

# HEF4021B

## 8-bit static shift register

Rev. 9 — 30 August 2013

Product data sheet

### 1. General description

The HEF4021B is an 8-bit static shift register (parallel-to-serial converter) with a synchronous serial data input (DS), a clock input (CP), an asynchronous active HIGH parallel load input (PL), eight asynchronous parallel data inputs (D0 to D7) and buffered parallel outputs from the last three stages (Q5 to Q7).

Each register stage is a D-type master-slave flip-flop with a set direct (SD) and clear direct (CD) input. Information on D0 to D7 is asynchronously loaded into the register while PL is HIGH, independent of CP and DS. When PL is LOW, data on DS is shifted into the first register position and all the data in the register is shifted one position to the right on the LOW-to-HIGH transition of CP. Schmitt trigger action makes the clock input highly tolerant of slower 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.

### 2. Features and benefits

- Tolerant of slower rise and fall times
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Specified from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$
- Complies with JEDEC standard JESD 13-B

### 3. Ordering information

**Table 1. Ordering information**

All types operate from  $-40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ .

| Type number | Package | Description  | Version  |
|-------------|---------|--|----------|
|             | Name    |  |          |
| HEF4021BP   | DIP16   | plastic dual in-line package; 16 leads (300 mil)                       | SOT38-4  |
| HEF4021BT   | SO16    | plastic small outline package; 16 leads; body width 3.9 mm             | SOT109-1 |
| HEF4021BTT  | TSSOP16 | plastic thin shrink small outline package; 16 leads; body width 4.4 mm | SOT403-1 |



