# 74HCU04

## Hex unbuffered inverter

Rev. 7 — 8 December 2015 Product data sheet

## 1. General description

The 74HCU04 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 $V_{CC}$.

## 2. Features and benefits

- Complies with JEDEC standard JESD7A
- Balanced propagation delays
- ESD protection:
  - HBM JESD22-A114F exceeds 2000 V
  - MM JESD22-A115-A exceeds 200 V
- Multiple package options
- Specified from –40 °C to +125 °C

## 3. Ordering information

**Table 1. Ordering information**

| Type number | Package | | | |
|---|---|---|---|---|
| | Temperature range | Name | Description | Version |
| 74HCU04D | –40 °C to +125 °C | SO14 | plastic small outline package; 14 leads; body width 3.9 mm | SOT108-1 |
| 74HCU04DB | –40 °C to +125 °C | SSOP14 | plastic shrink small outline package; 14 leads; body width 5.3 mm | SOT337-1 |
| 74HCU04PW | –40 °C to +125 °C | TSSOP14 | plastic thin shrink small outline package; 14 leads; body width 4.4 mm | SOT402-1 |
| 74HCU04BQ | –40 °C to +125 °C | DHVQFN14 | plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body 2.5 × 3 × 0.85 mm | SOT762-1 |

## 4. Functional diagram

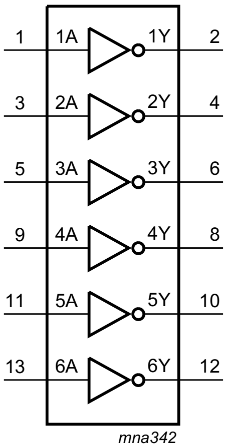



**Fig 1. Logic symbol**

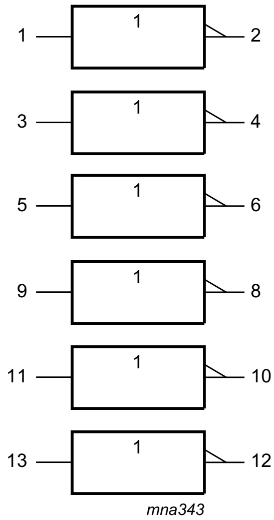



**Fig 2. IEC logic symbol**

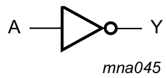



**Fig 3. Logic diagram (one inverter)**

## 5. Pinning information

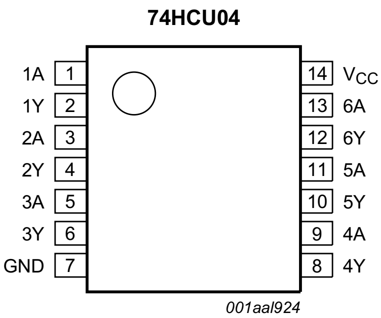
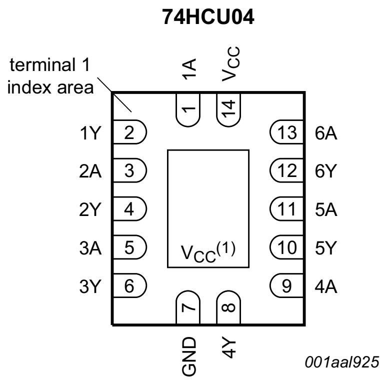



**Fig 4. Pin configuration SO14 and (T)SSOP14**




Transparent top view

(1) This is not a supply pin. The substrate is attached to this pad using conductive die attach material. There is no electrical or mechanical requirement to solder this pad. However, if it is soldered, the solder land should remain floating or be connected to $V_{CC}$.

**Fig 5. Pin configuration DHVQFN14**

### 5.1 Pin description

**Table 2. Pin description**

| Symbol | Pin | Description |
|---|---|---|
| 1A, 2A, 3A, 4A, 5A, 6A | 1, 3, 5, 9, 11, 13 | data input |
| 1Y, 2Y, 3Y, 4Y, 5Y, 6Y | 2, 4, 6, 8, 10, 12 | data output |
| GND | 7 | ground (0 V) |
| $V_{CC}$ | 14 | supply voltage |

## 6. Functional description

**Table 3. Function table**

*H = HIGH voltage level; L = LOW voltage level*

| Input | Output |
|---|---|
| nA | nY |
| L | H |
| H | L |

## 7. Limiting values

**Table 4. Limiting values**

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

| Symbol | Parameter | Conditions | Min | Max | Unit |
|---|---|---|---|---|---|
| $V_{CC}$ | supply voltage | | –0.5 | +7.0 | V |
| $I_{IK}$ | input clamping current | $V_I < –0.5$ V or $V_I > V_{CC} + 0.5$ V [1] | - | ±20 | mA |
| $I_{OK}$ | output clamping current | $V_O < –0.5$ V or $V_O > V_{CC} + 0.5$ V [1] | - | ±50 | mA |
| $I_O$ | output current | $–0.5$ V $< V_O < V_{CC} + 0.5$ V | - | ±25 | mA |
| $I_{CC}$ | supply current | | - | 50 | mA |
| $I_{GND}$ | ground current | | –50 | - | mA |
| $T_{stg}$ | storage temperature | | –65 | +150 | °C |
| $P_{tot}$ | total power dissipation | SO14, (T)SSOP14 and DHVQFN14 packages [2] | - | 500 | mW |

