

# XC7SHU04

## Inverter

Rev. 01 — 7 September 2009

Product data sheet

## 1. General description

The XC7SHU04 is a high-speed Si-gate CMOS device. It provides an inverting single stage function.

## 2. Features

- Symmetrical output impedance
- High noise immunity
- Low power dissipation
- Balanced propagation delays
- ESD protection:
  - ◆ HBM JESD22-A114E: exceeds 2000 V
  - ◆ MM JESD22-A115-A: exceeds 200 V
  - ◆ CDM JESD22-C101C: exceeds 1000 V
- 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  |
| XC7SHU04GW  | $-40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$ | TSSOP5 | plastic thin shrink small outline package;<br>5 leads; body width 1.25 mm | SOT353-1 |
| XC7SHU04GV  | $-40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$ | SC-74A | plastic surface-mounted package; 5 leads                                  | SOT753   |

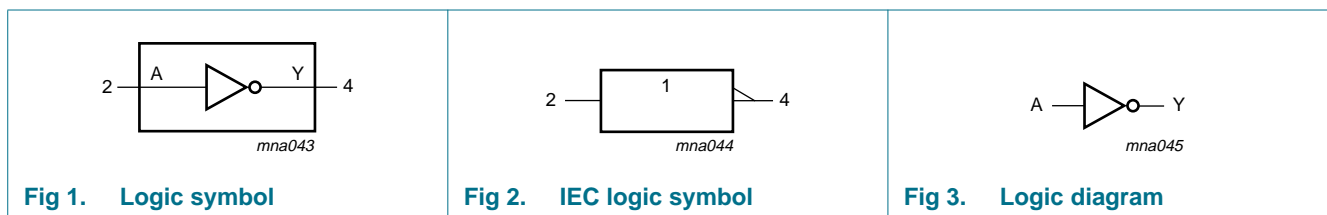
## 4. Marking

Table 2. Marking codes

| Type number | Marking <sup>[1]</sup> |
|-------------|------------------------|
| XC7SHU04GW  | fD                     |
| XC7SHU04GV  | fU4                    |

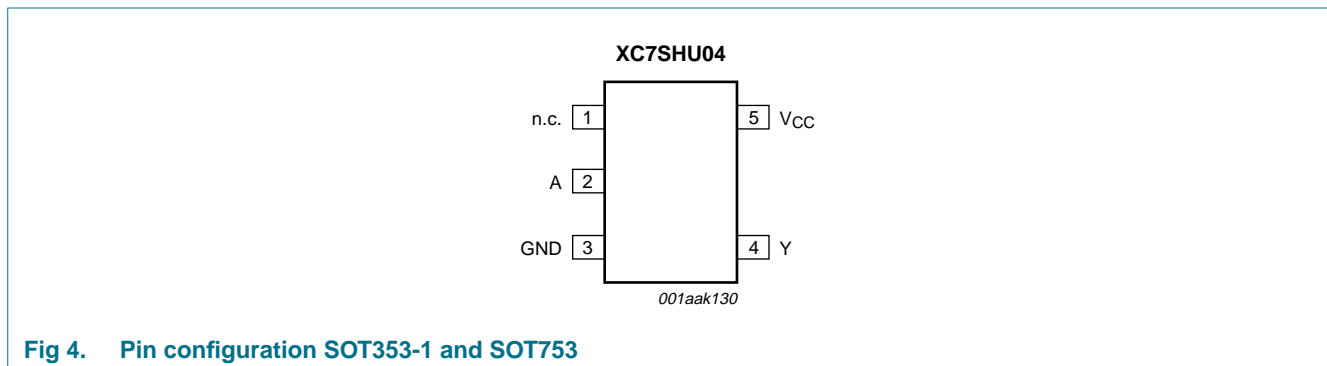
[1] The pin 1 indicator is located on the lower left corner of the device, below the marking code.

