# HEF4069UB

## Hex inverter

Rev. 8 — 16 November 2011 | 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.

## 2. Features and benefits

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

## 3. Applications

- Oscillator

## 4. Ordering information

**Table 1. Ordering information**

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

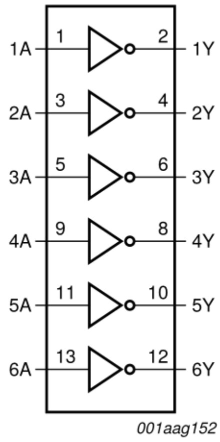



Fig 1. Functional diagram

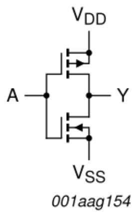



Fig 2. Schematic diagram (one inverter)

## 6. Pinning information

### 6.1 Pinning

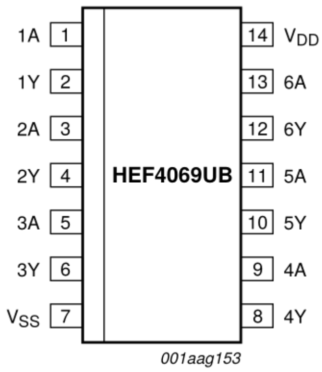



Fig 3. Pin configuration

### 6.2 Pin description

Table 2. Pin description

| Symbol | Pin | Description |
|---|---|---|
| 1A to 6A | 1, 3, 5, 9, 11, 13 | input |
| 1Y to 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 | | | | |
| | | 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 °C, $P_{tot}$ derates linearly with 12 mW/K.

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

[3] For TSSOP14 packages: above $T_{amb}$ = 60 °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 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 |
| $I_{OH}$ | 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 Figure 4; for test circuit see Figure 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 |

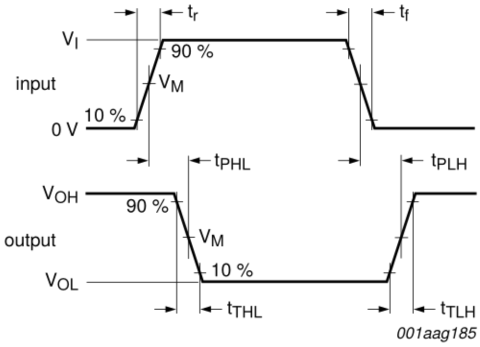
[1] The typical value of the propagation delay and output transition time can be calculated with the extrapolation formula ($C_L$ in pF).

**Table 7. Dynamic power dissipation**

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

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

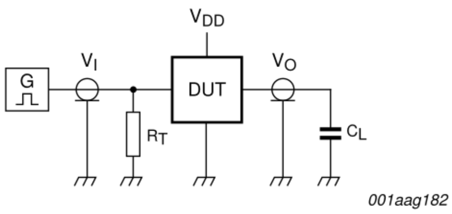
## 11. Waveforms




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:

$C_L$ = load capacitance including jig and probe capacitance;

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

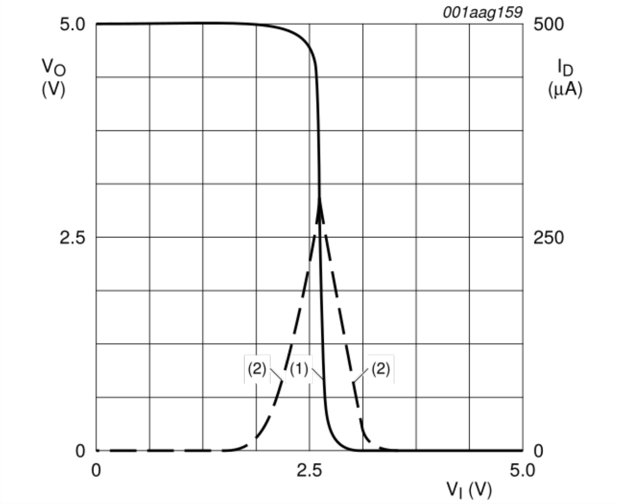
For test data refer to Table 8.