[1] The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

[2] For SO14 package: $P_{tot}$ derates linearly with 8 mW/K above 70 °C.
For (T)SSOP14 packages: $P_{tot}$ derates linearly with 5.5 mW/K above 60 °C.
For DHVQFN14 packages: $P_{tot}$ derates linearly with 4.5 mW/K above 60 °C.

## 8. Recommended operating conditions

**Table 5. Recommended operating conditions**

*Voltages are referenced to GND (ground = 0 V).*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{CC}$ | supply voltage | | 2.0 | 5.0 | 6.0 | V |
| $V_I$ | input voltage | | 0 | - | $V_{CC}$ | V |
| $V_O$ | output voltage | | 0 | - | $V_{CC}$ | V |
| $T_{amb}$ | ambient temperature | | –40 | +25 | +125 | °C |

## 9. Static characteristics

**Table 6. Static characteristics**

*Voltages are referenced to GND (ground = 0 V).*

| Symbol | Parameter | Conditions | 25 °C | | | –40 °C to +85 °C | | –40 °C to +125 °C | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | Min | Max | Min | Max | |
| $V_{IH}$ | HIGH-level input voltage | $V_{CC}$ = 2.0 V | 1.7 | 1.4 | - | 1.7 | - | 1.7 | - | V |
| | | $V_{CC}$ = 4.5 V | 3.6 | 2.6 | - | 3.6 | - | 3.6 | - | V |
| | | $V_{CC}$ = 5.5 V | 4.8 | 3.4 | - | 4.8 | - | 4.8 | - | V |
| $V_{IL}$ | LOW-level input voltage | $V_{CC}$ = 2.0 V | - | 0.6 | 0.3 | - | 0.3 | - | 0.3 | V |
| | | $V_{CC}$ = 4.5 V | - | 1.9 | 0.9 | - | 0.9 | - | 0.9 | V |
| | | $V_{CC}$ = 5.5 V | - | 2.6 | 1.2 | - | 1.2 | - | 1.2 | V |
| $V_{OH}$ | HIGH-level output voltage | $V_I$ = $V_{IH}$ or $V_{IL}$ | | | | | | | | |
| | | $I_O$ = –20 μA; $V_{CC}$ = 2.0 V | 1.8 | 2.0 | - | 1.8 | - | 1.8 | - | V |
| | | $I_O$ = –20 μA; $V_{CC}$ = 4.5 V | 4.0 | 4.5 | - | 4.0 | - | 4.0 | - | V |
| | | $I_O$ = –4.0 mA; $V_{CC}$ = 4.5 V | 3.98 | 4.32 | - | 3.84 | - | 3.7 | - | V |
| | | $I_O$ = –20 μA; $V_{CC}$ = 6.0 V | 5.5 | 6.0 | - | 5.5 | - | 5.5 | - | V |
| | | $I_O$ = –5.2 mA; $V_{CC}$ = 6.0 V | 5.48 | 5.81 | - | 5.34 | - | 5.2 | - | V |
| $V_{OL}$ | LOW-level output voltage | $V_I$ = $V_{IH}$ or $V_{IL}$ | | | | | | | | |
| | | $I_O$ = 20 μA; $V_{CC}$ = 2.0 V | - | 0 | 0.2 | - | 0.2 | - | 0.2 | V |
| | | $I_O$ = 20 μA; $V_{CC}$ = 4.5 V | - | 0 | 0.5 | - | 0.5 | - | 0.5 | V |
| | | $I_O$ = 4.0 mA; $V_{CC}$ = 4.5 V | - | 0.15 | 0.26 | - | 0.33 | - | 0.4 | V |
| | | $I_O$ = 20 μA; $V_{CC}$ = 6.0 V | - | 0 | 0.5 | - | 0.5 | - | 0.5 | V |
| | | $I_O$ = 5.2 mA; $V_{CC}$ = 6.0 V | - | 0.16 | 0.26 | - | 0.33 | - | 0.4 | V |
| $I_I$ | input leakage current | $V_I$ = $V_{CC}$ or GND; $V_{CC}$ = 6.0 V | - | - | ±0.1 | - | ±1.0 | - | ±1.0 | μA |
| $I_{CC}$ | supply current | $V_I$ = $V_{CC}$ or GND; $I_O$ = 0 A; $V_{CC}$ = 6.0 V | - | - | 2 | - | 20 | - | 20 | μA |
| $C_I$ | input capacitance | | - | 3.5 | - | - | - | - | - | pF |

