

# HEF4093B

Quad 2-input NAND Schmitt trigger

Rev. 9 — 15 December 2015

Product data sheet

## 1. General description

The HEF4093B is a quad two-input NAND gate. Each input has a Schmitt trigger circuit. The gate switches at different points for positive-going and negative-going signals. The difference between the positive voltage ( $V_{T+}$ ) and the negative voltage ( $V_{T-}$ ) is defined as hysteresis voltage ( $V_H$ ).

It operates over a recommended  $V_{DD}$  power supply range of 3 V to 15 V referenced to  $V_{SS}$  (usually ground). Unused inputs must be connected to  $V_{DD}$ ,  $V_{SS}$ , or another input.

## 2. Features and benefits

- Schmitt trigger input discrimination
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Specified from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  and  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Complies with JEDEC standard JESD 13-B

## 3. Applications

- Wave and pulse shapers
- Astable multivibrators
- Monostable multivibrators

## 4. Ordering information

Table 1. Ordering information

All types operate from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$

Type number	Package		
	Name	Description	Version
HEF4093BT	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1

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## 5. Functional diagram

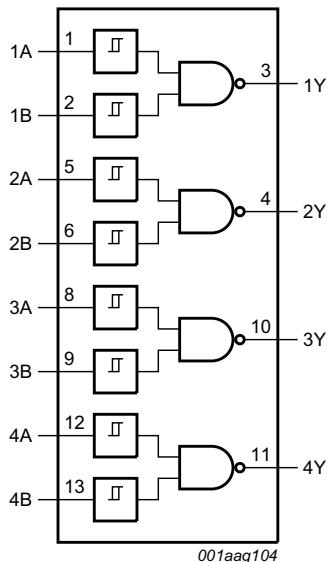


Fig 1. Functional diagram

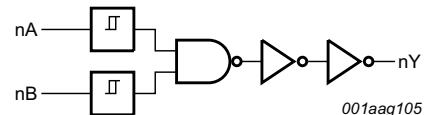


Fig 2. Logic diagram (one gate)

## 6. Pinning information

### 6.1 Pinning

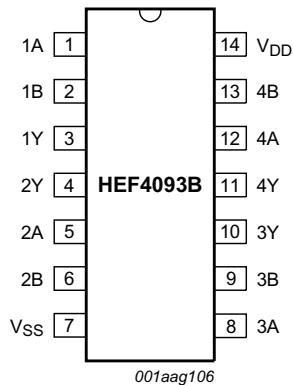


Fig 3. Pin configuration

## 6.2 Pin description

**Table 2.** Pin description

Symbol	Pin	Description
1A to 4A	1, 5, 8, 12	input
1B to 4B	2, 6, 9, 13	input
1Y to 4Y	3, 4, 10, 11	output
V <sub>DD</sub>	14	supply voltage
V <sub>SS</sub>	7	ground (0 V)

## 7. Functional description

**Table 3.** Function table<sup>[1]</sup>

Input		Output
nA	nB	nY
L	L	H
L	H	H
H	L	H
H	H	L

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

## 8. Limiting values

**Table 4.** Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to V<sub>SS</sub> = 0 V (ground).

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>DD</sub>	supply voltage		-0.5	+18	V
I <sub>IK</sub>	input clamping current	V <sub>I</sub> < -0.5 V or V <sub>I</sub> > V <sub>DD</sub> + 0.5 V	-	±10	mA
V <sub>I</sub>	input voltage		-0.5	V <sub>DD</sub> + 0.5	V
I <sub>OK</sub>	output clamping current	V <sub>O</sub> < -0.5 V or V <sub>O</sub> > V <sub>DD</sub> + 0.5 V	-	±10	mA
I <sub>I/O</sub>	input/output current		-	±10	mA
I <sub>DD</sub>	supply current		-	50	mA
T <sub>stg</sub>	storage temperature		-65	+150	°C
T <sub>amb</sub>	ambient temperature		-40	+125	°C
P <sub>tot</sub>	total power dissipation	T <sub>amb</sub> = -40 °C to +125 °C SO14 <sup>[1]</sup>	-	500	mW
P	power dissipation	per output	-	100	mW

[1] For SO14 packages: above T<sub>amb</sub> = 70 °C, P<sub>tot</sub> derates linearly with 8 mW/K.