**Fig 5. Test circuit for measuring switching times**

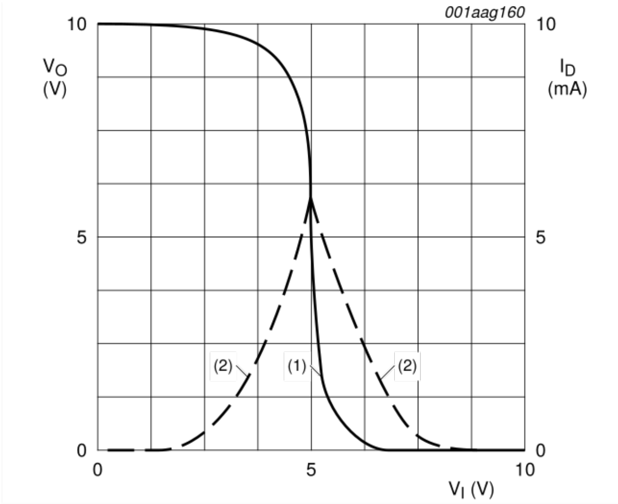
**Table 8. Test data**

| Supply voltage | Input | | Load |
|---|---|---|---|
| $V_{DD}$ | $V_I$ | $t_r$, $t_f$ | $C_L$ |
| 5 V to 15 V | $V_{SS}$ or $V_{DD}$ | ≤ 20 ns | 50 pF |

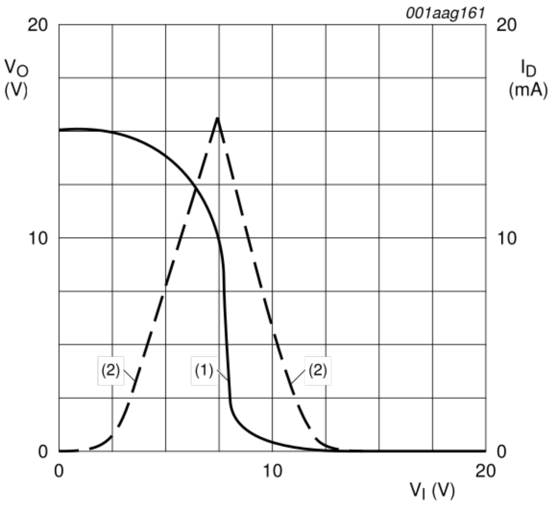
## 11.1 Transfer characteristics




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**

## 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 × C1, provided R1 << R2 and R2 × C2 << R1 × 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:

$$T_1 = R1C1In\frac{V_{DD} + V_{ST}}{V_{ST}}$$

$$T_2 = R1C1In\frac{2V_{DD} - V_{ST}}{V_{DD} - V_{ST}}$$

$V_{ST}$ = 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 $V_{ST}$.

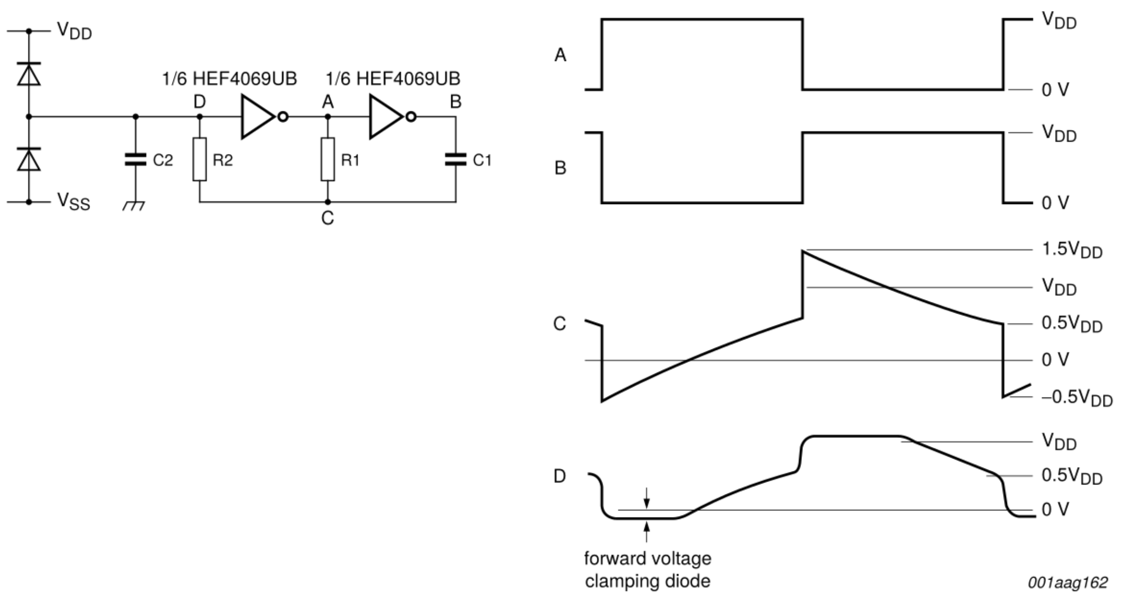
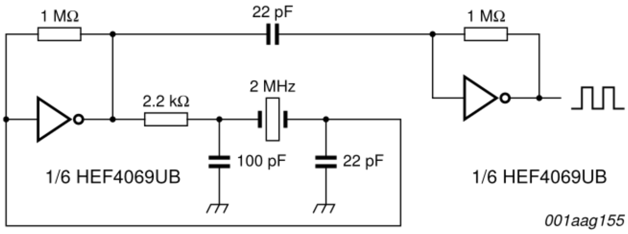



