

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

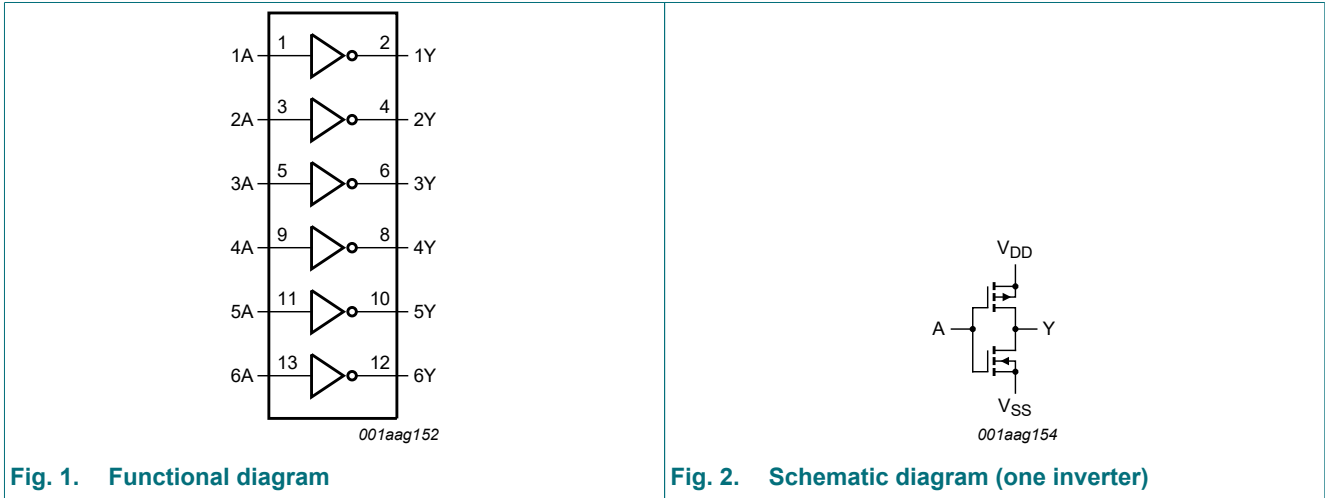


Fig. 1. Functional diagram

Fig. 2. Schematic diagram (one inverter)

6. Pinning information

6.1. Pinning

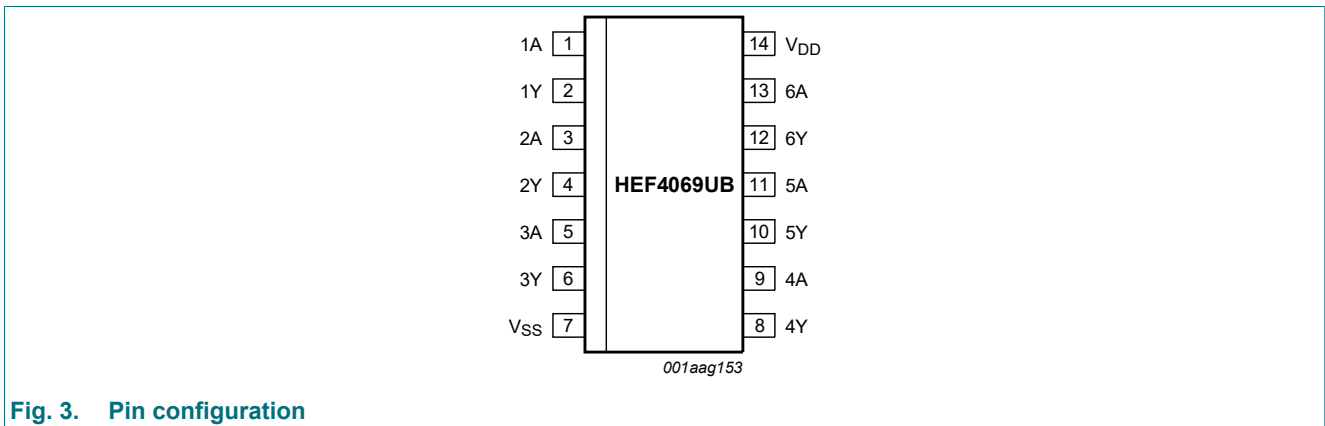


Fig. 3. Pin configuration

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 _{SS} | 7 | ground (0 V) |
| V _{DD} | 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 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 [1] | - | 500 | mW |
| P | power dissipation | per output | - | 100 | mW |

