

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 °C to $+85\text{ °C}$ and from -40 °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

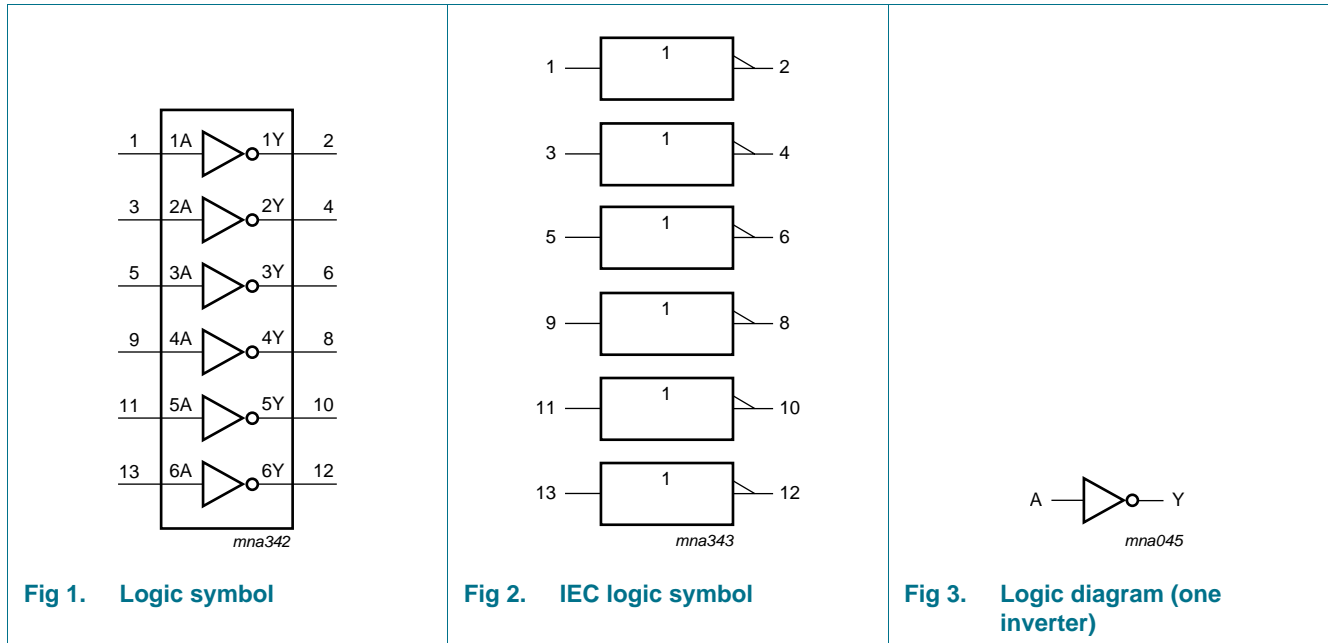
3. Ordering information

Table 1. Ordering information

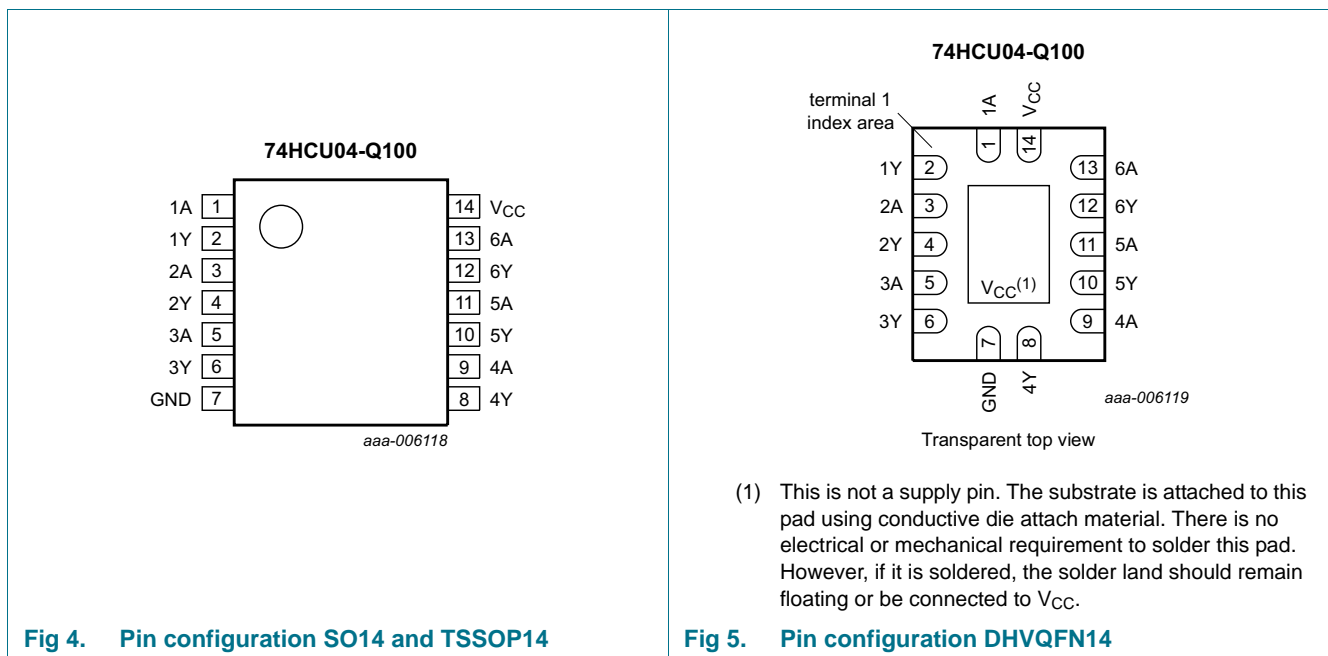
Type number	Package			
	Temperature range	Name	Description	Version
74HCU04D-Q100	-40 °C to $+125\text{ °C}$	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
74HCU04PW-Q100	-40 °C to $+125\text{ °C}$	TSSOP14	plastic thin shrink small outline package; 14 leads; body width 4.4 mm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

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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 _{CC}	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 _{CC}	supply voltage		-0.5	+7.0	V
I _{IK}	input clamping current	V _I < -0.5 V or V _I > V _{CC} + 0.5 V	[1]	±20	mA
I _{OK}	output clamping current	V _O < -0.5 V or V _O > V _{CC} + 0.5 V	[1]	±50	mA
I _O	output current	-0.5 V < V _O < V _{CC} + 0.5 V	-	±25	mA
I _{CC}	supply current		-	50	mA
I _{GND}	ground current		-50	-	mA
T _{stg}	storage temperature		-65	+150	°C
