

# 74HCU04-Q100

Hex unbuffered inverter

Rev. 2 — 22 October 2015

Product data sheet

## 1. General description

The 74HCU04-Q100 is a hex unbuffered inverter. Inputs include clamp diodes that enable the use of current limiting resistors to interface inputs to voltages in excess of  $V_{CC}$ .

This product has been qualified to the Automotive Electronics Council (AEC) standard Q100 (Grade 1) and is suitable for use in automotive applications.

## 2. Features and benefits

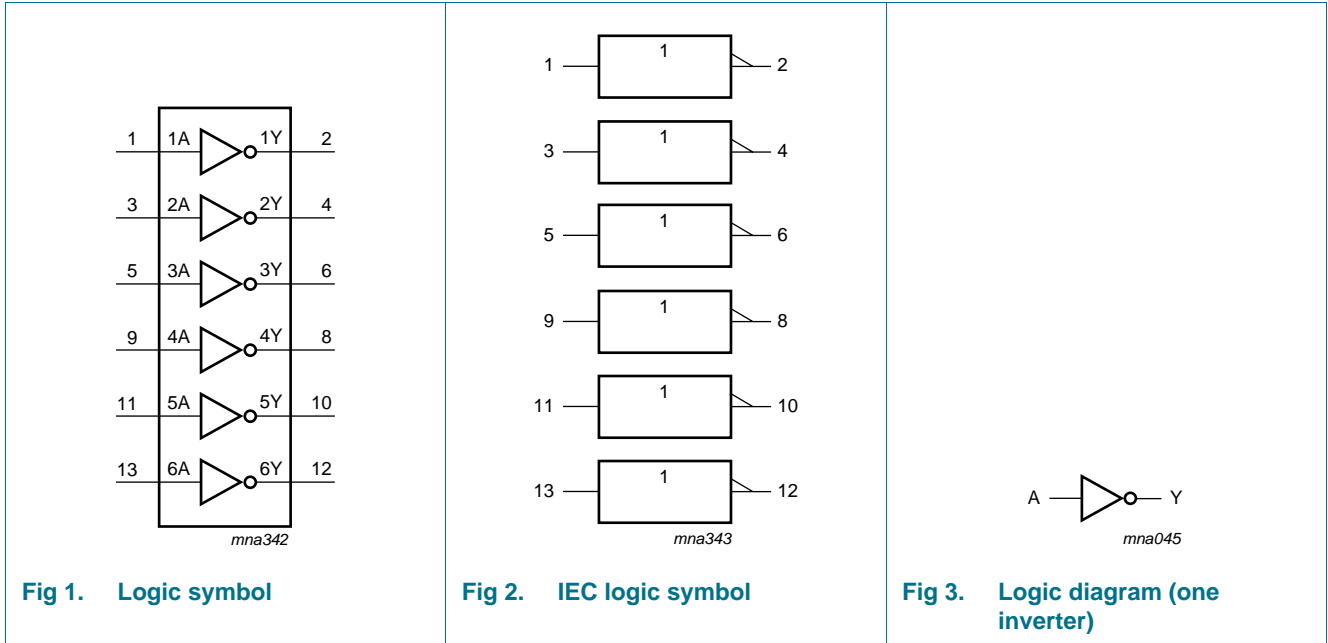
- Automotive product qualification in accordance with AEC-Q100 (Grade 1)
  - ◆ Specified from  $-40\text{ °C}$  to  $+85\text{ °C}$  and from  $-40\text{ °C}$  to  $+125\text{ °C}$
- Complies with JEDEC standard JESD7A
- Balanced propagation delays
- ESD protection:
  - ◆ MIL-STD-883, method 3015 exceeds 2000 V
  - ◆ HBM JESD22-A114F exceeds 2000 V
  - ◆ MM JESD22-A115-A exceeds 200 V ( $C = 200\text{ pF}$ ,  $R = 0\text{ }\Omega$ )
- Multiple package options

