

# HEF4013B-Q100

## Dual D-type flip-flop

Rev. 2 — 20 February 2013

Product data sheet

## 1. General description

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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

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- 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

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- 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                                                            |          |
| HEF4013BP-Q100  | DIP14   | plastic dual in-line package; 14 leads (300 mil)                       | SOT27-1  |
| 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

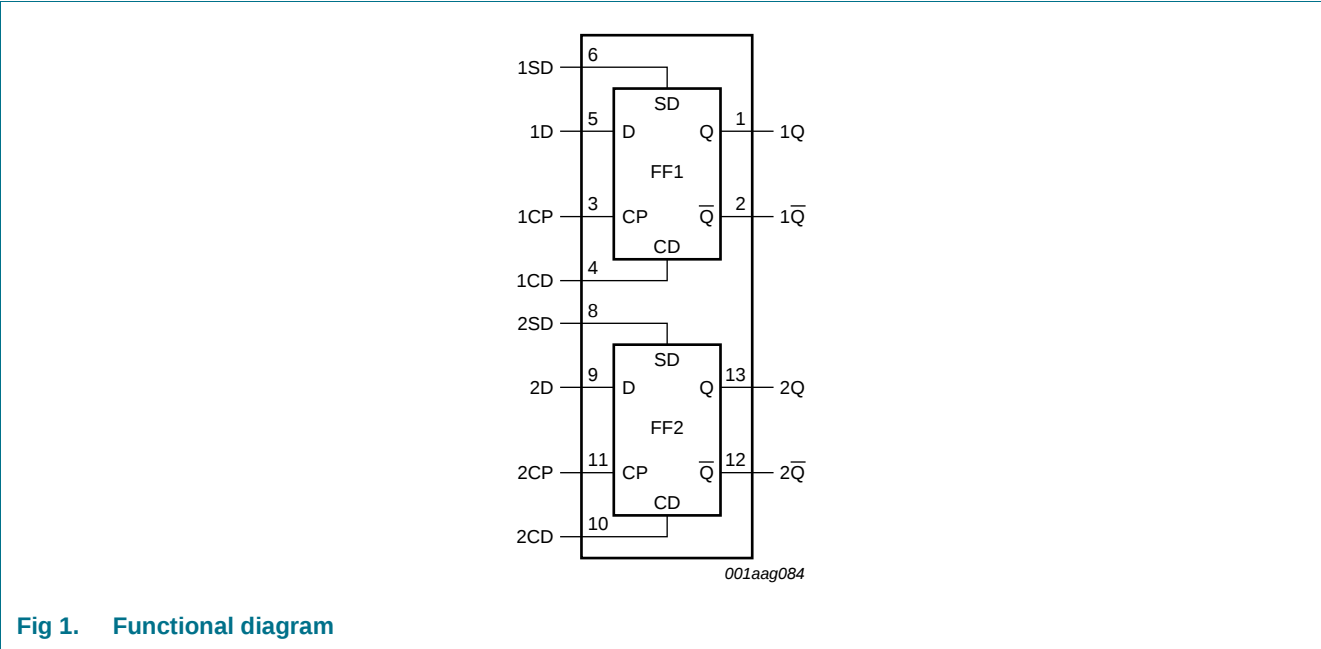


Fig 1. Functional diagram

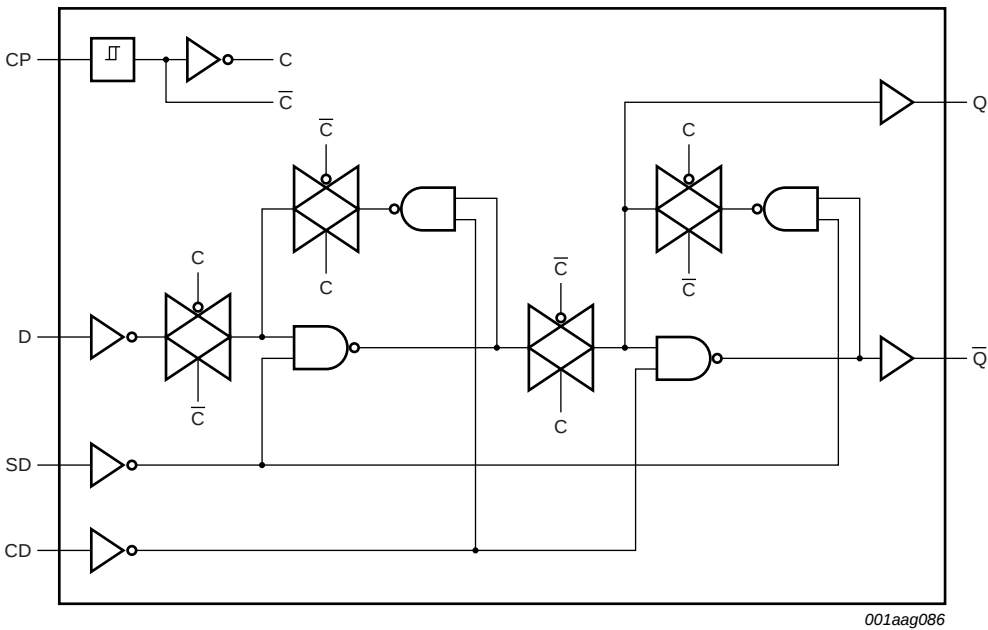


Fig 2. Logic diagram (one flip-flop)

6. Pinning information

6.1 Pinning

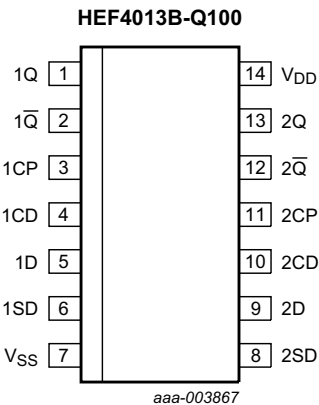


Fig 3. Pin configuration

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) |

Table 2. Pin description ...continued

| Symbol          | Pin   | Description                                   |
|-----------------|-------|-----------------------------------------------|
| 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 <sub>SS</sub> | 7     | ground (0 V)                                  |
| V <sub>DD</sub> | 14    | supply voltage                                |

## 7. Functional description

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

| 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<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                                |                  |                       |      |
|                  |                         | DIP14                                                               | <sup>[1]</sup> - | 750                   | mW   |
|                  |                         | SO14                                                                | <sup>[2]</sup> - | 500                   | mW   |
|                  |                         | TSSOP14                                                             | <sup>[3]</sup> - | 500                   | mW   |
| P                | power dissipation       | per output                                                          | -                | 100                   | mW   |

[1] For DIP14 packages: above T<sub>amb</sub> = 70 °C, P<sub>tot</sub> derates linearly with 12 mW/K.