P _{tot}	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}								
		$I_O = -20$ μ A; $V_{CC} = 2.0$ V	1.8	2.0	-	1.8	-	1.8	-	V
		$I_O = -20$ μ 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
		$I_O = -20$ μ 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}								
		$I_O = 20$ μ A; $V_{CC} = 2.0$ V	-	0	0.2	-	0.2	-	0.2	V
		$I_O = 20$ μ 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
		$I_O = 20$ μ 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	-	-	± 0.1	-	± 1.0	-	± 1.0	μ A
		$V_I = V_{CC}$ or GND; $I_O = 0$ A; $V_{CC} = 6.0$ V	-	-	2	-	20	-	20	μ 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 _{pd}	propagation delay	nA to nY; see Figure 6	[1]					
		V _{CC} = 2.0 V; C _L = 50 pF		19	70	90	105	ns
		V _{CC} = 4.5 V; C _L = 50 pF		7	14	18	21	ns
		V _{CC} = 5.0 V; C _L = 15 pF		5	-	-	-	ns
t _t	transition time	V _{CC} = 6.0 V; C _L = 50 pF		6	12	15	18	ns
		see Figure 6	[2]					
		V _{CC} = 2.0 V; C _L = 50 pF		19	75	95	110	ns
		V _{CC} = 4.5 V; C _L = 50 pF		7	15	19	22	ns
C _{PD}	power dissipation capacitance	V _{CC} = 6.0 V; C _L = 50 pF		6	13	16	19	ns
		per inverter; V _I = GND to V _{CC}	[3]	10	-			pF

