

HEF4013B-Q100

Dual D-type flip-flop

Rev. 3 — 15 December 2015

Product data sheet

1. General description

The HEF4013B-Q100 is a dual D-type flip-flop that features independent set-direct input (SD), clear-direct input (CD), clock input (CP) and outputs (Q, \bar{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 Schmitt trigger action of the clock inputs, 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). Connect unused inputs to V_{DD} , V_{SS} , or another input.

This product has been qualified to the Automotive Electronics Council (AEC) standard Q100 (Grade 1) and is suitable for use in automotive applications.

2. Features and benefits

- Automotive product qualification in accordance with AEC-Q100 (Grade 1)
 - ◆ Specified from $-40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$ and from $-40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$
- Tolerant of slow clock rise and fall times
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- ESD protection:
 - ◆ MIL-STD-883, method 3015 exceeds 2000 V
 - ◆ HBM JESD22-A114F exceeds 2000 V
 - ◆ MM JESD22-A115-A exceeds 200 V ($C = 200\text{ pF}$, $R = 0\text{ }\Omega$)
- Complies with JEDEC standard JESD 13-B

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		Version
	Name	Description	
HEF4013BT-Q100	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
HEF4013BTT-Q100	TSSOP14	plastic thin shrink small outline package; 14 leads; body width 4.4 mm	SOT402-1