**Fig 7. Astable relaxation oscillator**

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.




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.

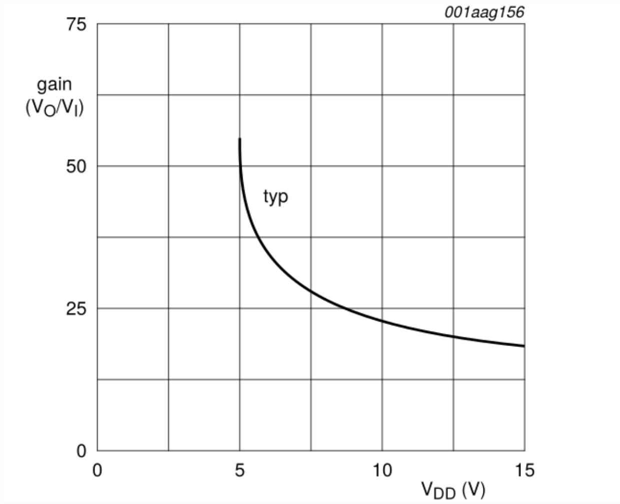



**Fig 9. Typical voltage gain as a function of supply voltage**

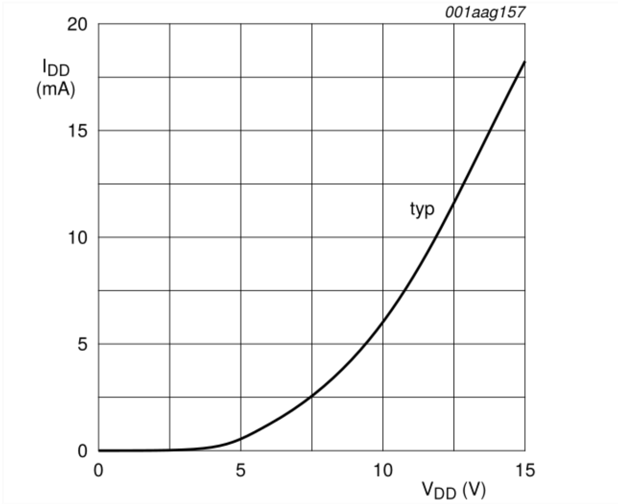



**Fig 10. Typical supply current as a function of supply voltage**

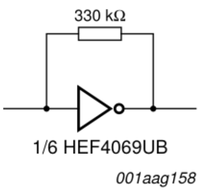
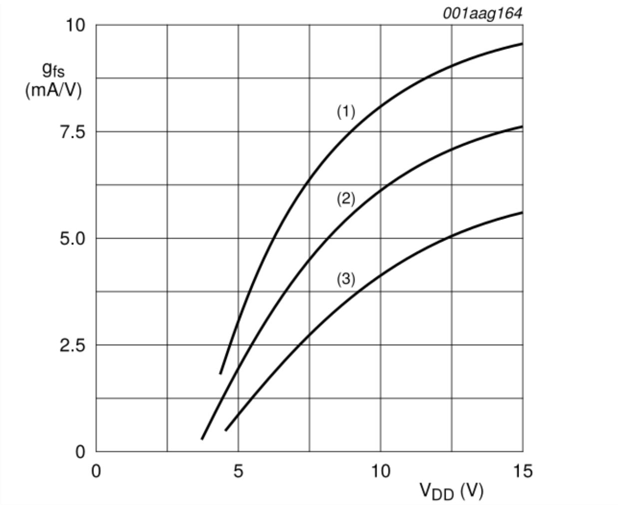