## 10. Dynamic characteristics

**Table 7. Dynamic characteristics**

*Voltages are referenced to GND (ground = 0 V); For test circuit see Figure 7.*

| Symbol | Parameter | Conditions | 25 °C | | –40 °C to +85 °C | –40 °C to +125 °C | Unit |
|---|---|---|---|---|---|---|---|
| | | | Typ | Max | Max | Max | |
| $t_{pd}$ | propagation delay | nA to nY; see Figure 6 [1] | | | | | |
| | | $V_{CC}$ = 2.0 V; $C_L$ = 50 pF | 19 | 70 | 90 | 105 | ns |
| | | $V_{CC}$ = 4.5 V; $C_L$ = 50 pF | 7 | 14 | 18 | 21 | ns |
| | | $V_{CC}$ = 5.0 V; $C_L$ = 15 pF | 5 | - | - | - | ns |
| | | $V_{CC}$ = 6.0 V; $C_L$ = 50 pF | 6 | 12 | 15 | 18 | ns |
| $t_t$ | transition time | see Figure 6 [2] | | | | | |
| | | $V_{CC}$ = 2.0 V; $C_L$ = 50 pF | 19 | 75 | 95 | 110 | ns |
| | | $V_{CC}$ = 4.5 V; $C_L$ = 50 pF | 7 | 15 | 19 | 22 | ns |
| | | $V_{CC}$ = 6.0 V; $C_L$ = 50 pF | 6 | 13 | 16 | 19 | ns |
| $C_{PD}$ | power dissipation capacitance | per inverter; $V_I$ = GND to $V_{CC}$ [3] | 10 | - | - | - | pF |

[1] $t_{pd}$ is the same as $t_{PHL}$, $t_{PLH}$.

[2] $t_t$ is the same as $t_{THL}$, $t_{TLH}$.

[3] $C_{PD}$ is used to determine the dynamic power dissipation ($P_D$ in μW).

$P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ where:

$f_i$ = input frequency in MHz;

$f_o$ = output frequency in MHz;

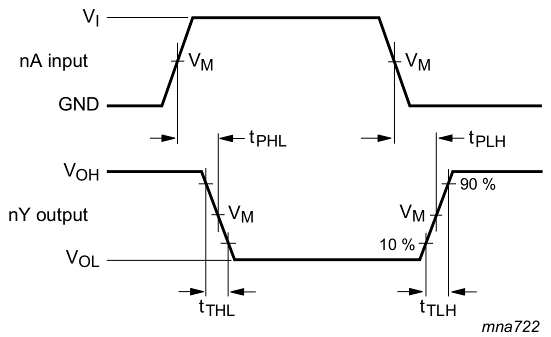
$C_L$ = output load capacitance in pF;

$V_{CC}$ = supply voltage in V;

N = number of inputs switching;

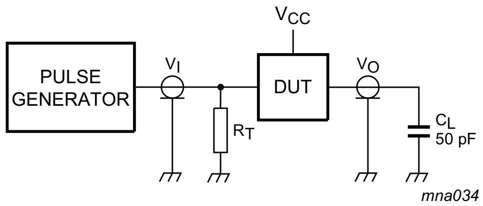
$\Sigma(C_L \times V_{CC}^2 \times f_o)$ = sum of outputs.

## 11. Waveforms




$V_M = 0.5 \times V_{CC}$; $V_I$ = GND to $V_{CC}$.

**Fig 6. The input (nA) to output (nY) propagation delay times**



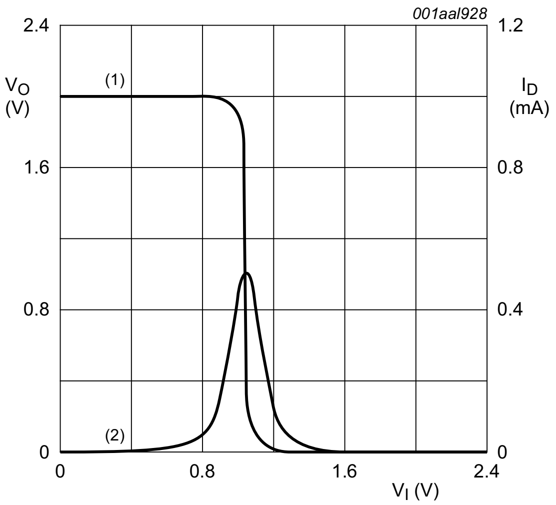

Definitions for test circuit:

$C_L$ = Load capacitance including jig and probe capacitance.

$R_T$ = Termination resistance should be equal to output impedance $Z_o$ of the pulse generator.

