

HEF4013B

Dual D-type flip-flop

Rev. 11 — 9 March 2023

Product data sheet

1. General description

The HEF4013B is a dual D-type flip-flop with set and reset; positive-edge trigger. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of V_{DD} . Schmitt-trigger action on the clock input makes the circuit highly tolerant of slower clock rise and fall times.

2. Features and benefits

- Wide supply voltage range from 3.0 V to 15.0 V
- CMOS low power dissipation
- High noise immunity
- Tolerant of slow clock rise and fall times
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Specified from -40 °C to +125 °C
- Complies with JEDEC standard JESD 13-B
- ESD protection:
 - HBM JESD22-A114F exceeds 2000 V
 - MM JESD22-A115-B exceeds 200 V

3. Applications

- Counters and dividers
- Registers
- Toggle flip-flops

4. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
HEF4013BT	-40 °C to +125 °C	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
HEF4013BTT	-40 °C to +125 °C	TSSOP14	plastic thin shrink small outline package; 14 leads; body width 4.4 mm	SOT402-1

5. Functional diagram

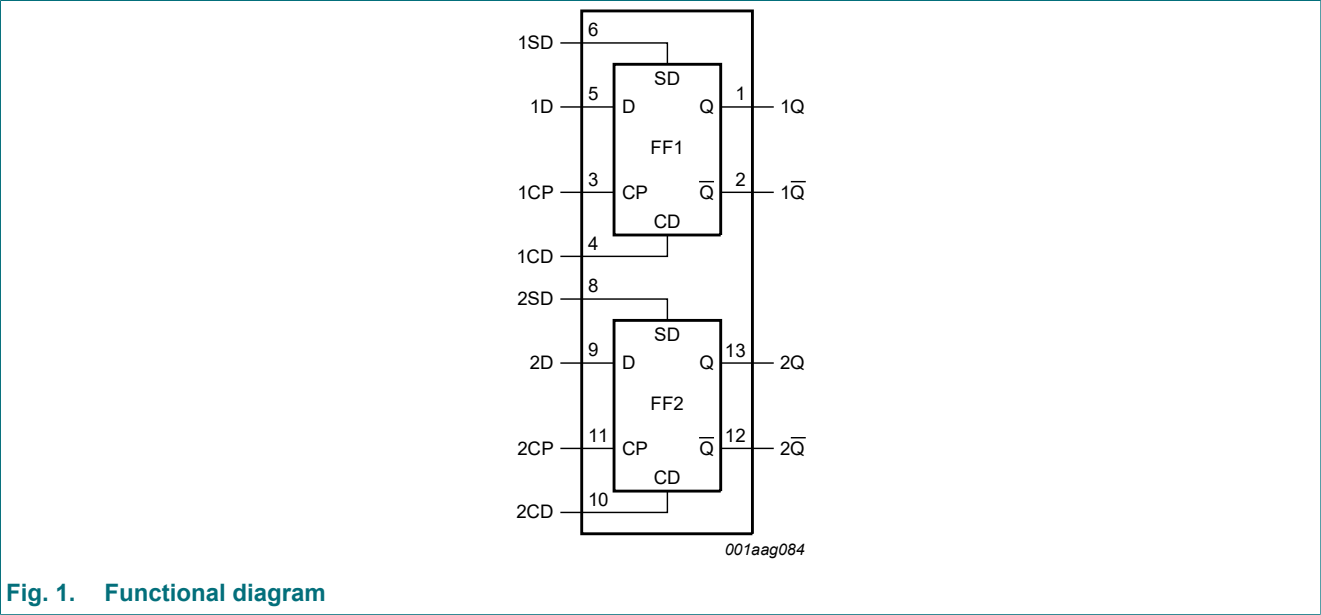


Fig. 1. Functional diagram

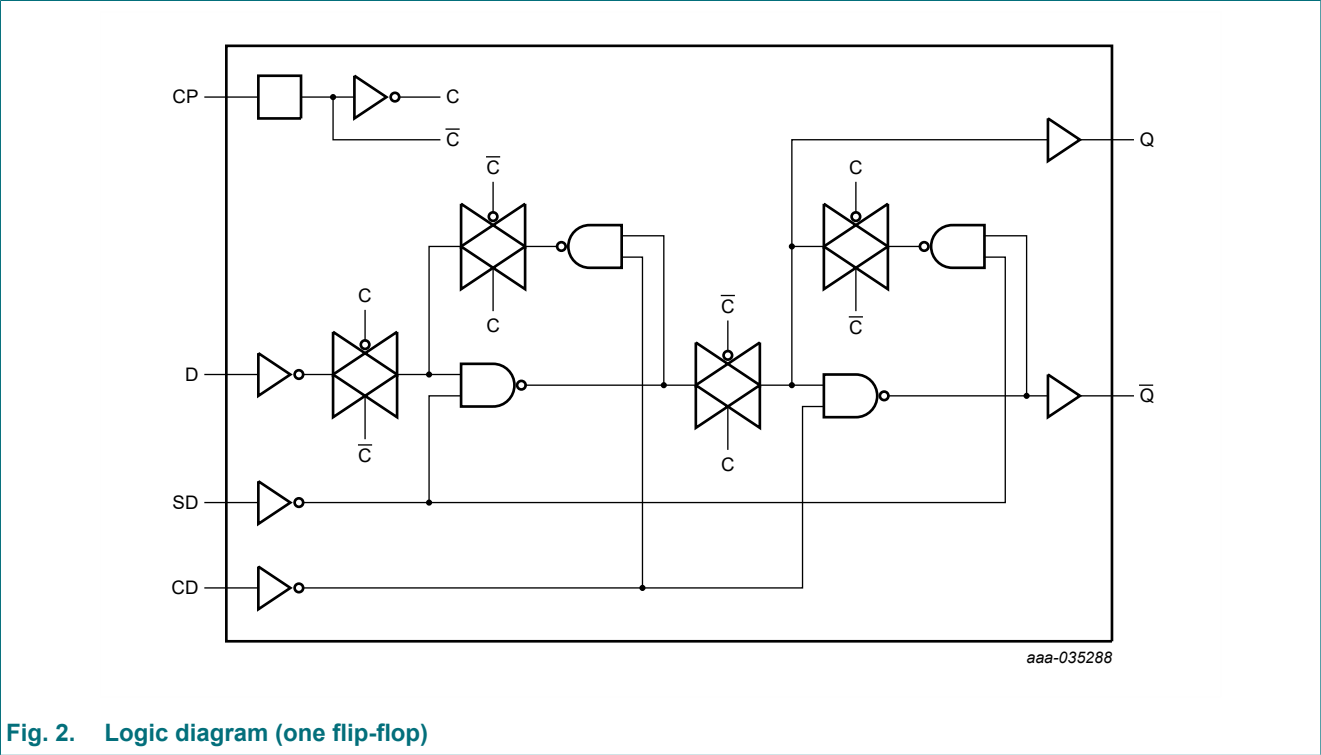
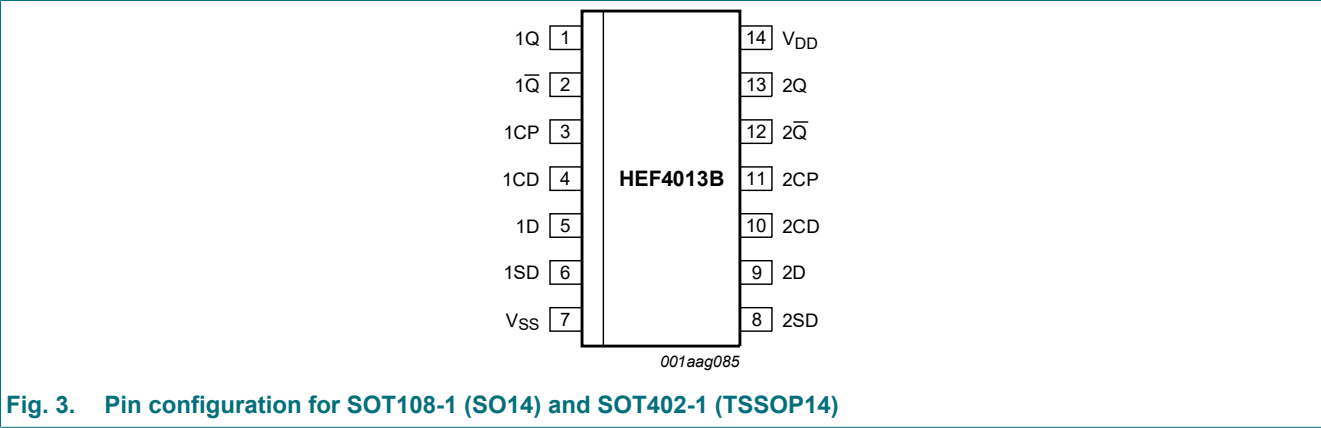


