

74AHCU04

Hex unbuffered inverter

Rev. 4 — 7 December 2015

Product data sheet

1. General description

The 74AHCU04 is high-speed Si-gate CMOS devices and is pin compatible with low power Schottky TTL (LSTTL). It is specified in compliance with JEDEC standard No. 7A.

The 74AHCU04 is a general purpose hex unbuffered inverter. Each of the six inverters is a single stage.

2. Features and benefits

- Low power dissipation
- Balanced propagation delays
- Inputs accepts voltages higher than V_{CC}
- ESD protection:
 - ◆ HBM JESD22-A114F: exceeds 2000 V
 - ◆ MM JESD22-A115-A: exceeds 200 V
 - ◆ CDM JESD22-C101C: exceeds 1000 V
- Multiple package options
- Specified from -40°C to $+125^{\circ}\text{C}$

3. Ordering information

Table 1. Ordering information

| Type number | Package | | | | Version |
|-------------|---|----------|--|--|----------|
| | Temperature range | Name | Description | | |
| 74AHCU04D | -40°C to $+125^{\circ}\text{C}$ | SO14 | plastic small outline package; 14 leads; body width 3.9 mm | | SOT108-1 |
| 74AHCU04PW | -40°C to $+125^{\circ}\text{C}$ | TSSOP14 | plastic thin shrink small outline package; 14 leads; body width 4.4 mm | | SOT402-1 |
| 74AHCU04BQ | -40°C to $+125^{\circ}\text{C}$ | DHVQFN14 | plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body $2.5 \times 3 \times 0.85$ mm | | SOT762-1 |



4. Functional diagram

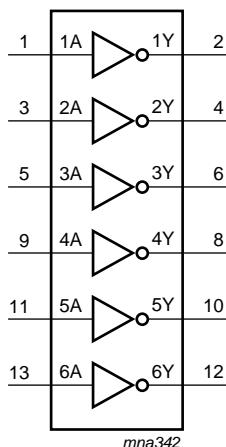


Fig 1. Logic symbol

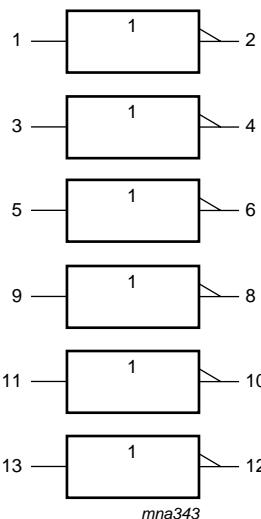


Fig 2. IEC logic symbol

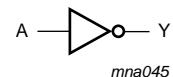


Fig 3. Logic diagram (one inverter)

5. Pinning information

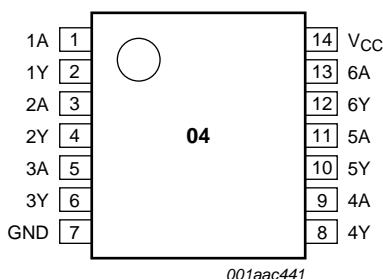
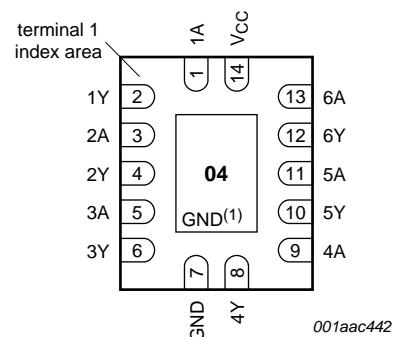


Fig 4. Pin configuration SO14 and TSSOP14



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 GND.