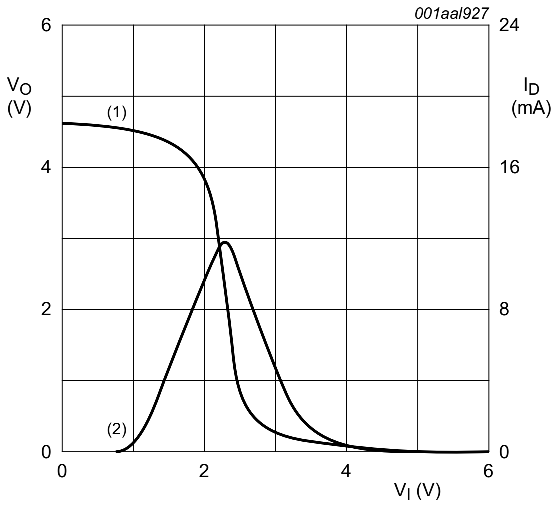
**Fig 7. Test circuit for measuring switching times**

## 12. Typical transfer characteristics



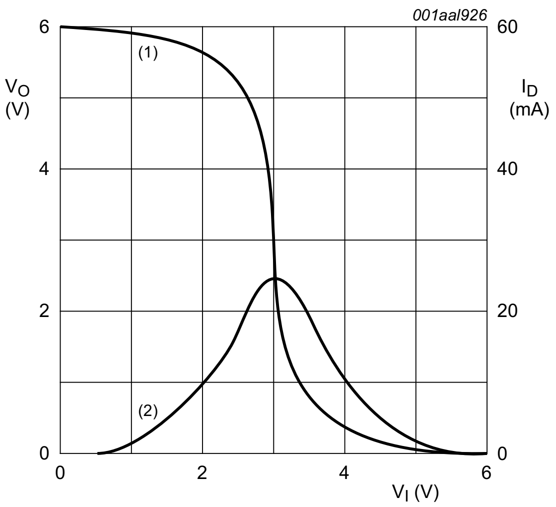

$T_{amb}$ = 25 °C.

**Fig 8. $V_{CC}$ = 2.0 V; $I_O$ = 0 A**



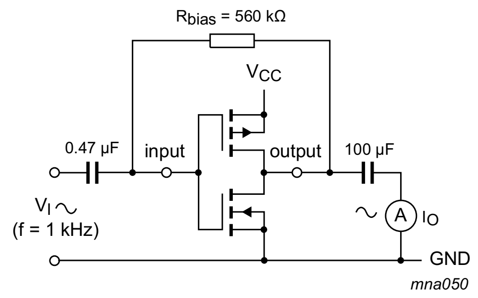

$T_{amb}$ = 25 °C.

**Fig 9. $V_{CC}$ = 4.5 V; $I_O$ = 0 A**




$T_{amb}$ = 25 °C.

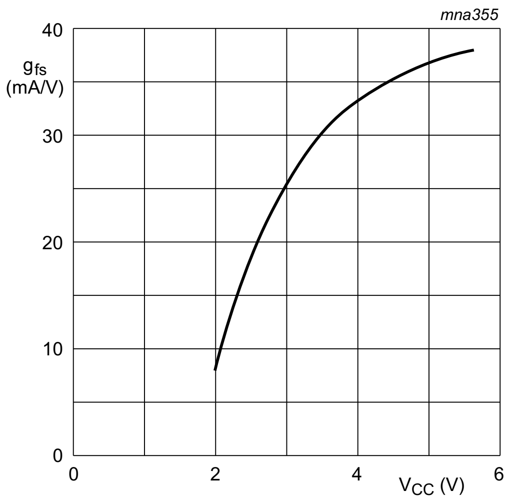
**Fig 10. $V_{CC}$ = 6.0 V; $I_O$ = 0 A**




$$g_{fs} = \frac{\Delta I_O}{\Delta V_I}$$

$f_i$ = 1 kHz at $V_O$ is constant

**Fig 11. Test set-up for measuring forward transconductance**




$T_{amb}$ = 25 °C.

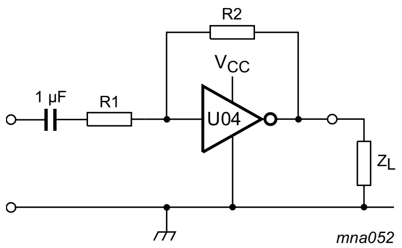
**Fig 12. Typical forward transconductance as a function of the supply voltage**

## 13. Application information

Some applications are:

- Linear amplifier (see Figure 13)
- Crystal oscillator design (see Figure 14)
- Astable multivibrator (see Figure 15)

**Remark:** All values given are typical unless otherwise specified.




Maximum $V_{o(p-p)} = V_{CC} - 2.0$ V centered at $0.5 \times V_{CC}$.