Fig. 2. Logic diagram (one flip-flop)

6. Pinning information

6.1. Pinning



6.2. Pin description

Table 2. Pin description

Symbol	Pin	Description
1Q, 2Q	1, 13	true output
1Q̄, 2Q̄	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)
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

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

Control			Input	Output	
nSD	nCD	nCP	nD	nQ	nQ̄
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

8. Limiting values

Table 4. Limiting values

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

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DD}	supply voltage		-0.5	+18	V
I_{IK}	input clamping current	$V_I < -0.5\text{ V}$ or $V_I > V_{DD} + 0.5\text{ V}$	-	± 10	mA
V_I	input voltage		-0.5	$V_{DD} + 0.5$	V
I_{OK}	output clamping current	$V_O < -0.5\text{ V}$ or $V_O > V_{DD} + 0.5\text{ V}$	-	± 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	$T_{amb} = -40\text{ °C}$ to $+125\text{ °C}$ [1]	-	500	mW
P	power dissipation	per output	-	100	mW

- [1] For SOT108-1 (SO14) package: P_{tot} derates linearly with 10.1 mW/K above 100 °C.
For SOT402-1 (TSSOP14) package: P_{tot} derates linearly with 7.3 mW/K above 81 °C.

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	nCP, nCD, nD, nSD inputs			
		$V_{DD} = 5\text{ V}$	-	3.75	$\mu\text{s/V}$
		$V_{DD} = 10\text{ V}$	-	0.5	$\mu\text{s/V}$
		$V_{DD} = 15\text{ V}$	-	0.08	$\mu\text{s/V}$

10. Static characteristics

Table 6. Static characteristics

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

Symbol	Parameter	Conditions	V_{DD}	$T_{amb} = -40\text{ °C}$		$T_{amb} = +25\text{ °C}$		$T_{amb} = +85\text{ °C}$		$T_{amb} = +125\text{ °C}$		Unit
				Min	Max	Min	Max	Min	Max	Min	Max	
V_{IH}	HIGH-level input voltage	$ I_O < 1\text{ }\mu\text{A}$	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\text{ }\mu\text{A}$	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\text{ }\mu\text{A}$	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\text{ }\mu\text{A}$	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	$V_O = 2.5\text{ V}$	5 V	-	-1.7	-	-1.4	-	-1.1	-	-1.1	mA
		$V_O = 4.6\text{ V}$	5 V	-	-0.64	-	-0.5	-	-0.36	-	-0.36	mA
		$V_O = 9.5\text{ V}$	10 V	-	-1.6	-	-1.3	-	-0.9	-	-0.9	mA
		$V_O = 13.5\text{ V}$	15 V	-	-4.2	-	-3.4	-	-2.4	-	-2.4	mA
I_{OL}	LOW-level output current	$V_O = 0.4\text{ V}$	5 V	0.64	-	0.5	-	0.36	-	0.36	-	mA
		$V_O = 0.5\text{ V}$	10 V	1.6	-	1.3	-	0.9	-	0.9	-	mA
		$V_O = 1.5\text{ V}$	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\text{ 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

$T_{amb} = 25\text{ }^{\circ}\text{C}$, unless otherwise specified. For test circuit see Fig. 6.

