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Kind regards,

Team Nexperia

# HEF4069UB-Q100

## Hex inverter

Rev. 2 — 9 September 2014

Product data sheet

## 1. General description

The HEF4069UB-Q100 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.

This product has been qualified to the Automotive Electronics Council (AEC) standard Q100 (Grade 1) and is suitable for use in automotive applications.

## 2. Features and benefits

- Automotive product qualification in accordance with AEC-Q100 (Grade 1)
  - ◆ Specified from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  and from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- ESD protection:
  - ◆ MIL-STD-883, method 3015 exceeds 2000 V
  - ◆ HBM JESD22-A114F exceeds 2000 V
  - ◆ MM JESD22-A115-A exceeds 200 V ( $C = 200\text{ pF}$ ,  $R = 0\text{ }\Omega$ )
- Complies with JEDEC standard JESD 13-B

## 3. Applications

- Oscillator

## 4. Ordering information

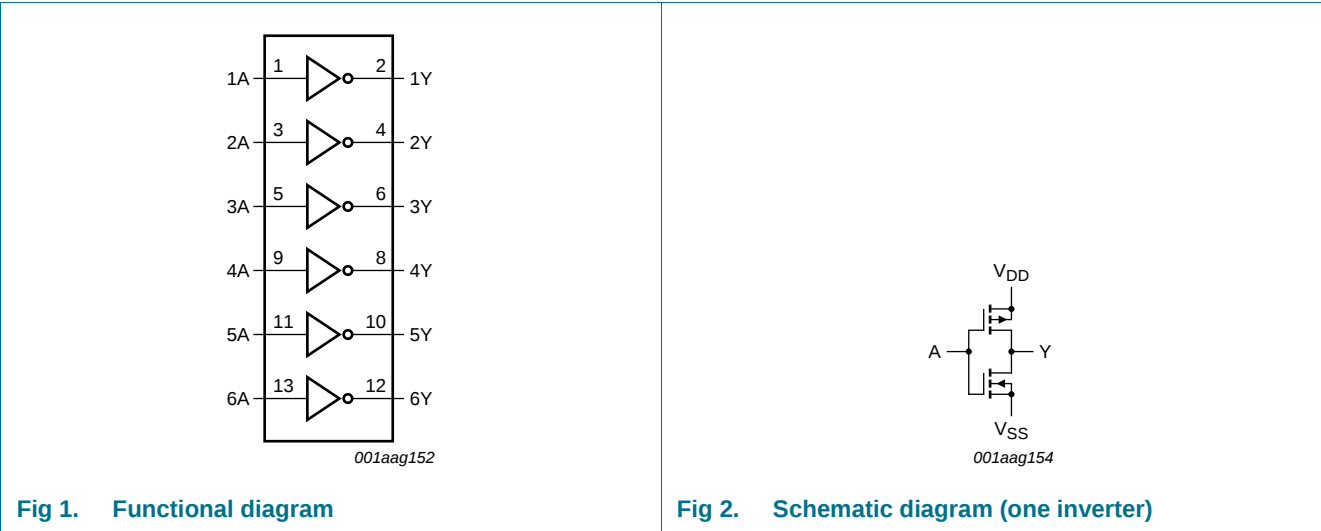
**Table 1.** Ordering information

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

| Type number      | Package |                                                                        |          |
|------------------|---------|------------------------------------------------------------------------|----------|
|                  | Name    | Description                                                            | Version  |
| HEF4069UBT-Q100  | SO14    | plastic small outline package; 14 leads; body width 3.9 mm             | SOT108-1 |
| HEF4069UBTT-Q100 | TSSOP14 | plastic thin shrink small outline package; 14 leads; body width 4.4 mm | SOT402-1 |