5. Functional diagram

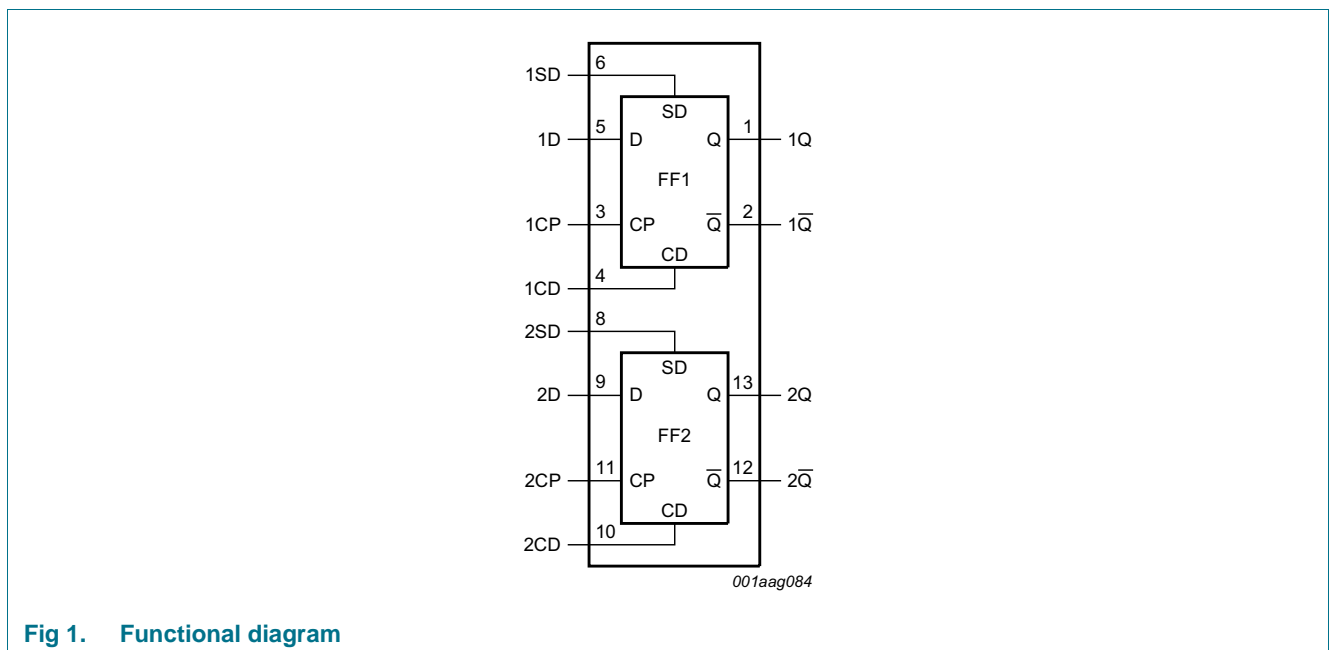


Fig 1. Functional diagram

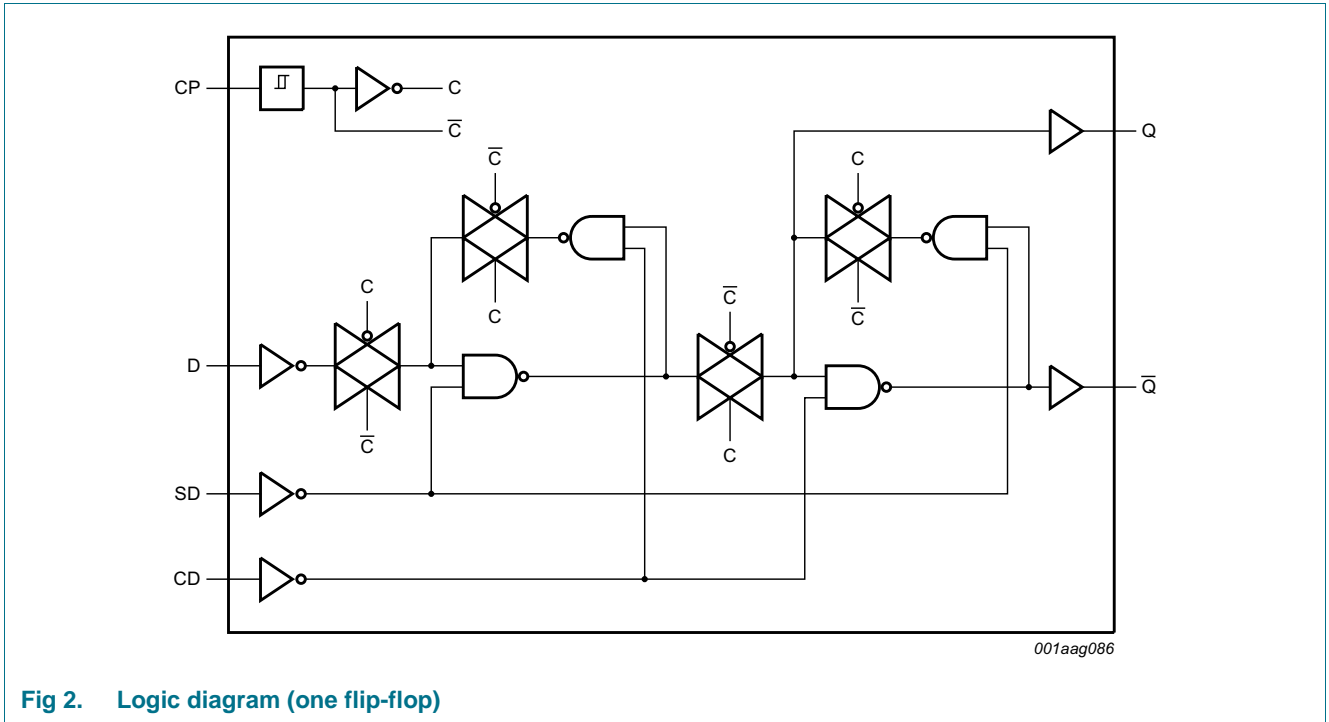


Fig 2. Logic diagram (one flip-flop)