## 5. Functional diagram



## 6. Pinning information

### 6.1 Pinning



### 6.2 Pin description

Table 3. Pin description

| Symbol          | Pin | Description    |
|-----------------|-----|----------------|
| n.c.            | 1   | not connected  |
| A               | 2   | data input     |
| GND             | 3   | ground (0 V)   |
| Y               | 4   | data output    |
| V <sub>CC</sub> | 5   | supply voltage |

## 7. Functional description

**Table 4. Function table**

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

| Input | Output |
|-------|--------|
| A     | Y      |
| L     | H      |
| H     | L      |

## 8. Limiting values

**Table 5. 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     | V    |
| $I_{OK}$  | output clamping current | $V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V | -        | $\pm 20$ | mA   |
| $I_O$     | output current          | $-0.5$ V $< V_O < V_{CC} + 0.5$ V        | -        | $\pm 25$ | 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] -    | 250      | mW   |

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

[2] For both TSSOP5 and SC-74A packages: above 87.5 °C the value of  $P_{tot}$  derates linearly with 4.0 mW/K.

## 9. Recommended operating conditions

**Table 6. 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 | $V_{CC} = 3.3$ V $\pm 0.3$ V | -   | -   | 100      | ns/V |
|                     |                                     | $V_{CC} = 5.0$ V $\pm 0.5$ V | -   | -   | 20       | ns/V |

## 10. Static characteristics

**Table 7. 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   | -   | -    | 1.7              | -    | 1.7               | -    | V    |
|                 |                           | V <sub>CC</sub> = 3.0 V   | 2.4   | -   | -    | 2.4              | -    | 2.4               | -    | V    |
|                 |                           | V <sub>CC</sub> = 5.5 V   | 4.4   | -   | -    | 4.4              | -    | 4.4               | -    | V    |
| V <sub>IL</sub> | LOW-level input voltage   | V <sub>CC</sub> = 2.0 V   | -     | -   | 0.3  | -                | 0.3  | -                 | 0.3  | V    |
|                 |                           | V <sub>CC</sub> = 3.0 V   | -     | -   | 0.6  | -                | 0.6  | -                 | 0.6  | V    |
|                 |                           | V <sub>CC</sub> = 5.5 V   | -     | -   | 1.1  | -                | 1.1  | -                 | 1.1  | 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> = -50 μA; V <sub>CC</sub> = 2.0 V  | 1.9   | 2.0 | -    | 1.9              | -    | 1.9               | -    | V    |
|                 |                           | I <sub>O</sub> = -50 μA; V <sub>CC</sub> = 3.0 V  | 2.9   | 3.0 | -    | 2.9              | -    | 2.9               | -    | V    |
|                 |                           | I <sub>O</sub> = -50 μA; V <sub>CC</sub> = 4.5 V  | 4.4   | 4.5 | -    | 4.4              | -    | 4.4               | -    | V    |
|                 |                           | I <sub>O</sub> = -4.0 mA; V <sub>CC</sub> = 3.0 V   | 2.58  | -   | -    | 2.48             | -    | 2.40              | -    | V    |
|                 |                           | I <sub>O</sub> = -8.0 mA; V <sub>CC</sub> = 4.5 V   | 3.94  | -   | -    | 3.8              | -    | 3.70              | -    | V    |
| V <sub>OL</sub> | LOW-level output voltage  | V <sub>I</sub> = V <sub>IH</sub> or V <sub>IL</sub>                                       |       |     |      |                  |      |                   |      |      |
|                 |                           | I <sub>O</sub> = 50 μA; V <sub>CC</sub> = 2.0 V   | -     | 0   | 0.1  | -                | 0.1  | -                 | 0.1  | V    |
|                 |                           | I <sub>O</sub> = 50 μA; V <sub>CC</sub> = 3.0 V   | -     | 0   | 0.1  | -                | 0.1  | -                 | 0.1  | V    |
|                 |                           | I <sub>O</sub> = 50 μA; V <sub>CC</sub> = 4.5 V   | -     | 0   | 0.1  | -                | 0.1  | -                 | 0.1  | V    |
|                 |                           | I <sub>O</sub> = 4.0 mA; V <sub>CC</sub> = 3.0 V  | -     | -   | 0.36 | -                | 0.44 | -                 | 0.55 | V    |
|                 |                           | I <sub>O</sub> = 8.0 mA; V <sub>CC</sub> = 4.5 V  | -     | -   | 0.36 | -                | 0.44 | -                 | 0.55 | V    |
| I <sub>I</sub>  | input leakage current     | V <sub>I</sub> = 5.5 V or GND;<br>V <sub>CC</sub> = 0 V to 5.5 V                          | -     | -   | 0.1  | -                | 1.0  | -                 | 2.0  | μA   |
| I <sub>CC</sub> | supply current            | V <sub>I</sub> = V <sub>CC</sub> or GND; I <sub>O</sub> = 0 A;<br>V <sub>CC</sub> = 5.5 V | -     | -   | 1.0  | -                | 10   | -                 | 40   | μA   |
| C <sub>I</sub>  | input capacitance         |   | -     | 1.5 | 10   | -                | 10   | -                 | 10   | pF   |