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

[3] For TSSOP14 packages: above T<sub>amb</sub> = 60 °C, P<sub>tot</sub> 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 | $V_{DD} = 5\text{ V}$  | -   | 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     | -                         | $\pm 0.1$ | -                         | $\pm 0.1$ | -                         | $\pm 1.0$ | -                          | $\pm 1.0$ | $\mu\text{A}$ |
| $I_{DD}$ | supply current            | all valid input combinations;<br>$ I_O  = 0\text{ A}$ | 5 V      | -                         | 1.0       | -                         | 1.0       | -                         | 30        | -                          | 30        | $\mu\text{A}$ |
|          |                           |                                                       | 10 V     | -                         | 2.0       | -                         | 2.0       | -                         | 60        | -                          | 60        | $\mu\text{A}$ |
|          |                           |                                                       | 15 V     | -                         | 4.0       | -                         | 4.0       | -                         | 120       | -                          | 120       | $\mu\text{A}$ |
| $C_I$    | 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 <a href="#">Figure 4</a> | 5 V      | <a href="#">[1]</a> $83 + 0.55 \times C_L$ | -   | 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      | <a href="#">[1]</a> $73 + 0.55 \times C_L$ | -   | 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      | <a href="#">[1]</a> $73 + 0.55 \times C_L$ | -   | 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 <a href="#">Figure 4</a> | 5 V      | <a href="#">[1]</a> $68 + 0.55 \times C_L$ | -   | 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      | <a href="#">[1]</a> $48 + 0.55 \times C_L$ | -   | 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      | <a href="#">[1]</a> $33 + 0.55 \times C_L$ | -   | 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 <a href="#">Figure 4</a>                              | 5 V      | <a href="#">[1]</a> $10 + 1.00 \times C_L$ | -   | 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 <a href="#">Figure 4</a>                   | 5 V      |                                            | 40  | 20  | -   | ns   |
|           |                               |                                                           | 10 V     |                                            | 25  | 10  | -   | ns   |
|           |                               |                                                           | 15 V     |                                            | 15  | 5   | -   | ns   |
| $t_h$     | hold time                     | nD to nCP; see <a href="#">Figure 4</a>                   | 5 V      |                                            | 20  | 0   | -   | ns   |
|           |                               |                                                           | 10 V     |                                            | 20  | 0   | -   | ns   |
|           |                               |                                                           | 15 V     |                                            | 15  | 0   | -   | ns   |
| $t_w$     | pulse width                   | nCP input LOW; see <a href="#">Figure 4</a>               | 5 V      |                                            | 60  | 30  | -   | ns   |
|           |                               |                                                           | 10 V     |                                            | 30  | 15  | -   | ns   |
|           |                               |                                                           | 15 V     |                                            | 20  | 10  | -   | ns   |
|           |                               | nSD input HIGH; see <a href="#">Figure 5</a>              | 5 V      |                                            | 50  | 25  | -   | ns   |
|           |                               |                                                           | 10 V     |                                            | 24  | 12  | -   | ns   |
|           |                               |                                                           | 15 V     |                                            | 20  | 10  | -   | ns   |
|           |                               | nCD input HIGH; see <a href="#">Figure 5</a>              | 5 V      |                                            | 50  | 25  | -   | ns   |
|           |                               |                                                           | 10 V     |                                            | 24  | 12  | -   | ns   |
|           |                               |                                                           | 15 V     |                                            | 20  | 10  | -   | ns   |

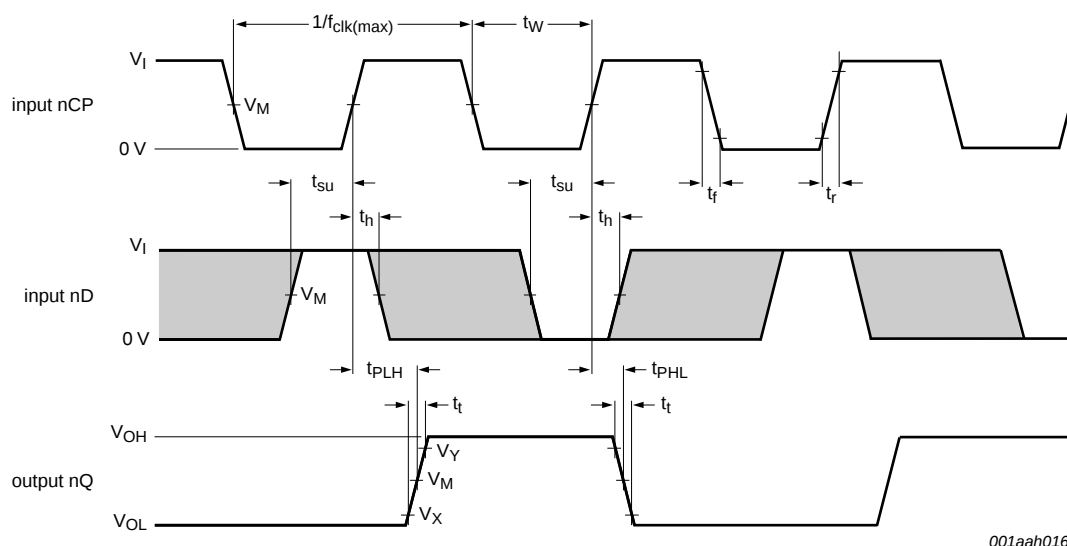
**Table 7. Dynamic characteristics ...continued** $T_{amb} = 25\text{ }^{\circ}\text{C}$ ; unless otherwise specified. For test circuit see [Figure 6](#).

