

# 74HC2GU04-Q100

Dual unbuffered inverter

Rev. 2 — 17 September 2014

Product data sheet

## 1. General description

The 74HC2GU04-Q100 is a high-speed Si-gate CMOS device.

The 74HC2GU04-Q100 provides two unbuffered inverters.

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  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$  and from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$
- Wide supply voltage range from 2.0 V to 6.0 V
- Complies with JEDEC standard no. 7A
- High noise immunity
- ESD protection:
  - ◆ HBM JESD22-A114F exceeds 2000 V
  - ◆ MM JESD22-A115-A exceeds 200 V
- Low power dissipation
- Balanced propagation delays
- Multiple package options
- ESD protection:
  - ◆ MIL-STD-883, method 3015 exceeds 2000 V
  - ◆ HBM JESD22-A114F exceeds 2000 V
  - ◆ MM JESD22-A115-A exceeds 200 V ( $C = 200\text{ pF}$ ,  $R = 0\text{ }\Omega$ )

## 3. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
74HC2GU04GW-Q100	$-40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$	SC-88	plastic surface-mounted package; 6 leads	SOT363
74HC2GU04GV-Q100	$-40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$	SC-74	plastic surface-mounted package (TSOP6); 6 leads	SOT457

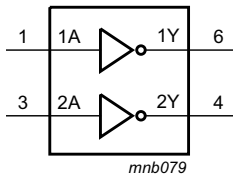
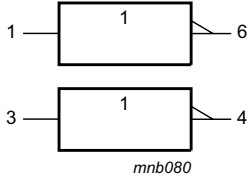
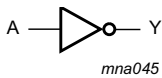


## 4. Marking

Table 2. Marking

Type number	Marking code
74HC2GU04GW-Q100	PD
74HC2GU04GV-Q100	HU4

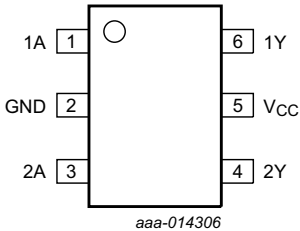
## 5. Functional diagram

		
<b>Fig 1. Logic symbol</b>	<b>Fig 2. IEC logic symbol</b>	<b>Fig 3. Logic diagram (one gate)</b>

## 6. Pinning information

### 6.1 Pinning

**74HC2GU04-Q100**



**Fig 4. Pin configuration**

### 6.2 Pin description

Table 3. Pin description

Symbol	Pin	Description
1A	1	data input
GND	2	ground (0 V)
2A	3	data input
2Y	4	data output
V <sub>CC</sub>	5	supply voltage
1Y	6	data output

## 7. Functional description

Table 4. Function table<sup>[1]</sup>

Input	Output
nA	nY
L	H
H	L

- [1] H = HIGH voltage level;  
L = LOW voltage level.

## 8. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{CC}$	supply voltage		-0.5	+7.0	V
$I_{IK}$	input clamping current	$V_I < -0.5\text{ V}$ or $V_I > V_{CC} + 0.5\text{ V}$	[1]	-	±20 mA
$I_{OK}$	output clamping current	$V_O < -0.5\text{ V}$ or $V_O > V_{CC} + 0.5\text{ V}$	[1]	-	±20 mA
$I_O$	output current	$V_O = -0.5\text{ V}$ to $V_{CC} + 0.5\text{ V}$	[1]	-	±25 mA
$I_{CC}$	supply current		[1]	-	+50 mA
$I_{GND}$	ground current		[1]	-	-50 mA
$T_{stg}$	storage temperature		-65	+150	°C
$P_{tot}$	total power dissipation		[2]	-	250 mW

- [1] The minimum input and output voltage ratings may be exceeded if the input and output current ratings are observed.  
[2] For SC-88 and SC-74 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

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
$t_r$	rise time	except for Schmitt trigger inputs				
		$V_{CC} = 2.0\text{ V}$	-	-	1000	ns
		$V_{CC} = 4.5\text{ V}$	-	-	500	ns
		$V_{CC} = 6.0\text{ V}$	-	-	400	ns
$t_f$	fall time	except for Schmitt trigger inputs				
		$V_{CC} = 2.0\text{ V}$	-	-	1000	ns
		$V_{CC} = 4.5\text{ V}$	-	-	500	ns
		$V_{CC} = 6.0\text{ V}$	-	-	400	ns