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, 6 | 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 | -20 | - | mA |
| V _I | input voltage | | [1] | -0.5 | +7.0 |
| I _{OK} | output clamping current | V _O < -0.5 V or V _O > V _{CC} + 0.5 V | - | ±20 | mA |
| I _O | output current | -0.5 V < V _O < V _{CC} + 0.5 V | - | ±25 | mA |
| I _{CC} | supply current | | - | 75 | mA |
| I _{GND} | ground current | | -75 | - | mA |
| T _{STG} | storage temperature | | -65 | +150 | °C |
| P _{TOT} | total power dissipation | T _{AMB} = -40 °C to +125 °C | [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 packages: above 70 °C the value of P_{TOT} derates linearly with 8 mW/K.

For TSSOP14 packages: above 60 °C the value of P_{TOT} derates linearly with 5.5 mW/K.

For DHVQFN14 packages: above 60 °C the value of P_{TOT} derates linearly with 4.5 mW/K.

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 | 5.5 | V |
| V_I | input voltage | | 0 | - | 5.5 | V |
| V_O | output voltage | | 0 | - | V_{CC} | V |
| T_{amb} | ambient temperature | | -40 | +25 | +125 | °C |
| $\Delta t/\Delta V$ | input transition rise and fall rate | $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$ | - | - | 100 | ns/V |
| | | $V_{CC} = 5.0 \text{ V} \pm 0.5 \text{ V}$ | - | - | 20 | ns/V |

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 | $V_{CC} = 2.0 \text{ V}$ | 1.7 | - | - | 1.7 | - | 1.7 | - | V |
| | | $V_{CC} = 3.0 \text{ V}$ | 2.4 | - | - | 2.4 | - | 2.4 | - | V |
| | | $V_{CC} = 5.5 \text{ V}$ | 4.4 | - | - | 4.4 | - | 4.4 | - | V |
| V_{IL} | LOW-level input voltage | $V_{CC} = 2.0 \text{ V}$ | - | - | 0.3 | - | 0.3 | - | 0.3 | V |
| | | $V_{CC} = 3.0 \text{ V}$ | - | - | 0.6 | - | 0.6 | - | 0.6 | V |
| | | $V_{CC} = 5.5 \text{ V}$ | - | - | 1.1 | - | 1.1 | - | 1.1 | V |
| V_{OH} | HIGH-level output voltage | $V_I = V_{IH}$ or V_{IL} | | | | | | | | |
| | | $I_O = -50 \mu\text{A}; V_{CC} = 2.0 \text{ V}$ | 1.8 | 2.0 | - | 1.8 | - | 1.8 | - | V |
| | | $I_O = -50 \mu\text{A}; V_{CC} = 3.0 \text{ V}$ | 2.7 | 3.0 | - | 2.7 | - | 2.7 | - | V |
| | | $I_O = -50 \mu\text{A}; V_{CC} = 4.5 \text{ V}$ | 4.0 | 4.5 | - | 4.0 | - | 4.0 | - | V |
| | | $I_O = -4.0 \text{ mA}; V_{CC} = 3.0 \text{ V}$ | 2.58 | - | - | 2.48 | - | 2.4 | - | V |
| | | $I_O = -8.0 \text{ mA}; V_{CC} = 4.5 \text{ V}$ | 3.94 | - | - | 3.8 | - | 3.7 | - | V |
| V_{OL} | LOW-level output voltage | $V_I = V_{IH}$ or V_{IL} | | | | | | | | |
| | | $I_O = 50 \mu\text{A}; V_{CC} = 2.0 \text{ V}$ | - | 0 | 0.2 | - | 0.2 | - | 0.2 | V |
| | | $I_O = 50 \mu\text{A}; V_{CC} = 3.0 \text{ V}$ | - | 0 | 0.3 | - | 0.3 | - | 0.3 | V |
| | | $I_O = 50 \mu\text{A}; V_{CC} = 4.5 \text{ V}$ | - | 0 | 0.5 | - | 0.5 | - | 0.5 | V |
| | | $I_O = 4.0 \text{ mA}; V_{CC} = 3.0 \text{ V}$ | - | - | 0.36 | - | 0.44 | - | 0.55 | V |
| | | $I_O = 8.0 \text{ mA}; V_{CC} = 4.5 \text{ V}$ | - | - | 0.36 | - | 0.44 | - | 0.55 | V |
| I_I | input leakage current | $V_I = 5.5 \text{ V}$ or GND; $V_{CC} = 0 \text{ V}$ to 5.5 V | - | - | 0.1 | - | 1.0 | - | 2.0 | μA |
| I_{CC} | supply current | $V_I = V_{CC}$ or GND; $I_O = 0 \text{ A}$; $V_{CC} = 5.5 \text{ V}$ | - | - | 2.0 | - | 20 | - | 40 | μA |
| C_I | input capacitance | | - | 3 | 10 | - | 10 | - | 10 | pF |