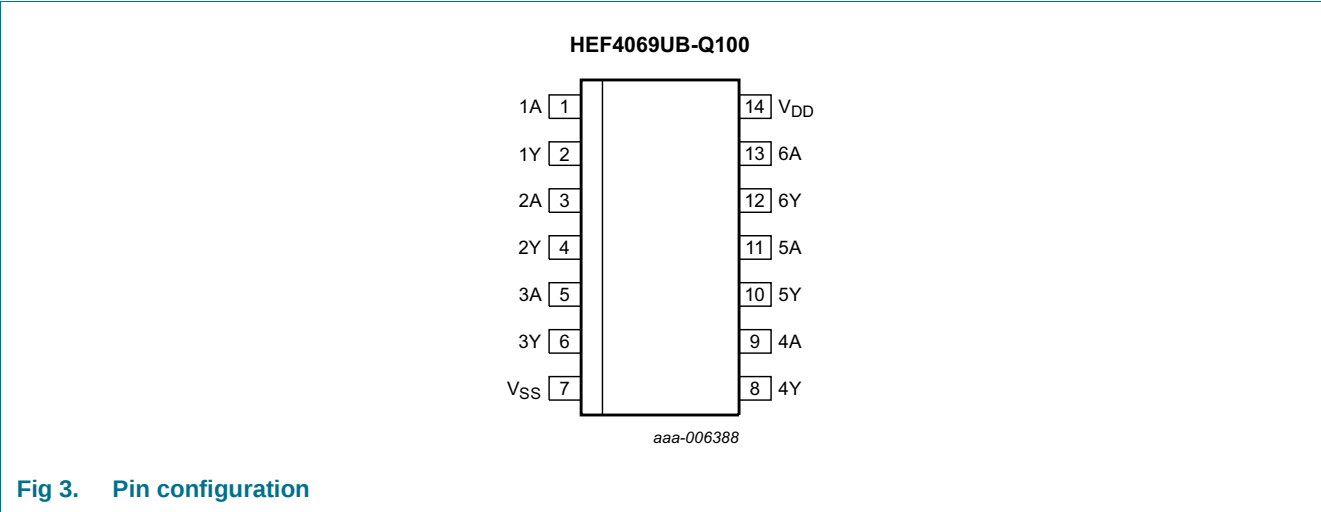


5. Functional diagram



6. Pinning information

6.1 Pinning



6.2 Pin description

Table 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   |
| $I_{IO}$  | 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 | $T_{amb} = -40\text{ °C to }+125\text{ °C}$            |                     |      |                |      |
|           |                         | SO14                                                   | <a href="#">[1]</a> | -    | 500            | mW   |
|           |                         | TSSOP14                                                | <a href="#">[2]</a> | -    | 500            | mW   |
| $P$       | power dissipation       | per output                                             |                     | -    | 100            | mW   |

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

[2] 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   |

## 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                                          | $V_{DD}$ | $T_{amb} = -40\text{ °C}$ |           | $T_{amb} = +25\text{ °C}$ |           | $T_{amb} = +85\text{ °C}$ |           | $T_{amb} = +125\text{ °C}$ |           | Unit          |
|----------|---------------------------|-----------------------------------------------------|----------|---------------------------|-----------|---------------------------|-----------|---------------------------|-----------|----------------------------|-----------|---------------|
|          |                           |                                                     |          | Min                       | Max       | Min                       | Max       | Min                       | Max       | Min                        | Max       |               |
| $V_{IH}$ | 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**

$T_{amb} = 25\text{ }^{\circ}\text{C}$ ; for waveforms see [Figure 4](#); 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   | 5 V      | $18\text{ ns} + (0.55\text{ ns/pF})C_L$ | -   | 45  | 90  | ns   |
|           |                                    |            | 10 V     | $9\text{ ns} + (0.23\text{ ns/pF})C_L$  | -   | 20  | 40  | ns   |
|           |                                    |            | 15 V     | $7\text{ ns} + (0.16\text{ ns/pF})C_L$  | -   | 15  | 25  | ns   |
| $t_{PLH}$ | LOW to HIGH propagation delay      | nA to nY   | 5 V      | $13\text{ ns} + (0.55\text{ ns/pF})C_L$ | -   | 40  | 80  | ns   |
|           |                                    |            | 10 V     | $9\text{ ns} + (0.23\text{ ns/pF})C_L$  | -   | 20  | 40  | ns   |
|           |                                    |            | 15 V     | $7\text{ ns} + (0.16\text{ ns/pF})C_L$  | -   | 15  | 30  | ns   |
| $t_{THL}$ | HIGH to LOW output transition time | output nY  | 5 V      | $10\text{ ns} + (1.00\text{ ns/pF})C_L$ | -   | 60  | 120 | ns   |
|           |                                    |            | 10 V     | $9\text{ ns} + (0.42\text{ ns/pF})C_L$  | -   | 30  | 60  | ns   |
|           |                                    |            | 15 V     | $6\text{ ns} + (0.28\text{ ns/pF})C_L$  | -   | 20  | 40  | ns   |
| $t_{TLH}$ | LOW to HIGH output transition time | output nY  | 5 V      | $10\text{ ns} + (1.00\text{ ns/pF})C_L$ | -   | 60  | 120 | ns   |
|           |                                    |            | 10 V     | $9\text{ ns} + (0.42\text{ ns/pF})C_L$  | -   | 30  | 60  | ns   |
|           |                                    |            | 15 V     | $6\text{ ns} + (0.28\text{ ns/pF})C_L$  | -   | 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;<br>$f_o$ = output frequency in MHz;<br>$C_L$ = output load capacitance in pF;<br>$\Sigma(f_o \times C_L)$ = sum of the outputs;<br>$V_{DD}$ = supply voltage in V. |
|        |                           | 10 V     | $P_D = 4000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2\text{ (}\mu\text{W)}$  |                                                                                                                                                                                                    |
|        |                           | 15 V     | $P_D = 22000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2\text{ (}\mu\text{W)}$ |                                                                                                                                                                                                    |

