

# HEF4516B

## Binary up/down counter

Rev. 04 — 12 March 2009

Product data sheet

## 1. General description

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The HEF4516B is an edge-triggered synchronous 4-bit binary up/down counter with a clock input (CP), an up/down count control input (UP/DN), an active LOW count enable input ( $\overline{CE}$ ), an asynchronous active HIGH parallel load input (PL), four parallel inputs (D0 to D3), four parallel outputs (Q0 to Q3), an active LOW terminal count output ( $\overline{TC}$ ), and an overriding asynchronous master reset input (MR).

Information on D0 to D3 is loaded into the counter while PL is HIGH, independent of all other input conditions except for MR which must be LOW. When PL and  $\overline{CE}$  are LOW, the counter changes on the LOW-to-HIGH transition of CP. Input UP/DN determines the direction of the count, counting up when HIGH and counting down when LOW. When counting up,  $\overline{TC}$  is LOW when Q0 and Q3 are HIGH and  $\overline{CE}$  is LOW. When counting down,  $\overline{TC}$  is LOW when Q0 to Q3 and  $\overline{CE}$  are LOW. A HIGH on MR resets the counter (Q0 to Q3 = LOW) independent of all other input conditions.

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. It is also suitable for use over the full industrial (–40 °C to +85 °C) temperature range.

## 2. Features

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- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Operates across the full industrial temperature range –40 °C to +85 °C
- Complies with JEDEC standard JESD 13-B
- ESD protection:
  - ◆ HBM JESD22-A114E exceeds 2000 V
  - ◆ MM JESD22-A115-A exceeds 200 V

## 3. Applications

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- Industrial

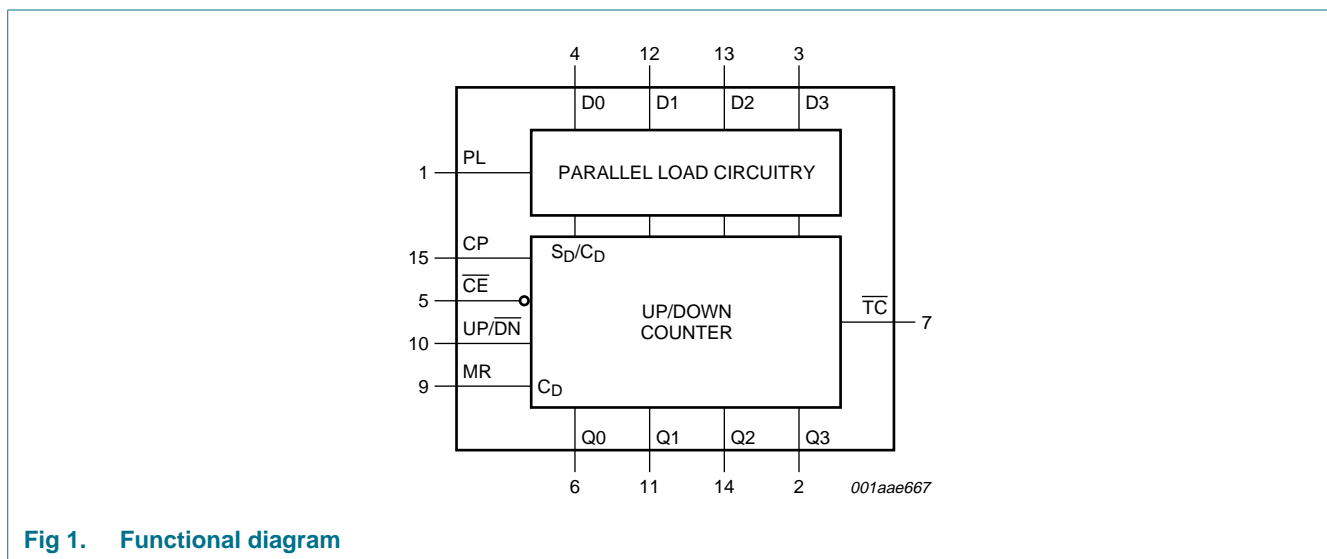
## 4. Ordering information

**Table 1. Ordering information**

All types operate from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ .

Type number	Package		Version
	Name	Description	
HEF4516BP	DIP16	plastic dual in-line package; 16-leads (300 mil)	SOT38-4
HEF4516BT	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

