Hex inverter

74AHCU04

FEATURES

- ESD protection:
  HBM EIA/JESD22-A114-A exceeds 2000 V
  MM EIA/JESD22-A115-A exceeds 200 V
  CDM EIA/JESD22-C101 exceeds 1000 V
- Balanced propagation delays
- All inputs have Schmitt-trigger actions
- Inputs accepts voltages higher than V_{CC}
- Specified from −40 to +85 and +125 °C.

DESCRIPTION

The 74AHCU04 is high-speed Si-gate CMOS devices and is pin compatible with low power Schottky TTL (LSTTL). It is specified in compliance with JEDEC standard No. 7A.

The 74AHCU04 is a general purpose hex inverter. Each of the six inverters is a single stage.

FUNCTION TABLE

See note 1.

INPUT nA	OUTPUT nY
L	H
H	L

Note

1. H = HIGH voltage level;
   L = LOW voltage level.

QUICK REFERENCE DATA

GND = 0 V; T_{amb} = 25 °C; $t_r = t_f \leq 3.0$ ns.

SYMBOL	PARAMETER	CONDITIONS	TYPICAL	UNIT
t_{PHL}/t_{PLH}	propagation delay nA to nY	C_L = 15 pF; V_{CC} = 5 V	1.5	ns
C_I	input capacitance	$V_I = V_{CC}$ or GND	3.0	pF
C_O	output capacitance		4.0	pF
C_{PD}	power dissipation capacitance	C_L = 50 pF; f = 1 MHz; notes 1 and 2	9.1	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in µW).
   $P_D = C_{PD} \times V_{CC}^2 \times f_i + \sum (C_L \times V_{CC}^2 \times f_o)$ where:
   f_i = input frequency in MHz;
   f_o = output frequency in MHz;
   $\sum (C_L \times V_{CC}^2 \times f_o)$ = sum of outputs;
   C_L = output load capacitance in pF;
   V_{CC} = supply voltage in Volts.
2. The condition is V_I = GND to V_{CC}.

PINNING

PIN	SYMBOL	DESCRIPTION
1, 3, 5, 9, 11 and 13	1A to 6A	data inputs
2, 4, 6, 8, 10 and 12	1Y to 6Y	data outputs
7	GND	ground (0 V)
14	V_{CC}	DC supply voltage

Hex inverter 74AHCU04

ORDERING INFORMATION

OUTSIDE NORTH AMERICA	NORTH AMERICA	PACKAGES			
		PINS	PACKAGE	MATERIAL	CODE
74AHCU04D	74AHCU04D	14	SO	plastic	SOT108-1
74AHCU04PW	74AHC04PW DH	14	TSSOP	plastic	SOT402-1

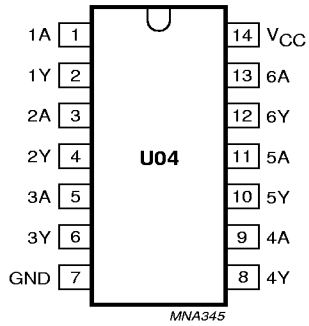


Fig.1 Pin configuration.

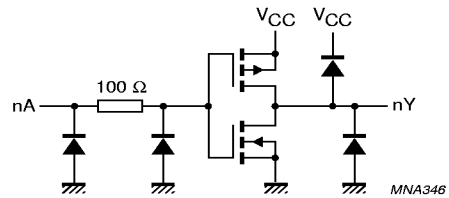


Fig.2 Schematic diagram (one inverter).

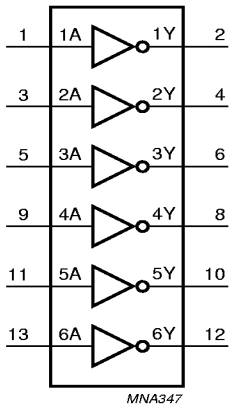


Fig.3 Functional diagram.