10. Dynamic characteristics

Table 7. Dynamic characteristics

GND = 0 V; For test circuit see [Figure 7](#).

| Symbol | Parameter | Conditions | 25 °C | | | −40 °C to +85 °C | | −40 °C to +125 °C | | Unit |
|----------|-------------------------------|---|-------|-----|-----|------------------|-----|-------------------|-----|------|
| | | | Min | Typ | Max | Min | Max | Min | Max | |
| t_{pd} | propagation delay | nA to nY; see Figure 6 | [1] | | | | | | | |
| | | $V_{CC} = 3.0 \text{ V to } 3.6 \text{ V}$ | [2] | | | | | | | |
| | | $C_L = 15 \text{ pF}$ | | - | 3.0 | 7.1 | 1.0 | 8.5 | 1.0 | 9.0 |
| | | $C_L = 50 \text{ pF}$ | | - | 3.4 | 10.6 | 1.0 | 12.0 | 1.0 | 13.5 |
| | | $V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$ | [3] | | | | | | | |
| | | $C_L = 15 \text{ pF}$ | | - | 2.4 | 5.5 | 1.0 | 6.5 | 1.0 | 7.0 |
| | | $C_L = 50 \text{ pF}$ | | - | 3.5 | 7.0 | 1.0 | 8.0 | 1.0 | 9.0 |
| C_{PD} | power dissipation capacitance | $C_L = 50 \text{ pF}; f_i = 1 \text{ MHz}; V_I = \text{GND to } V_{CC}$ | [4] | - | 9.1 | - | - | - | - | pF |

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

[2] Typical values are measured at $V_{CC} = 3.3 \text{ V}$.

[3] Typical values are measured at $V_{CC} = 5.0 \text{ V}$.

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

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

f_i = input frequency in MHz;

f_o = output frequency in MHz;

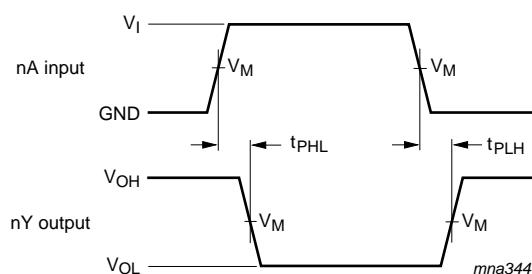
C_L = output load capacitance in pF;

V_{CC} = supply voltage in V;

N = number of inputs switching;

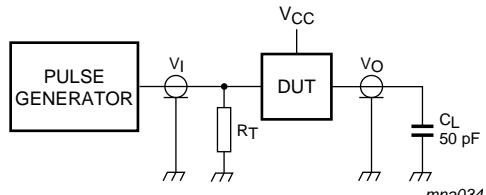
$\sum(C_L \times V_{CC}^2 \times f_o)$ = sum of outputs.

11. Waveforms



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

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



Test data is given in [Table 7](#).

