HEF4013B

Dual D-type flip-flop

Rev. 04 — 15 May 2008 Product data sheet

1. General description

The HEF4013B is a dual D-type flip-flop that features independent set-direct input (SD), clear-direct input (CD), clock input (CP) and outputs (Q, $\overline{Q}$). Data is accepted when CP is LOW and is transferred to the output on the positive-going edge of the clock. The active HIGH asynchronous CD and SD inputs are independent and override the D or CP inputs. The outputs are buffered for best system performance. The clock input's Schmitt-trigger action makes the circuit highly tolerant of slower clock rise and fall times.

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. The device is suitable for use over both the industrial (–40 °C to +85 °C) and automotive (–40 °C to +125 °C) temperature ranges.

2. Features

- Tolerant of slow clock rise and fall times
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Operates across the automotive temperature range from –40 °C to +125 °C
- Complies with JEDEC standard JESD 13-B
- ESD protection:
  - HBM JESD22-A114E exceeds 2000 V
  - MM JESD22-A115-A exceeds 200 V

3. Applications

- Counters and dividers
- Registers
- Toggle flip-flops

4. Ordering information

Table 1. Ordering information

All types operate from −40 °C to +125 °C

Type number	Package		
	Name	Description	Version
HEF4013BP	DIP14	plastic dual in-line package; 14 leads (300 mil)	SOT27-1
HEF4013BT	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
HEF4013BTT	TSSOP14	plastic thin shrink small outline package; 14 leads; body width 4.4 mm	SOT402-1

5. Functional diagram

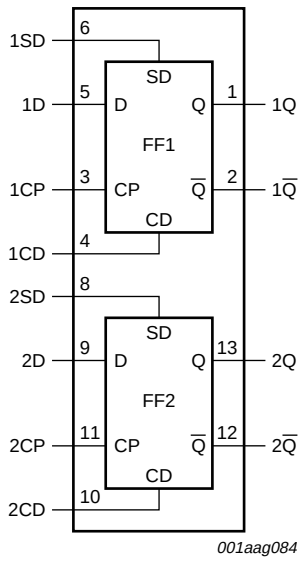


Fig 1. Functional diagram

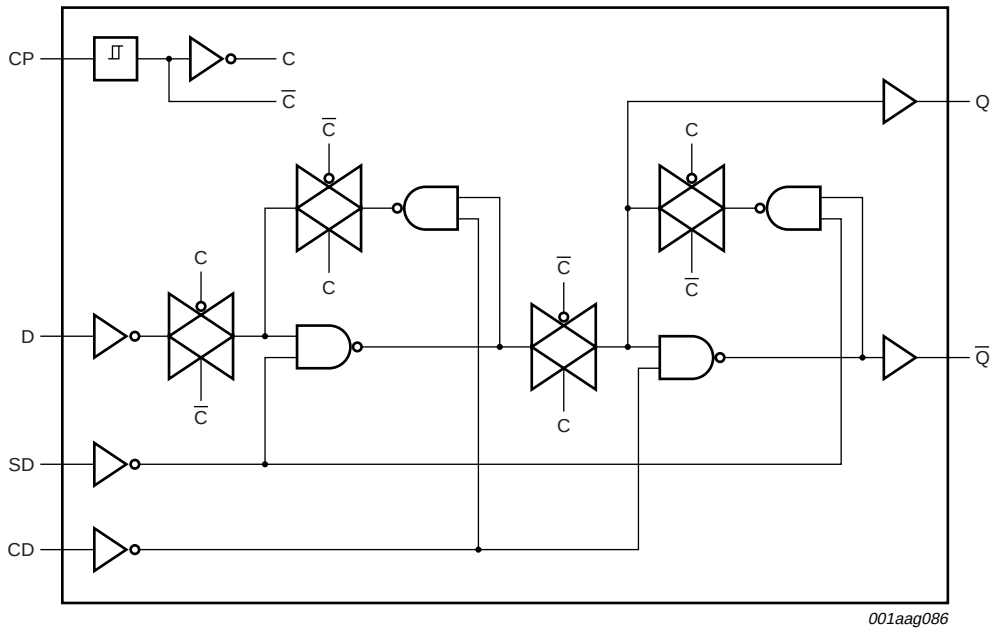


Fig 2. Logic diagram (one flip-flop)