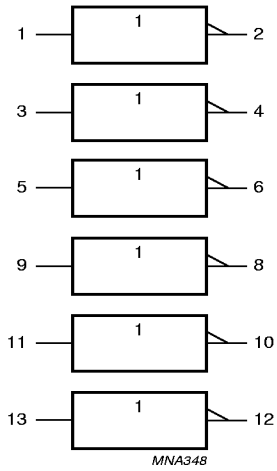


Fig.4 IEC logic symbol.

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC 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}	operating ambient temperature range	see DC and AC characteristics per device	−40	+25	+85	°C
			−40	+25	+125	°C
t_r, t_f ($\Delta t/\Delta f$)	input rise and fall rates	V_{CC} = 3.3 V ±0.3 V	–	–	100	ns/V
		V_{CC} = 5 V ±0.5 V	–	–	20	

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134); voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage		−0.5	+7.0	V
V_I	input voltage range		−0.5	+7.0	V
I_{IK}	DC input diode current	$V_I < -0.5$ V; note 1	–	−20	mA
I_{OK}	DC output diode current	$V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V; note 1	–	±20	mA
I_O	DC output source or sink current	-0.5 V $< V_O < V_{CC} + 0.5$ V	–	±25	mA
I_{CC}	DC V_{CC} or GND current		–	±75	mA
T_{stg}	storage temperature range		−65	+150	°C
P_D	power dissipation per package	for temperature range: −40 to +125 °C; note 2	–	500	mW

Notes

1. The input and output voltage ratings may be exceeded if the input and output current ratings are observed.
2. For SO packages: above 70 °C the value of P_D derates linearly with 8 mW/K.
   For TSSOP packages: above 60 °C the value of P_D derates linearly with 5.5 mW/K.

DC CHARACTERISTICS

Over recommended operating conditions; voltage are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	TEST CONDITIONS		T_{amb} (°C)							UNIT
		OTHER	V_{CC} (V)	25			−40 to +85		−40 to +125		
				MIN.	TYP.	MAX.	MIN.	MAX.	MIN.	MAX.	
V_{IH}	HIGH-level input voltage		2.0	1.7	–	–	1.7	–	1.7	–	V
			3.0	2.4	–	–	2.4	–	2.4	–	
			5.5	4.4	–	–	4.4	–	4.4	–	
V_{IL}	LOW-level input voltage		2.0	–	–	0.3	–	0.3	–	0.3	V
			3.0	–	–	0.6	–	0.6	–	0.6	
			5.5	–	–	1.1	–	1.1	–	1.1	
V_{OH}	HIGH-level output voltage; all outputs	$V_I = V_{IH}$ or V_{IL}; $I_O = -50$ µA	2.0	1.8	2.0	–	1.8	–	1.8	–	V
			3.0	2.7	3.0	–	2.7	–	2.7	–	
			4.5	4.0	4.5	–	4.0	–	4.0	–	
	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}; $I_O = -4.0$ mA	3.0	2.58	–	–	2.48	–	2.40	–	V
		$V_I = V_{IH}$ or V_{IL}; $I_O = -8.0$ mA	4.5	3.94	–	–	3.8	–	3.7	–	
V_{OL}	LOW-level output voltage; all outputs	$V_I = V_{IH}$ or V_{IL}; $I_O = 50$ µA	2.0	–	0	0.2	–	0.2	–	0.2	V
			3.0	–	0	0.3	–	0.3	–	0.3	
			4.5	–	0	0.5	–	0.5	–	0.5	
	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}; $I_O = 4$ mA	3.0	–	–	0.36	–	0.44	–	0.55	V
		$V_I = V_{IH}$ or V_{IL}; $I_O = 8$ mA	4.5	–	–	0.36	–	0.44	–	0.55	
I_I	input leakage current	$V_I = V_{CC}$ or GND	5.5	–	–	0.1	–	1.0	–	2.0	µA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND	5.5	–	–	±0.25	–	±2.5	–	±10.0	µA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; $I_O = 0$	5.5	–	–	2.0	–	20	–	40	µA
C_I	input capacitance			–	3	10	–	10	–	10	pF

AC CHARACTERISTICS

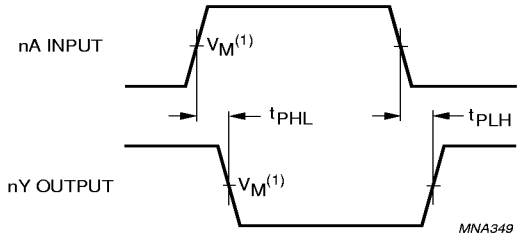
GND = 0 V; $t_r = t_f \leq 3.0$ ns.