| Symbol         | Parameter               | Conditions                                 | $V_{DD}$ | Extrapolation formula | Min | Typ | Max | Unit |
|----------------|-------------------------|--------------------------------------------|----------|-----------------------|-----|-----|-----|------|
| $t_{rec}$      | recovery time           | nSD input;<br>see <a href="#">Figure 5</a> | 5 V      |                       | +15 | -5  | -   | ns   |
|                |                         |                                            | 10 V     |                       | 15  | 0   | -   | ns   |
|                |                         |                                            | 15 V     |                       | 15  | 0   | -   | ns   |
|                |                         | nCD input;<br>see <a href="#">Figure 5</a> | 5 V      |                       | 40  | 25  | -   | ns   |
|                |                         |                                            | 10 V     |                       | 25  | 10  | -   | ns   |
|                |                         |                                            | 15 V     |                       | 25  | 10  | -   | ns   |
| $f_{clk(max)}$ | maximum clock frequency | see <a href="#">Figure 4</a>               | 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;                |
|        |                           | 10 V     | $P_D = 3600 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2\text{ }\mu\text{W}$ | $f_o$ = output frequency in MHz;               |
|        |                           | 15 V     | $P_D = 9000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2\text{ }\mu\text{W}$ | $C_L$ = output load capacitance in pF;         |
|        |                           |          |                                                                                     | $\Sigma(f_o \times C_L)$ = sum of the outputs; |
|        |                           |          |                                                                                     | $V_{DD}$ = supply voltage in V.                |

## 12. Waveforms

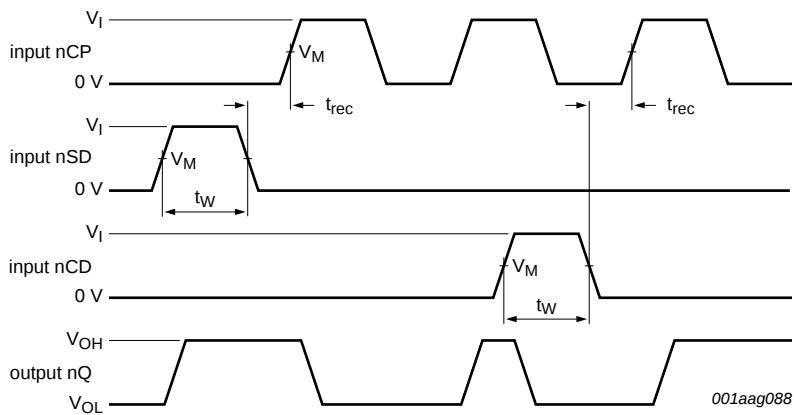


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Set-up and hold times are shown as positive values but may be specified as negative values.

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**

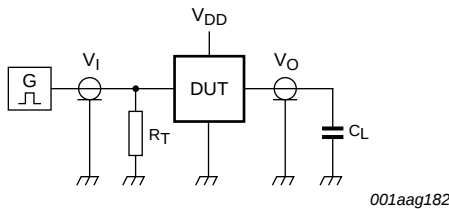


Recovery times are shown as positive values but may be specified as negative values.  
 Measurement points are given in [Table 9](#).