6. Pinning information

6.1 Pinning

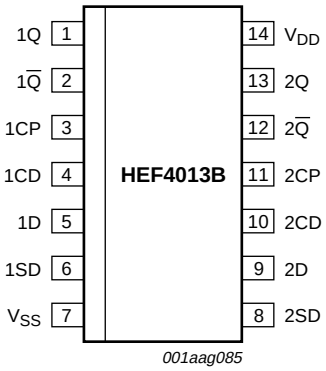


Fig 3. Pin configuration

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
1Q, 2Q	1, 13	true output
1$\overline{Q}$, 2$\overline{Q}$	2, 12	complement output
1CP, 2CP	3, 11	clock input (LOW to HIGH edge-triggered)
1CD, 2CD	4, 10	asynchronous clear-direct input (active HIGH)

Table 2. Pin description *...continued*

Symbol	Pin	Description
1D, 2D	5, 9	data input
1SD, 2SD	6, 8	asynchronous set-direct input (active HIGH)
V_{SS}	7	ground (0 V)
V_{DD}	14	supply voltage

7. Functional description

Table 3. Function table[1]

Control			Input	Output	
nSD	nCD	nCP	nD	nQ	$n\overline{Q}$
H	L	X	X	H	L
L	H	X	X	L	H
H	H	X	X	H	H
L	L	↑	L	L	H
L	L	↑	H	H	L

[1] H = HIGH voltage level; L = LOW voltage level; X = don't care; ↑ = LOW-to-HIGH clock transition.

8. Limiting values

Table 4. Limiting values

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

Symbol	Parameter	Conditions		Min	Max	Unit
V_{DD}	supply voltage			–0.5	+18	V
I_{IK}	input clamping current	$V_I < 0.5$ V or $V_I > V_{DD} + 0.5$ V		-	±10	mA
V_I	input voltage			–0.5	$V_{DD} + 0.5$	V
I_{OK}	output clamping current	$V_O < 0.5$ V or $V_O > V_{DD} + 0.5$ V		-	±10	mA
$I_{I/O}$	input/output current			-	±10	mA
I_{DD}	supply current			-	50	mA
T_{stg}	storage temperature			–65	+150	°C
T_{amb}	ambient temperature			–40	+125	°C
P_{tot}	total power dissipation	T_{amb} = –40 °C to +125 °C				
		DIP14	[1]	-	750	mW
		SO14	[2]	-	500	mW
		TSSOP14	[3]	-	500	mW
P	power dissipation	per output		-	100	mW

[1] For DIP14 packages: above T_{amb} = 70 °C, P_{tot} derates linearly with 12 mW/K.

[2] For SO14 packages: above T_{amb} = 70 °C, P_{tot} derates linearly with 8 mW/K.

[3] For TSSOP14 packages: above T_{amb} = 60 °C, P_{tot} derates linearly with 5.5 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		–40	+125	°C
$\Delta t/\Delta V$	input transition rise and fall rate	V_{DD} = 5 V	-	3.75	ns/V
		V_{DD} = 10 V	-	0.5	ns/V
		V_{DD} = 15 V	-	0.08	ns/V

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_{IH}	HIGH-level input voltage	$\|I_O\|$ < 1 µA	5 V	3.5	-	3.5	-	3.5	-	3.5	-	V
			10 V	7.0	-	7.0	-	7.0	-	7.0	-	V
			15 V	11.0	-	11.0	-	11.0	-	11.0	-	V
V_{IL}	LOW-level input voltage	$\|I_O\|$ < 1 µA	5 V	-	1.5	-	1.5	-	1.5	-	1.5	V
			10 V	-	3.0	-	3.0	-	3.0	-	3.0	V
			15 V	-	4.0	-	4.0	-	4.0	-	4.0	V
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	-	±0.1	-	±0.1	-	±1.0	-	±1.0	µA
I_{DD}	supply current	all valid input combinations; $\|I_O\|$ = 0 A	5 V	-	1.0	-	1.0	-	30	-	30	µA
			10 V	-	2.0	-	2.0	-	60	-	60	µA
			15 V	-	4.0	-	4.0	-	120	-	120	µA
C_I	input capacitance		-	-	-	-	7.5	-	-	-	-	pF

11. Dynamic characteristics

Table 7. Dynamic characteristics

T_{amb} = 25 °C; unless otherwise specified. For test circuit see Figure 6.

