

# HEF4069UB

## Hex inverter

Rev. 04 — 4 July 2008

Product data sheet

## 1. General description

The HEF4069UB is a general purpose hex inverter. Each inverter has a single stage.

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.

It is suitable for use over both the industrial ( $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ ) and automotive ( $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ ) temperature ranges.

## 2. Features

- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Operates across the automotive temperature range from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$
- Complies with JEDEC standard JESD 13-B
- ESD protection:
  - ◆ HBM JESD22-A114E exceeds 2000 V
  - ◆ MM JESD22-A115-A exceeds 200 V

## 3. Applications

- Oscillator
- Automotive and industrial

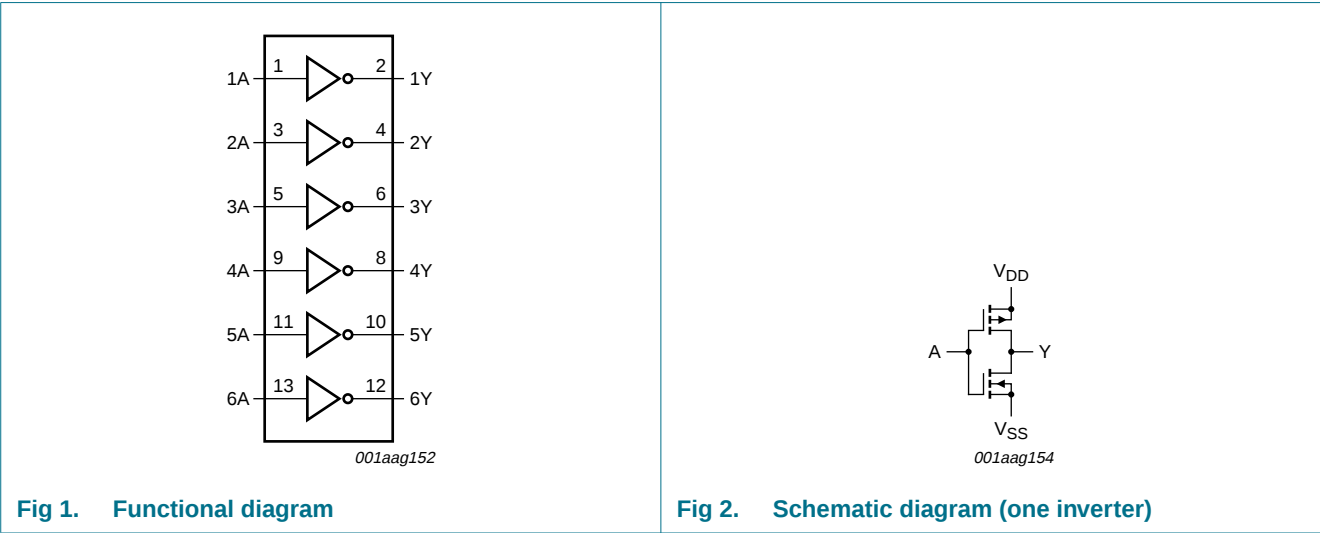
## 4. Ordering information

**Table 1.** Ordering information

All types operate from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ .

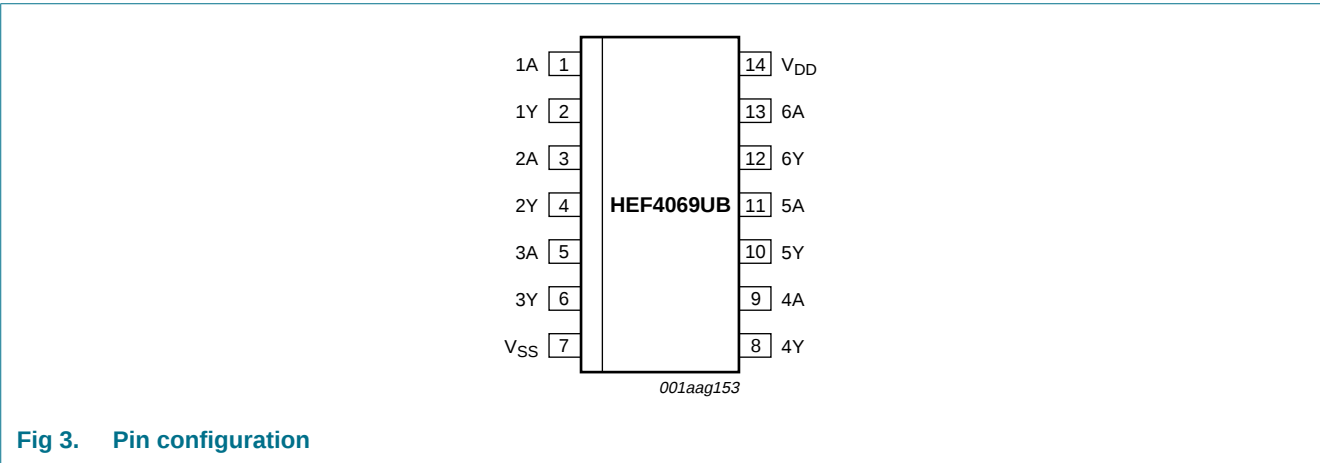
| Type number | Package |                                                                        |          |
|-------------|---------|------------------------------------------------------------------------|----------|
|             | Name    | Description                                                            | Version  |
| HEF4069UBP  | DIP14   | plastic dual in-line package; 14 leads (300 mil)                       | SOT27-1  |
| HEF4069UBT  | SO14    | plastic small outline package; 14 leads; body width 3.9 mm             | SOT108-1 |
| HEF4069UBTT | TSSOP14 | plastic thin shrink small outline package; 14 leads; body width 4.4 mm | SOT402-1 |

5. Functional diagram



6. Pinning information

6.1 Pinning



6.2 Pin description

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

## 7. Limiting values

**Table 3. Limiting values**

*In accordance with the Absolute Maximum Rating System (IEC 60134).*

| 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 | $T_{amb} = -40 \text{ °C to } +125 \text{ °C}$          |       |                |      |
|           |                         | DIP14                                                   | [1] - | 750            | mW   |
|           |                         | SO14                                                    | [2] - | 500            | mW   |
|           |                         | TSSOP14                                                 | [3] - | 500            | mW   |
| P         | power dissipation       | per output                                              | -     | 100            | mW   |

[1] For DIP14 packages: above  $T_{amb} = 70 \text{ °C}$ ,  $P_{tot}$  derates linearly with 12 mW/K.