[1] For SOT108-1 (SO14) package: P_{tot} derates linearly with 10.1 mW/K above 100 °C.
For SOT402-1 (TSSOP14) package: P_{tot} 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 _{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 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 _{IH} | HIGH-level input voltage | I _O < 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 _{IL} | LOW-level input voltage | I _O < 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 _{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 |

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

10. Dynamic characteristics

Table 6. Dynamic characteristics

T_{amb} = 25 °C; for waveforms see Fig. 4; for test circuit see Fig. 5.

| Symbol | Parameter | Conditions | V _{DD} | Extrapolation formula [1] | Min | Typ | Max | Unit |
|------------------|------------------------------------|------------|-----------------|------------------------------------|-----|-----|-----|------|
| t _{PHL} | HIGH to LOW propagation delay | nA to nY | 5 V | 18 ns + (0.55 ns/pF)C _L | - | 45 | 90 | ns |
| | | | 10 V | 9 ns + (0.23 ns/pF)C _L | - | 20 | 40 | ns |
| | | | 15 V | 7 ns + (0.16 ns/pF)C _L | - | 15 | 25 | ns |
| t _{PLH} | LOW to HIGH propagation delay | nA to nY | 5 V | 13 ns + (0.55 ns/pF)C _L | - | 40 | 80 | ns |
| | | | 10 V | 9 ns + (0.23 ns/pF)C _L | - | 20 | 40 | ns |
| | | | 15 V | 7 ns + (0.16 ns/pF)C _L | - | 15 | 30 | ns |
| t _{THL} | HIGH to LOW output transition time | output nY | 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 | output nY | 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 |

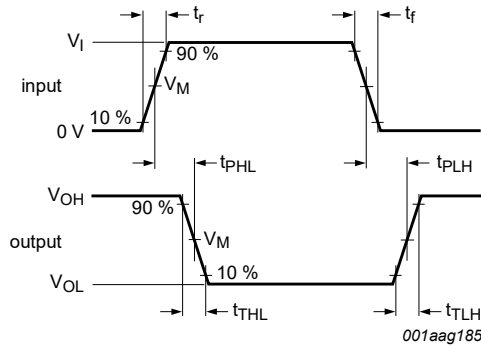
[1] The typical value of the propagation delay and output transition time can be calculated with the extrapolation formula (C_L in pF).

Table 7. Dynamic power dissipation

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

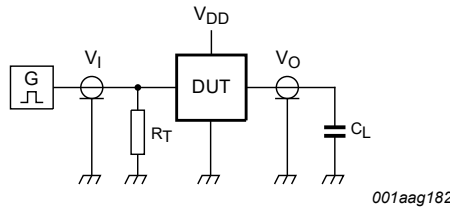
| Symbol | Parameter | V _{DD} | Typical formula | Where |
|----------------|---------------------------|-----------------|---|---|
| P _D | dynamic power dissipation | 5 V | P _D = 600 × f _i + Σ(f _o × C _L) × V _{DD} ² (µW) | f _i = input frequency in MHz; f _o = output frequency in MHz; C _L = output load capacitance in pF; Σ(f _o × C _L) = sum of the outputs; V _{DD} = supply voltage in V. |
| | | 10 V | P _D = 4000 × f _i + Σ(f _o × C _L) × V _{DD} ² (µW) | |
| | | 15 V | P _D = 22000 × f _i + Σ(f _o × C _L) × V _{DD} ² (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