Symbol	Parameter	Conditions	V_{DD}		Extrapolation formula	Min	Typ	Max	Unit
t_{PHL}	HIGH to LOW propagation delay	nCP to nQ, $n\overline{Q}$; see Figure 4	5 V	[1]	$83 + 0.55 \times C_L$	-	110	220	ns
			10 V		$34 + 0.23 \times C_L$	-	45	90	ns
			15 V		$22 + 0.16 \times C_L$	-	30	60	ns
		nSD to $n\overline{Q}$	5 V	[1]	$73 + 0.55 \times C_L$	-	100	200	ns
			10 V		$29 + 0.23 \times C_L$	-	40	80	ns
			15 V		$22 + 0.16 \times C_L$	-	30	60	ns
		nCD to nQ	5 V	[1]	$73 + 0.55 \times C_L$	-	100	200	ns
			10 V		$29 + 0.23 \times C_L$	-	40	80	ns
			15 V		$22 + 0.16 \times C_L$	-	30	60	ns
t_{PLH}	LOW to HIGH propagation delay	nCP to nQ, $n\overline{Q}$; see Figure 4	5 V	[1]	$68 + 0.55 \times C_L$	-	95	190	ns
			10 V		$29 + 0.23 \times C_L$	-	40	80	ns
			15 V		$22 + 0.16 \times C_L$	-	30	60	ns
		nSD to nQ	5 V	[1]	$48 + 0.55 \times C_L$	-	75	150	ns
			10 V		$24 + 0.23 \times C_L$	-	35	70	ns
			15 V		$17 + 0.16 \times C_L$	-	25	50	ns
		nCD to $n\overline{Q}$	5 V	[1]	$33 + 0.55 \times C_L$	-	60	120	ns
			10 V		$19 + 0.23 \times C_L$	-	30	60	ns
			15 V		$12 + 0.16 \times C_L$	-	20	40	ns
t_t	transition time	see Figure 4	5 V	[1]	$10 + 1.00 \times C_L$	-	60	120	ns
			10 V		$9 + 0.42 \times C_L$	-	30	60	ns
			15 V		$6 + 0.28 \times C_L$	-	20	40	ns
t_{su}	set-up time	nD to nCP; see Figure 4	5 V			40	20	-	ns
			10 V			25	10	-	ns
			15 V			15	5	-	ns
t_h	hold time	nD to nCP; see Figure 4	5 V			20	0	-	ns
			10 V			20	0	-	ns
			15 V			15	0	-	ns
t_W	pulse width	nCP input LOW; see Figure 4 and 5	5 V			60	30	-	ns
			10 V			30	15	-	ns
			15 V			20	10	-	ns
		nSD input HIGH; see Figure 4 and 5	5 V			50	25	-	ns
			10 V			24	12	-	ns
			15 V			20	10	-	ns
		nCD input HIGH; see Figure 5	5 V			50	25	-	ns
			10 V			24	12	-	ns
			15 V			20	10	-	ns

Table 7. Dynamic characteristics *...continued*

T_{amb} = 25 °C; unless otherwise specified. For test circuit see Figure 6.

Symbol	Parameter	Conditions	V_{DD}	Extrapolation formula	Min	Typ	Max	Unit
t_{rec}	recovery time	nSD input; see Figure 5	5 V		+15	–5	-	ns
			10 V		15	0	-	ns
			15 V		15	0	-	ns
		nCD input; see Figure 5	5 V		40	25	-	ns
			10 V		25	10	-	ns
			15 V		25	10	-	ns
$f_{clk(max)}$	maximum clock frequency	see Figure 4	5 V		7	14	-	MHz
			10 V		14	28	-	MHz
			15 V		20	40	-	MHz

