XC7SHU04

Inverter

Rev. 2 — 11 January 2022 Product data sheet

1. General description

The XC7SHU04 is a high-speed Si-gate CMOS device. It provides an inverting single stage function.

2. Features

- Symmetrical output impedance
- High noise immunity
- Low power dissipation
- CMOS input levels
- Balanced propagation delays
- ESD protection:
  - HBM JESD22-A114E: exceeds 2000 V
  - MM JESD22-A115-A: exceeds 200 V
  - CDM JESD22-C101C: exceeds 1000 V
- Specified from -40 °C to +125 °C

3. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
XC7SHU04GW	-40 °C to +125 °C	TSSOP5	plastic thin shrink small outline package; 5 leads; body width 1.25 mm	SOT353-1
XC7SHU04GV	-40 °C to +125 °C	SC-74A	plastic surface-mounted package; 5 leads	SOT753

4. Marking

Table 2. Marking codes

Type number	Marking [1]
XC7SHU04GW	fD
XC7SHU04GV	fU4

[1] The pin 1 indicator is located on the lower left corner of the device, below the marking code.

5. Functional diagram

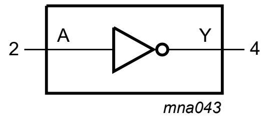


Fig. 1. Logic symbol

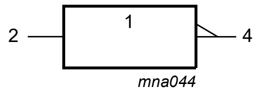


Fig. 2. IEC logic symbol

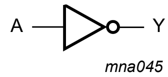


Fig. 3. Logic diagram

6. Pinning information

6.1. Pinning

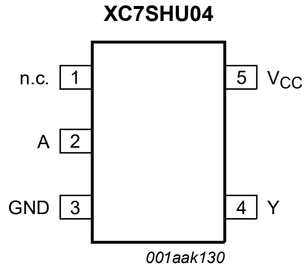


Fig. 4. Pin configuration SOT353-1 (TSSOP5) and SOT753 (SC-74A)

6.2. Pin description

Table 3. Pin description

Symbol	Pin	Description
n.c.	1	not connected
A	2	data input
GND	3	ground (0 V)
Y	4	data output
V_{CC}	5	supply voltage

7. Functional description

Table 4. Function table

H = HIGH voltage level; L = LOW voltage level

Input	Output
A	**Y**
L	H
H	L

8. Limiting values

Table 5. 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	-20	-	mA
V_I	input voltage	[1]	-0.5	+7.0	V
I_{OK}	output clamping current	V_O < -0.5 V or V_O > V_{CC} + 0.5 V	-	±20	mA
I_O	output current	-0.5 V < V_O < V_{CC} + 0.5 V	-	±25	mA
I_{CC}	supply current		-	75	mA
I_{GND}	ground current		-75	-	mA
T_{stg}	storage temperature		-65	+150	°C
P_{tot}	total power dissipation	T_{amb} = -40 °C to +125 °C [2]	-	250	mW

[1] The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

[2] For SOT353-1 (TSSOP5) package: P_{tot} derates linearly with 3.3 mW/K above 74 °C.
For SOT753 (SC-74A) package: P_{tot} derates linearly with 3.8 mW/K above 85 °C.

9. Recommended operating conditions

Table 6. 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	5.5	V
V_I	input voltage		0	-	5.5	V
V_O	output voltage		0	-	V_{CC}	V
T_{amb}	ambient temperature		-40	+25	+125	°C
Δt/ΔV	input transition rise and fall rate	V_{CC} = 3.3 V ± 0.3 V	-	-	100	ns/V
		V_{CC} = 5.0 V ± 0.5 V	-	-	20	ns/V