SYMBOL	PARAMETER	TEST CONDITIONS		T_{amb} (°C)							UNIT
		WAVEFORMS	C_L	25			−40 to +85		−40 to +125		
				MIN.	TYP.	MAX.	MIN.	MAX.	MIN.	MAX.	
V_{CC} = 3.0 to 3.6 V; note 1											
t_{PHL}/t_{PLH}	propagation delay nA to nY	see Figs 5 and 6	15 pF	–	3.0	7.1	1.0	8.5	1.0	9.0	ns
			50 pF	–	4.3	10.6	1.0	12	1.0	13.5	ns
V_{CC} = 4.5 to 5.5 V; note 2											
t_{PHL}/t_{PLH}	propagation delay nA to nY	see Figs 5 and 6	15 pF	–	2.4	5.5	1.0	6.5	1.0	7.0	ns
			50 pF	–	3.5	7.0	1.0	8.0	1.0	9.0	ns

Notes

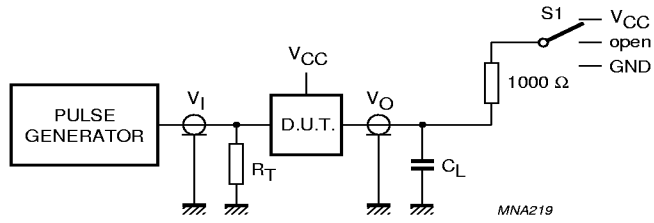
1. Typical values at V_{CC} = 3.3 V.
2. Typical values at V_{CC} = 5.0 V.

AC WAVEFORMS



V_I INPUT REQUIREMENTS	$V_M^{(1)}$ INPUT	$V_M^{(1)}$ OUTPUT
GND to V_{CC}	50% V_{CC}	50% V_{CC}

Fig.5 The input (nA) to output (nY) propagation delay.



TEST	S_1
t_{PLH}/t_{PHL}	open
t_{PLZ}/t_{PZL}	V_{CC}
t_{PHZ}/t_{PZH}	GND

Fig.6 Load circuitry for switching times.

TYPICAL TRANSFER CHARACTERISTICS

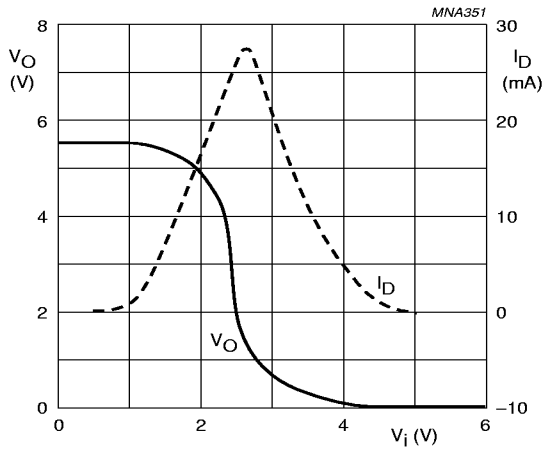


Fig.7 V_{CC} = 5.5 V; I_O = 0.

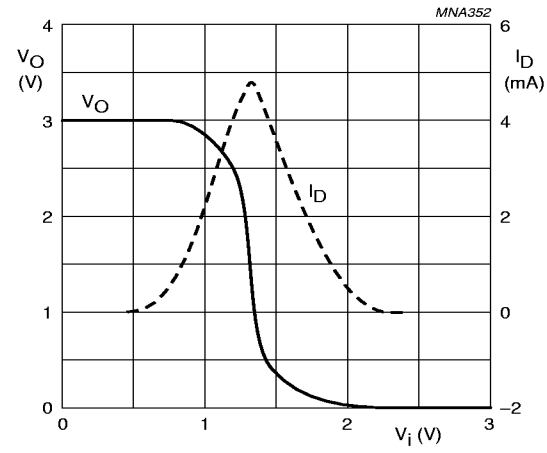


Fig.8 V_{CC} = 3.0 V; I_O = 0.