[1] t_{pd} is the same as t_{PHL}, t_{PLH}.

[2] t_t is the same as t_{THL}, t_{TLH}.

[3] C_{PD} is used to determine the dynamic power dissipation (P_D 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_i = input frequency in MHz;

f_o = output frequency in MHz;

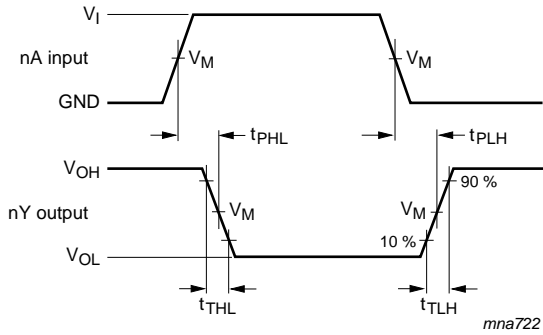
C_L = output load capacitance in pF;

V_{CC} = supply voltage in V;

N = number of inputs switching;

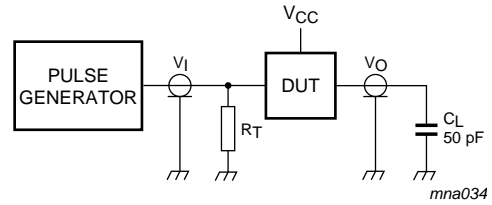
∑(C_L × V_{CC}² × f_o) = sum of outputs.

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



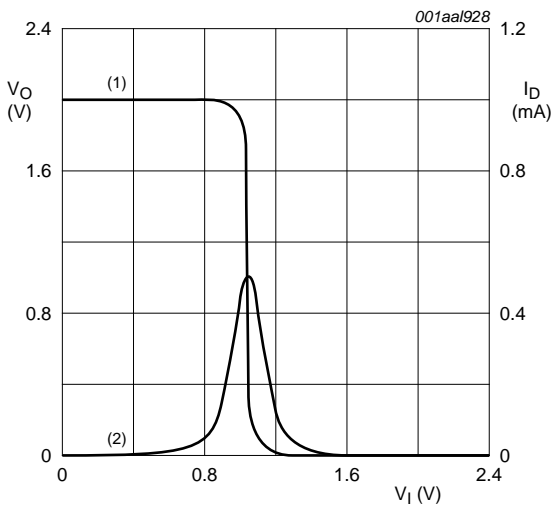
Definitions for test circuit:

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.

