

# HEF4069UB

Hex unbuffered inverter

Rev. 10 — 10 February 2022

Product data sheet

## 1. General description

The HEF4069UB is a hex unbuffered inverter. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of  $V_{DD}$ .

## 2. Features and benefits

- Wide supply voltage range from 3.0 V to 15.0 V
- CMOS low power dissipation
- High noise immunity
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Complies with JEDEC standard JESD 13-B
- ESD protection:
  - HBM JESD22-A114F exceeds 2000 V
  - MM JESD22-A115-B exceeds 200 V
- Specified from -40 °C to +85 °C and -40 °C to +125 °C

## 3. Applications

- Oscillator

## 4. Ordering information

Table 1. Ordering information

| Type number | Package           |         |                                                                        |          |
|-------------|-------------------|---------|------------------------------------------------------------------------|----------|
|             | Temperature range | Name    | Description                                                            | Version  |
| HEF4069UBT  | -40 °C to +125 °C | SO14    | plastic small outline package; 14 leads; body width 3.9 mm             | SOT108-1 |
| HEF4069UBTT | -40 °C to +125 °C | TSSOP14 | plastic thin shrink small outline package; 14 leads; body width 4.4 mm | SOT402-1 |

## 5. Functional diagram

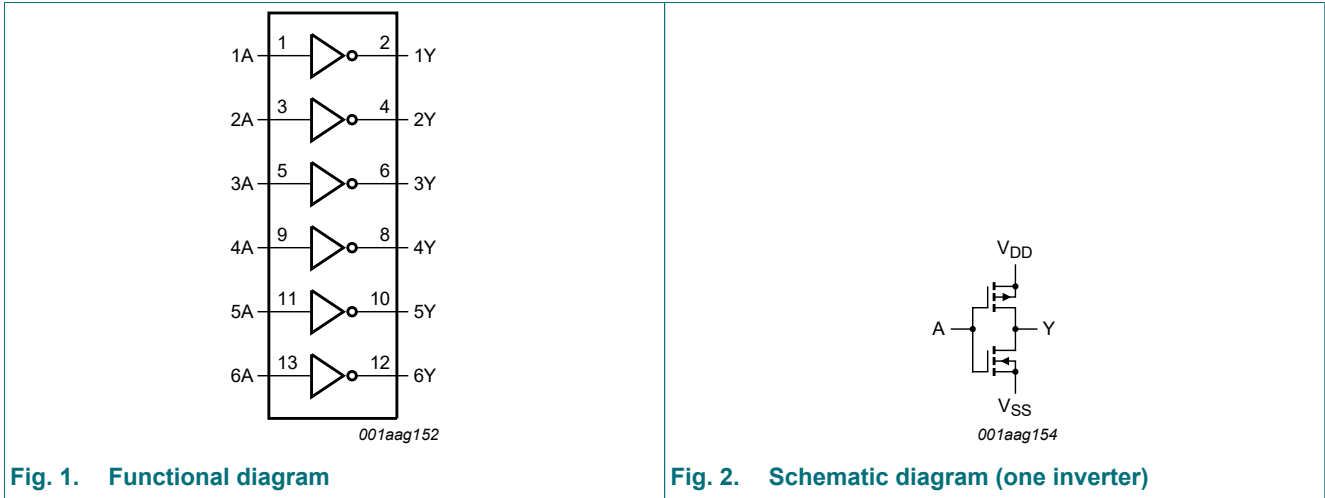


Fig. 1. Functional diagram

Fig. 2. Schematic diagram (one inverter)

