

# HEF4520B

## Dual binary counter

Rev. 8 — 1 March 2022

Product data sheet

## 1. General description

The HEF4520B is a dual 4-bit internally synchronous binary counter with two clock inputs (nCP0 and nCP1), buffered outputs from all four bit positions (nQ0 to nQ3) and an asynchronous master reset input (nMR). The counter advances on either the LOW-to-HIGH transition of nCP0 if nCP1 is HIGH or the HIGH-to-LOW transition of nCP1 if nCP0 is LOW. Either nCP0 or nCP1 may be used as the clock input to the counter and the other clock input may be used as a clock enable input. A HIGH on nMR resets the counter (nQ0 to nQ3 = LOW) independent of nCP0 and nCP1. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of  $V_{DD}$ .

## 2. Features and benefits

- Tolerant of slow clock rise and fall times
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Wide supply voltage range from 3.0 V to 15.0 V
- CMOS low power dissipation
- High noise immunity
- Standardized symmetrical output characteristics
- Complies with JEDEC standard JESD 13-B
- ESD protection:
  - HBM JESD22-A114F exceeds 2000 V
  - MM JESD22-A115-B exceeds 200 V
- Specified from -40 °C to +85 °C

## 3. Ordering information

Table 1. Ordering information

| Type number | Package           |      |  |          |
|-------------|-------------------|------|--|----------|
|             | Temperature range | Name | Description  | Version  |
| HEF4520BT   | -40 °C to +85 °C  | SO16 | plastic small outline package; 16 leads; body width 3.9 mm | SOT109-1 |