## 9. Recommended operating conditions

**Table 5. Recommended operating conditions**

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{DD}$	supply voltage		3	15	V
$V_I$	input voltage		0	$V_{DD}$	V
$T_{amb}$	ambient temperature	in free air	-40	+125	°C

## 10. Static characteristics

**Table 6. Static characteristics**

$V_{SS} = 0$  V;  $V_I = V_{SS}$  or  $V_{DD}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	$V_{DD}$	$T_{amb} = -40$ °C		$T_{amb} = +25$ °C		$T_{amb} = +85$ °C		$T_{amb} = +125$ °C		Unit
				Min	Max	Min	Max	Min	Max	Min	Max	
$V_{OH}$	HIGH-level output voltage	$ I_O  < 1$ μA	5 V	4.95	-	4.95	-	4.95	-	4.95	-	V
			10 V	9.95	-	9.95	-	9.95	-	9.95	-	V
			15 V	14.95	-	14.95	-	14.95	-	14.95	-	V
$V_{OL}$	LOW-level output voltage	$ I_O  < 1$ μA	5 V	-	0.05	-	0.05	-	0.05	-	0.05	V
			10 V	-	0.05	-	0.05	-	0.05	-	0.05	V
			15 V	-	0.05	-	0.05	-	0.05	-	0.05	V
$I_{OH}$	HIGH-level output current	$V_O = 2.5$ V	5 V	-	-1.7	-	-1.4	-	-1.1	-	-1.1	mA
		$V_O = 4.6$ V	5 V	-	-0.64	-	-0.5	-	-0.36	-	-0.36	mA
		$V_O = 9.5$ V	10 V	-	-1.6	-	-1.3	-	-0.9	-	-0.9	mA
		$V_O = 13.5$ V	15 V	-	-4.2	-	-3.4	-	-2.4	-	-2.4	mA
$I_{OL}$	LOW-level output current	$V_O = 0.4$ V	5 V	0.64	-	0.5	-	0.36	-	0.36	-	mA
		$V_O = 0.5$ V	10 V	1.6	-	1.3	-	0.9	-	0.9	-	mA
		$V_O = 1.5$ V	15 V	4.2	-	3.4	-	2.4	-	2.4	-	mA
$I_I$	input leakage current		15 V	-	$\pm 0.1$	-	$\pm 0.1$	-	$\pm 1.0$	-	$\pm 1.0$	μA
$I_{DD}$	supply current	all valid input combinations; $I_O = 0$ A	5 V	-	0.25	-	0.25	-	7.5	-	7.5	μA
			10 V	-	0.5	-	0.5	-	15.0	-	15.0	μA
			15 V	-	1.0	-	1.0	-	30.0	-	30.0	μA
$C_I$	input capacitance			-	-	-	7.5	-	-	-	-	pF

## 11. Dynamic characteristics

**Table 7. Dynamic characteristics**

$T_{amb} = 25^\circ\text{C}$ ;  $C_L = 50 \text{ pF}$ ;  $t_r = t_f \leq 20 \text{ ns}$ ; wave forms see [Figure 4](#); test circuit see [Figure 5](#); unless otherwise specified.

