

# 74HCU04

Hex unbuffered inverter

Rev. 7 — 8 December 2015

## 1. General description

[Product data sheet](#)

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

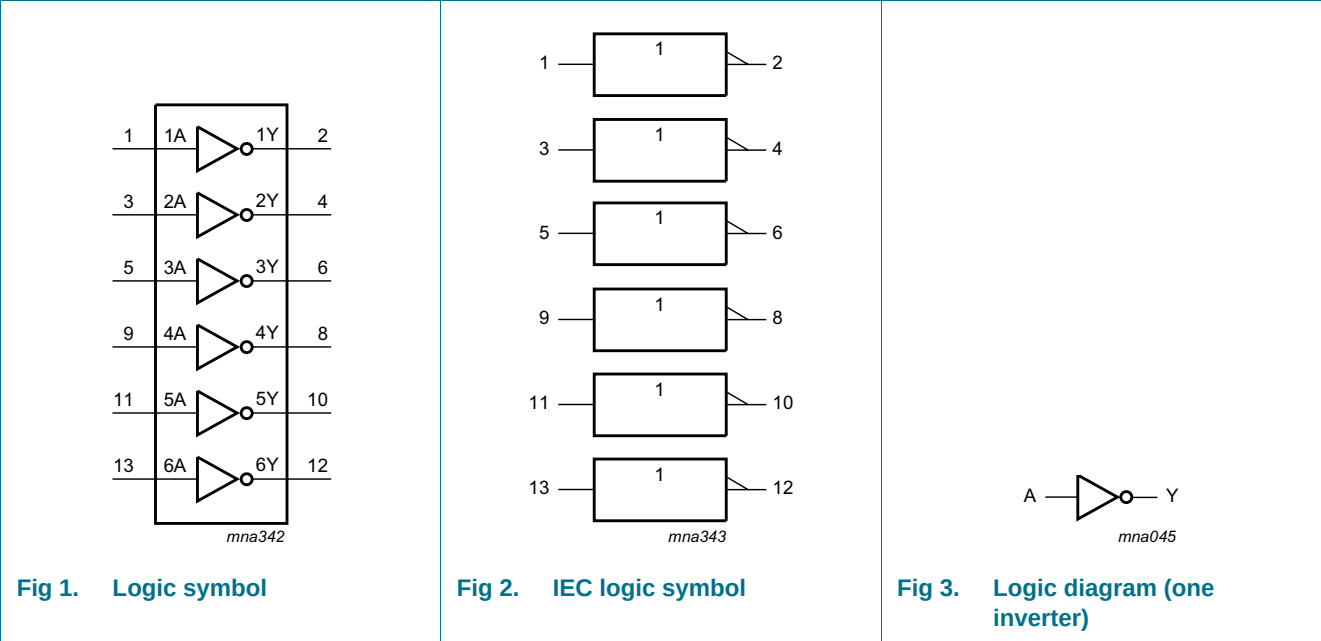
- Complies with JEDEC standard JESD7A
- Balanced propagation delays
- ESD protection:
  - ◆ HBM JESD22-A114F exceeds 2000 V
  - ◆ MM JESD22-A115-A exceeds 200 V
- Multiple package options
- Specified from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$