## 6. Pinning information

### 6.1. Pinning

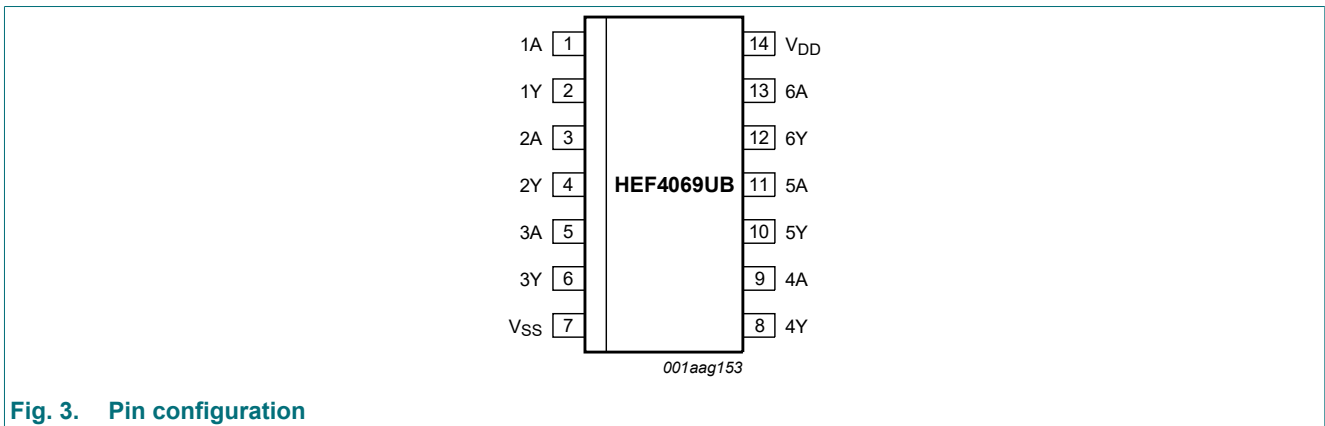


Fig. 3. Pin configuration

### 6.2. Pin description

Table 2. Pin description

| Symbol                 | Pin                | Description    |
|------------------------|--------------------|----------------|
| 1A, 2A, 3A, 4A, 5A, 6A | 1, 3, 5, 9, 11, 13 | input          |
| 1Y, 2Y, 3Y, 4Y, 5Y, 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 <sub>DD</sub>  | supply voltage          |                                                                     | -0.5 | +18                   | V    |
| I <sub>IK</sub>  | input clamping current  | V <sub>I</sub> < -0.5 V or V <sub>I</sub> > V <sub>DD</sub> + 0.5 V | -    | ±10                   | mA   |
| V <sub>I</sub>   | input voltage           |                                                                     | -0.5 | V <sub>DD</sub> + 0.5 | V    |
| I <sub>OK</sub>  | output clamping current | V <sub>O</sub> < -0.5 V or V <sub>O</sub> > V <sub>DD</sub> + 0.5 V | -    | ±10                   | mA   |
| I <sub>I/O</sub> | input/output current    |                                                                     | -    | ±10                   | mA   |
| I <sub>DD</sub>  | supply current          |                                                                     | -    | 50                    | mA   |
| T <sub>stg</sub> | storage temperature     |                                                                     | -65  | +150                  | °C   |
| T <sub>amb</sub> | ambient temperature     |                                                                     | -40  | +125                  | °C   |
| P <sub>tot</sub> | total power dissipation | T <sub>amb</sub> = -40 °C to +125 °C [1]                            | -    | 500                   | mW   |
| P                | power dissipation       | per output                                                          | -    | 100                   | mW   |

[1] For SOT108-1 (SO14) package: P<sub>tot</sub> derates linearly with 10.1 mW/K above 100 °C.  
For SOT402-1 (TSSOP14) package: P<sub>tot</sub> derates linearly with 7.3 mW/K above 81 °C.

## 8. Recommended operating conditions

**Table 4. Recommended operating conditions**

| Symbol           | Parameter           | Conditions  | Min | Typ | Max             | Unit |
|------------------|---------------------|-------------|-----|-----|-----------------|------|
| V <sub>DD</sub>  | supply voltage      |             | 3   | -   | 15              | V    |
| V <sub>I</sub>   | input voltage       |             | 0   | -   | V <sub>DD</sub> | V    |
| T <sub>amb</sub> | ambient temperature | in free air | -40 | -   | +125            | °C   |

## 9. Static characteristics

**Table 5. Static characteristics**

V<sub>SS</sub> = 0 V; V<sub>I</sub> = V<sub>SS</sub> or V<sub>DD</sub>; unless otherwise specified.

| 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>IH</sub> | HIGH-level input voltage  | I <sub>O</sub>   < 1 μA | 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 <sub>IL</sub> | LOW-level input voltage   | I <sub>O</sub>   < 1 μA | 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 <sub>OH</sub> | HIGH-level output voltage | I <sub>O</sub>   < 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 <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    |

| 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   |      |
| 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         | digital inputs                                        |                 | -                         | -     | -                         | 7.5  | -                         | -     | -                          | -     | pF   |

## 10. Dynamic characteristics

Table 6. Dynamic characteristics

T<sub>amb</sub> = 25 °C; 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 to nY   | 5 V             | 18 ns + (0.55 ns/pF)C <sub>L</sub> | -   | 45  | 90  | ns   |
|                  |                                    |            | 10 V            | 9 ns + (0.23 ns/pF)C <sub>L</sub>  | -   | 20  | 40  | ns   |
|                  |                                    |            | 15 V            | 7 ns + (0.16 ns/pF)C <sub>L</sub>  | -   | 15  | 25  | ns   |
| t <sub>PLH</sub> | LOW to HIGH propagation delay      | nA to nY   | 5 V             | 13 ns + (0.55 ns/pF)C <sub>L</sub> | -   | 40  | 80  | ns   |
|                  |                                    |            | 10 V            | 9 ns + (0.23 ns/pF)C <sub>L</sub>  | -   | 20  | 40  | ns   |
|                  |                                    |            | 15 V            | 7 ns + (0.16 ns/pF)C <sub>L</sub>  | -   | 15  | 30  | ns   |
| t <sub>THL</sub> | HIGH to LOW output transition time | output nY  | 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 | output nY  | 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   |