**Fig 11. Test set-up**

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

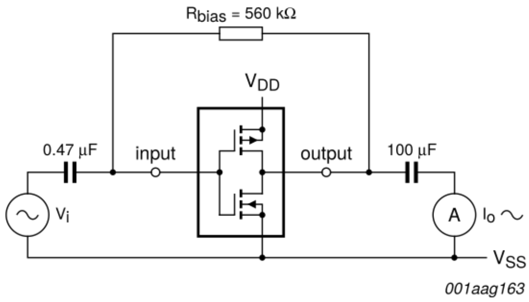



(1) Average +2σ; where: 'σ' is the standard deviation.

(2) Average.

(3) Average −2σ; where: 'σ' is the standard deviation.

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



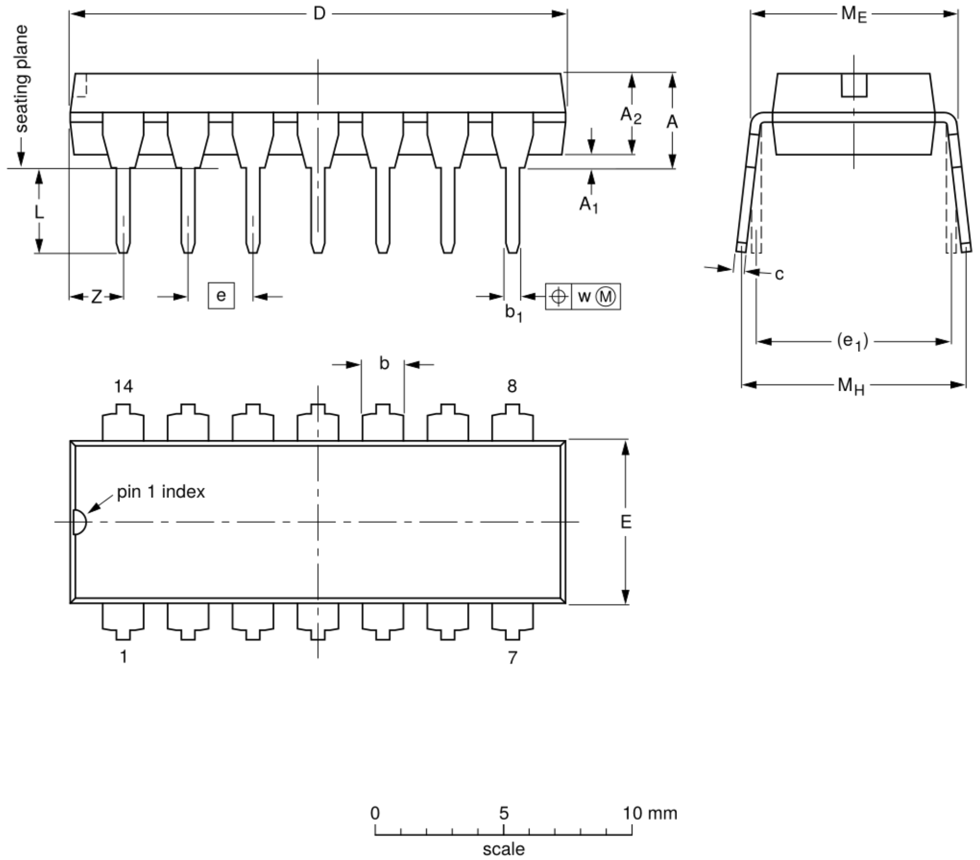

$g_{fs} = \frac{dI_o}{dV_i}$ at $V_O$ is constant.