## 3. Ordering information

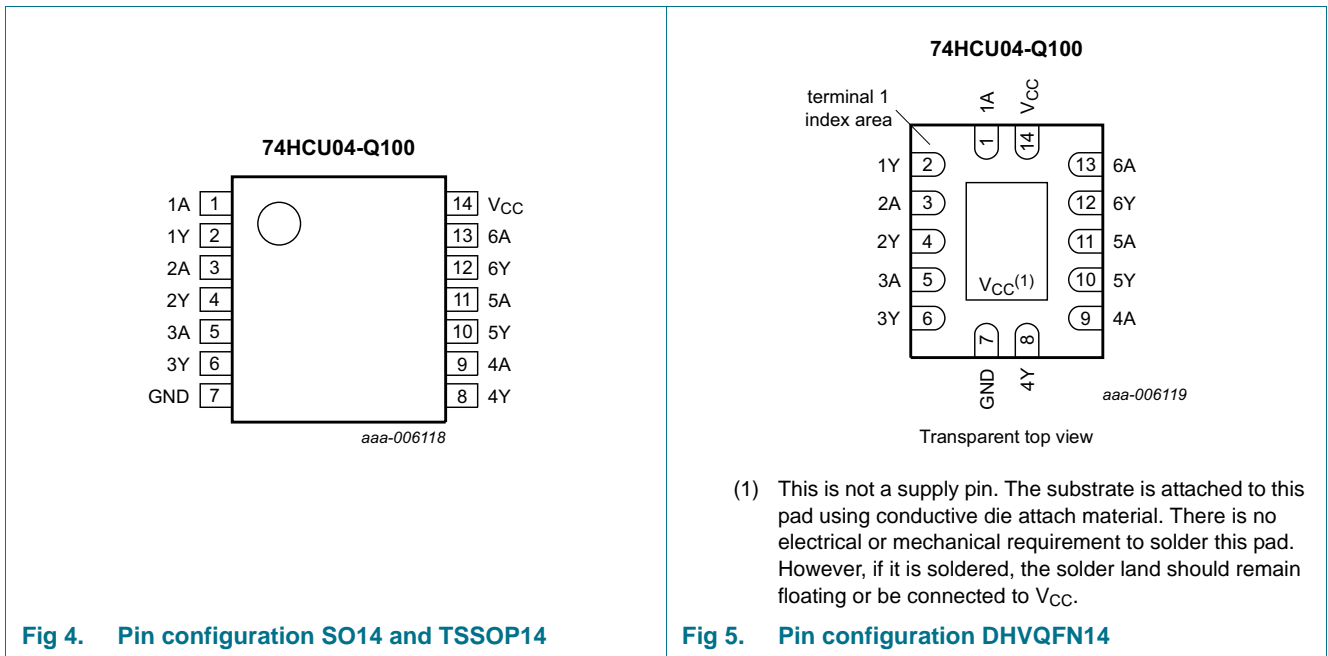
Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
74HCU04D-Q100	$-40\text{ °C}$ to $+125\text{ °C}$	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
74HCU04PW-Q100	$-40\text{ °C}$ to $+125\text{ °C}$	TSSOP14	plastic thin shrink small outline package; 14 leads; body width 4.4 mm	SOT402-1
74HCU04BQ-Q100	$-40\text{ °C}$ 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