### 4. Functional diagram

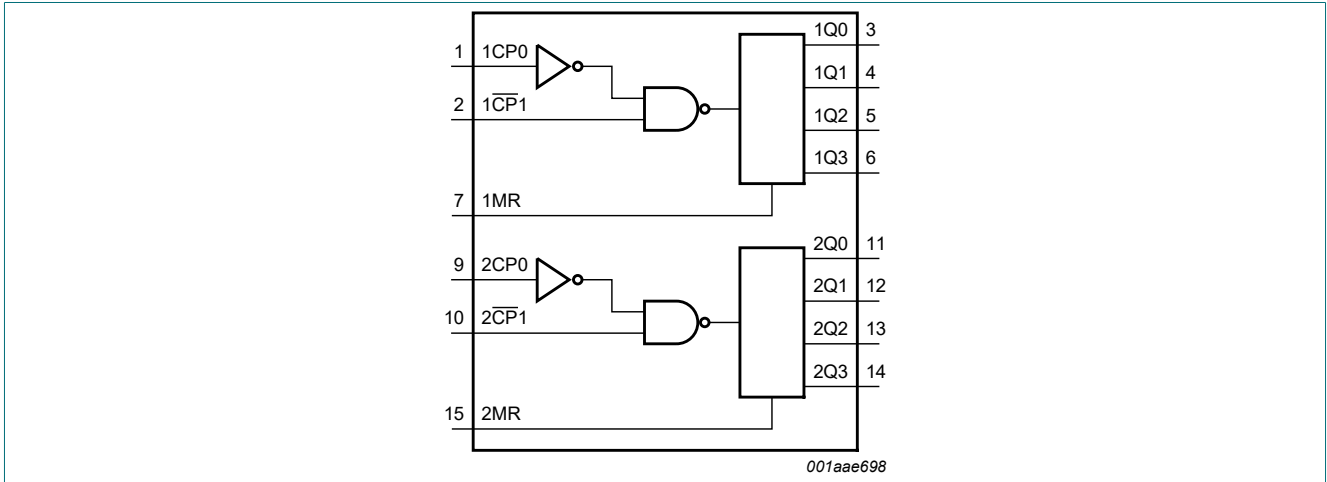


Fig. 1. Functional diagram

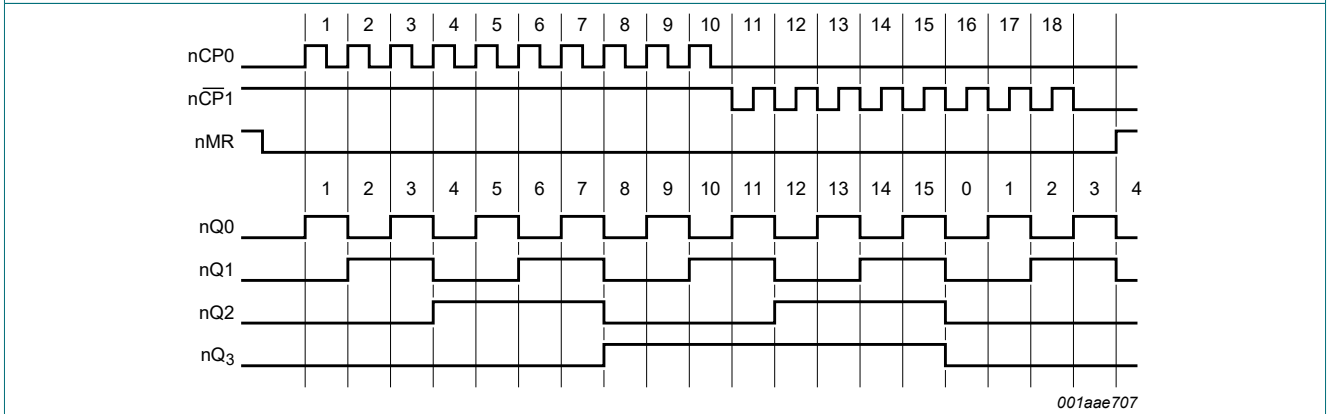


Fig. 2. Timing diagram

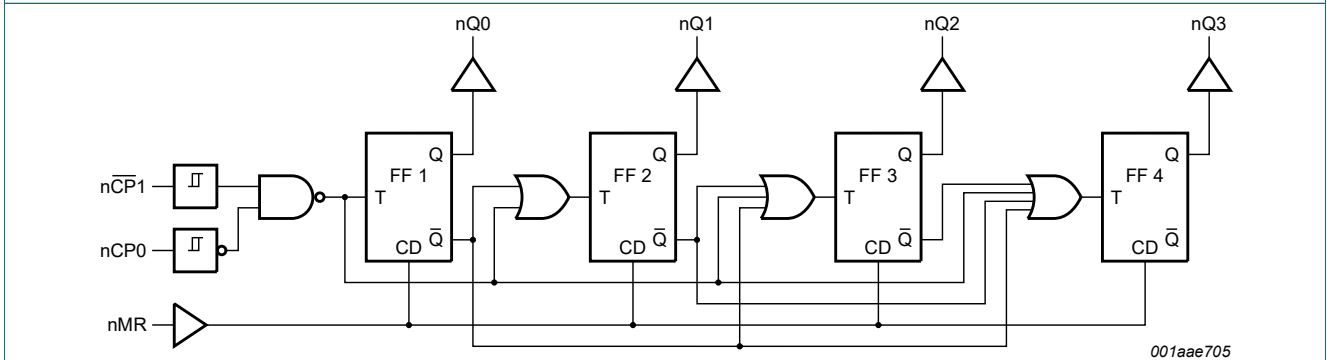


Fig. 3. Logic diagram for one counter

## 5. Pinning information

### 5.1. Pinning

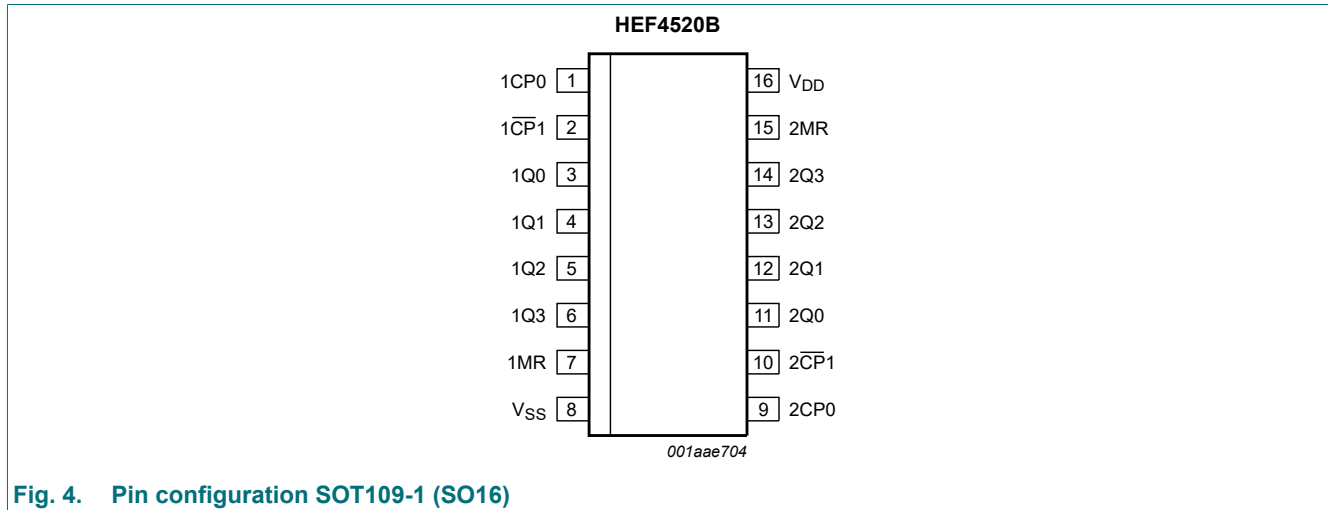


Fig. 4. Pin configuration SOT109-1 (SO16)

### 5.2. Pin description

Table 2. Pin description

| Symbol             | Pin            | Description                         |
|--------------------|----------------|-------------------------------------|
| 1CP0, 2CP0         | 1, 9           | clock input (LOW-to-HIGH triggered) |
| 1CP1, 2CP1         | 2, 10          | clock input (HIGH-to-LOW triggered) |
| 1Q0, 1Q1, 1Q2, 1Q3 | 3, 4, 5, 6     | output                              |
| 1MR, 2MR           | 7, 15          | master reset input                  |
| V <sub>SS</sub>    | 8              | ground supply voltage               |
| 2Q0, 2Q1, 2Q2, 2Q3 | 11, 12, 13, 14 | output                              |
| V <sub>DD</sub>    | 16             | supply voltage                      |

## 6. Functional description

Table 3. Function table

*H = HIGH voltage level; L = LOW voltage level; X = don't care; ↑ = positive-going transition; ↓ = negative-going transition.*

| nCP0 | nCP1 | nMR | Mode             |
|------|------|-----|------------------|
| ↑    | H    | L   | counter advances |
| L    | ↓    | L   | counter advances |
| ↓    | X    | L   | no change        |
| X    | ↑    | L   | no change        |