## 3. Ordering information

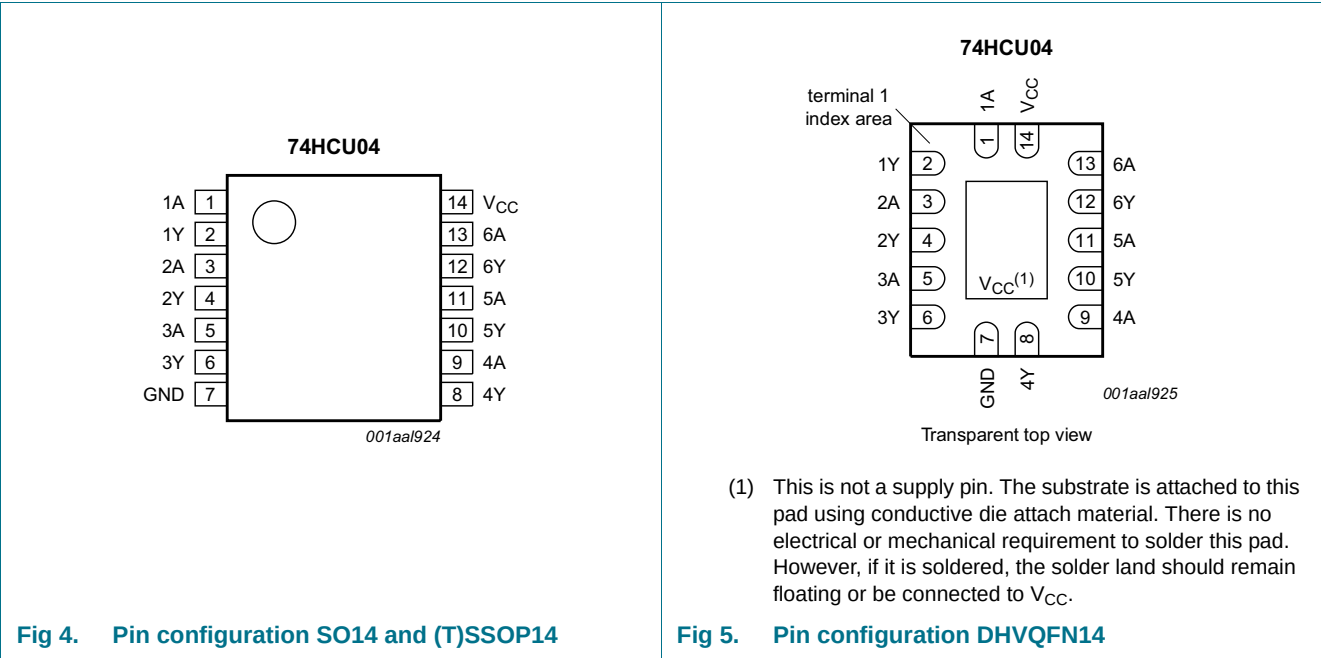
Table 1. Ordering information

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

4. Functional diagram



5. Pinning information



## 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 <sub>CC</sub>        | 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 <sub>CC</sub>  | supply voltage          |                                                                         | −0.5 | +7.0 | V    |
| I <sub>IK</sub>  | input clamping current  | V <sub>I</sub> < −0.5 V or V <sub>I</sub> > V <sub>CC</sub> + 0.5 V [1] | -    | ±20  | mA   |
| I <sub>OK</sub>  | output clamping current | V <sub>O</sub> < −0.5 V or V <sub>O</sub> > V <sub>CC</sub> + 0.5 V [1] | -    | ±50  | mA   |
| I <sub>O</sub>   | output current          | −0.5 V < V <sub>O</sub> < V <sub>CC</sub> + 0.5 V                       | -    | ±25  | mA   |
| I <sub>CC</sub>  | supply current          |                                                                         | -    | 50   | mA   |
| I <sub>GND</sub> | ground current          |                                                                         | −50  | -    | mA   |
| T <sub>stg</sub> | storage temperature     |                                                                         | −65  | +150 | °C   |
| P <sub>tot</sub> | 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<sub>tot</sub> derates linearly with 8 mW/K above 70 °C.  
 For (T)SSOP14 packages: P<sub>tot</sub> derates linearly with 5.5 mW/K above 60 °C.  
 For DHVQFN14 packages: P<sub>tot</sub> 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 <sub>CC</sub>  | supply voltage      |            | 2.0 | 5.0 | 6.0             | V    |
| V <sub>I</sub>   | input voltage       |            | 0   | -   | V <sub>CC</sub> | V    |
| V <sub>O</sub>   | output voltage      |            | 0   | -   | V <sub>CC</sub> | V    |
| T <sub>amb</sub> | 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 <sub>IH</sub> | HIGH-level input voltage  | V <sub>CC</sub> = 2.0 V                                                                | 1.7   | 1.4  | -    | 1.7              | -    | 1.7               | -   | V    |
|                 |                           | V <sub>CC</sub> = 4.5 V                                                                | 3.6   | 2.6  | -    | 3.6              | -    | 3.6               | -   | V    |
|                 |                           | V <sub>CC</sub> = 5.5 V                                                                | 4.8   | 3.4  | -    | 4.8              | -    | 4.8               | -   | V    |
| V <sub>IL</sub> | LOW-level input voltage   | V <sub>CC</sub> = 2.0 V                                                                | -     | 0.6  | 0.3  | -                | 0.3  | -                 | 0.3 | V    |
|                 |                           | V <sub>CC</sub> = 4.5 V                                                                | -     | 1.9  | 0.9  | -                | 0.9  | -                 | 0.9 | V    |
|                 |                           | V <sub>CC</sub> = 5.5 V                                                                | -     | 2.6  | 1.2  | -                | 1.2  | -                 | 1.2 | V    |
| V <sub>OH</sub> | HIGH-level output voltage | V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                    |       |      |      |                  |      |                   |     |      |
|                 |                           | I <sub>O</sub> = -20 µA; V <sub>CC</sub> = 2.0 V                                       | 1.8   | 2.0  | -    | 1.8              | -    | 1.8               | -   | V    |
|                 |                           | I <sub>O</sub> = -20 µA; V <sub>CC</sub> = 4.5 V                                       | 4.0   | 4.5  | -    | 4.0              | -    | 4.0               | -   | V    |
|                 |                           | I <sub>O</sub> = -4.0 mA; V <sub>CC</sub> = 4.5 V                                      | 3.98  | 4.32 | -    | 3.84             | -    | 3.7               | -   | V    |
|                 |                           | I <sub>O</sub> = -20 µA; V <sub>CC</sub> = 6.0 V                                       | 5.5   | 6.0  | -    | 5.5              | -    | 5.5               | -   | V    |
