# 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 °C to +85 °C and from –40 °C to +125 °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 pF, R = 0 Ω)

## 3. Ordering information

**Table 1. Ordering information**

| Type number | Package | | | |
|---|---|---|---|---|
| | Temperature range | Name | Description | Version |
| 74HC2GU04GW-Q100 | –40 °C to +125 °C | SC-88 | plastic surface-mounted package; 6 leads | SOT363 |
| 74HC2GU04GV-Q100 | –40 °C to +125 °C | SC-74 | plastic surface-mounted package (TSOP6); 6 leads | SOT457 |

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# 4. Marking

**Table 2. Marking**

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

# 5. Functional diagram

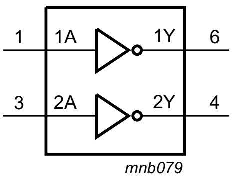



**Fig 1. Logic symbol**

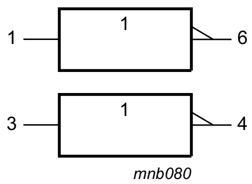



**Fig 2. IEC logic symbol**

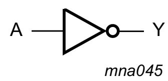



**Fig 3. Logic diagram (one gate)**

# 6. Pinning information

## 6.1 Pinning

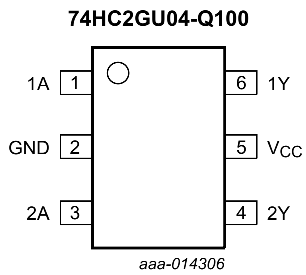



**Fig 4. Pin configuration**

## 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 |
| $V_{CC}$ | 5 | supply voltage |
| 1Y | 6 | data output |

## 7. Functional description

**Table 4. Function table[1]**

| 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 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] | - | ±20 | mA |
| $I_O$ | output current | $V_O$ = –0.5 V to $V_{CC}$ + 0.5 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 V | - | - | 1000 | ns |
| | | $V_{CC}$ = 4.5 V | - | - | 500 | ns |
| | | $V_{CC}$ = 6.0 V | - | - | 400 | ns |
| $t_f$ | fall time | except for Schmitt trigger inputs | | | | |
| | | $V_{CC}$ = 2.0 V | - | - | 1000 | ns |
| | | $V_{CC}$ = 4.5 V | - | - | 500 | ns |
| | | $V_{CC}$ = 6.0 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 |
|---|---|---|---|---|---|---|
| **$T_{amb}$ = 25 °C** | | | | | | |
| $V_{IH}$ | HIGH-level input voltage | $V_{CC}$ = 2.0 V | 1.7 | 1.1 | - | V |
| | | $V_{CC}$ = 4.5 V | 3.6 | 2.4 | - | V |
| | | $V_{CC}$ = 6.0 V | 4.8 | 3.1 | - | V |
| $V_{IL}$ | LOW-level input voltage | $V_{CC}$ = 2.0 V | - | 0.9 | 0.3 | V |
| | | $V_{CC}$ = 4.5 V | - | 2.1 | 0.9 | V |
| | | $V_{CC}$ = 6.0 V | - | 2.9 | 1.2 | V |