| ↑    | L    | L   | no change        |
| H    | ↓    | L   | no change        |
| X    | X    | H   | nQ0 to nQ3 = LOW |

## 7. 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 | -    | $\pm 10$       | 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 | -    | $\pm 10$       | mA   |
| $I_{I/O}$ | input/output current    |  | -    | $\pm 10$       | mA   |
| $I_{DD}$  | supply current          |  | -    | 50             | mA   |
| $T_{stg}$ | storage temperature     | per output                               | -65  | +150           | °C   |
| $T_{amb}$ | ambient temperature     |  | -40  | +85            | °C   |
| $P_{tot}$ | total power dissipation | SO16 package                             | -    | 500            | mW   |
| $P$       | power dissipation       |  | -    | 100            | mW   |

## 8. Recommended operating conditions

**Table 5. Recommended operating conditions**

| Symbol              | Parameter                           | Conditions      | Min | Typ | Max      | Unit            |
|---------------------|-------------------------------------|-----------------|-----|-----|----------|-----------------|
| $V_{DD}$            | supply voltage                      |                 | 3   | -   | 15       | V               |
| $V_I$               | input voltage                       |                 | 0   | -   | $V_{DD}$ | V               |
| $T_{amb}$           | ambient temperature                 | in free air     | -40 | -   | +85      | °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     | $\mu\text{s/V}$ |