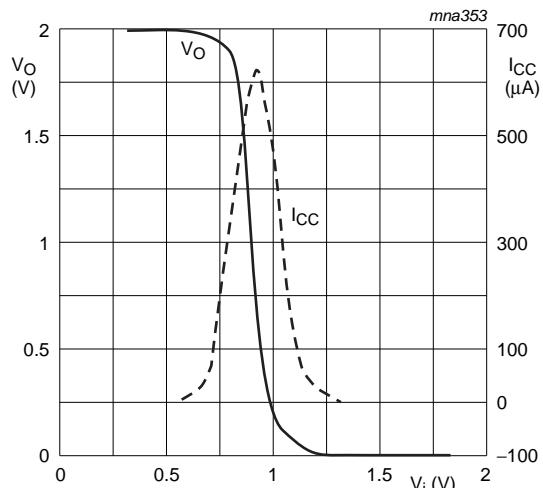
Definitions for test circuit:

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.

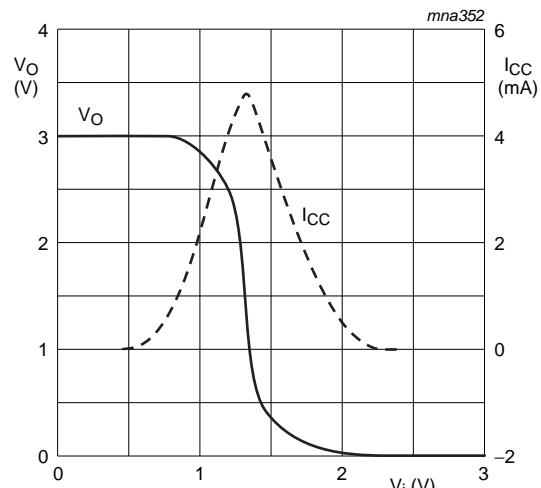
Fig 7. Load circuit for switching times

12. Typical transfer characteristics



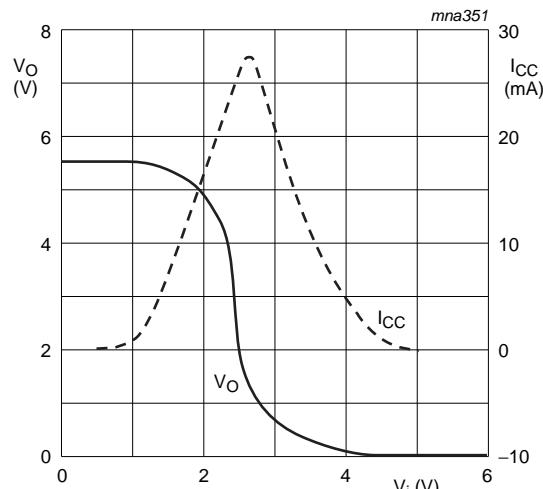
$T_{amb} = 25^{\circ}\text{C}$.

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



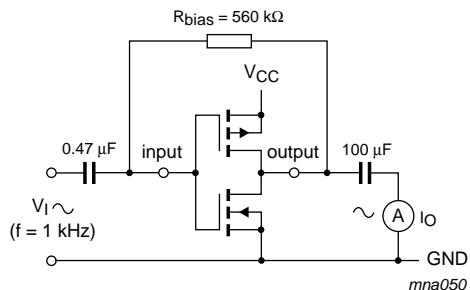
$T_{amb} = 25^{\circ}\text{C}$.

Fig 9. $V_{CC} = 3.0 \text{ V}$; $I_O = 0 \text{ A}$



$T_{amb} = 25^{\circ}\text{C}$.

