

# 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

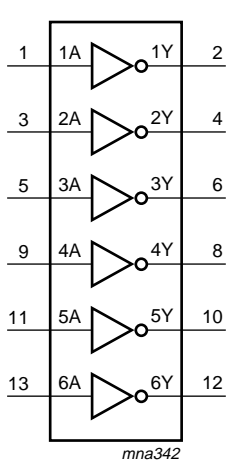
- Low power dissipation
- Balanced propagation delays
- Inputs accepts voltages higher than  $V_{CC}$
- ESD protection:
  - ◆ HBM JESD22-A114E: exceeds 2000 V
  - ◆ MM JESD22-A115-A: exceeds 200 V
  - ◆ CDM JESD22-C101C: exceeds 1000 V
- Multiple package options
- Specified from  $-40\text{ }^{\circ}\text{C}$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

## 3. Ordering information

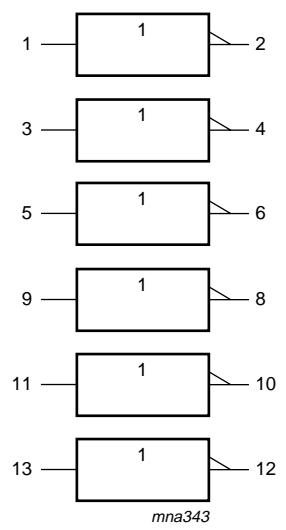
Table 1. Ordering information

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

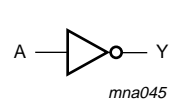
### 4. Functional diagram



**Fig 1. Logic symbol**

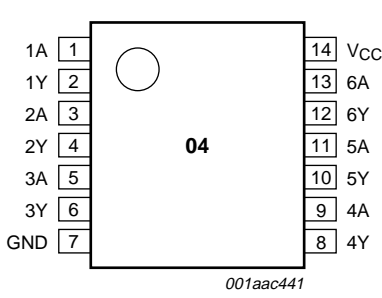


**Fig 2. IEC logic symbol**

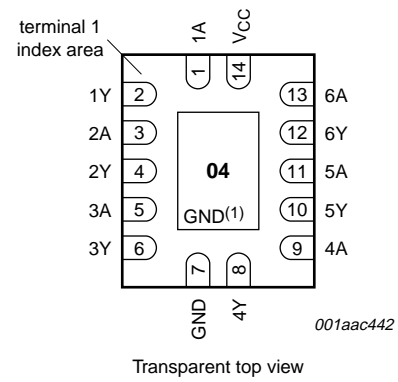


**Fig 3. Logic diagram (one inverter)**

### 5. Pinning information



**Fig 4. Pin configuration SO14 and TSSOP14**



**Fig 5. Pin configuration DHVQFN14**

(1) The die substrate is attached to the exposed die pad using conductive die attach material. It can not be used as a supply pin or input.

#### 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
		I <sub>O</sub> = -8.0 mA; V <sub>CC</sub> = 4.5 V	3.94	-	-	3.8	-	3.7	-	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>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; 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; V <sub>CC</sub> = 5.5 V	-	-	2.0	-	20	-	40	μA
C <sub>I</sub>	input capacitance		-	3	10	-	10	-	10	pF