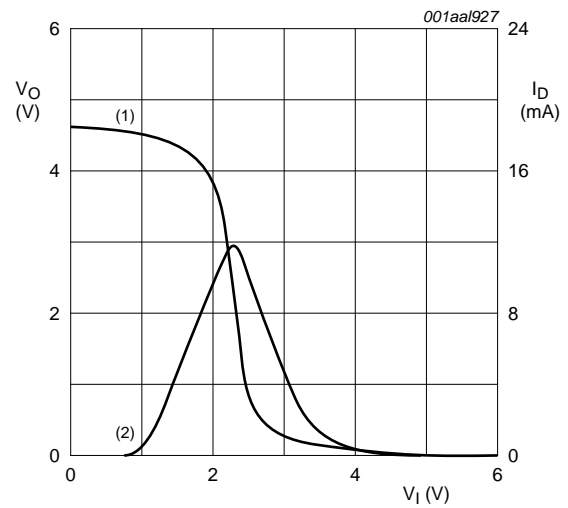
Fig 7. Load circuit for switching times

12. Typical transfer characteristics



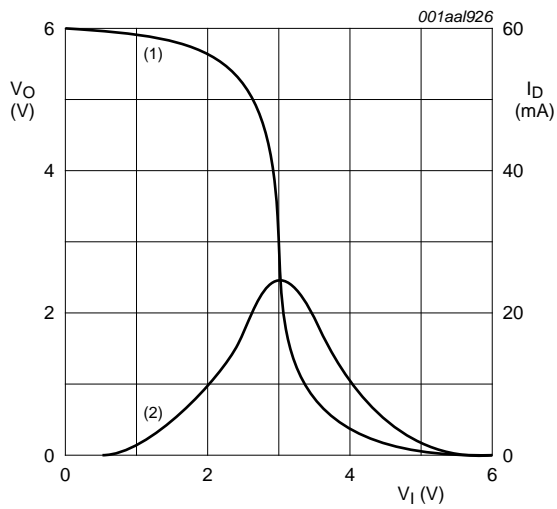
$T_{amb} = 25 \text{ }^\circ\text{C}.$

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



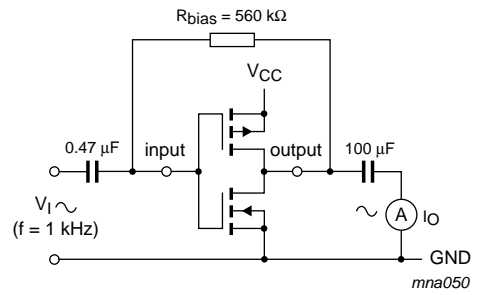
$T_{amb} = 25 \text{ }^\circ\text{C}.$

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



T_{amb} = 25 °C.

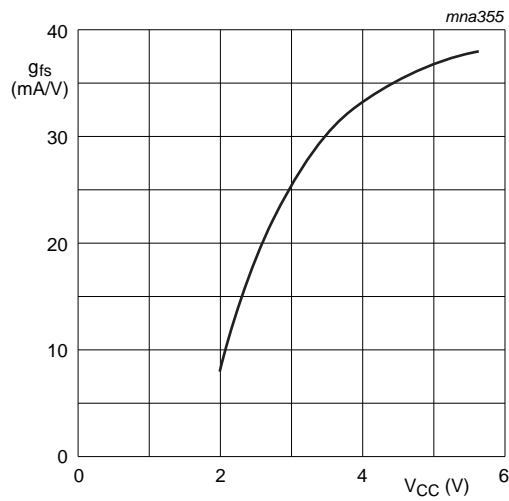
Fig 10. V_{CC} = 6.0 V; I_O = 0 A



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

f_i = 1 kHz at V_O is constant

Fig 11. Test set-up for measuring forward transconductance



T_{amb} = 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.