## 9. Static characteristics

**Table 6. Static characteristics**

$V_{SS} = 0$  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 |      | Unit |
|----------|---------------------------|---|----------|--------------------|------|-------------------|------|-------------------|------|------|
|          |                           |   |          | Min                | Max  | Min               | Max  | Min               | Max  |      |
| $V_{IH}$ | HIGH-level input voltage  | $ I_O  < 1$ $\mu\text{A}$                                 | 5 V      | 3.5                | -    | 3.5               | -    | 3.5               | -    | V    |
|          |                           |   | 10 V     | 7.0                | -    | 7.0               | -    | 7.0               | -    | V    |
|          |                           |   | 15 V     | 11.0               | -    | 11.0              | -    | 11.0              | -    | V    |
| $V_{IL}$ | LOW-level input voltage   | $ I_O  < 1$ $\mu\text{A}$                                 | 5 V      | -                  | 1.5  | -                 | 1.5  | -                 | 1.5  | V    |
|          |                           |   | 10 V     | -                  | 3.0  | -                 | 3.0  | -                 | 3.0  | V    |
|          |                           |   | 15 V     | -                  | 4.0  | -                 | 4.0  | -                 | 4.0  | V    |
| $V_{OH}$ | HIGH-level output voltage | $ I_O  < 1$ $\mu\text{A}$ ;<br>$V_I = V_{SS}$ or $V_{DD}$ | 5 V      | 4.95               | -    | 4.95              | -    | 4.95              | -    | V    |
|          |                           |   | 10 V     | 9.95               | -    | 9.95              | -    | 9.95              | -    | V    |
|          |                           |   | 15 V     | 14.95              | -    | 14.95             | -    | 14.95             | -    | V    |
| $V_{OL}$ | LOW-level output voltage  | $ I_O  < 1$ $\mu\text{A}$ ;<br>$V_I = V_{SS}$ or $V_{DD}$ | 5 V      | -                  | 0.05 | -                 | 0.05 | -                 | 0.05 | V    |
|          |                           |   | 10 V     | -                  | 0.05 | -                 | 0.05 | -                 | 0.05 | V    |
|          |                           |   | 15 V     | -                  | 0.05 | -                 | 0.05 | -                 | 0.05 | V    |

| Symbol          | Parameter                 | Conditions   | V <sub>DD</sub> | T <sub>amb</sub> = -40 °C |       | T <sub>amb</sub> = 25 °C |       | T <sub>amb</sub> = 85 °C |       | Unit |
|-----------------|---------------------------|--|-----------------|---------------------------|-------|--------------------------|-------|--------------------------|-------|------|
|                 |                           |  |                 | Min                       | Max   | Min                      | Max   | Min                      | Max   |      |
| I <sub>OH</sub> | HIGH-level output current | V <sub>O</sub> = 2.5 V   | 5 V             | -                         | -1.7  | -                        | -1.4  | -                        | -1.1  | mA   |
|                 |                           | V <sub>O</sub> = 4.6 V   | 5 V             | -                         | -0.52 | -                        | -0.44 | -                        | -0.36 | mA   |
|                 |                           | V <sub>O</sub> = 9.5 V   | 10 V            | -                         | -1.3  | -                        | -1.1  | -                        | -0.9  | mA   |
|                 |                           | V <sub>O</sub> = 13.5 V  | 15 V            | -                         | -3.6  | -                        | -3.0  | -                        | -2.4  | mA   |
| I <sub>OL</sub> | LOW-level output current  | V <sub>O</sub> = 0.4 V   | 5 V             | 0.52                      | -     | 0.44                     | -     | 0.36                     | -     | mA   |
|                 |                           | V <sub>O</sub> = 0.5 V   | 10 V            | 1.3                       | -     | 1.1                      | -     | 0.9                      | -     | mA   |
|                 |                           | V <sub>O</sub> = 1.5 V   | 15 V            | 3.6                       | -     | 3.0                      | -     | 2.4                      | -     | mA   |
| I <sub>I</sub>  | input leakage current     | V <sub>DD</sub> = 15 V   | 15 V            | -                         | ±0.3  | -                        | ±0.3  | -                        | ±1.0  | µA   |
| I <sub>DD</sub> | supply current            | I <sub>O</sub> = 0 A;<br>V <sub>I</sub> = V <sub>SS</sub> or V <sub>DD</sub> | 5 V             | -                         | 20    | -                        | 20    | -                        | 150   | µA   |
|                 |                           |  | 10 V            | -                         | 40    | -                        | 40    | -                        | 300   | µA   |
|                 |                           |  | 15 V            | -                         | 80    | -                        | 80    | -                        | 600   | µA   |
| C <sub>I</sub>  | input capacitance         |  | -               | -                         | -     | 7.5                      | -     | -                        | pF    |      |