| $V_{OH}$ | HIGH-level output voltage | $V_I = V_{IH}$ or $V_{IL}$ | | | | |
| | | $I_O$ = –20 μA; $V_{CC}$ = 2.0 V | 1.9 | 2.0 | - | V |
| | | $I_O$ = –20 μA; $V_{CC}$ = 4.5 V | 4.4 | 4.5 | - | V |
| | | $I_O$ = –20 μA; $V_{CC}$ = 6.0 V | 5.9 | 6.0 | - | V |
| | | $I_O$ = –4.0 mA; $V_{CC}$ = 4.5 V | 4.13 | 4.32 | - | V |
| | | $I_O$ = –5.2 mA; $V_{CC}$ = 6.0 V | 5.63 | 5.81 | - | V |
| $V_{OL}$ | LOW-level output voltage | $V_I = V_{IH}$ or $V_{IL}$ | | | | |
| | | $I_O$ = 20 μA; $V_{CC}$ = 2.0 V | - | 0 | 0.1 | V |
| | | $I_O$ = 20 μA; $V_{CC}$ = 4.5 V | - | 0 | 0.1 | V |
| | | $I_O$ = 20 μA; $V_{CC}$ = 6.0 V | - | 0 | 0.1 | V |
| | | $I_O$ = 4.0 mA; $V_{CC}$ = 4.5 V | - | 0.15 | 0.26 | V |
| | | $I_O$ = 5.2 mA; $V_{CC}$ = 6.0 V | - | 0.16 | 0.26 | V |
| $I_I$ | input leakage current | $V_I$ = GND or $V_{CC}$; $V_{CC}$ = 6.0 V | - | - | ±0.1 | μA |
| $I_{CC}$ | supply current | $V_I$ = GND or $V_{CC}$; $I_O$ = 0 A; $V_{CC}$ = 6.0 V | - | - | 1.0 | μA |
| $C_I$ | input capacitance | | - | 3.0 | - | pF |
| **$T_{amb}$ = –40 °C to +85 °C** | | | | | | |
| $V_{IH}$ | HIGH-level input voltage | $V_{CC}$ = 2.0 V | 1.7 | 1.1 | - | V |
| | | $V_{CC}$ = 4.5 V | 3.6 | 2.4 | - | V |
| | | $V_{CC}$ = 6.0 V | 4.8 | 3.1 | - | V |
| $V_{IL}$ | LOW-level input voltage | $V_{CC}$ = 2.0 V | - | 0.9 | 0.3 | V |
| | | $V_{CC}$ = 4.5 V | - | 2.1 | 0.9 | V |
| | | $V_{CC}$ = 6.0 V | - | 2.9 | 1.2 | V |
| $V_{OH}$ | HIGH-level output voltage | $V_I = V_{IH}$ or $V_{IL}$ | | | | |
| | | $I_O$ = –20 μA; $V_{CC}$ = 2.0 V | 1.9 | 2.0 | - | V |
| | | $I_O$ = –20 μA; $V_{CC}$ = 4.5 V | 4.4 | 4.5 | - | V |
| | | $I_O$ = –20 μA; $V_{CC}$ = 6.0 V | 5.9 | 6.0 | - | V |
| | | $I_O$ = –4.0 mA; $V_{CC}$ = 4.5 V | 4.13 | 4.32 | - | V |
| | | $I_O$ = –5.2 mA; $V_{CC}$ = 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 |
|---|---|---|---|---|---|---|
| $V_{OL}$ | LOW-level output voltage | $V_I = V_{IH}$ or $V_{IL}$ | | | | |
| | | $I_O$ = 20 μA; $V_{CC}$ = 2.0 V | - | 0 | 0.1 | V |
| | | $I_O$ = 20 μA; $V_{CC}$ = 4.5 V | - | 0 | 0.1 | V |
| | | $I_O$ = 20 μA; $V_{CC}$ = 6.0 V | - | 0 | 0.1 | V |
| | | $I_O$ = 4.0 mA; $V_{CC}$ = 4.5 V | - | 0.15 | 0.33 | V |
| | | $I_O$ = 5.2 mA; $V_{CC}$ = 6.0 V | - | 0.16 | 0.33 | V |