| V <sub>OL</sub> | LOW-level output voltage  | I <sub>O</sub> = -5.2 mA; V <sub>CC</sub> = 6.0 V                                      | 5.48  | 5.81 | -    | 5.34             | -    | 5.2               | -   | V    |
|                 |                           | V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                    |       |      |      |                  |      |                   |     |      |
|                 |                           | I <sub>O</sub> = 20 µA; V <sub>CC</sub> = 2.0 V                                        | -     | 0    | 0.2  | -                | 0.2  | -                 | 0.2 | V    |
|                 |                           | I <sub>O</sub> = 20 µA; V <sub>CC</sub> = 4.5 V                                        | -     | 0    | 0.5  | -                | 0.5  | -                 | 0.5 | V    |
|                 |                           | I <sub>O</sub> = 4.0 mA; V <sub>CC</sub> = 4.5 V                                       | -     | 0.15 | 0.26 | -                | 0.33 | -                 | 0.4 | V    |
| I <sub>I</sub>  | input leakage current     | I <sub>O</sub> = 20 µA; V <sub>CC</sub> = 6.0 V                                        | -     | 0    | 0.5  | -                | 0.5  | -                 | 0.5 | V    |
|                 |                           | I <sub>O</sub> = 5.2 mA; V <sub>CC</sub> = 6.0 V                                       | -     | 0.16 | 0.26 | -                | 0.33 | -                 | 0.4 | V    |
| I <sub>CC</sub> | supply current            | V <sub>I</sub> = V <sub>CC</sub> or GND; I <sub>O</sub> = 0 A; V <sub>CC</sub> = 6.0 V | -     | -    | 2    | -                | 20   | -                 | 20  | µA   |
| C <sub>I</sub>  | 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<br>+85 °C | –40 °C to<br>+125 °C | Unit |
|-----------------|-------------------------------|---------------------------------------------------------------------------|-------|-----|---------------------|----------------------|------|
|                 |                               |                                                                           | Typ   | Max | Max                 | Max                  |      |
| t <sub>pd</sub> | propagation delay             | nA to nY; see <a href="#">Figure 6</a> <a href="#">[1]</a>                |       |     |                     |                      |      |
|                 |                               | V <sub>CC</sub> = 2.0 V; C <sub>L</sub> = 50 pF                           | 19    | 70  | 90                  | 105                  | ns   |
|                 |                               | V <sub>CC</sub> = 4.5 V; C <sub>L</sub> = 50 pF                           | 7     | 14  | 18                  | 21                   | ns   |
|                 |                               | V <sub>CC</sub> = 5.0 V; C <sub>L</sub> = 15 pF                           | 5     | -   | -                   | -                    | ns   |
|                 |                               | V <sub>CC</sub> = 6.0 V; C <sub>L</sub> = 50 pF                           | 6     | 12  | 15                  | 18                   | ns   |
| t <sub>t</sub>  | transition time               | see <a href="#">Figure 6</a> <a href="#">[2]</a>                          |       |     |                     |                      |      |
|                 |                               | V <sub>CC</sub> = 2.0 V; C <sub>L</sub> = 50 pF                           | 19    | 75  | 95                  | 110                  | ns   |
|                 |                               | V <sub>CC</sub> = 4.5 V; C <sub>L</sub> = 50 pF                           | 7     | 15  | 19                  | 22                   | ns   |
|                 |                               | V <sub>CC</sub> = 6.0 V; C <sub>L</sub> = 50 pF                           | 6     | 13  | 16                  | 19                   | ns   |
| C <sub>PD</sub> | power dissipation capacitance | per inverter; V <sub>I</sub> = GND to V <sub>CC</sub> <a href="#">[3]</a> | 10    | -   | -                   | -                    | pF   |