**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    | $0.5V_{DD}$ | $0.5V_{DD}$ | $0.1V_{DD}$ | $0.9V_{DD}$ |



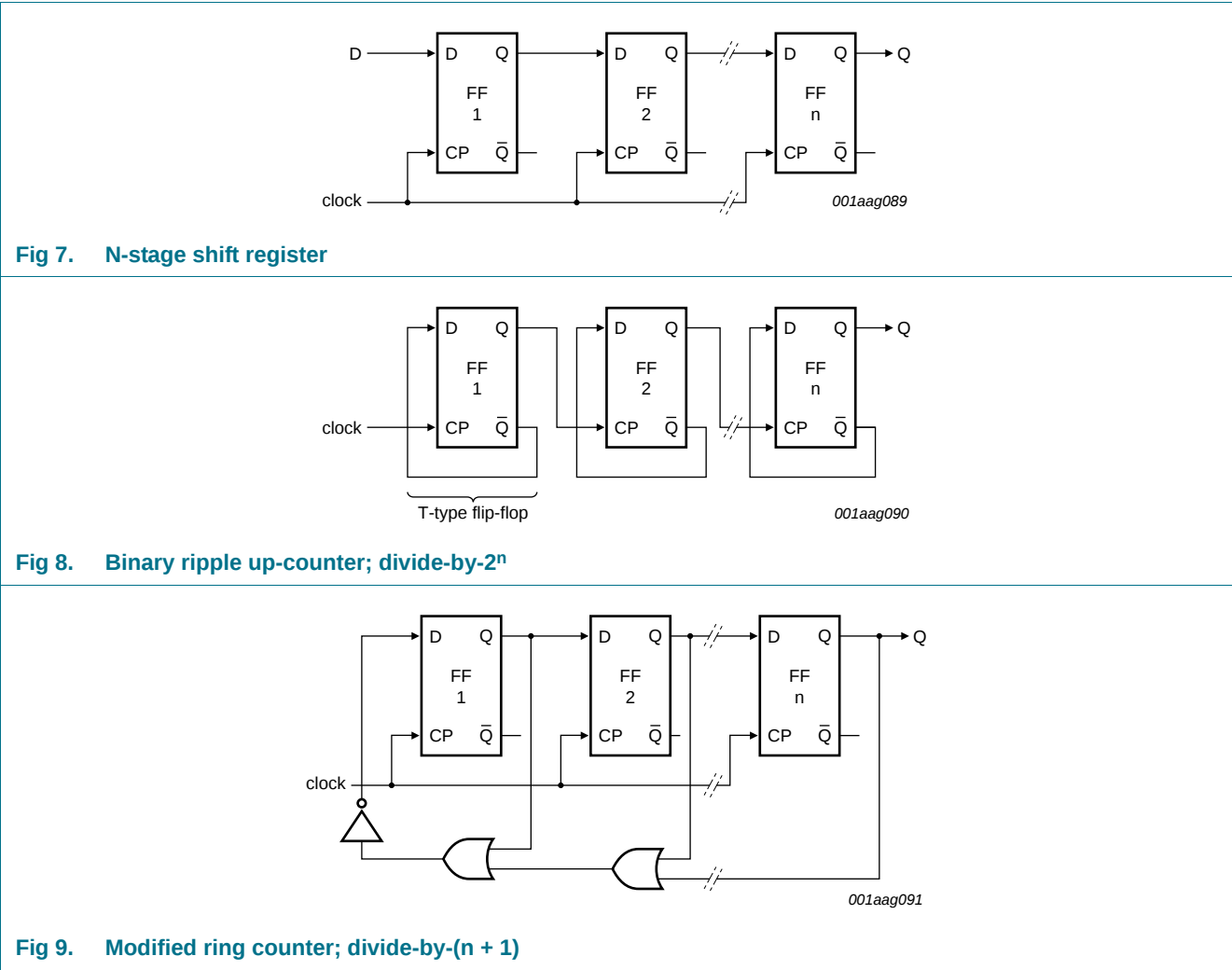
Test and measurement data is given in [Table 10](#);  
 Definitions test circuit:  
 DUT = Device Under Test.  
 $R_T$  = Termination resistance should be equal to output impedance  $Z_o$  of the pulse generator.  
 $C_L$  = Load capacitance including jig and probe capacitance.

