

# 74AHC04

## Hex inverter

Rev. 03 — 14 November 2007

Product data sheet

### 1. General description

The 74AHC04 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 74AHC04 is a general purpose hex inverter. Each of the six inverters is a single stage.

### 2. Features

- Low power dissipation
- Balanced propagation delays
- Inputs accepts voltages higher than  $V_{CC}$
- ESD protection:
  - ◆ HBM JESD22-A114E: exceeds 2000 V
  - ◆ MM JESD22-A115-A: exceeds 200 V
  - ◆ CDM JESD22-C101C: exceeds 1000 V
- Multiple package options
- Specified from  $-40\text{ °C}$  to  $+125\text{ °C}$

### 3. Ordering information

Table 1. Ordering information

| Type number | Package                             |          |   | Version  |
|-------------|-------------------------------------|----------|---|----------|
|             | Temperature range                   | Name     | Description   |          |
| 74AHC04D    | $-40\text{ °C}$ to $+125\text{ °C}$ | SO14     | plastic small outline package; 14 leads; body width 3.9 mm  | SOT108-1 |
| 74AHC04PW   | $-40\text{ °C}$ to $+125\text{ °C}$ | TSSOP14  | plastic thin shrink small outline package; 14 leads; body width 4.4 mm  | SOT402-1 |
| 74AHC04BQ   | $-40\text{ °C}$ to $+125\text{ °C}$ | 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

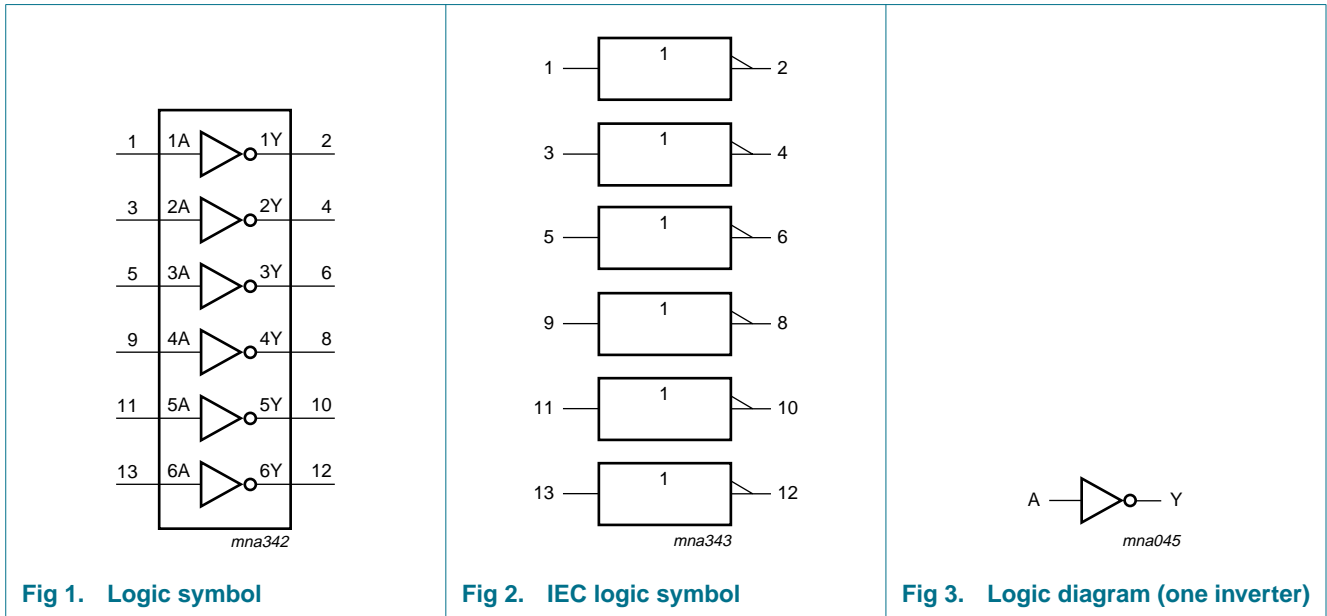


Fig 1. Logic symbol

Fig 2. IEC logic symbol

Fig 3. Logic diagram (one inverter)