[1] t<sub>pd</sub> is the same as t<sub>PHL</sub>, t<sub>PLH</sub>.

[2] t<sub>t</sub> is the same as t<sub>THL</sub>, t<sub>TLH</sub>.

[3] C<sub>PD</sub> is used to determine the dynamic power dissipation (P<sub>D</sub> 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<sub>i</sub> = input frequency in MHz;

f<sub>o</sub> = output frequency in MHz;

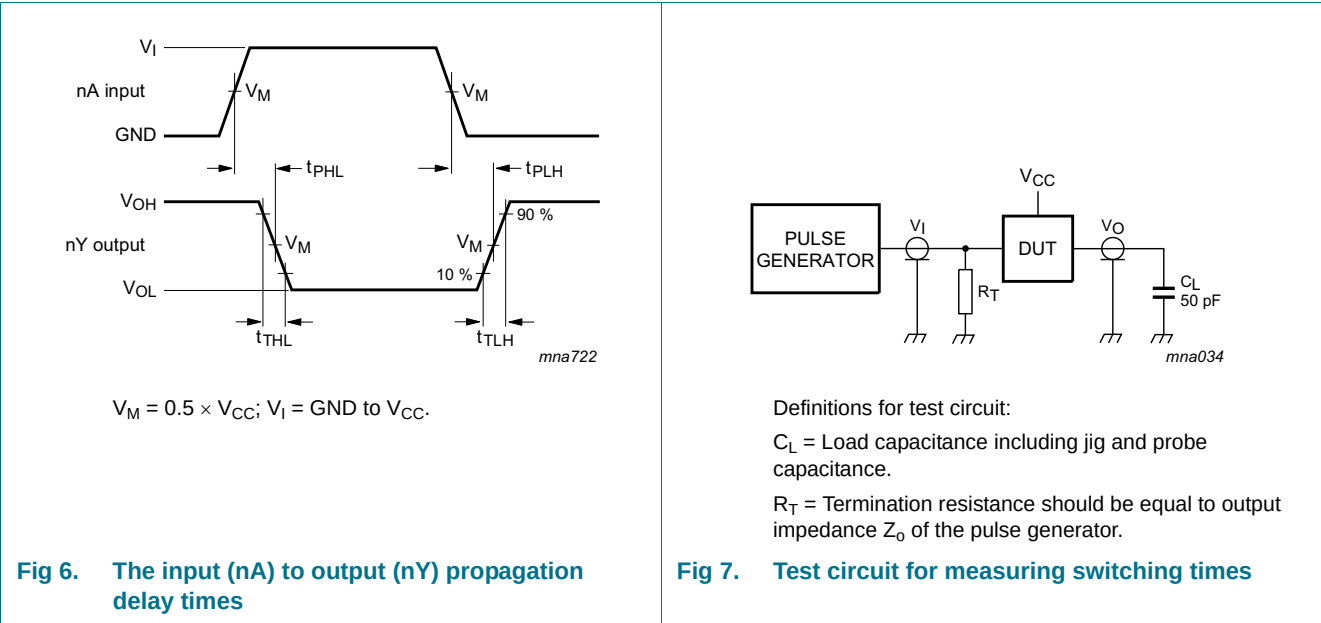
C<sub>L</sub> = output load capacitance in pF;

V<sub>CC</sub> = supply voltage in V;

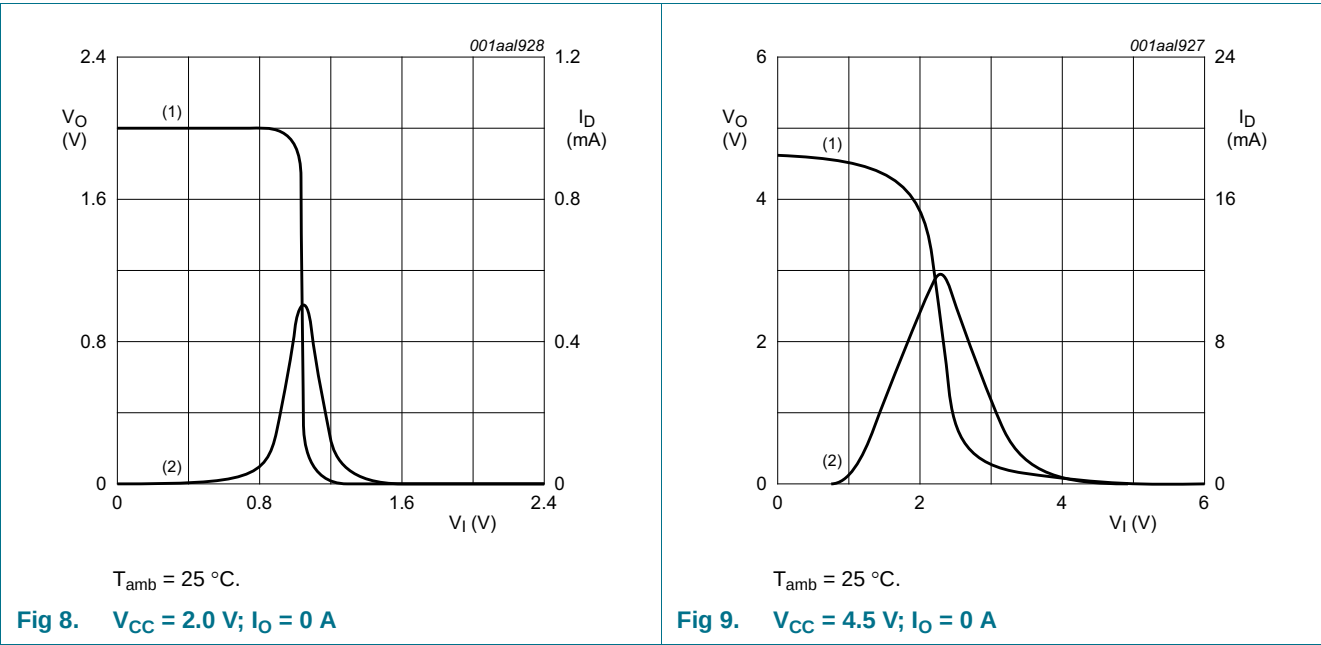
N = number of inputs switching;