4. Functional diagram

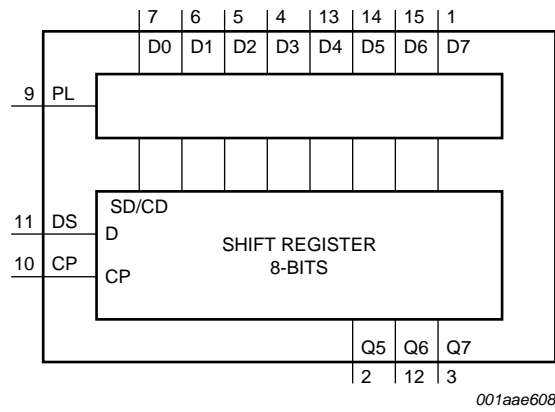


Fig 1. Functional diagram

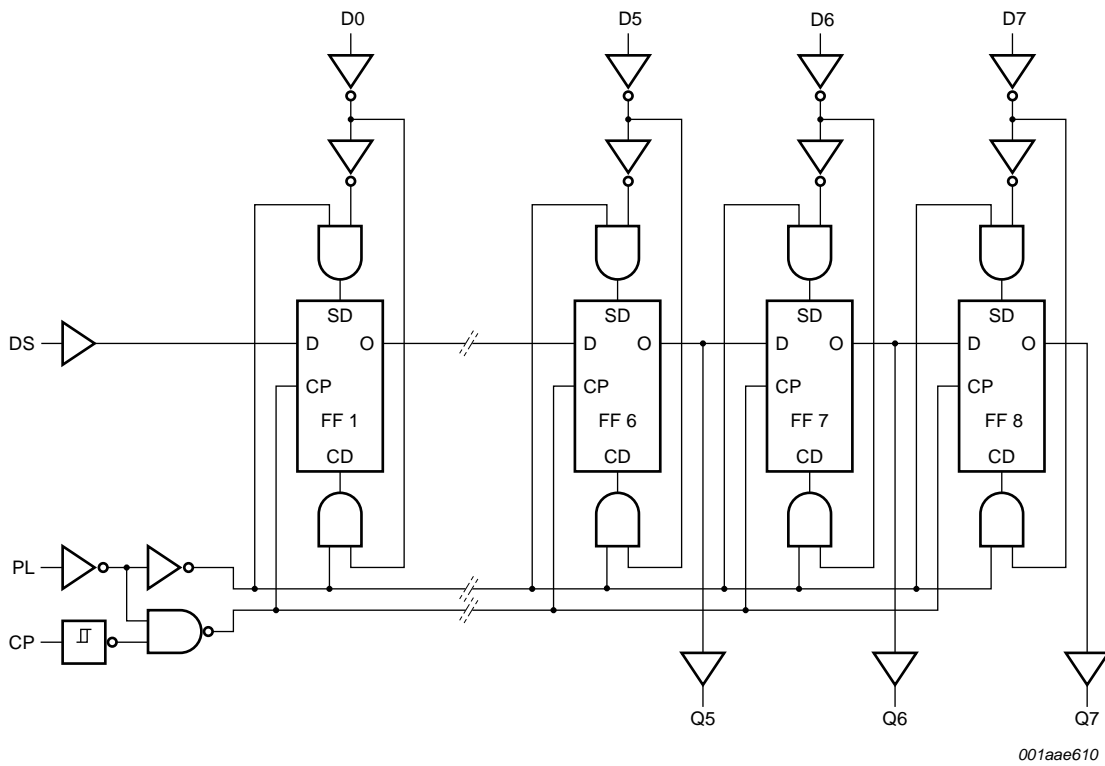


Fig 2. Logic diagram

## 5. Pinning information

### 5.1 Pinning

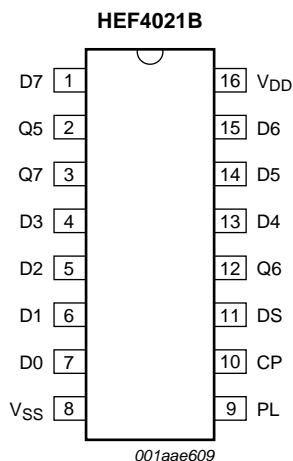


Fig 3. Pin configuration

### 5.2 Pin description

Table 2. Pin description

| Symbol          | Pin                      | Description   |
|-----------------|--------------------------|---|
| Q5 to Q7        | 2, 12, 3                 | buffered parallel output from the last three stages |
| D0 to D7        | 7, 6, 5, 4, 13, 14,15, 1 | parallel data input                                 |
| V <sub>SS</sub> | 8                        | ground supply voltage                               |
| PL              | 9                        | parallel load input                                 |
| CP              | 10                       | clock input (LOW-to-HIGH edge-triggered)            |
| DS              | 11                       | serial data input                                   |
| V <sub>DD</sub> | 16                       | supply voltage                                      |

## 6. Functional description

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

| Number of clock transitions | Inputs |        |    | Outputs |        |    |
|-----------------------------|--------|--------|----|---------|--------|----|
|                             | CP     | DS     | PL | Q5      | Q6     | Q7 |
| <b>Serial operation</b>     |        |        |    |         |        |    |
| 1                           | ↑      | data 1 | L  | X       | X      | X  |
| 2                           | ↑      | data 2 | L  | X       | X      | X  |
| 3                           | ↑      | data 3 | L  | X       | X      | X  |
| 6                           | ↑      | X      | L  | data 1  | X      | X  |
| 7                           | ↑      | X      | L  | data 2  | data 1 | X  |

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

| Number of clock transitions | Inputs |    |    | Outputs   |           |           |
|-----------------------------|--------|----|----|-----------|-----------|-----------|
|                             | CP     | DS | PL | Q5        | Q6        | Q7        |
| 8                           | ↑      | X  | L  | data 3    | data 2    | data 1    |
|                             | ↓      | X  | L  | no change | no change | no change |
| <b>Parallel operation</b>   |        |    |    |           |           |           |
|                             | X      | X  | H  | D5        | D6        | D7        |

- [1] H = HIGH voltage level; L = LOW voltage level; X = don't care;  
 ↑ = LOW to HIGH clock transition; ↓ = HIGH to LOW clock transition;  
 data n = data (HIGH or LOW) on the DS input at the n<sup>th</sup> ↑ CP transition.

## 7. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

| 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                                  |                |                       |      |    |
|                  |                         | DIP16 package   | <sup>[1]</sup> | -                     | 750  | mW |
|                  |                         | SO16 and TSSOP16 package  | <sup>[2]</sup> | -                     | 500  | mW |
| P                | power dissipation       | per output  | -              | 100                   | mW   |    |

- [1] For DIP16 package: P<sub>tot</sub> derates linearly with 12 mW/K above 70 °C.  
 [2] For SO16 package: P<sub>tot</sub> derates linearly with 8 mW/K above 70 °C.  
 For TSSOP16 package: P<sub>tot</sub> derates linearly with 5.5 mW/K above 60 °C.

## 8. Recommended operating conditions

Table 5. Recommended operating conditions

| Symbol           | Parameter                           | Conditions             | Min | Typ | Max             | Unit |
|------------------|-------------------------------------|------------------------|-----|-----|-----------------|------|
| V <sub>DD</sub>  | supply voltage                      |                        | 3   | -   | 15              | V    |
| V <sub>I</sub>   | input voltage                       |                        | 0   | -   | V <sub>DD</sub> | V    |
| T <sub>amb</sub> | ambient temperature                 | in free air            | -40 | -   | +125            | °C   |
| Δt/ΔV            | input transition rise and fall rate | V <sub>DD</sub> = 5 V  | -   | -   | 3.75            | μs/V |
|                  |                                     | V <sub>DD</sub> = 10 V | -   | -   | 0.5             | μs/V |
|                  |                                     | V <sub>DD</sub> = 15 V | -   | -   | 0.08            | μs/V |