## 10. Dynamic characteristics

**Table 7. Dynamic characteristics**

V<sub>SS</sub> = 0 V; T<sub>amb</sub> = 25 °C; unless otherwise specified. For test circuit see Fig. 6.

| Symbol           | Parameter                     | Conditions                                 | V <sub>DD</sub> | Extrapolation formula [1]          | Min | Typ | Max | Unit |
|------------------|-------------------------------|--|-----------------|------------------------------------|-----|-----|-----|------|
| t <sub>PHL</sub> | HIGH to LOW propagation delay | nCP0, nCP1 to nQn; see Fig. 5              | 5 V             | 83 ns + (0.55 ns/pF)C <sub>L</sub> | -   | 110 | 220 | 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   |
|                  |                               | nMR to nQn; see Fig. 5                     | 5 V             | 48 ns + (0.55 ns/pF)C <sub>L</sub> | -   | 75  | 150 | ns   |
|                  |                               |  | 10 V            | 24 ns + (0.23 ns/pF)C <sub>L</sub> | -   | 35  | 70  | ns   |
|                  |                               |  | 15 V            | 17 ns + (0.16 ns/pF)C <sub>L</sub> | -   | 25  | 50  | ns   |
| t <sub>PLH</sub> | LOW to HIGH propagation delay | nCP0, nCP1 to nQn; see Fig. 5              | 5 V             | 83 ns + (0.55 ns/pF)C <sub>L</sub> | -   | 110 | 220 | 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               | nQn; see Fig. 5                            | 5 V             | 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>w</sub>   | pulse width                   | nCP0 input LOW; minimum width; see Fig. 5  | 5 V             |                                    | 60  | 30  | -   | ns   |
|                  |                               |  | 10 V            |                                    | 30  | 15  | -   | ns   |
|                  |                               |  | 15 V            |                                    | 20  | 10  | -   | ns   |
|                  |                               | nCP1 input HIGH; minimum width; see Fig. 5 | 5 V             |                                    | 60  | 30  | -   | ns   |
|                  |                               |  | 10 V            |                                    | 30  | 15  | -   | ns   |
|                  |                               |  | 15 V            |                                    | 20  | 10  | -   | ns   |
|                  |                               | nMR input HIGH; minimum width; see Fig. 5  | 5 V             |                                    | 30  | 15  | -   | ns   |
|                  |                               |  | 10 V            |                                    | 20  | 10  | -   | ns   |
|                  |                               |  | 15 V            |                                    | 16  | 8   | -   | ns   |

| Symbol           | Parameter         | Conditions                  | V <sub>DD</sub> | Extrapolation formula [1] | Min | Typ | Max | Unit |
|------------------|-------------------|-----------------------------|-----------------|---------------------------|-----|-----|-----|------|
| t <sub>su</sub>  | set-up time       | nCP0 to nCP1;<br>see Fig. 5 | 5 V             |                           | 50  | 25  | -   | ns   |
|                  |                   |                             | 10 V            |                           | 30  | 15  | -   | ns   |
|                  |                   |                             | 15 V            |                           | 20  | 10  | -   | ns   |
|                  |                   | nCP1 to nCP0;<br>see Fig. 5 | 5 V             |                           | 50  | 25  | -   | ns   |
|                  |                   |                             | 10 V            |                           | 30  | 15  | -   | ns   |
|                  |                   |                             | 15 V            |                           | 20  | 10  | -   | ns   |
| t <sub>rec</sub> | recovery time     | see Fig. 5                  | 5 V             |                           | 50  | 25  | -   | ns   |
|                  |                   |                             | 10 V            |                           | 30  | 15  | -   | ns   |
|                  |                   |                             | 15 V            |                           | 20  | 10  | -   | ns   |
| f <sub>max</sub> | maximum frequency | nCP0, nCP1; see Fig. 5      | 5 V             |                           | 8   | 16  | -   | MHz  |
|                  |                   |                             | 10 V            |                           | 15  | 30  | -   | MHz  |
|                  |                   |                             | 15 V            |                           | 20  | 40  | -   | MHz  |