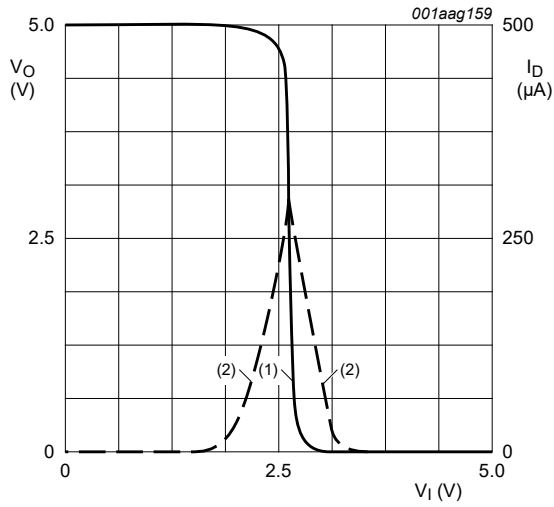
For test data refer to [Table 8](#).
 Definitions for test circuit:
 C_L = load capacitance including jig and probe capacitance;
 R_T = termination resistance should be equal to the output impedance Z_o of the pulse generator.

Fig. 5. Test circuit for measuring switching times

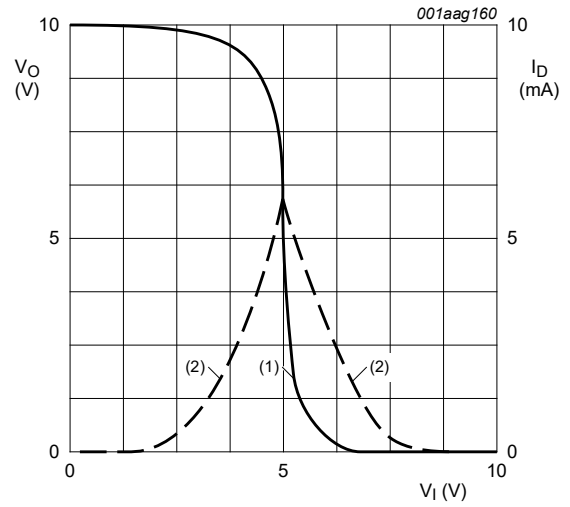
Table 8. Test data

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