## 11. Dynamic characteristics

**Table 8. Dynamic characteristics**  
*GND = 0 V. For test circuit see Figure 6.*

| Symbol          | Parameter                     | Conditions   | 25 °C |     |      | -40 °C to +85 °C |      | -40 °C to +125 °C |      | Unit |
|-----------------|-------------------------------|--|-------|-----|------|------------------|------|-------------------|------|------|
|                 |                               |  | Min   | Typ | Max  | Min              | Max  | Min               | Max  |      |
| t <sub>pd</sub> | propagation delay             | A to Y; see Figure 5 [1]                               |       |     |      |                  |      |                   |      |      |
|                 |                               | V <sub>CC</sub> = 3.0 V to 3.6 V [2]                   |       |     |      |                  |      |                   |      |      |
|                 |                               | C <sub>L</sub> = 15 pF                                 | -     | 3.4 | 7.1  | 1.0              | 8.5  | 1.0               | 10.0 | ns   |
|                 |                               | C <sub>L</sub> = 50 pF                                 | -     | 4.9 | 10.6 | 1.0              | 12.0 | 1.0               | 13.5 | ns   |
|                 |                               | V <sub>CC</sub> = 4.5 V to 5.5 V [3]                   |       |     |      |                  |      |                   |      |      |
|                 |                               | C <sub>L</sub> = 15 pF                                 | -     | 2.6 | 5.5  | 1.0              | 6.0  | 1.0               | 7.0  | ns   |
|                 |                               | C <sub>L</sub> = 50 pF                                 | -     | 3.6 | 7.0  | 1.0              | 8.0  | 1.0               | 9.0  | ns   |
| C <sub>PD</sub> | power dissipation capacitance | per buffer;<br>V <sub>I</sub> = GND to V <sub>CC</sub> | [4]   | -   | 14   | -                | -    | -                 | -    | pF   |

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

[2] Typical values are measured at V<sub>CC</sub> = 3.3 V.

[3] Typical values are measured at V<sub>CC</sub> = 5.0 V.

[4] C<sub>PD</sub> is used to determine the dynamic power dissipation P<sub>D</sub> (μW).

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

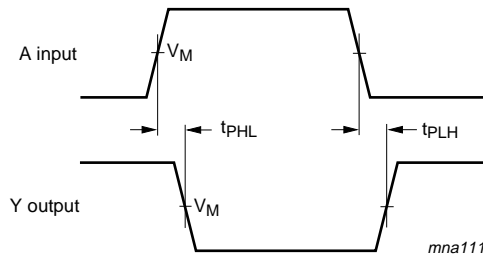
f<sub>i</sub> = input frequency in MHz;

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

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

V<sub>CC</sub> = supply voltage in Volts.

## 12. Waveforms

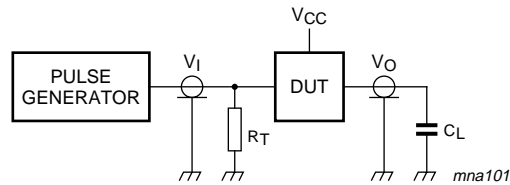


Measurement points are given in [Table 9](#).