Symbol	Parameter	Conditions	V <sub>DD</sub>	Extrapolation formula <sup>[1]</sup>	Min	Typ	Max	Unit
t <sub>PHL</sub>	HIGH to LOW propagation delay	nA or nB to nY	5 V	$63 \text{ ns} + (0.55 \text{ ns/pF})C_L$	-	90	185	ns
			10 V	$29 \text{ ns} + (0.23 \text{ ns/pF})C_L$	-	40	80	ns
			15 V	$22 \text{ ns} + (0.16 \text{ ns/pF})C_L$	-	30	60	ns
t <sub>PLH</sub>	LOW to HIGH propagation delay	nA or nB to nY	5 V	$58 \text{ ns} + (0.55 \text{ ns/pF})C_L$	-	85	170	ns
			10 V	$29 \text{ ns} + (0.23 \text{ ns/pF})C_L$	-	40	80	ns
			15 V	$22 \text{ ns} + (0.16 \text{ ns/pF})C_L$	-	30	60	ns
t <sub>THL</sub>	HIGH to LOW output transition time	nY to LOW	5 V	$10 \text{ ns} + (1.00 \text{ ns/pF})C_L$	-	60	120	ns
			10 V	$9 \text{ ns} + (0.42 \text{ ns/pF})C_L$	-	30	60	ns
			15 V	$6 \text{ ns} + (0.28 \text{ ns/pF})C_L$	-	20	40	ns
t <sub>TLH</sub>	LOW to HIGH output transition time	nA or nB to HIGH	5 V	$10 \text{ ns} + (1.00 \text{ ns/pF})C_L$	-	60	120	ns
			10 V	$9 \text{ ns} + (0.42 \text{ ns/pF})C_L$	-	30	60	ns
			15 V	$6 \text{ ns} + (0.28 \text{ ns/pF})C_L$	-	20	40	ns

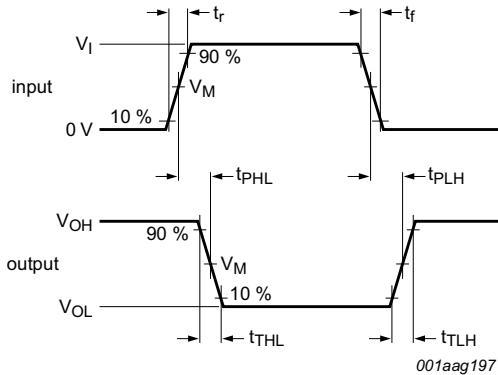
[1] Typical value of the propagation delay and output transition time can be calculated with the extrapolation formula ( $C_L$  in pF).

**Table 8. Dynamic power dissipation**

$V_{SS} = 0 \text{ V}$ ;  $t_r = t_f \leq 20 \text{ ns}$ ;  $T_{amb} = 25^\circ\text{C}$ .

Symbol	Parameter	V <sub>DD</sub>	Typical formula	where:
P <sub>D</sub>	dynamic power dissipation	5 V	$P_D = 1300 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2 (\mu\text{W})$	$f_i$ = input frequency in MHz; $f_o$ = output frequency in MHz;
		10 V	$P_D = 6400 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2 (\mu\text{W})$	$C_L$ = output load capacitance in pF; $\Sigma(f_o \times C_L)$ = sum of the outputs;
		15 V	$P_D = 18700 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2 (\mu\text{W})$	$V_{DD}$ = supply voltage in V.

## 12. Waveforms



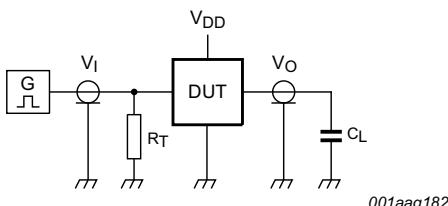
Measurement points are given in [Table 9](#).

Logic levels:  $V_{OL}$  and  $V_{OH}$  are typical output voltage levels that occur with the output load.  
 $t_r, t_f$  = input rise and fall times.

**Fig 4. Propagation delay and output transition time**

**Table 9. Measurement points**

Supply voltage	Input	Output
$V_{DD}$	$V_M$	$V_M$
5 V to 15 V	$0.5V_{DD}$	$0.5V_{DD}$



Test data given in [Table 10](#).

Definitions for test circuit:

DUT = Device Under Test.

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

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

**Fig 5. Test circuit for measuring switching times**

**Table 10. Test data**

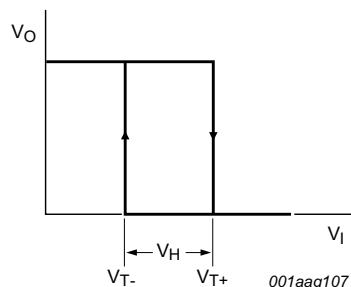
Supply voltage	Input	Load
$V_{DD}$	$V_I$	$C_L$
5 V to 15 V	$V_{SS}$ or $V_{DD}$	$\leq 20 \text{ ns}$
		50 pF