| $I_I$ | input leakage current | $V_I$ = GND or $V_{CC}$; $V_{CC}$ = 6.0 V | - | - | ±1.0 | μA |
| $I_{CC}$ | supply current | $V_I$ = GND or $V_{CC}$; $I_O$ = 0 A; $V_{CC}$ = 6.0 V | - | - | 10.0 | μA |
| **$T_{amb}$ = –40 °C to +125 °C** | | | | | | |
| $V_{IH}$ | HIGH-level input voltage | $V_{CC}$ = 2.0 V | 1.7 | - | - | V |
| | | $V_{CC}$ = 4.5 V | 3.6 | - | - | V |
| | | $V_{CC}$ = 6.0 V | 4.8 | - | - | V |
| $V_{IL}$ | LOW-level input voltage | $V_{CC}$ = 2.0 V | - | - | 0.3 | V |
| | | $V_{CC}$ = 4.5 V | - | - | 0.9 | V |
| | | $V_{CC}$ = 6.0 V | - | - | 1.2 | V |
| $V_{OH}$ | HIGH-level output voltage | $V_I = V_{IH}$ or $V_{IL}$ | | | | |
| | | $I_O$ = –20 μA; $V_{CC}$ = 2.0 V | 1.9 | - | - | V |
| | | $I_O$ = –20 μA; $V_{CC}$ = 4.5 V | 4.4 | - | - | V |
| | | $I_O$ = –20 μA; $V_{CC}$ = 6.0 V | 5.9 | - | - | V |
| | | $I_O$ = –4.0 mA; $V_{CC}$ = 4.5 V | 3.7 | - | - | V |
| | | $I_O$ = –5.2 mA; $V_{CC}$ = 6.0 V | 5.2 | - | - | V |
| $V_{OL}$ | LOW-level output voltage | $V_I = V_{IH}$ or $V_{IL}$ | | | | |
| | | $I_O$ = 20 μA; $V_{CC}$ = 2.0 V | - | - | 0.1 | V |
| | | $I_O$ = 20 μA; $V_{CC}$ = 4.5 V | - | - | 0.1 | V |
| | | $I_O$ = 20 μA; $V_{CC}$ = 6.0 V | - | - | 0.1 | V |
| | | $I_O$ = 4.0 mA; $V_{CC}$ = 4.5 V | - | - | 0.4 | V |
| | | $I_O$ = 5.2 mA; $V_{CC}$ = 6.0 V | - | - | 0.4 | V |
| $I_I$ | input leakage current | $V_I$ = GND or $V_{CC}$; $V_{CC}$ = 6.0 V | - | - | ±1.0 | μA |
| $I_{CC}$ | supply current | $V_I$ = GND or $V_{CC}$; $I_O$ = 0 A; $V_{CC}$ = 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) | |
| $t_{pd}$ | propagation delay | nA to nY; see Figure 5 | [1] | | | | | | | |
| | | $V_{CC}$ = 2.0 V; $C_L$ = 50 pF | | - | 13 | 60 | - | 75 | 90 | ns |
| | | $V_{CC}$ = 4.5 V; $C_L$ = 50 pF | | - | 6 | 12 | - | 15 | 18 | ns |
| | | $V_{CC}$ = 6.0 V; $C_L$ = 50 pF | | - | 5 | 10 | - | 13 | 15 | ns |
| $t_t$ | transition time | nY; see Figure 5 | [2] | | | | | | | |
| | | $V_{CC}$ = 2.0 V; $C_L$ = 50 pF | | - | 18 | 75 | - | 95 | 125 | ns |
| | | $V_{CC}$ = 4.5 V; $C_L$ = 50 pF | | - | 6 | 15 | - | 19 | 25 | ns |
| | | $V_{CC}$ = 6.0 V; $C_L$ = 50 pF | | - | 5 | 13 | - | 16 | 20 | ns |
| $C_{PD}$ | power dissipation capacitance | $V_I$ = GND to $V_{CC}$ | [3] | - | 5 | - | - | - | - | pF |