**Fig 5. Input (A) to output (Y) propagation delays**

**Table 9. Measurement point**

| Type     | Input           | Input               | Output              |
|----------|-----------------|---------------------|---------------------|
|          | $V_I$           | $V_M$               | $V_M$               |
| XC7SHU04 | GND to $V_{CC}$ | $0.5 \times V_{CC}$ | $0.5 \times V_{CC}$ |



Test data is given in [Table 10](#). 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 6. Load circuitry for switching times**

**Table 10. Test data**

| Type     | Input    |               | Load         | Test               |
|----------|----------|---------------|--------------|--------------------|
|          | $V_I$    | $t_r, t_f$    | $C_L$        |                    |
| XC7SHU04 | $V_{CC}$ | $\leq 3.0$ ns | 15 pF, 50 pF | $t_{PLH}, t_{PHL}$ |

13. Typical transfer characteristics

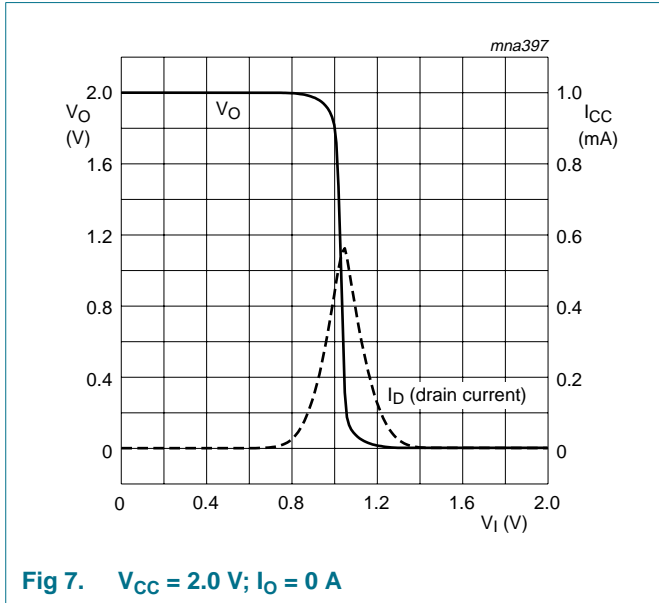