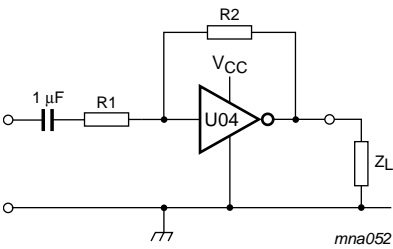
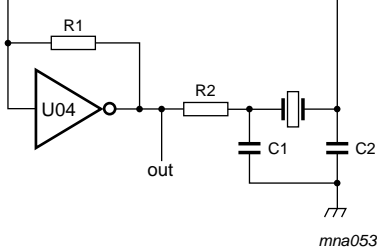
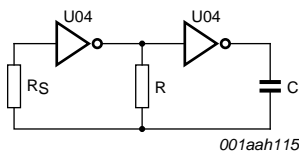
 <p>Maximum $V_{O(p-p)} = V_{CC} - 2.0 \text{ V}$ centered at $0.5 \times V_{CC}$.</p> $G_v = - \frac{G_{ol}}{1 + \frac{R1}{R2}(1 + G_{ol})}$ <p> G_{ol} = open loop gain G_v = voltage gain $R1 \geq 3 \text{ k}\Omega$, $R2 \leq 1 \text{ M}\Omega$ $Z_L > 10 \text{ k}\Omega$; $G_{ol} = 20$ (typical) $V_{CC} = 6.0 \text{ V}$ Typical unity gain bandwidth product is 5 MHz. </p> <p>Fig 13. Used as a linear amplifier</p>	 <p> $C1 = 47 \text{ pF}$ (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 $f_i = 10 \text{ MHz}$. </p> <p>Fig 14. Crystal oscillator configuration</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 Ω	220 k Ω	56 pF	20 pF
16 kHz to 24.9 kHz	22 M Ω	220 k Ω	56 pF	10 pF
25 kHz to 54.9 kHz	22 M Ω	100 k Ω	56 pF	10 pF
55 kHz to 129.9 kHz	22 M Ω	100 k Ω	47 pF	5 pF
130 kHz to 199.9 kHz	22 M Ω	47 k Ω	47 pF	5 pF
200 kHz to 349.9 kHz	10 M Ω	47 k Ω	47 pF	5 pF
350 kHz to 600 kHz	10 M Ω	47 k Ω	47 pF	5 pF

Table 9. Optimum value for R2

Frequency	R2	Optimum for
3 kHz	2.0 kΩ	minimum required I _{CC}
	8.0 kΩ	minimum influence due to change in V _{CC}
6 kHz	1.0 kΩ	minimum required I _{CC}
	4.7 kΩ	minimum influence by V _{CC}
10 kHz	0.5 kΩ	minimum required I _{CC}
	2.0 kΩ	minimum influence by V _{CC}
14 kHz	0.5 kΩ	minimum required I _{CC}
	1.0 kΩ	minimum influence by V _{CC}
>14 kHz	-	replace R2 by C3 with a typical value of 35 pF

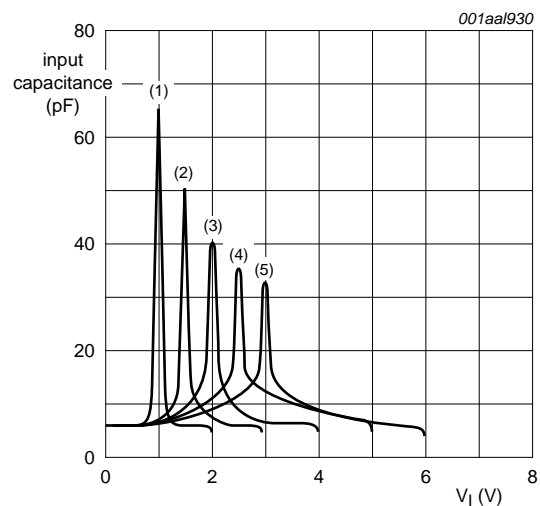


$$f = \frac{1}{T} \approx \frac{1}{2.2RC}$$

$$R_S \approx 2 \times R$$

The average I_{CC} (mA) is approximately
 3.5 + 0.05 × f (MHz) × C (pF) at V_{CC} = 5.0 V.

Fig 15. Astable multivibrator



V_{CC} = 2.0 V
 V_{CC} = 3.0 V
 V_{CC} = 4.0 V
 V_{CC} = 5.0 V
 V_{CC} = 6.0 V
 T_{amb} = 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