## 13. Transfer characteristics

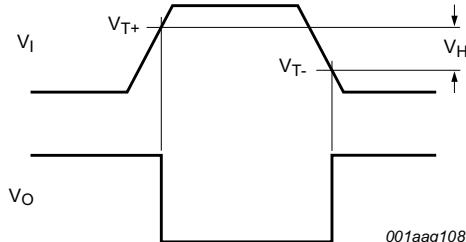
**Table 11. Transfer characteristics**

$V_{SS} = 0 \text{ V}$ ;  $T_{amb} = 25 \text{ }^{\circ}\text{C}$ ; see [Figure 6](#) and [Figure 7](#).

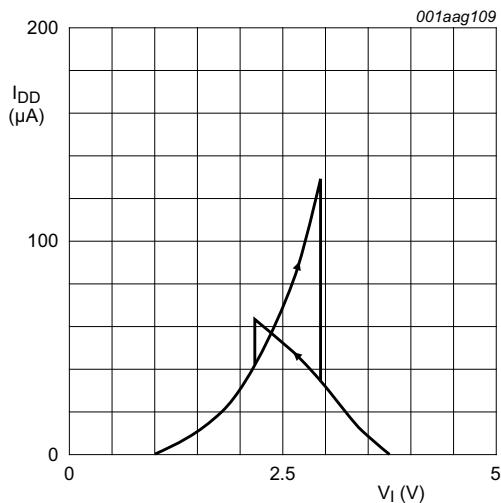
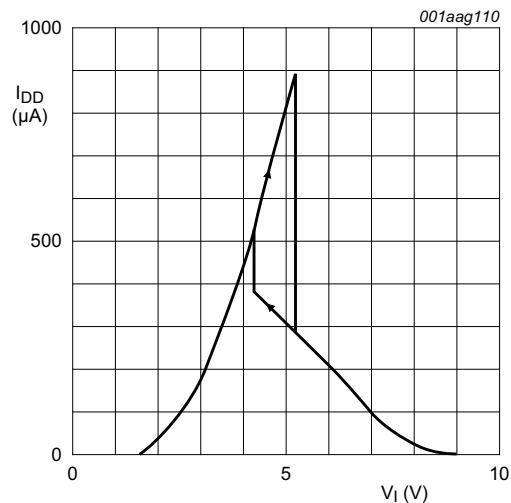
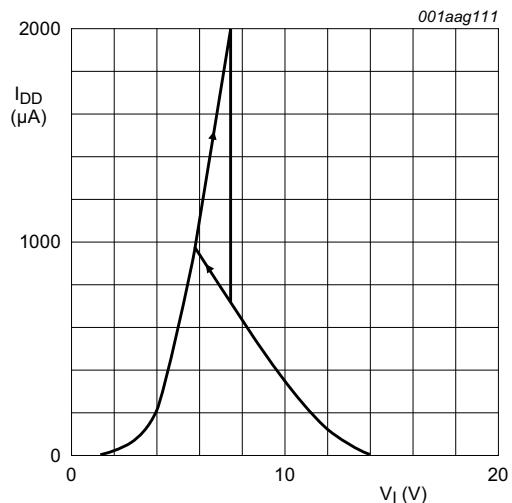
Symbol	Parameter	Conditions	$V_{DD}$	Min	Typ	Max	Unit
$V_{T+}$	positive-going threshold voltage		5 V	1.9	2.9	3.5	V
			10 V	3.6	5.2	7	V
			15 V	4.7	7.3	11	V
$V_{T-}$	negative-going threshold voltage		5 V	1.5	2.2	3.1	V
			10 V	3	4.2	6.4	V
			15 V	4	6.0	10.3	V
$V_H$	hysteresis voltage		5 V	0.4	0.7	-	V
			10 V	0.6	1.0	-	V
			15 V	0.7	1.3	-	V