Fig 7.  $V_{CC} = 2.0\text{ V}; I_O = 0\text{ A}$

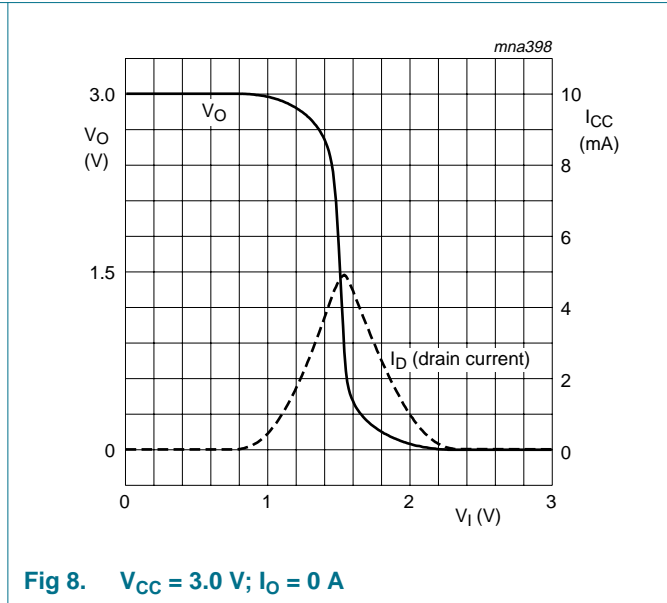


Fig 8.  $V_{CC} = 3.0\text{ V}; I_O = 0\text{ A}$

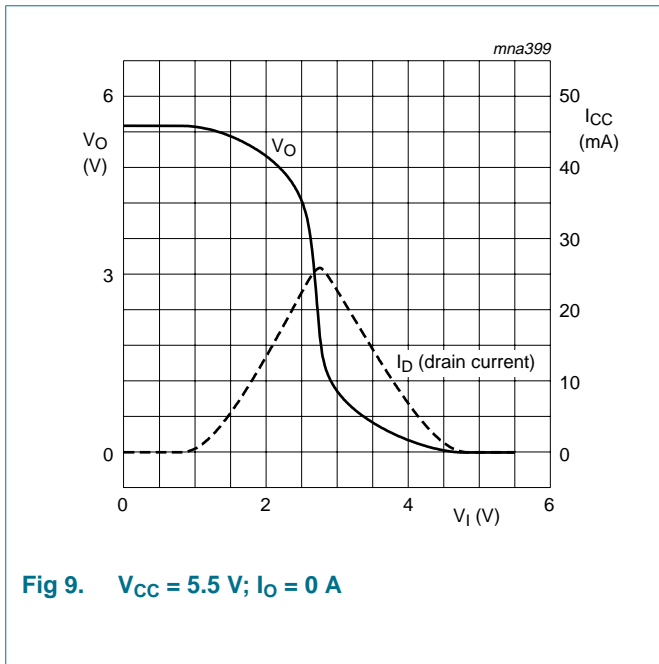


Fig 9.  $V_{CC} = 5.5\text{ V}; I_O = 0\text{ A}$

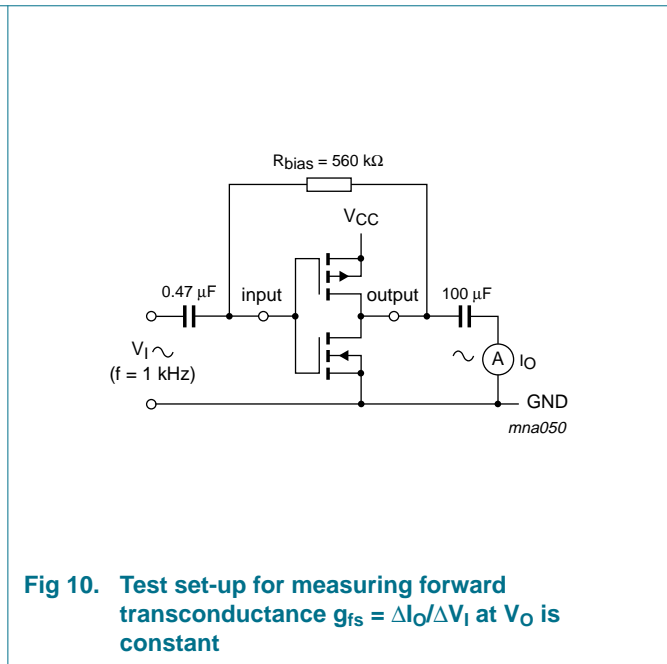


Fig 10. Test set-up for measuring forward transconductance  $g_{fs} = \Delta I_O / \Delta V_I$  at  $V_O$  is constant

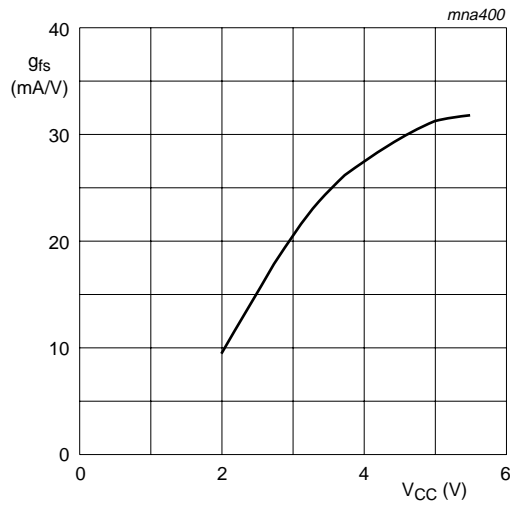


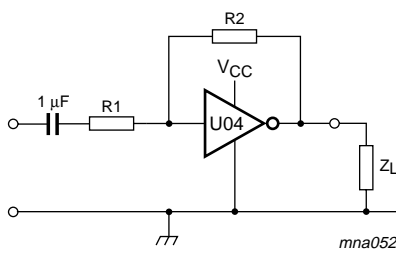
Fig 11. Typical forward transconductance  $g_{fs}$  as a function of the supply voltage at  $T_{amb} = 25\text{ }^{\circ}\text{C}$

### 14. Application information

Some applications are:

- Linear amplifier (see [Figure 12](#))
- In crystal oscillator design (see [Figure 13](#))

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



Maximum  $V_{o(p-p)} = V_{CC} - 1.5\text{ V}$  centered at  $0.5 \times V_{CC}$ .