**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 $V_{DD}$ | $\leq 20\text{ ns}$ | 50 pF |

13. Application information



14. Package outline

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

SOT27-1

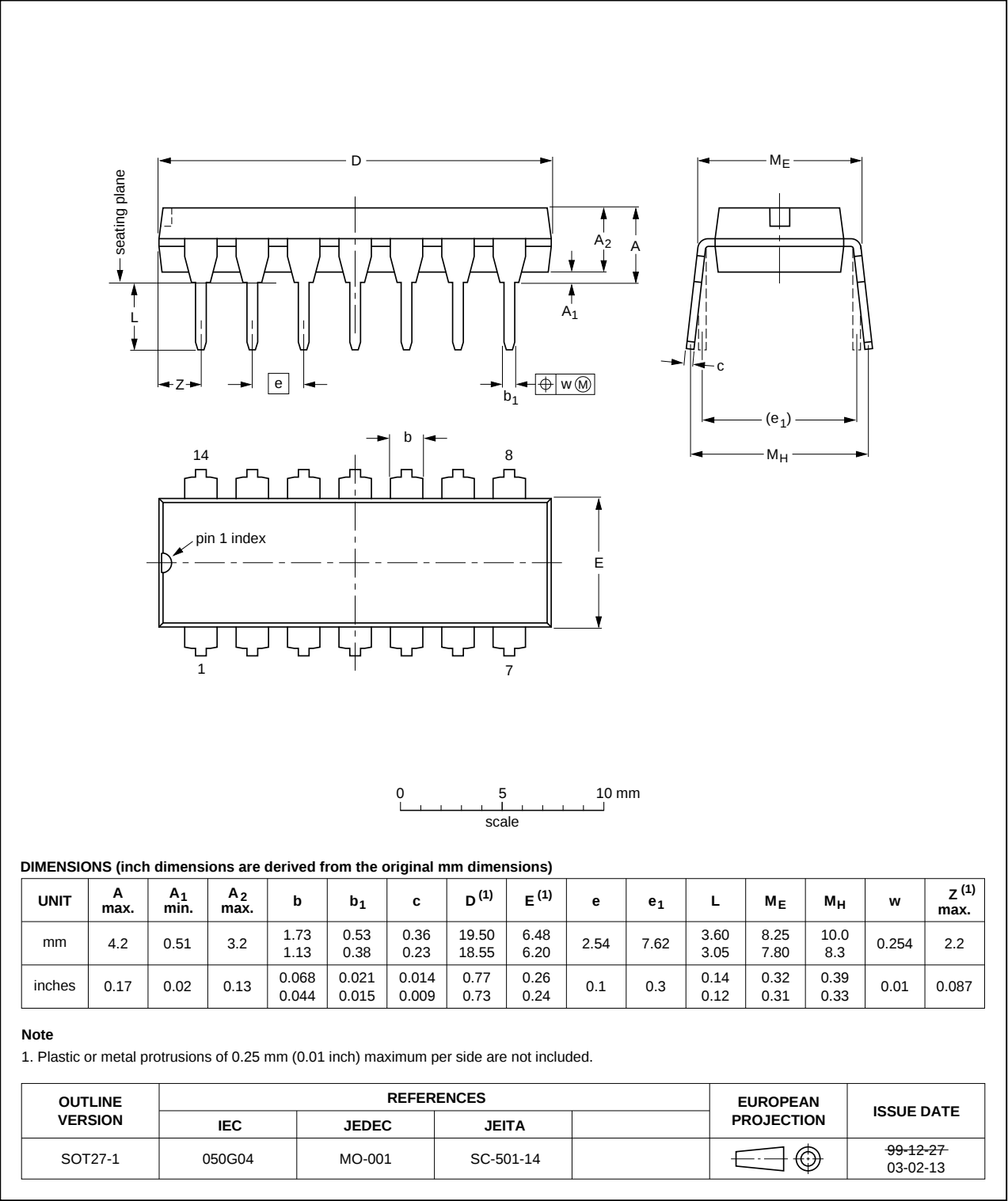


Fig 10. Package outline SOT27-1 (DIP14)