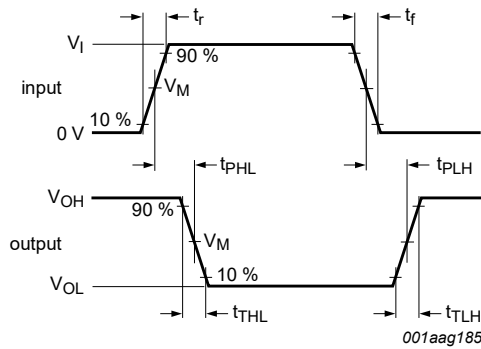
[1] The typical value of the propagation delay and output transition time can be calculated with the extrapolation formula (C<sub>L</sub> in pF).

Table 7. 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.

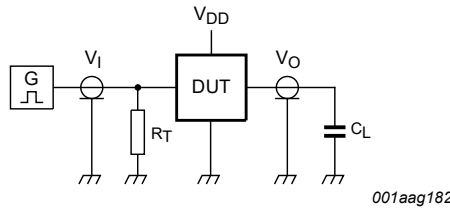
| Symbol         | Parameter                 | V <sub>DD</sub> | Typical formula                                                                                                   | Where                                                                                                                                                                                                                                           |
|----------------|---------------------------|-----------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| P <sub>D</sub> | dynamic power dissipation | 5 V             | P <sub>D</sub> = 600 × 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> = 4000 × 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> = 22000 × f <sub>i</sub> + Σ(f <sub>o</sub> × C <sub>L</sub> ) × V <sub>DD</sub> <sup>2</sup> (µW) |                                                                                                                                                                                                                                                 |

10.1. Waveforms and test circuit



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



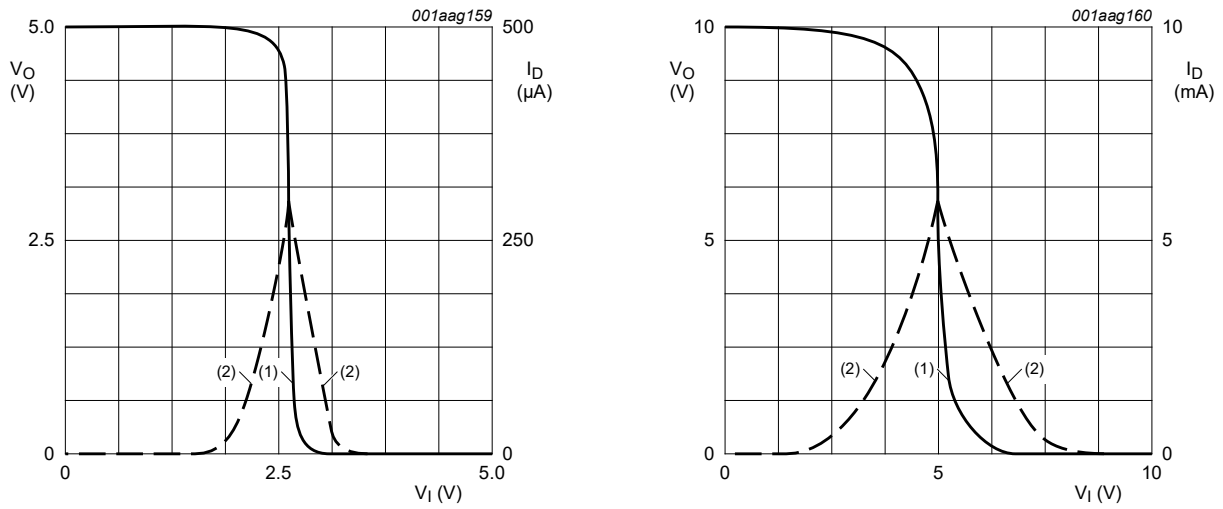
For test data refer to [Table 8](#).  
 Definitions for test circuit:  
 $C_L$  = load capacitance including jig and probe capacitance;  
 $R_T$  = termination resistance should be equal to the output impedance  $Z_o$  of the pulse generator.

