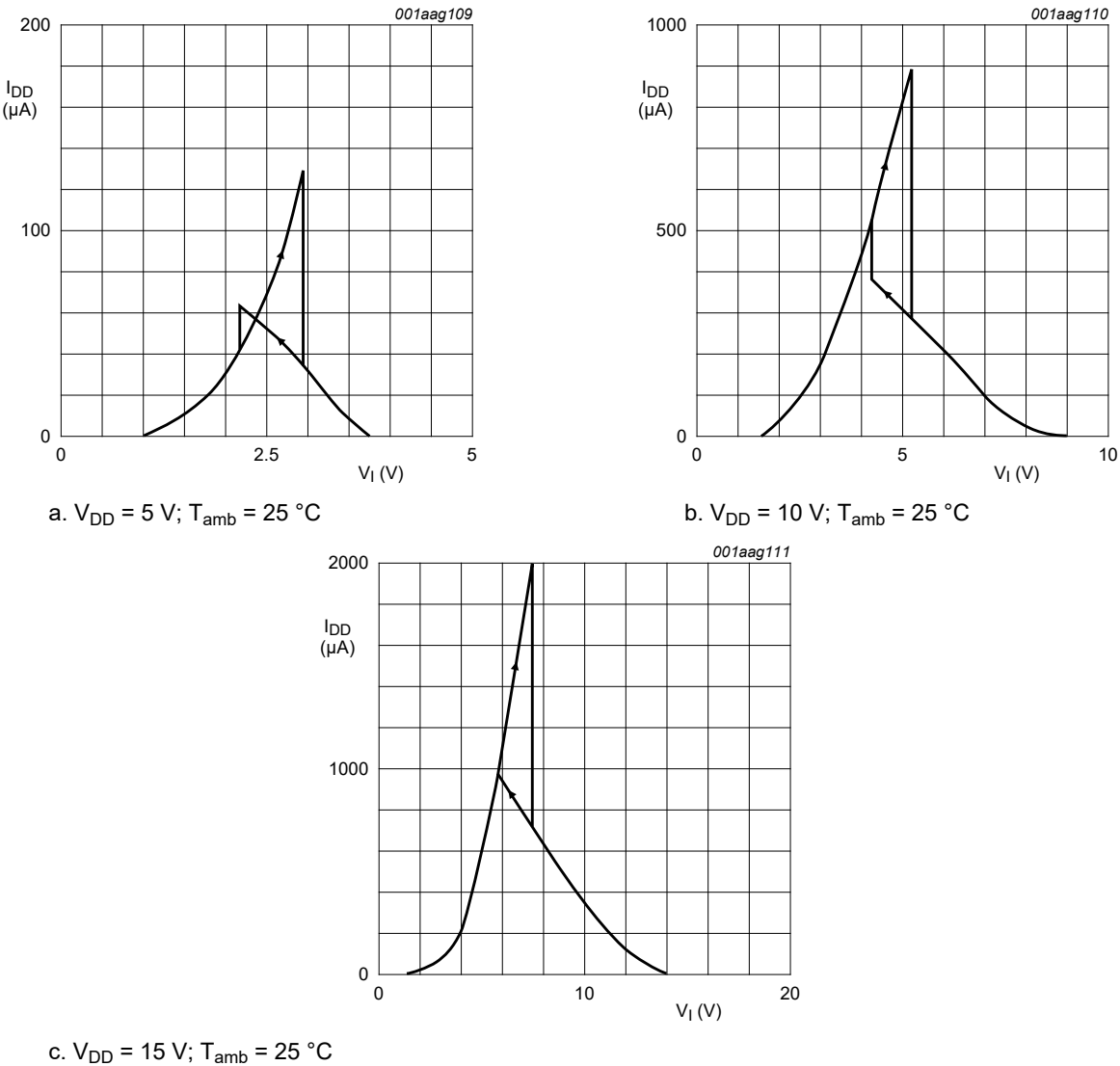


Fig. 8. Typical drain current as a function of input

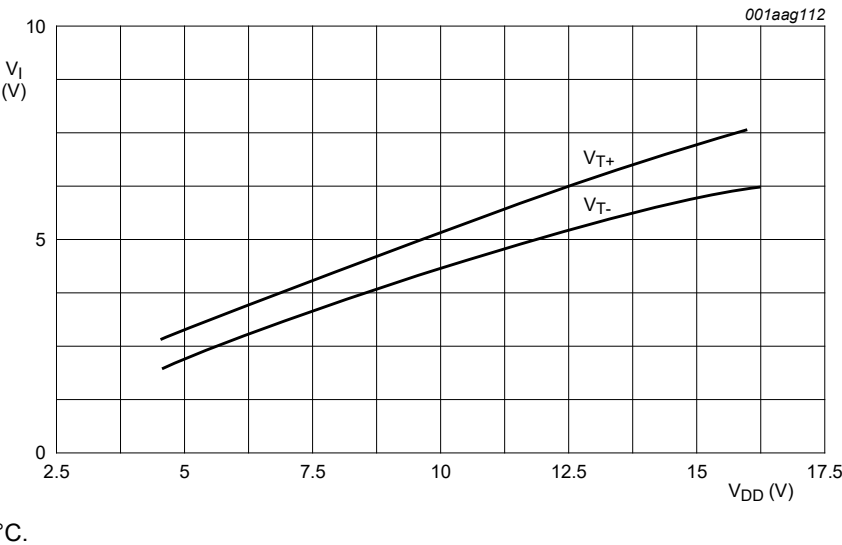


Fig. 9. Typical switching levels as a function of supply voltage

## 13. Application information

Some examples of applications for the HEF4093B are:

- Wave and pulse shapers
- Astable multivibrators
- Monostable multivibrators

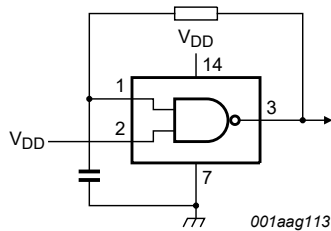


Fig. 10. Astable multivibrator

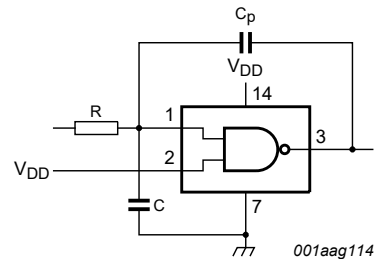


Fig. 11. Schmitt trigger driven via a high-impedance input

If a Schmitt trigger is driven via a high-impedance ( $R > 1 \text{ k}\Omega$ ), then it is necessary to incorporate a capacitor  $C$  with a value of  $\frac{C}{C_p} > \frac{V_{DD} - V_{SS}}{V_H}$ ; otherwise oscillation can occur on the edges of a pulse.

$C_p$  is the external parasitic capacitance between inputs and output; the value depends on the circuit board layout.

**Remark:** The two inputs may be connected together, but this will result in a larger through-current at the moment of switching.