6. Pinning information

6.1 Pinning

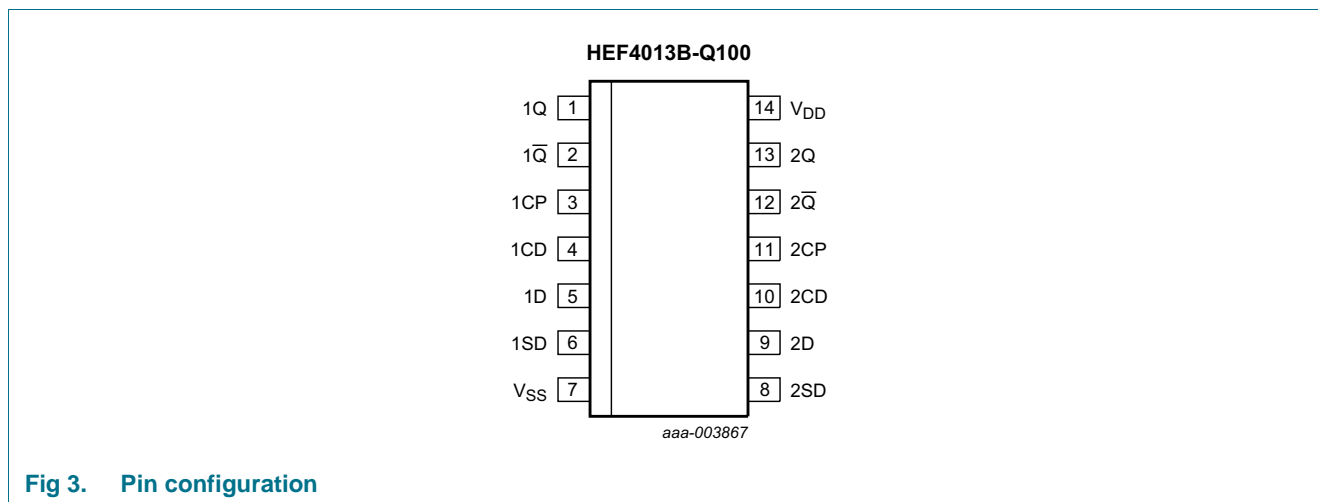


Fig 3. Pin configuration

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
1Q, 2Q	1, 13	true output
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^[1]

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

[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			
		SO14 [1]	-	500	mW
		TSSOP14 [2]	-	500	mW
P	power dissipation	per output	-	100	mW

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

[2] 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	$\mu\text{s/V}$
		$V_{DD} = 10$ V	-	0.5	$\mu\text{s/V}$
		$V_{DD} = 15$ 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 [Figure 6](#).

Symbol	Parameter	Conditions	V_{DD}	Extrapolation formula	Min	Typ	Max	Unit
t_{PHL}	HIGH to LOW propagation delay	nCP to nQ, \overline{nQ} ; 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 \overline{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
		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, \overline{nQ} ; 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 \overline{nQ}	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	5 V		60	30	-	ns
			10 V		30	15	-	ns
			15 V		20	10	-	ns
		nSD input HIGH; see Figure 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 $T_{amb} = 25\text{ }^{\circ}\text{C}$; 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 $V_{SS} = 0\text{ V}$; $t_r = t_f \leq 20\text{ ns}$; $T_{amb} = 25\text{ }^{\circ}\text{C}$.