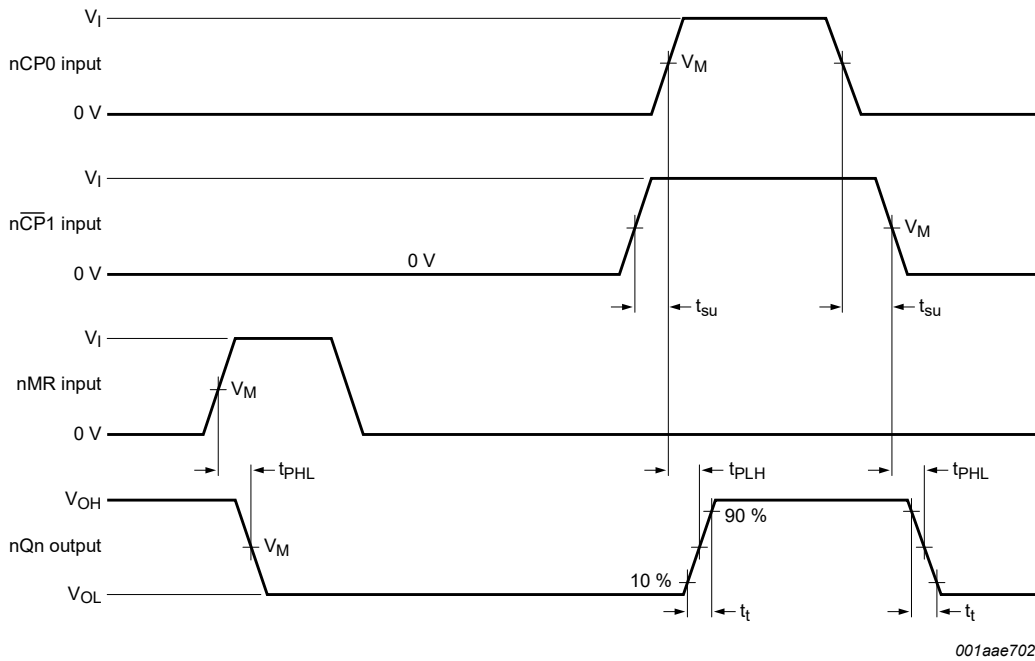
[1] The typical values of the propagation delay and transition times are calculated from the extrapolation formulas shown (C<sub>L</sub> in pF).

**Table 8. Dynamic power dissipation P<sub>D</sub>**

P<sub>D</sub> can be calculated from the formulas shown. V<sub>SS</sub> = 0 V; t<sub>r</sub> = t<sub>f</sub> ≤ 20 ns; T<sub>amb</sub> = 25 °C.

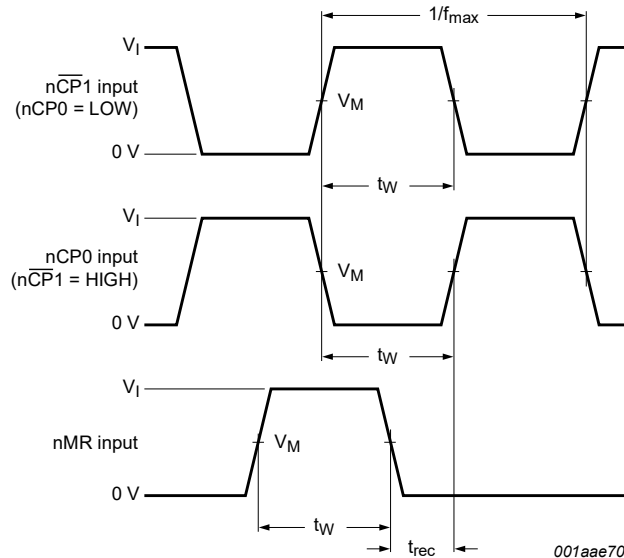
| Symbol         | Parameter                 | V <sub>DD</sub> | Typical formula for P <sub>D</sub> (μW)                           | Where:  |
|----------------|---------------------------|-----------------|---|---|
| P <sub>D</sub> | dynamic power dissipation | 5 V             | $P_D = 850 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$   | f <sub>i</sub> = input frequency in MHz,<br>f <sub>o</sub> = output frequency in MHz,<br>C <sub>L</sub> = output load capacitance in pF,<br>V <sub>DD</sub> = supply voltage in V,<br>Σ(f <sub>o</sub> × C <sub>L</sub> ) = sum of the outputs. |
|                |                           | 10 V            | $P_D = 3800 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$  |   |
|                |                           | 15 V            | $P_D = 10200 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$ |   |