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

[3] For TSSOP14 packages: above  $T_{amb} = 60 \text{ °C}$ ,  $P_{tot}$  derates linearly with 5.5 mW/K.

## 8. Recommended operating conditions

**Table 4. Recommended operating conditions**

| Symbol              | Parameter                           | Conditions              | Min | Typ | 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   |
| $\Delta t/\Delta V$ | input transition rise and fall rate | $V_{DD} = 5 \text{ V}$  | -   | -   | 3.75     | ns/V |
|                     |                                     | $V_{DD} = 10 \text{ V}$ | -   | -   | 0.5      | ns/V |
|                     |                                     | $V_{DD} = 15 \text{ V}$ | -   | -   | 0.08     | ns/V |

## 9. Static characteristics

**Table 5. Static characteristics**
 $V_{SS} = 0\text{ V}$ ;  $V_I = V_{SS}$  or  $V_{DD}$ ; unless otherwise specified.

| Symbol   | Parameter                 | Conditions                                          | $V_{DD}$ | $T_{amb} = -40\text{ }^{\circ}\text{C}$ |           | $T_{amb} = +25\text{ }^{\circ}\text{C}$ |           | $T_{amb} = +85\text{ }^{\circ}\text{C}$ |           | $T_{amb} = +125\text{ }^{\circ}\text{C}$ |           | Unit          |
|----------|---------------------------|-----------------------------------------------------|----------|-----------------------------------------|-----------|-----------------------------------------|-----------|-----------------------------------------|-----------|------------------------------------------|-----------|---------------|
|          |                           |                                                     |          | Min                                     | Max       | Min                                     | Max       | Min                                     | Max       | Min                                      | Max       |               |
| $V_{IH}$ | HIGH-level input voltage  | $ I_O  < 1\text{ }\mu\text{A}$                      | 5 V      | 4                                       | -         | 4                                       | -         | 4                                       | -         | 4                                        | -         | V             |
|          |                           |                                                     | 10 V     | 8                                       | -         | 8                                       | -         | 8                                       | -         | 8                                        | -         | V             |
|          |                           |                                                     | 15 V     | 12.5                                    | -         | 12.5                                    | -         | 12.5                                    | -         | 12.5                                     | -         | V             |
|          |                           |                                                     |          |                                         |           |                                         |           |                                         |           |                                          |           |               |
| $V_{IL}$ | LOW-level input voltage   | $ I_O  < 1\text{ }\mu\text{A}$                      | 5 V      | -                                       | 1         | -                                       | 1         | -                                       | 1         | -                                        | 1         | V             |
|          |                           |                                                     | 10 V     | -                                       | 2         | -                                       | 2         | -                                       | 2         | -                                        | 2         | V             |
|          |                           |                                                     | 15 V     | -                                       | 2.5       | -                                       | 2.5       | -                                       | 2.5       | -                                        | 2.5       | V             |
|          |                           |                                                     |          |                                         |           |                                         |           |                                         |           |                                          |           |               |
| $V_{OH}$ | 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             |
| $V_{OL}$ | LOW-level output voltage  | $ I_O  < 1\text{ }\mu\text{A}$                      | 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 | $V_O = 2.5\text{ V}$                                | 5 V      | -1.7                                    | -         | -1.4                                    | -         | -1.1                                    | -         | -1.1                                     | -         | mA            |
|          |                           | $V_O = 4.6\text{ V}$                                | 5 V      | -0.64                                   | -         | -0.5                                    | -         | -0.36                                   | -         | -0.36                                    | -         | mA            |
|          |                           | $V_O = 9.5\text{ V}$                                | 10 V     | -1.6                                    | -         | -1.3                                    | -         | -0.9                                    | -         | -0.9                                     | -         | mA            |
|          |                           | $V_O = 13.5\text{ V}$                               | 15 V     | -4.2                                    | -         | -3.4                                    | -         | -2.4                                    | -         | -2.4                                     | -         | mA            |
| $I_{OL}$ | LOW-level output current  | $V_O = 0.4\text{ V}$                                | 5 V      | 0.64                                    | -         | 0.5                                     | -         | 0.36                                    | -         | 0.36                                     | -         | mA            |
|          |                           | $V_O = 0.5\text{ V}$                                | 10 V     | 1.6                                     | -         | 1.3                                     | -         | 0.9                                     | -         | 0.9                                      | -         | mA            |
|          |                           | $V_O = 1.5\text{ V}$                                | 15 V     | 4.2                                     | -         | 3.4                                     | -         | 2.4                                     | -         | 2.4                                      | -         | mA            |
| $I_I$    | input leakage current     |                                                     | 15 V     | -                                       | $\pm 0.1$ | -                                       | $\pm 0.1$ | -                                       | $\pm 1.0$ | -                                        | $\pm 1.0$ | $\mu\text{A}$ |
| $I_{DD}$ | supply current            | all valid input combinations;<br>$I_O = 0\text{ A}$ | 5 V      | -                                       | 0.25      | -                                       | 0.25      | -                                       | 7.5       | -                                        | 7.5       | $\mu\text{A}$ |
|          |                           |                                                     | 10 V     | -                                       | 0.5       | -                                       | 0.5       | -                                       | 15.0      | -                                        | 15.0      | $\mu\text{A}$ |
|          |                           |                                                     | 15 V     | -                                       | 1.0       | -                                       | 1.0       | -                                       | 30.0      | -                                        | 30.0      | $\mu\text{A}$ |
| $C_i$    | input capacitance         | digital inputs                                      |          | -                                       | -         | -                                       | 7.5       | -                                       | -         | -                                        | -         | pF            |