11. Waveforms

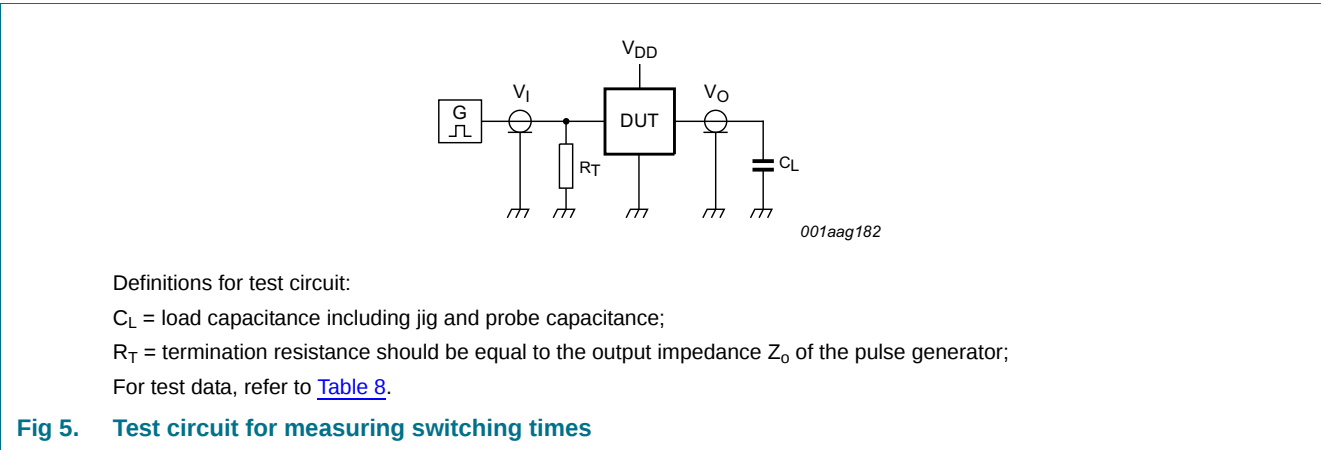
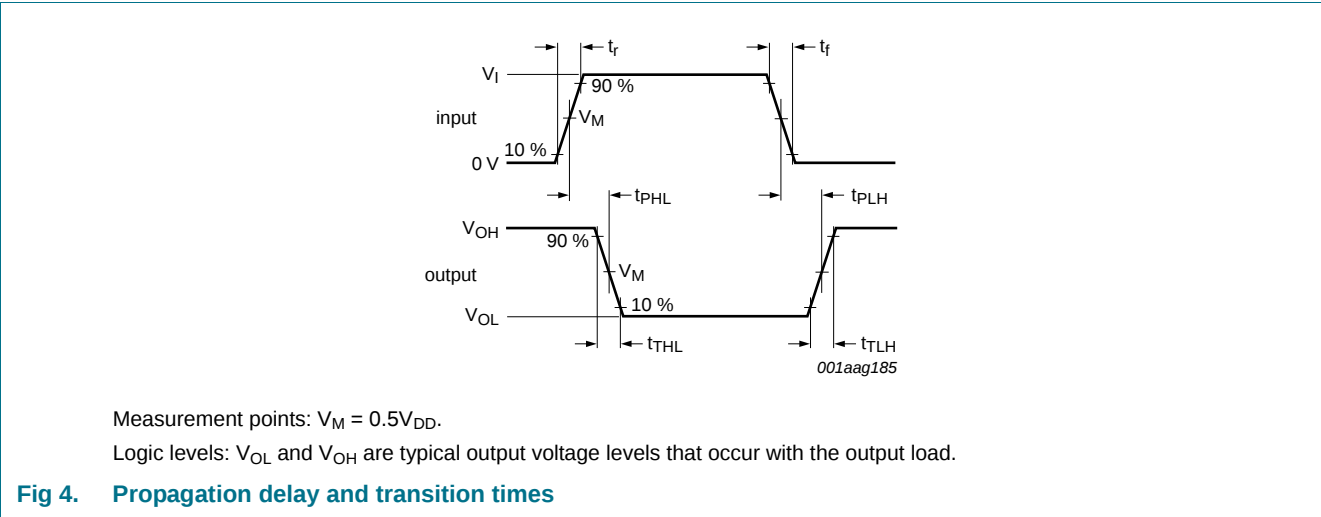
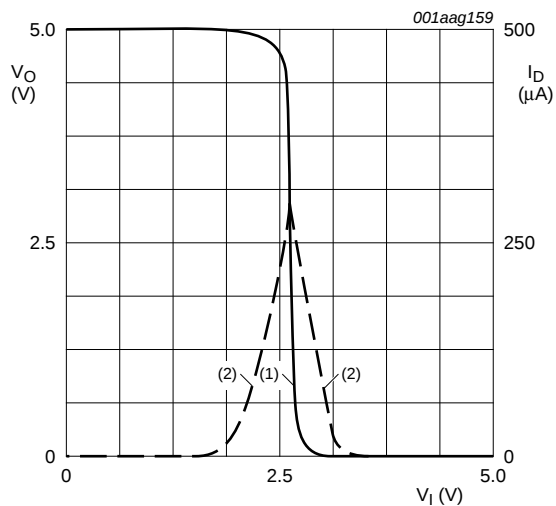