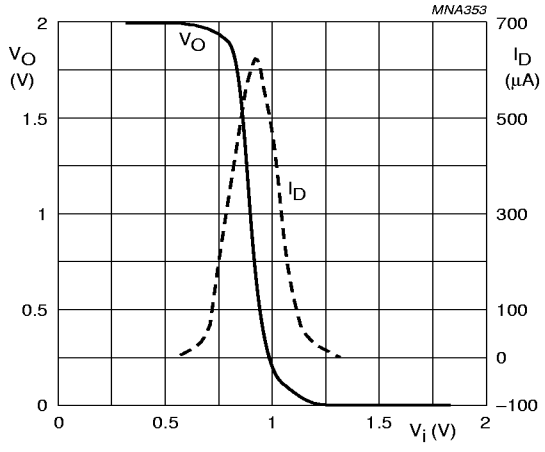


Fig.9 V_{CC} = 2.0 V; I_O = 0.

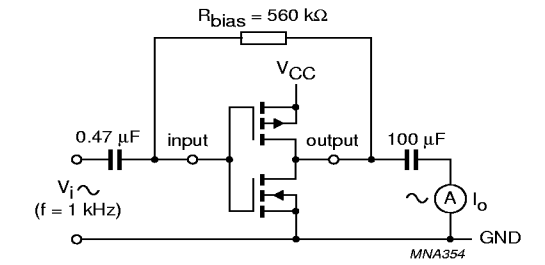


Fig.10 Test set-up for measuring forward transconductance $g_{fs} = dI_o/dV_i$ at V_o is constant (see Fig.11).

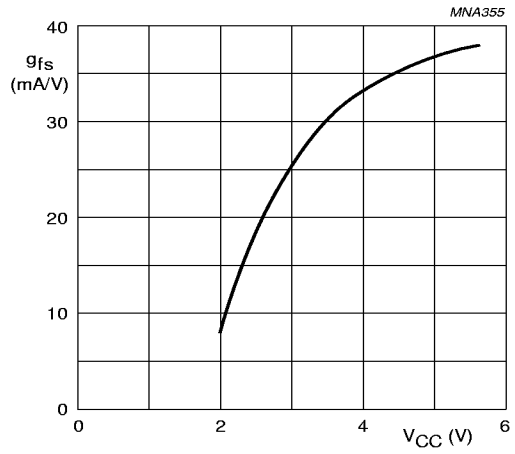


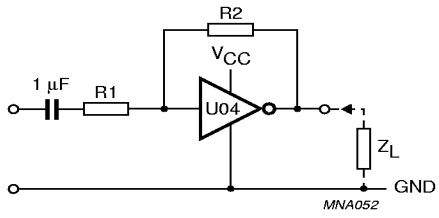
Fig.11 Typical forward transconductance g_{fs} as a function of the supply voltage at T_{amb} = 25 °C.

APPLICATION INFORMATION

Some applications for the AHCU04 are:

- Linear amplifier (see Fig.12)
- In crystal oscillator design (see Fig.13)
- Astable multivibrator (see Fig.14).

All values given are typical unless otherwise specified.



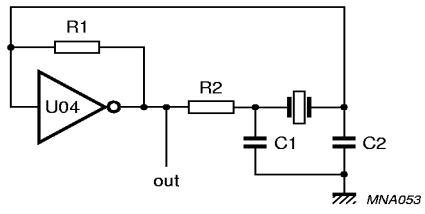
Z_L > 10 kΩ; A_{OL} = 12 (typical)

$$A_u = -\frac{A_{OL}}{1 + \frac{R1}{R2}(1 + A_{OL})} \; ;$$

$$V_{0\ max\ (p\text{-}p)} \approx V_{CC} - 2\ V \text{ centered at } \frac{1}{2}V_{CC}$$

R1 ≥ 3 kΩ, R2 ≤ 1 MΩ.
Typical unity gain bandwidth product is 5 MHz.
A_{OL} = open loop amplification.
A_u = voltage amplification.