## 9. 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     | $V_{DD} = 15\text{ V}$         | 15 V     | -                         | $\pm 0.1$ | -                        | $\pm 0.1$ | -                        | $\pm 1.0$ | -                         | $\pm 1.0$ | $\mu\text{A}$ |
| $I_{DD}$ | supply current            | $I_O = 0\text{ A}$             | 5 V      | -                         | 5         | -                        | 5         | -                        | 150       | -                         | 150       | $\mu\text{A}$ |
|          |                           |                                | 10 V     | -                         | 10        | -                        | 10        | -                        | 300       | -                         | 300       | $\mu\text{A}$ |
|          |                           |                                | 15 V     | -                         | 20        | -                        | 20        | -                        | 600       | -                         | 600       | $\mu\text{A}$ |
| $C_I$    | input capacitance         | -                              | -        | -                         | -         | 7.5                      | -         | -                        | -         | -                         | pF        |               |

## 10. Dynamic characteristics

**Table 7. Dynamic characteristics**

$V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ °C}$ ; for test circuit see [Figure 7](#); unless otherwise specified.

| Symbol    | Parameter                     | Conditions                               | $V_{DD}$ | Extrapolation formula                          | Min | Typ | Max | Unit |
|-----------|-------------------------------|--|----------|--|-----|-----|-----|------|
| $t_{PHL}$ | HIGH to LOW propagation delay | CP to Qn<br>see <a href="#">Figure 4</a> | 5 V      | <a href="#">[1]</a> 98 ns + (0.55 ns/pF) $C_L$ | -   | 125 | 250 | ns   |
|           |                               |  | 10 V     | 44 ns + (0.23 ns/pF) $C_L$                     | -   | 55  | 110 | ns   |
|           |                               |  | 15 V     | 32 ns + (0.16 ns/pF) $C_L$                     | -   | 40  | 80  | ns   |
|           |                               | PL to Qn<br>see <a href="#">Figure 4</a> | 5 V      | 93 ns + (0.55 ns/pF) $C_L$                     | -   | 120 | 240 | ns   |
|           |                               |  | 10 V     | 44 ns + (0.23 ns/pF) $C_L$                     | -   | 55  | 110 | ns   |
|           |                               |  | 15 V     | 32 ns + (0.16 ns/pF) $C_L$                     | -   | 40  | 80  | ns   |

**Table 7. Dynamic characteristics ...continued**  
 $V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ °C}$ ; for test circuit see [Figure 7](#); unless otherwise specified.

| Symbol                | Parameter                     | Conditions   | V <sub>DD</sub> | Extrapolation formula                             | Min | Typ | Max | Unit |
|-----------------------|-------------------------------|--|-----------------|---|-----|-----|-----|------|
| t <sub>PLH</sub>      | LOW to HIGH propagation delay | CP to Qn<br>see <a href="#">Figure 4</a>                     | 5 V             | <sup>[1]</sup> 88 ns + (0.55 ns/pF)C <sub>L</sub> | -   | 115 | 230 | ns   |
|                       |                               |  | 10 V            | 39 ns + (0.23 ns/pF)C <sub>L</sub>                | -   | 50  | 100 | ns   |
|                       |                               |  | 15 V            | 32 ns + (0.16 ns/pF)C <sub>L</sub>                | -   | 40  | 80  | ns   |
|                       |                               | PL to Qn<br>see <a href="#">Figure 4</a>                     | 5 V             | 78 ns + (0.55 ns/pF)C <sub>L</sub>                | -   | 105 | 210 | ns   |
|                       |                               |  | 10 V            | 39 ns + (0.23 ns/pF)C <sub>L</sub>                | -   | 50  | 100 | ns   |
|                       |                               |  | 15 V            | 32 ns + (0.16 ns/pF)C <sub>L</sub>                | -   | 40  | 80  | ns   |
| t <sub>t</sub>        | transition time               | Qn; see <a href="#">Figure 4</a>                             | 5 V             | <sup>[1]</sup> 10 ns + (1.00 ns/pF)C <sub>L</sub> | -   | 60  | 120 | ns   |
|                       |                               |  | 10 V            | 9 ns + (0.42 ns/pF)C <sub>L</sub>                 | -   | 30  | 60  | ns   |
|                       |                               |  | 15 V            | 6 ns + (0.28 ns/pF)C <sub>L</sub>                 | -   | 20  | 40  | ns   |
| t <sub>su</sub>       | set-up time                   | DS to CP;<br>see <a href="#">Figure 5</a>                    | 5 V             |   | +25 | -15 | -   | ns   |
|                       |                               |  | 10 V            |   | +25 | -10 | -   | ns   |
|                       |                               |  | 15 V            |   | +15 | -5  | -   | ns   |
|                       |                               | Dn to PL;<br>see <a href="#">Figure 6</a>                    | 5 V             |   | 50  | 25  | -   | ns   |
|                       |                               |  | 10 V            |   | 30  | 10  | -   | ns   |
|                       |                               |  | 15 V            |   | 20  | 5   | -   | ns   |
| t <sub>h</sub>        | hold time                     | DS to CP;<br>see <a href="#">Figure 5</a>                    | 5 V             |   | 40  | 20  | -   | ns   |
|                       |                               |  | 10 V            |   | 20  | 10  | -   | ns   |
|                       |                               |  | 15 V            |   | 15  | 8   | -   | ns   |
|                       |                               | Dn to PL;<br>see <a href="#">Figure 6</a>                    | 5 V             |   | +15 | -10 | -   | ns   |
|                       |                               |  | 10 V            |   | 15  | 0   | -   | ns   |
|                       |                               |  | 15 V            |   | 15  | 0   | -   | ns   |
| t <sub>w</sub>        | pulse width                   | CP = LOW;<br>minimum width;<br>see <a href="#">Figure 5</a>  | 5 V             |   | 70  | 35  | -   | ns   |
|                       |                               |  | 10 V            |   | 30  | 15  | -   | ns   |
|                       |                               |  | 15 V            |   | 24  | 12  | -   | ns   |
|                       |                               | PL = HIGH;<br>minimum width;<br>see <a href="#">Figure 6</a> | 5 V             |   | 70  | 35  | -   | ns   |
|                       |                               |  | 10 V            |   | 30  | 15  | -   | ns   |
|                       |                               |  | 15 V            |   | 24  | 12  | -   | ns   |
| t <sub>rec</sub>      | recovery time                 | PL input;<br>see <a href="#">Figure 6</a>                    | 5 V             |   | 50  | 10  | -   | ns   |
|                       |                               |  | 10 V            |   | 40  | 5   | -   | ns   |
|                       |                               |  | 15 V            |   | 35  | 5   | -   | ns   |
| f <sub>clk(max)</sub> | maximum clock frequency       | CP input;<br>see <a href="#">Figure 5</a>                    | 5 V             |   | 6   | 13  | -   | MHz  |
|                       |                               |  | 10 V            |   | 15  | 30  | -   | MHz  |
|                       |                               |  | 15 V            |   | 20  | 40  | -   | MHz  |