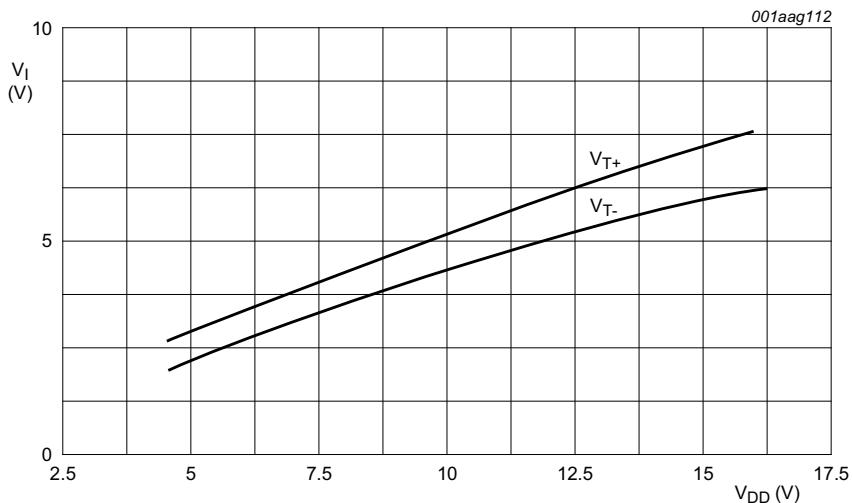


**Fig 6. Transfer characteristic**



**Fig 7. Waveforms showing definition of  $V_{T+}$  and  $V_{T-}$  (between limits at 30 % and 70 %) and  $V_H$**

a.  $V_{DD} = 5 \text{ V}; T_{amb} = 25 \text{ }^{\circ}\text{C}$ b.  $V_{DD} = 10 \text{ V}; T_{amb} = 25 \text{ }^{\circ}\text{C}$ c.  $V_{DD} = 15 \text{ V}; T_{amb} = 25 \text{ }^{\circ}\text{C}$ **Fig 8. Typical drain current as a function of input**



T<sub>amb</sub> = 25 °C.

Fig 9. Typical switching levels as a function of supply voltage

## 14. Application information

Some examples of applications for the HEF4093B are:

- Wave and pulse shapers
- Astable multivibrators
- Monostable multivibrators

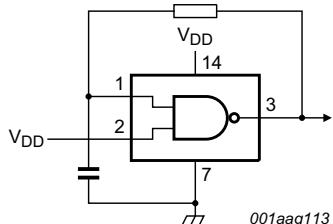


Fig 10. Astable multivibrator

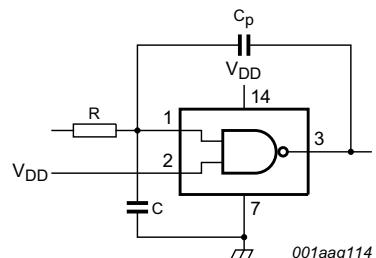


Fig 11. Schmitt trigger driven via a high-impedance input

If a Schmitt trigger is driven via a high-impedance ( $R > 1 \text{ k}\Omega$ ), then it is necessary to incorporate a capacitor C with a value of  $\frac{C}{C_P} > \frac{V_{DD} - V_{SS}}{V_H}$ ; otherwise oscillation can occur on the edges of a pulse.

C<sub>P</sub> is the external parasitic capacitance between inputs and output; the value depends on the circuit board layout.

**Remark:** The two inputs may be connected together, but this will result in a larger through-current at the moment of switching.