Symbol	Parameter	Conditions	V _{DD}	Extrapolation formula	Min	Typ	Max	Unit
t _{PHL}	HIGH to LOW propagation delay	nCP to nQ, nQ̄; see Fig. 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 nQ̄	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, nQ̄; see Fig. 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 nQ̄	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 Fig. 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 Fig. 4	5 V		40	20	-	ns
			10 V		25	10	-	ns
			15 V		15	5	-	ns
t _h	hold time	nD to nCP; see Fig. 4	5 V		20	0	-	ns
			10 V		20	0	-	ns
			15 V		15	0	-	ns
t _w	pulse width	nCP input LOW; see Fig. 4	5 V		60	30	-	ns
			10 V		30	15	-	ns
			15 V		20	10	-	ns
		nSD input HIGH; see Fig. 5	5 V		50	25	-	ns
			10 V		24	12	-	ns
			15 V		20	10	-	ns
		nCD input HIGH; see Fig. 5	5 V		50	25	-	ns
			10 V		24	12	-	ns
			15 V		20	10	-	ns

Symbol	Parameter	Conditions	V _{DD}	Extrapolation formula	Min	Typ	Max	Unit
t _{rec}	recovery time	nSD input; see Fig. 5	5 V		+15	-5	-	ns
			10 V		15	0	-	ns
			15 V		15	0	-	ns
		nCD input; see Fig. 5	5 V		40	25	-	ns
			10 V		25	10	-	ns
			15 V		25	10	-	ns
f _{clk(max)}	maximum clock frequency	see Fig. 4	5 V		7	14	-	MHz
			10 V		14	28	-	MHz
			15 V		20	40	-	MHz

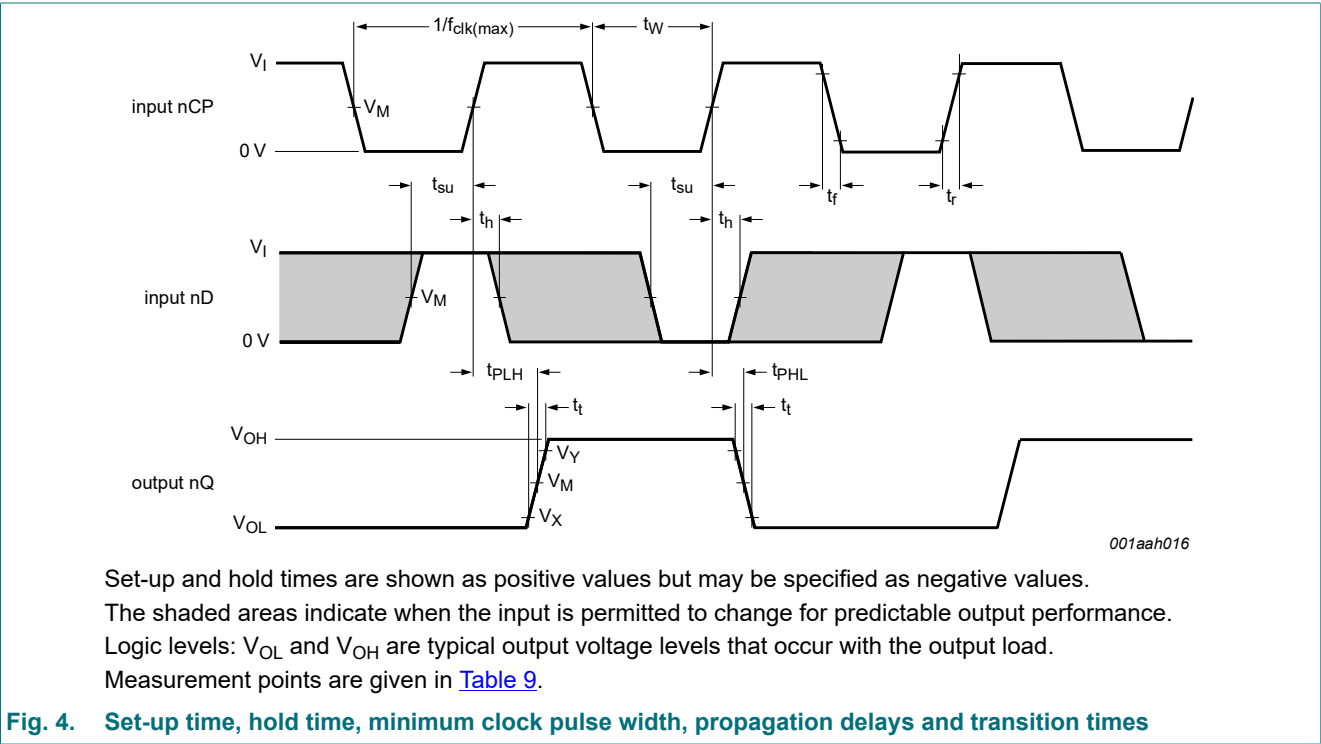
[1] Typical values of the propagation delays and output transition times can be calculated with the extrapolation formulas (C_L in pF).