## 10. Static characteristics

**Table 7. Static characteristics**

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>T<sub>amb</sub> = 25 °C</b>						
V <sub>IH</sub>	HIGH-level input voltage	V <sub>CC</sub> = 2.0 V	1.7	1.1	-	V
		V <sub>CC</sub> = 4.5 V	3.6	2.4	-	V
		V <sub>CC</sub> = 6.0 V	4.8	3.1	-	V
V <sub>IL</sub>	LOW-level input voltage	V <sub>CC</sub> = 2.0 V	-	0.9	0.3	V
		V <sub>CC</sub> = 4.5 V	-	2.1	0.9	V
		V <sub>CC</sub> = 6.0 V	-	2.9	1.2	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> = -20 μA; V <sub>CC</sub> = 2.0 V	1.9	2.0	-	V
		I <sub>O</sub> = -20 μA; V <sub>CC</sub> = 4.5 V	4.4	4.5	-	V
		I <sub>O</sub> = -20 μA; V <sub>CC</sub> = 6.0 V	5.9	6.0	-	V
		I <sub>O</sub> = -4.0 mA; V <sub>CC</sub> = 4.5 V	4.13	4.32	-	V
		I <sub>O</sub> = -5.2 mA; V <sub>CC</sub> = 6.0 V	5.63	5.81	-	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> = 20 μA; V <sub>CC</sub> = 2.0 V	-	0	0.1	V
		I <sub>O</sub> = 20 μA; V <sub>CC</sub> = 4.5 V	-	0	0.1	V
		I <sub>O</sub> = 20 μA; V <sub>CC</sub> = 6.0 V	-	0	0.1	V
		I <sub>O</sub> = 4.0 mA; V <sub>CC</sub> = 4.5 V	-	0.15	0.26	V
		I <sub>O</sub> = 5.2 mA; V <sub>CC</sub> = 6.0 V	-	0.16	0.26	V
I <sub>I</sub>	input leakage current	V <sub>I</sub> = GND or V <sub>CC</sub> ; V <sub>CC</sub> = 6.0 V	-	-	±0.1	μA
I <sub>CC</sub>	supply current	V <sub>I</sub> = GND or V <sub>CC</sub> ; I <sub>O</sub> = 0 A; V <sub>CC</sub> = 6.0 V	-	-	1.0	μA
C <sub>I</sub>	input capacitance		-	3.0	-	pF
<b>T<sub>amb</sub> = -40 °C to +85 °C</b>						
V <sub>IH</sub>	HIGH-level input voltage	V <sub>CC</sub> = 2.0 V	1.7	1.1	-	V
		V <sub>CC</sub> = 4.5 V	3.6	2.4	-	V
		V <sub>CC</sub> = 6.0 V	4.8	3.1	-	V
V <sub>IL</sub>	LOW-level input voltage	V <sub>CC</sub> = 2.0 V	-	0.9	0.3	V
		V <sub>CC</sub> = 4.5 V	-	2.1	0.9	V
		V <sub>CC</sub> = 6.0 V	-	2.9	1.2	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> = -20 μA; V <sub>CC</sub> = 2.0 V	1.9	2.0	-	V
		I <sub>O</sub> = -20 μA; V <sub>CC</sub> = 4.5 V	4.4	4.5	-	V
		I <sub>O</sub> = -20 μA; V <sub>CC</sub> = 6.0 V	5.9	6.0	-	V
		I <sub>O</sub> = -4.0 mA; V <sub>CC</sub> = 4.5 V	4.13	4.32	-	V
		I <sub>O</sub> = -5.2 mA; V <sub>CC</sub> = 6.0 V	5.63	5.81	-	V

