# HEF4093B

## Quad 2-input NAND Schmitt trigger

**Rev. 9 — 15 December 2015** **Product data sheet**

## 1. General description

The HEF4093B 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 3 V to 15 V referenced to $V_{SS}$ (usually ground). Unused inputs must be connected to $V_{DD}$, $V_{SS}$, or another input.

## 2. Features and benefits

- Schmitt trigger input discrimination
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Specified from –40 °C to +85 °C and –40 °C to +125 °C
- Complies with JEDEC standard JESD 13-B

## 3. Applications

- Wave and pulse shapers
- Astable multivibrators
- Monostable multivibrators

## 4. Ordering information

**Table 1. Ordering information**

*All types operate from –40 °C to +125 °C*

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| HEF4093BT | SO14 | plastic small outline package; 14 leads; body width 3.9 mm | SOT108-1 |

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## 5. Functional diagram

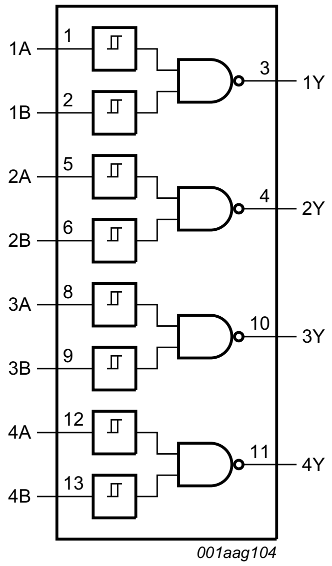



Fig 1. Functional diagram

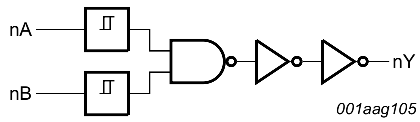



Fig 2. Logic diagram (one gate)

## 6. Pinning information

### 6.1 Pinning

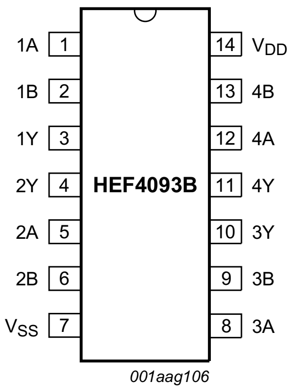



Fig 3. Pin configuration

### 6.2 Pin description

**Table 2. Pin description**

| Symbol | Pin | Description |
|---|---|---|
| 1A to 4A | 1, 5, 8, 12 | input |
| 1B to 4B | 2, 6, 9, 13 | input |
| 1Y to 4Y | 3, 4, 10, 11 | output |
| $V_{DD}$ | 14 | supply voltage |
| $V_{SS}$ | 7 | ground (0 V) |

## 7. Functional description

**Table 3. Function table[1]**

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

[1] H = HIGH voltage level; L = LOW voltage level.

## 8. Limiting values

**Table 4. Limiting values**

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

| Symbol | Parameter | Conditions | Min | Max | Unit |
|---|---|---|---|---|---|
| $V_{DD}$ | supply voltage | | –0.5 | +18 | V |
| $I_{IK}$ | input clamping current | $V_I < -0.5$ V or $V_I > V_{DD} + 0.5$ V | - | ±10 | mA |
| $V_I$ | input voltage | | –0.5 | $V_{DD}$ + 0.5 | V |
| $I_{OK}$ | output clamping current | $V_O < -0.5$ V or $V_O > V_{DD} + 0.5$ V | - | ±10 | mA |
| $I_{I/O}$ | input/output current | | - | ±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 °C to +125 °C | | | |
| | | SO14 [1] | - | 500 | mW |
| P | power dissipation | per output | - | 100 | mW |

[1] For SO14 packages: above $T_{amb}$ = 70 °C, $P_{tot}$ derates linearly with 8 mW/K.