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

12. Waveforms

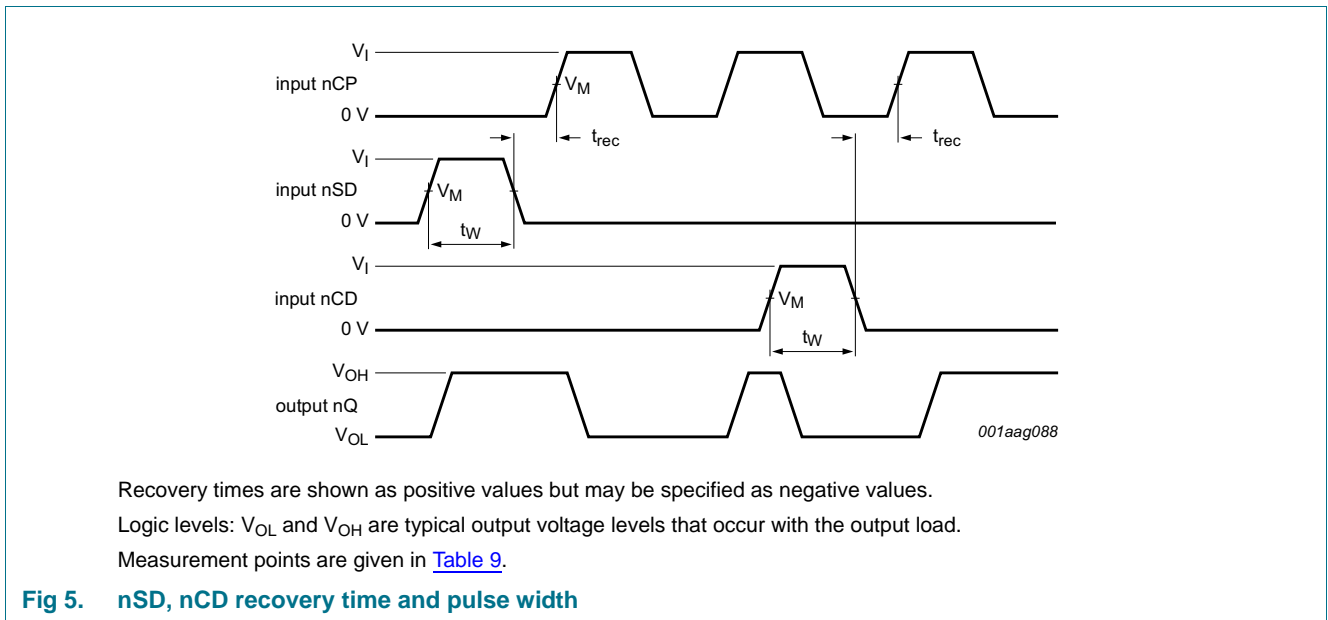
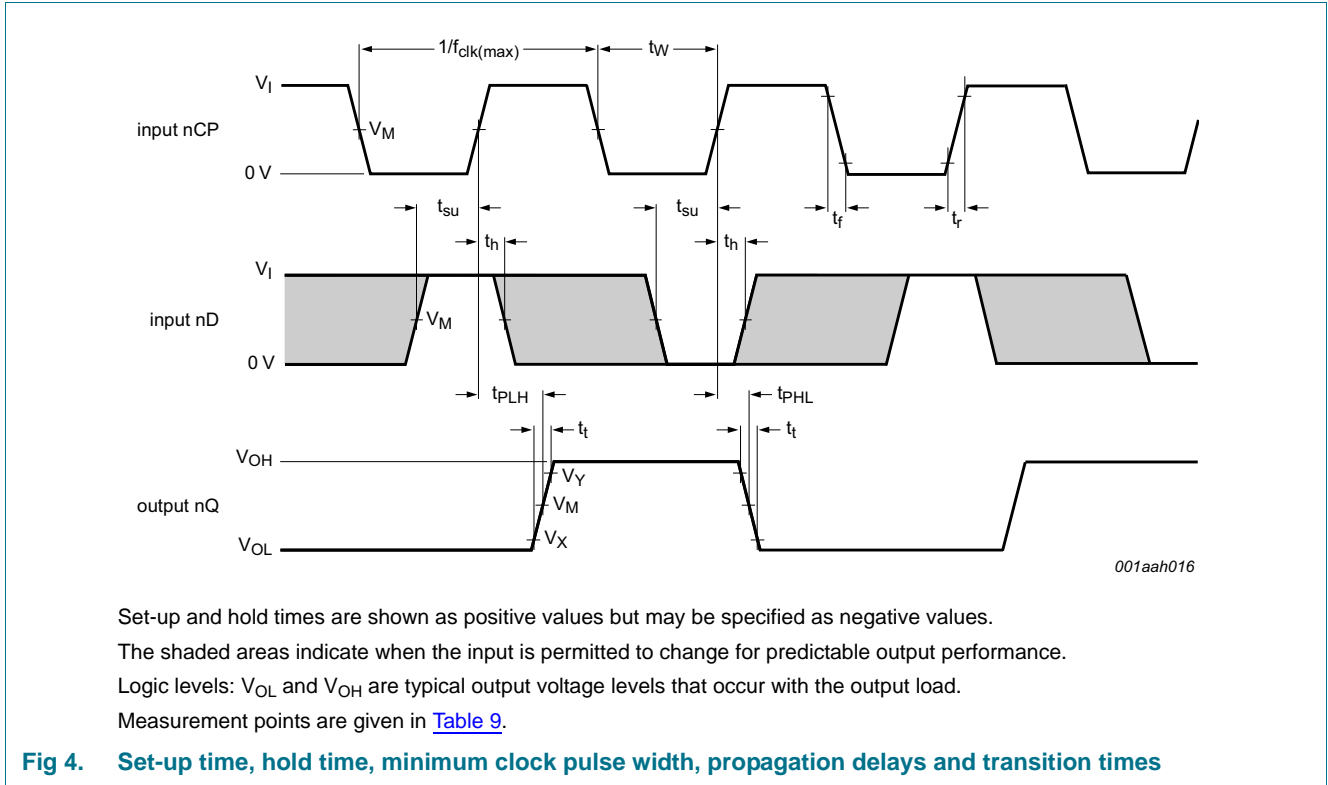
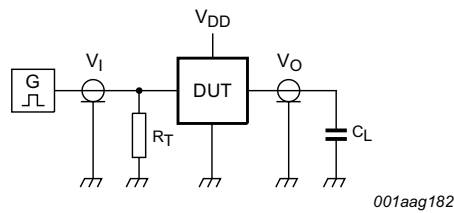