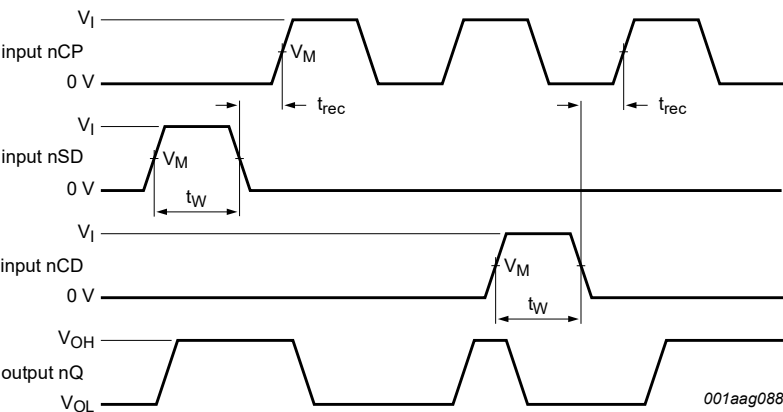
Table 8. Dynamic power dissipation

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

Symbol	Parameter	V _{DD}	Typical formula	Where
P _D	dynamic power dissipation	5 V	$P_D = 850 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2 \mu W$	f _i = input frequency in MHz; f _o = output frequency in MHz; C _L = output load capacitance in pF; Σ(f _o × C _L) = sum of the outputs; V _{DD} = supply voltage in V.
		10 V	$P_D = 3600 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2 \mu W$	
		15 V	$P_D = 9000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2 \mu W$	

11.1. Waveforms and test circuit



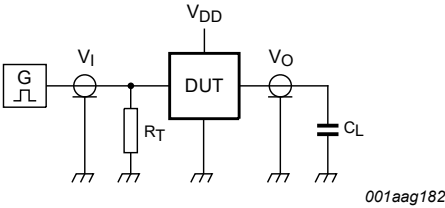


Recovery times are shown as positive values but may be specified as negative values.
Logic levels: V_{OL} and V_{OH} are typical output voltage levels that occur with the output load.
Measurement points are given in [Table 9](#).

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:
 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}	$\leq 20\text{ ns}$	50 pF