## 10. Dynamic characteristics

**Table 6. Dynamic characteristics**
 $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $C_L = 50\text{ pF}$ ;  $t_r = t_f \leq 20\text{ ns}$ ; for test circuit see [Figure 5](#).

| Symbol    | Parameter                     | Conditions                                | $V_{DD}$ | Extrapolation formula <sup>[1]</sup> | Min | Typ | Max | Unit |
|-----------|-------------------------------|-------------------------------------------|----------|--------------------------------------|-----|-----|-----|------|
| $t_{PHL}$ | HIGH to LOW propagation delay | nA to nY;<br>see <a href="#">Figure 4</a> | 5 V      | $18 + 0.55 \times C_L$               | -   | 45  | 90  | ns   |
|           |                               |                                           | 10 V     | $9 + 0.23 \times C_L$                | -   | 20  | 40  | ns   |
|           |                               |                                           | 15 V     | $7 + 0.16 \times C_L$                | -   | 15  | 25  | ns   |

Table 6. Dynamic characteristics ...continued  
 $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $C_L = 50\text{ pF}$ ;  $t_r = t_f \leq 20\text{ ns}$ ; for test circuit see Figure 5.

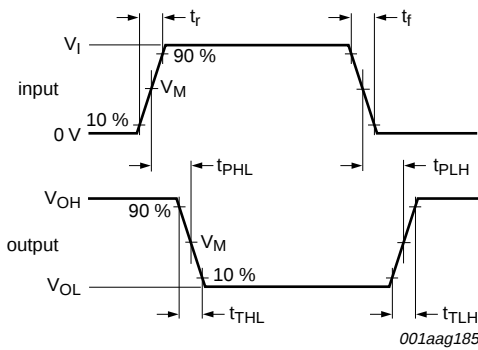
| Symbol    | Parameter                          | Conditions                 | $V_{DD}$ | Extrapolation formula <sup>[1]</sup> | Min | Typ | Max | Unit |
|-----------|------------------------------------|----------------------------|----------|--------------------------------------|-----|-----|-----|------|
| $t_{PLH}$ | LOW to HIGH propagation delay      | nA to nY;<br>see Figure 4  | 5 V      | $13 + 0.55 \times C_L$               | -   | 40  | 80  | ns   |
|           |                                    |                            | 10 V     | $9 + 0.23 \times C_L$                | -   | 20  | 40  | ns   |
|           |                                    |                            | 15 V     | $7 + 0.16 \times C_L$                | -   | 15  | 30  | ns   |
| $t_{THL}$ | HIGH to LOW output transition time | output nY;<br>see Figure 4 | 5 V      | $10 + 1.00 \times C_L$               | -   | 60  | 120 | ns   |
|           |                                    |                            | 10 V     | $9 + 0.42 \times C_L$                | -   | 30  | 60  | ns   |
|           |                                    |                            | 15 V     | $6 + 0.28 \times C_L$                | -   | 20  | 40  | ns   |
| $t_{TLH}$ | LOW to HIGH output transition time | output nY;<br>see Figure 4 | 5 V      | $10 + 1.00 \times C_L$               | -   | 60  | 120 | ns   |
|           |                                    |                            | 10 V     | $9 + 0.42 \times C_L$                | -   | 30  | 60  | ns   |
|           |                                    |                            | 15 V     | $6 + 0.28 \times C_L$                | -   | 20  | 40  | ns   |

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

Table 7. Dynamic power dissipation  
 $V_{SS} = 0\text{ V}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

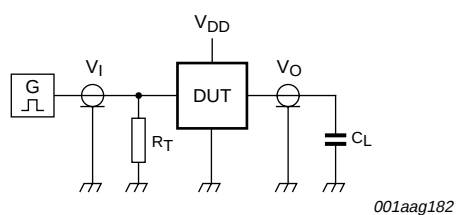
| Symbol | Parameter                 | $V_{DD}$ | Typical formula                                                                        | where                                                                                                                       |
|--------|---------------------------|----------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| $P_D$  | dynamic power dissipation | 5 V      | $P_D = 600 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2\text{ (}\mu\text{W)}$   | $f_i$ = input frequency in MHz;                                                                                             |
|        |                           | 10 V     | $P_D = 4000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2\text{ (}\mu\text{W)}$  | $f_o$ = output frequency in MHz;                                                                                            |
|        |                           | 15 V     | $P_D = 22000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2\text{ (}\mu\text{W)}$ | $C_L$ = output load capacitance in pF;<br>$\Sigma(f_o \times C_L)$ = sum of the outputs;<br>$V_{DD}$ = supply voltage in V. |

11. Waveforms



Measurement points:  $V_M = 0.5V_{DD}$ .  
Logic levels:  $V_{OL}$  and  $V_{OH}$  are typical output voltage levels that occur with the output load.

Fig 4. Propagation delay and transition times



Definitions for test circuit:

$V_{DD} = 5\text{ V to }15\text{ V}$ ;

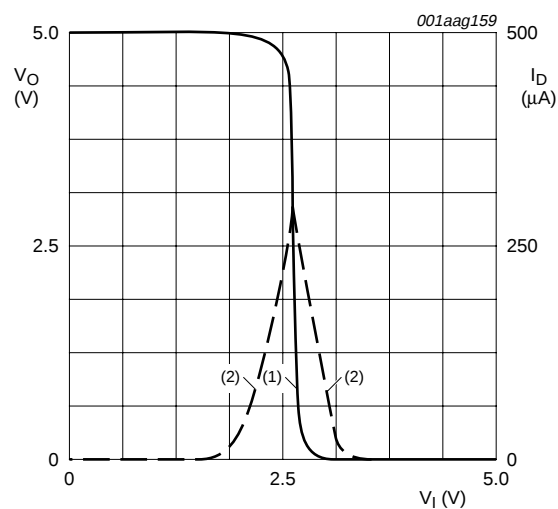
$V_I = V_{SS}\text{ or }V_{DD}$ ;