[1] $t_{pd}$ is the same as $t_{PLH}$ and $t_{PHL}$

[2] $t_t$ is the same as $t_{TLH}$ and $t_{THL}$

[3] $C_{PD}$ is used to determine the dynamic power dissipation ($P_D$ in μW).

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

$f_i$ = input frequency in MHz;

$f_o$ = output frequency in MHz;

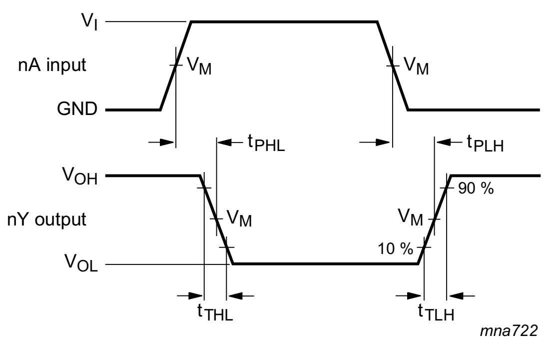
$C_L$ = output load capacitance in pF;

$V_{CC}$ = supply voltage in V;

N = number of inputs switching;

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

## 12. Waveforms



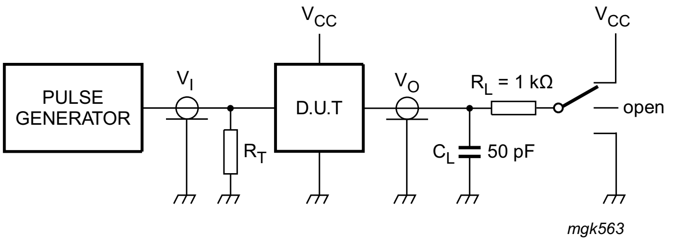

Measurement points are given in Table 9.

$V_{OL}$ and $V_{OH}$ 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 | $0.5V_{CC}$ |




Test data is given in Table 10.

Definitions test circuit:

$R_L$ = Load resistance.

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

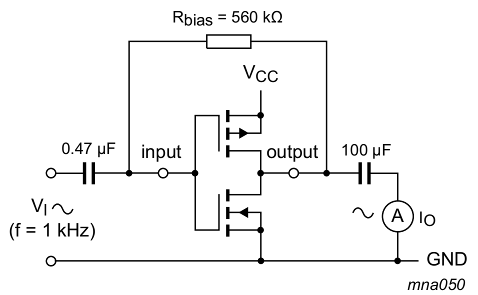
$R_T$ = Termination resistance should be equal to output impedance $Z_o$ of the pulse generator.

**Fig 6. Test circuit for measuring switching times**

**Table 10. Test data**

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

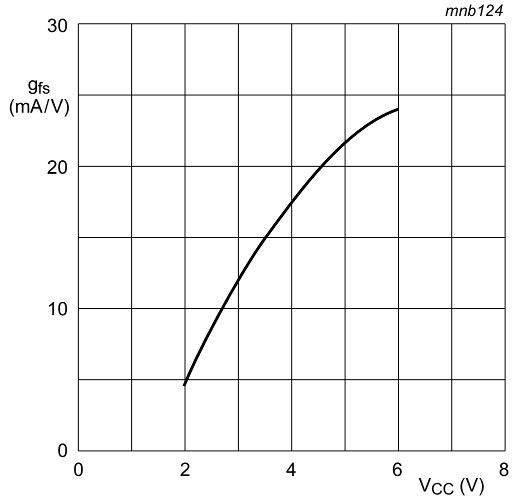
## 13. Additional characteristics




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

$V_O$ is constant.

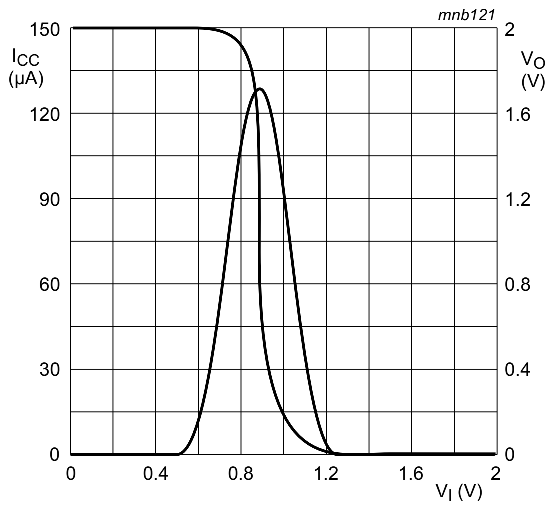
**Fig 7. Test set-up for measuring forward transconductance**




$T_{amb}$ = 25 °C.

