

HEF4013B-Q100

Dual D-type flip-flop

Rev. 4 — 23 November 2021

Product data sheet

1. General description

The HEF4013B-Q100 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} .

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 °C to +85 °C and from -40 °C to +125 °C
- 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
- 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 pF, R = 0 Ω)
- Complies with JEDEC standard JESD 13-B

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-Q100 | -40 °C to +125 °C | SO14 | plastic small outline package; 14 leads; body width 3.9 mm | SOT108-1 |
| HEF4013BTT-Q100 | -40 °C to +125 °C | TSSOP14 | plastic thin shrink small outline package; 14 leads; body width 4.4 mm | SOT402-1 |

5. Functional diagram

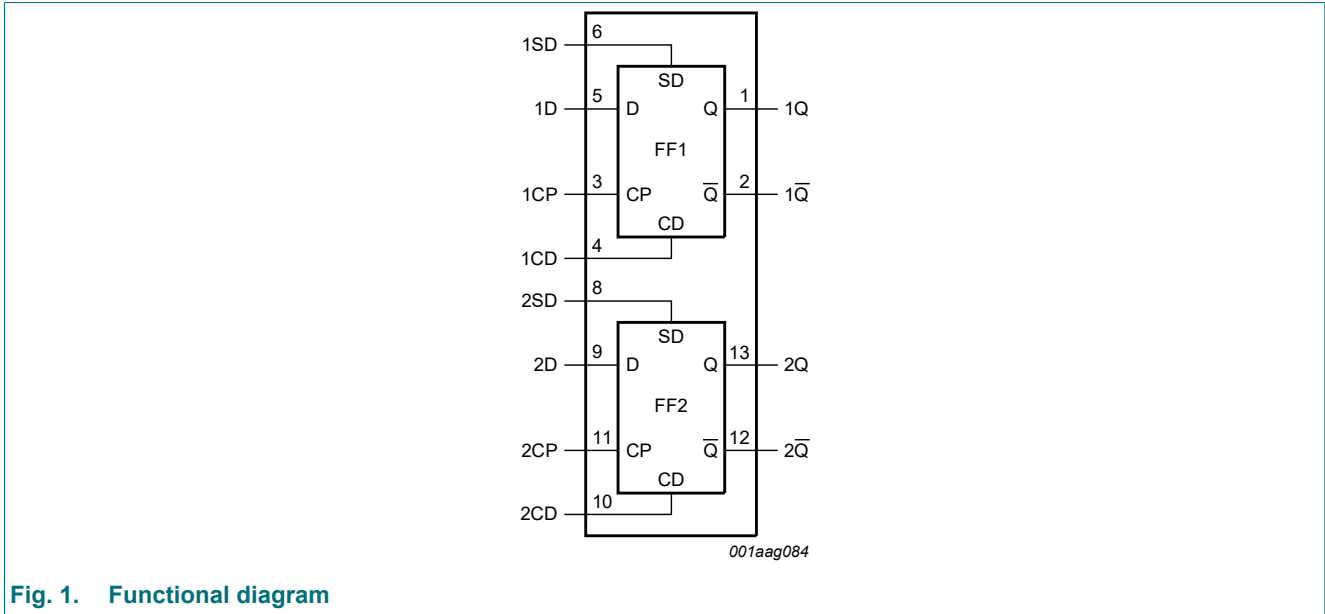


Fig. 1. Functional diagram

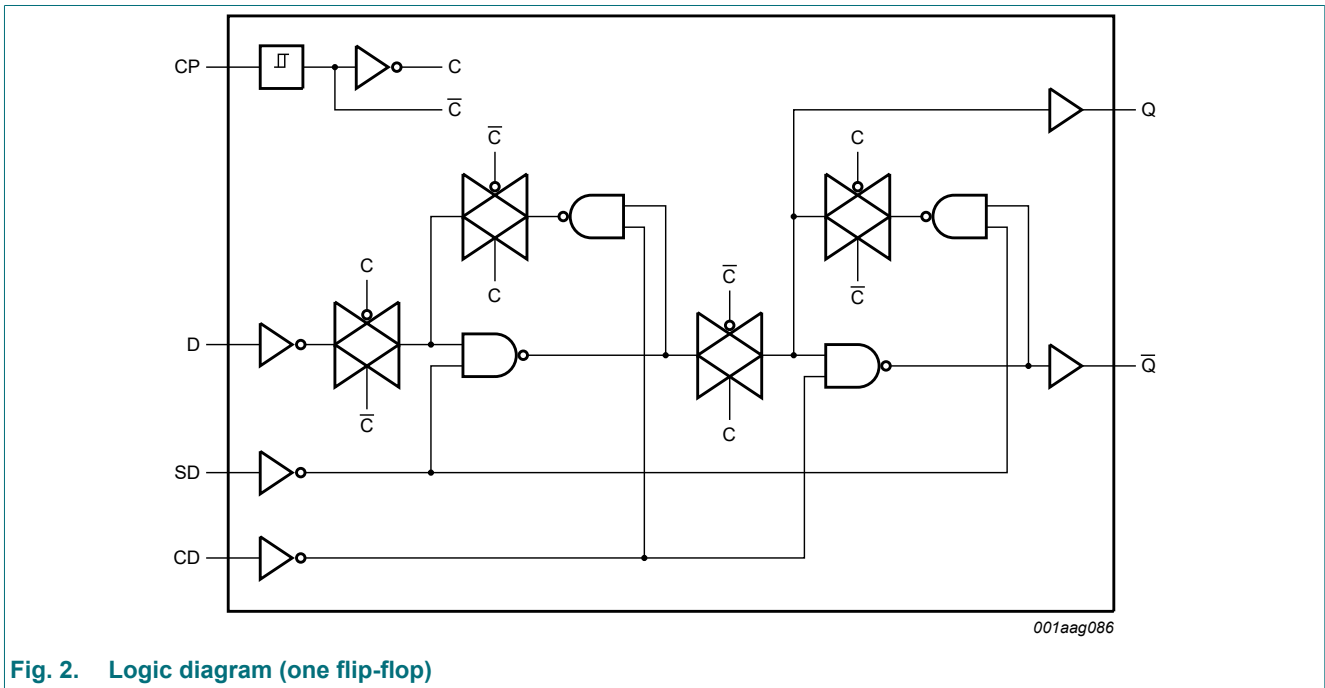


Fig. 2. Logic diagram (one flip-flop)

6. Pinning information

6.1. Pinning

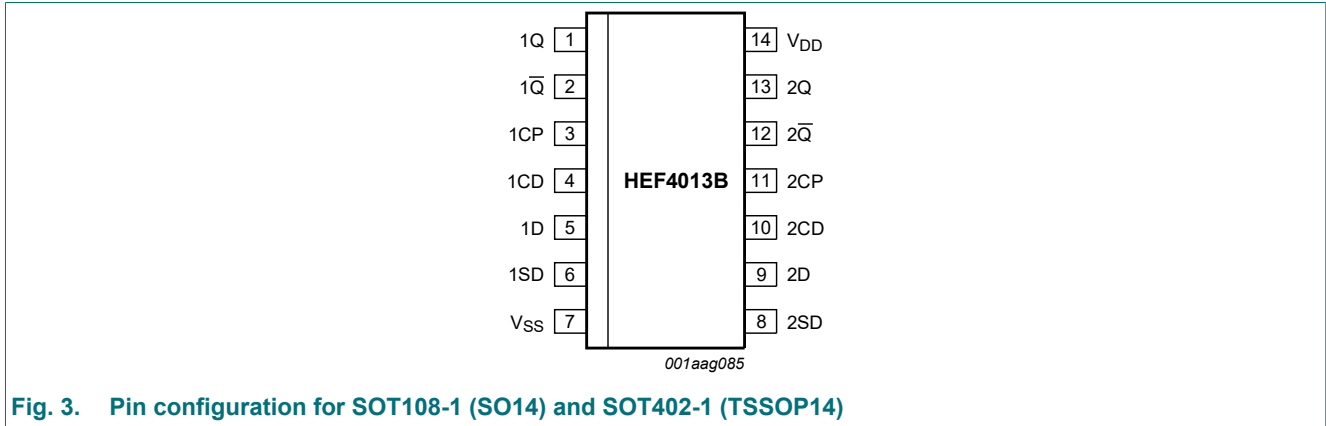


Fig. 3. Pin configuration for SOT108-1 (SO14) and SOT402-1 (TSSOP14)