**Table 7. Static characteristics ...continued**

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
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> = 20 μA; V <sub>CC</sub> = 2.0 V	-	0	0.1	V
		I <sub>O</sub> = 20 μA; V <sub>CC</sub> = 4.5 V	-	0	0.1	V
		I <sub>O</sub> = 20 μA; V <sub>CC</sub> = 6.0 V	-	0	0.1	V
		I <sub>O</sub> = 4.0 mA; V <sub>CC</sub> = 4.5 V	-	0.15	0.33	V
		I <sub>O</sub> = 5.2 mA; V <sub>CC</sub> = 6.0 V	-	0.16	0.33	V
I <sub>I</sub>	input leakage current	V <sub>I</sub> = GND or V <sub>CC</sub> ; V <sub>CC</sub> = 6.0 V	-	-	±1.0	μA
I <sub>CC</sub>	supply current	V <sub>I</sub> = GND or V <sub>CC</sub> ; I <sub>O</sub> = 0 A; V <sub>CC</sub> = 6.0 V	-	-	10.0	μA
<b>T<sub>amb</sub> = -40 °C to +125 °C</b>						
V <sub>IH</sub>	HIGH-level input voltage	V <sub>CC</sub> = 2.0 V	1.7	-	-	V
		V <sub>CC</sub> = 4.5 V	3.6	-	-	V
		V <sub>CC</sub> = 6.0 V	4.8	-	-	V
V <sub>IL</sub>	LOW-level input voltage	V <sub>CC</sub> = 2.0 V	-	-	0.3	V
		V <sub>CC</sub> = 4.5 V	-	-	0.9	V
		V <sub>CC</sub> = 6.0 V	-	-	1.2	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> = -20 μA; V <sub>CC</sub> = 2.0 V	1.9	-	-	V
		I <sub>O</sub> = -20 μA; V <sub>CC</sub> = 4.5 V	4.4	-	-	V
		I <sub>O</sub> = -20 μA; V <sub>CC</sub> = 6.0 V	5.9	-	-	V
		I <sub>O</sub> = -4.0 mA; V <sub>CC</sub> = 4.5 V	3.7	-	-	V
		I <sub>O</sub> = -5.2 mA; V <sub>CC</sub> = 6.0 V	5.2	-	-	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> = 20 μA; V <sub>CC</sub> = 2.0 V	-	-	0.1	V
		I <sub>O</sub> = 20 μA; V <sub>CC</sub> = 4.5 V	-	-	0.1	V
		I <sub>O</sub> = 20 μA; V <sub>CC</sub> = 6.0 V	-	-	0.1	V
		I <sub>O</sub> = 4.0 mA; V <sub>CC</sub> = 4.5 V	-	-	0.4	V
		I <sub>O</sub> = 5.2 mA; V <sub>CC</sub> = 6.0 V	-	-	0.4	V
I <sub>I</sub>	input leakage current	V <sub>I</sub> = GND or V <sub>CC</sub> ; V <sub>CC</sub> = 6.0 V	-	-	±1.0	μA
I <sub>CC</sub>	supply current	V <sub>I</sub> = GND or V <sub>CC</sub> ; I <sub>O</sub> = 0 A; V <sub>CC</sub> = 6.0 V	-	-	20.0	μA

## 11. Dynamic characteristics

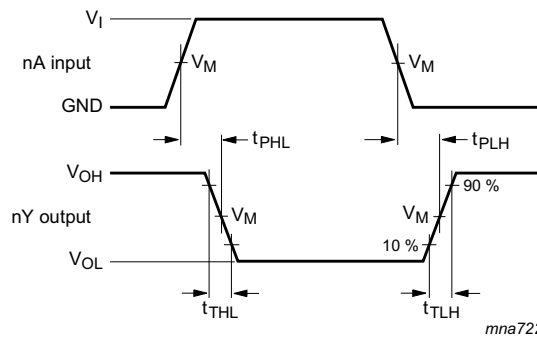
**Table 8. Dynamic characteristics**

Voltages are referenced to GND (ground = 0 V); for test circuit, see [Figure 6](#).

Symbol	Parameter	Conditions	25 °C			-40 °C to +125 °C			Unit	
			Min	Typ	Max	Min	Max (85 °C)	Max (125 °C)		
t <sub>pd</sub>	propagation delay	nA to nY; see <a href="#">Figure 5</a>	[1]							
		V <sub>CC</sub> = 2.0 V; C <sub>L</sub> = 50 pF		-	13	60	-	75	90	ns
		V <sub>CC</sub> = 4.5 V; C <sub>L</sub> = 50 pF		-	6	12	-	15	18	ns
		V <sub>CC</sub> = 6.0 V; C <sub>L</sub> = 50 pF		-	5	10	-	13	15	ns
t <sub>t</sub>	transition time	nY; see <a href="#">Figure 5</a>	[2]							
		V <sub>CC</sub> = 2.0 V; C <sub>L</sub> = 50 pF		-	18	75	-	95	125	ns
		V <sub>CC</sub> = 4.5 V; C <sub>L</sub> = 50 pF		-	6	15	-	19	25	ns
		V <sub>CC</sub> = 6.0 V; C <sub>L</sub> = 50 pF		-	5	13	-	16	20	ns
C <sub>PD</sub>	power dissipation capacitance	V <sub>I</sub> = GND to V <sub>CC</sub>	[3]	-	5	-	-	-	pF	

- [1] t<sub>pd</sub> is the same as t<sub>PLH</sub> and t<sub>PHL</sub>
- [2] t<sub>t</sub> is the same as t<sub>TLH</sub> and t<sub>THL</sub>
- [3] C<sub>PD</sub> is used to determine the dynamic power dissipation (P<sub>D</sub> in μW).  
 $P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$  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 V;  
 N = number of inputs switching;  
 Σ(C<sub>L</sub> × V<sub>CC</sub><sup>2</sup> × f<sub>o</sub>) = sum of the outputs.