5. Pinning information



## 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
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 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		[2]		
	SO14, TSSOP14 and DHVQFN14 packages		-	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:  $P_{tot}$  derates linearly with 8 mW/K above 70 °C.  
 For TSSOP14 packages:  $P_{tot}$  derates linearly with 5.5 mW/K above 60 °C.  
 For DHVQFN14 packages:  $P_{tot}$  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
$V_{CC}$	supply voltage		2.0	5.0	6.0	V
$V_I$	input voltage		0	-	$V_{CC}$	V
$V_O$	output voltage		0	-	$V_{CC}$	V
$T_{amb}$	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	
$V_{IH}$	HIGH-level input voltage	$V_{CC} = 2.0$ V	1.7	1.4	-	1.7	-	1.7	-	V
		$V_{CC} = 4.5$ V	3.6	2.6	-	3.6	-	3.6	-	V
		$V_{CC} = 5.5$ V	4.8	3.4	-	4.8	-	4.8	-	V
$V_{IL}$	LOW-level input voltage	$V_{CC} = 2.0$ V	-	0.6	0.3	-	0.3	-	0.3	V
		$V_{CC} = 4.5$ V	-	1.9	0.9	-	0.9	-	0.9	V
		$V_{CC} = 5.5$ V	-	2.6	1.2	-	1.2	-	1.2	V
$V_{OH}$	HIGH-level output voltage	$V_I = V_{IH}$ or $V_{IL}$								
		$I_O = -20$ $\mu$ A; $V_{CC} = 2.0$ V	1.8	2.0	-	1.8	-	1.8	-	V
		$I_O = -20$ $\mu$ A; $V_{CC} = 4.5$ V	4.0	4.5	-	4.0	-	4.0	-	V
		$I_O = -4.0$ mA; $V_{CC} = 4.5$ V	3.98	4.32	-	3.84	-	3.7	-	V
		$I_O = -20$ $\mu$ A; $V_{CC} = 6.0$ V	5.5	6.0	-	5.5	-	5.5	-	V
$V_{OL}$	LOW-level output voltage	$V_I = V_{IH}$ or $V_{IL}$								
		$I_O = 20$ $\mu$ A; $V_{CC} = 2.0$ V	-	0	0.2	-	0.2	-	0.2	V
		$I_O = 20$ $\mu$ A; $V_{CC} = 4.5$ V	-	0	0.5	-	0.5	-	0.5	V
		$I_O = 4.0$ mA; $V_{CC} = 4.5$ V	-	0.15	0.26	-	0.33	-	0.4	V
		$I_O = 20$ $\mu$ A; $V_{CC} = 6.0$ V	-	0	0.5	-	0.5	-	0.5	V
$I_I$	input leakage current	$V_I = V_{CC}$ or GND; $V_{CC} = 6.0$ V	-	-	$\pm 0.1$	-	$\pm 1.0$	-	$\pm 1.0$	$\mu$ A
		$V_I = V_{CC}$ or GND; $I_O = 0$ A; $V_{CC} = 6.0$ V	-	-	2	-	20	-	20	$\mu$ A
$C_I$	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 +85 °C	-40 °C to +125 °C	Unit
			Typ	Max	Max	Max	
t <sub>pd</sub>	propagation delay	nA to nY; see <a href="#">Figure 6</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>					
		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>	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).

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

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

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

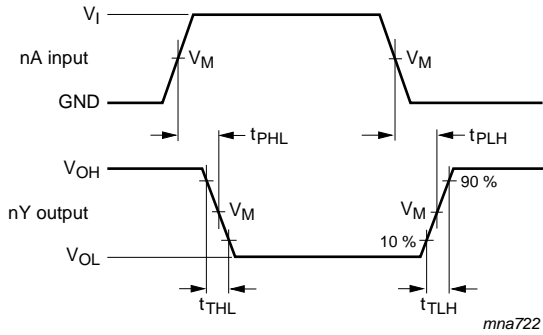
C<sub>L</sub> = output load capacitance in pF;

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

N = number of inputs switching;

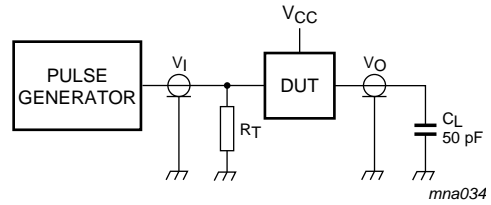
$\sum(C_L \times V_{CC}^2 \times f_o)$  = sum of outputs.

11. Waveforms



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

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



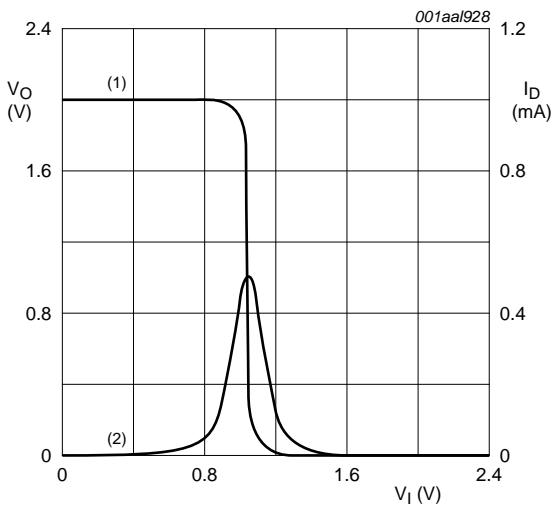
Definitions for test circuit:

$C_L$  = Load capacitance including jig and probe capacitance.