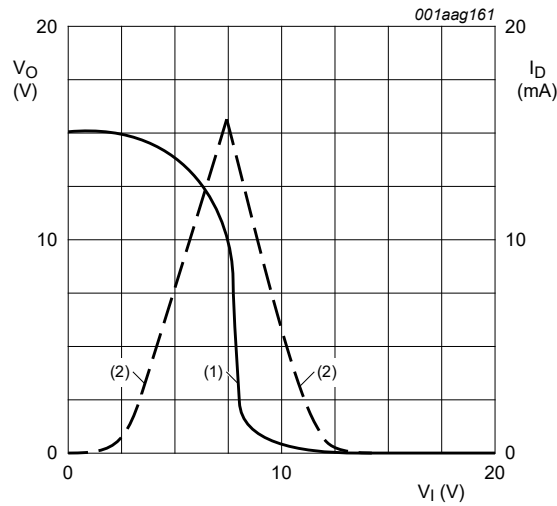
10.2. Transfer characteristics



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

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 $T_p = T_1 + T_2$,

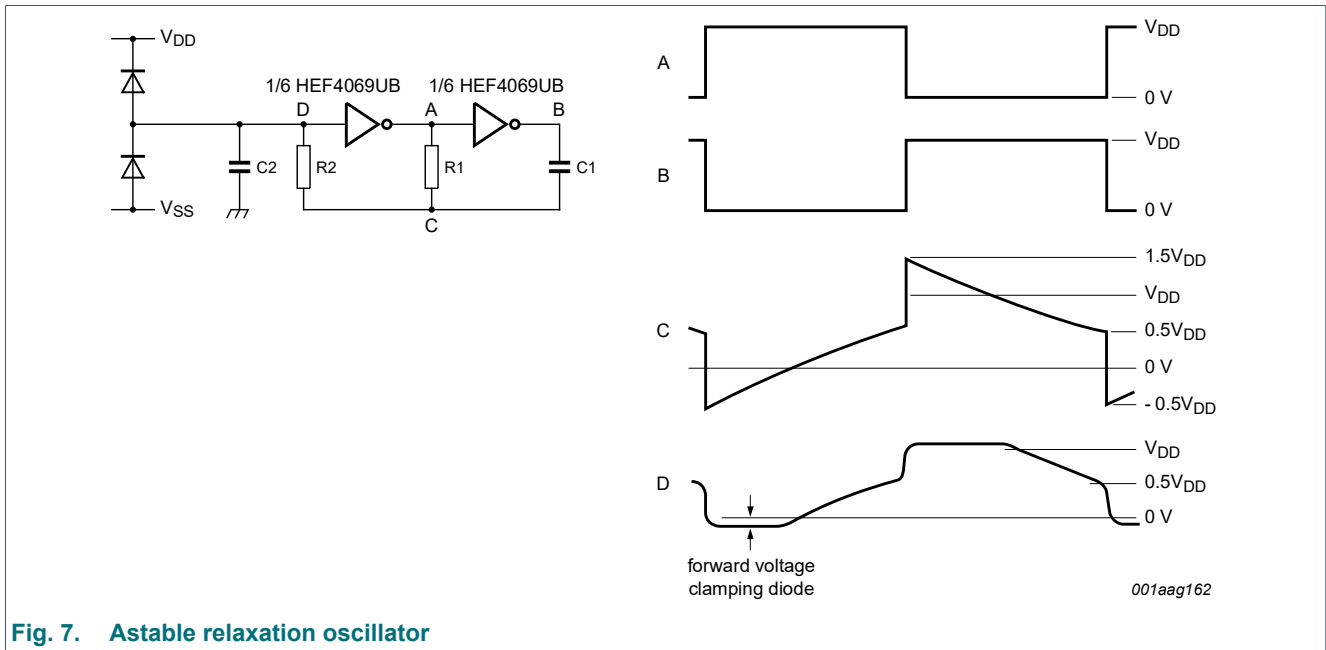
where:

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

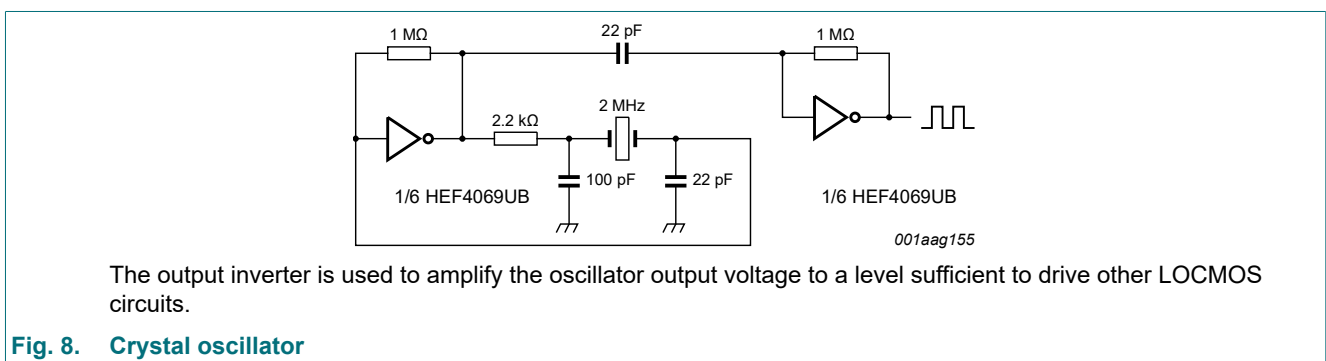
$$T_2 = R1C1 \ln \frac{2V_{DD} - V_{ST}}{V_{DD} - V_{ST}}$$

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.