$$G_v = -\frac{G_{ol}}{1 + \frac{R1}{R2}(1 + G_{ol})}$$

$G_{ol}$ = open loop gain

$G_v$ = voltage gain

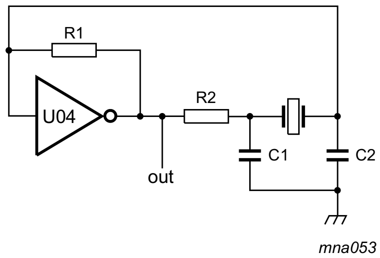
R1 ≥ 3 kΩ, R2 ≤ 1 MΩ

$Z_L$ > 10 kΩ; $G_{ol}$ = 20 (typical)

$V_{CC}$ = 6.0 V

Typical unity gain bandwidth product is 5 MHz.

**Fig 13. Used as a linear amplifier**




C1 = 47 pF (typical)

C2 = 33 pF (typical)

R1 = 1 MΩ to 10 MΩ (typical

R2 optimum value depends on the frequency and required stability against changes in $V_{CC}$ or average minimum $I_{CC}$. $I_{CC}$ is typically 5 mA at $V_{CC}$ = 5 V and $f_i$ = 10 MHz.

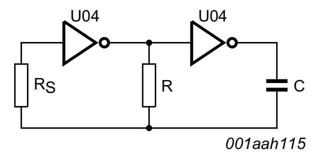
**Fig 14. Crystal oscillator configuration**

**Table 8. External components for resonator (f < 1 MHz)**
*All values given are typical and must be used as an initial set-up.*

| Frequency | R1 | R2 | C1 | C2 |
|---|---|---|---|---|
| 10 kHz to 15.9 kHz | 22 MΩ | 220 kΩ | 56 pF | 20 pF |
| 16 kHz to 24.9 kHz | 22 MΩ | 220 kΩ | 56 pF | 10 pF |
| 25 kHz to 54.9 kHz | 22 MΩ | 100 kΩ | 56 pF | 10 pF |
| 55 kHz to 129.9 kHz | 22 MΩ | 100 kΩ | 47 pF | 5 pF |
| 130 kHz to 199.9 kHz | 22 MΩ | 47 kΩ | 47 pF | 5 pF |
| 200 kHz to 349.9 kHz | 10 MΩ | 47 kΩ | 47 pF | 5 pF |
| 350 kHz to 600 kHz | 10 MΩ | 47 kΩ | 47 pF | 5 pF |

**Table 9. Optimum value for R2**

| Frequency | R2 | Optimum for |
|---|---|---|
| 3 kHz | 2.0 kΩ | minimum required $I_{CC}$ |
| | 8.0 kΩ | minimum influence due to change in $V_{CC}$ |
| 6 kHz | 1.0 kΩ | minimum required $I_{CC}$ |
| | 4.7 kΩ | minimum influence by $V_{CC}$ |
| 10 kHz | 0.5 kΩ | minimum required $I_{CC}$ |
| | 2.0 kΩ | minimum influence by $V_{CC}$ |
| 14 kHz | 0.5 kΩ | minimum required $I_{CC}$ |
| | 1.0 kΩ | minimum influence by $V_{CC}$ |
| >14 kHz | - | replace R2 by C3 with a typical value of 35 pF |

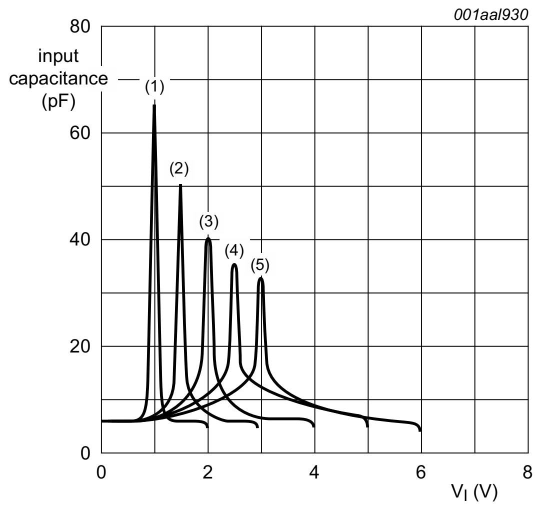



$$f = \frac{1}{T} \approx \frac{1}{2.2RC}$$

$$R_S \approx 2 \times R$$

The average $I_{CC}$ (mA) is approximately 3.5 + 0.05 × f (MHz) × C (pF) at $V_{CC}$ = 5.0 V.