$R_T$  = Termination resistance should be equal to output impedance  $Z_o$  of the pulse generator.

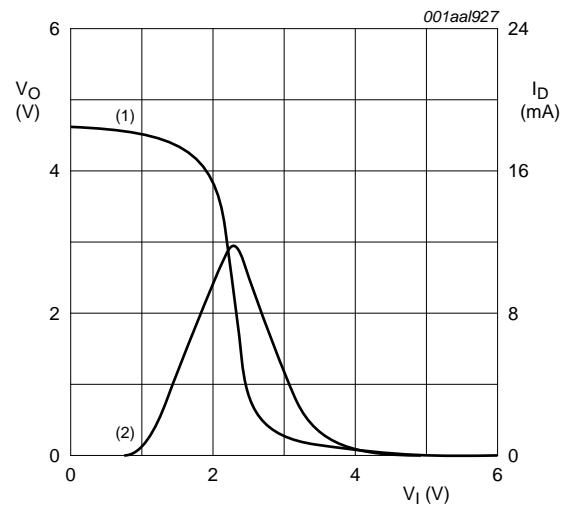
Fig 7. Load circuit for switching times

12. Typical transfer characteristics



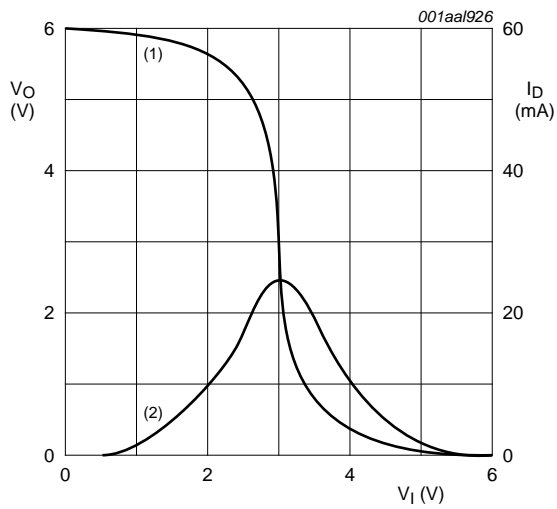
$T_{amb} = 25 \text{ }^\circ\text{C}$ .

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



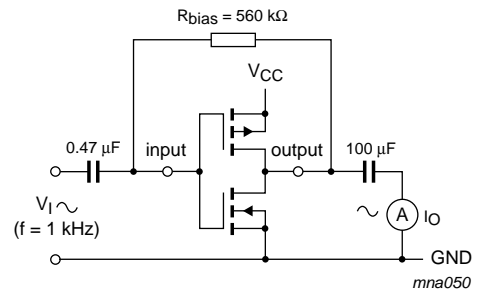
$T_{amb} = 25 \text{ }^\circ\text{C}$ .

Fig 9.  $V_{CC} = 4.5 \text{ V}$ ;  $I_O = 0 \text{ A}$



T<sub>amb</sub> = 25 °C.

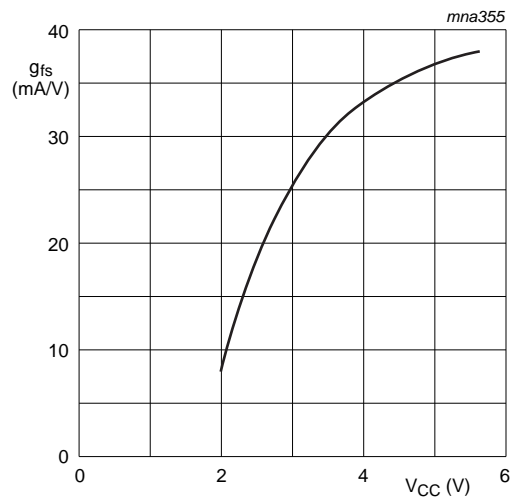
Fig 10. V<sub>CC</sub> = 6.0 V; I<sub>O</sub> = 0 A



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

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.