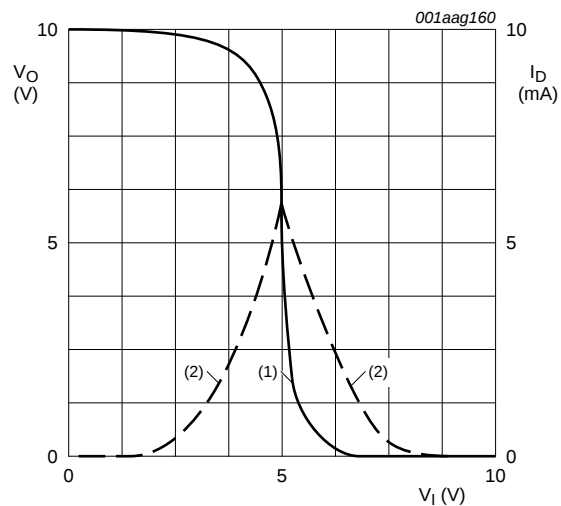
Table 8. Test data

| 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 |

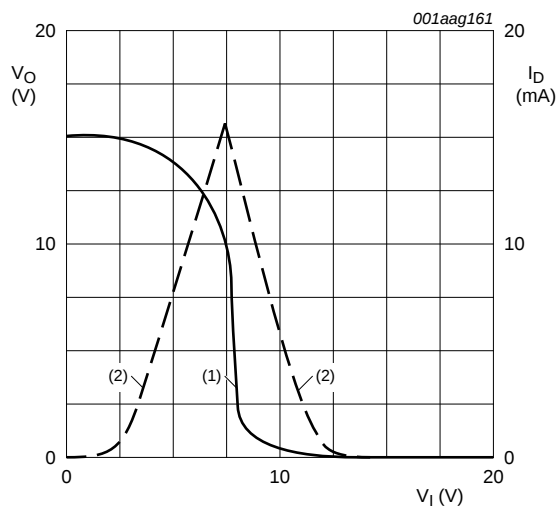
## 11.1 Transfer characteristics



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-Q100.