10. Static characteristics

Table 7. 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	-	-	1.7	-	1.7	-	V
		V_{CC} = 3.0 V	2.4	-	-	2.4	-	2.4	-	V
		V_{CC} = 5.5 V	4.4	-	-	4.4	-	4.4	-	V
V_{IL}	LOW-level input voltage	V_{CC} = 2.0 V	-	-	0.3	-	0.3	-	0.3	V
		V_{CC} = 3.0 V	-	-	0.6	-	0.6	-	0.6	V
		V_{CC} = 5.5 V	-	-	1.1	-	1.1	-	1.1	V
V_{OH}	HIGH-level output voltage	V_I = V_{IH} or V_{IL}								
		I_O = -50 μA; V_{CC} = 2.0 V	1.9	2.0	-	1.9	-	1.9	-	V
		I_O = -50 μA; V_{CC} = 3.0 V	2.9	3.0	-	2.9	-	2.9	-	V
		I_O = -50 μA; V_{CC} = 4.5 V	4.4	4.5	-	4.4	-	4.4	-	V
		I_O = -4.0 mA; V_{CC} = 3.0 V	2.58	-	-	2.48	-	2.40	-	V
		I_O = -8.0 mA; V_{CC} = 4.5 V	3.94	-	-	3.8	-	3.70	-	V
V_{OL}	LOW-level output voltage	V_I = V_{IH} or V_{IL}								
		I_O = 50 μA; V_{CC} = 2.0 V	-	0	0.1	-	0.1	-	0.1	V
		I_O = 50 μA; V_{CC} = 3.0 V	-	0	0.1	-	0.1	-	0.1	V
		I_O = 50 μA; V_{CC} = 4.5 V	-	0	0.1	-	0.1	-	0.1	V
		I_O = 4.0 mA; V_{CC} = 3.0 V	-	-	0.36	-	0.44	-	0.55	V
		I_O = 8.0 mA; V_{CC} = 4.5 V	-	-	0.36	-	0.44	-	0.55	V
I_I	input leakage current	V_I = 5.5 V or GND; V_{CC} = 0 V to 5.5 V	-	-	0.1	-	1.0	-	2.0	μA
I_{CC}	supply current	V_I = V_{CC} or GND; I_O = 0 A; V_{CC} = 5.5 V	-	-	1.0	-	10	-	40	μA
C_I	input capacitance		-	1.5	10	-	10	-	10	pF

11. Dynamic characteristics

Table 8. Dynamic characteristics

GND = 0 V. For test circuit see Fig. 6.

Symbol	Parameter	Conditions	25 °C			-40 °C to +85 °C		-40 °C to +125 °C		Unit
			Min	Typ	Max	Min	Max	Min	Max	
t_{pd}	propagation delay	A to Y; see Fig. 5 [1]								
		V_{CC} = 3.0 V to 3.6 V [2]								
		C_L = 15 pF	-	3.4	7.1	1.0	8.5	1.0	10.0	ns
		C_L = 50 pF	-	4.9	10.6	1.0	12.0	1.0	13.5	ns
		V_{CC} = 4.5 V to 5.5 V [3]								
		C_L = 15 pF	-	2.6	5.5	1.0	6.0	1.0	7.0	ns
		C_L = 50 pF	-	3.6	7.0	1.0	8.0	1.0	9.0	ns
C_{PD}	power dissipation capacitance	per buffer; V_I = GND to V_{CC} [4]	-	14	-	-	-	-	-	pF

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

[2] Typical values are measured at V_{CC} = 3.3 V.

[3] Typical values are measured at V_{CC} = 5.0 V.

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

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

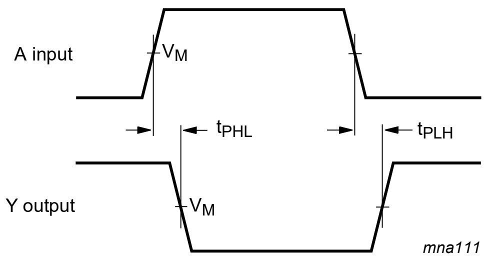
f_i = input frequency in MHz;

f_o = output frequency in MHz;

C_L = output load capacitance in pF;

V_{CC} = supply voltage in Volts.

11.1. Waveforms and test circuit

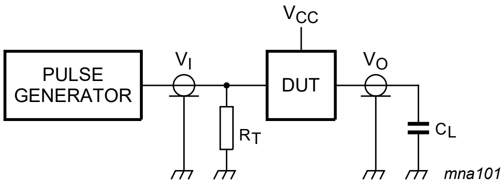


Measurement points are given in Table 9.