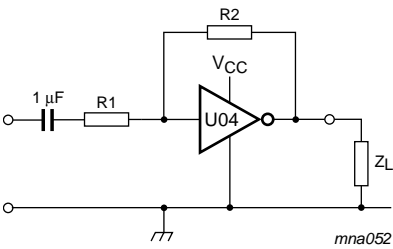
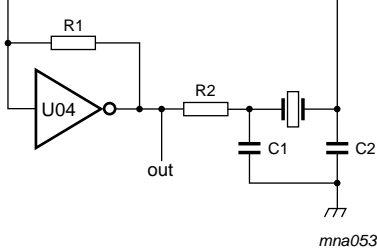
Fig 12. Typical forward transconductance as a function of the supply voltage

### 13. Application information

Some applications are:

- Linear amplifier (see [Figure 13](#))
- Crystal oscillator design (see [Figure 14](#))
- Astable multivibrator (see [Figure 15](#))

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

 <p>Maximum <math>V_{O(p-p)} = V_{CC} - 2.0 \text{ V}</math> centered at <math>0.5 \times V_{CC}</math>.</p> $G_v = - \frac{G_{ol}}{1 + \frac{R1}{R2}(1 + G_{ol})}$ <p> <math>G_{ol}</math> = open loop gain  <math>G_v</math> = voltage gain  <math>R1 \geq 3 \text{ k}\Omega</math>, <math>R2 \leq 1 \text{ M}\Omega</math>  <math>Z_L &gt; 10 \text{ k}\Omega</math>; <math>G_{ol} = 20</math> (typical)  <math>V_{CC} = 6.0 \text{ V}</math>                      Typical unity gain bandwidth product is 5 MHz.                 </p> <p><b>Fig 13. Used as a linear amplifier</b></p>	 <p> <math>C1 = 47 \text{ pF}</math> (typical)  <math>C2 = 33 \text{ pF}</math> (typical)  <math>R1 = 1 \text{ M}\Omega</math> to <math>10 \text{ M}\Omega</math> (typical)  <math>R2</math> optimum value depends on the frequency and required stability against changes in <math>V_{CC}</math> or average minimum <math>I_{CC}</math>. <math>I_{CC}</math> is typically 5 mA at <math>V_{CC} = 5 \text{ V}</math> and <math>f_i = 10 \text{ MHz}</math>.                 </p> <p><b>Fig 14. Crystal oscillator configuration</b></p>
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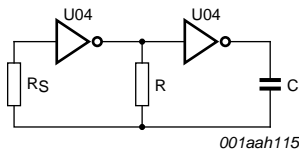
**Table 8. External components for resonator ( $f < 1 \text{ MHz}$ )**  
 All values given are typical and must be used as an initial set-up.

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 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

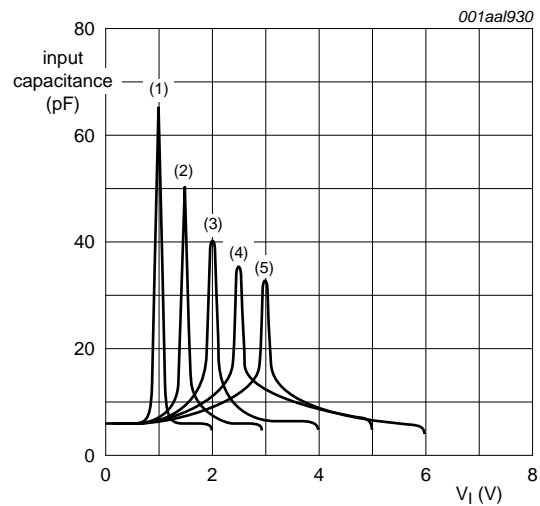


$$f = \frac{1}{T} \approx \frac{1}{2.2RC}$$

$$R_S \approx 2 \times R$$

The average I<sub>CC</sub> (mA) is approximately  
 3.5 + 0.05 × f (MHz) × C (pF) at V<sub>CC</sub> = 5.0 V.

Fig 15. Astable multivibrator



V<sub>CC</sub> = 2.0 V  
 V<sub>CC</sub> = 3.0 V  
 V<sub>CC</sub> = 4.0 V  
 V<sub>CC</sub> = 5.0 V  
 V<sub>CC</sub> = 6.0 V  
 T<sub>amb</sub> = 25 °C.