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

SOT108-1

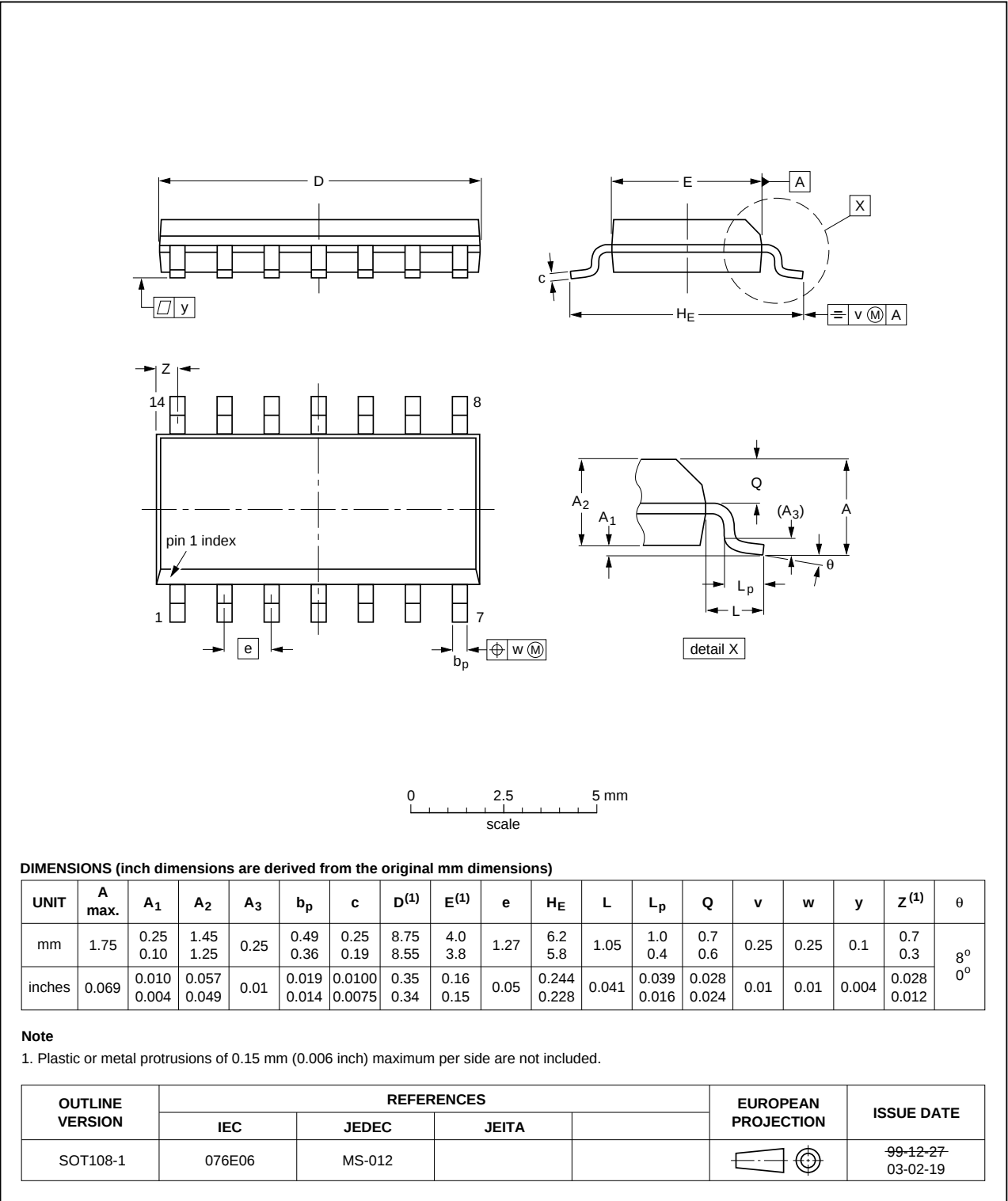


Fig 11. Package outline SOT108-1 (SO14)