Fig. 5. Test circuit for measuring switching times

Table 8. Test data

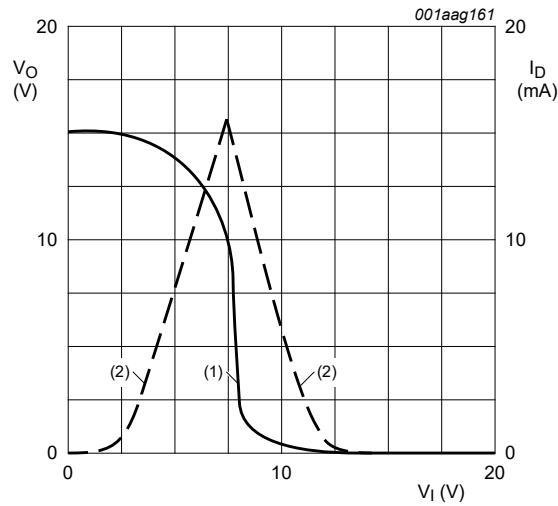
| Supply voltage | Input                | Load         |
|----------------|----------------------|--------------|
| $V_{DD}$       | $V_I$                | $C_L$        |
| 5 V to 15 V    | $V_{SS}$ or $V_{DD}$ | $\leq 20$ ns |

10.2. Transfer characteristics



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

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



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

(1)  $V_O$  = output voltage.  
 (2)  $I_D$  = drain current.

Fig. 6. Typical transfer characteristics

## 11. Application information

Some examples of applications for HEF4069UB.

[Fig. 7](#) shows an astable relaxation oscillator using two HEF4069UB inverters and two 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  $T_p = T_1 + T_2$ ,

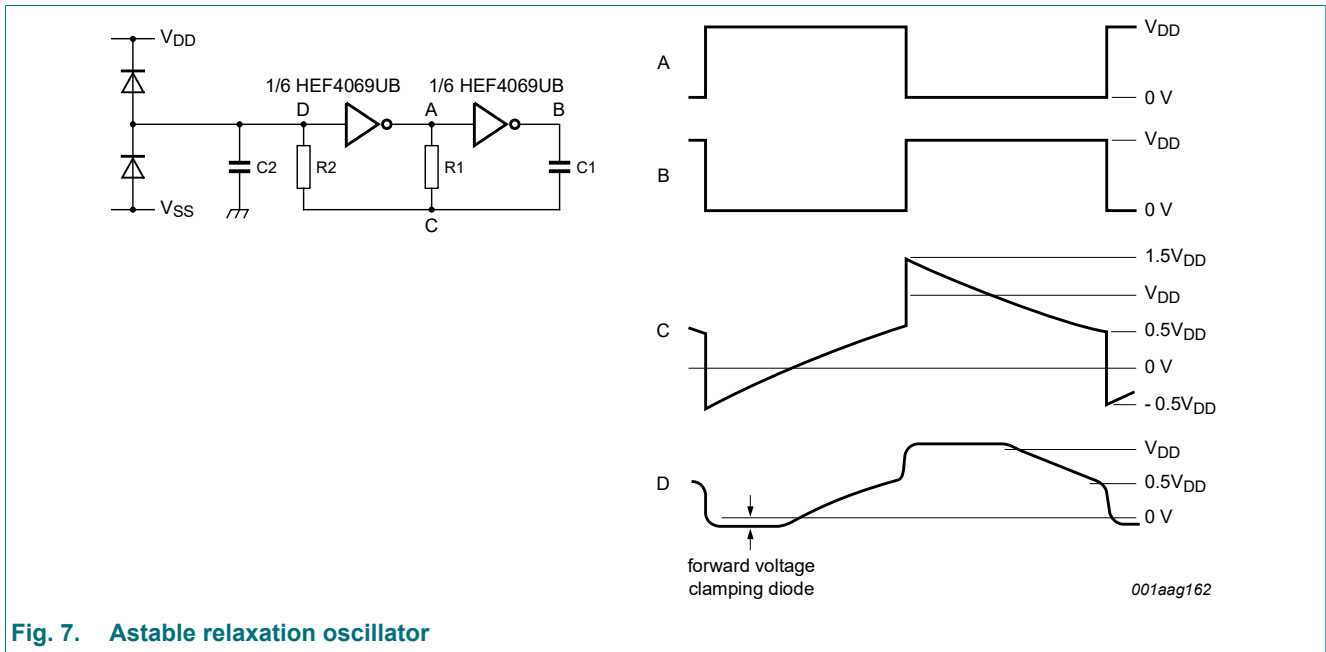
where:

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

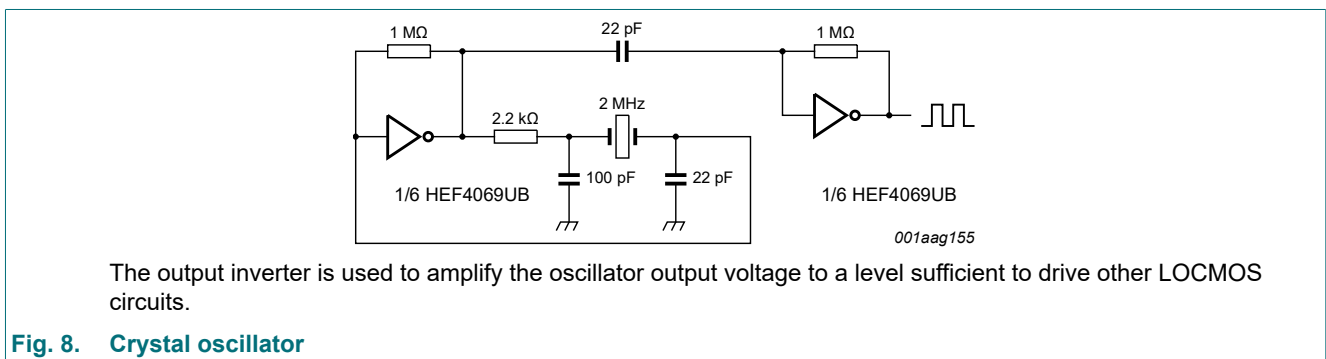
$$T_2 = R1C1 \ln \frac{2V_{DD} - V_{ST}}{V_{DD} - V_{ST}}$$

$V_{ST}$  = 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. 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.



The output inverter is used to amplify the oscillator output voltage to a level sufficient to drive other LOCMOS circuits.