## 15. Package outline

SO14: plastic small outline package; 14 leads; body width 3.9 mm

SOT108-1

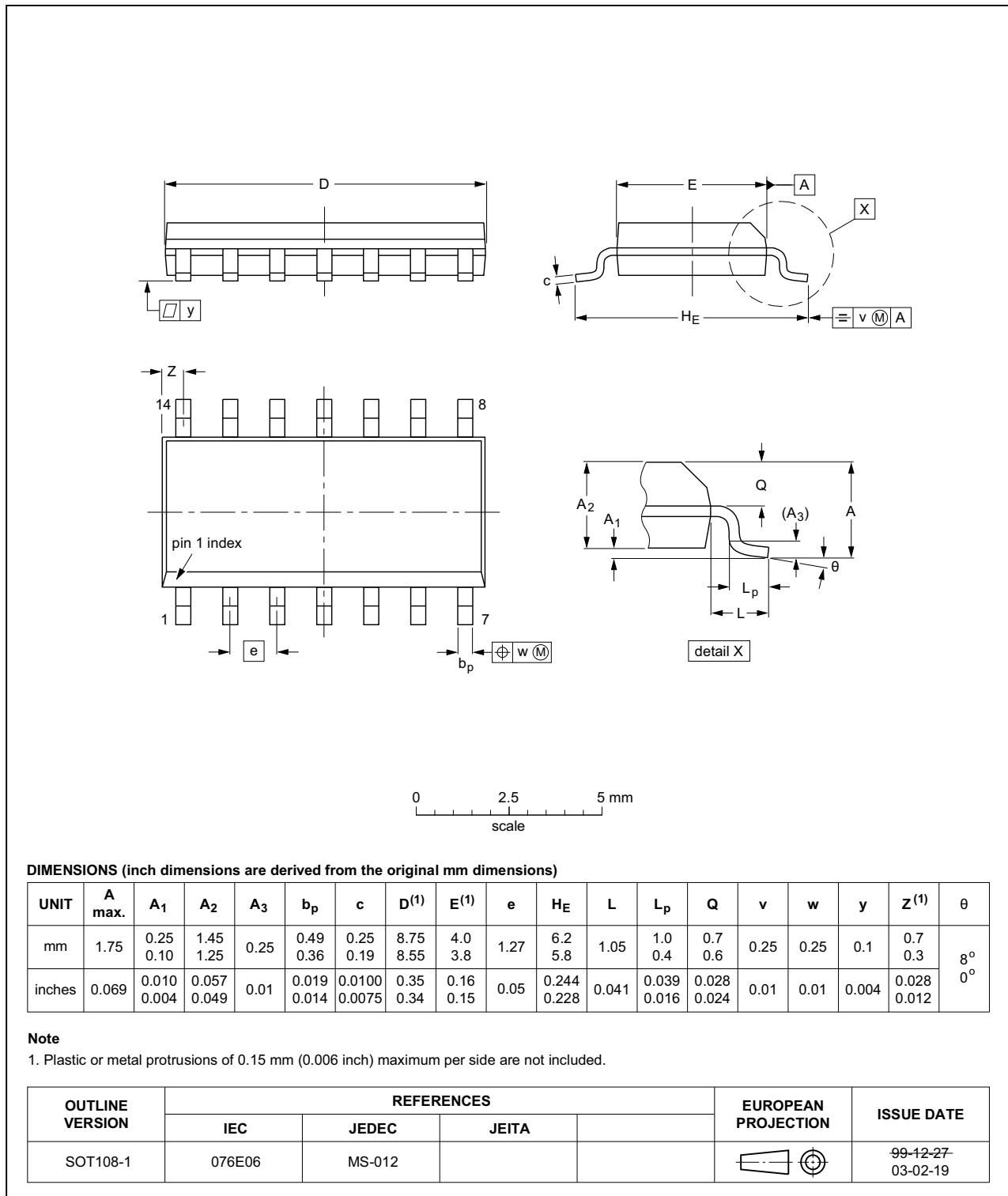


Fig 12. Package outline SOT108-1 (SO14)

## 16. Abbreviations

Table 12. Abbreviations

Acronym	Description
DUT	Device Under Test

## 17. Revision history

Table 13. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4093B v.9	20151215	Product data sheet	-	HEF4093B v.8
Modifications:	• Type number HEF4093BP (SOT27-1) removed.			
HEF4093B v.8	20111121	Product data sheet	-	HEF4093B v.7
Modifications:	• <a href="#">Table 6</a> : $I_{OH}$ minimum values changed to maximum			
HEF4093B v.7	20100901	Product data sheet	-	HEF4093B v.6
HEF4093B v.6	20091202	Product data sheet	-	HEF4093B v.5
HEF4093B v.5	20090728	Product data sheet	-	HEF4093B v.4
HEF4093B v.4	20080612	Product data sheet	-	HEF4093B_CNV v.3
HEF4093B_CNV v.3	19950101	Product specification	-	HEF4093B_CNV v.2
HEF4093B_CNV v.2	19950101	Product specification	-	-

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### 18.1 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".

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