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

SOT402-1

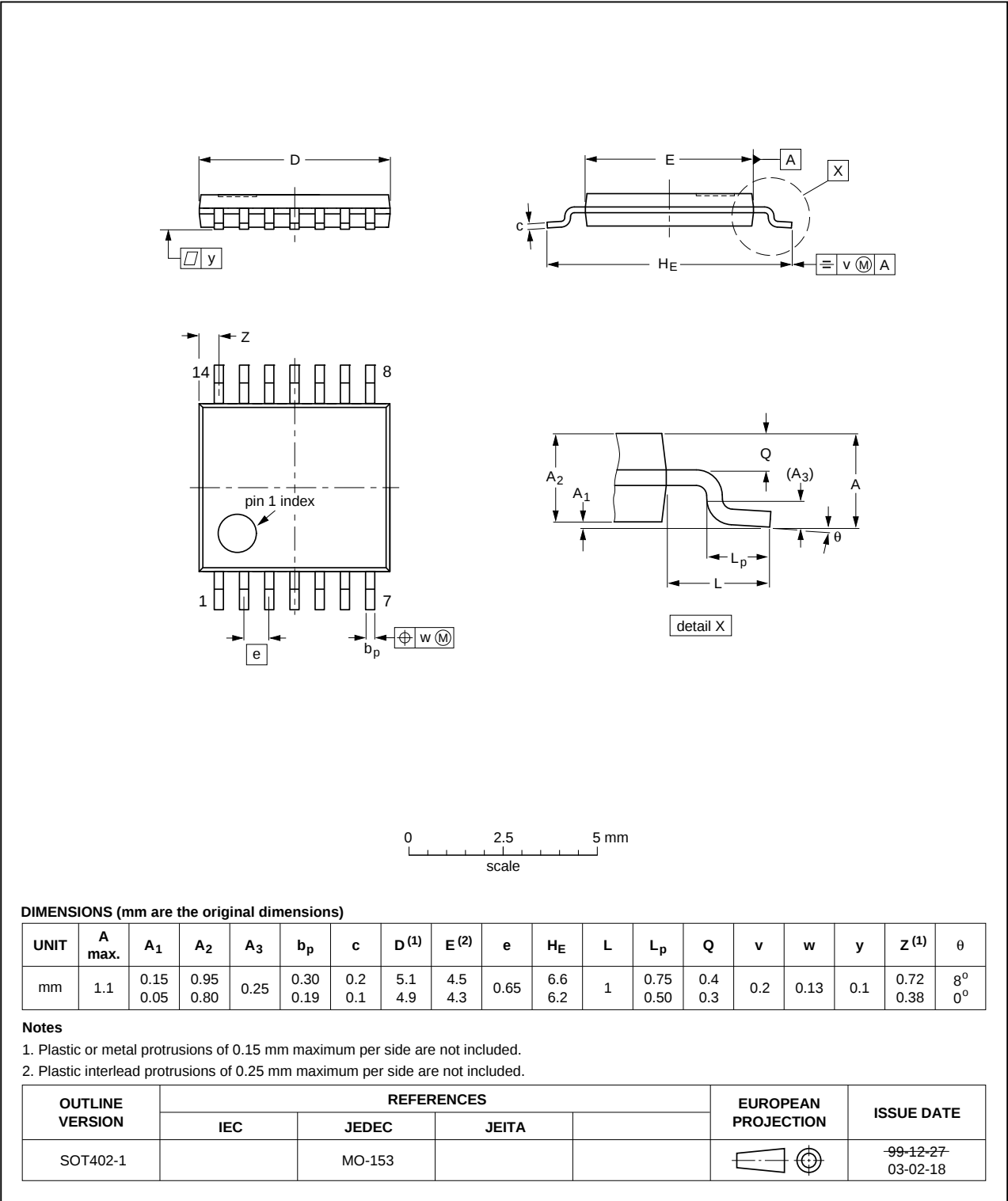


Fig 12. Package outline SOT402-1 (TSSOP14)

## 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.2 | 20130220                        | Product data sheet | -             | HEF4013B_Q100 |
| Modifications:    | • HEF4013BP-Q100 (DIP14) added. |                    |               |               |
| HEF4013B_Q100 v.1 | 20120807                        | Product data sheet | -             | -             |

## 17. Legal information

### 17.1 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.                       |
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[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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