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

$G_{ol}$  = open loop gain

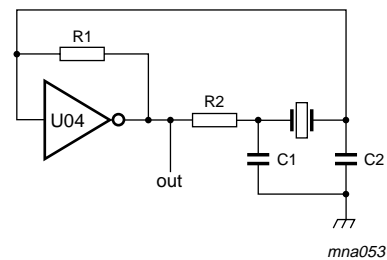
$G_v$  = voltage gain

$R1 \geq 3\text{ k}\Omega$ ,  $R2 \leq 1\text{ M}\Omega$

$Z_L > 10\text{ k}\Omega$ ;  $G_{ol} = 20$  (typ.)

Typical unity gain bandwidth product is 5 MHz.

Fig 12. Used as a linear amplifier



$C1 = 47\text{ pF}$  (typ.)

$C2 = 22\text{ pF}$  (typ.)

$R1 = 1\text{ M}\Omega$  to  $10\text{ M}\Omega$  (typ.)

$R2$  optimum value depends on the frequency and required stability against changes in  $V_{CC}$  or average minimum  $I_{CC}$  ( $I_{CC}$  is typically 2 mA at  $V_{CC} = 3\text{ V}$  and  $f = 1\text{ MHz}$ ).

Fig 13. Crystal oscillator configuration



**Table 11. 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 M $\Omega$ | 220 k $\Omega$ | 56 pF | 20 pF |
| 16 kHz to 24.9 kHz   | 22 M $\Omega$ | 220 k $\Omega$ | 56 pF | 10 pF |
| 25 kHz to 54.9 kHz   | 22 M $\Omega$ | 100 k $\Omega$ | 56 pF | 10 pF |
| 55 kHz to 129.9 kHz  | 22 M $\Omega$ | 100 k $\Omega$ | 47 pF | 5 pF  |
| 130 kHz to 199.9 kHz | 22 M $\Omega$ | 47 k $\Omega$  | 47 pF | 5 pF  |
| 200 kHz to 349.9 kHz | 22 M $\Omega$ | 47 k $\Omega$  | 47 pF | 5 pF  |
| 350 kHz to 600 kHz   | 22 M $\Omega$ | 47 k $\Omega$  | 47 pF | 5 pF  |

**Table 12. Optimum value for R2**

| Frequency | R2             | Optimum for  |
|-----------|----------------|--|
| 3 kHz     | 2.0 k $\Omega$ | minimum required I <sub>CC</sub>                   |
|           | 8.0 k $\Omega$ | minimum influence due to change in V <sub>CC</sub> |
| 6 kHz     | 1.0 k $\Omega$ | minimum required I <sub>CC</sub>                   |
|           | 4.7 k $\Omega$ | minimum influence by V <sub>CC</sub>               |
| 10 kHz    | 0.5 k $\Omega$ | minimum required I <sub>CC</sub>                   |
|           | 2.0 k $\Omega$ | minimum influence by V <sub>CC</sub>               |
| 14 kHz    | 0.5 k $\Omega$ | minimum required I <sub>CC</sub>                   |
|           | 1.0 k $\Omega$ | minimum influence by V <sub>CC</sub>               |
| > 14 kHz  | -              | replace R2 by C3 with a typical value of 35 pF     |