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 $V_{SS} = 0$ 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 [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 | $V_{DD} = 5$ 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 °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

$T_{amb} = 25\text{ }^{\circ}\text{C}$, 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 |

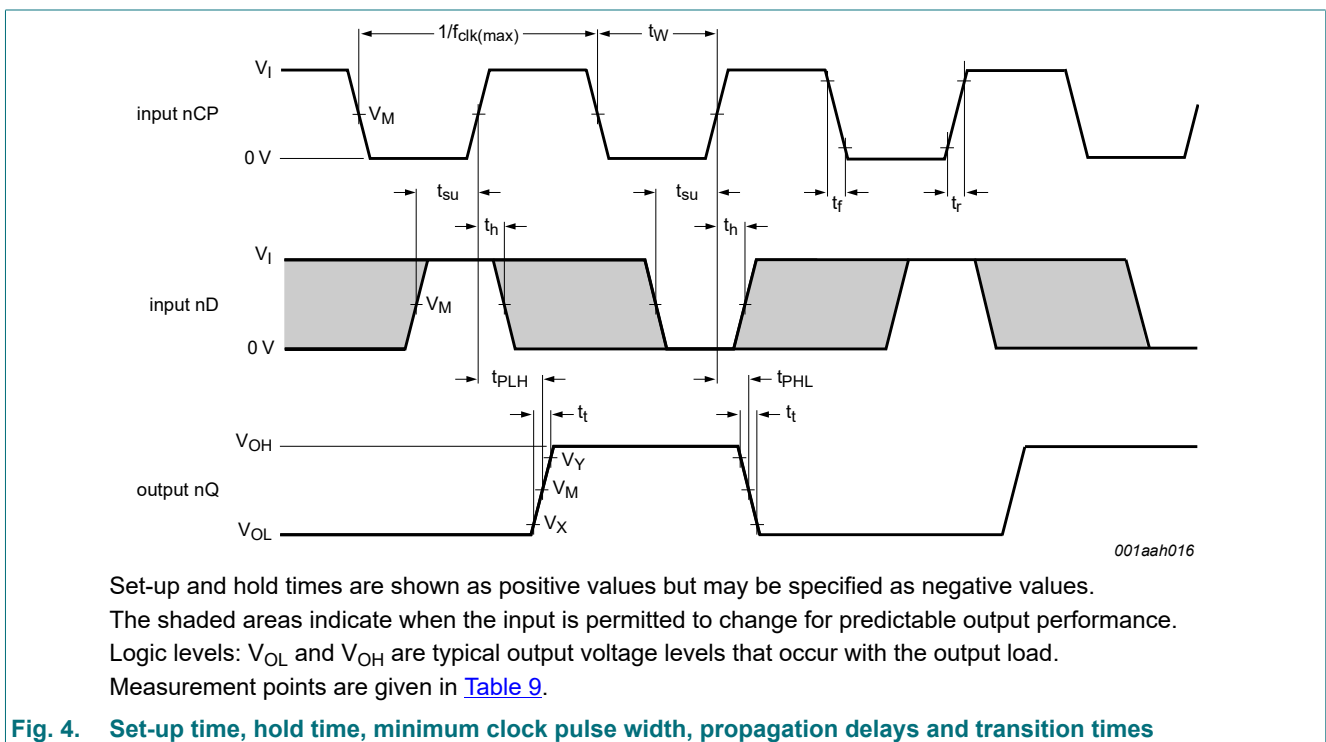
[1] Typical values of the propagation delays and output transition times can be calculated with the extrapolation formulas (C_L in pF).