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

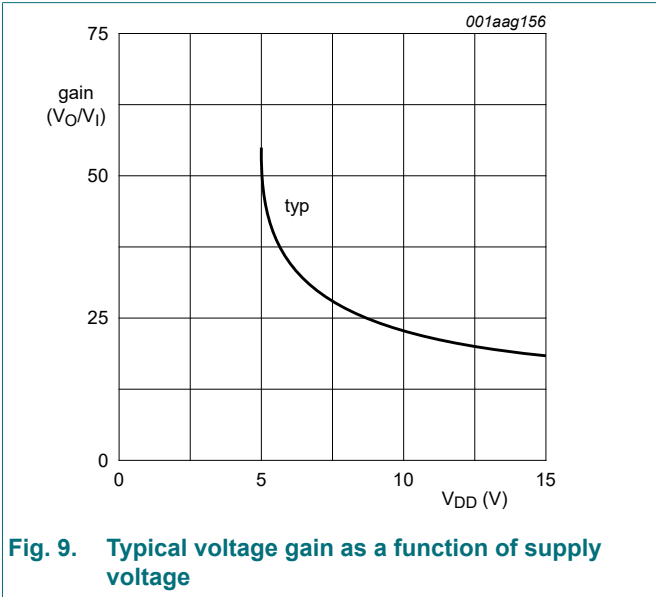


Fig. 9. Typical voltage gain as a function of supply voltage

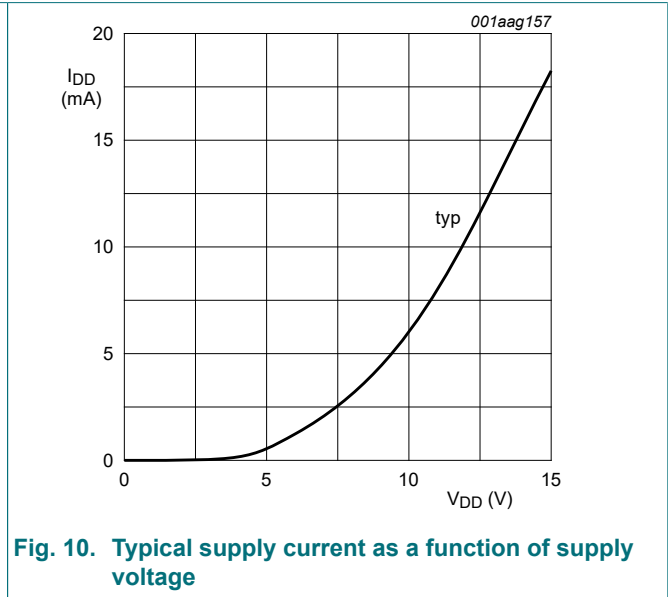


Fig. 10. Typical supply current as a function of supply voltage

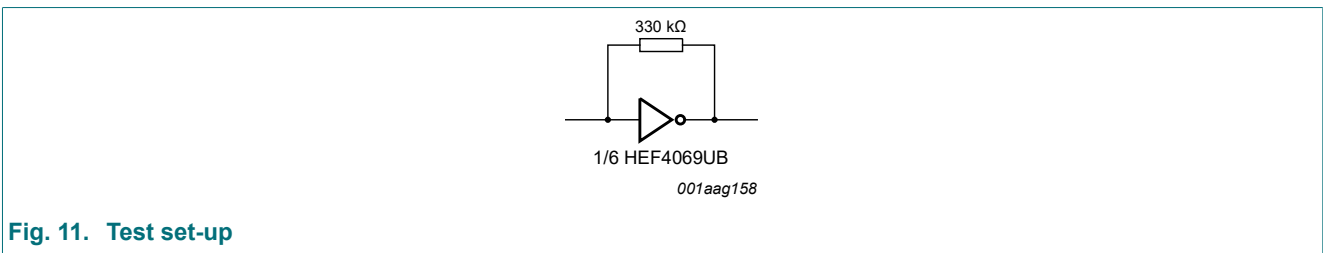


Fig. 11. Test set-up

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

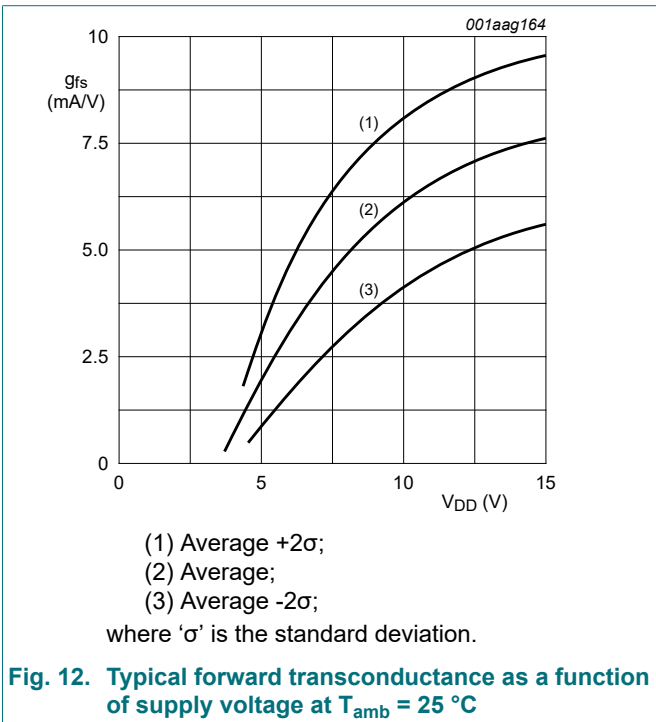


Fig. 12. Typical forward transconductance as a function of supply voltage at T<sub>amb</sub> = 25 °C