## 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 V; $V_I$ = $V_{SS}$ or $V_{DD}$; unless otherwise specified.*

| Symbol | Parameter | Conditions | $V_{DD}$ | $T_{amb}$ = –40 °C | | $T_{amb}$ = +25 °C | | $T_{amb}$ = +85 °C | | $T_{amb}$ = +125 °C | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | Min | Max | Min | Max | Min | Max | |
| $V_{OH}$ | HIGH-level output voltage | $\|I_O\|$ < 1 μA | 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 |
| $V_{OL}$ | LOW-level output voltage | $\|I_O\|$ < 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 |
| $I_{OH}$ | HIGH-level output current | $V_O$ = 2.5 V | 5 V | - | –1.7 | - | –1.4 | - | –1.1 | - | –1.1 | mA |
| | | $V_O$ = 4.6 V | 5 V | - | –0.64 | - | –0.5 | - | –0.36 | - | –0.36 | mA |
| | | $V_O$ = 9.5 V | 10 V | - | –1.6 | - | –1.3 | - | –0.9 | - | –0.9 | mA |
| | | $V_O$ = 13.5 V | 15 V | - | –4.2 | - | –3.4 | - | –2.4 | - | –2.4 | mA |
| $I_{OL}$ | LOW-level output current | $V_O$ = 0.4 V | 5 V | 0.64 | - | 0.5 | - | 0.36 | - | 0.36 | - | mA |
| | | $V_O$ = 0.5 V | 10 V | 1.6 | - | 1.3 | - | 0.9 | - | 0.9 | - | mA |
| | | $V_O$ = 1.5 V | 15 V | 4.2 | - | 3.4 | - | 2.4 | - | 2.4 | - | mA |
| $I_I$ | input leakage current | | 15 V | - | ±0.1 | - | ±0.1 | - | ±1.0 | - | ±1.0 | μA |
| $I_{DD}$ | supply current | all valid input combinations; $I_O$ = 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 |
| $C_I$ | input capacitance | | | - | - | - | 7.5 | - | - | - | - | pF |

## 11. Dynamic characteristics

**Table 7. Dynamic characteristics**

*$T_{amb}$ = 25 °C; $C_L$ = 50 pF; $t_r$ = $t_f$ ≤ 20 ns; wave forms see Figure 4; test circuit see Figure 5; unless otherwise specified.*

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

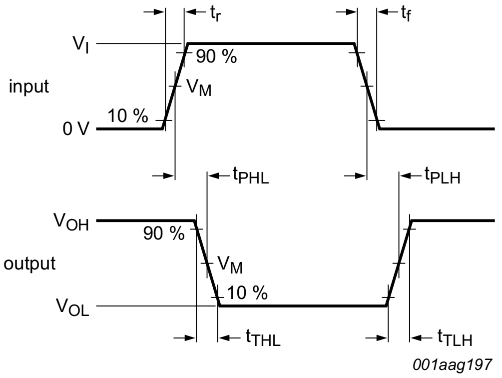
[1] Typical value of the propagation delay and output transition time can be calculated with the extrapolation formula ($C_L$ in pF).

**Table 8. Dynamic power dissipation**

*$V_{SS}$ = 0 V; $t_r$ = $t_f$ ≤ 20 ns; $T_{amb}$ = 25 °C.*

| Symbol | Parameter | $V_{DD}$ | Typical formula | where: |
|---|---|---|---|---|
| $P_D$ | dynamic power dissipation | 5 V | $P_D = 1300 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$ (μW) | $f_i$ = input frequency in MHz; |
| | | 10 V | $P_D = 6400 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$ (μW) | $f_o$ = output frequency in MHz; |
| | | 15 V | $P_D = 18700 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$ (μW) | $C_L$ = output load capacitance in pF; |
| | | | | $\Sigma(f_o \times C_L)$ = sum of the outputs; |
| | | | | $V_{DD}$ = supply voltage in V. |

## 12. Waveforms




Measurement points are given in Table 9.

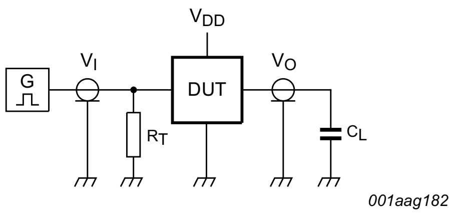
Logic levels: $V_{OL}$ and $V_{OH}$ are typical output voltage levels that occur with the output load.