15. Package outline

TSSOP5: plastic thin shrink small outline package; 5 leads; body width 1.25 mm

SOT353-1

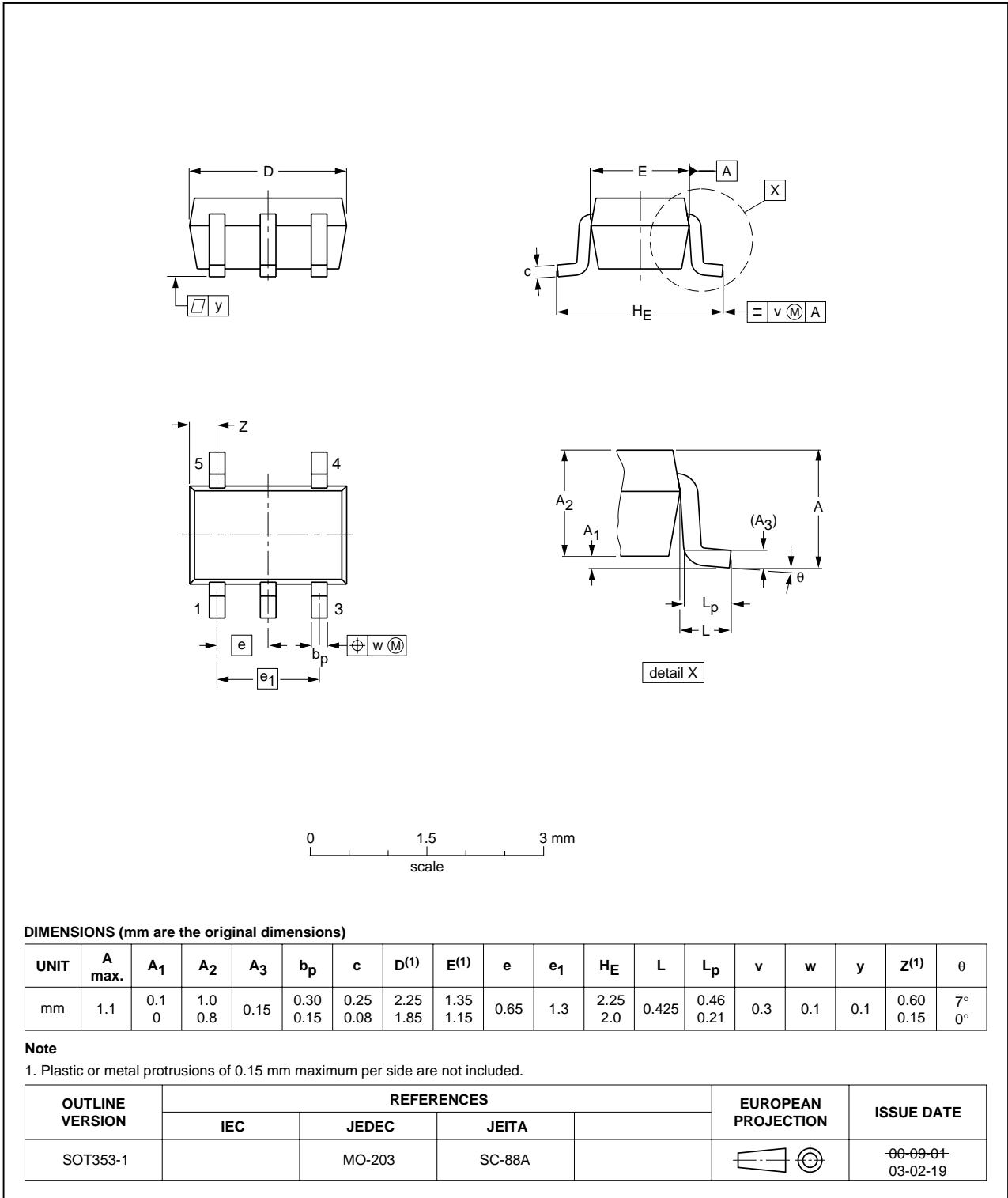


Fig 14. Package outline SOT353-1 (TSSOP5)