[Figure 7](#) shows an astable relaxation oscillator using two HEF4069UB-Q100 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  $T_p = T_1 + T_2$ ,

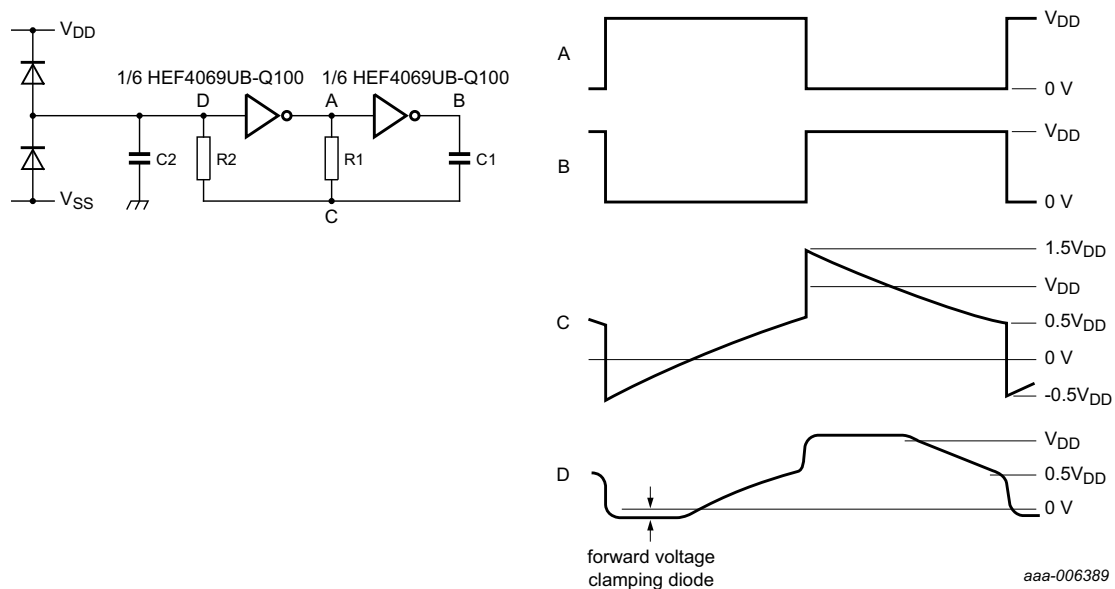
where:

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

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

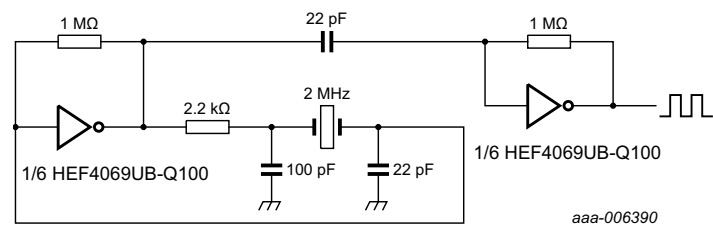
$V_{ST}$  = the signal threshold level of the inverter.

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-Q100 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 8. Crystal oscillator

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-Q100.