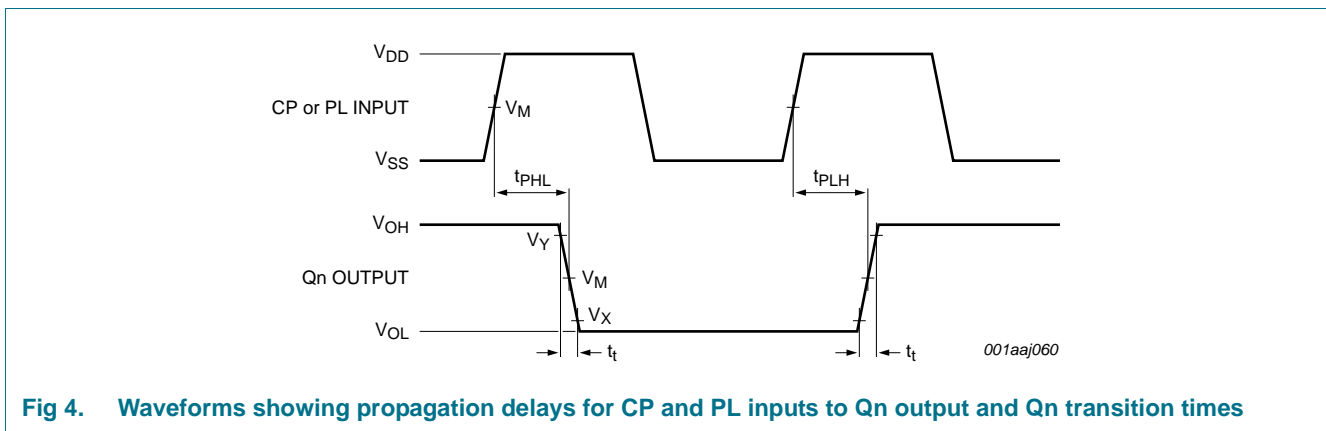
[1] The typical values of the propagation delay and transition times are calculated from the extrapolation formulas shown (C<sub>L</sub> in pF).