Plastic surface-mounted package; 5 leads

SOT753

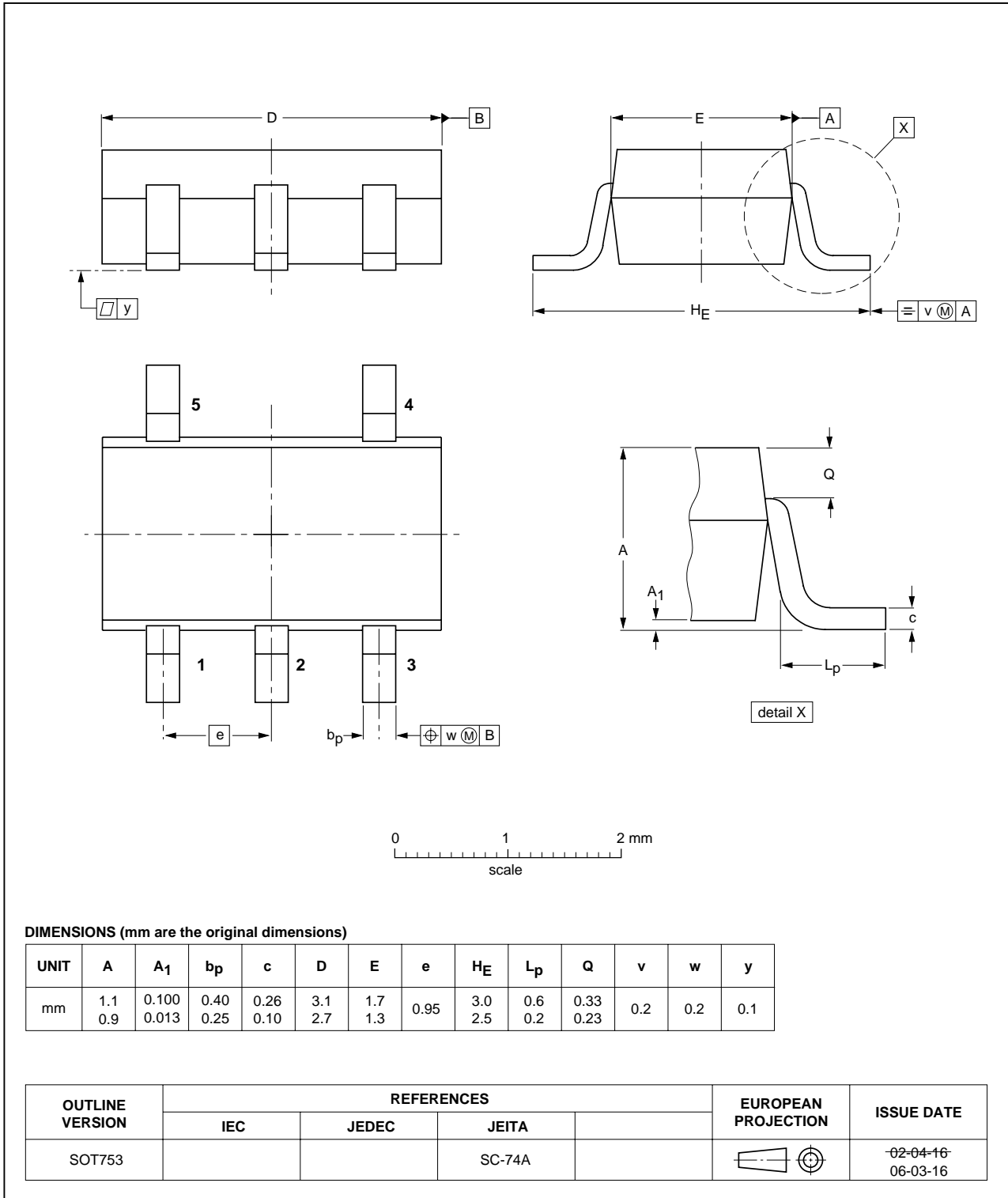


Fig 15. Package outline SOT753 (SC-74A)

## 16. Abbreviations

Table 13. Abbreviations

| Acronym | Description             |
|---------|-------------------------|
| CDM     | Charged Device Model    |
| DUT     | Device Under Test       |
| ESD     | ElectroStatic Discharge |
| HBM     | Human Body Model        |
| MM      | Machine Model           |

## 17. Revision history

Table 14. Revision history

| Document ID | Release date | Data sheet status  | Change notice | Supersedes |
|-------------|--------------|--------------------|---------------|------------|
| XC7SHU04_1  | 20090907     | Product data sheet | -             | -          |

## 18. Legal information

### 18.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | 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.nexperia.com>.

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