Fig 16. Input capacitance as function of input voltage

14. Package outline

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

SOT108-1

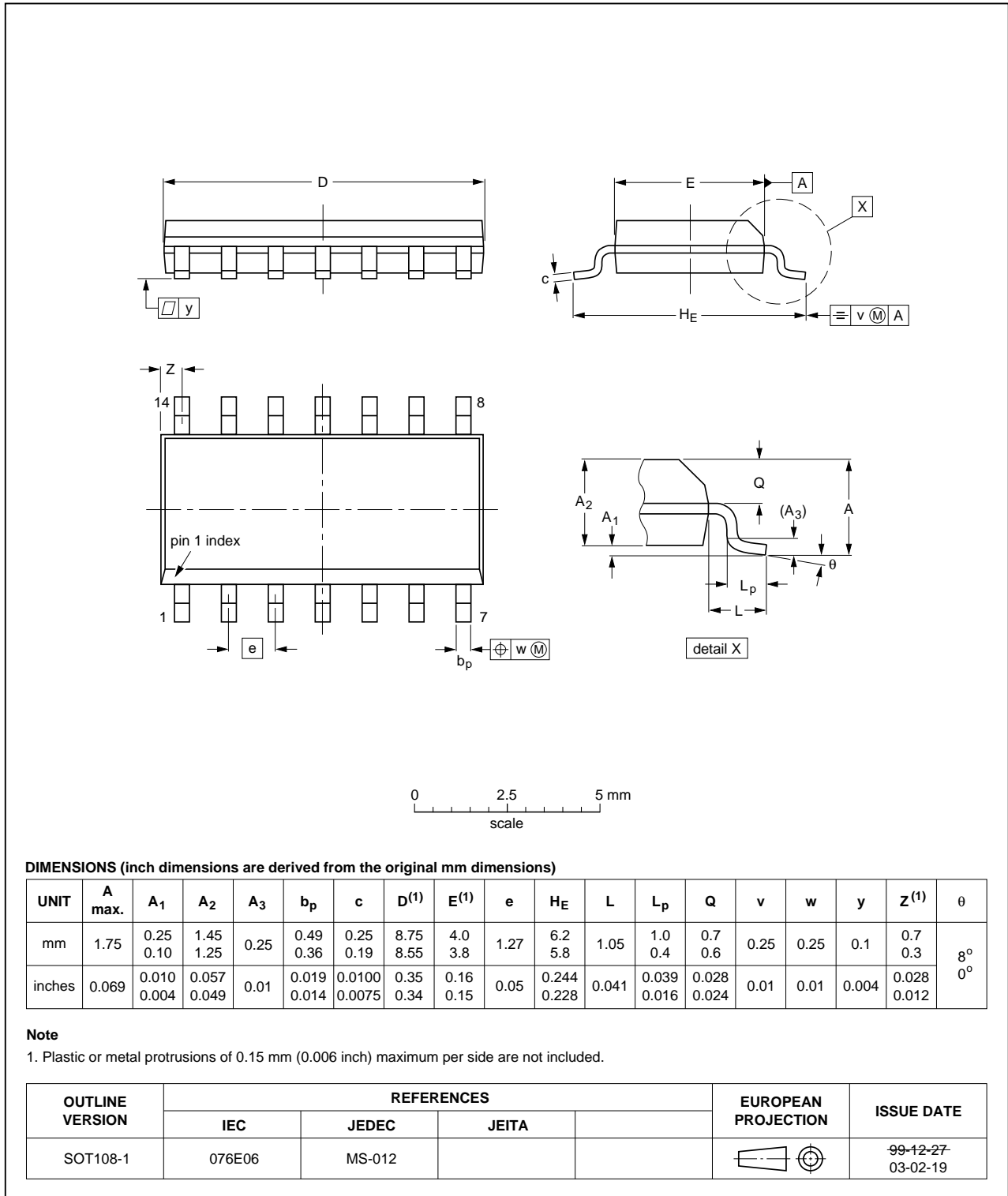


Fig 17. Package outline SOT108-1 (SO14)