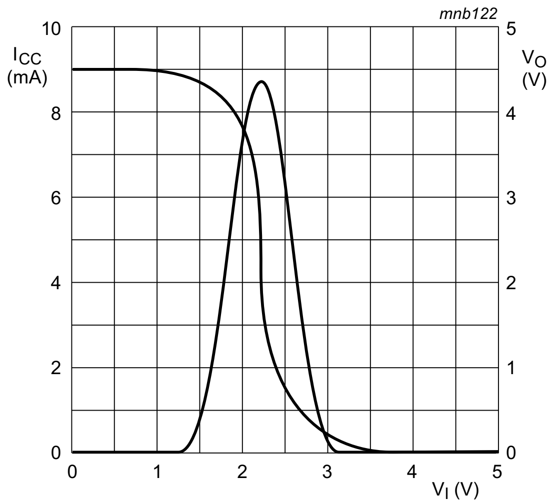
**Fig 8. Typical forward transconductance as a function of supply voltage**

## 14. Typical transfer characteristics



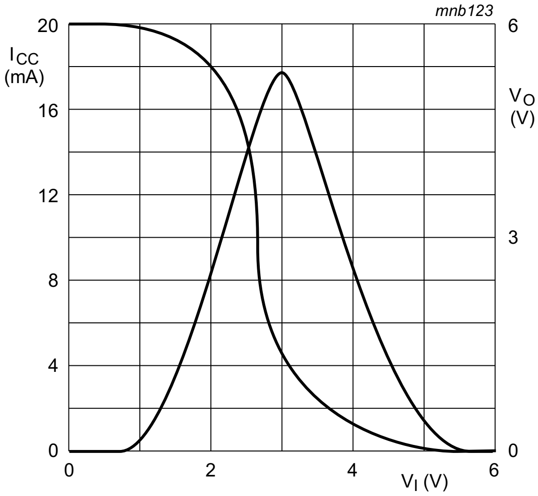

$V_{CC}$ = 2.0 V; $I_O$ = 0 A.

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




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

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




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

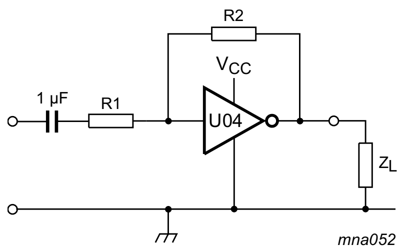
**Fig 11. Typical transfer characteristics $V_{CC}$ = 6.0 V**

## 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 kΩ.

R1 ≥ 3 kΩ.

R2 ≤ 1 MΩ.

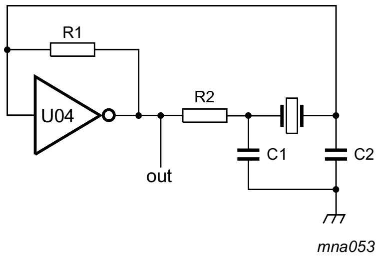
Open loop amplification: $A_{OL}$ = 20.

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

$V_{o(p-p)} = V_{CC} - 1.5$ 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 mA at $V_{CC}$ = 3.0 V and f = 1 MHz).