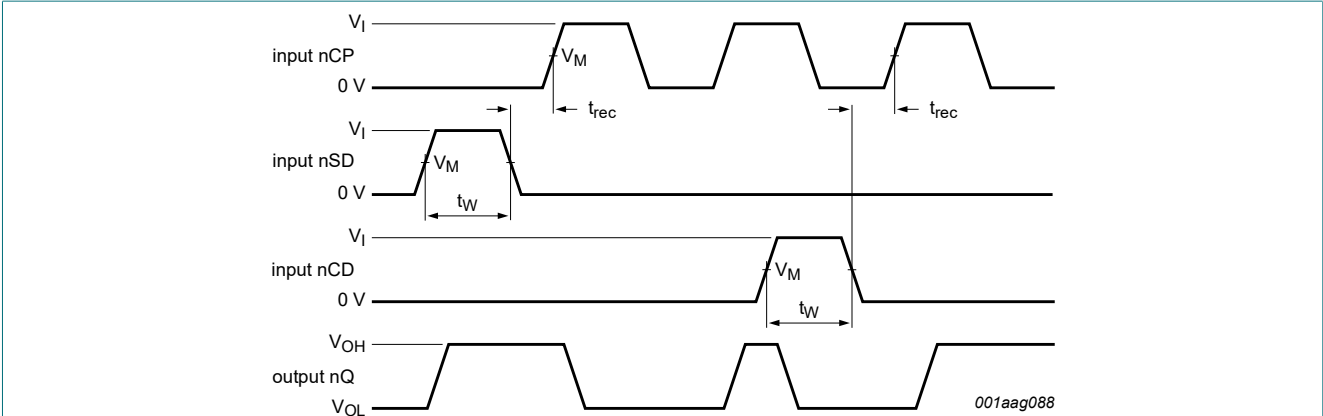
Table 8. Dynamic power dissipation

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



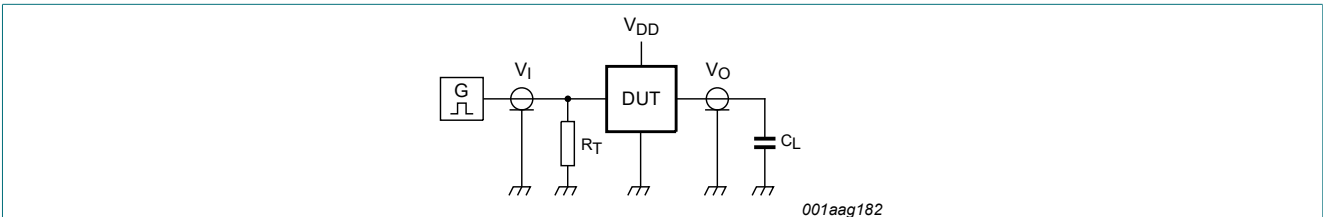


Recovery times are shown as positive values but may be specified as negative values.
 Logic levels: V_{OL} and V_{OH} are typical output voltage levels that occur with the output load.
 Measurement points are given in [Table 9](#).

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} | ≤ 20 ns | 50 pF |

12. Application information

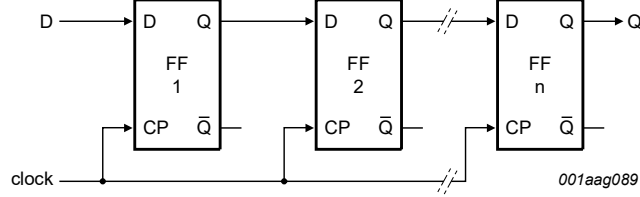


Fig. 7. N-stage shift register

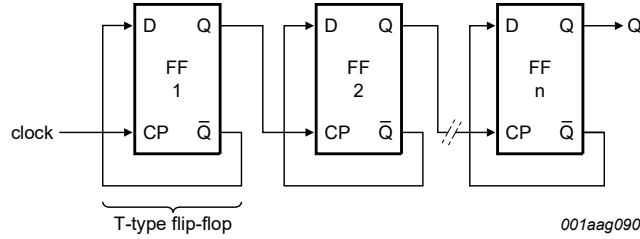


Fig. 8. Binary ripple up-counter; divide-by- 2^n

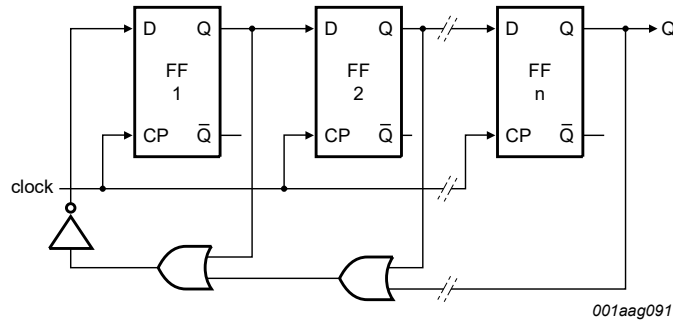


Fig. 9. Modified ring counter; divide-by-($n + 1$)