$f_i$ = 1 kHz

**Fig 13. Test set-up**

## 13. Package outline

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




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

| UNIT | A max. | $A_1$ min. | $A_2$ max. | b | $b_1$ | c | D (1) | E (1) | e | $e_1$ | L | $M_E$ | $M_H$ | w | Z (1) max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 4.2 | 0.51 | 3.2 | 1.73<br>1.13 | 0.53<br>0.38 | 0.36<br>0.23 | 19.50<br>18.55 | 6.48<br>6.20 | 2.54 | 7.62 | 3.60<br>3.05 | 8.25<br>7.80 | 10.0<br>8.3 | 0.254 | 2.2 |
| inches | 0.17 | 0.02 | 0.13 | 0.068<br>0.044 | 0.021<br>0.015 | 0.014<br>0.009 | 0.77<br>0.73 | 0.26<br>0.24 | 0.1 | 0.3 | 0.14<br>0.12 | 0.32<br>0.31 | 0.39<br>0.33 | 0.01 | 0.087 |

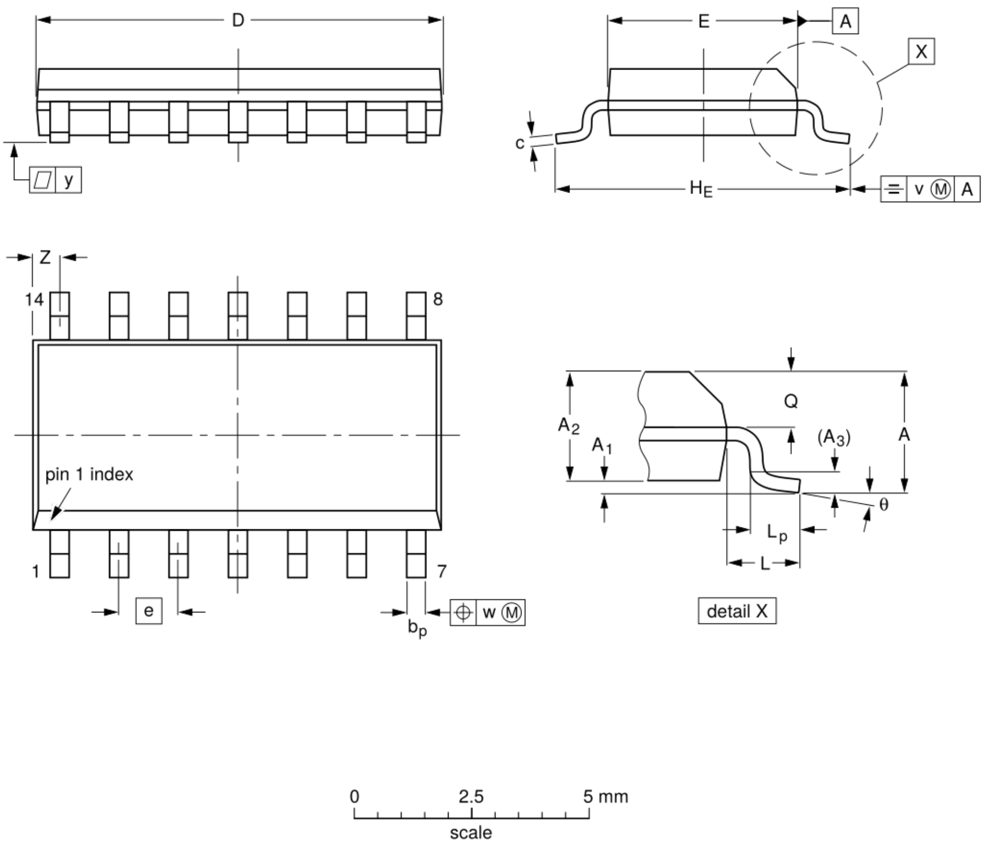
**Note**

1. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT27-1 | 050G04 | MO-001 | SC-501-14 | | | ~~99-12-27~~<br>03-02-13 |