Fig. 5. Input (A) to output (Y) propagation delays

Table 9. Measurement point

Input	Input	Output
V_I	V_M	V_M
GND to V_{CC}	0.5 × V_{CC}	0.5 × V_{CC}



Test data is given in Table 10.
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. 6. Test circuit for measuring switching times

Table 10. Test data

Input		Load	Test
V_I	t_r, t_f	C_L	
V_{CC}	≤ 3.0 ns	15 pF, 50 pF	t_{PLH}, t_{PHL}

12. Typical transfer characteristics

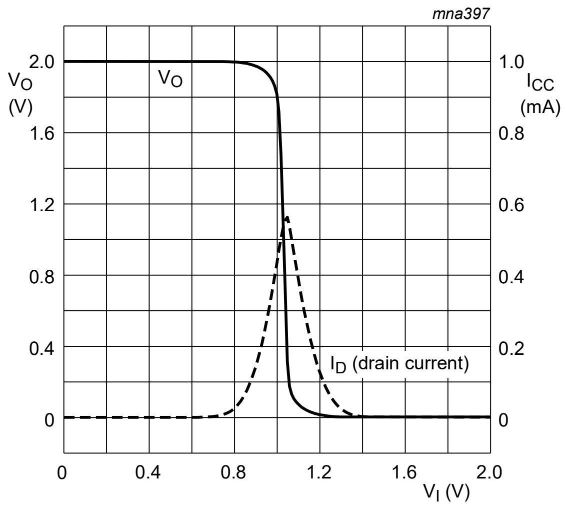


Fig. 7. V_{CC} = 2.0 V; I_O = 0 A

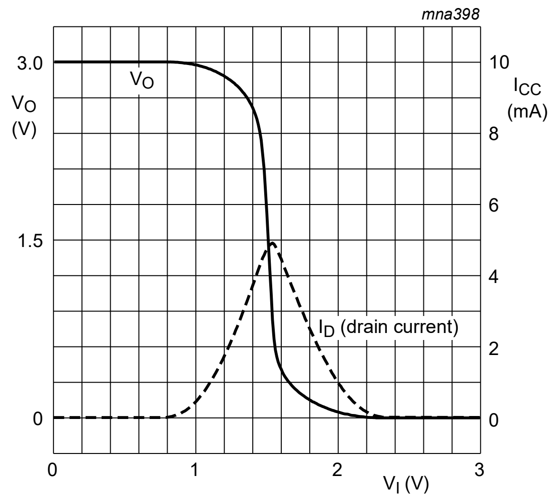


Fig. 8. V_{CC} = 3.0 V; I_O = 0 A

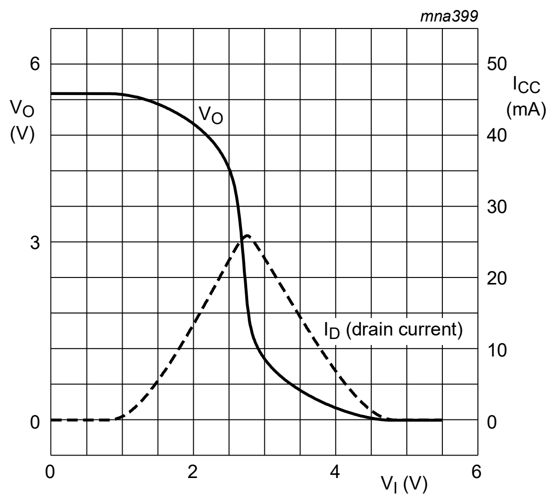


Fig. 9. V_{CC} = 5.5 V; I_O = 0 A

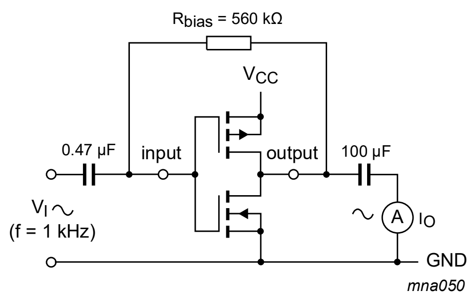


Fig. 10. Test set-up for measuring forward transconductance $g_{fs} = \Delta I_O / \Delta V_I$ at V_O is constant