**Table 8. Dynamic power dissipation  $P_D$**

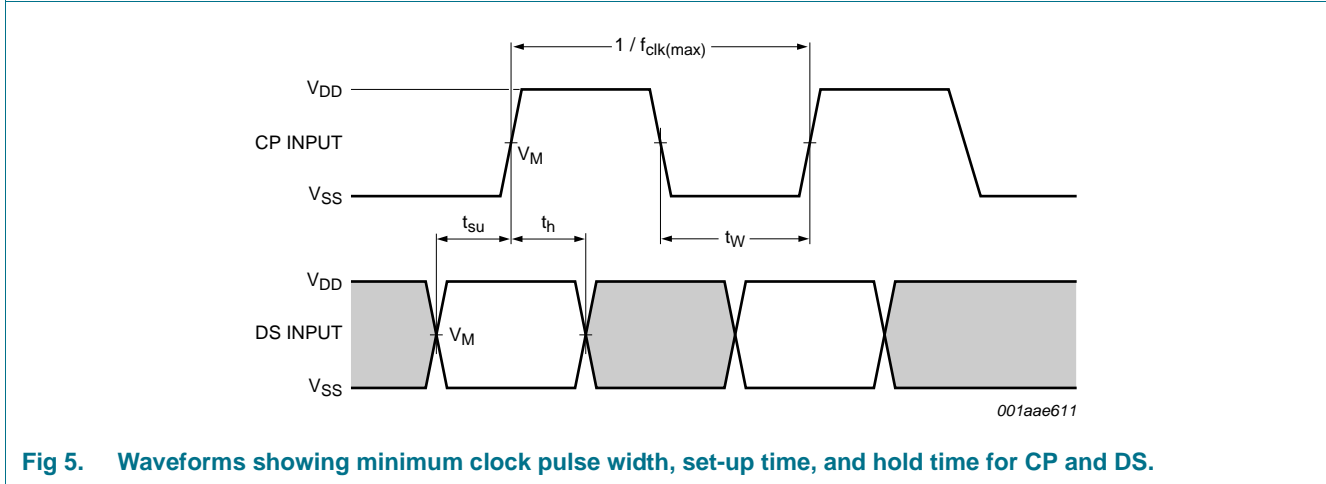
$P_D$  can be calculated from the formulas shown.  $V_{SS} = 0\text{ V}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .

| Symbol | Parameter                 | $V_{DD}$ | Typical formula for $P_D$ ( $\mu\text{W}$ )                       | where:  |
|--------|---------------------------|----------|---|---|
| $P_D$  | dynamic power dissipation | 5 V      | $P_D = 900 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$   | $f_i$ = input frequency in MHz,   |
|        |                           | 10 V     | $P_D = 4300 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$  | $f_o$ = output frequency in MHz,  |
|        |                           | 15 V     | $P_D = 12000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$ | $C_L$ = output load capacitance in pF,<br>$V_{DD}$ = supply voltage in V,<br>$\Sigma(f_o \times C_L)$ = sum of the outputs. |

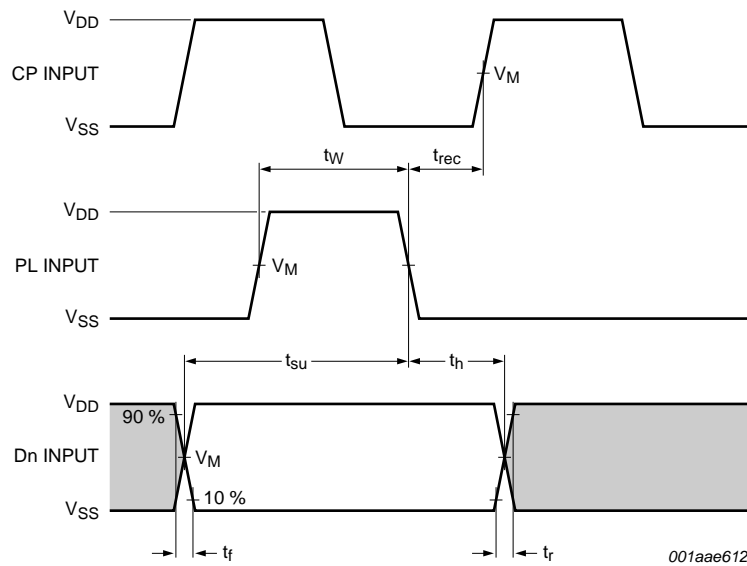
## 11. Waveforms



**Fig 4. Waveforms showing propagation delays for CP and PL inputs to Qn output and Qn transition times**



**Fig 5. Waveforms showing minimum clock pulse width, set-up time, and hold time for CP and DS.**

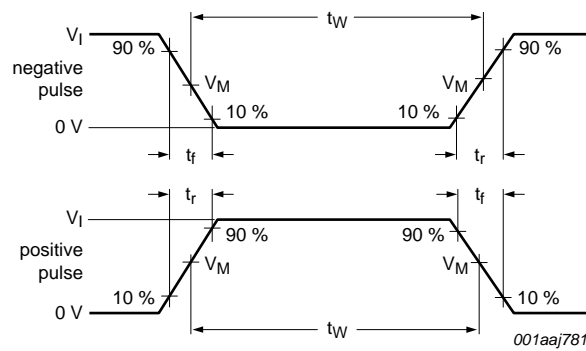


Set-up times and hold times are shown as positive values but may be specified as negative values; Measurement points are given in [Table 9](#).