12. Application information

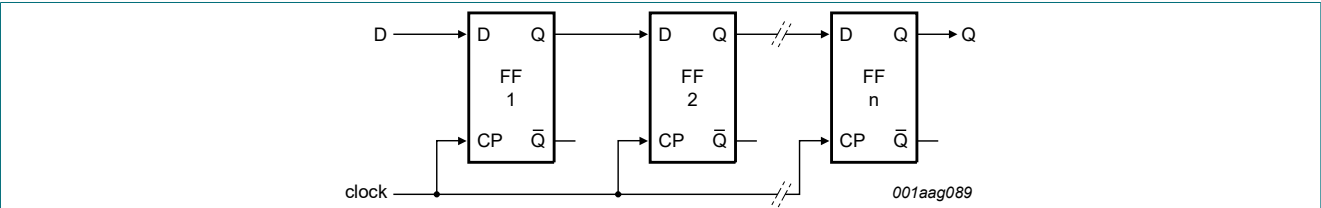


Fig. 7. N-stage shift register

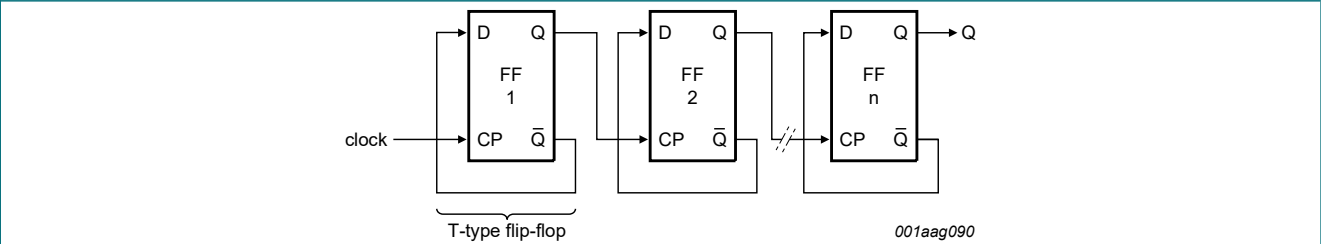


Fig. 8. Binary ripple up-counter; divide-by-2ⁿ

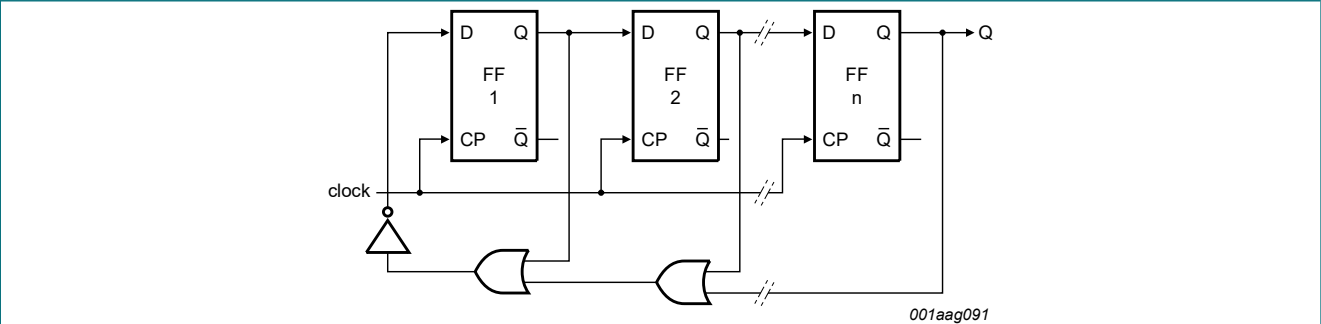


Fig. 9. Modified ring counter; divide-by-(n + 1)