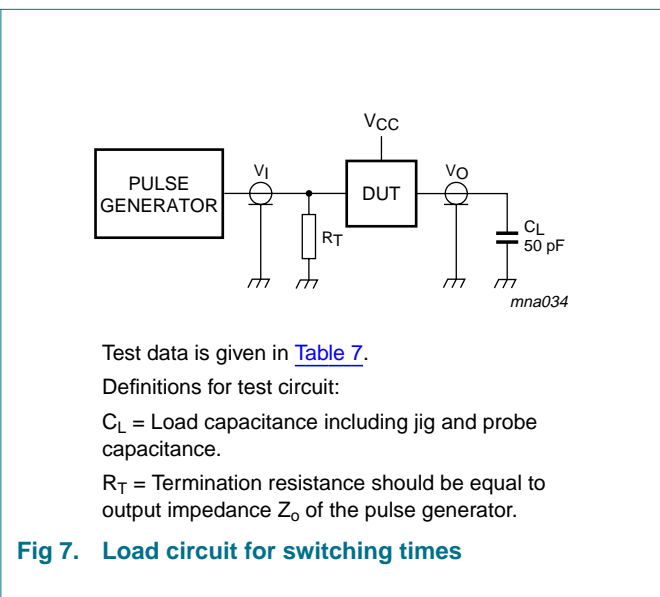
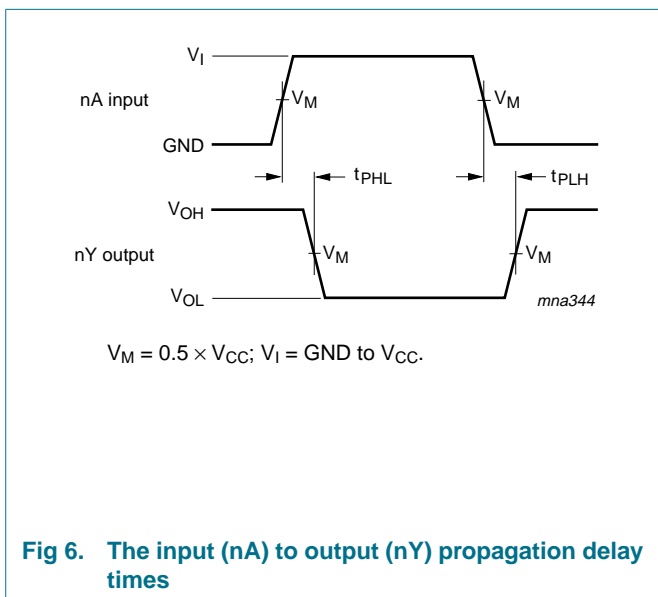
## 10. Dynamic characteristics

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

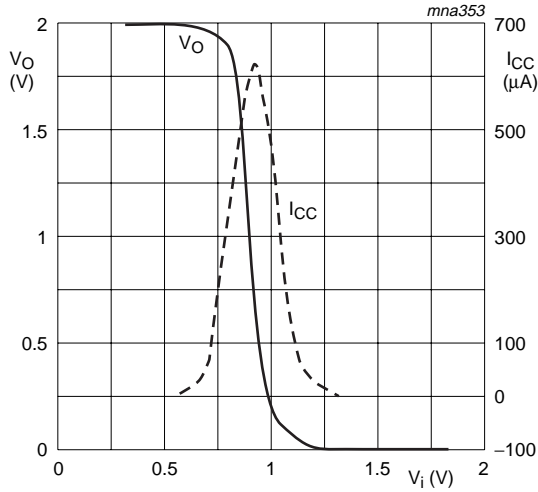
Symbol	Parameter	Conditions	25 °C			-40 °C to +85 °C		-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
t <sub>pd</sub>	propagation delay	nA to nY; see Figure 6 <a href="#">[1]</a>								
		V <sub>CC</sub> = 3.0 V to 3.6 V <a href="#">[2]</a>								
		C <sub>L</sub> = 15 pF	-	3.0	7.1	1.0	8.5	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 <a href="#">[3]</a>								
		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> <a href="#">[4]</a>	-	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