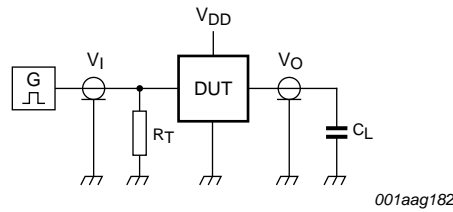
**Fig 6. Waveforms showing minimum pulse width and recovery time for PL; set-up and hold times for Dn to PL.**

**Table 9. Measurement points**

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



a. Input waveform



b. Test circuit

Test data is given in [Table 10](#).

Definitions for test circuit:

DUT = Device Under Test.

$C_L$  = load capacitance including jig and probe capacitance.

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

Fig 7. Test circuit for measuring switching times

Table 10. Test data

| Supply voltage | Input                | Load         |
|----------------|----------------------|--------------|
| $V_{DD}$       | $V_I$                | $C_L$        |
| 5 V to 15 V    | $V_{SS}$ or $V_{DD}$ | 50 pF        |
|                | $t_r, t_f$           | $\leq 20$ ns |

12. Package outline

DIP16: plastic dual in-line package; 16 leads (300 mil)

SOT38-4

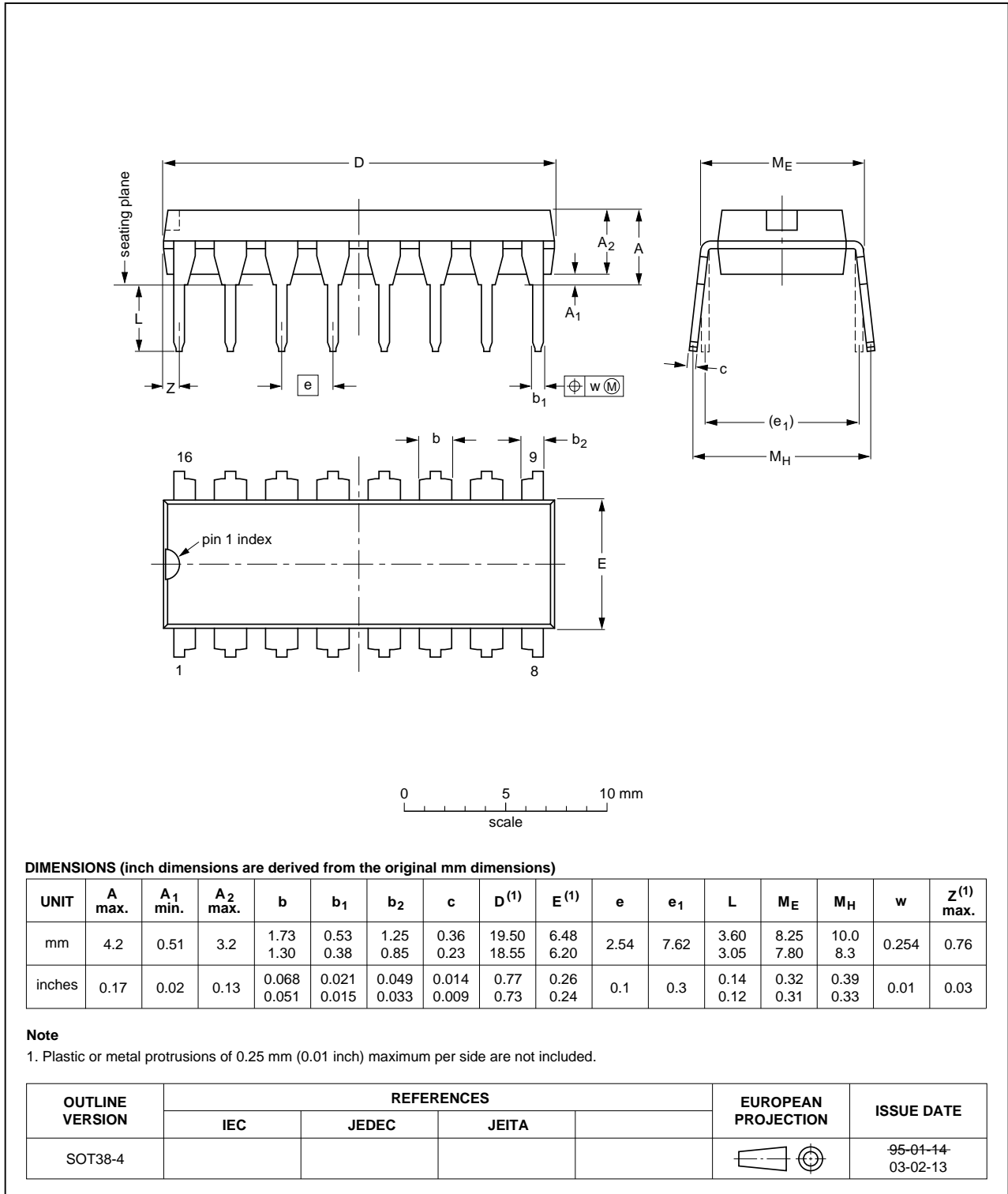


Fig 8. Package outline SOT38-4 (DIP16)