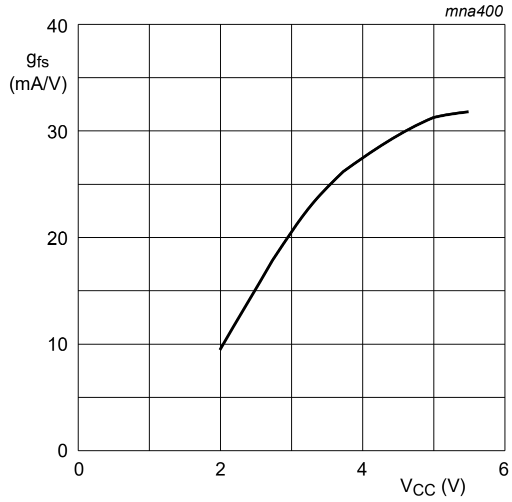


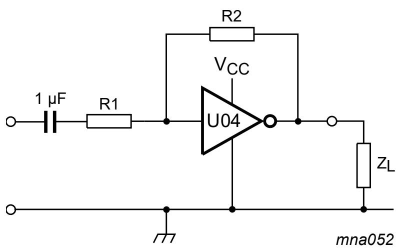
Fig. 11. Typical forward transconductance g_{fs} as a function of the supply voltage at T_{amb} = 25 °C

13. Application information

Some applications are:

- Linear amplifier (see Fig. 12)
- In crystal oscillator design (see Fig. 13)

Remark: All values given are typical unless otherwise specified.



Maximum $V_{o(p-p)}$ = V_{CC} - 1.5 V centered at 0.5 × V_{CC}.

$$G_v = - \frac{G_{ol}}{1 + \frac{R1}{R2}\left(1 + G_{ol}\right)}$$

G_{ol} = open loop gain

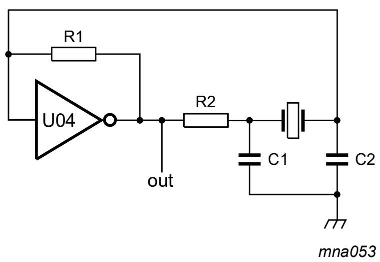
G_v = voltage gain

R1 ≥ 3 kΩ, R2 ≤ 1 MΩ

Z_L > 10 kΩ; G_{ol} = 20 (typ.)

Typical unity gain bandwidth product is 5 MHz.

Fig. 12. Used as a linear amplifier



C1 = 47 pF (typ.)

C2 = 22 pF (typ.)

R1 = 1 MΩ to 10 MΩ (typ.)

R2 optimum value depends on the frequency and required stability against changes in V_{CC} or average minimum I_{CC} (I_{CC} is typically 2 mA when V_{CC} = 3 V and f = 1 MHz).

Fig. 13. Crystal oscillator configuration

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

All values given are typical and must be used as an initial set-up.