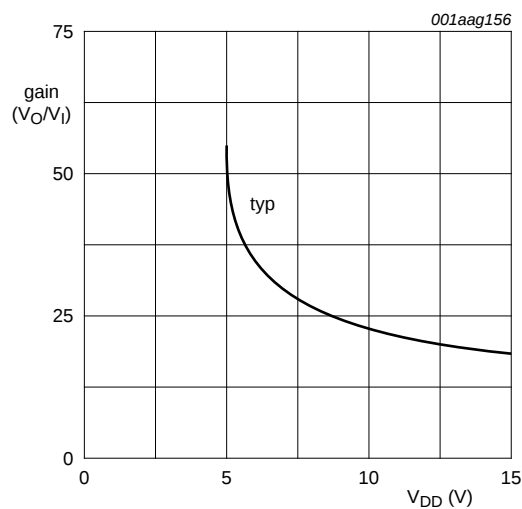


Fig 9. Typical voltage gain as a function of supply voltage

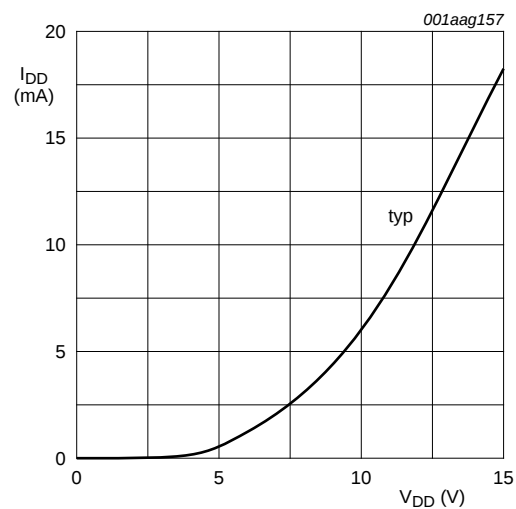


Fig 10. Typical supply current as a function of supply voltage

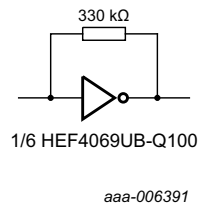
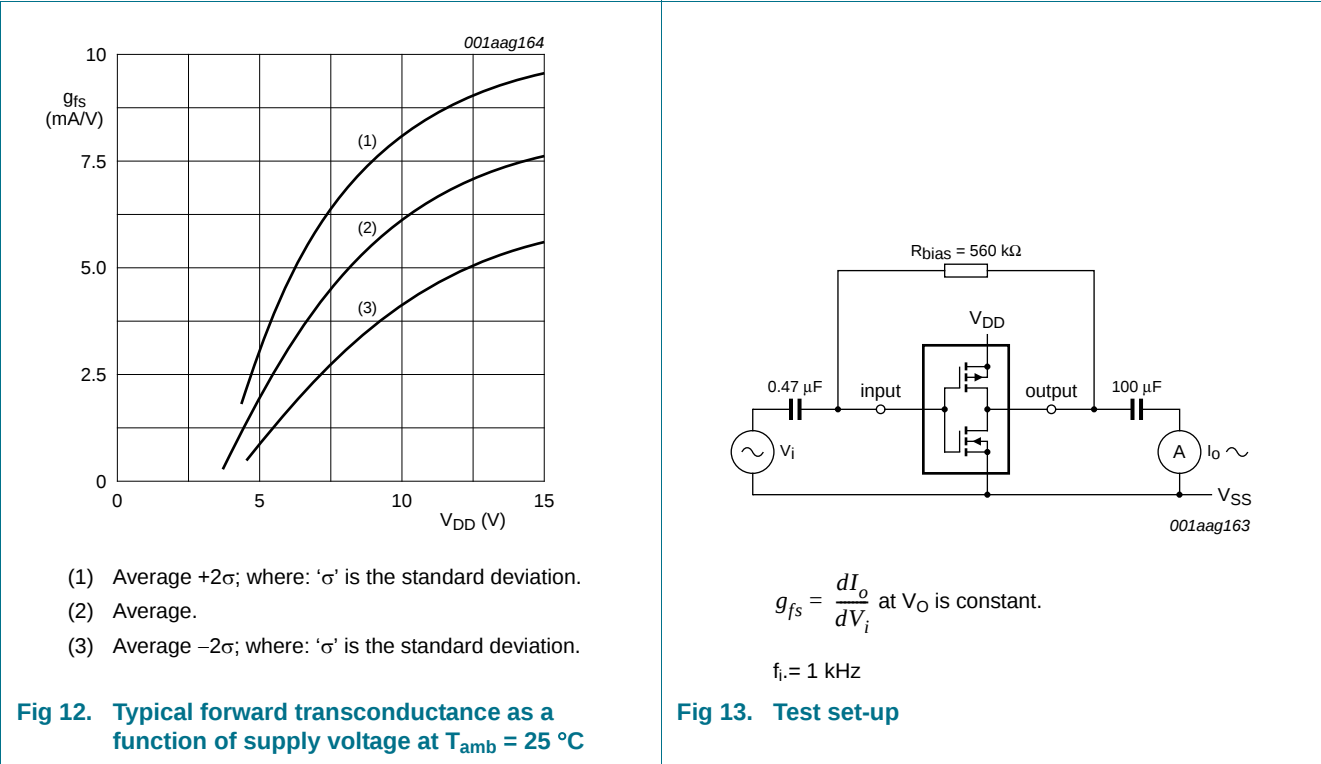