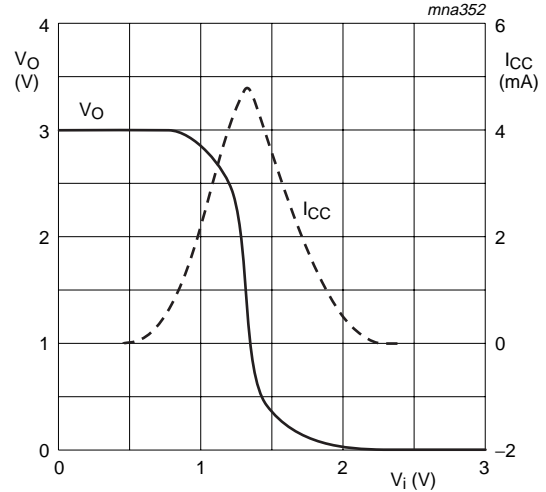


12. Typical transfer characteristics



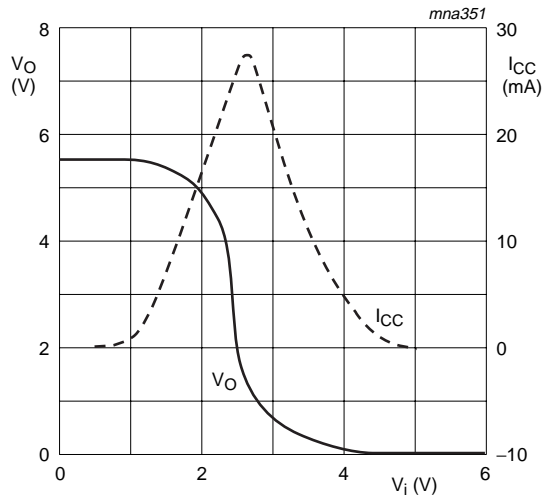
$T_{amb} = 25\text{ }^\circ\text{C}$ .

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



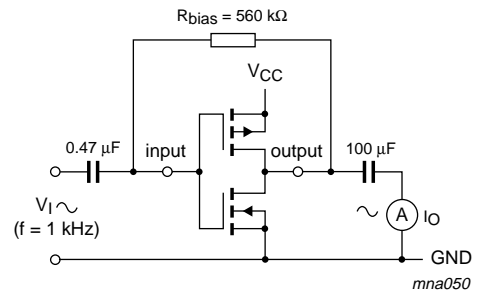
$T_{amb} = 25\text{ }^\circ\text{C}$ .

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



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

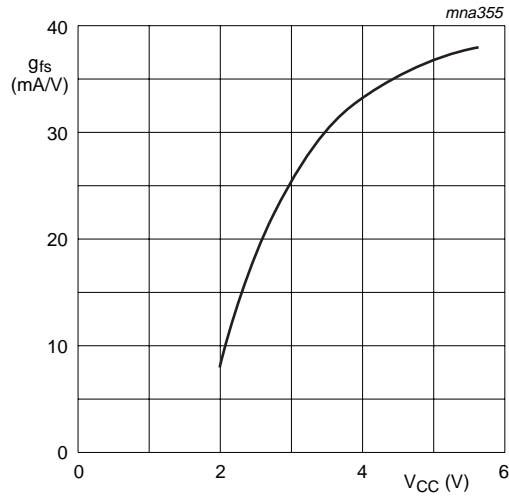
Fig 10.  $V_{CC} = 5.5\text{ V}$ ;  $I_O = 0\text{ A}$



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

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

Fig 11. Test set-up for measuring forward transconductance



T<sub>amb</sub> = 25 °C.

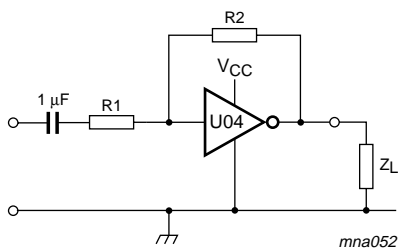
Fig 12. Typical forward transconductance as a function of the supply voltage