Fig.12 Used as a linear amplifier.



C1 = 47 pF (typical).
C2 = 33 pF (typical).
R1 = 1 to 10 MΩ (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 V and f = 10 MHz).

Fig.13 Crystal oscillator configuration.

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

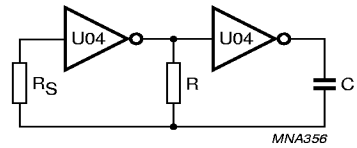
FREQUENCY (kHz)	R1 (MΩ)	R2 (kΩ)	C1 (pF)	C2 (pF)
10 to 15.9	22	220	56	20
16 to 24.9	22	220	56	10
25 to 54.9	22	100	56	10
55 to 129.9	22	100	47	5
130 to 199.9	22	47	47	5
200 to 349.9	10	47	47	5
350 to 600	10	47	47	5

Note

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

Table 2 Optimum value for R2

FREQUENCY (kHz)	R2 (kΩ)	OPTIMUM FOR
3	2.0	minimum required I_{CC}
	8.0	minimum influence due to change in V_{CC}
6	1.0	minimum required I_{CC}
	4.7	minimum influence by V_{CC}
10	0.5	minimum required I_{CC}
	2.0	minimum influence by V_{CC}
14	0.5	minimum required I_{CC}
	1.0	minimum influence by V_{CC}
>14	replace R2 by C3 with a typical value of 35 pF	



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

$R_S \approx 2 \times R$

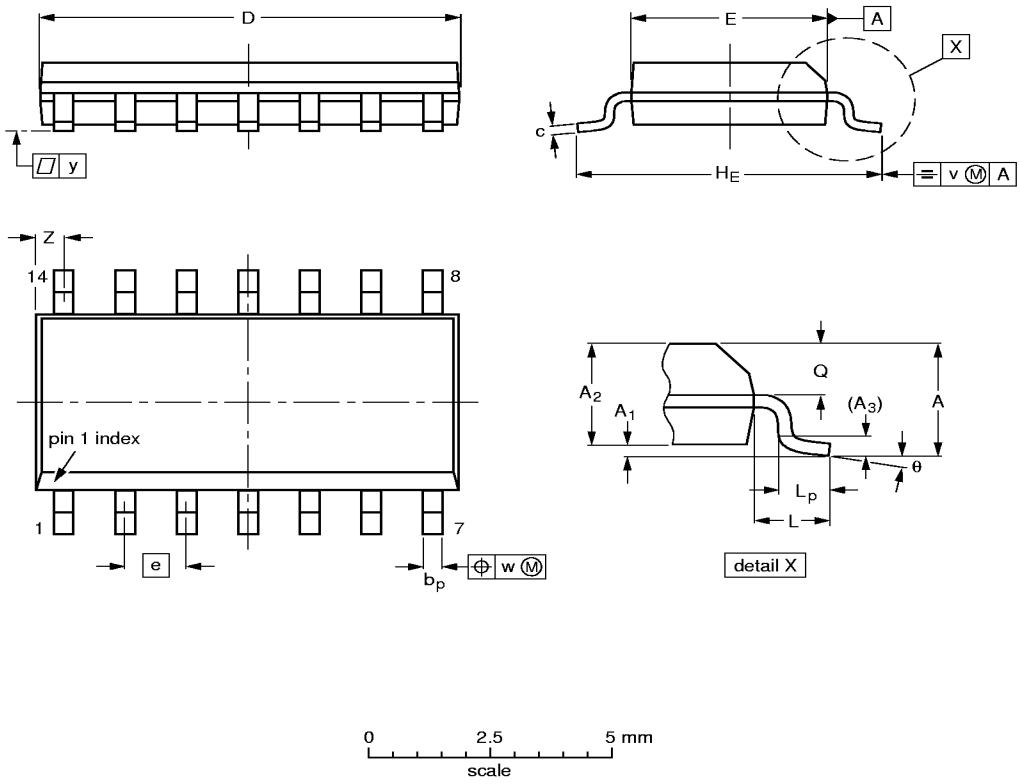
$1 = \frac{1}{T} \approx \frac{1}{2.2RC}$

Fig.14 Used as an astable multivibrator.