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

SOT402-1

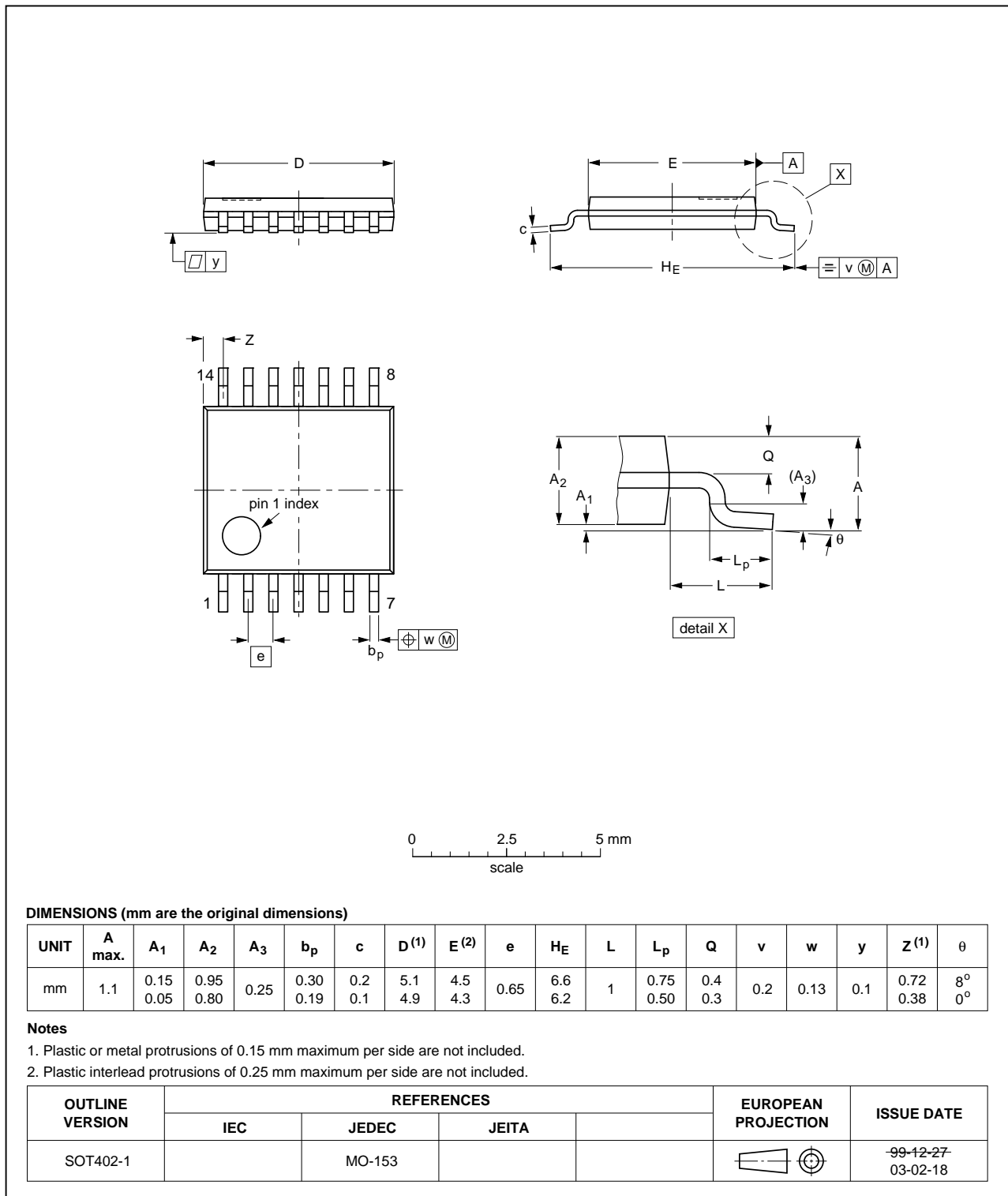


Fig 18. Package outline SOT402-1 (TSSOP14)