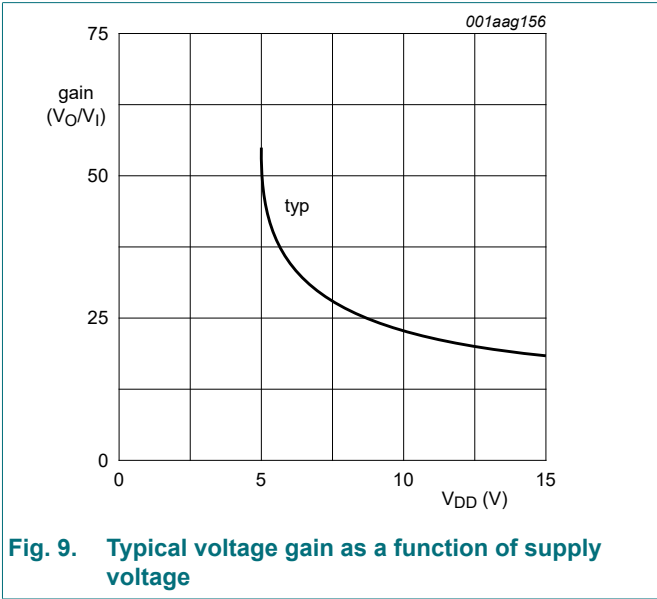


Fig. 9. Typical voltage gain as a function of supply voltage

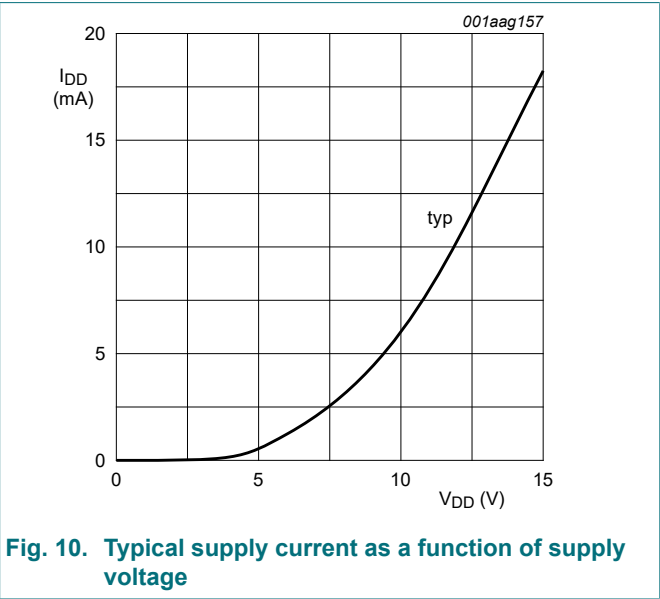


Fig. 10. Typical supply current as a function of supply voltage

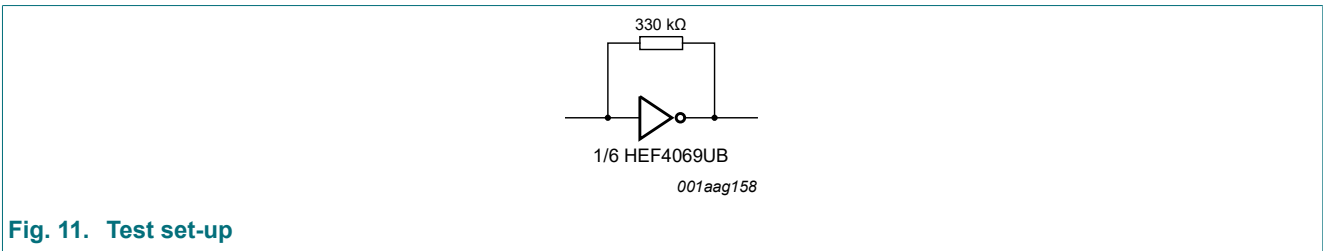


Fig. 11. Test set-up

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

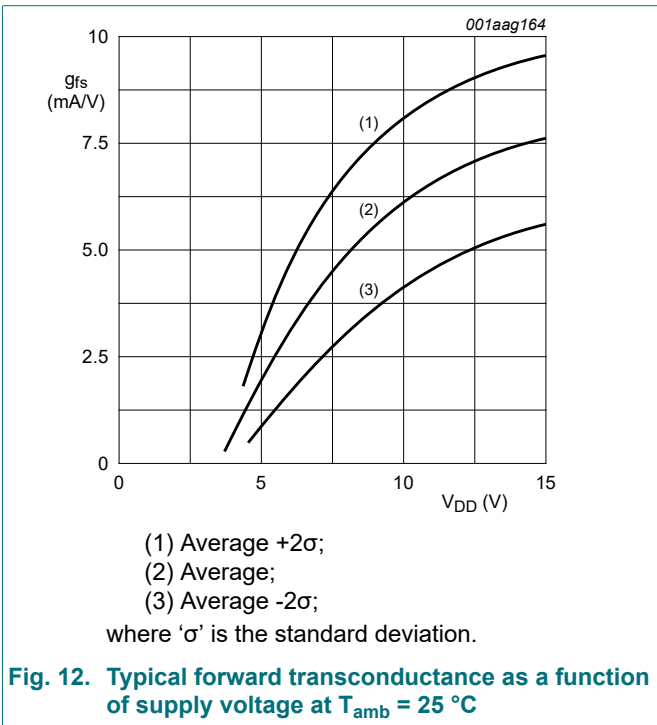


Fig. 12. Typical forward transconductance as a function of supply voltage at T_{amb} = 25 °C