10.1. Waveforms and test circuit



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a. nCP0 and nCP1 set-up times, propagation delays and output transition times



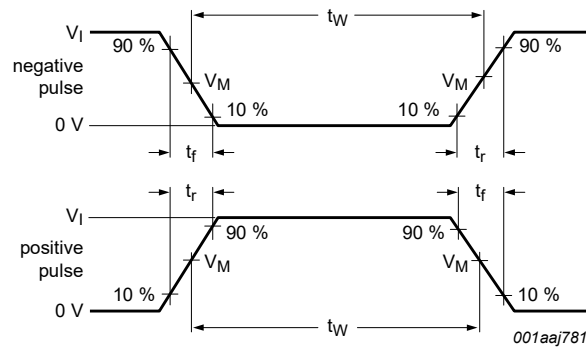
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b. nMR recovery time, minimum nCP0, nCP1, and nMR pulse widths and maximum frequency

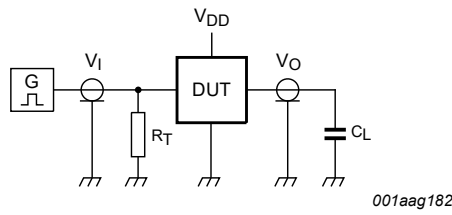
Measurement points are given in [Table 9](#).

The logic levels  $V_{OH}$  and  $V_{OL}$  are typical output voltage levels that occur with the output load.

Fig. 5. Waveforms showing measurements for switching times



a. Input waveforms



b. Test circuit

Test data is given in [Table 9](#).

Definitions for test circuit:

$C_L$  = Load capacitance including jig and probe capacitance;

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

Fig. 6. Test circuit for measuring switching times

Table 9. Measurement points and test data

| Supply voltage | Input    |                  |              | Load  |
|----------------|----------|------------------|--------------|-------|
| $V_{DD}$       | $V_I$    | $V_M$            | $t_r, t_f$   | $C_L$ |
| 5 V to 15 V    | $V_{DD}$ | $0.5 \times V_I$ | $\leq 20$ ns | 50 pF |