SO16: plastic small outline package; 16 leads; body width 3.9 mm

SOT109-1

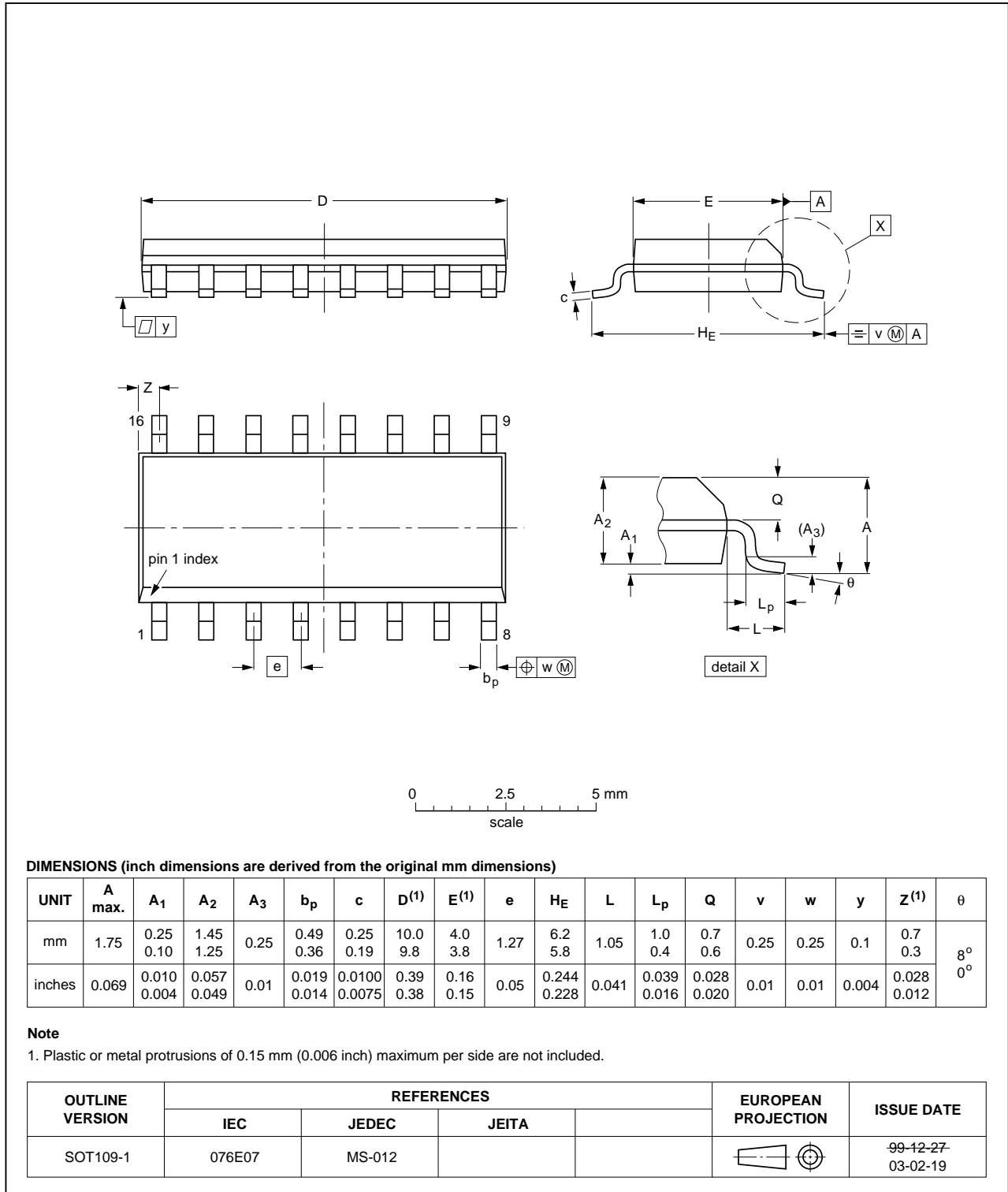


Fig 9. Package outline SOT109-1 (SO16)