13. Package outline

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

SOT108-1

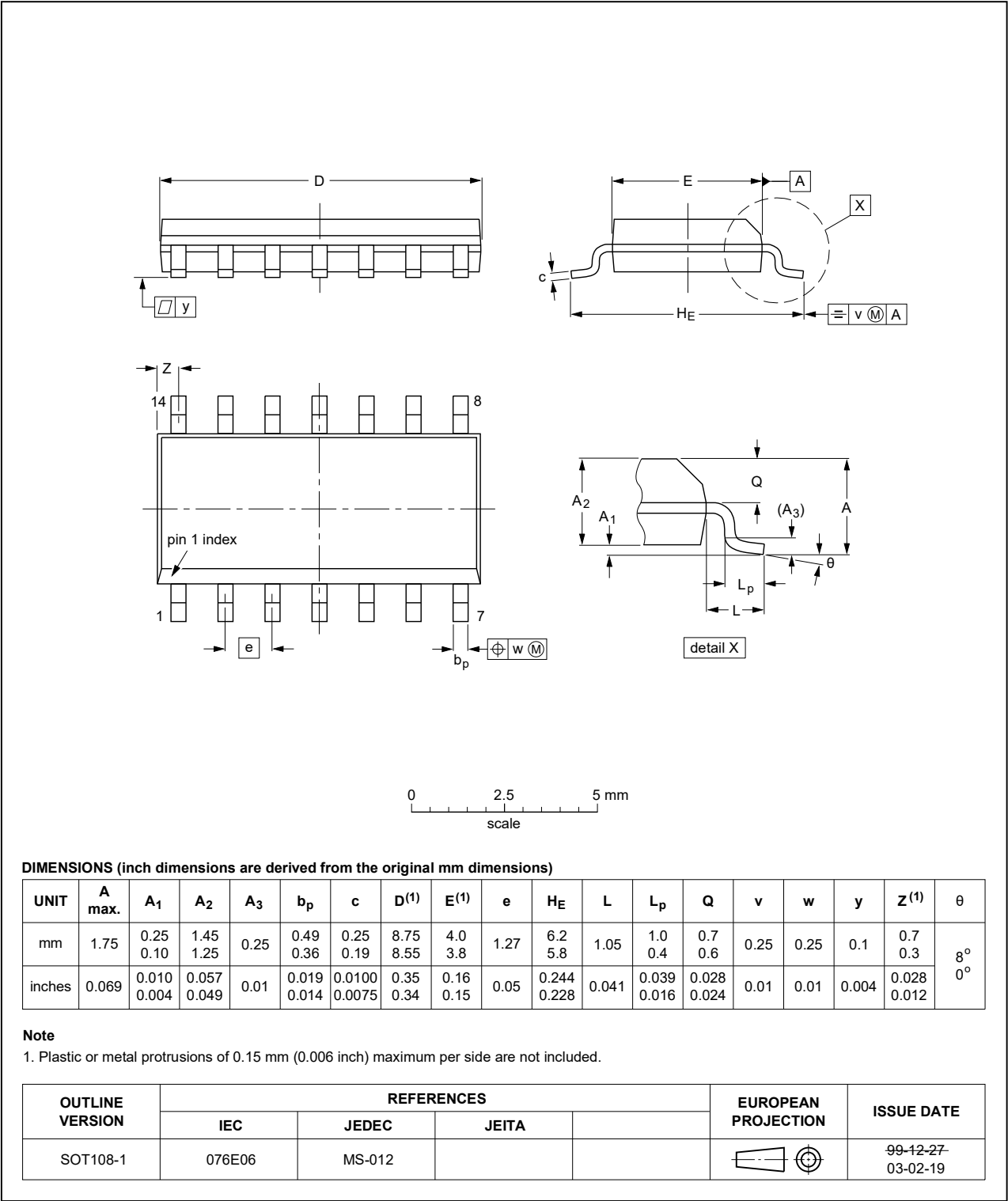


Fig. 10. Package outline SOT108-1 (SO14)

TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm

SOT402-1

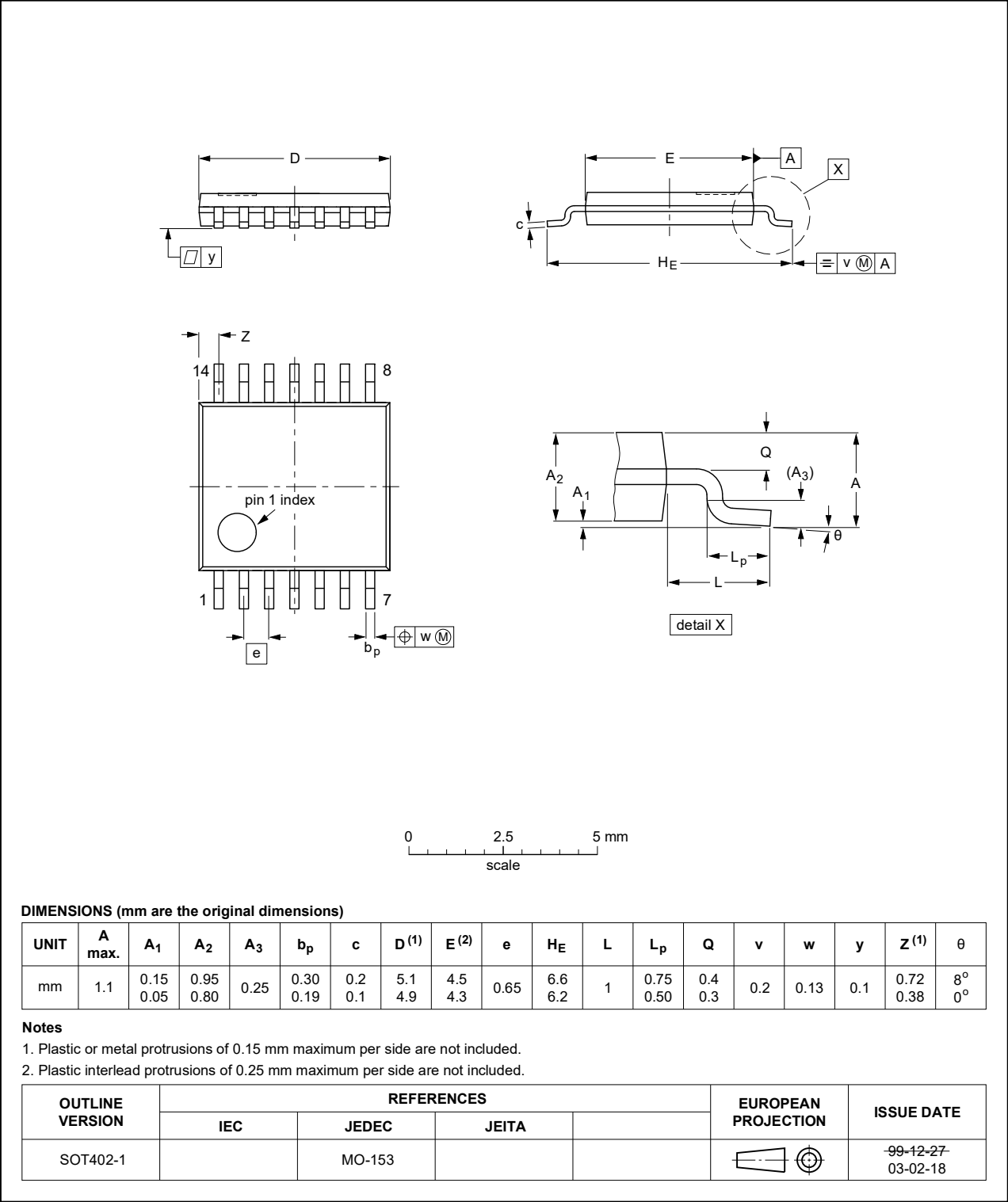


Fig. 11. Package outline SOT402-1 (TSSOP14)

14. Abbreviations

Table 11. Abbreviations

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

15. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4013B v.11	20230309	Product data sheet	-	HEF4013B v.10
Modifications:	- Section 1 updated - Fig. 2: Schmitt-trigger symbol removed (errata).			
HEF4013B v.10	20211123	Product data sheet	-	HEF4013B v.9
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 1 and Section 2 updated. - Table 4: Derating values for P_{tot} total power dissipation updated.			
HEF4013B v.9	20151210	Product data sheet	-	HEF4013B v.8
Modifications:	Type number HEF4013BP (SOT27-1) removed.			
HEF4013B v.8	20111121	Product data sheet	-	HEF4013B v.7
Modifications:	- Legal pages updated. - Changes in "General description", "Features and benefits" and "Applications".			
HEF4013B v.7	20110913	Product data sheet	-	HEF4013B v.6
HEF4013B v.6	20091027	Product data sheet	-	HEF4013B v.5
HEF4013B v.5	20090619	Product data sheet	-	HEF4013B v.4
HEF4013B v.4	20080515	Product data sheet	-	HEF4013B_CNV v.3
HEF4013B_CNV v.3	19950101	Product specification	-	HEF4013B_CNV v.2
HEF4013B_CNV v.2	19950101	Product specification	-	-

16. 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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