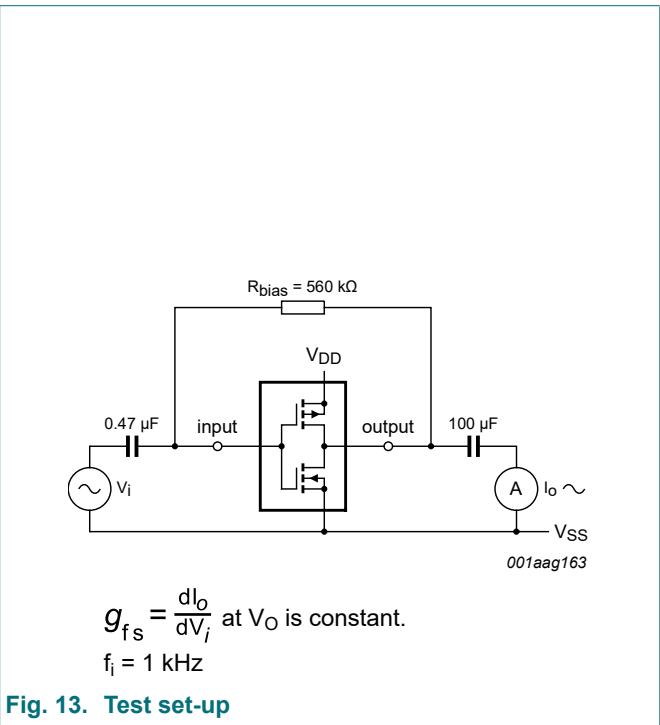


Fig. 13. Test set-up

12. Package outline

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