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

11. Waveforms



12. Typical transfer characteristics



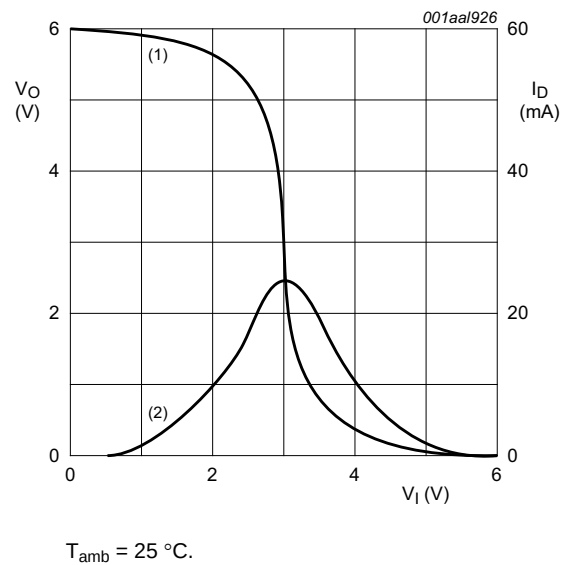
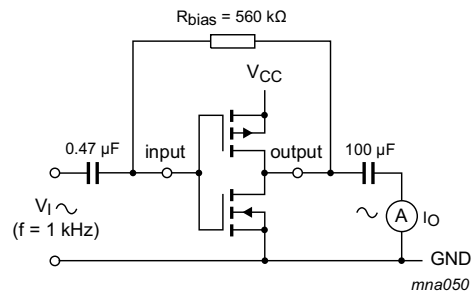


Fig 10.  $V_{CC} = 6.0\text{ V}$ ;  $I_O = 0\text{ A}$



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

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

Fig 11. Test set-up for measuring forward transconductance

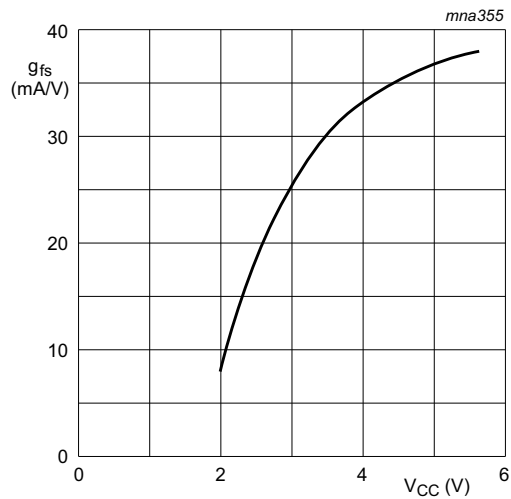


Fig 12. Typical forward transconductance as a function of the supply voltage

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  $V_{o(p-p)} = V_{CC} - 2.0\text{ V}$  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  
 $R1 \geq 3\text{ k}\Omega$ ,  $R2 \leq 1\text{ M}\Omega$   
 $Z_L > 10\text{ k}\Omega$ ;  $G_{ol} = 20$  (typical)  
 $V_{CC} = 6.0\text{ V}$   
 Typical unity gain bandwidth product is 5 MHz.

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

$C1 = 47\text{ pF}$  (typical)  
 $C2 = 33\text{ pF}$  (typical)  
 $R1 = 1\text{ M}\Omega$  to  $10\text{ M}\Omega$  (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  $V_{CC} = 5\text{ V}$  and  $f_i = 10\text{ MHz}$ .

**Fig 14. Crystal oscillator configuration**

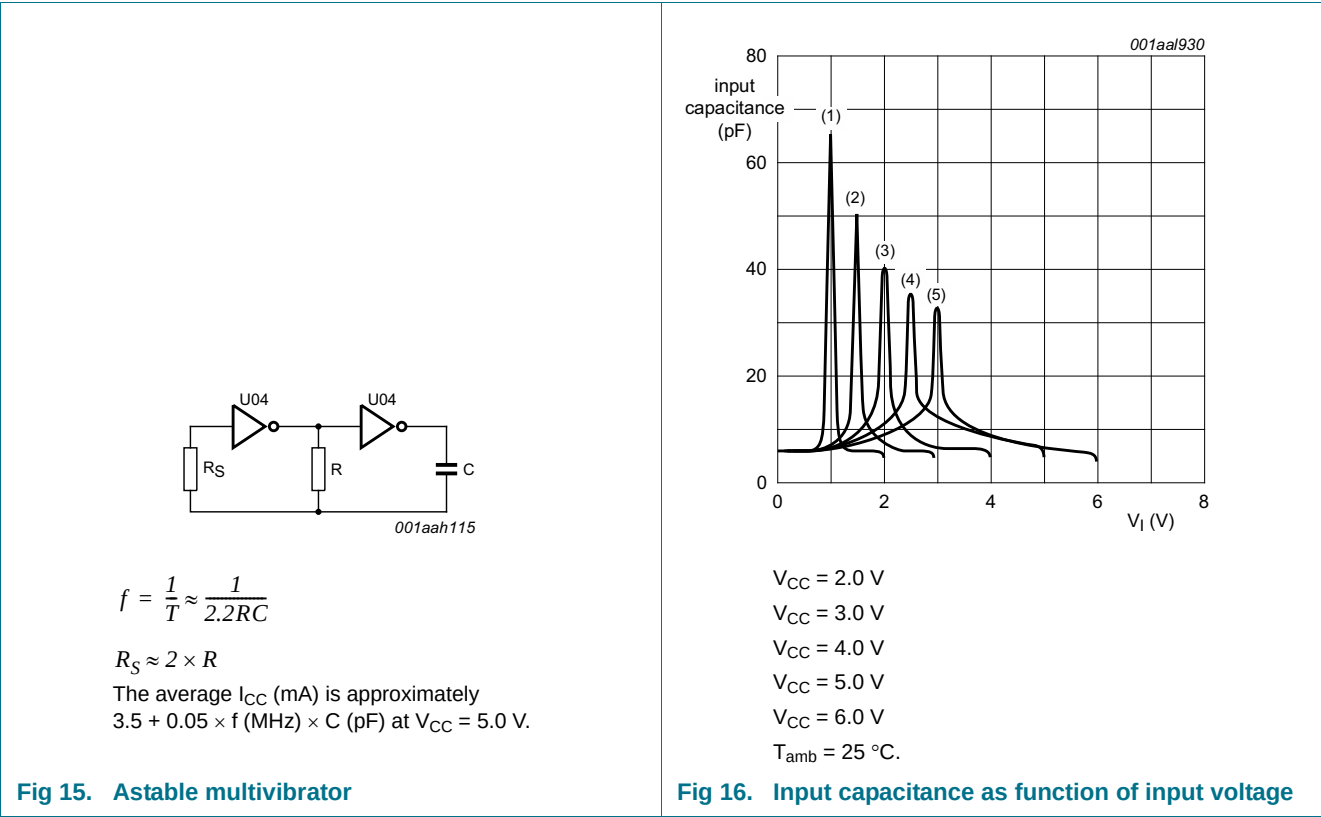
**Table 8. External components for resonator (f < 1 MHz)**  
 All values given are typical and must be used as an initial set-up.