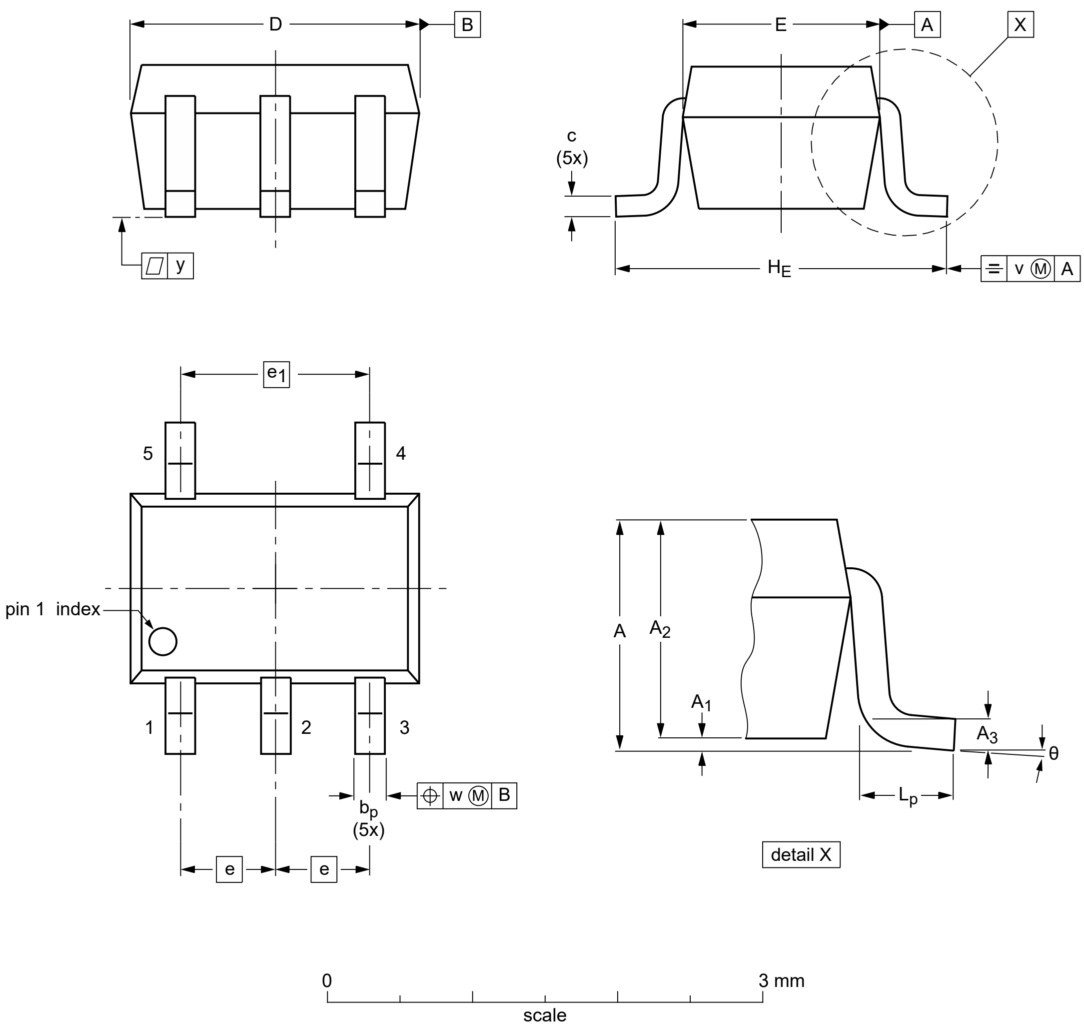
Frequency	R1	R2	C1	C2
10 kHz to 15.9 kHz	22 MΩ	220 kΩ	56 pF	20 pF
16 kHz to 24.9 kHz	22 MΩ	220 kΩ	56 pF	10 pF
25 kHz to 54.9 kHz	22 MΩ	100 kΩ	56 pF	10 pF
55 kHz to 129.9 kHz	22 MΩ	100 kΩ	47 pF	5 pF
130 kHz to 199.9 kHz	22 MΩ	47 kΩ	47 pF	5 pF
200 kHz to 349.9 kHz	22 MΩ	47 kΩ	47 pF	5 pF
350 kHz to 600 kHz	22 MΩ	47 kΩ	47 pF	5 pF

Table 12. 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

14. Package outline

TSSOP5: plastic thin shrink small outline package; 5 leads; body width 1.25 mm **SOT353-1**



Dimensions (mm are the original dimensions)

Unit		A	A_1	A_2	A_3	b_p	c	D(1)	E(1)	e	e_1	H_E	L_p	v	w	y	θ
mm	max	1.1	0.1	1.0	0.15	0.30	0.25	2.2	1.35	0.65	1.3	2.4	0.46	0.3	0.1	0.1	8°
	min	0.8	0	0.8		0.15	0.08	1.8	1.15			1.8	0.26				0°