**Fig 15. Astable multivibrator**

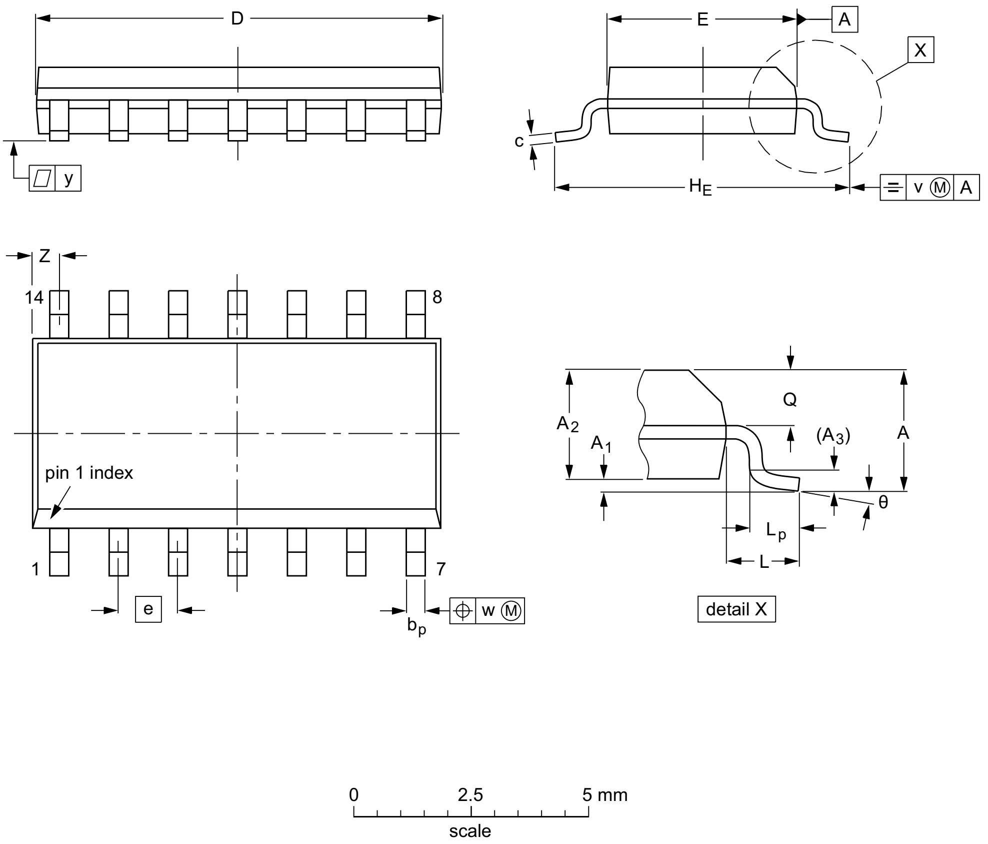



(1) $V_{CC}$ = 2.0 V
(2) $V_{CC}$ = 3.0 V
(3) $V_{CC}$ = 4.0 V
(4) $V_{CC}$ = 5.0 V
(5) $V_{CC}$ = 6.0 V
$T_{amb}$ = 25 °C.