13. Package outline

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

SOT108-1

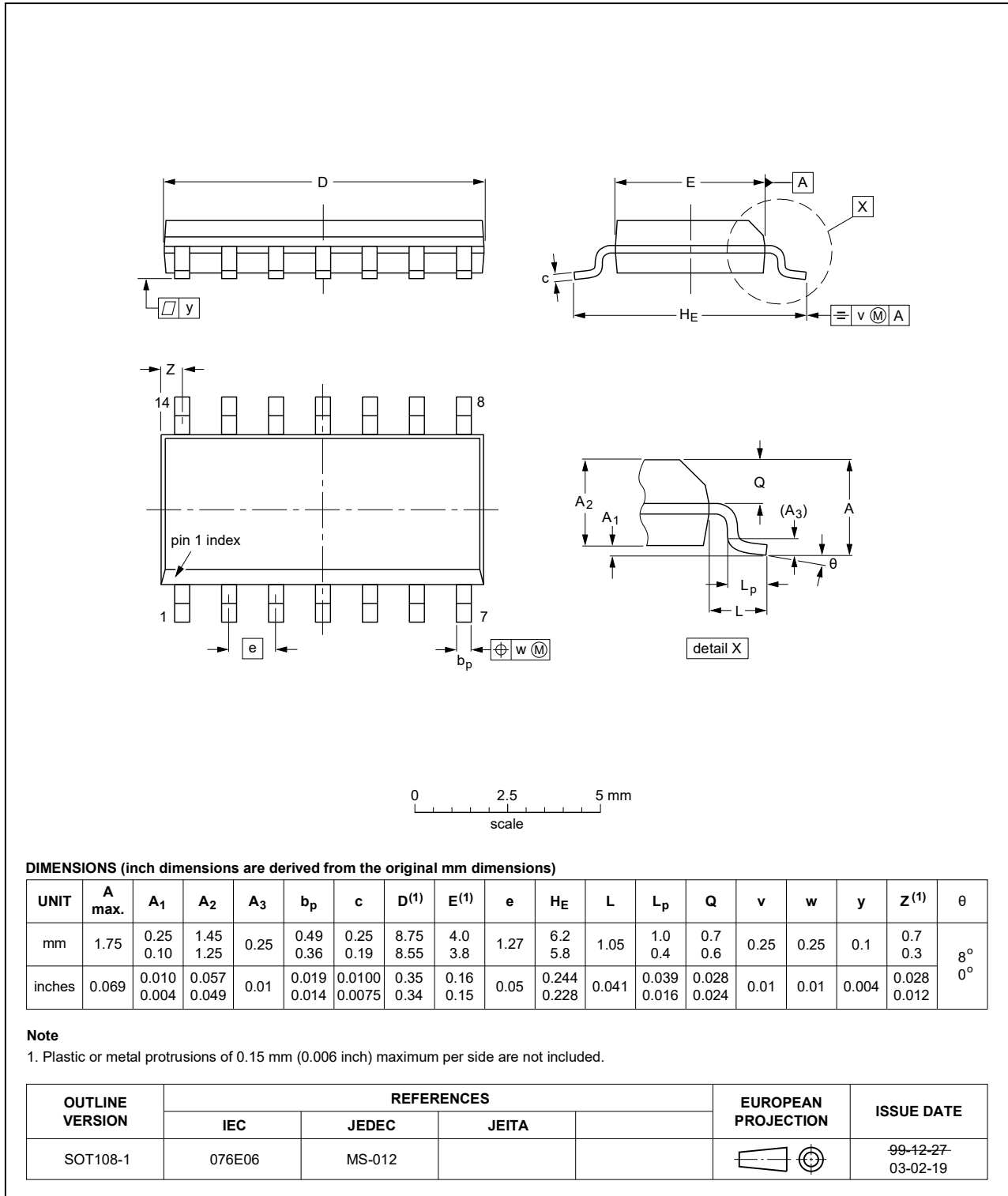


Fig. 10. Package outline SOT108-1 (SO14)