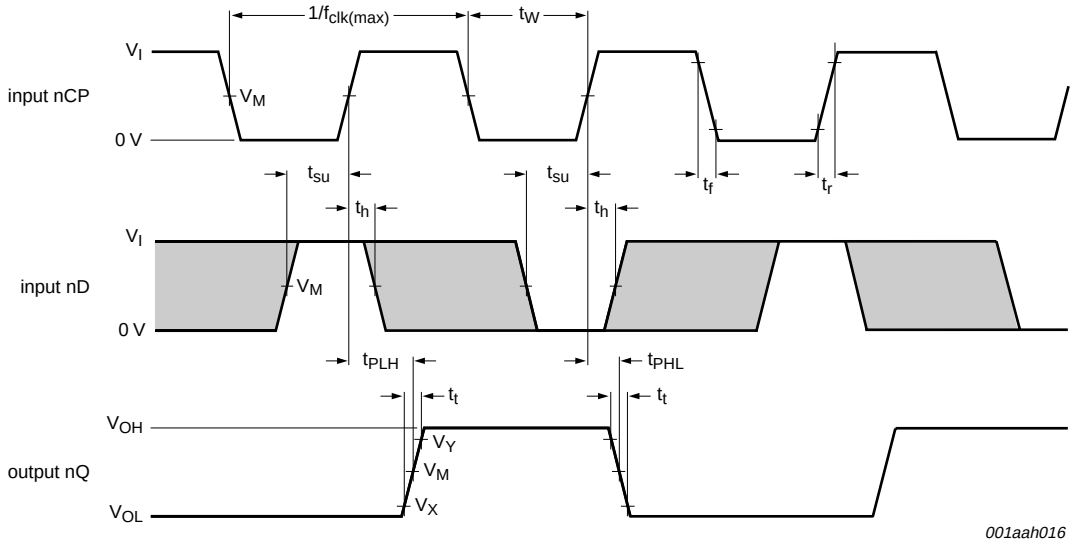
[1] Typical values of the propagation delays and output transition times can be calculated with the extrapolation formulas. C_L is given in pF.

Table 8. Dynamic power dissipation

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

Symbol	Parameter	V_{DD}	Typical formula	Where
P_D	dynamic power dissipation	5 V	$P_D = 850 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$ µW	f_i = input frequency in MHz;
		10 V	$P_D = 3600 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$ µW	f_o = output frequency in MHz;
		15 V	$P_D = 9000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$ µW	C_L = output load capacitance in pF; $\Sigma(f_o \times C_L)$ = sum of the outputs; V_{DD} = supply voltage in V.

12. Waveforms

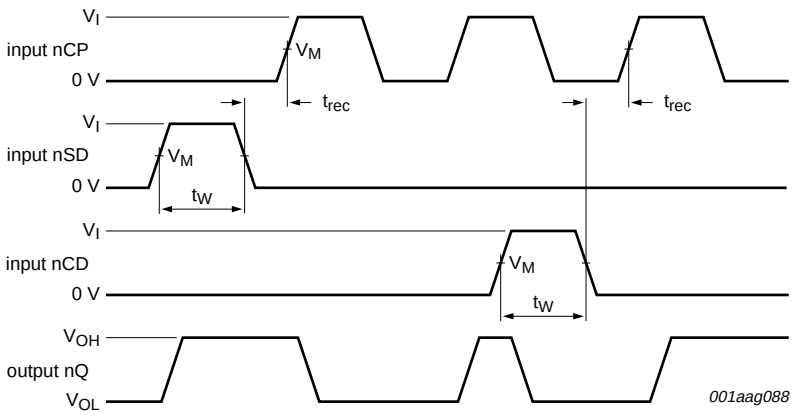


Set-up and hold times are shown as positive values but may be specified as negative values.

The shaded areas indicate when the input is permitted to change for predictable output performance.

Measurement points are given in Table 9.

Fig 4. Set-up time, hold time, minimum clock pulse width, propagation delays and transition times



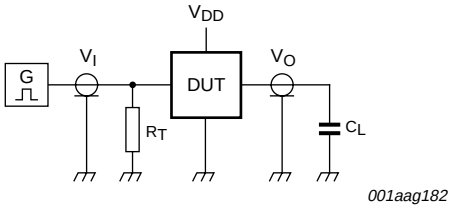
Recovery times are shown as positive values but may be specified as negative values.

Measurement points are given in Table 9.

Fig 5. nSD, nCD recovery time and pulse width

Table 9. Measurement points

Supply voltage	Input	Output		
V_{DD}	V_M	V_M	V_X	V_Y
5 V to 15 V	$0.5V_{DD}$	$0.5V_{DD}$	$0.1V_{DD}$	$0.9V_{DD}$



Test and measurement data is given in Table 10;

Definitions test circuit:

DUT = Device Under Test.

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

C_L = Load capacitance including jig and probe capacitance.