**Fig 13. Crystal oscillator application**

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

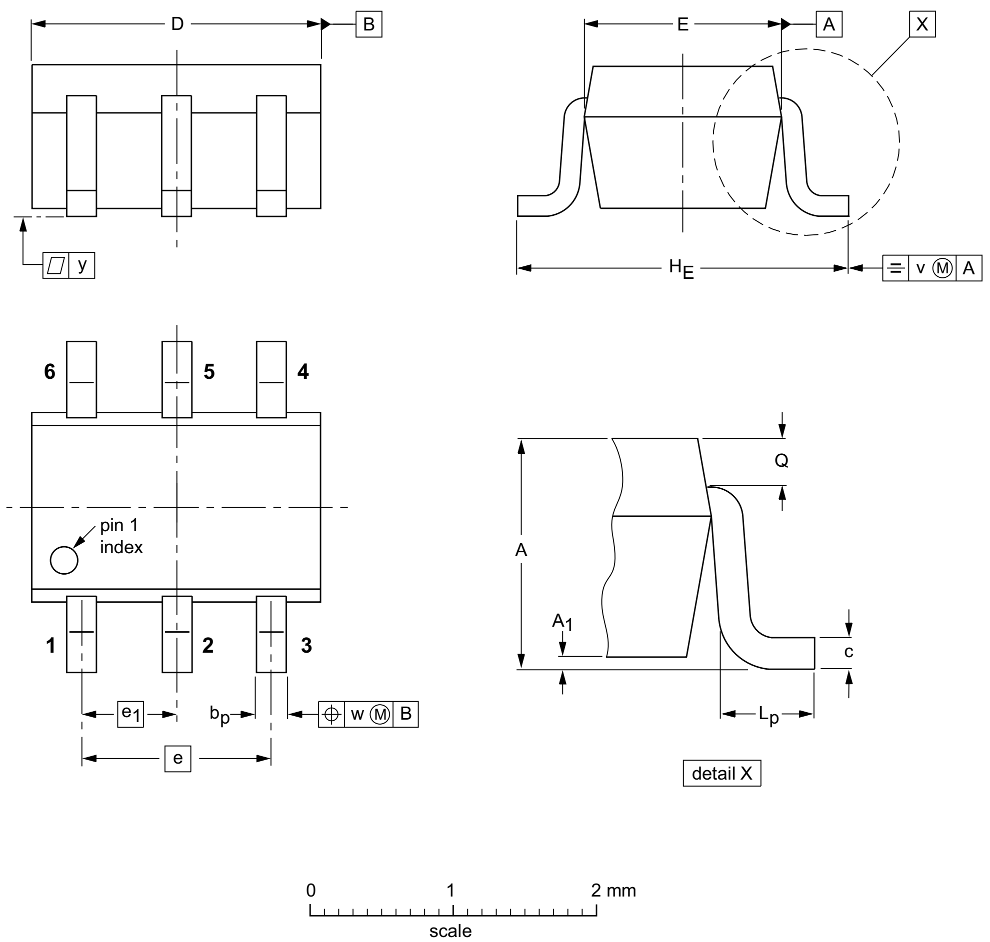
| Frequency | R1 | R2 | C1 | C2 |
|---|---|---|---|---|
| 10 kHz to 15.9 kHz | 2.2 MΩ | 220 kΩ | 56 pF | 20 pF |
| 16 kHz to 24.9 kHz | 2.2 MΩ | 220 kΩ | 56 pF | 10 pF |
| 25 kHz to 54.9 kHz | 2.2 MΩ | 100 kΩ | 56 pF | 10 pF |
| 55 kHz to 129.9 kHz | 2.2 MΩ | 100 kΩ | 47 pF | 5 pF |
| 130 kHz to 199.9 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**