| 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 <sub>CC</sub>                   |
|           | 8.0 kΩ | minimum influence due to change in V <sub>CC</sub> |
| 6 kHz     | 1.0 kΩ | minimum required I <sub>CC</sub>                   |
|           | 4.7 kΩ | minimum influence by V <sub>CC</sub>               |
| 10 kHz    | 0.5 kΩ | minimum required I <sub>CC</sub>                   |
|           | 2.0 kΩ | minimum influence by V <sub>CC</sub>               |
| 14 kHz    | 0.5 kΩ | minimum required I <sub>CC</sub>                   |
|           | 1.0 kΩ | minimum influence by V <sub>CC</sub>               |
| >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

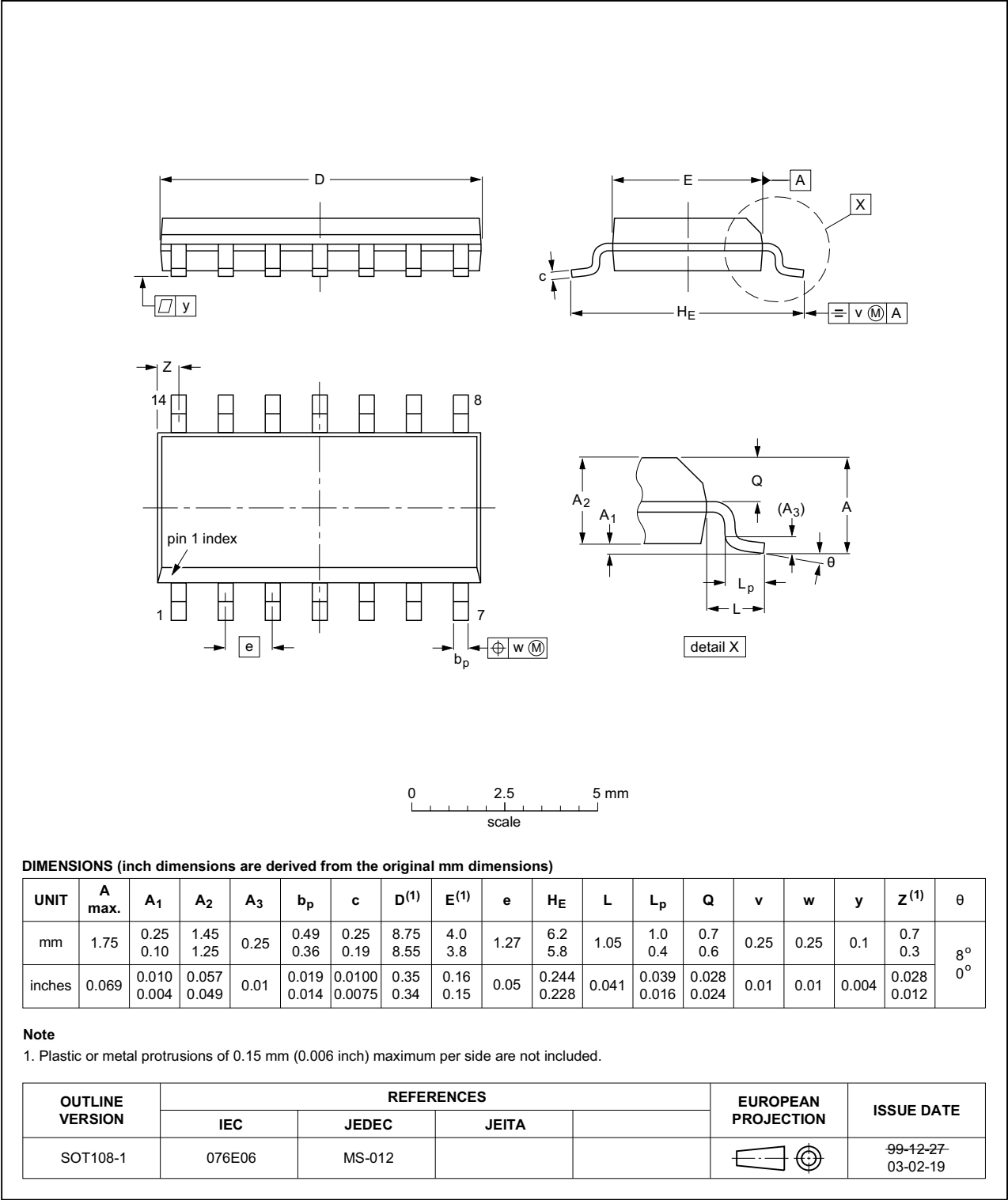


Fig 17. Package outline SOT108-1 (SO14)

SSOP14: plastic shrink small outline package; 14 leads; body width 5.3 mm

SOT337-1

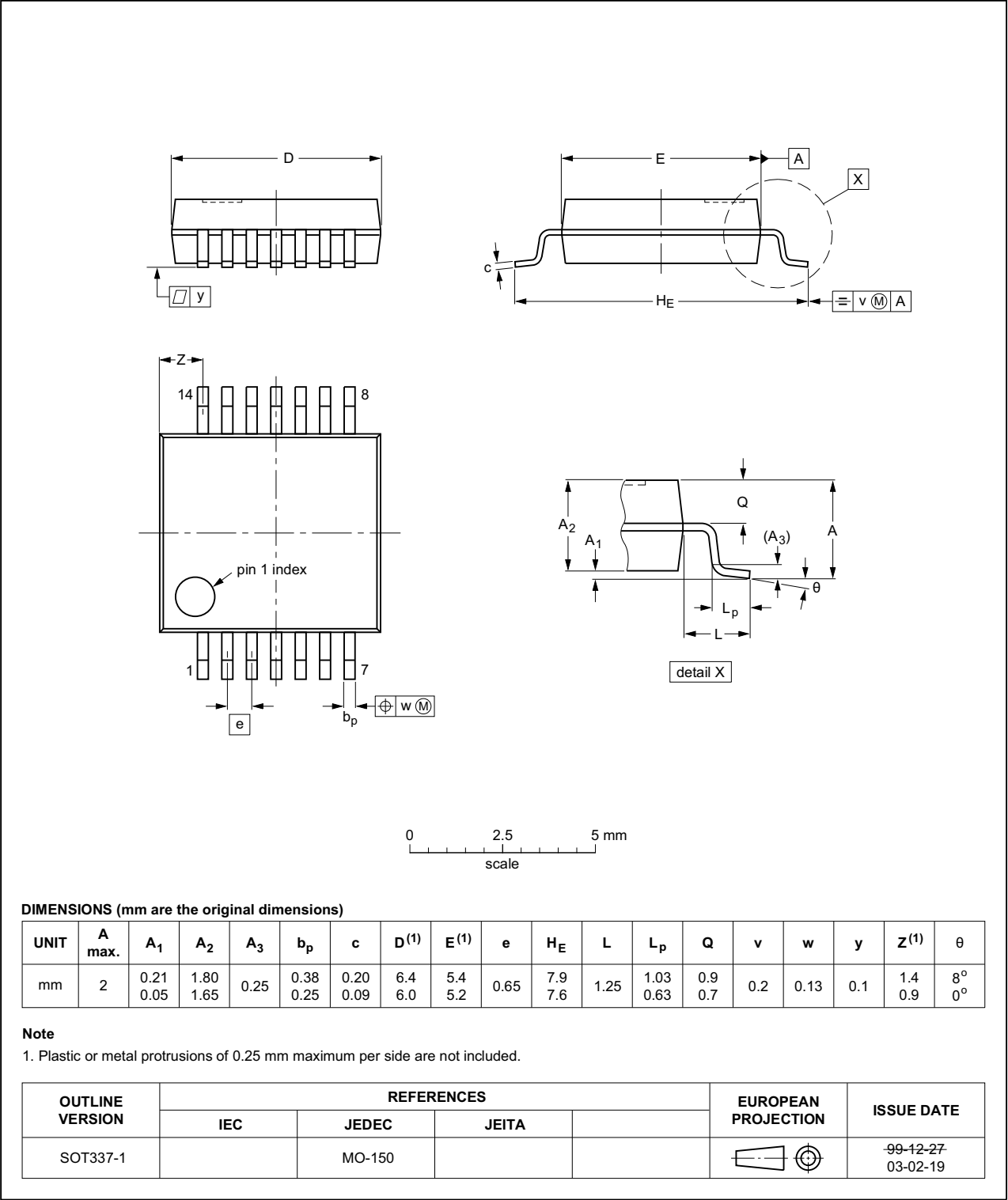


Fig 18. Package outline SOT337-1 (SSOP14)