SOT108-1

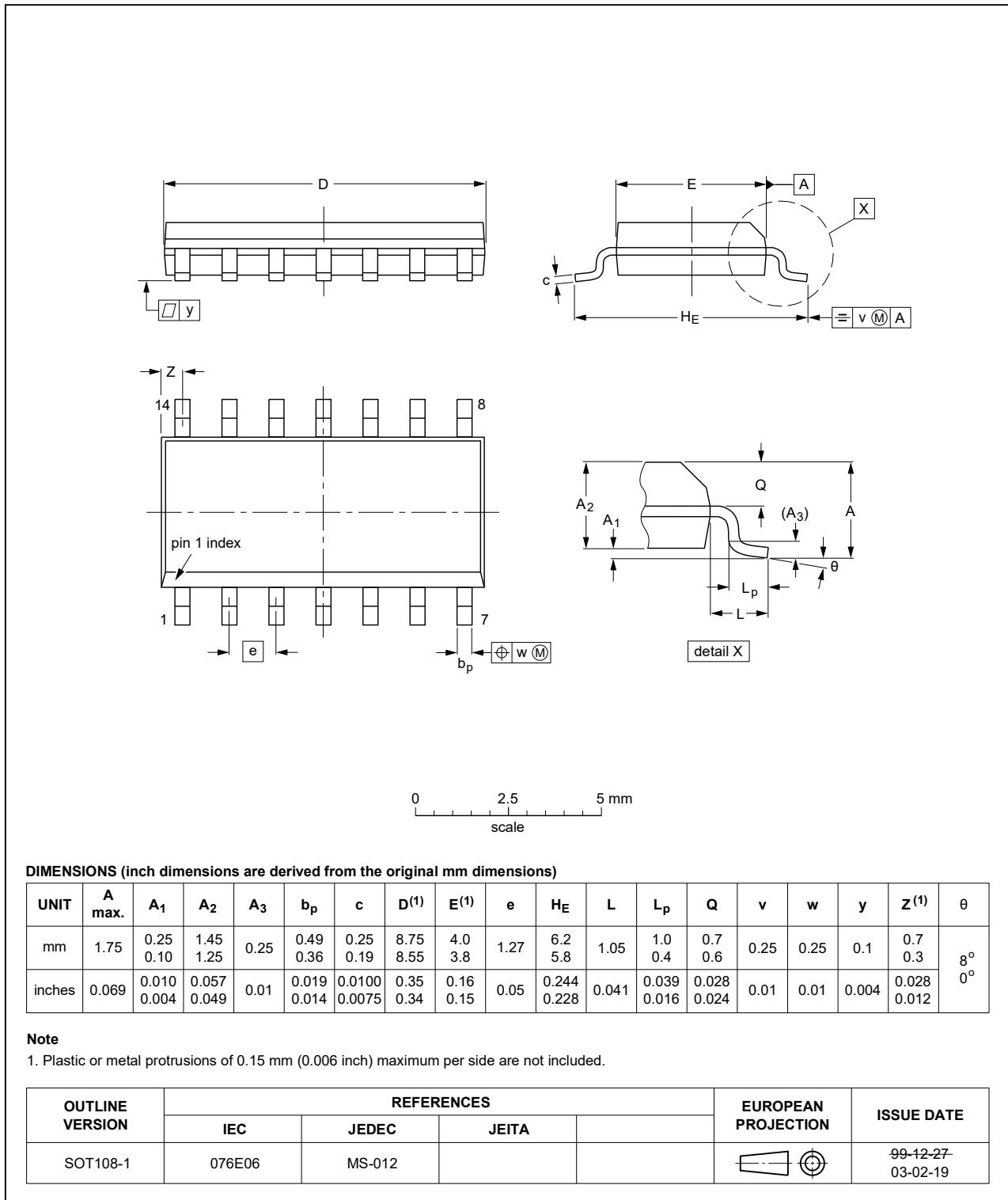


Fig. 14. Package outline SOT108-1 (SO14)