Hex inverter 74AHCU04

PACKAGE OUTLINES

SO14: plastic small outline package; 14 leads; body width 3.9 mm **SOT108-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

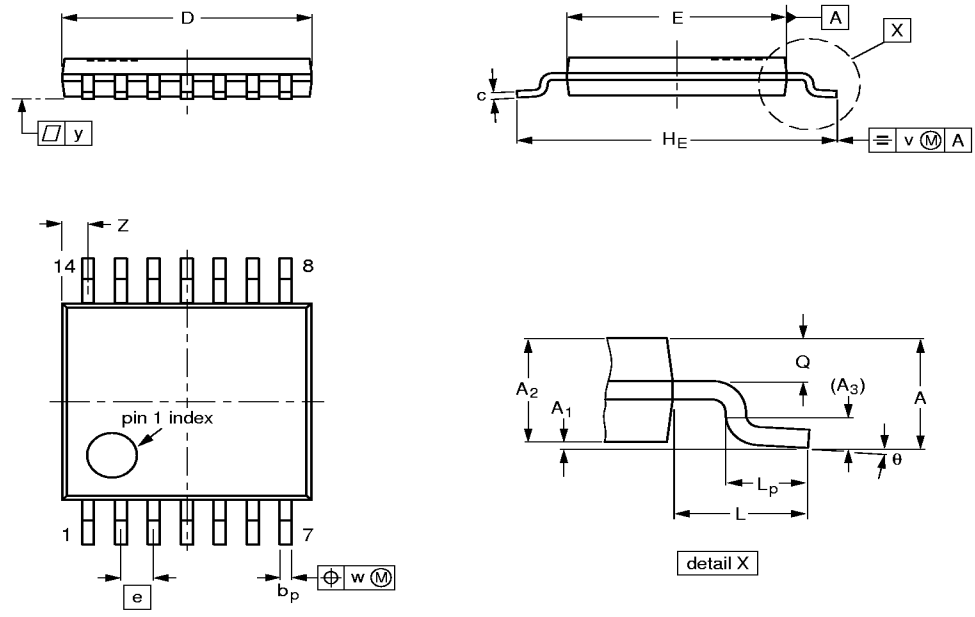
UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	8.75 8.55	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.35 0.34	0.16 0.15	0.050	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

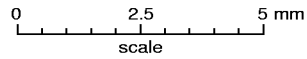
Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT108-1	076E06S	MS-012AB				~~95-01-23~~ 97-05-22

TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm **SOT402-1**





DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (2)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	1.10	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1.0	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.72 0.38	8° 0°

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT402-1		MO-153				~~94-07-12~~ 95-04-04

SOLDERING

Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering is not always suitable for surface mount ICs, or for printed-circuit boards with high population densities. In these situations reflow soldering is often used.

Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several methods exist for reflowing; for example, infrared/convection heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 250 °C. The top-surface temperature of the packages should preferable be kept below 230 °C.

Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
  - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
  - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

  The footprint must incorporate solder thieves at the downstream end.
- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time is 4 seconds at 250 °C.
A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

Suitability of surface mount IC packages for wave and reflow soldering methods

PACKAGE	SOLDERING METHOD	
	WAVE	REFLOW(1)
BGA, LFBGA, SQFP, TFBGA	not suitable	suitable
HLQFP, HSQFP, HSOP, HTQFP, HTSSOP, SMS	not suitable(2)	suitable
PLCC(3), SO, SOJ	suitable	suitable
LQFP, QFP, TQFP	not recommended(3)(4)	suitable
SSOP, TSSOP, VSO	not recommended(5)	suitable

Notes

1. All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the *"Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods"*.
2. These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).
3. If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
4. Wave soldering is only suitable for LQFP, TQFP and QFP packages with a pitch (e) equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
5. Wave soldering is only suitable for SSOP and TSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.