$C_L = \text{load capacitance including jig and probe capacitance} = 50\text{ pF}$ ;

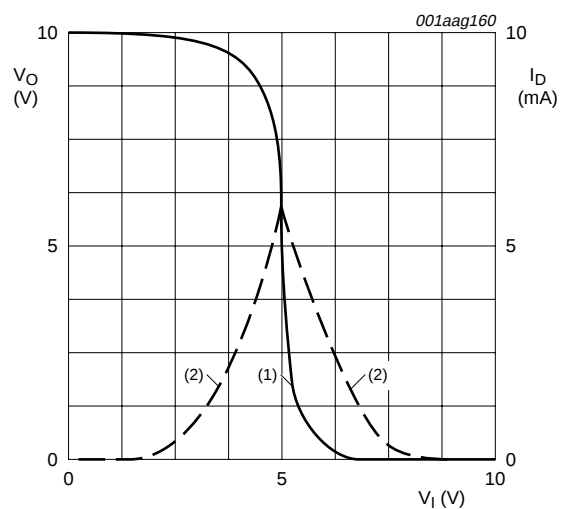
$R_T = \text{termination resistance should be equal to the output impedance } Z_o \text{ of the pulse generator}$ ;

**Fig 5. Test circuit**

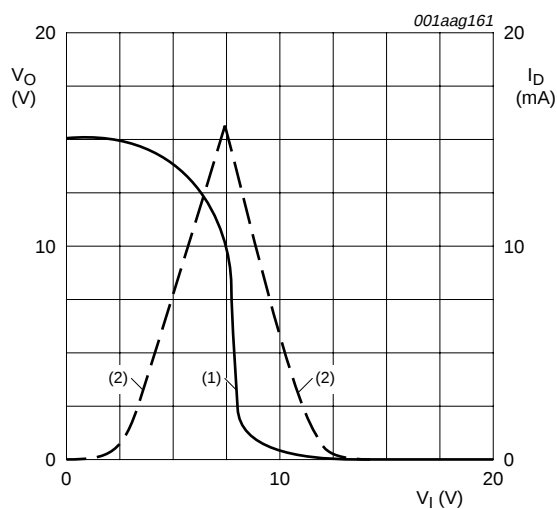
## 11.1 Transfer characteristics



a.  $V_{DD} = 5\text{ V}$ ;  $I_O = 0\text{ A}$



b.  $V_{DD} = 10\text{ V}$ ;  $I_O = 0\text{ A}$



c.  $V_{DD} = 15\text{ V}$ ;  $I_O = 0\text{ A}$

(1)  $V_O$  = output voltage.

(2)  $I_D$  = drain current.

**Fig 6. Typical transfer characteristics**

## 12. Application information

Some examples of applications for the HEF4069UB.

[Figure 7](#) shows an astable relaxation oscillator using two HEF4069UB inverters and 2 BAW62 diodes. The oscillation frequency is mainly determined by  $R1 \times C1$ , provided  $R1 \ll R2$  and  $R2 \times C2 \ll R1 \times C1$ .

The function of  $R2$  is to minimize the influence of the forward voltage across the protection diodes on the frequency;  $C2$  is a stray (parasitic) capacitance.

The period  $T_p$  is given by  $T_p = T_1 + T_2$ ,

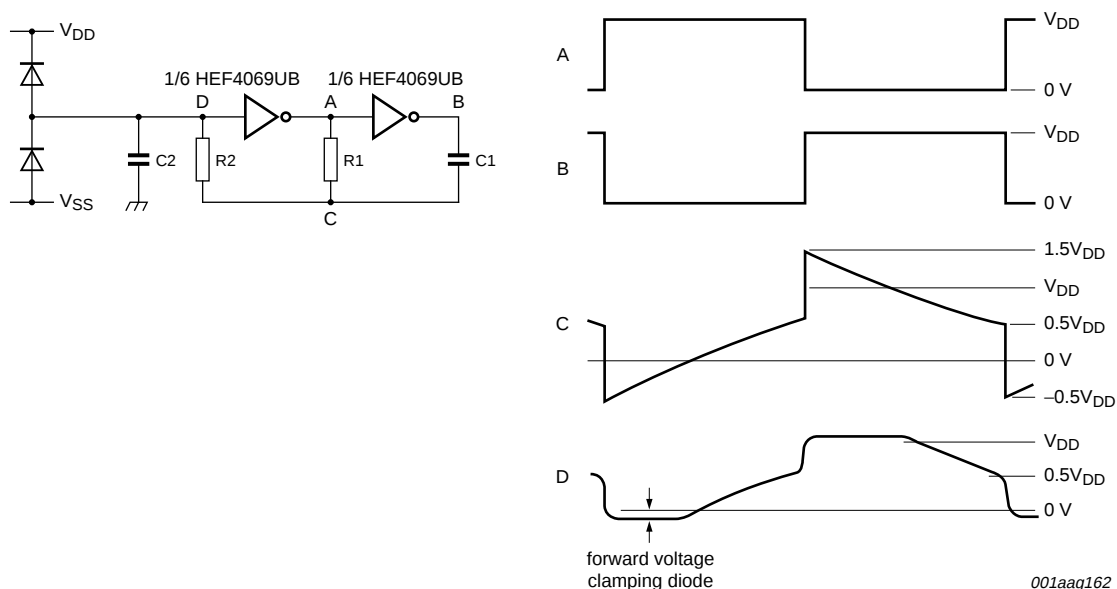
where:

$$T_1 = R1C1 \ln \frac{V_{DD} + V_{ST}}{V_{ST}}$$

$$T_2 = R1C1 \ln \frac{2V_{DD} - V_{ST}}{V_{DD} - V_{ST}}$$

$V_{ST}$  = the signal threshold level of the inverter.