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

SOT402-1

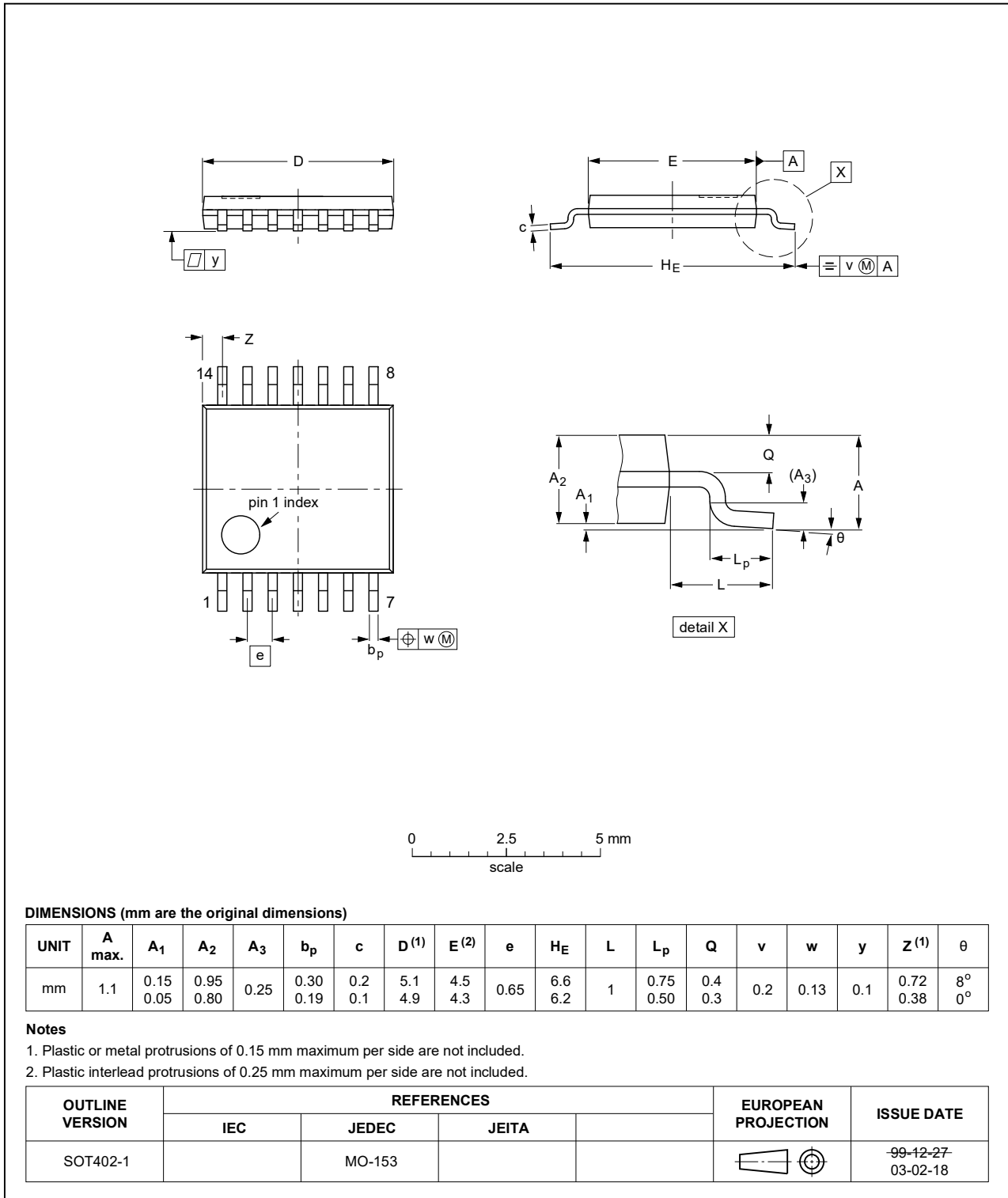


Fig. 15. Package outline SOT402-1 (TSSOP14)

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"> The format of this data sheet has been redesigned to comply with the identity guidelines of Nexperia. Legal texts have been adapted to the new company name where appropriate. Section 1 and Section 2 updated. Table 3: Derating values for P_{tot} total power dissipation updated. | | | |
| HEF4069UB v.9 | 20151216 | Product data sheet | - | HEF4069UB v.8 |
| Modifications: | <ul style="list-style-type: none"> Type number HEF4069UBP (SOT27-1) removed. | | | |
| HEF4069UB v.8 | 20111116 | Product data sheet | - | HEF4069UB v.7 |
| Modifications: | <ul style="list-style-type: none"> Legal pages updated. Changes in "General description", "Features and benefits" and "Applications". | | | |
| 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".
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