$t_r$, $t_f$ = input rise and fall times.

**Fig 4. Propagation delay and output transition time**

**Table 9. Measurement points**

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




Test data given in Table 10.

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 5. Test circuit for measuring switching times**

**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 |

## 13. Transfer characteristics

**Table 11. Transfer characteristics**

*$V_{SS}$ = 0 V; $T_{amb}$ = 25 °C; see Figure 6 and Figure 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 |

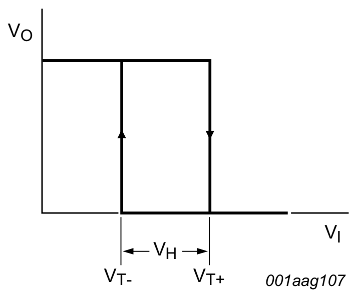



**Fig 6. Transfer characteristic**

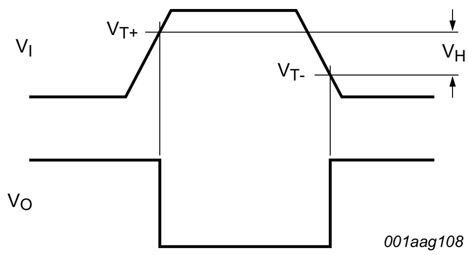
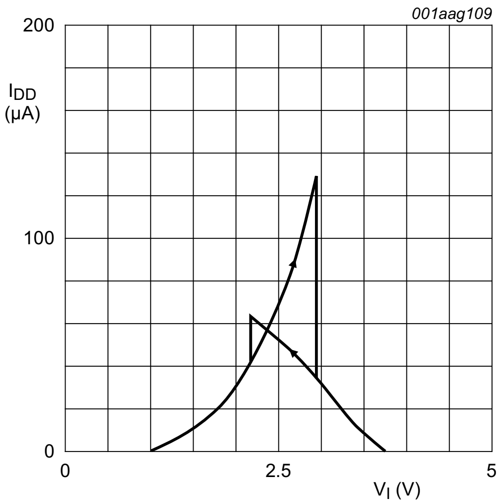
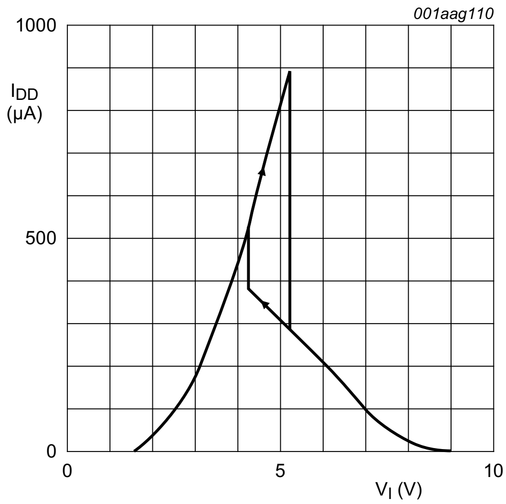