The period is fairly independent of  $V_{DD}$ ,  $V_{ST}$  and temperature. The duty factor, however, is influenced by  $V_{ST}$ .



**Fig 7. Astable relaxation oscillator**

Figure 8 shows a crystal oscillator for frequencies up to 10 MHz using two HEF4069UB inverters. The second inverter amplifies the oscillator output voltage to a level sufficient to drive other Local Oxidation CMOS (LOCMOS) circuits.

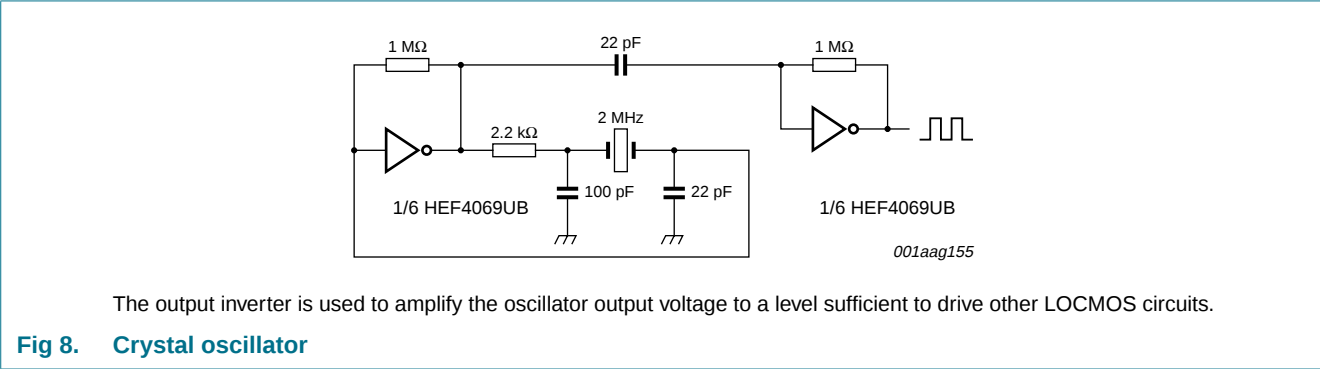


Figure 9 and Figure 10 show voltage gain and supply current. Figure 11 shows the test set-up and an example of an analog amplifier using one HEF4069UB.

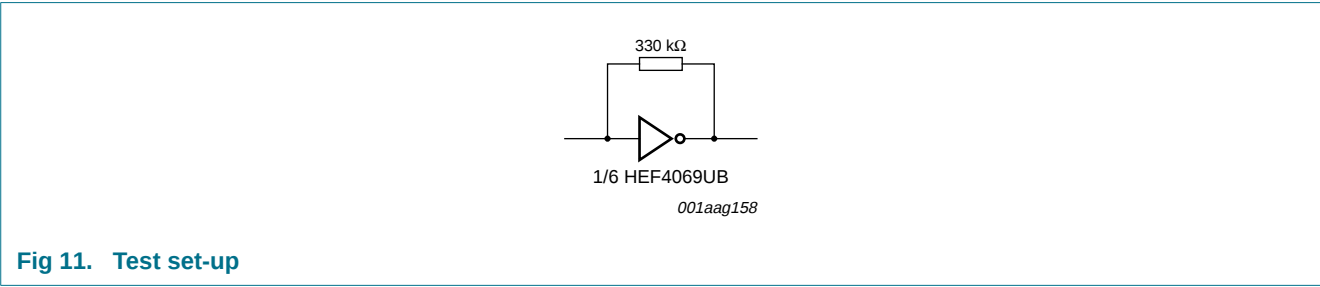
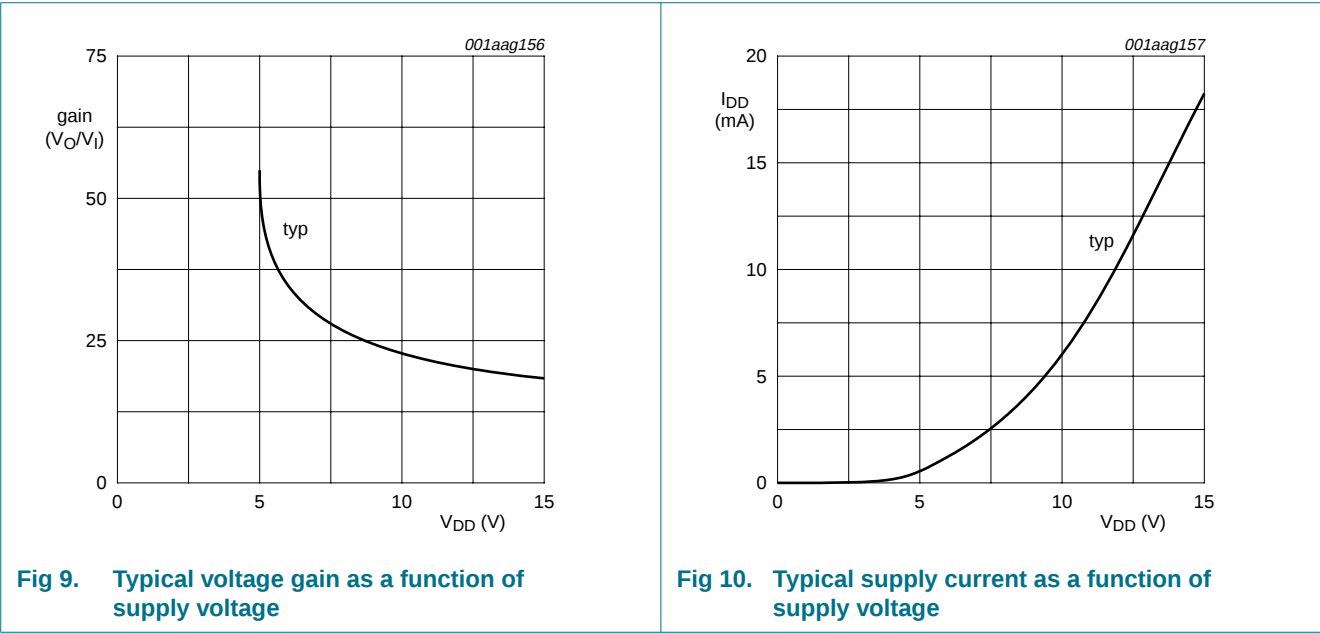


Figure 12 shows typical forward transconductance and Figure 13 shows the test set-up.