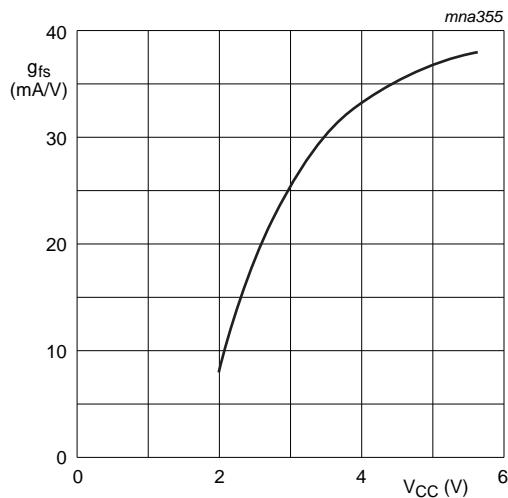
Fig 10. $V_{CC} = 5.5 \text{ V}$; $I_O = 0 \text{ A}$



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

$f_i = 1 \text{ kHz}$ at V_O is constant

Fig 11. Test set-up for measuring forward transconductance



T_{amb} = 25 °C.

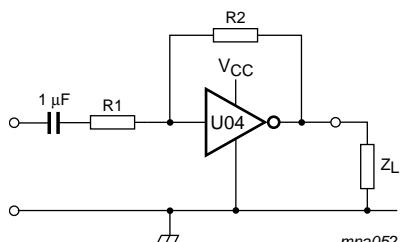
Fig 12. Typical forward transconductance as a function of the supply voltage

13. Application information

Some applications are:

- Linear amplifier (see [Figure 13](#))
- In crystal oscillator design (see [Figure 14](#))

Remark: All values given are typical unless otherwise specified.



Maximum V_{o(p-p)} = V_{CC} – 1.5 V centered at 0.5 × V_{CC}.

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

G_{ol} = open loop gain

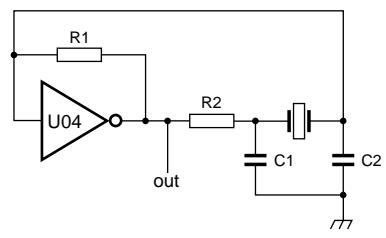
G_v = voltage gain

R1 ≥ 3 kΩ, R2 ≤ 1 MΩ

Z_L > 10 kΩ; G_{ol} = 12 (typical)