## 12. Waveforms



Measurement points are given in [Table 9](#).  
 V<sub>OL</sub> and V<sub>OH</sub> are typical voltage output levels that occur with the output load.

**Fig 5. The data input (nA) to output (nY) propagation delays and output transition times**

Table 9. Measurement points

Input			Output
$V_M$	$V_I$	$t_r = t_f$	$V_M$
$0.5V_{CC}$	GND to $V_{CC}$	6.0 ns	$0.5V_{CC}$

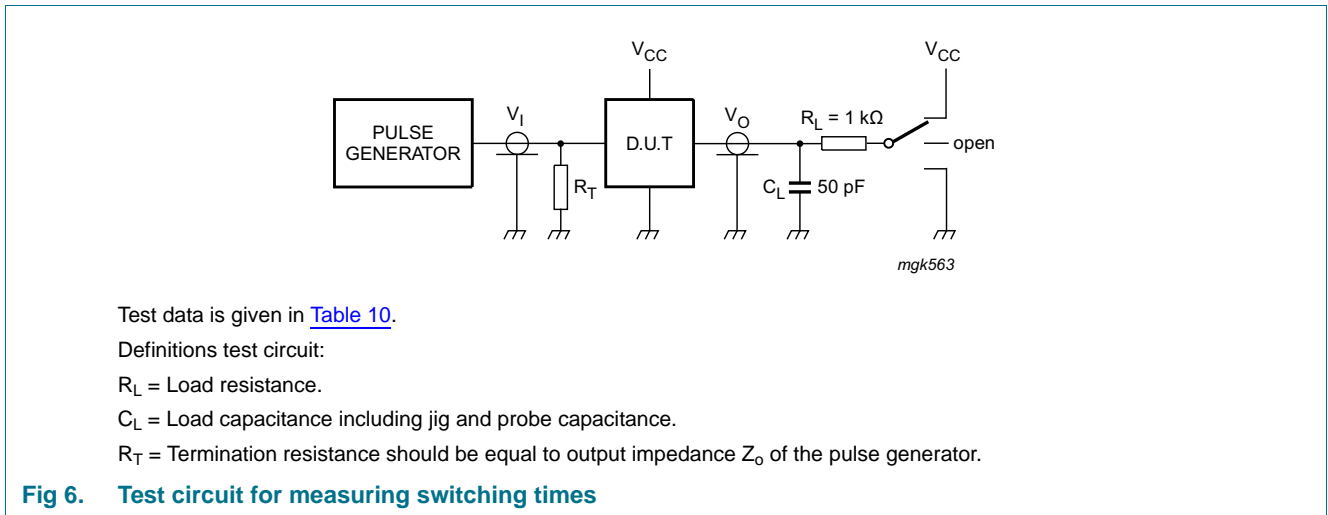
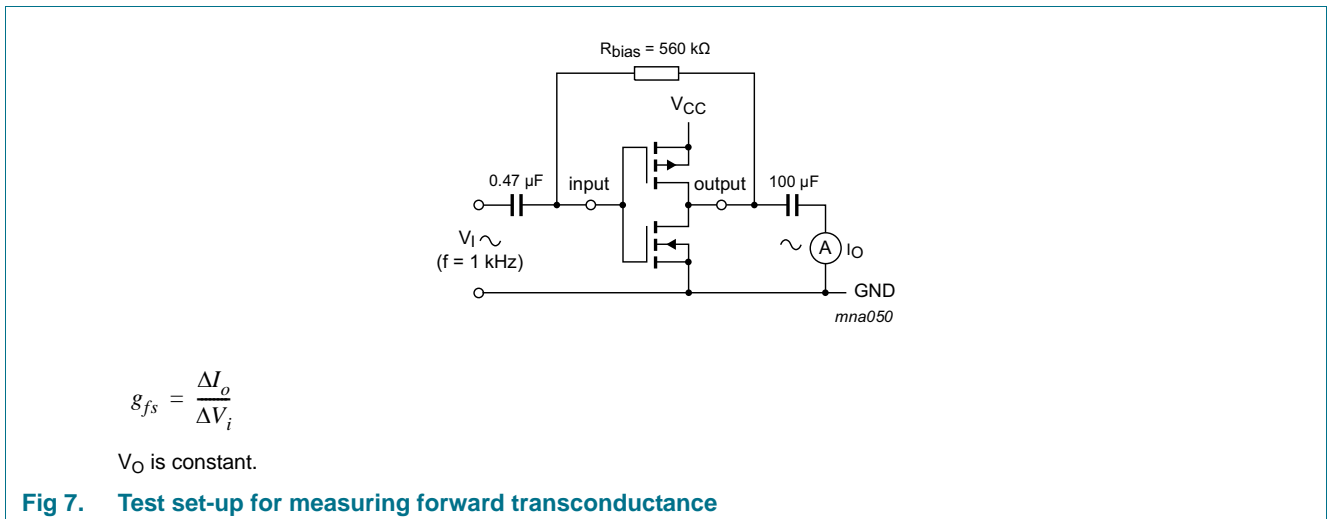
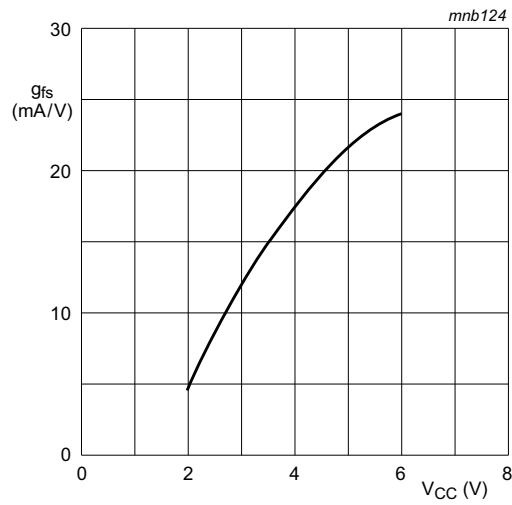