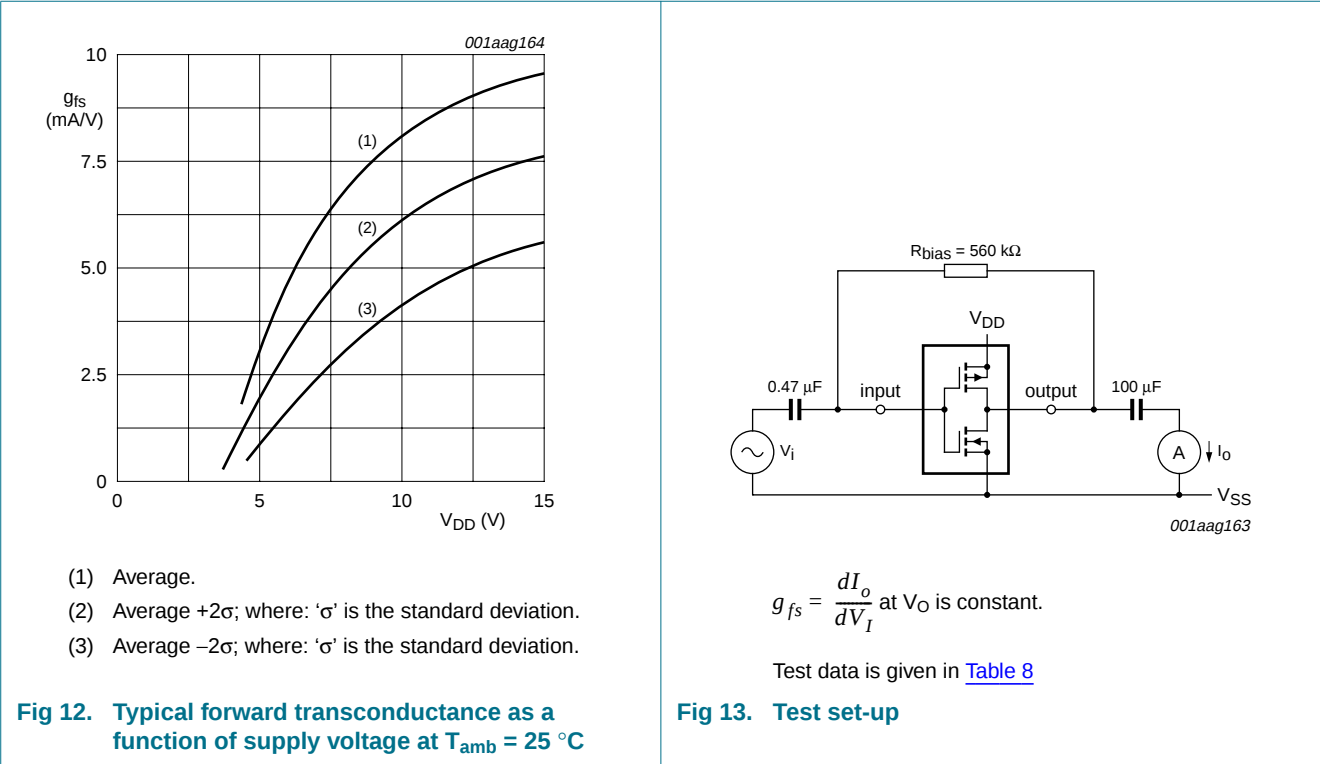


Table 8. Test data

| Supply voltage | Input                |       |                     |
|----------------|----------------------|-------|---------------------|
| $V_{DD}$       | $V_I$                | $f_i$ | $t_r, t_f$          |
| 5 V to 15 V    | $V_{SS}$ or $V_{DD}$ | 1 kHz | $\leq 20\text{ ns}$ |