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 |

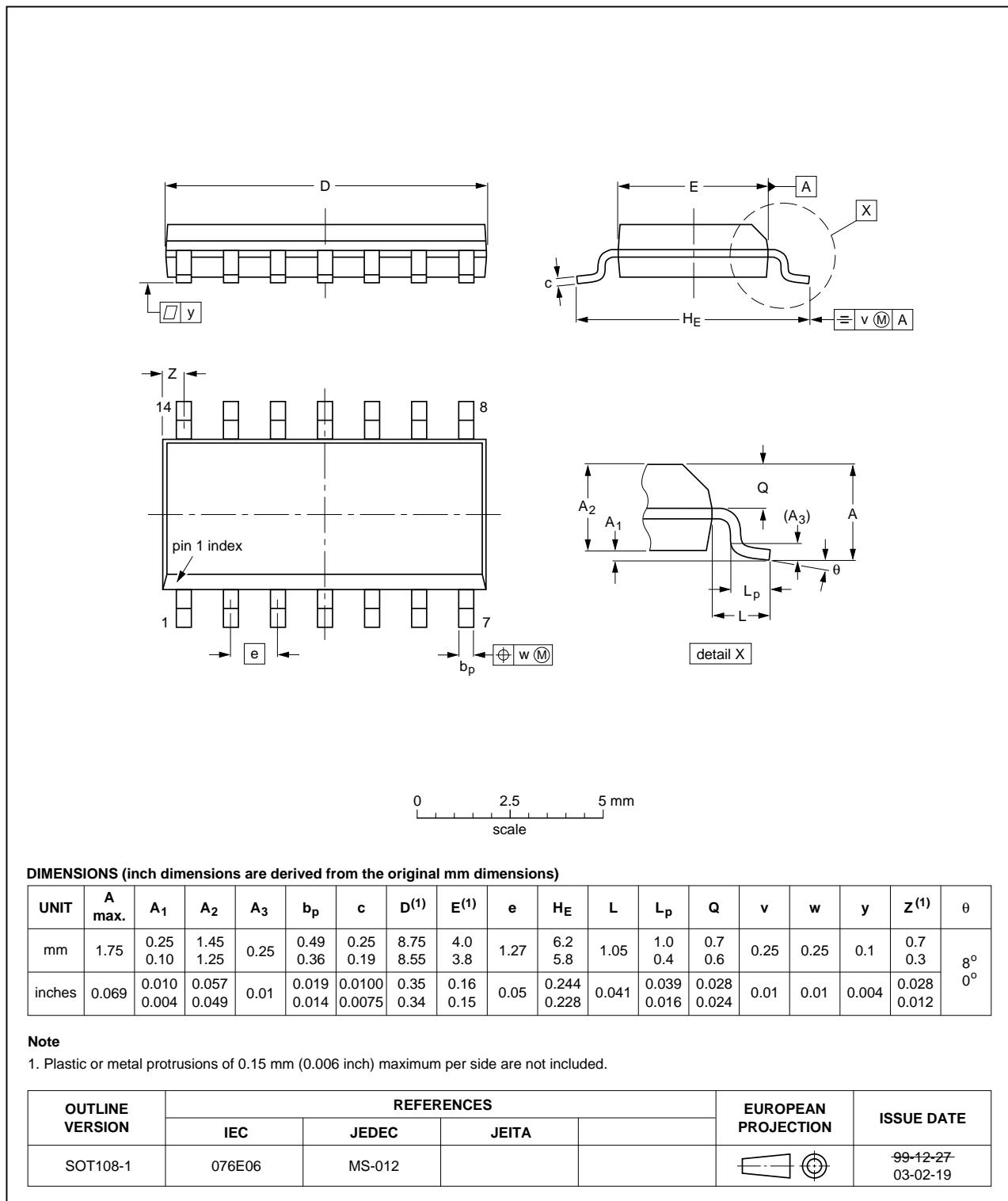
Table 9. Optimum value for R2

| 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 |

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 0.10 | 0.25 1.25 | 1.45 1.25 | 0.25 | 0.49 0.36 | 0.25 0.19 | 8.75 8.55 | 4.0 3.8 | 1.27 | 6.2 5.8 | 1.05 | 1.0 0.4 | 0.7 0.6 | 0.25 | 0.25 | 0.1 | 0.7 0.3 | 8° 0° |
| inches | 0.069 0.004 | 0.010 0.049 | 0.057 0.049 | 0.01 | 0.019 0.014 | 0.0100 0.0075 | 0.35 0.34 | 0.16 0.15 | 0.05 | 0.244 0.228 | 0.041 | 0.039 0.016 | 0.028 0.024 | 0.01 | 0.01 | 0.004 | 0.028 0.012 | 0° 0° |

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 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