Table 9. Measurement points

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

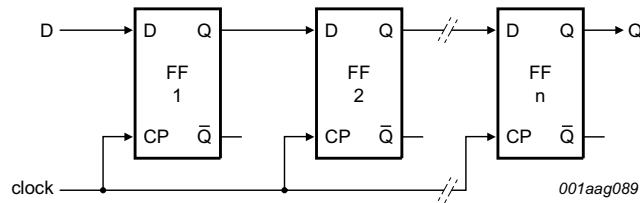


Fig 7. N-stage shift register

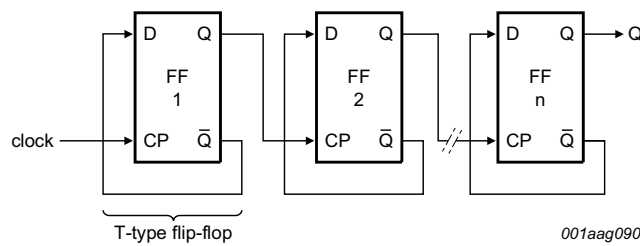


Fig 8. Binary ripple up-counter; divide-by- 2^n

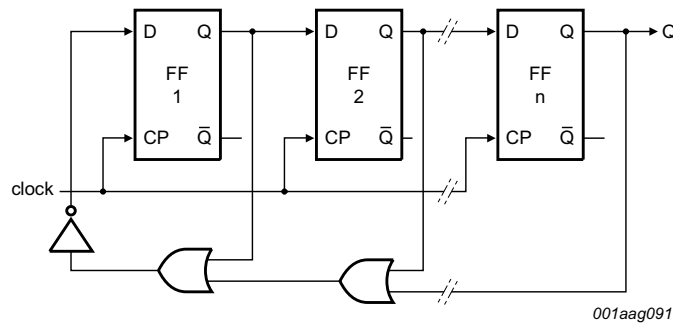


Fig 9. Modified ring counter; divide-by-($n + 1$)