### 5. Pinning information

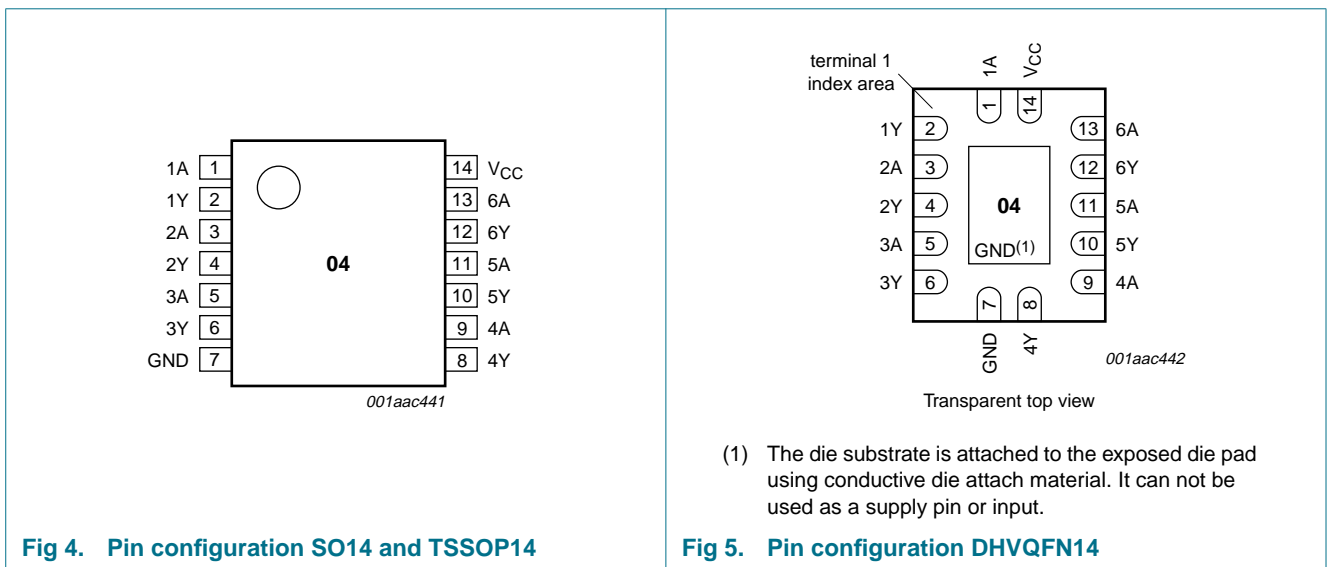


Fig 4. Pin configuration SO14 and TSSOP14

Fig 5. Pin configuration DHVQFN14

#### 5.1 Pin description

Table 2. Pin description

| Symbol | Pin | Description |
|--------|-----|-------------|
| 1A     | 1   | data input  |
| 1Y     | 2   | data output |
| 2A     | 3   | data input  |
| 2Y     | 4   | data output |