**Fig 16. Input capacitance as function of input voltage**

## 14. Package outline

**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 | |

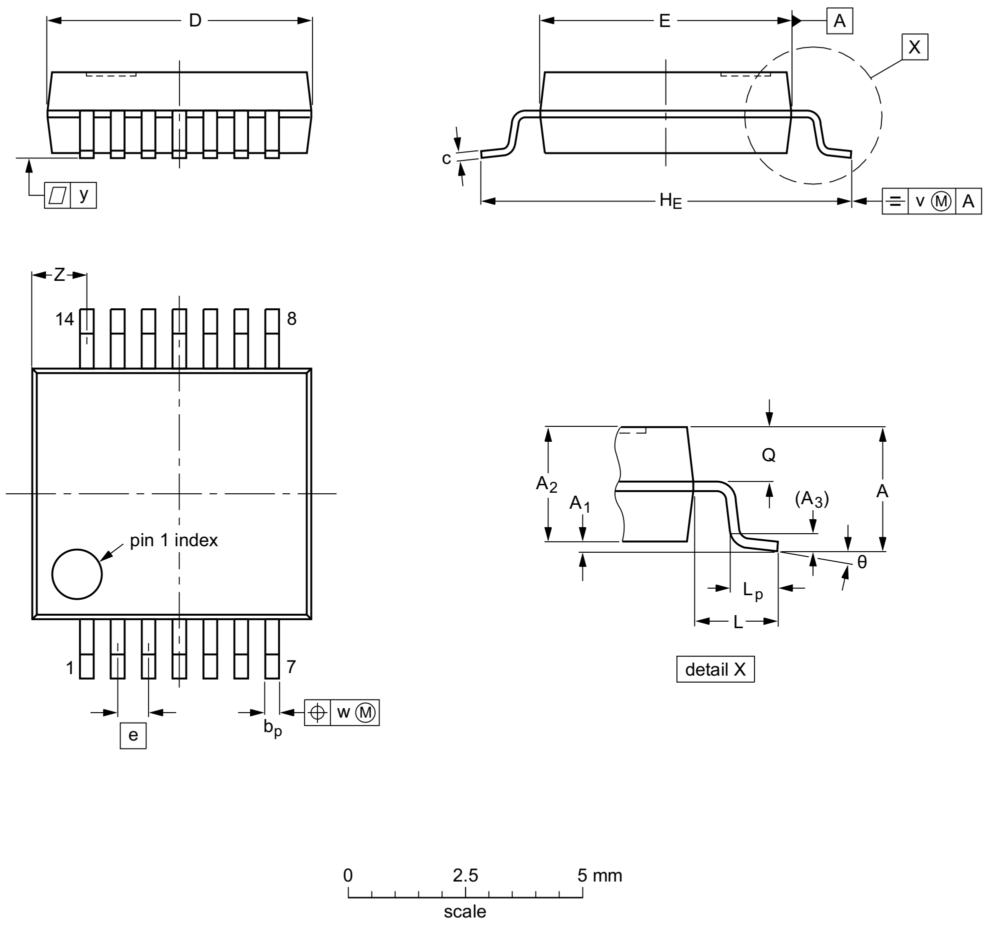
**Note**

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 17. Package outline SOT108-1 (SO14)**

**SSOP14: plastic shrink small outline package; 14 leads; body width 5.3 mm** **SOT337-1**




**DIMENSIONS (mm are the original 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 | 2 | 0.21<br>0.05 | 1.80<br>1.65 | 0.25 | 0.38<br>0.25 | 0.20<br>0.09 | 6.4<br>6.0 | 5.4<br>5.2 | 0.65 | 7.9<br>7.6 | 1.25 | 1.03<br>0.63 | 0.9<br>0.7 | 0.2 | 0.13 | 0.1 | 1.4<br>0.9 | 8°<br>0° |

**Note**

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

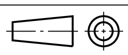
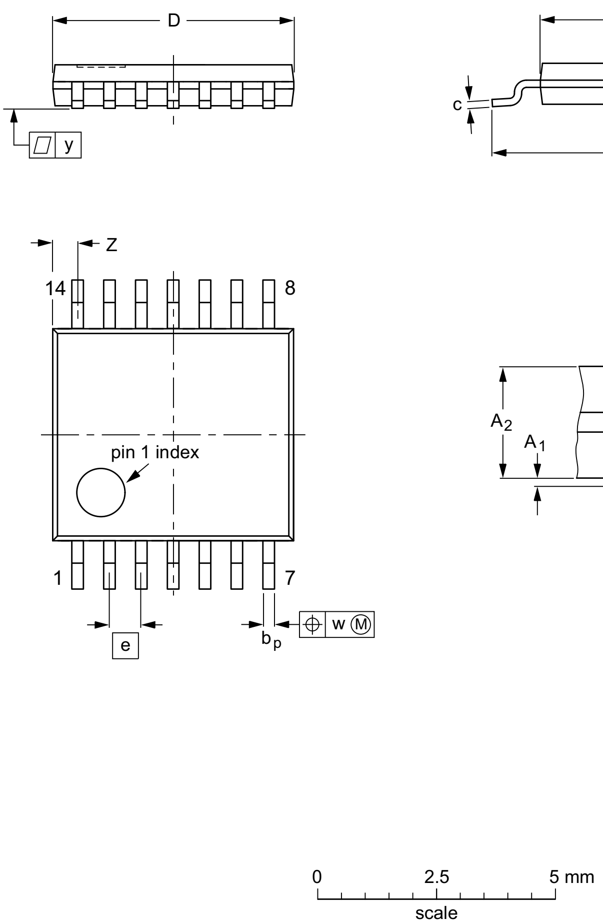
| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT337-1 | | MO-150 | | |  | ~~99-12-27~~<br>03-02-19 |