Table 10. Test data

Input		Test
$V_I$	$t_r, t_f$	$t_{PHL}, t_{PLH}$
GND to $V_{CC}$	6 ns	open

### 13. Additional characteristics

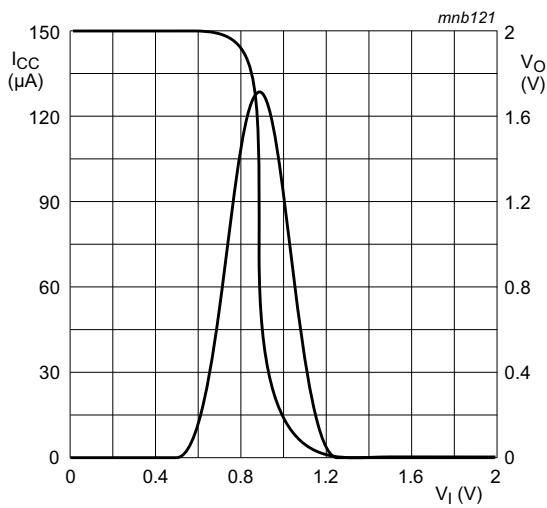




$T_{amb} = 25\text{ }^{\circ}\text{C}$ .

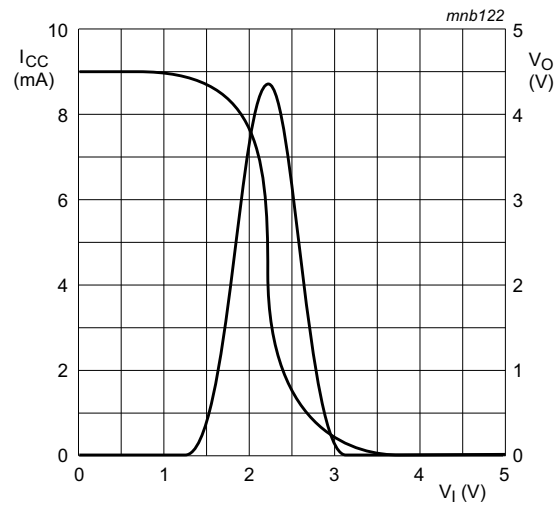
Fig 8. Typical forward transconductance as a function of supply voltage