**Table 2.** Pin description ...continued

| Symbol          | Pin | Description    |
|-----------------|-----|----------------|
| 3A              | 5   | data input     |
| 3Y              | 6   | data output    |
| GND             | 7   | ground (0 V)   |
| 4Y              | 8   | data output    |
| 4A              | 9   | data input     |
| 5Y              | 10  | data output    |
| 5A              | 11  | data input     |
| 6Y              | 12  | data output    |
| 6A              | 13  | data input     |
| 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   | -20      | -    | mA   |
| V <sub>I</sub>   | input voltage           |   | [1] -0.5 | +7.0 | V    |
| 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 | -        | ±20  | 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          |   | -        | 75   | mA   |
| I <sub>GND</sub> | ground current          |   | -75      | -    | mA   |
| T <sub>stg</sub> | storage temperature     |   | -65      | +150 | °C   |
| P <sub>tot</sub> | total power dissipation | T <sub>amb</sub> = -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<sub>tot</sub> derates linearly with 8 mW/K.  
 For TSSOP14 packages: above 60 °C the value of P<sub>tot</sub> derates linearly with 5.5 mW/K.  
 For DHVQFN14 packages: above 60 °C the value of P<sub>tot</sub> 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 <sub>CC</sub>  | supply voltage                      |                                 | 2.0 | 5.0 | 5.5             | V    |
| V <sub>I</sub>   | input voltage                       |                                 | 0   | -   | 5.5             | V    |
| V <sub>O</sub>   | output voltage                      |                                 | 0   | -   | V <sub>CC</sub> | V    |
| T <sub>amb</sub> | ambient temperature                 |                                 | -40 | +25 | +125            | °C   |
| Δt/ΔV            | input transition rise and fall rate | V <sub>CC</sub> = 3.3 V ± 0.3 V | -   | -   | 100             | ns/V |
|                  |                                     | V <sub>CC</sub> = 5.0 V ± 0.5 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 <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  | 1.8   | 2.0 | -    | 1.8              | -    | 1.8               | -    | V    |
|                 |                           | I <sub>O</sub> = -50 μA; V <sub>CC</sub> = 3.0 V  | 2.7   | 3.0 | -    | 2.7              | -    | 2.7               | -    | V    |
|                 |                           | I <sub>O</sub> = -50 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> = 3.0 V   | 2.58  | -   | -    | 2.48             | -    | 2.4               | -    | 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   | 0.2  | -                | 0.2  | -                 | 0.2  | V    |
|                 |                           | I <sub>O</sub> = 50 μA; V <sub>CC</sub> = 3.0 V   | -     | 0   | 0.3  | -                | 0.3  | -                 | 0.3  | V    |
|                 |                           | I <sub>O</sub> = 50 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> = 3.0 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 | -     | -   | 2.0  | -                | 20   | -                 | 40   | μA   |
| C <sub>I</sub>  | input capacitance         |   | -     | 3   | 10   | -                | 10   | -                 | 10   | pF   |

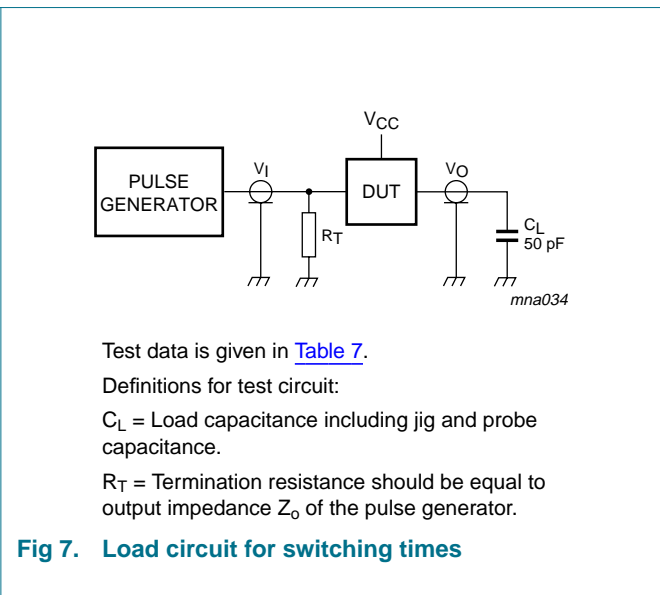
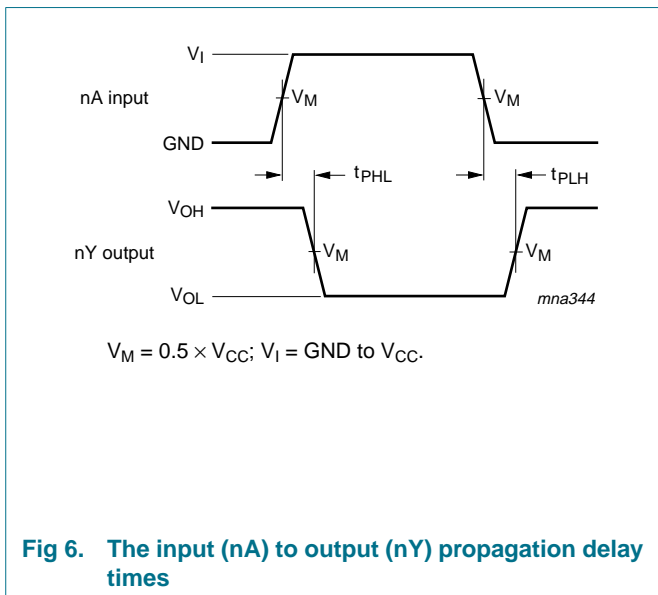
## 10. Dynamic characteristics