14. Package outline

SO14: plastic small outline package; 14 leads; body width 3.9 mm

SOT108-1

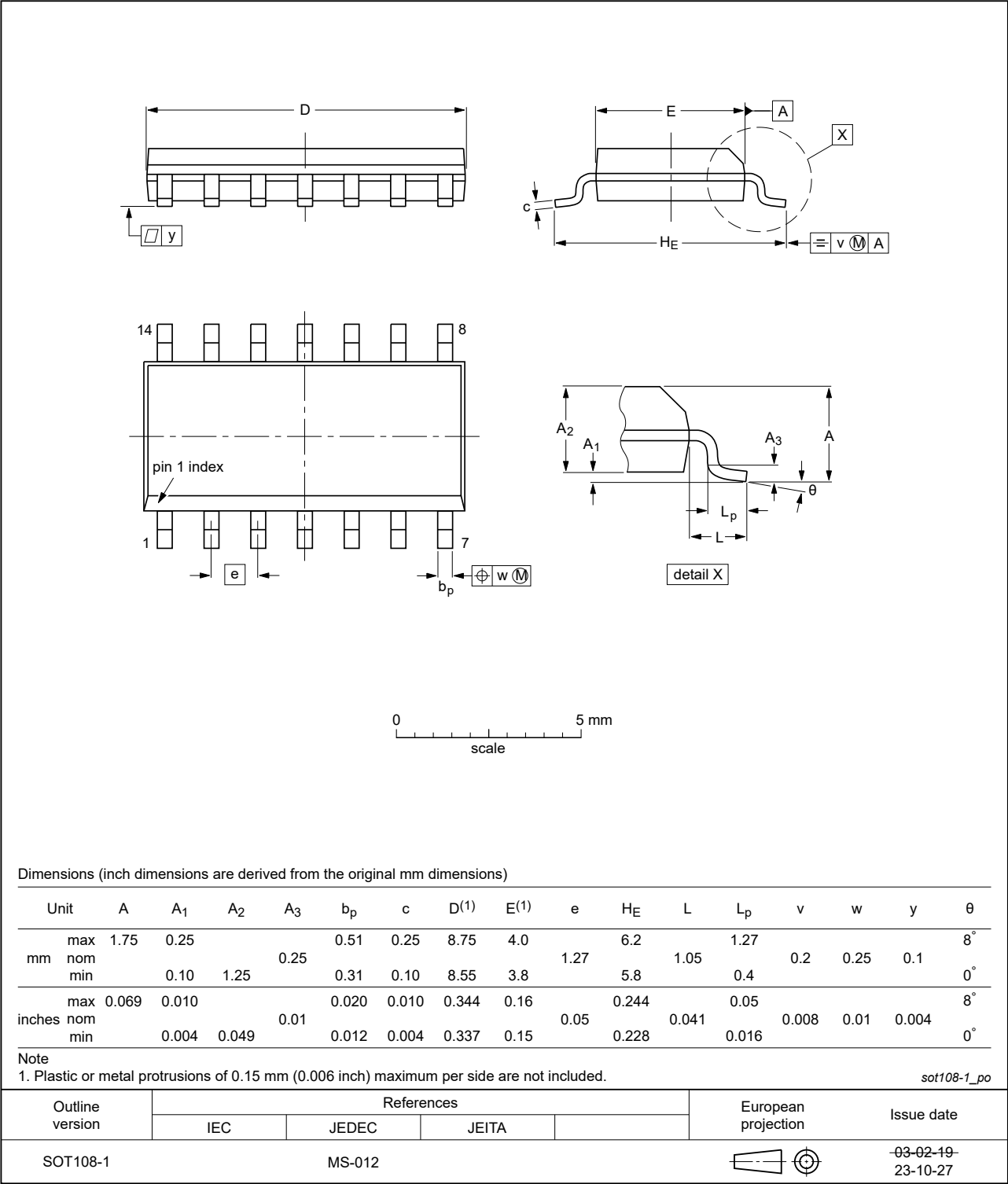


Fig. 12. Package outline SOT108-1 (SO14)

15. Abbreviations

Table 12. Abbreviations

| Acronym | Description                               |
|---------|-------------------------------------------|
| ANSI    | American National Standards Institute     |
| CDM     | Charged Device Model                      |
| CMOS    | Complementary Metal-Oxide Semiconductor   |
| DUT     | Device Under Test                         |
| ESD     | ElectroStatic Discharge                   |
| ESDA    | ElectroStatic Discharge Association       |
| HBM     | Human Body Model                          |
| JEDEC   | Joint Electron Device Engineering Council |

16. Revision history

Table 13. Revision history

| Document ID      | Release date                                                                                                                                                                                                                                                                                                                                                                       | Data sheet status     | Change notice | Supersedes       |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------|------------------|
| HEF4093B v.11    | 20240905                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet    | -             | HEF4093B v.10    |
| Modifications:   | <ul style="list-style-type: none"><li>Section 2: ESD specification updated according to the latest JEDEC standard.</li><li>Fig. 12: Aligned SO package outline drawing to JEDEC MS-012</li></ul>                                                                                                                                                                                   |                       |               |                  |
| HEF4093B v.10    | 20220225                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet    | -             | HEF4093B v.9     |
| Modifications:   | <ul style="list-style-type: none"><li>The format of this data sheet has been redesigned to comply with the identity guidelines of Nexperia.</li><li>Legal texts have been adapted to the new company name where appropriate.</li><li>Table 4: Derating values for P<sub>tot</sub> total power dissipation updated.</li><li>Section 1, Section 2, and Section 15 updated.</li></ul> |                       |               |                  |
| HEF4093B v.9     | 20151215                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet    | -             | HEF4093B v.8     |
| Modifications:   | <ul style="list-style-type: none"><li>Type number HEF4093BP (SOT27-1) removed.</li></ul>                                                                                                                                                                                                                                                                                           |                       |               |                  |