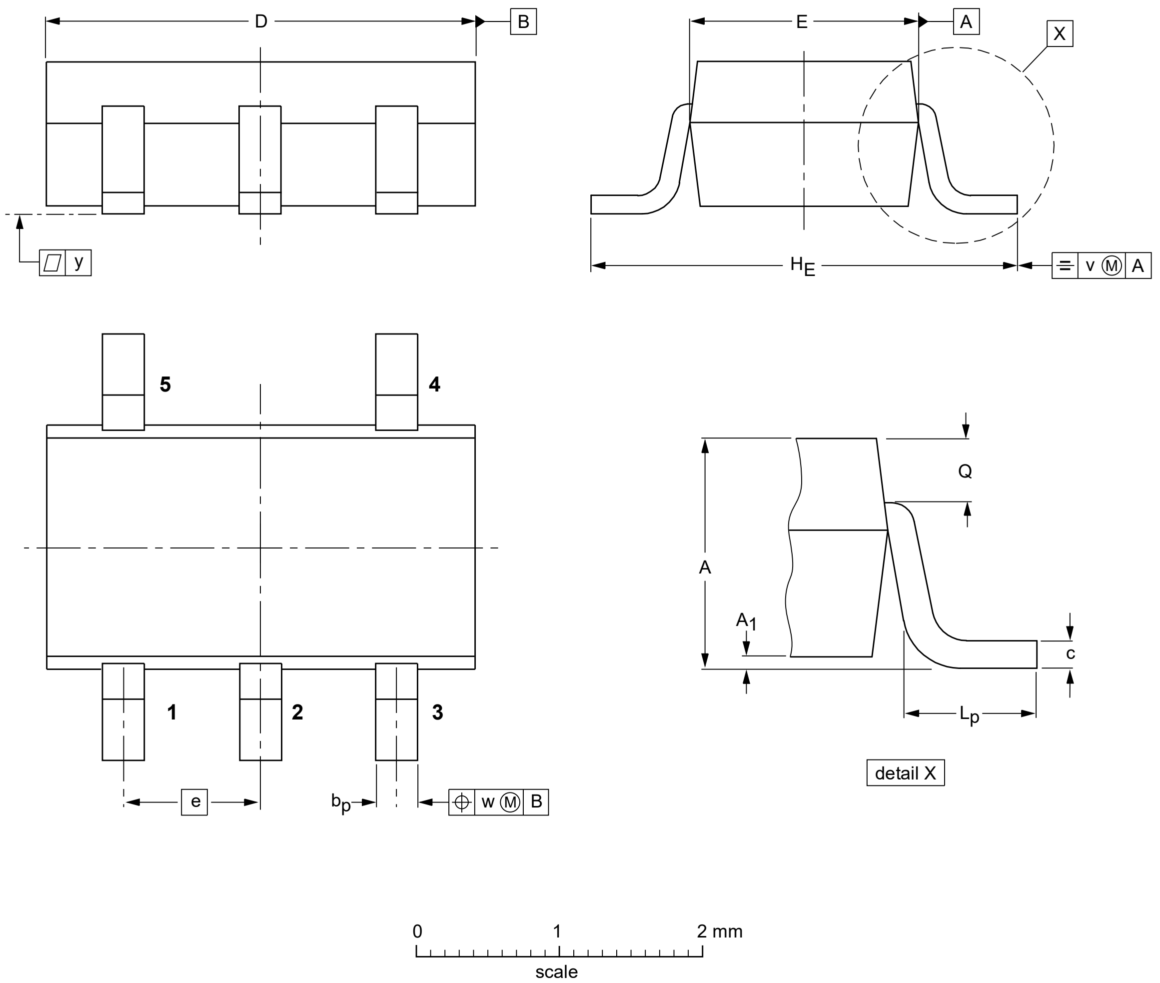
Note
1. Plastic or metal protrusions of 0.2 mm maximum per side are not included.

sot353-1_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT353-1		MO-203	SC-88A			~~21-12-15~~ 21-12-16

Fig. 14. Package outline SOT353-1 (TSSOP5)

Plastic surface-mounted package; 5 leads **SOT753**



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 0.9	0.100 0.013	0.40 0.25	0.26 0.10	3.1 2.7	1.7 1.3	0.95	3.0 2.5	0.6 0.2	0.33 0.23	0.2	0.2	0.1

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT753			SC-74A			~~02-04-16~~ 06-03-16

Fig. 15. Package outline SOT753 (SC-74A)

15. Abbreviations

Table 13. Abbreviations

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

16. Revision history

Table 14. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
XC7SHU04 v.2	20220111	Product data sheet	-	XC7SHU04 v.1
Modifications:	• The format of this data sheet has been redesigned to comply with the identity guidelines of Nexperia. • Legal texts have been adapted to the new company name where appropriate. • Section 8: Derating values for P_{tot} total power dissipation updated. • Fig. 14: Package outline drawing SOT353-1 (TSSOP5) has changed.			
XC7SHU04 v.1	20090907	Product data sheet	-	-

17. Legal information

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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