**Table 7. Dynamic characteristics**  
*GND = 0 V; For test circuit see Figure 7.*

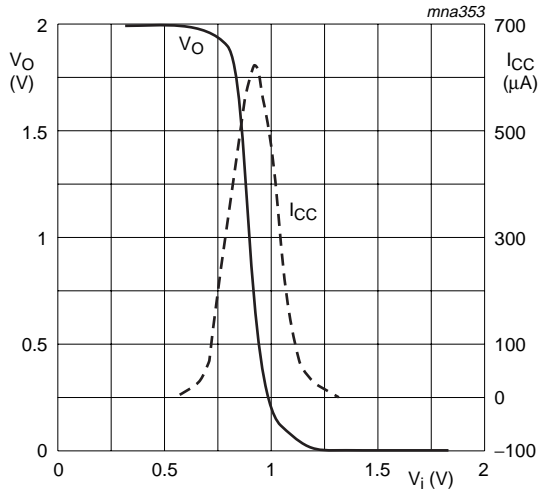
| Symbol          | Parameter                     | Conditions  | 25 °C |     |      | -40 °C to +85 °C |      | -40 °C to +125 °C |      | Unit |  |
|-----------------|-------------------------------|---|-------|-----|------|------------------|------|-------------------|------|------|--|
|                 |                               |   | Min   | Typ | Max  | Min              | Max  | Min               | Max  |      |  |
| t <sub>pd</sub> | propagation delay             | nA to nY; see Figure 6 [1]  |       |     |      |                  |      |                   |      |      |  |
|                 |                               | V <sub>CC</sub> = 3.0 V to 3.6 V [2]  |       |     |      |                  |      |                   |      |      |  |
|                 |                               | C <sub>L</sub> = 15 pF  | -     | 3.0 | 7.1  | 1.0              | 8.5  | 1.0               | 9.0  | ns   |  |
|                 |                               | C <sub>L</sub> = 50 pF  | -     | 3.4 | 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  | -     | 2.4 | 5.5  | 1.0              | 6.5  | 1.0               | 7.0  | ns   |  |
|                 |                               | C <sub>L</sub> = 50 pF  | -     | 3.5 | 7.0  | 1.0              | 8.0  | 1.0               | 9.0  | ns   |  |
| C <sub>PD</sub> | power dissipation capacitance | C <sub>L</sub> = 50 pF; f <sub>i</sub> = 1 MHz; V <sub>I</sub> = GND to V <sub>CC</sub> [4] | -     | 9.1 | -    | -                | -    | -                 | -    | 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> in μW).  
 $P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \sum(C_L \times V_{CC}^2 \times f_o)$  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;  
 $\sum(C_L \times V_{CC}^2 \times f_o)$  = sum of outputs.

## 11. Waveforms

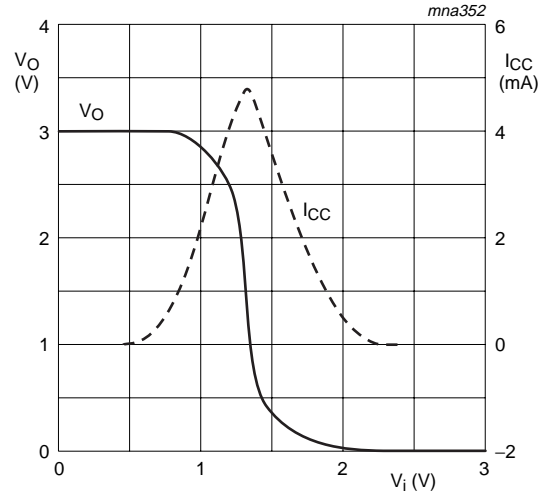


12. Typical transfer characteristics



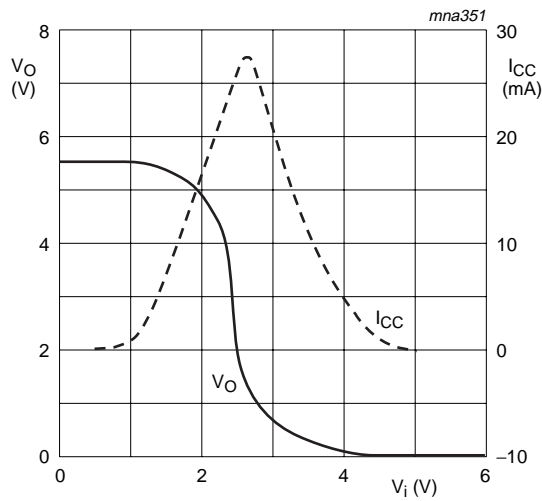
T<sub>amb</sub> = 25 °C.