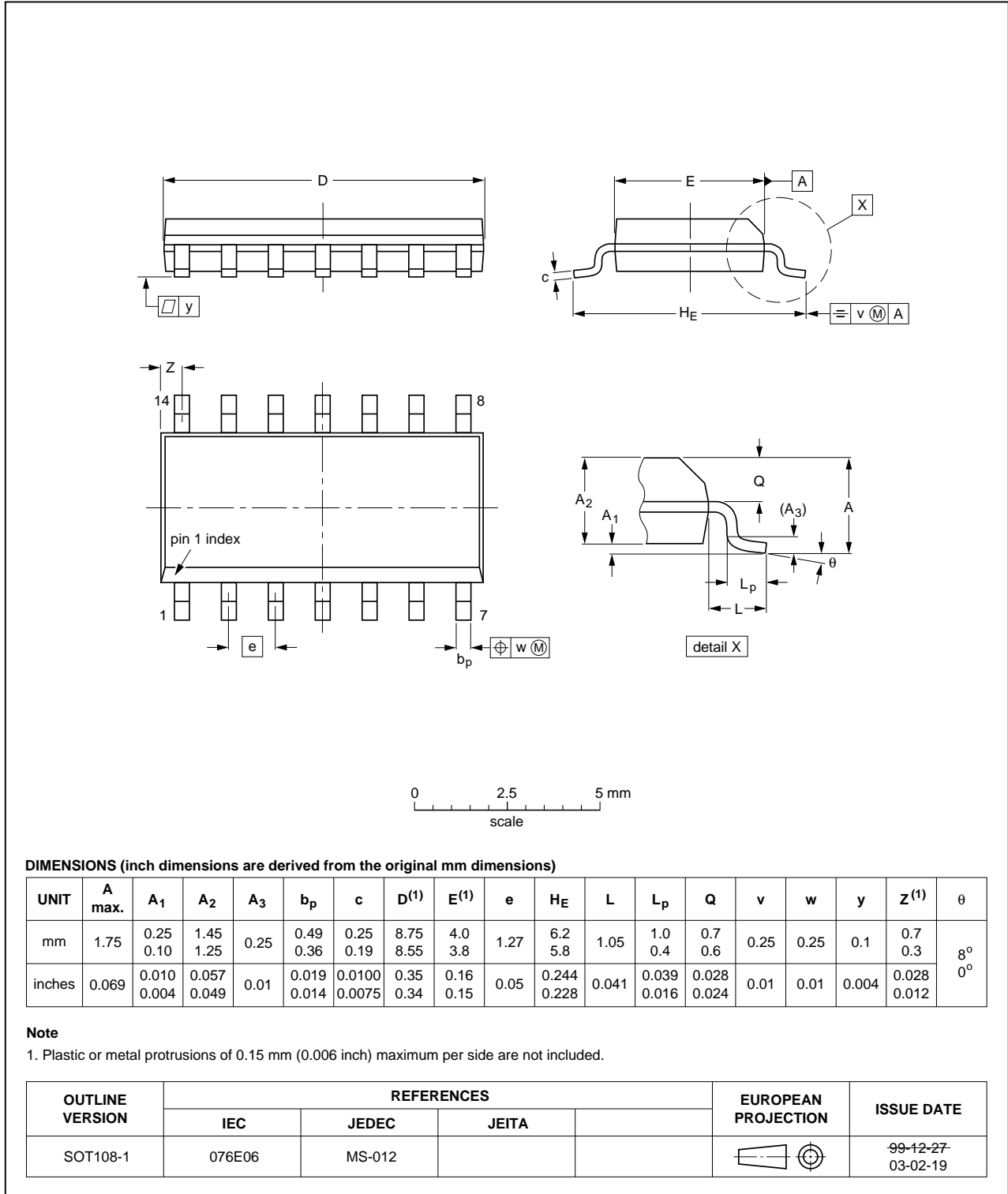


Fig 17. Package outline SOT108-1 (SO14)