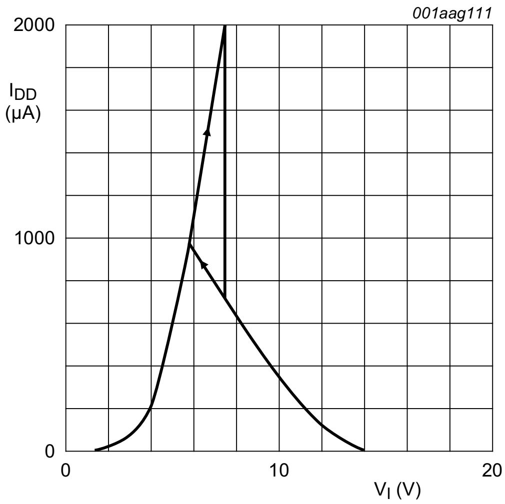

**Fig 7. Waveforms showing definition of $V_{T+}$ and $V_{T-}$ (between limits at 30 % and 70 %) and $V_H$**




a. $V_{DD}$ = 5 V; $T_{amb}$ = 25 °C

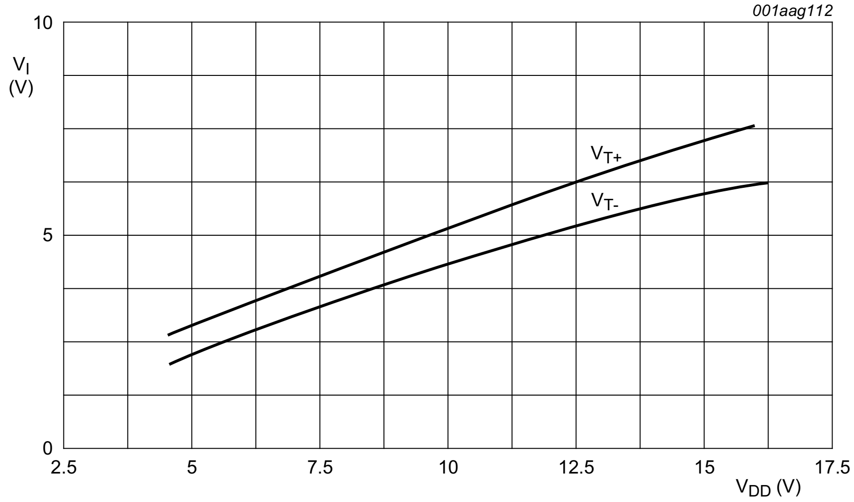



b. $V_{DD}$ = 10 V; $T_{amb}$ = 25 °C




c. $V_{DD}$ = 15 V; $T_{amb}$ = 25 °C

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




$T_{amb}$ = 25 °C.

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

## 14. Application information

Some examples of applications for the HEF4093B are:

- Wave and pulse shapers
- Astable multivibrators
- Monostable multivibrators

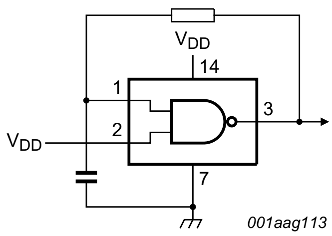



**Fig 10. Astable multivibrator**

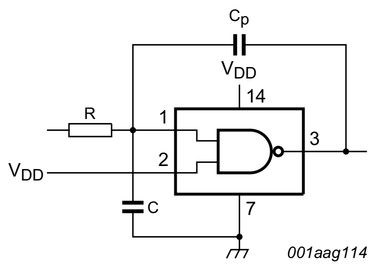



**Fig 11. Schmitt trigger driven via a high-impedance input**

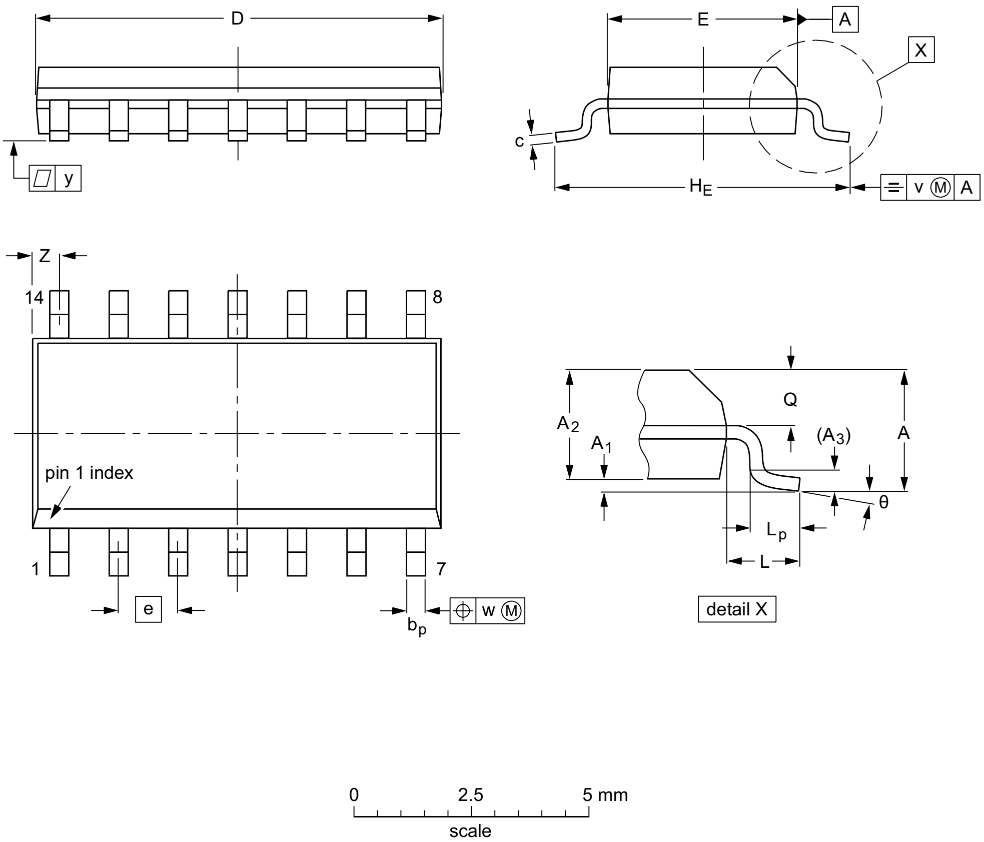
If a Schmitt trigger is driven via a high-impedance (R > 1 kΩ), then it is necessary to incorporate a capacitor C with a value of $\frac{C}{C_P} > \frac{V_{DD} - V_{SS}}{V_H}$; otherwise oscillation can occur on the edges of a pulse.

$C_p$ 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.

# 15. Package outline

**SO14: plastic small outline package; 14 leads; body width 3.9 mm** **SOT108-1**




**DIMENSIONS (inch dimensions are derived from the original mm dimensions)**

| UNIT | A max. | $A_1$ | $A_2$ | $A_3$ | $b_p$ | c | D(1) | E(1) | e | $H_E$ | L | $L_p$ | Q | v | w | y | Z(1) | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.75 | 0.25<br>0.10 | 1.45<br>1.25 | 0.25 | 0.49<br>0.36 | 0.25<br>0.19 | 8.75<br>8.55 | 4.0<br>3.8 | 1.27 | 6.2<br>5.8 | 1.05 | 1.0<br>0.4 | 0.7<br>0.6 | 0.25 | 0.25 | 0.1 | 0.7<br>0.3 | 8°<br>0° |
| inches | 0.069 | 0.010<br>0.004 | 0.057<br>0.049 | 0.01 | 0.019<br>0.014 | 0.0100<br>0.0075 | 0.35<br>0.34 | 0.16<br>0.15 | 0.05 | 0.244<br>0.228 | 0.041 | 0.039<br>0.016 | 0.028<br>0.024 | 0.01 | 0.01 | 0.004 | 0.028<br>0.012 | |

**Note**

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT108-1 | 076E06 | MS-012 | | | | ~~99-12-27~~<br>03-02-19 |

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

## 16. Abbreviations

**Table 12. Abbreviations**

| Acronym | Description |
|---|---|
| DUT | Device Under Test |

## 17. Revision history

**Table 13. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| HEF4093B v.9 | 20151215 | Product data sheet | - | HEF4093B v.8 |
| Modifications: | • Type number HEF4093BP (SOT27-1) removed. | | | |
| HEF4093B v.8 | 20111121 | Product data sheet | - | HEF4093B v.7 |
| Modifications: | • Table 6: $I_{OH}$ minimum values changed to maximum | | | |
| 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 | - | - |

# 18. Legal information

## 18.1 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".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nexperia.com.

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Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

## 19. Contact information

For more information, please visit: **http://www.nexperia.com**

For sales office addresses, please send an email to: **salesaddresses@nexperia.com**

## 20. Contents