Fig 8. V<sub>CC</sub> = 2.0 V; I<sub>O</sub> = 0 A



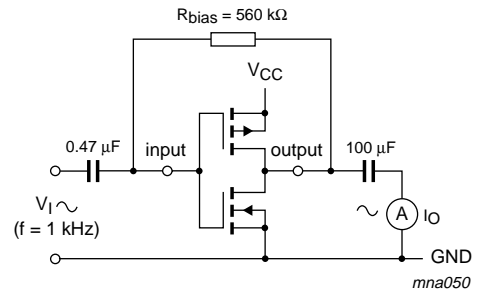
T<sub>amb</sub> = 25 °C.

Fig 9. V<sub>CC</sub> = 3.0 V; I<sub>O</sub> = 0 A



T<sub>amb</sub> = 25 °C.

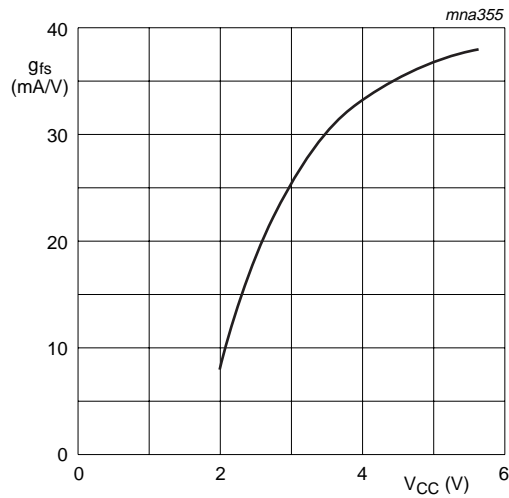
Fig 10. V<sub>CC</sub> = 5.5 V; I<sub>O</sub> = 0 A



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

f<sub>i</sub> = 1 kHz at V<sub>O</sub> is constant

Fig 11. Test set-up for measuring forward transconductance



T<sub>amb</sub> = 25 °C.

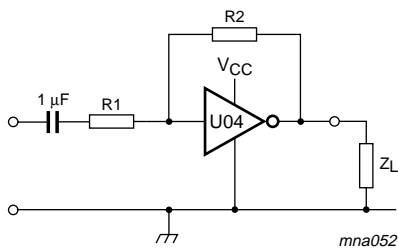
Fig 12. Typical forward transconductance as a function of the supply voltage

### 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.

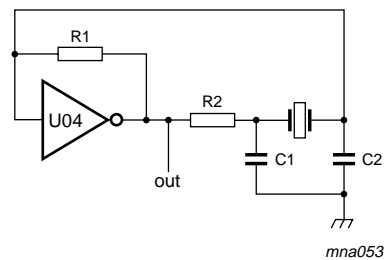


Maximum V<sub>o(p-p)</sub> = V<sub>CC</sub> - 1.5 V centered at 0.5 × V<sub>CC</sub>.

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

G<sub>ol</sub> = open loop gain  
 G<sub>v</sub> = voltage gain  
 R1 ≥ 3 kΩ, R2 ≤ 1 MΩ  
 Z<sub>L</sub> > 10 kΩ; G<sub>ol</sub> = 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<sub>CC</sub> or average minimum I<sub>CC</sub> (I<sub>CC</sub> is typically 5 mA at V<sub>CC</sub> = 5 V and f<sub>i</sub> = 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 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 | 10 M $\Omega$ | 47 k $\Omega$  | 47 pF | 5 pF  |
| 350 kHz to 600 kHz   | 10 M $\Omega$ | 47 k $\Omega$  | 47 pF | 5 pF  |