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

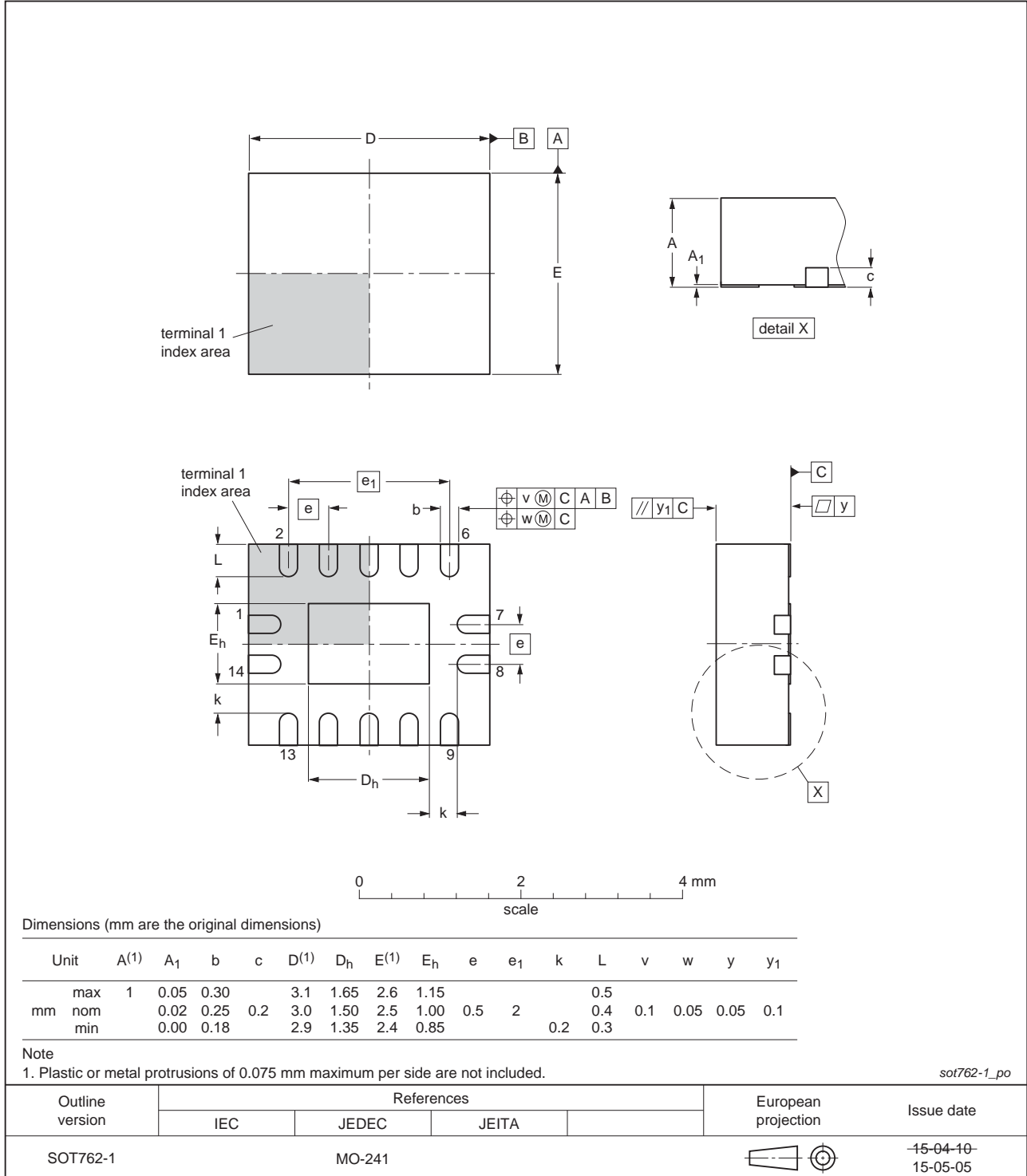


Fig 19. Package outline SOT762-1 (DHVQFN14)

## 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
MIL	Military
TTL	Transistor-Transistor Logic

## 16. Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
74HCU04_Q100 v.2	20151022	Product data sheet	-	74HCU04_Q100 v.1
Modifications:	• Conditions $V_{IL}$ and $V_{IH}$ corrected (errata).			
74HCU04_Q100 v.1	20130131	Product data sheet	-	-

## 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".

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