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

SOT402-1

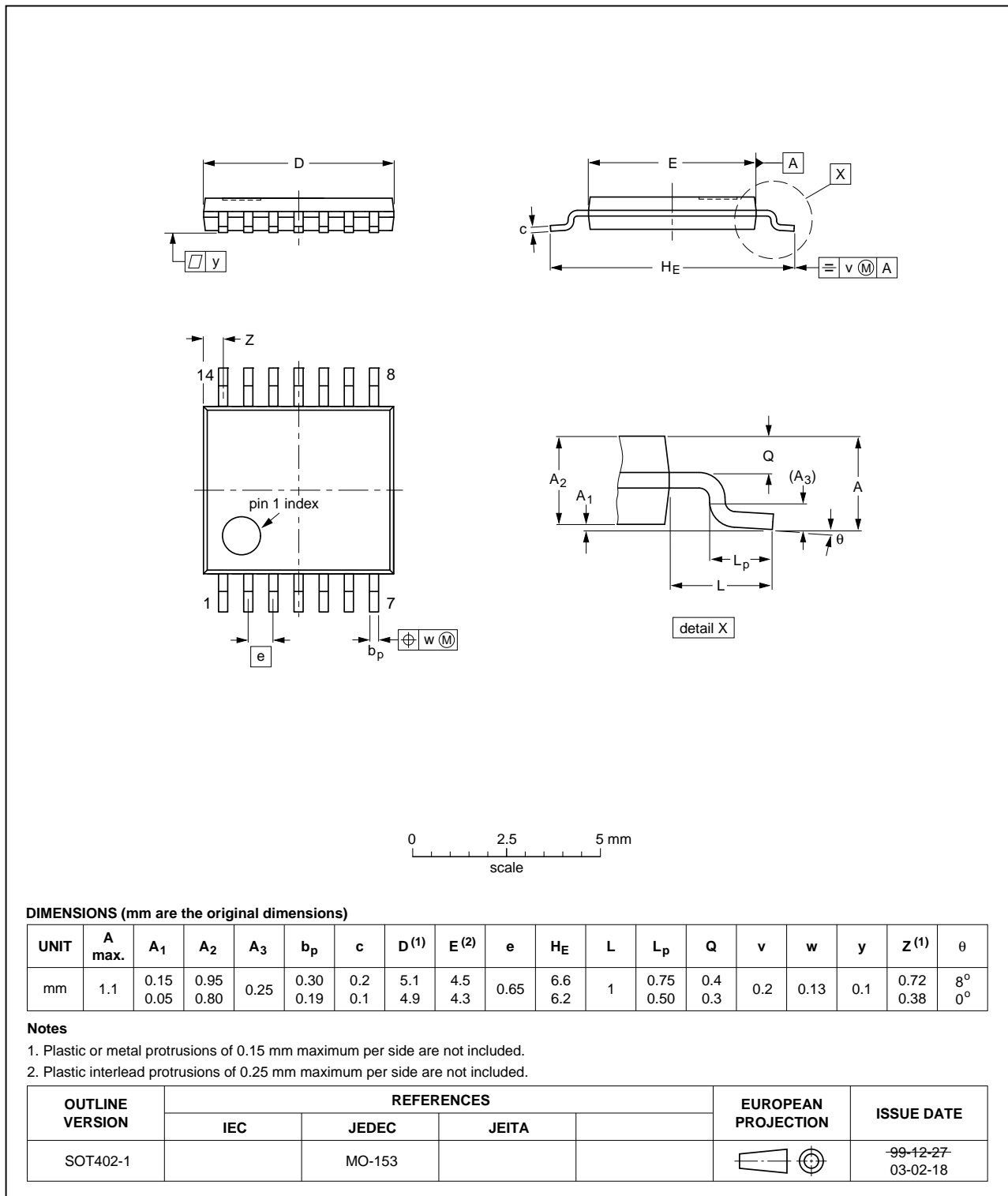


Fig 18. Package outline SOT402-1 (TSSOP14)