14. Package outline

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

SOT108-1

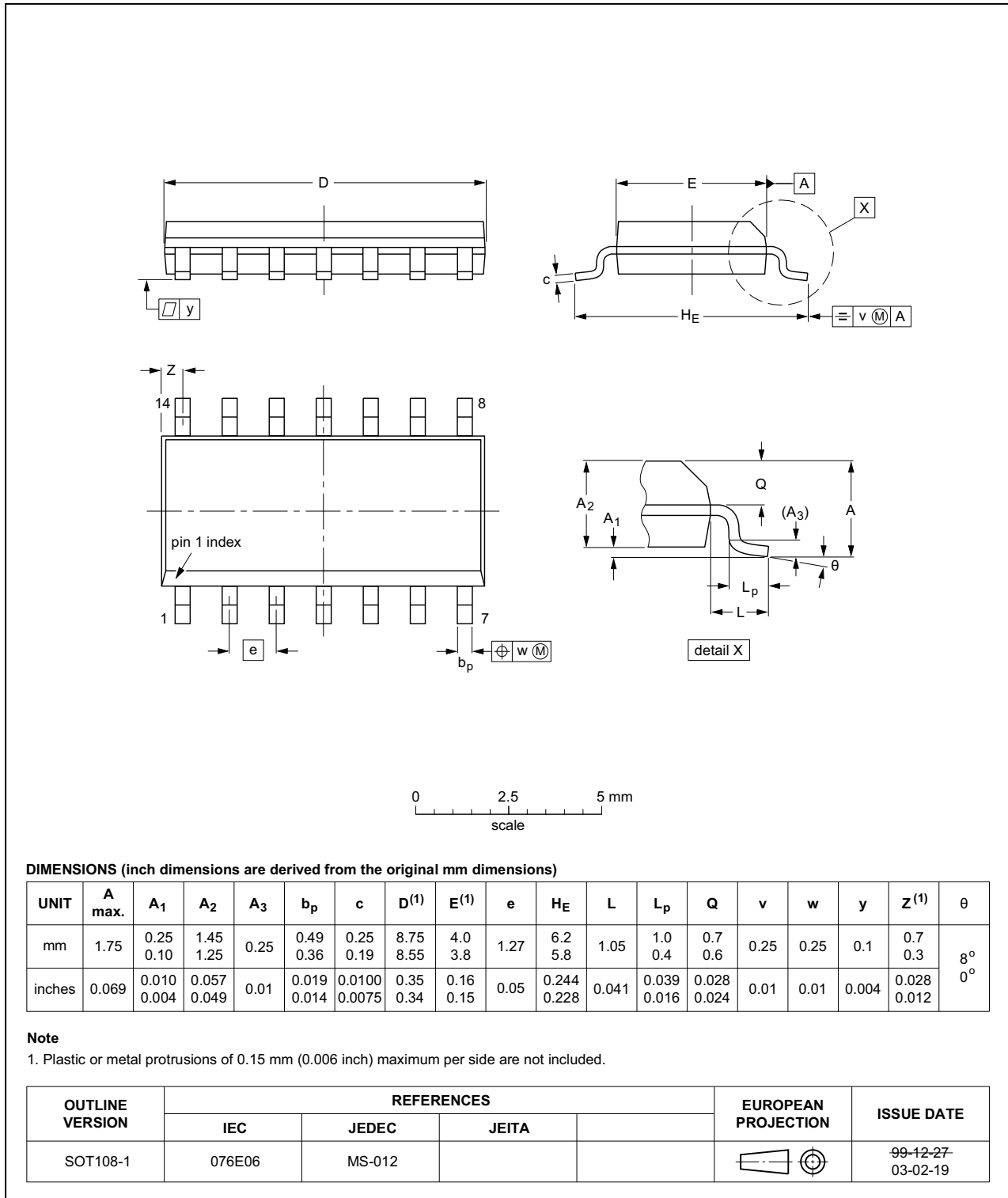


Fig 10. Package outline SOT108-1 (SO14)