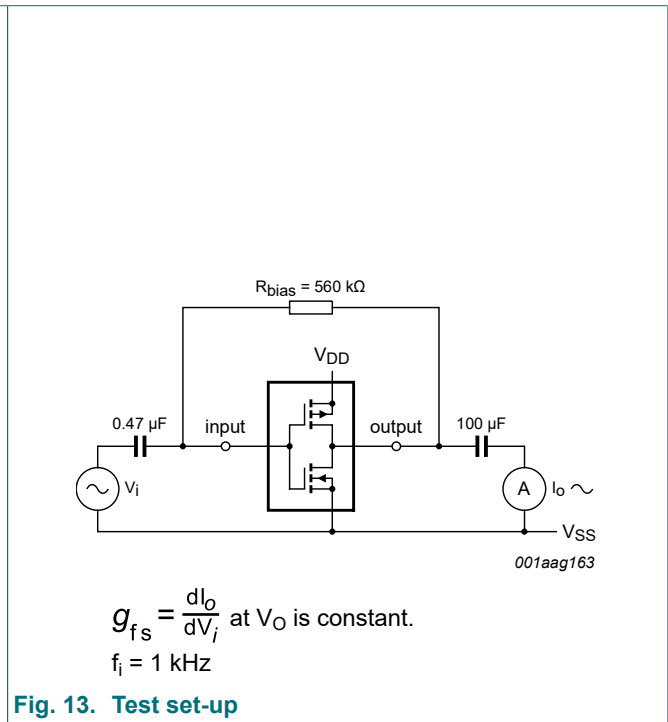


Fig. 13. Test set-up



## 12. Package outline

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

SOT108-1

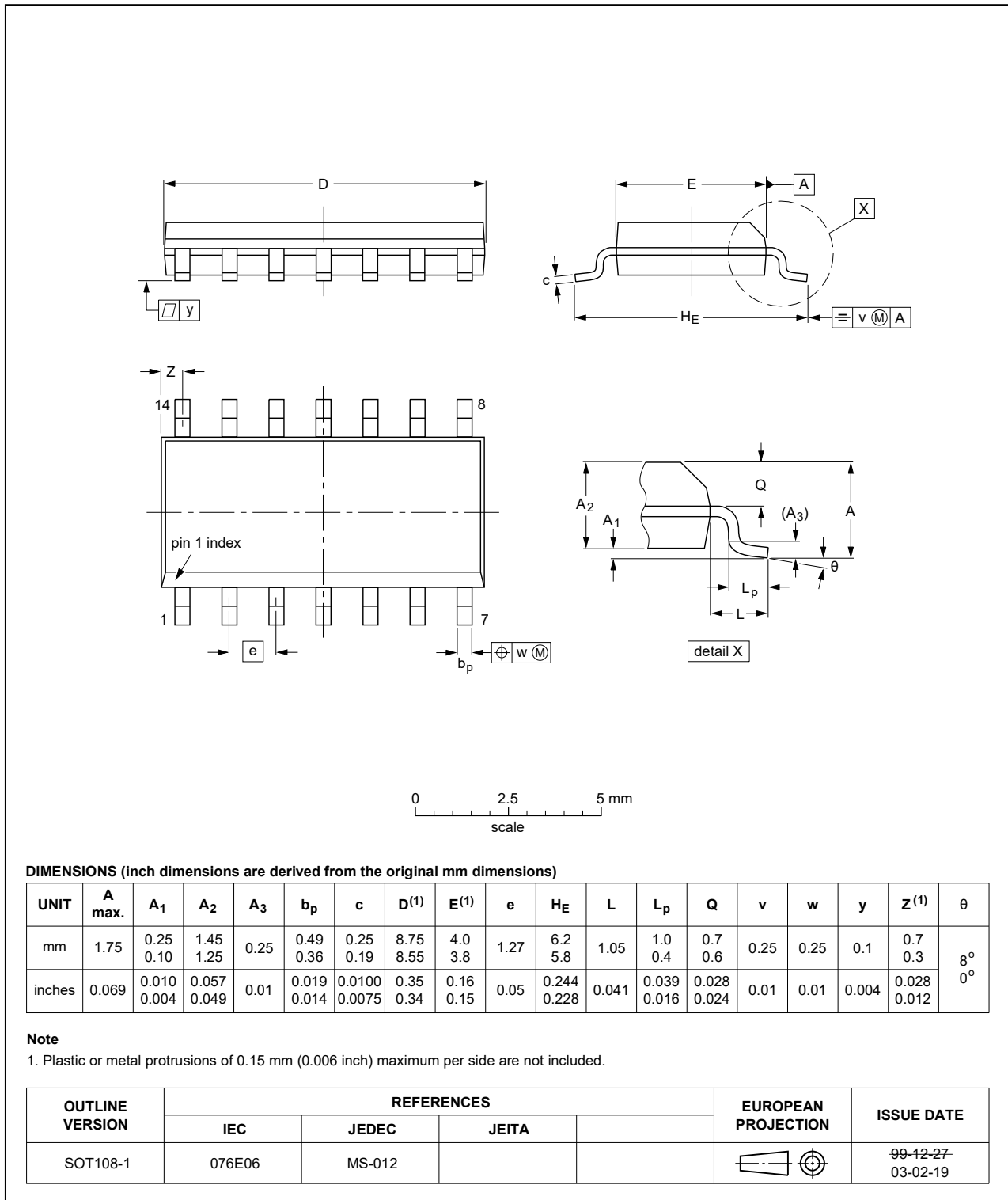


Fig. 14. Package outline SOT108-1 (SO14)