TSSOP16: plastic thin shrink small outline package; 16 leads; body width 4.4 mm

SOT403-1

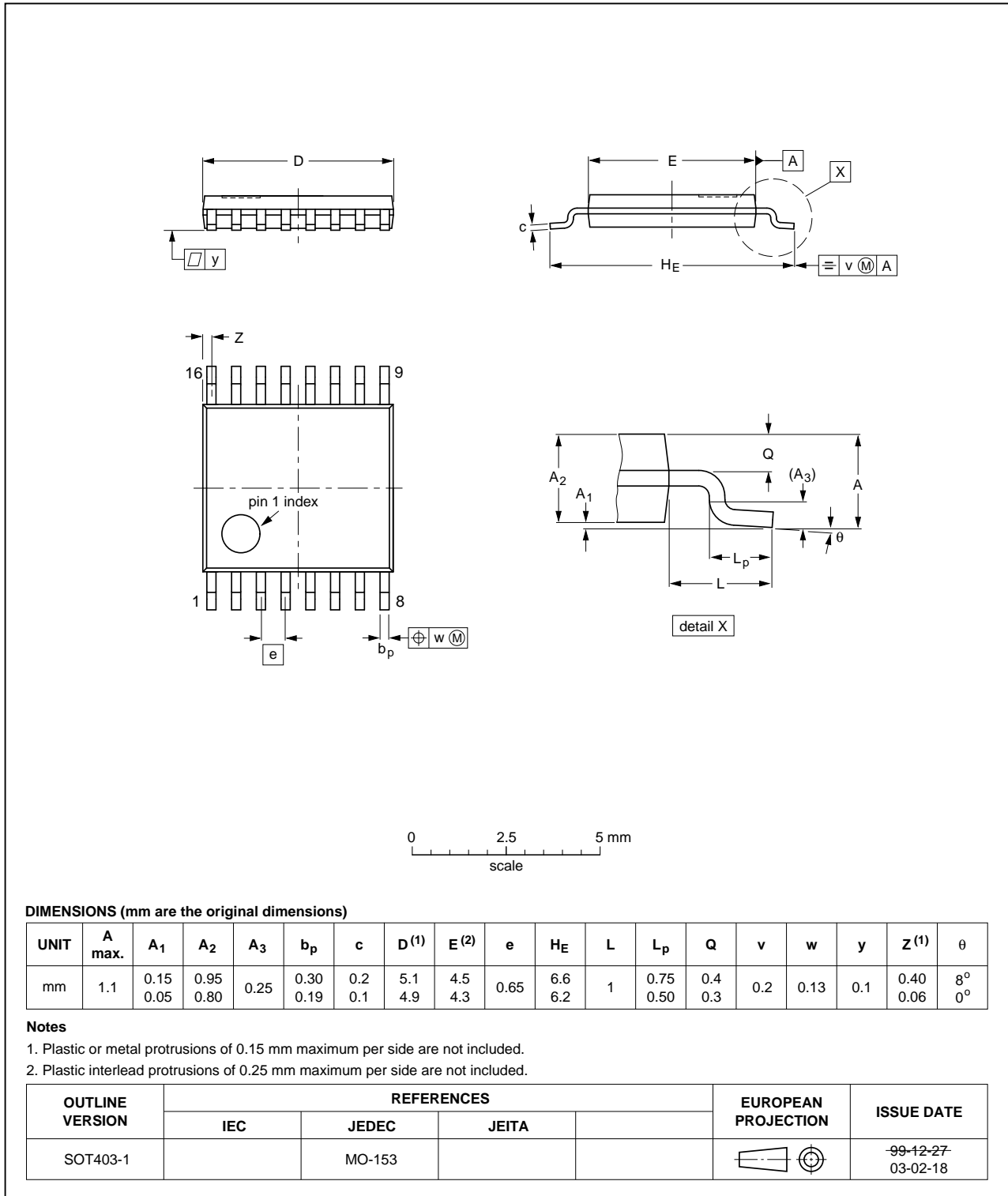


Fig 10. Package outline SOT403-1 (TSSOP16)

## 13. Revision history

Table 11. Revision history

| Document ID      | Release date   | Data sheet status     | Change notice | Supersedes       |
|------------------|--|-----------------------|---------------|------------------|
| HEF4021B v.9     | 20130830   | Product data sheet    | -             | HEF4021B v.8     |
| Modifications:   | <ul style="list-style-type: none"> <li>added type number HEF4021BTT.</li> </ul>  |                       |               |                  |
| HEF4021B v.8     | 20111118   | Product data sheet    | -             | HEF4021B v.7     |
| Modifications:   | <ul style="list-style-type: none"> <li>Legal pages updated.</li> <li>Changes in “General description” and “Features and benefits”.</li> <li>Section “Applications” removed.</li> </ul> |                       |               |                  |
| HEF4021B v.7     | 20111010   | Product data sheet    | -             | HEF4021B v.6     |
| HEF4021B v.6     | 20091127   | Product data sheet    | -             | HEF4021B v.5     |
| HEF4021B v.5     | 20090707   | Product data sheet    | -             | HEF4021B v.4     |
| HEF4021B v.4     | 20081110   | Product data sheet    | -             | HEF4021B_CNV v.3 |
| HEF4021B_CNV v.3 | 19950101   | Product specification | -             | HEF4021B_CNV v.2 |
| HEF4021B_CNV v.2 | 19950101   | Product specification | -             | -                |

## 14. Legal information

### 14.1 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.                       |
| 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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Date of release: 30 August 2013

Document identifier: HEF4021B



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