Fig 6. Test circuit for measuring switching times

Table 10. Test data

Supply voltage	Input		Load
V_{DD}	V_I	t_r, t_f	C_L
5 V to 15 V	V_{SS} or V_{DD}	≤ 20 ns	50 pF

13. Application information

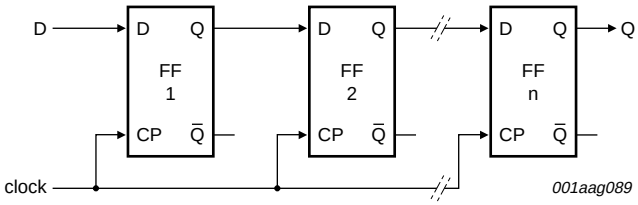


Fig 7. N-stage shift register

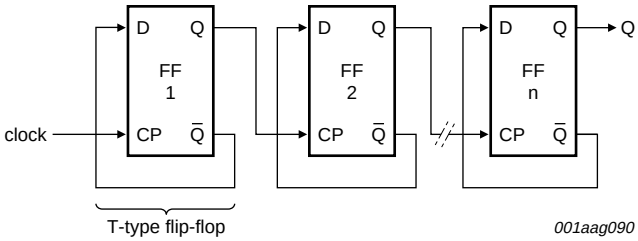


Fig 8. Binary ripple up-counter; divide-by-2^n

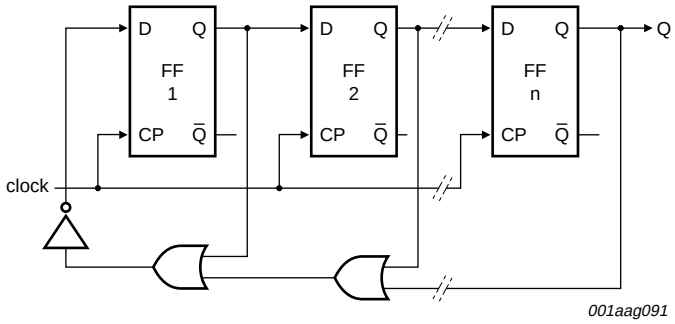
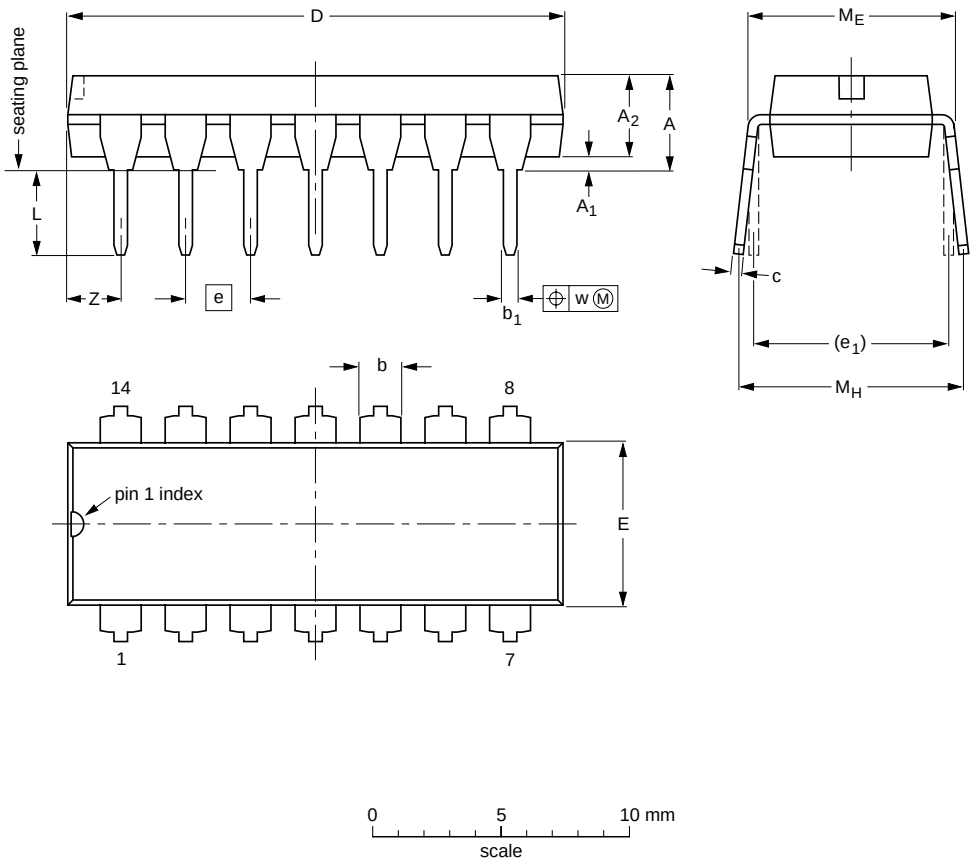