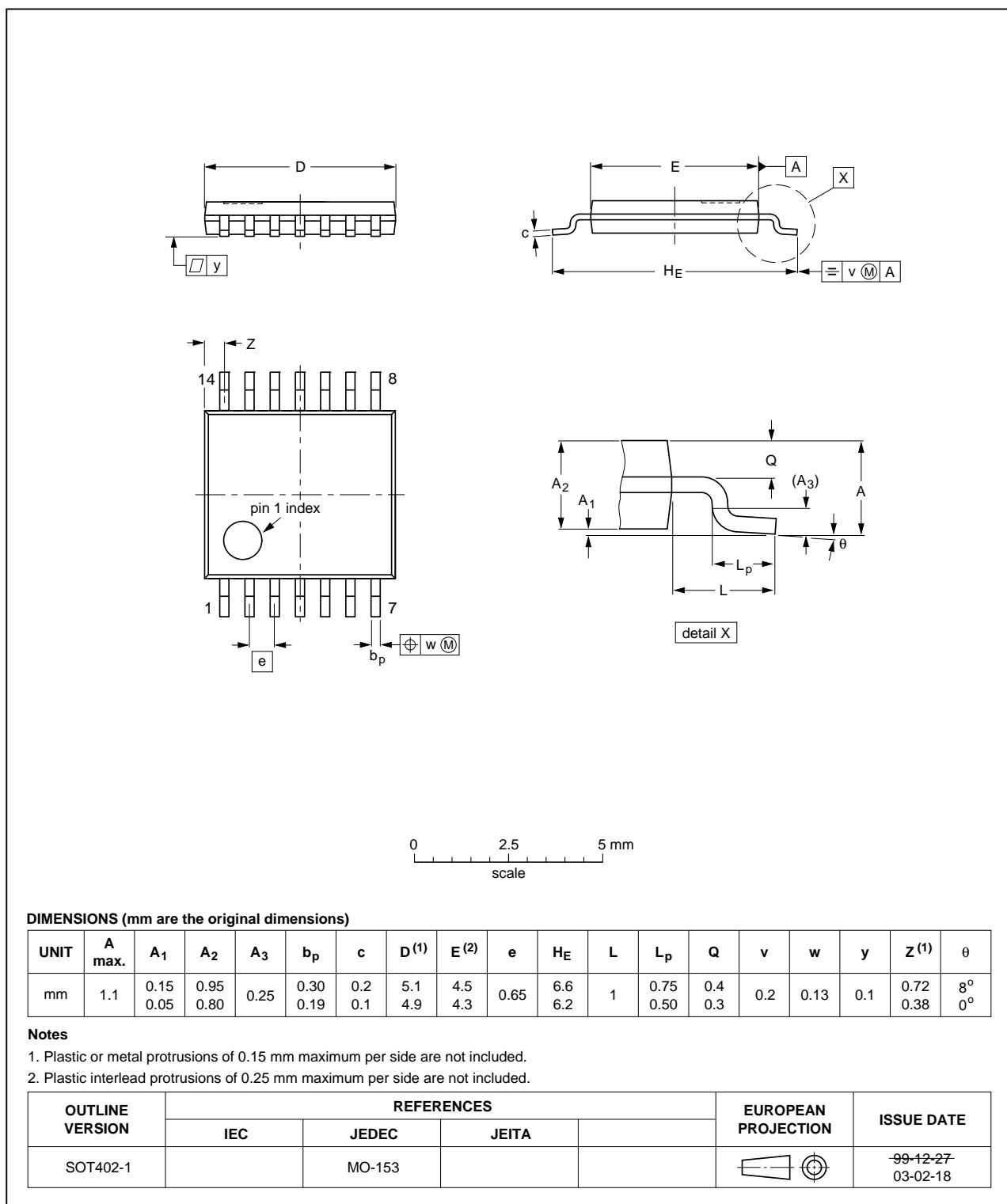


Fig 16. Package outline SOT402-1 (TSSOP14)