### 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

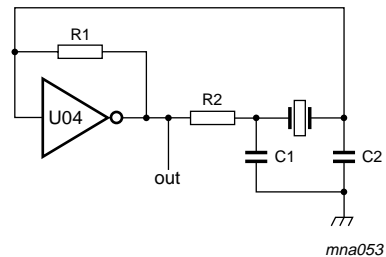
G<sub>v</sub> = voltage gain

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

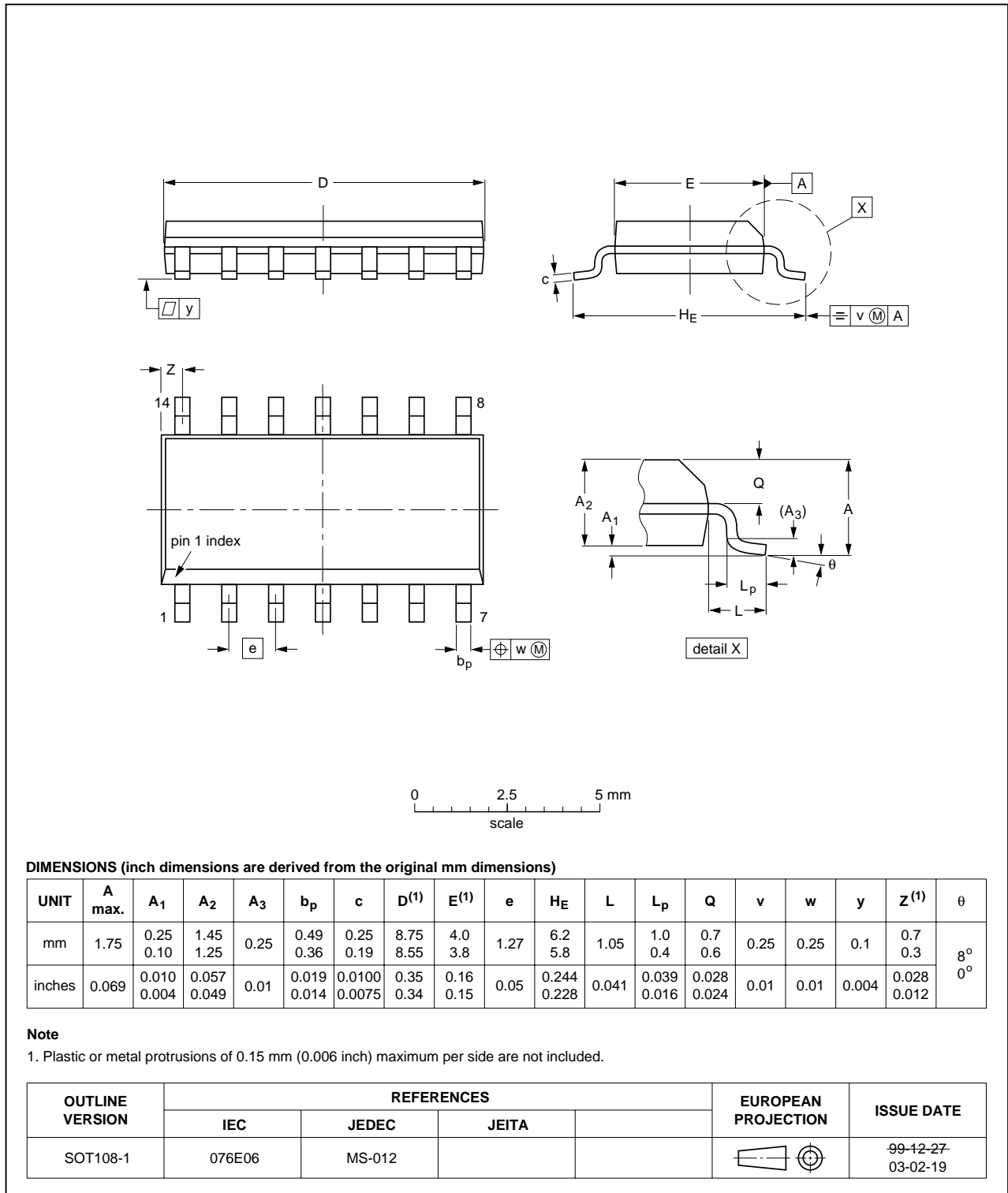


Fig 15. Package outline SOT108-1 (SO14)