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

SOT402-1

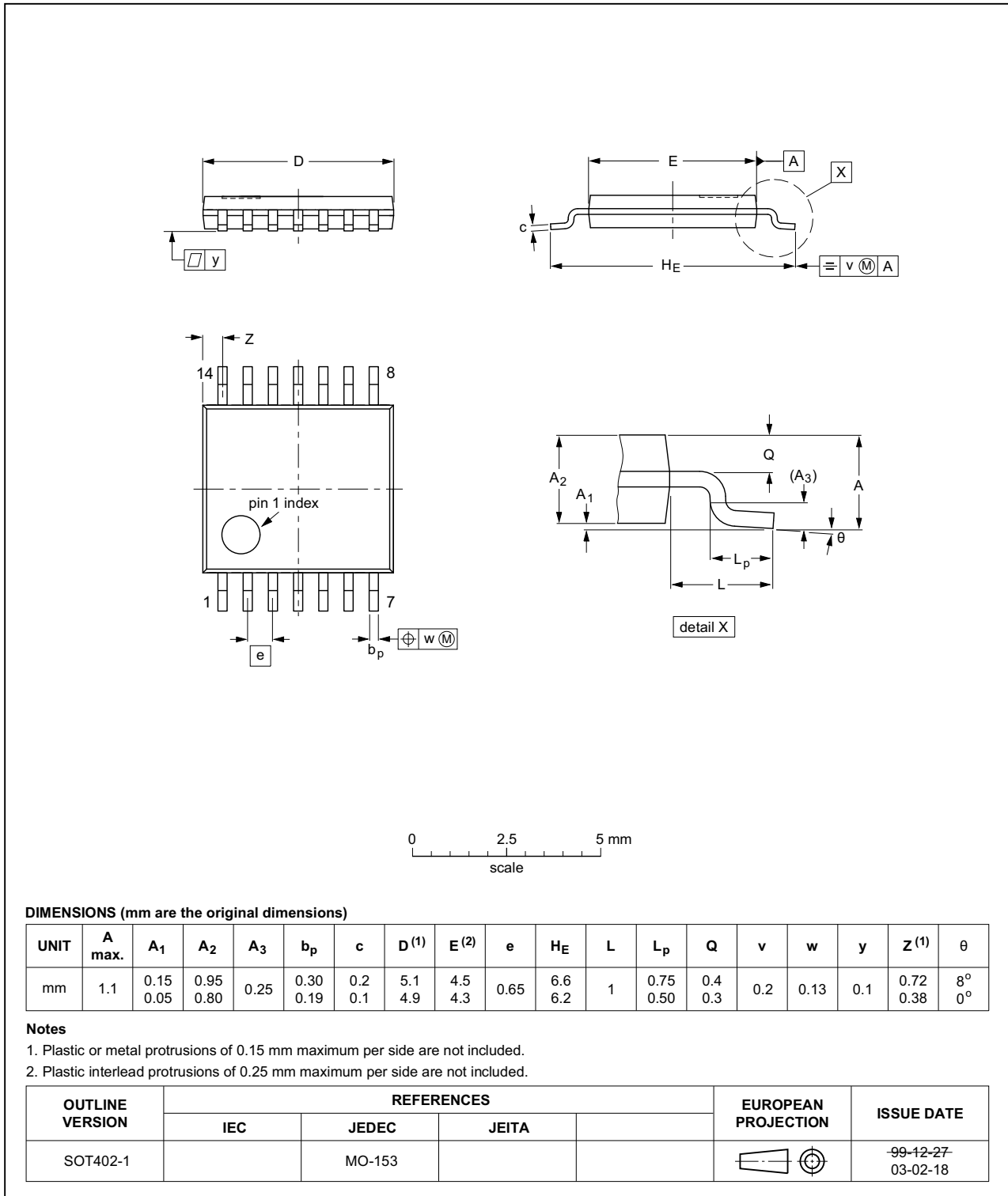


Fig 11. Package outline SOT402-1 (TSSOP14)

15. Abbreviations

Table 11. Abbreviations

Acronym	Description
HBM	Human Body Model
ESD	ElectroStatic Discharge
MM	Machine Model
MIL	Military

16. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4013B_Q100 v.3	20151215	Product data sheet	-	HEF4013B_Q100 v.2
Modifications:	<ul style="list-style-type: none"> Type number HEF4013BP-Q100 (SOT27-1) removed. 			
HEF4013B_Q100 v.2	20130220	Product data sheet	-	HEF4013B_Q100 v.1
Modifications:	<ul style="list-style-type: none"> HEF4013BP-Q100 (DIP14) added. 			
HEF4013B_Q100 v.1	20120807	Product data sheet	-	-

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".

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