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

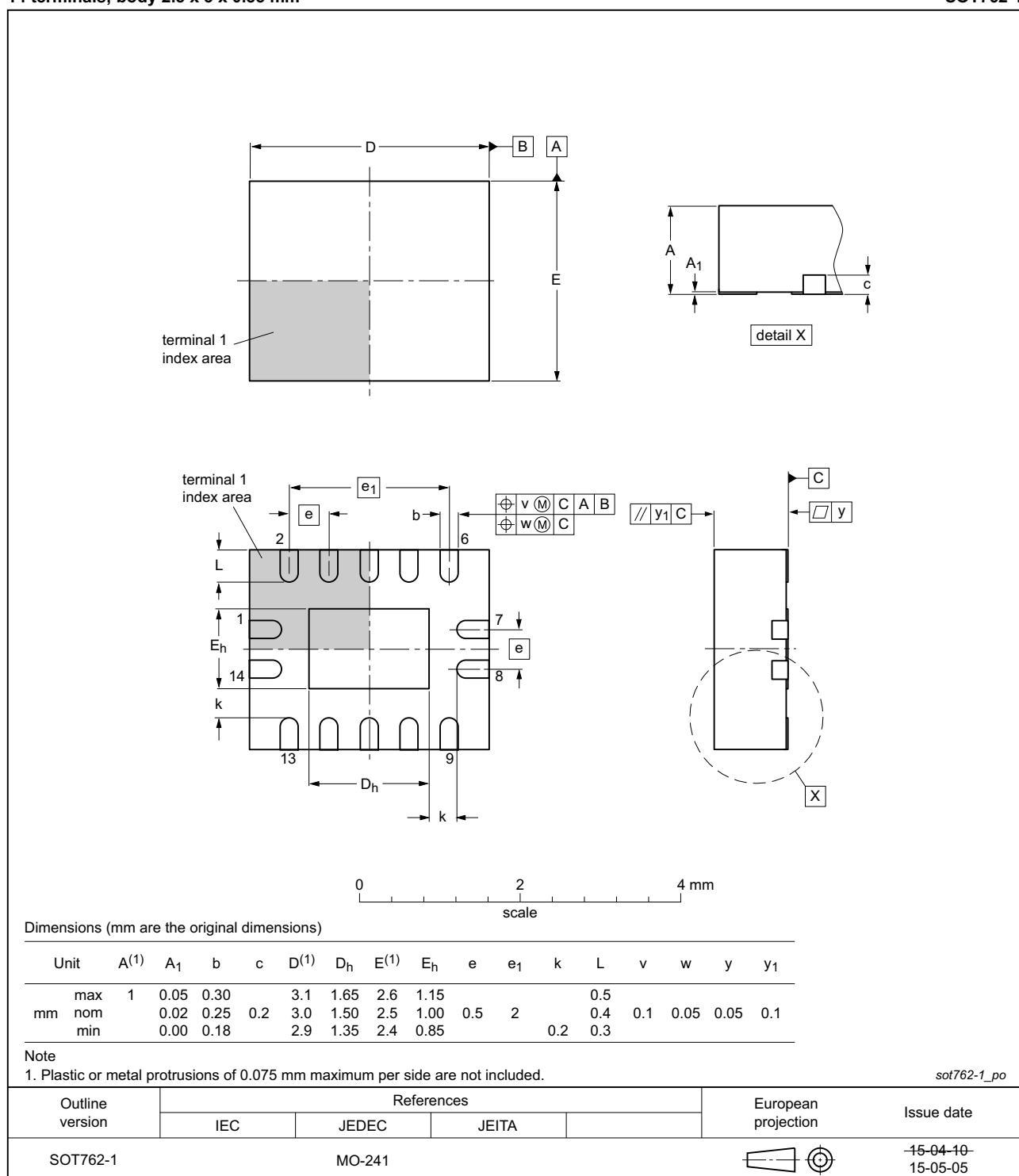


Fig 17. Package outline SOT762-1 (DHVQFN14)

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 |
|----------------|--|-----------------------|---------------|--------------|
| 74AHCU04 v.4 | 20151207 | Product data sheet | - | 74AHCU04 v.3 |
| Modifications: | <ul style="list-style-type: none"> Descriptive title updated. Added “unbuffered” (errata). | | | |
| 74AHCU04 v.3 | 20071114 | Product data sheet | - | 74AHCU04 v.2 |
| Modifications: | <ul style="list-style-type: none"> The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors. Legal texts have been adapted to the new company name where appropriate. Section 3: DHVQFN14 package added. Section 8: derating values added for DHVQFN14 package. Section 14: outline drawing added for DHVQFN14 package. | | | |
| 74AHCU04 v.2 | 19990927 | Product specification | - | 74AHCU04 v.1 |
| 74AHCU04 v.1 | 19990226 | 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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