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

SOT402-1

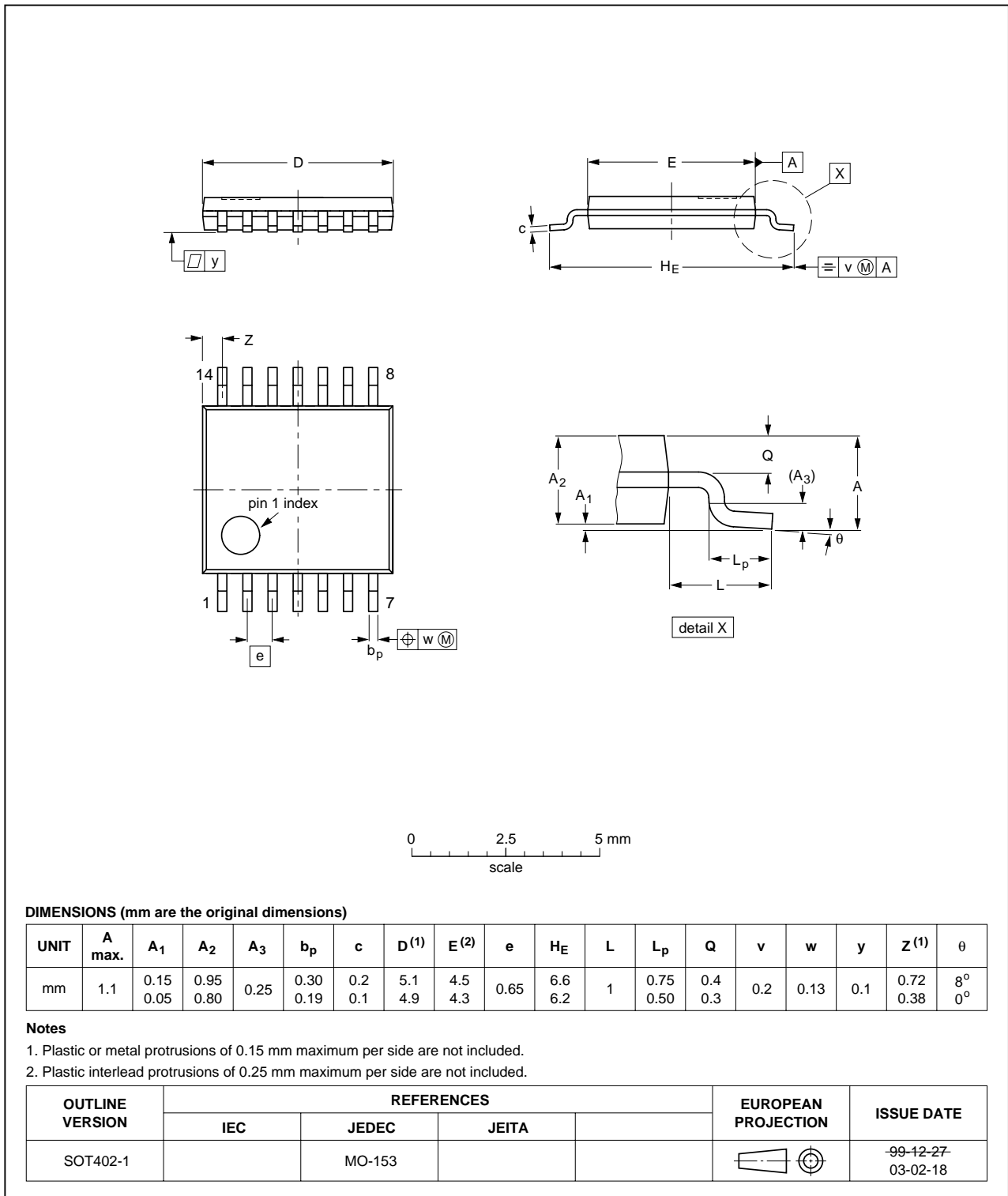


Fig 16. Package outline SOT402-1 (TSSOP14)