**Fig 14. Package outline SOT27-1 (DIP14)**

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




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

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

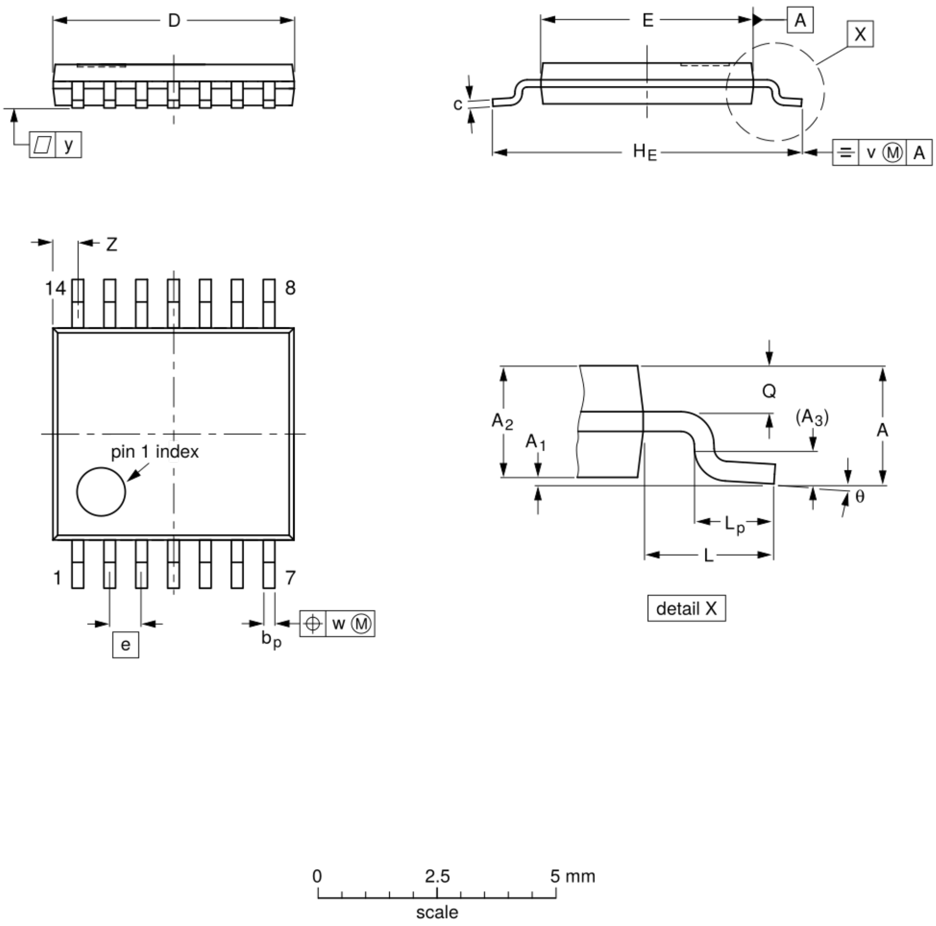
**Note**

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

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

**Fig 15. Package outline SOT108-1 (SO14)**

**TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm** **SOT402-1**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A max. | $A_1$ | $A_2$ | $A_3$ | $b_p$ | c | D [1] | E [2] | e | $H_E$ | L | $L_p$ | Q | v | w | y | Z [1] | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.1 | 0.15<br>0.05 | 0.95<br>0.80 | 0.25 | 0.30<br>0.19 | 0.2<br>0.1 | 5.1<br>4.9 | 4.5<br>4.3 | 0.65 | 6.6<br>6.2 | 1 | 0.75<br>0.50 | 0.4<br>0.3 | 0.2 | 0.13 | 0.1 | 0.72<br>0.38 | 8°<br>0° |

**Notes**

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

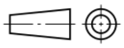
| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT402-1 | | MO-153 | | |  | ~~99-12-27~~<br>03-02-18 |

**Fig 16. Package outline SOT402-1 (TSSOP14)**

## 14. Revision history

**Table 9. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| HEF4069UB v.8 | 20111116 | Product data sheet | - | HEF4069UB v.7 |
| Modifications: | • Legal pages updated.<br>• 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

## 15.1 Data sheet status

| Document status[1][2] | Product status[3] | Definition |
|---|---|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification | This document contains data from the preliminary specification. |
| Product [short] data sheet | Production | This document contains the product specification. |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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

## 15.2 Definitions

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## 16. Contact information

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

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

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**Date of release: 16 November 2011**

**Document identifier: HEF4069UB**