### 14. Typical transfer characteristics



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

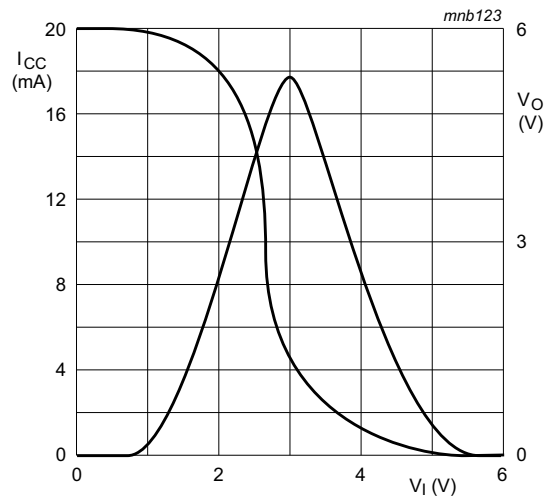
Fig 9. Typical transfer characteristics  $V_{CC} = 2.0\text{ V}$



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

Fig 10. Typical transfer characteristics  $V_{CC} = 4.5\text{ V}$





$V_{CC} = 6.0\text{ V}; I_O = 0\text{ A}.$

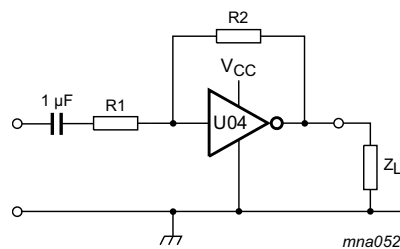
Fig 11. Typical transfer characteristics  $V_{CC} = 6.0\text{ V}$

## 15. Application information

Some applications for the 74HC2GU04-Q100 are:

- Linear amplifier (see [Figure 12](#))
- Crystal oscillator (see [Figure 13](#)).

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



$Z_L > 10\text{ k}\Omega.$

$R1 \geq 3\text{ k}\Omega.$

$R2 \leq 1\text{ M}\Omega.$

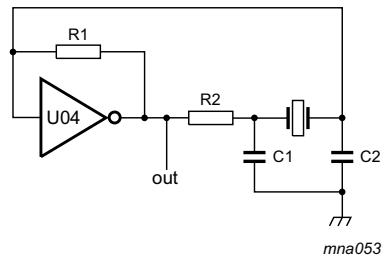
Open loop amplification:  $A_{OL} = 20.$

$$\text{Voltage amplification: } A_V = -\frac{A_{OL}}{1 + \frac{R1}{R2}(1 + A_{OL})}$$

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

Unity gain bandwidth product is 5 MHz.

Fig 12. Linear amplifier application



Test data is given in [Table 11](#) and [Table 12](#).

C1 = 47 pF.

C2 = 22 pF.

R1 = 1 MΩ to 10 MΩ.

R2 optimum value depends on the frequency and required stability against changes in  $V_{CC}$  or average minimum  $I_{CC}$  ( $I_{CC} = 2 \text{ mA}$  at  $V_{CC} = 3.0 \text{ V}$  and  $f = 1 \text{ MHz}$ ).

**Fig 13. Crystal oscillator application**

**Table 11. External components for resonator (f < 1 MHz)**

Frequency	R1	R2	C1	C2
10 kHz to 15.9 kHz	2.2 MΩ	220 kΩ	56 pF	20 pF
16 kHz to 24.9 kHz	2.2 MΩ	220 kΩ	56 pF	10 pF
25 kHz to 54.9 kHz	2.2 MΩ	100 kΩ	56 pF	10 pF
55 kHz to 129.9 kHz	2.2 MΩ	100 kΩ	47 pF	5 pF
130 kHz to 199.9 kHz	2.2 MΩ	47 kΩ	47 pF	5 pF
200 kHz to 349.9 kHz	2.2 MΩ	47 kΩ	47 pF	5 pF
350 kHz to 600 kHz	2.2 MΩ	47 kΩ	47 pF	5 pF

**Table 12. Optimum value for R2**

Frequency	R2	Optimum
3 kHz	2.0 kΩ	for minimum required $I_{CC}$
	8.0 kΩ	for minimum influence due to change in $V_{CC}$
6 kHz	1.0 kΩ	or minimum required $I_{CC}$
	4.7 kΩ	or minimum influence by $V_{CC}$
10 kHz	0.5 kΩ	or minimum required $I_{CC}$
	2.0 kΩ	or minimum influence by $V_{CC}$
14 kHz	0.5 kΩ	or minimum required $I_{CC}$
	2.0 kΩ	or minimum influence by $V_{CC}$
> 14 kHz	replace R2 by C3 = 35 pF (typical)	