Fig 11. Test set-up

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



13. Package outline

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

SOT108-1

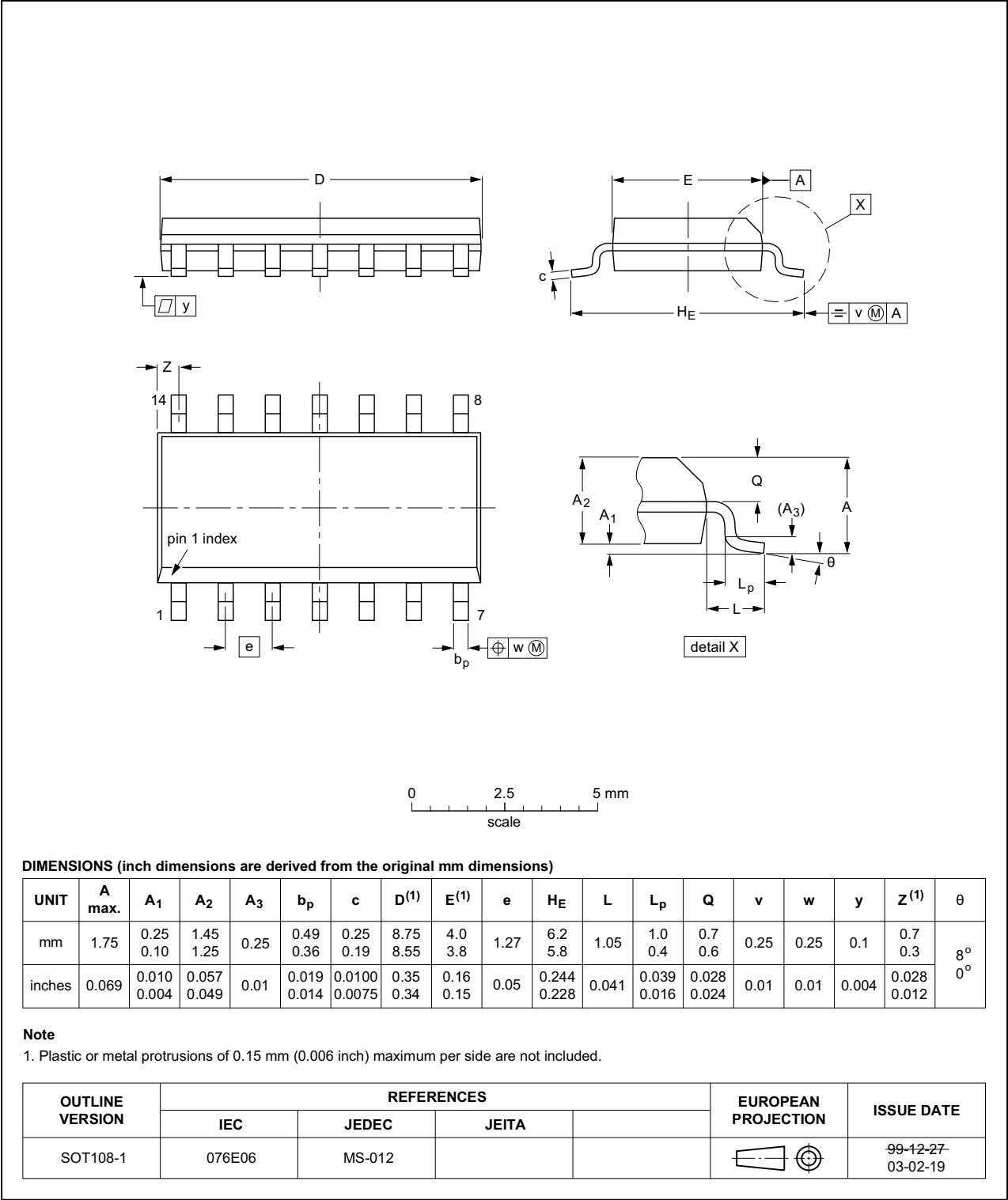


Fig 14. Package outline SOT108-1 (SO14)