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

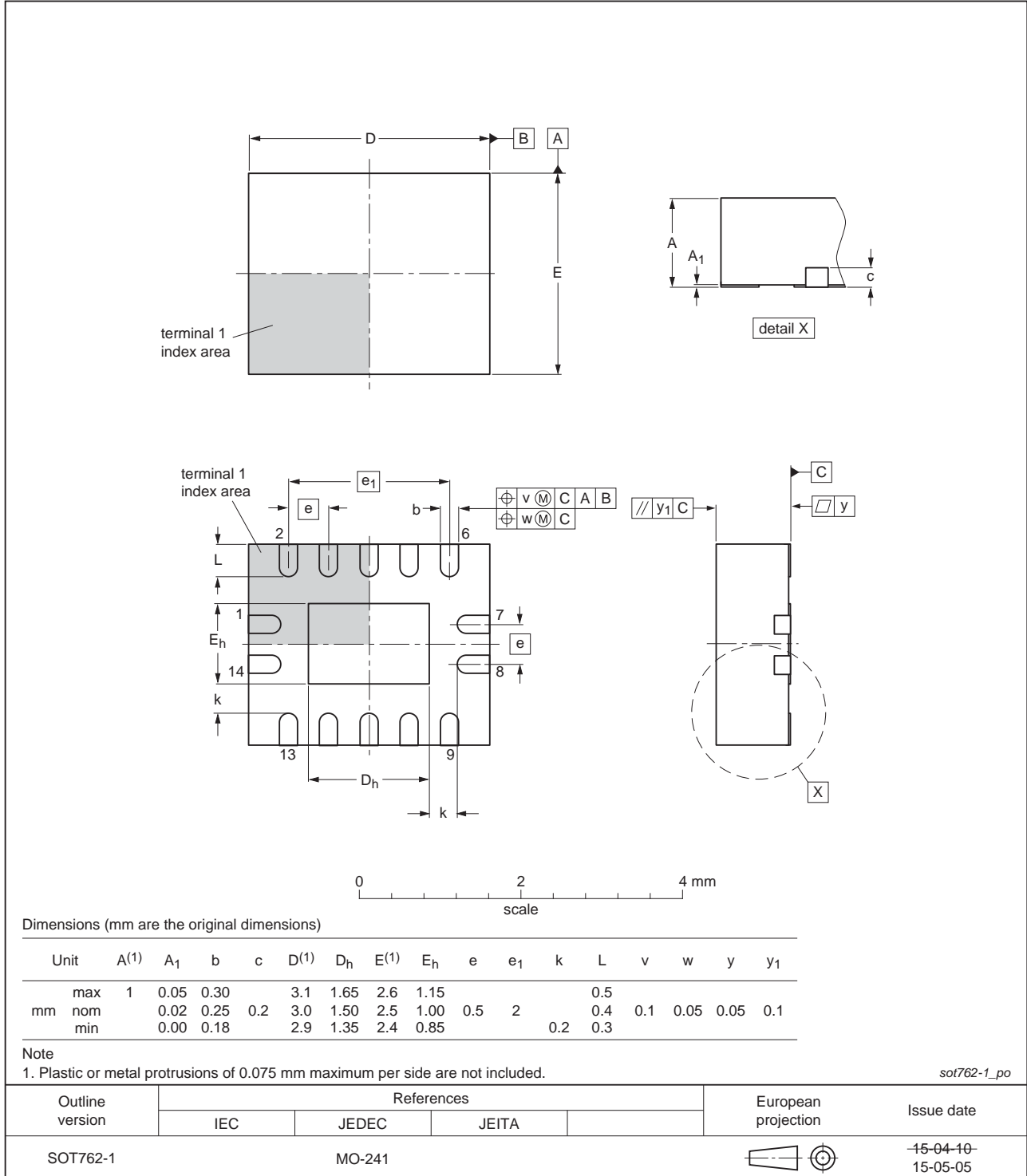


Fig 19. Package outline SOT762-1 (DHVQFN14)

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:	<ul style="list-style-type: none"> • 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 ^{[1][2]}	Product status ^[3]	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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