16. Package outline

Plastic surface-mounted package; 6 leads

SOT363

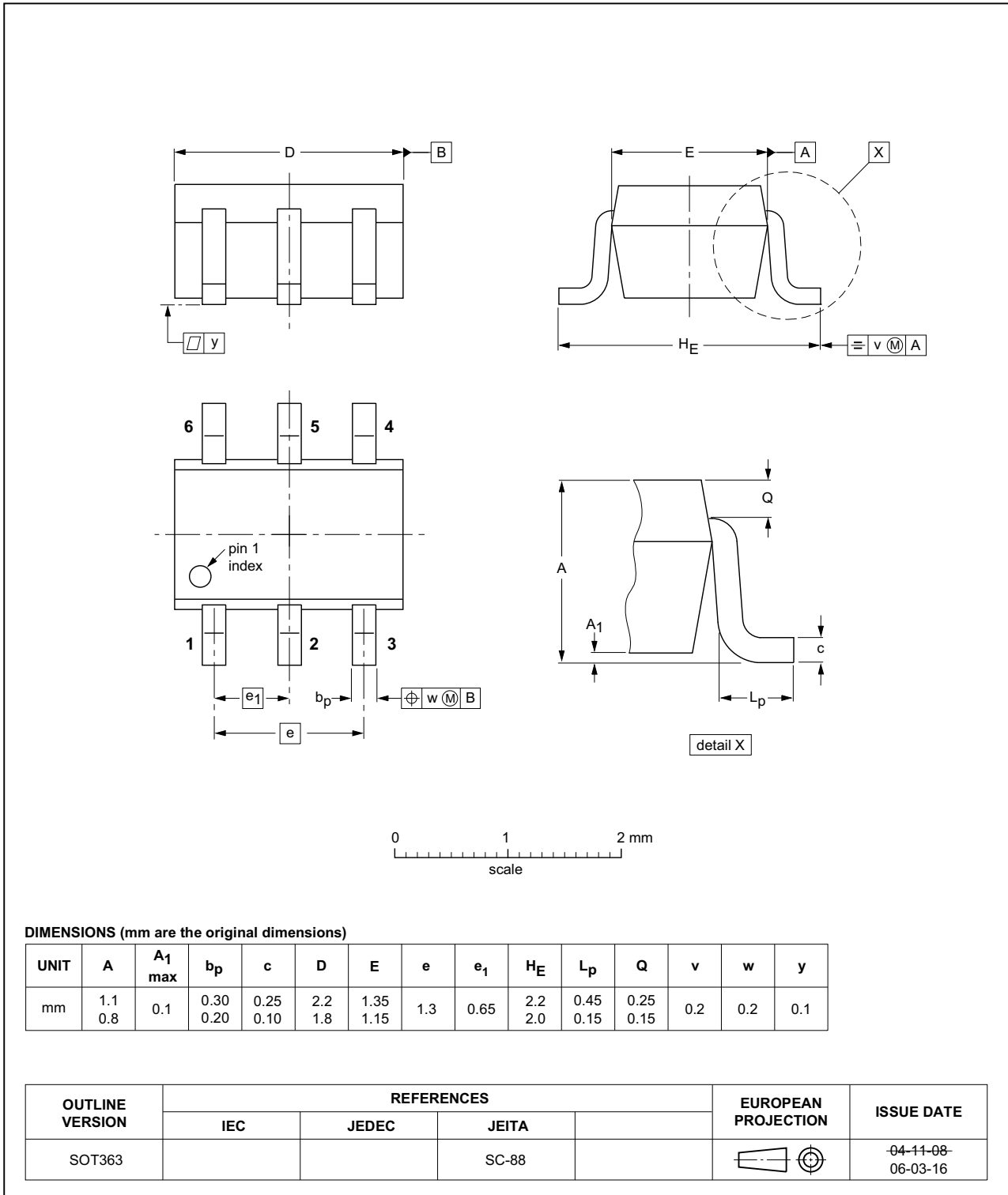


Fig 14. Package outline SOT363 (SC-88)