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

SOT402-1

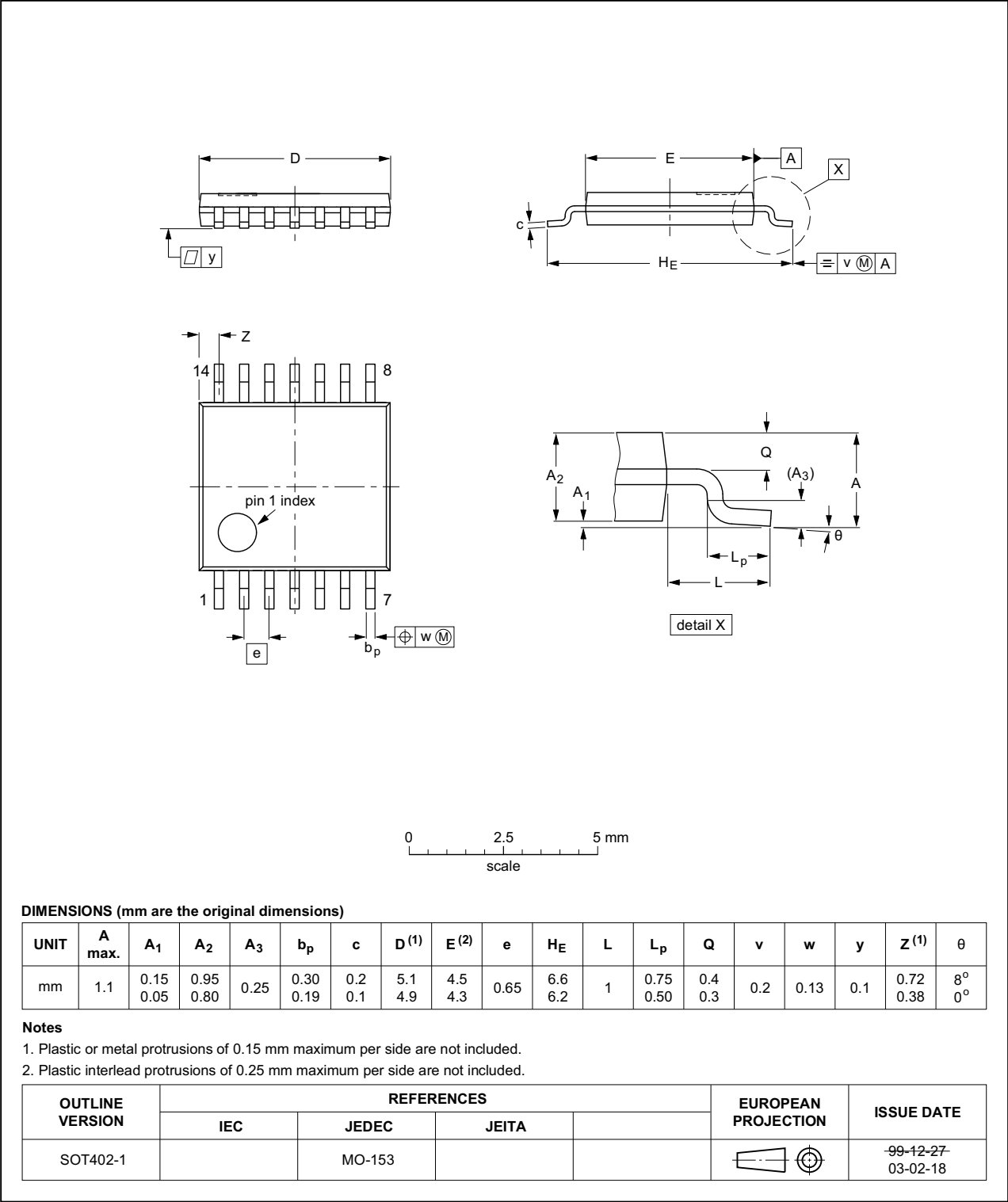


Fig 19. Package outline SOT402-1 (TSSOP14)



## 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:  | <ul style="list-style-type: none"> <li>Type number 74HCU04N (SOT27-1) removed.</li> <li>Conditions <math>V_{IL}</math> and <math>V_{IH}</math> corrected (errata).</li> </ul> |                       |               |                 |
| 74HCU04 v.6     | 20121227                                                                                                                                                                      | Product data sheet    | -             | 74HCU04 v.5     |
| Modifications:  | <ul style="list-style-type: none"> <li>New general description.</li> </ul>                                                                                                    |                       |               |                 |
| 74HCU04 v.5     | 20120806                                                                                                                                                                      | Product data sheet    | -             | 74HCU04 v.4     |
| Modifications:  | <ul style="list-style-type: none"> <li>Measurement points added to figure 6 (errata).</li> </ul>                                                                              |                       |               |                 |
| 74HCU04 v.4     | 20111212                                                                                                                                                                      | Product data sheet    | -             | 74HCU04 v.3     |
| Modifications:  | <ul style="list-style-type: none"> <li>Legal pages updated.</li> </ul>                                                                                                        |                       |               |                 |
| 74HCU04 v.3     | 20100916                                                                                                                                                                      | Product data sheet    | -             | 74HCU04_CNV v.2 |
| 74HCU04_CNV v.2 | 19970826                                                                                                                                                                      | Product specification | -             | -               |