**Fig 18. Package outline SOT337-1 (SSOP14)**

**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° |

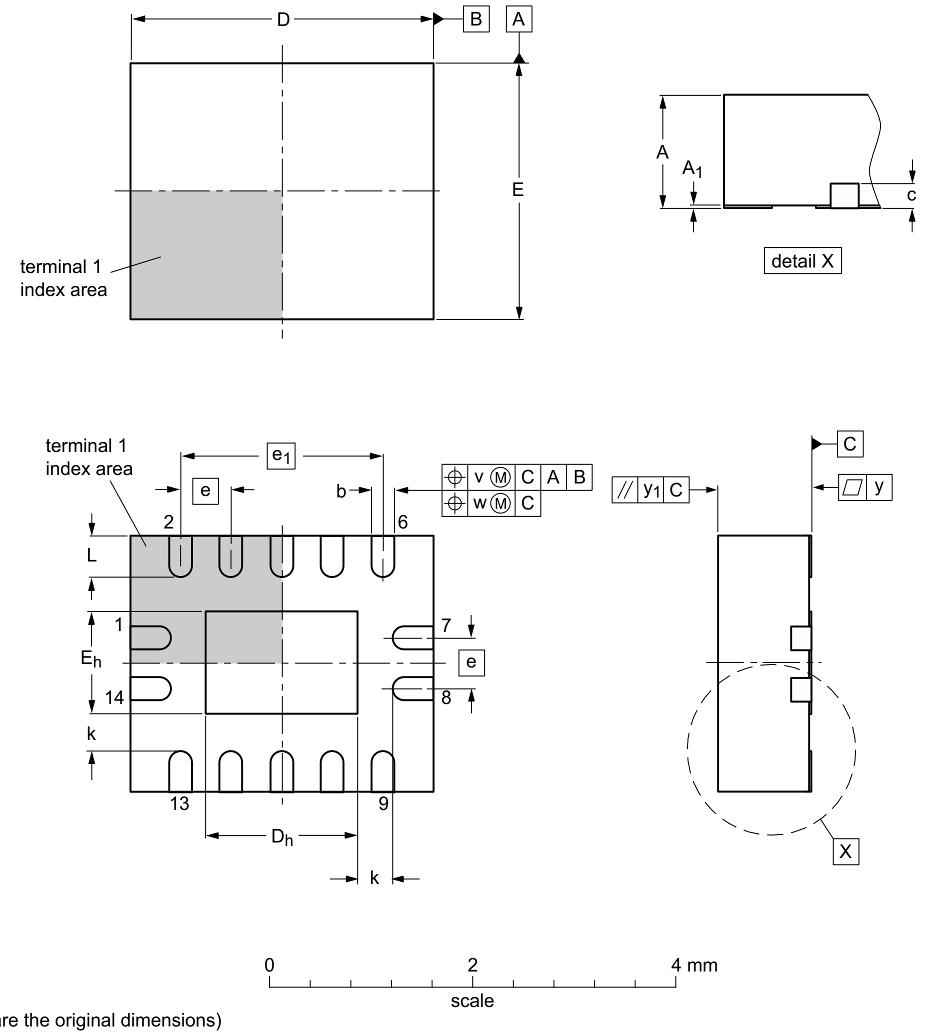
**Notes**

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 19. Package outline SOT402-1 (TSSOP14)**

**DHVQFN14: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body 2.5 x 3 x 0.85 mm** **SOT762-1**




Dimensions (mm are the original dimensions)

| Unit | | A(1) | $A_1$ | b | c | D(1) | $D_h$ | E(1) | $E_h$ | e | $e_1$ | k | L | v | w | y | $y_1$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | max | 1 | 0.05 | 0.30 | | 3.1 | 1.65 | 2.6 | 1.15 | | | | 0.5 | | | | |
| | nom | | 0.02 | 0.25 | 0.2 | 3.0 | 1.50 | 2.5 | 1.00 | 0.5 | 2 | | 0.4 | 0.1 | 0.05 | 0.05 | 0.1 |
| | min | | 0.00 | 0.18 | | 2.9 | 1.35 | 2.4 | 0.85 | | | 0.2 | 0.3 | | | | |

Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

*sot762-1_po*

| Outline version | References | | | | European projection | Issue date |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT762-1 | | MO-241 | | | | ~~15-04-10~~ 15-05-05 |

**Fig 20. Package outline SOT762-1 (DHVQFN14)**

## 15. Abbreviations

**Table 10. Abbreviations**

| Acronym | Description |
|---|---|
| CMOS | Complementary Metal Oxide Semiconductor |
| LSTTL | Low-power Schottky Transistor-Transistor Logic |
| ESD | ElectroStatic Discharge |
| HBM | Human Body Model |
| MM | Machine Model |
| CDM | Charge Device Model |
| TTL | Transistor-Transistor Logic |

## 16. Revision history

**Table 11. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| 74HCU04 v.7 | 20151208 | Product data sheet | - | 74HCU04 v.6 |
| Modifications: | • Type number 74HCU04N (SOT27-1) removed.<br>• Conditions $V_{IL}$ and $V_{IH}$ corrected (errata). | | | |
| 74HCU04 v.6 | 20121227 | Product data sheet | - | 74HCU04 v.5 |
| Modifications: | • New general description. | | | |
| 74HCU04 v.5 | 20120806 | Product data sheet | - | 74HCU04 v.4 |
| Modifications: | • Measurement points added to figure 6 (errata). | | | |
| 74HCU04 v.4 | 20111212 | Product data sheet | - | 74HCU04 v.3 |
| Modifications: | • Legal pages updated. | | | |
| 74HCU04 v.3 | 20100916 | Product data sheet | - | 74HCU04_CNV v.2 |
| 74HCU04_CNV v.2 | 19970826 | Product specification | - | - |

# 17. Legal information

## 17.1 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.

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## 19. Contents





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