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

SOT402-1

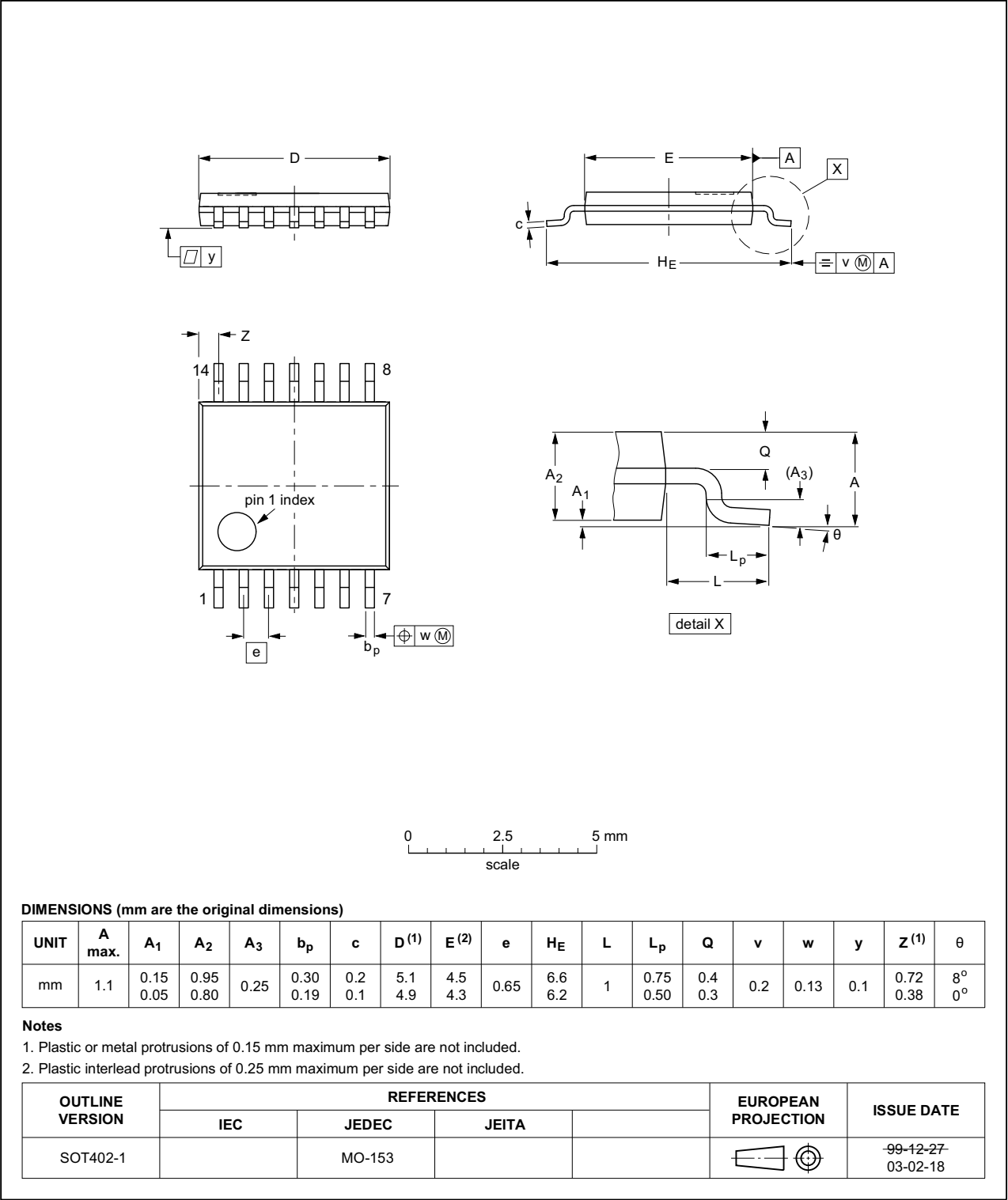


Fig 15. Package outline SOT402-1 (TSSOP14)

## 14. Abbreviations

Table 9. Abbreviations

| Acronym | Description             |
|---------|-------------------------|
| HBM     | Human Body Model        |
| ESD     | ElectroStatic Discharge |
| MM      | Machine Model           |
| MIL     | Military                |

## 15. Revision history

Table 10. Revision history

| Document ID        | Release date                                                                    | Data sheet status  | Change notice | Supersedes         |
|--------------------|---------------------------------------------------------------------------------|--------------------|---------------|--------------------|
| HEF4069UB_Q100 v.2 | 20140909                                                                        | Product data sheet | -             | HEF4069UB_Q100 v.1 |
| Modifications:     | • <a href="#">Section 2</a> : ESD protection: MIL-STD-833 changed to MIL-STD883 |                    |               |                    |
| HEF4069UB_Q100 v.1 | 20130228                                                                        | Product data sheet | -             | -                  |

## 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>.

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