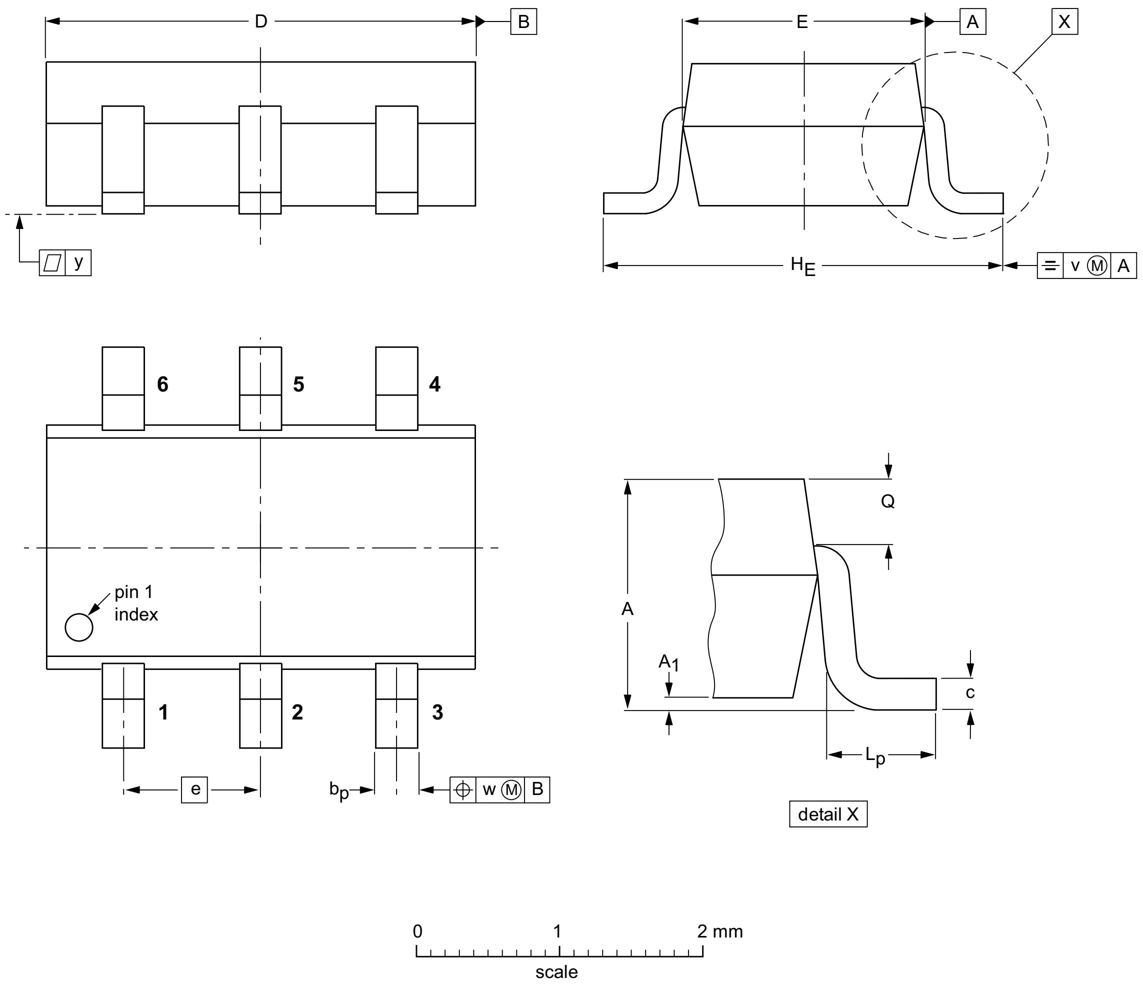

**DIMENSIONS (mm are the original dimensions)**

| UNIT | A | $A_1$ max | $b_p$ | c | D | E | e | $e_1$ | $H_E$ | $L_p$ | Q | v | w | y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.1<br>0.8 | 0.1 | 0.30<br>0.20 | 0.25<br>0.10 | 2.2<br>1.8 | 1.35<br>1.15 | 1.3 | 0.65 | 2.2<br>2.0 | 0.45<br>0.15 | 0.25<br>0.15 | 0.2 | 0.2 | 0.1 |

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT363 | | | SC-88 | | | ~~04-11-08~~<br>06-03-16 |

**Fig 14. Package outline SOT363 (SC-88)**

**Plastic surface-mounted package (TSOP6); 6 leads** **SOT457**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A | $A_1$ | $b_p$ | c | D | E | e | $H_E$ | $L_p$ | Q | v | w | y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.1<br>0.9 | 0.1<br>0.013 | 0.40<br>0.25 | 0.26<br>0.10 | 3.1<br>2.7 | 1.7<br>1.3 | 0.95 | 3.0<br>2.5 | 0.6<br>0.2 | 0.33<br>0.23 | 0.2 | 0.2 | 0.1 |

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT457 | | | SC-74 | | | ~~05-11-07~~<br>06-03-16 |

**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: | • Section 1: 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[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".

[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.nexperia.com.

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**Date of release: 17 September 2014**