**Table 9. 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     |



14. Package outline

SO14: plastic small outline package; 14 leads; body width 3.9 mm

SOT108-1

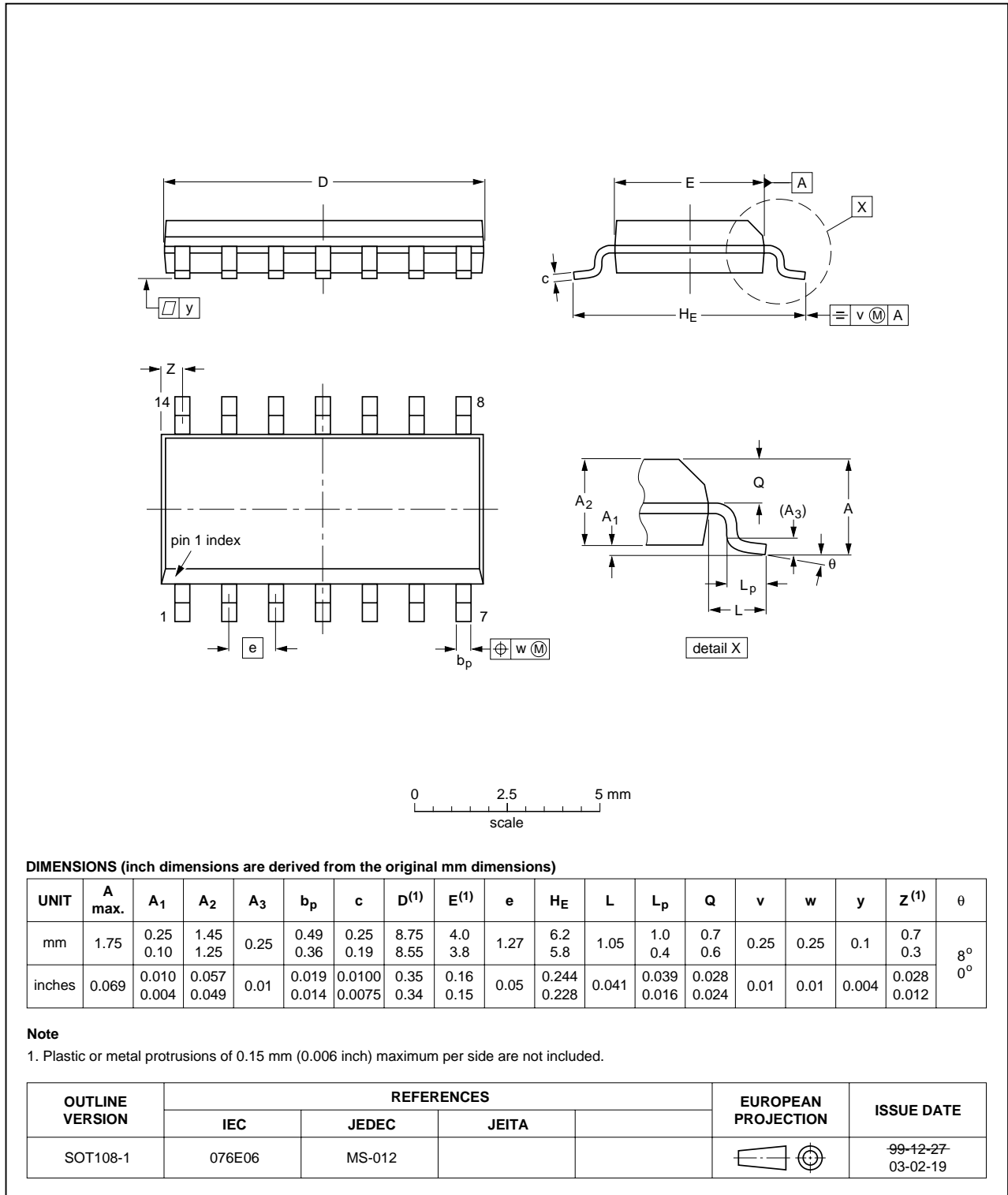


Fig 15. Package outline SOT108-1 (SO14)