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

SOT402-1

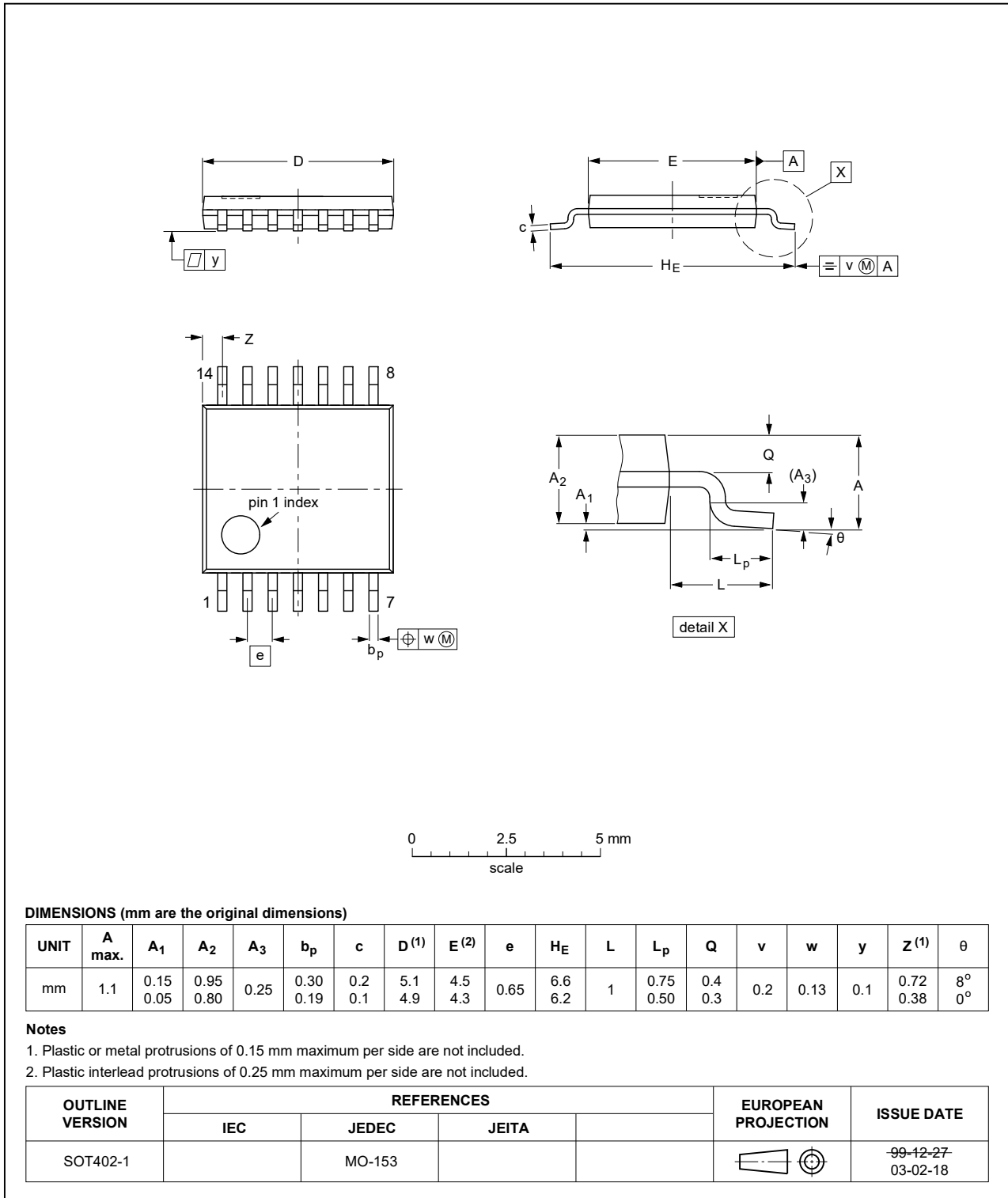


Fig. 15. Package outline SOT402-1 (TSSOP14)

## 13. Abbreviations

Table 9. Abbreviations

| Acronym | Description                                             |
|---------|---------------------------------------------------------|
| CMOS    | Complementary Metal-Oxide Semiconductor                 |
| DUT     | Device Under Test                                       |
| ESD     | ElectroStatic Discharge                                 |
| HBM     | Human Body Model                                        |
| LOC MOS | Local Oxidation Complementary Metal-Oxide Semiconductor |
| MM      | Machine Model                                           |

## 14. Revision history

Table 10. Revision history

| Document ID       | Release date                                                                                                                                                                                                                                                                                                                                                                                                                    | Data sheet status     | Change notice | Supersedes        |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------|-------------------|
| HEF4069UB v.10    | 20220210                                                                                                                                                                                                                                                                                                                                                                                                                        | Product data sheet    | -             | HEF4069UB 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><a href="#">Section 1</a> and <a href="#">Section 2</a> updated.</li> <li><a href="#">Table 3</a>: Derating values for <math>P_{tot}</math> total power dissipation updated.</li> </ul> |                       |               |                   |
| HEF4069UB v.9     | 20151216                                                                                                                                                                                                                                                                                                                                                                                                                        | Product data sheet    | -             | HEF4069UB v.8     |
| Modifications:    | <ul style="list-style-type: none"> <li>Type number HEF4069UBP (SOT27-1) removed.</li> </ul>                                                                                                                                                                                                                                                                                                                                     |                       |               |                   |
| HEF4069UB v.8     | 20111116                                                                                                                                                                                                                                                                                                                                                                                                                        | Product data sheet    | -             | HEF4069UB v.7     |
| Modifications:    | <ul style="list-style-type: none"> <li>Legal pages updated.</li> <li>Changes in "General description", "Features and benefits" and "Applications".</li> </ul>                                                                                                                                                                                                                                                                   |                       |               |                   |
| HEF4069UB v.7     | 20110511                                                                                                                                                                                                                                                                                                                                                                                                                        | Product data sheet    | -             | HEF4069UB v.6     |
| HEF4069UB v.6     | 20091208                                                                                                                                                                                                                                                                                                                                                                                                                        | Product data sheet    | -             | HEF4069UB v.5     |
| HEF4069UB v.5     | 20090723                                                                                                                                                                                                                                                                                                                                                                                                                        | Product data sheet    | -             | HEF4069UB v.4     |
| HEF4069UB v.4     | 20080704                                                                                                                                                                                                                                                                                                                                                                                                                        | Product data sheet    | -             | HEF4069UB_CNV v.3 |
| HEF4069UB_CNV v.3 | 19950101                                                                                                                                                                                                                                                                                                                                                                                                                        | Product specification | -             | HEF4069UB_CNV v.2 |
| HEF4069UB_CNV v.2 | 19950101                                                                                                                                                                                                                                                                                                                                                                                                                        | Product specification | -             | -                 |

## 15. 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".
- [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 <https://www.nexperia.com>.

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