### 11. Package outline

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

SOT109-1

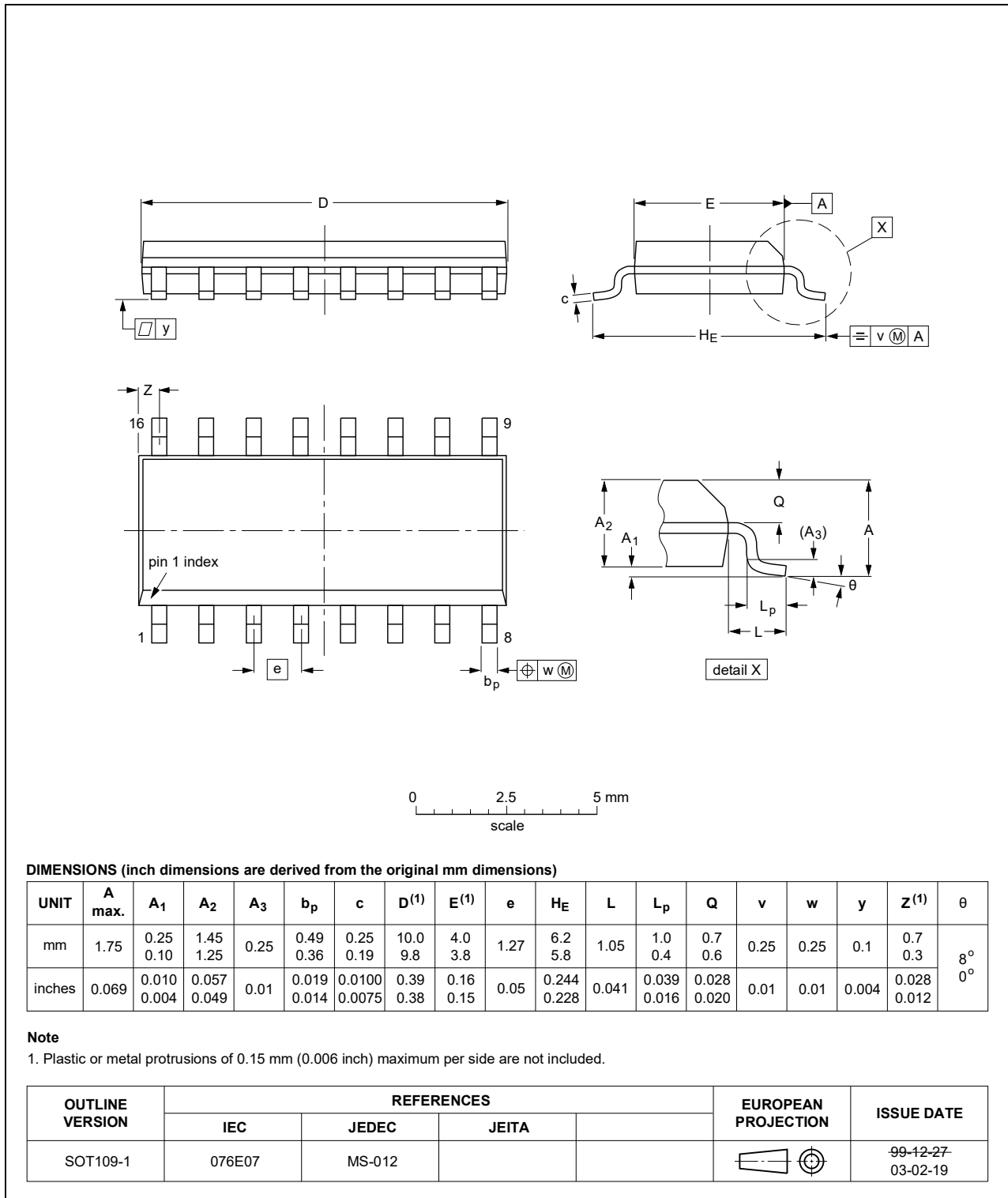


Fig. 7. Package outline SOT109-1 (SO16)

## 12. Abbreviations

Table 10. Abbreviations

| Acronym | Description             |
|---------|-------------------------|
| CDM     | Charged Device Model    |
| DUT     | Device Under Test       |
| ESD     | ElectroStatic Discharge |
| HBM     | Human Body Model        |
| MM      | Machine Model           |

## 13. Revision history

Table 11. Revision history

| Document ID      | Release date   | Data sheet status     | Change notice | Supersedes       |
|------------------|--|-----------------------|---------------|------------------|
| HEF4520B v.8     | 20220301   | Product data sheet    | -             | HEF4520B v.7     |
| Modifications:   | <ul style="list-style-type: none"> <li>The format of this data sheet has been redesigned to comply with the identity guidelines of Nexperia.</li> <li>Legal texts have been adapted to the new company name where appropriate.</li> <li><a href="#">Section 1</a>, <a href="#">Section 2</a>, and <a href="#">Section 12</a> updated.</li> </ul> |                       |               |                  |
| HEF4520B v.7     | 20160330   | Product data sheet    | -             | HEF4520B v.6     |
| Modifications:   | <ul style="list-style-type: none"> <li>Type number HEF4520BP (SOT38-4) removed.</li> </ul>   |                       |               |                  |
| HEF4520B v.6     | 20111118   | Product data sheet    | -             | HEF4520B v.5     |
| Modifications:   | <ul style="list-style-type: none"> <li>Section Applications removed</li> <li><a href="#">Table 6</a>: <math>I_{OH}</math> minimum values changed to maximum</li> </ul>   |                       |               |                  |
| HEF4520B v.5     | 20091210   | Product data sheet    | -             | HEF4520B v.4     |
| HEF4520B v.4     | 20090828   | Product data sheet    | -             | HEF4520B_CNV v.3 |
| HEF4520B_CNV v.3 | 19950101   | Product specification | -             | HEF4520B_CNV v.2 |
| HEF4520B_CNV v.2 | 19950101   | Product specification | -             | -                |

## 14. Legal information

### Data sheet status

| Document status [1][2]         | Product status [3] | Definition  |
|--------------------------------|--------------------|---|
| Objective [short] data sheet   | Development        | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification      | This document contains data from the preliminary specification.                       |
| Product [short] data sheet     | Production         | This document contains the product specification.                                     |

- [1] Please consult the most recently issued document before initiating or completing a design.
- [2] The term 'short data sheet' is explained in section "Definitions".
- [3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the internet at <https://www.nexperia.com>.

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