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

SOT402-1

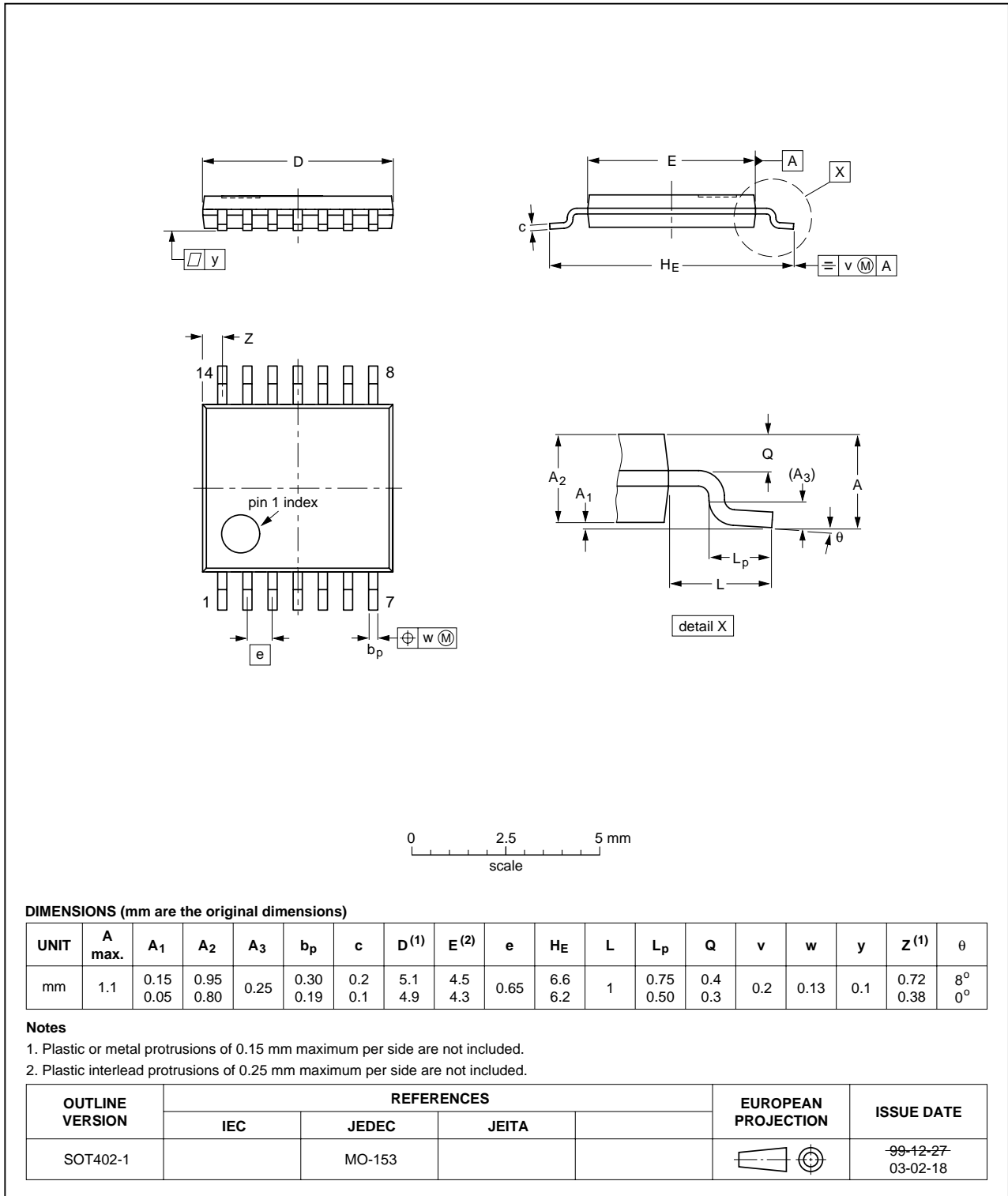


Fig 16. Package outline SOT402-1 (TSSOP14)