Fig 9. Modified ring counter; divide-by-(n + 1)

14. Package outline

DIP14: plastic dual in-line package; 14 leads (300 mil) **SOT27-1**



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

UNIT	A max.	A_1 min.	A_2 max.	b	b_1	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	4.2	0.51	3.2	1.73 1.13	0.53 0.38	0.36 0.23	19.50 18.55	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	2.2
inches	0.17	0.02	0.13	0.068 0.044	0.021 0.015	0.014 0.009	0.77 0.73	0.26 0.24	0.1	0.3	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.087

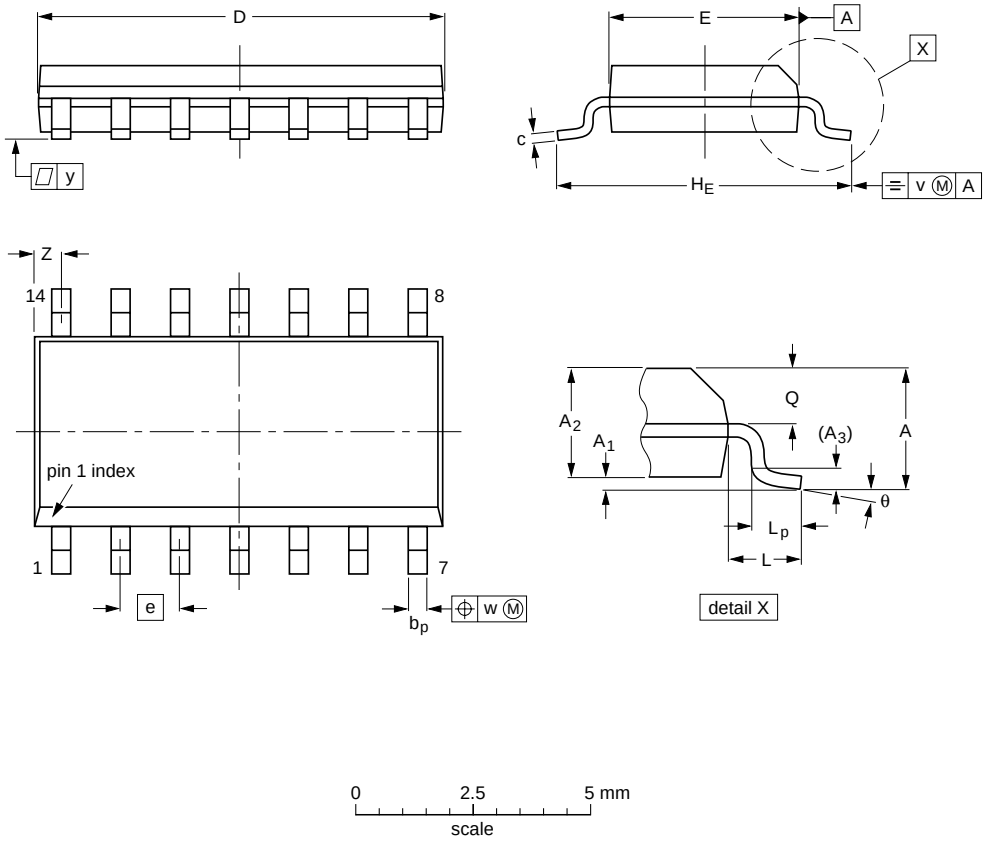
Note

1. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT27-1	050G04	MO-001	SC-501-14			~~99-12-27~~ 03-02-13

Fig 10. Package outline SOT27-1 (DIP14)

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^o 0^o
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	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