| HEF4093B v.8     | 20111121                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet    | -             | HEF4093B v.7     |
| Modifications:   | <ul style="list-style-type: none"><li>Table 6: I<sub>OH</sub> minimum values changed to maximum</li></ul>                                                                                                                                                                                                                                                                          |                       |               |                  |
| HEF4093B v.7     | 20100901                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet    | -             | HEF4093B v.6     |
| HEF4093B v.6     | 20091202                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet    | -             | HEF4093B v.5     |
| HEF4093B v.5     | 20090728                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet    | -             | HEF4093B v.4     |
| HEF4093B v.4     | 20080612                                                                                                                                                                                                                                                                                                                                                                           | Product data sheet    | -             | HEF4093B_CNV v.3 |
| HEF4093B_CNV v.3 | 19950101                                                                                                                                                                                                                                                                                                                                                                           | Product specification | -             | HEF4093B_CNV v.2 |
| HEF4093B_CNV v.2 | 19950101                                                                                                                                                                                                                                                                                                                                                                           | Product specification | -             | -                |

## 17. Legal information

### Data sheet status

| Document status [1][2]         | Product status [3] | Definition                                                                            |
|--------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Objective [short] data sheet   | Development        | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification      | This document contains data from the preliminary specification.                       |
| Product [short] data sheet     | Production         | This document contains the product specification.                                     |

- [1] Please consult the most recently issued document before initiating or completing a design.
- [2] The term 'short data sheet' is explained in section "Definitions".
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