13. Package outline

DIP14: plastic dual in-line package; 14 leads (300 mil) SOT27-1

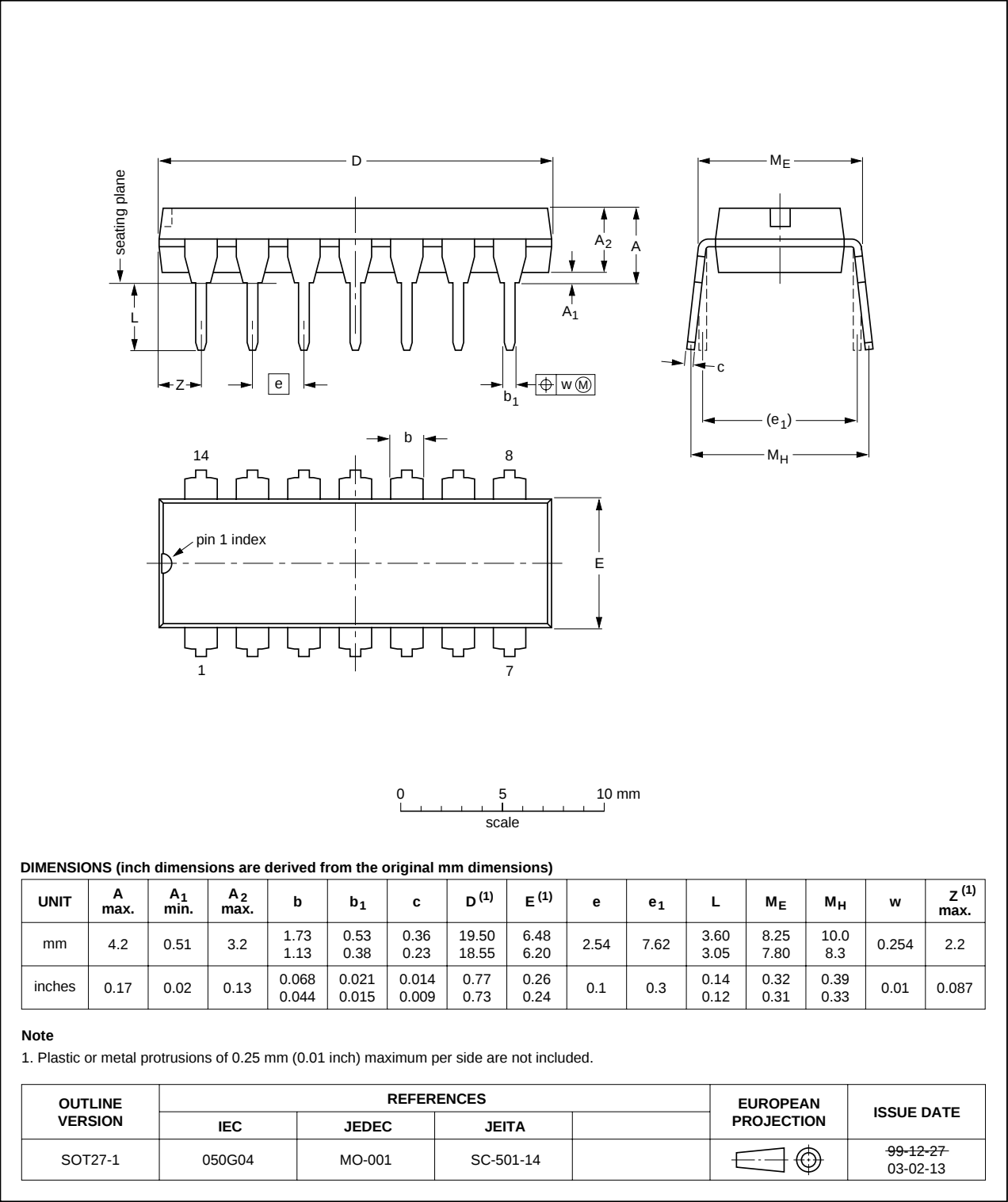


Fig 14. Package outline SOT27-1 (DIP14)

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

SOT108-1

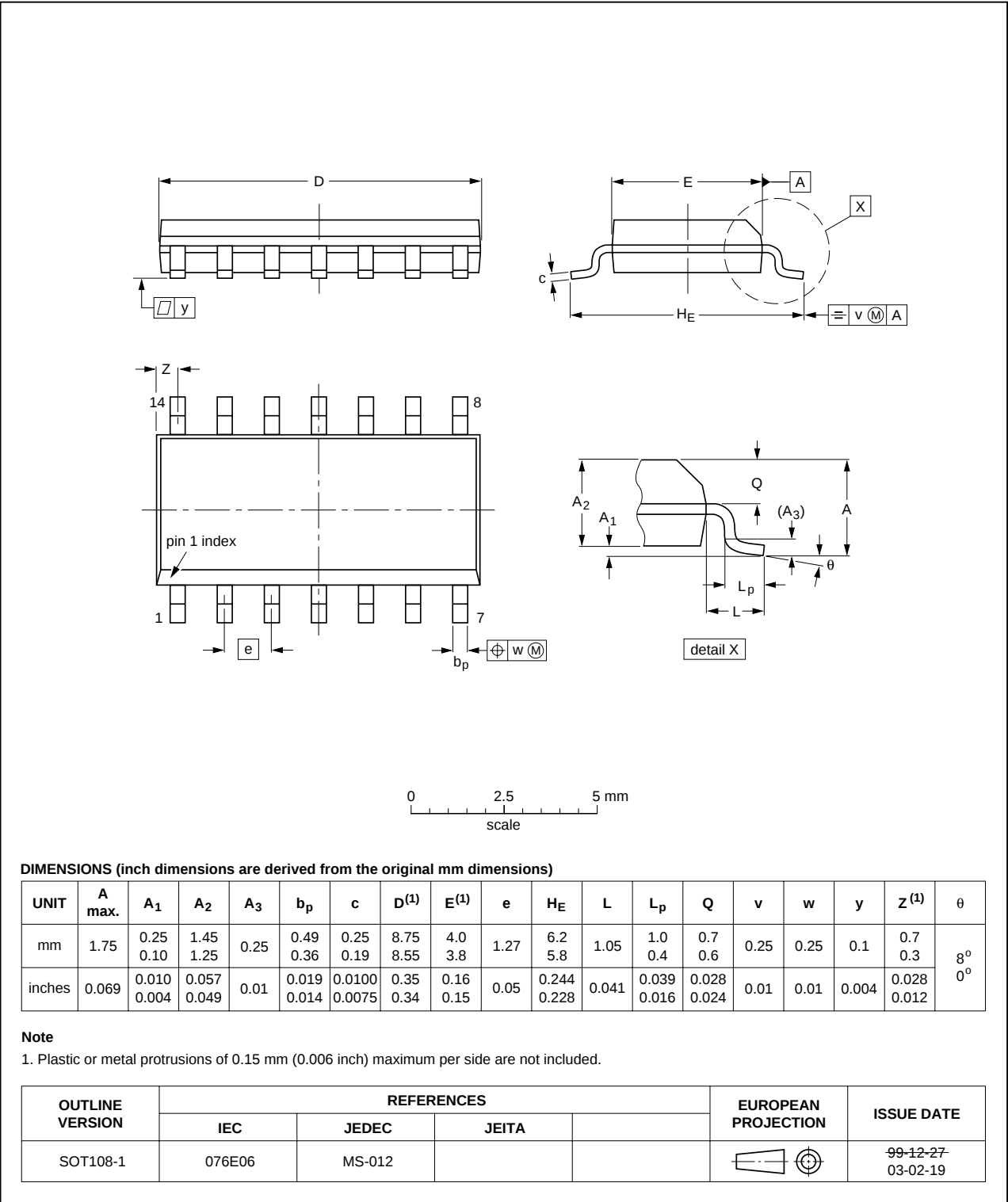


Fig 15. Package outline SOT108-1 (SO14)

TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm

SOT402-1

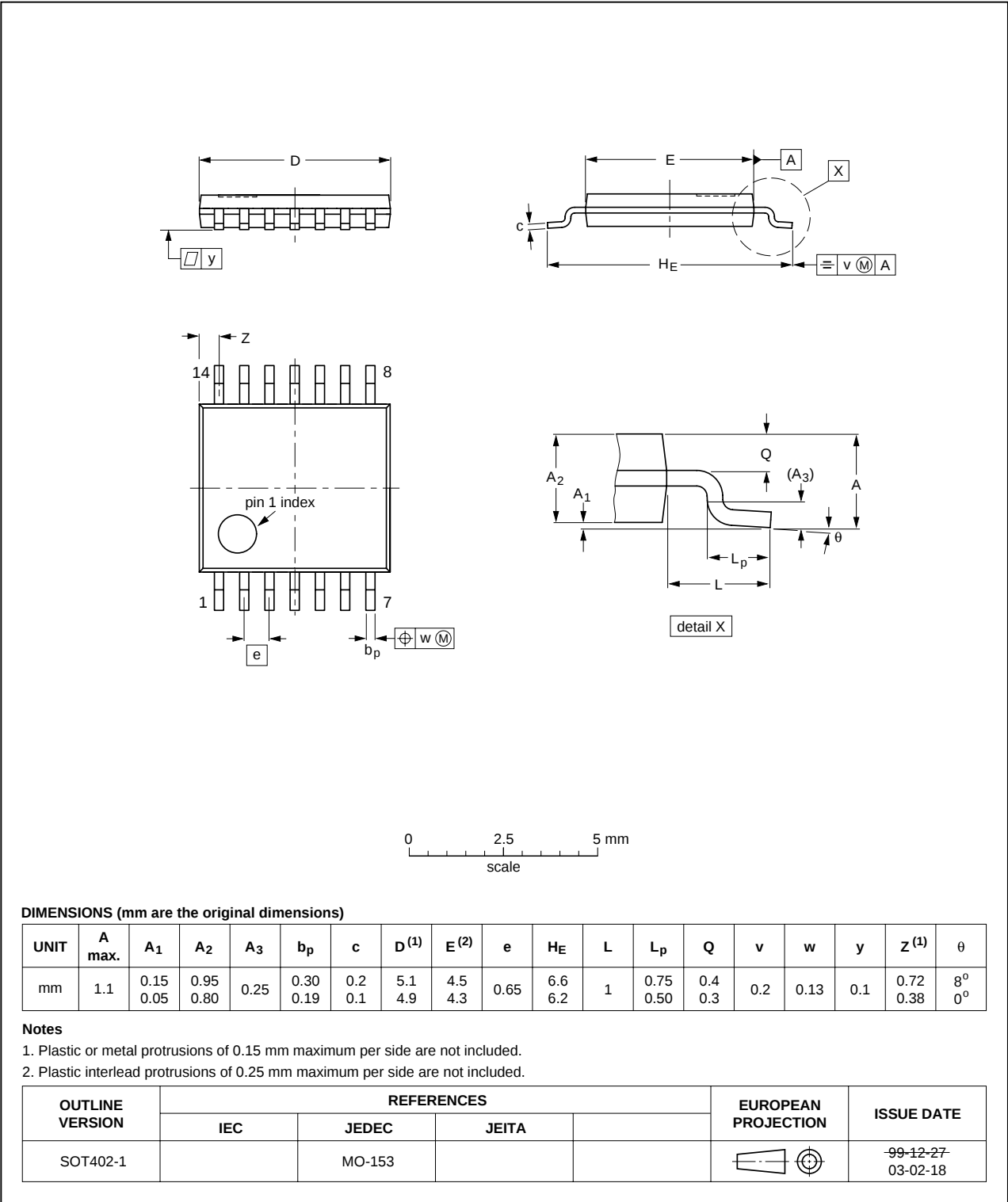


Fig 16. Package outline SOT402-1 (TSSOP14)

## 14. Abbreviations

Table 9. Abbreviations

| Acronym | Description             |
|---------|-------------------------|
| DUT     | Device Under Test       |
| ESD     | ElectroStatic Discharge |
| HBM     | Human Body Model        |
| MM      | Machine Model           |

## 15. Revision history

Table 10. Revision history

| Document ID     | Release date                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Data sheet status     | Change notice | Supersedes      |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------|-----------------|
| HEF4069UB_4     | 20080704                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Product data sheet    | -             | HEF4069UB_CNV_3 |
| Modifications:  | <ul style="list-style-type: none"><li>• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors.</li><li>• Legal texts have been adapted to the new company name where appropriate.</li><li>• Temperature range maximum increased from 85 °C to 125 °C throughout the data sheet.</li><li>• Package SOT73 removed and bare die package added to <a href="#">Section 4 "Ordering information"</a> and <a href="#">Section 13 "Package outline"</a>.</li><li>• <a href="#">Section 7 "Limiting values"</a> and <a href="#">Section 9 "Static characteristics"</a> added, taken from the HE4000B Family Specifications data sheet.</li><li>• <a href="#">Section 9 "Static characteristics"</a> <math>I_{OH}</math>, <math>I_{OL}</math>, <math>I_I</math> and <math>I_{DD}</math> values updated.</li><li>• Typical temperature coefficient for propagation delays and output transitions removed.</li><li>• <a href="#">Section 14 "Abbreviations"</a> added.</li></ul> |                       |               |                 |
| HEF4069UB_CNV_3 | 19950101                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Product specification | -             | HEF4069UB_CNV_2 |
| HEF4069UB_CNV_2 | 19950101                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Product specification | -             | -               |

## 16. Legal information

### 16.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | 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.nxp.com>.

### 16.2 Definitions

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