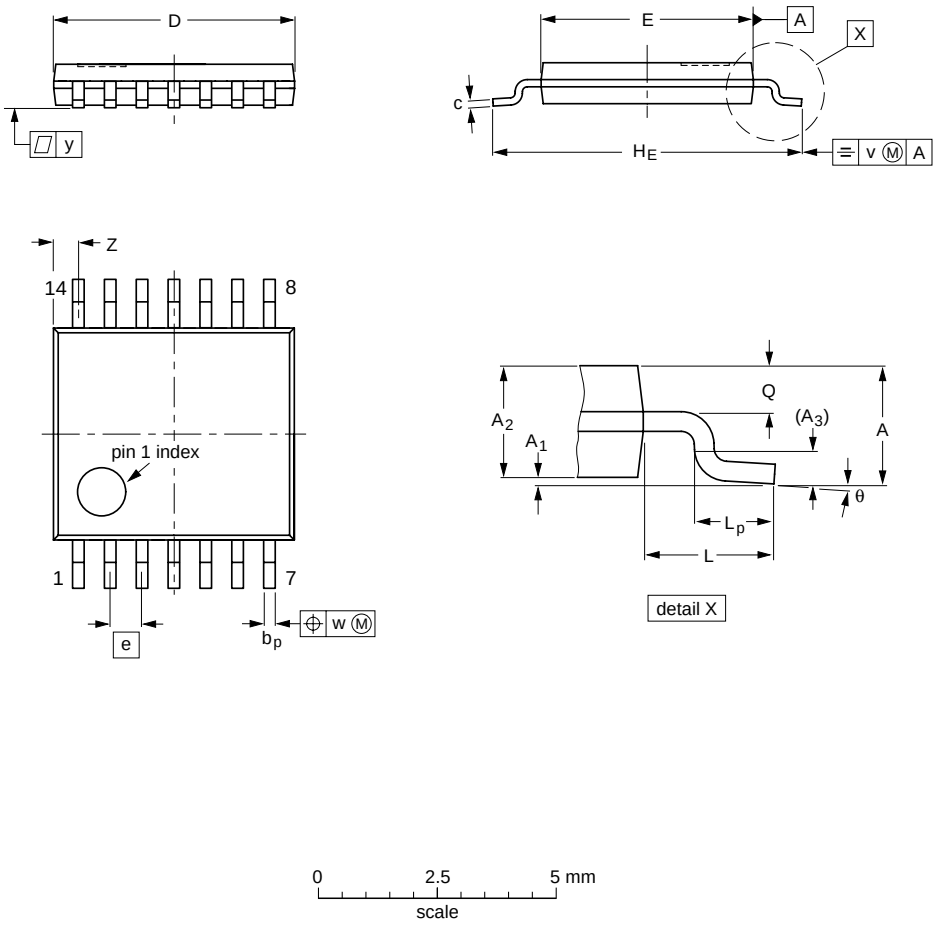
Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT108-1	076E06	MS-012				~~99-12-27~~ 03-02-19

Fig 11. Package outline SOT108-1 (SO14)

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	1.1	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	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.72 0.38	8^o 0^o

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	JEITA			
SOT402-1		MO-153				~~99-12-27~~ 03-02-18

Fig 12. Package outline SOT402-1 (TSSOP14)

15. Abbreviations

Table 11. Abbreviations

Acronym	Description
DUT	Device Under Test
ESD	ElectroStatic Discharge
HBM	Human Body Model
MM	Machine Model

16. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4013B_4	20080515	Product data sheet	-	HEF4013B_CNV_3
Modifications:	• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors. • Legal texts have been adapted to the new company name where appropriate. • Temperature range maximum increased from 85 °C to 125 °C throughout the data sheet. • Section 1 “General description” rewritten. • Section 2 “Features” added. • Package SOT73 removed and package SOT402-1 added to Section 4 “Ordering information” and Section 14 “Package outline”. • Pins renamed throughout with all drawings being changed to reflect new names. • Q(n + 1) and $\overline{Q}$(n + 1) deleted from Table 3 “Function table[1]” • Section 8 “Limiting values” and Section 10 “Static characteristics” added, taken from the HE4000B Family Specifications data sheet. • Section 9 “Recommended operating conditions” added. • Section 10 “Static characteristics” values for I_{DD}, I_{OL} and I_{OH} updated. • Table 7 “Dynamic characteristics” restructured. • Typical temperature coefficient for propagation delays and output transitions removed from Table 7 “Dynamic characteristics”. • New drawing for Figure 4 “Set-up time, hold time, minimum clock pulse width, propagation delays and transition times”. • V_M Labels added to Figure 5 “nSD, nCD recovery time and pulse width”. • Table 9 “Measurement points” and Table 10 “Test data” added. • Waveforms deleted from Figure 6 “Test circuit for measuring switching times”.			
HEF4013B_CNV_3	19950101	Product specification	-	HEF4013B_CNV_2
HEF4013B_CNV_2	19950101	Product specification	-	-

17. Legal information

17.1 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.nxp.com.

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19. Contents

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