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

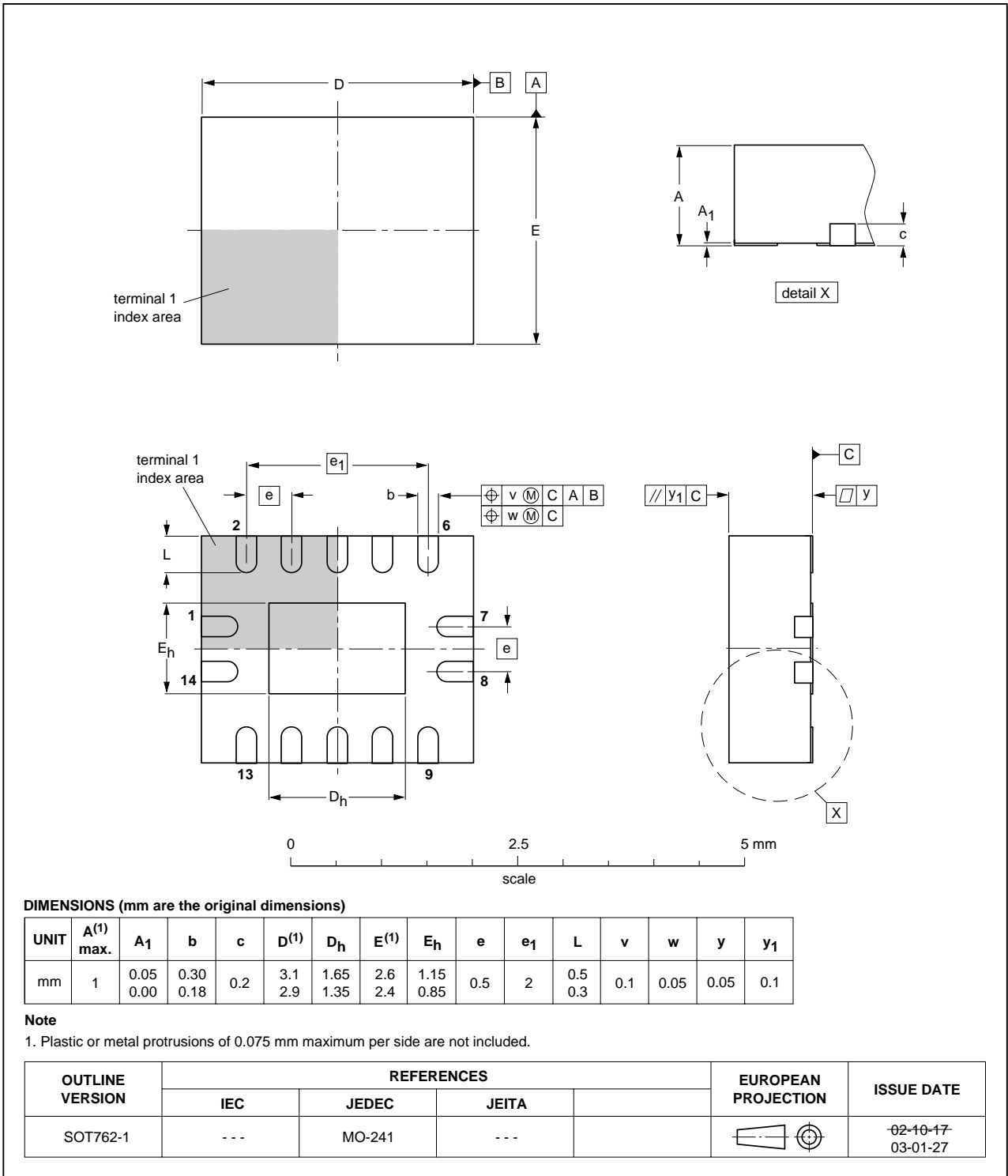


Fig 17. Package outline SOT762-1 (DHVQFN14)

## 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_3     | 20071114   | Product data sheet    | -             | 74AHCU04_2 |
| Modifications: | <ul style="list-style-type: none"> <li>• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors.</li> <li>• Legal texts have been adapted to the new company name where appropriate.</li> <li>• <a href="#">Section 3</a>: DHVQFN14 package added.</li> <li>• <a href="#">Section 8</a>: derating values added for DHVQFN14 package.</li> <li>• <a href="#">Section 14</a>: outline drawing added for DHVQFN14 package.</li> </ul> |                       |               |            |
| 74AHCU04_2     | 19990927   | Product specification | -             | 74AHCU04_1 |
| 74AHCU04_1     | 19990226   | Product specification | -             | -          |

## 17. Legal information

### 17.1 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.nxp.com>.

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For sales office addresses, please send an email to: [salesaddresses@nxp.com](mailto:salesaddresses@nxp.com)

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