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

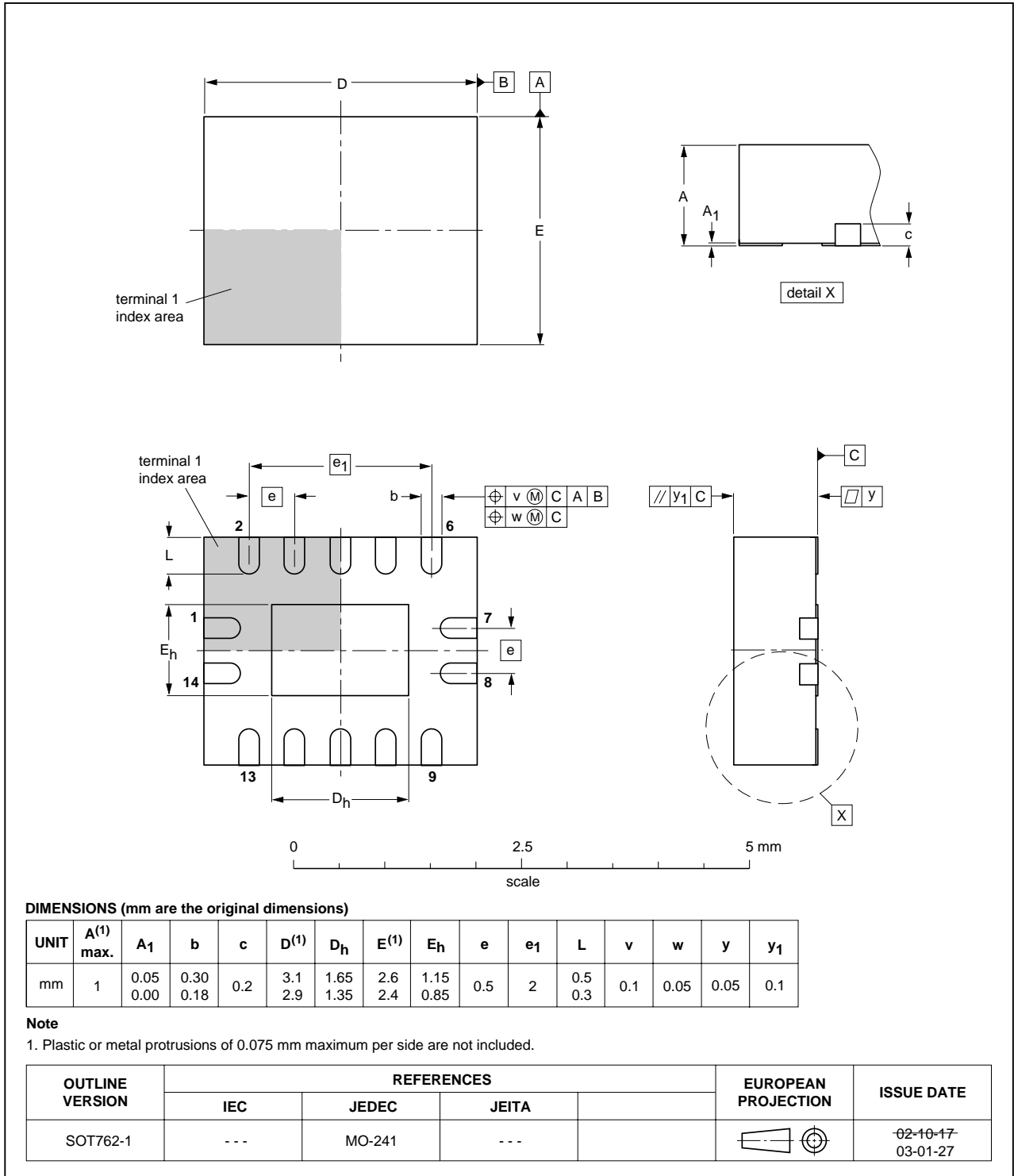


Fig 17. Package outline SOT762-1 (DHVQFN14)

## 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
74AHC04_3	20071114	Product data sheet	-	74AHC04_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>			
74AHC04_2	19990927	Product specification	-	74AHC04_1
74AHC04_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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