Plastic surface-mounted package (TSOP6); 6 leads

SOT457

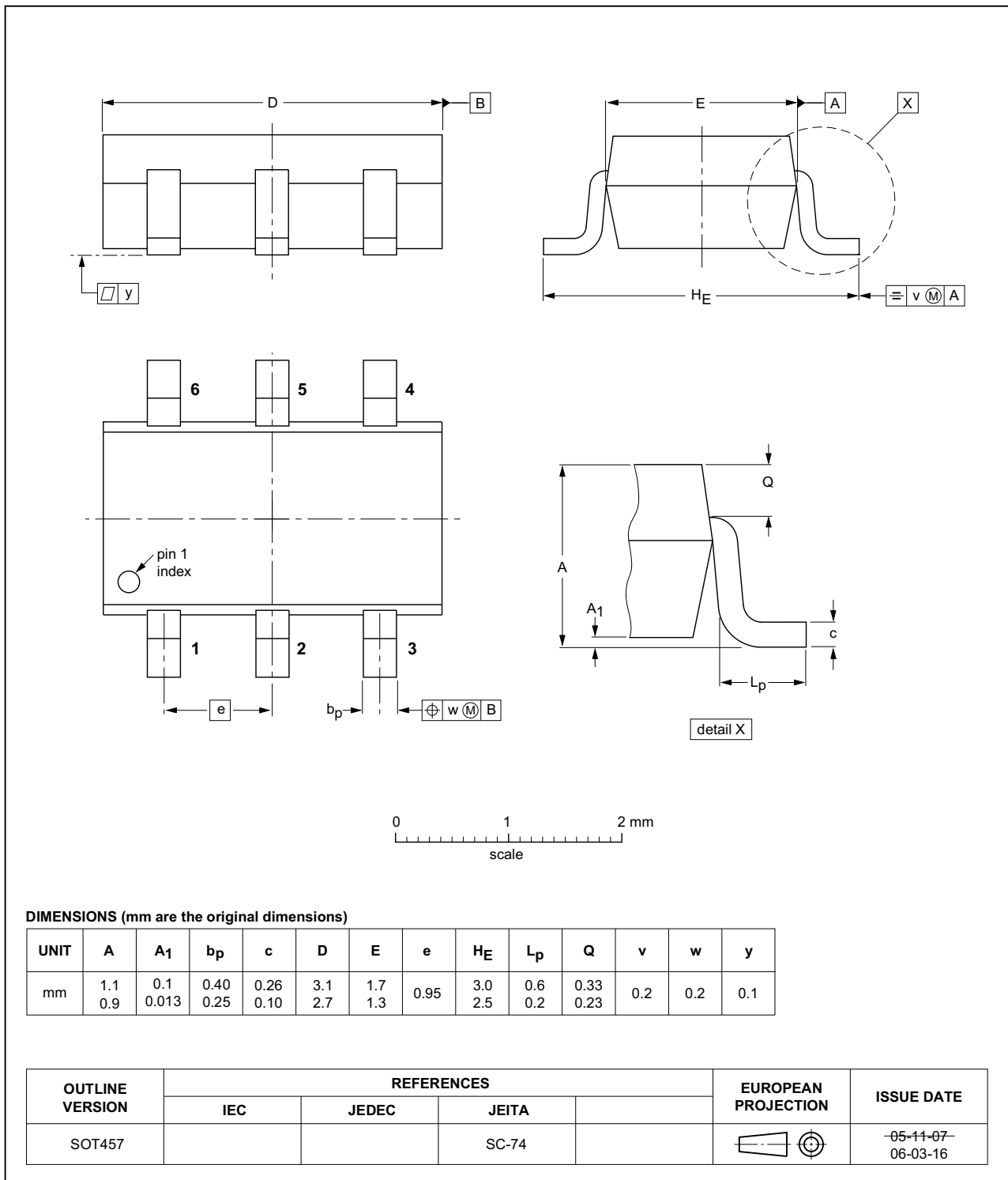


Fig 15. Package outline SOT457 (SC-74)

## 17. Abbreviations

Table 13. Abbreviations

Acronym	Description
CMOS	Complementary Metal Oxide Semiconductor
ESD	ElectroStatic Discharge
HBM	Human Body Model
MIL	Military
MM	Machine Model
DUT	Device Under Test

## 18. Revision history

Table 14. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
74HC2GU04_Q100 v.2	20140917	Product data sheet	-	74HC2GU04_Q100 v.1
Modifications:	• <a href="#">Section 1</a> : Q100 automotive statement added in the general description.			
74HC2GU04_Q100 v.1	20140825	Product data sheet	-	-

## 19. Legal information

### 19.1 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>.

### 19.2 Definitions

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