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

SOT402-1

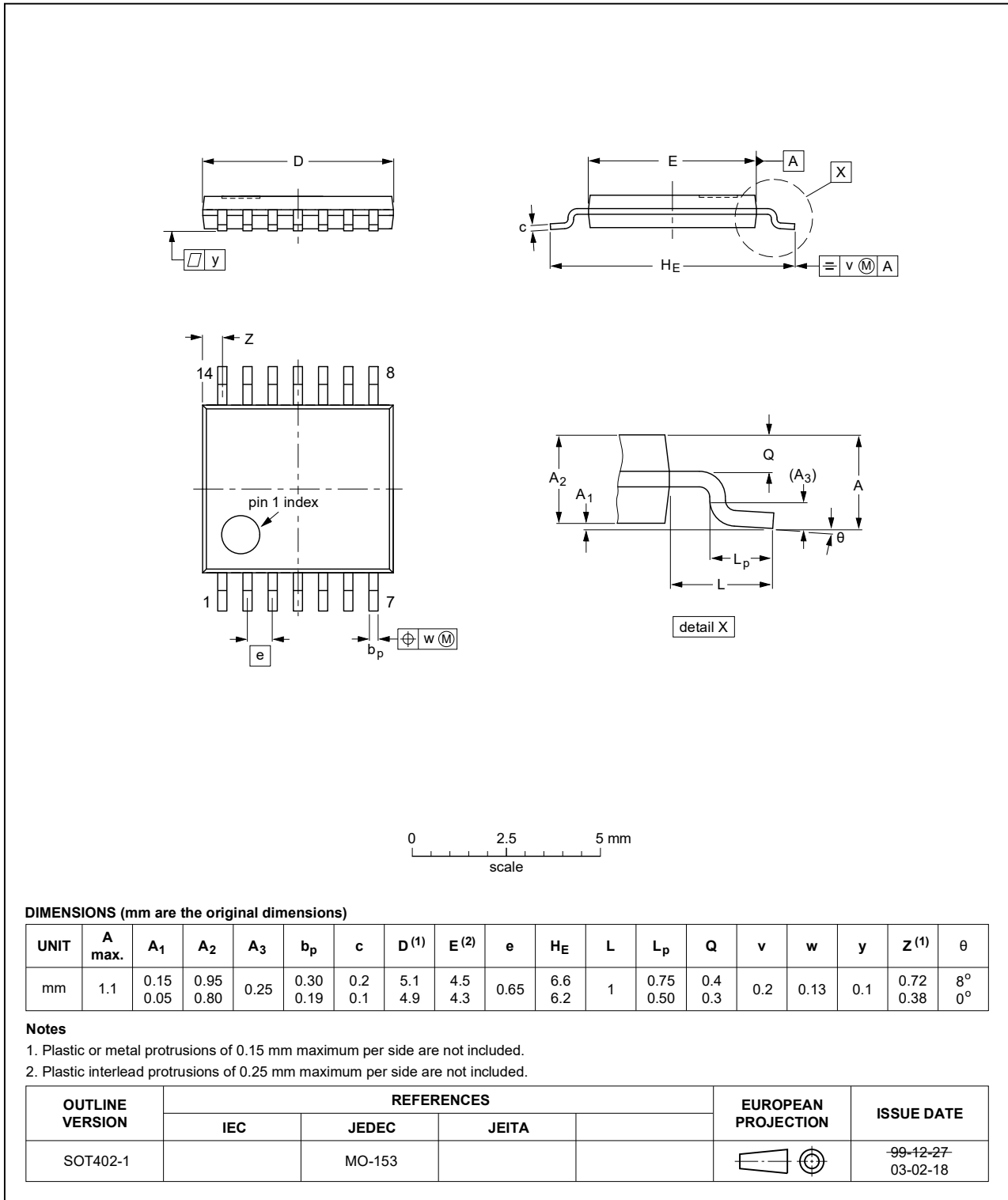


Fig. 11. Package outline SOT402-1 (TSSOP14)

14. Abbreviations

Table 11. Abbreviations

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

15. Revision history

Table 12. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|-------------------|---|--------------------|---------------|-------------------|
| HEF4013B_Q100 v.4 | 20211123 | Product data sheet | - | HEF4013B_Q100 v.3 |
| Modifications: | <ul style="list-style-type: none"> 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_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 | - | - |

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. |

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- [2] The term 'short data sheet' is explained in section "Definitions".
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