## 5. Functional diagram



**Fig 1. Functional diagram**

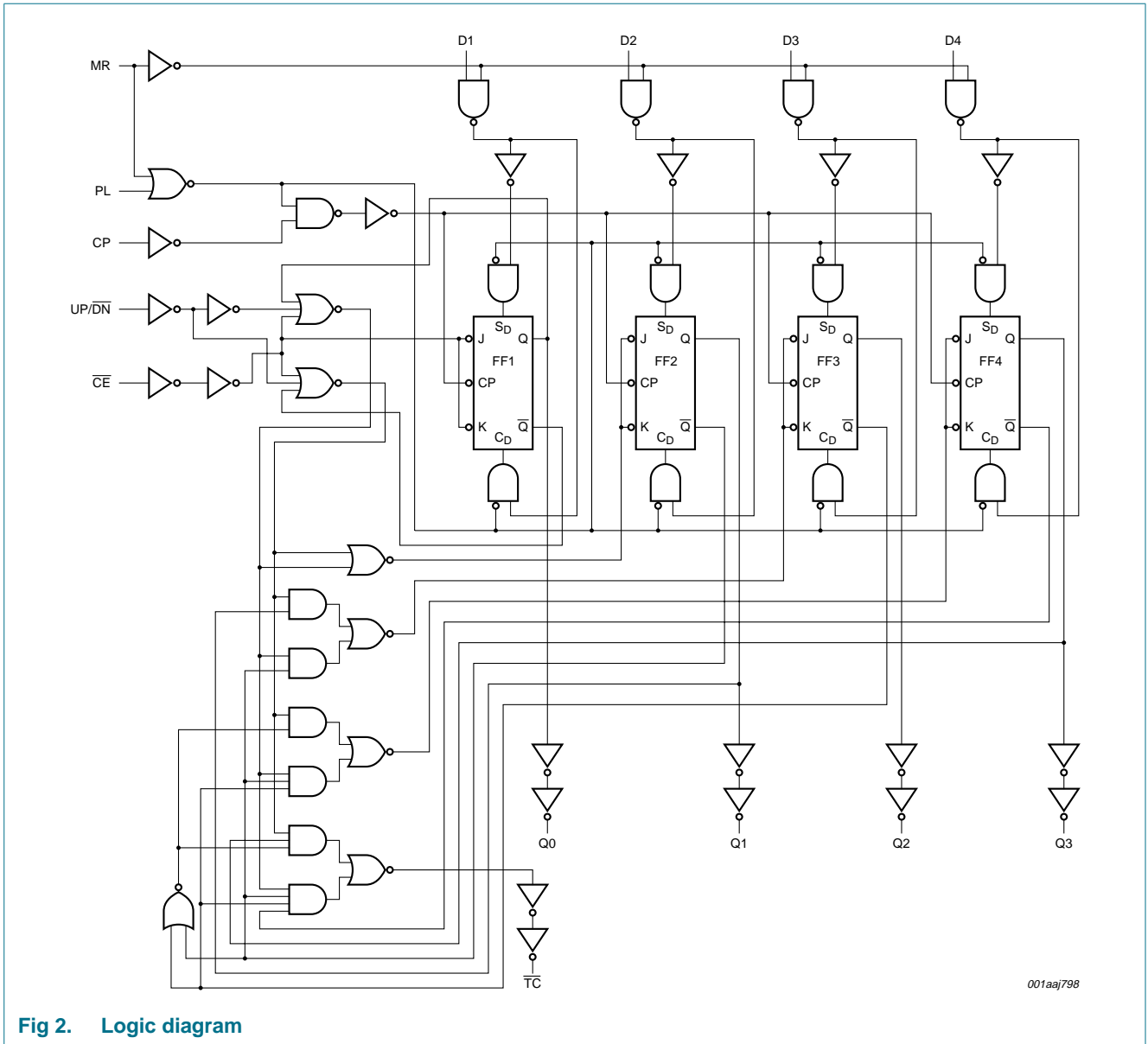
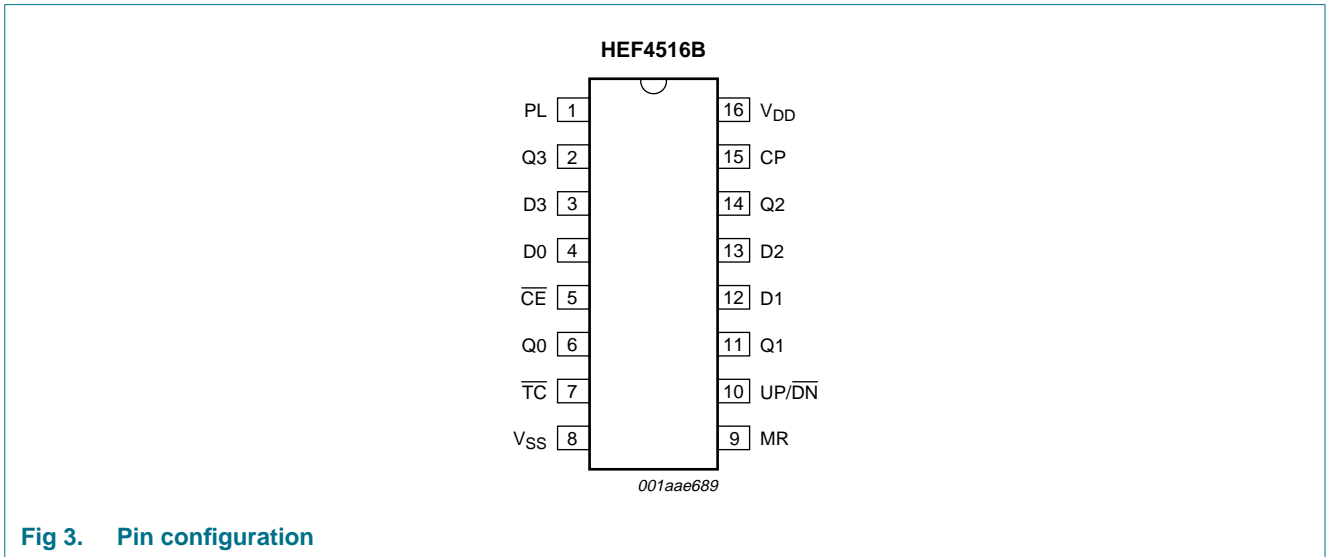


Fig 2. Logic diagram

## 6. Pinning information

### 6.1 Pinning



### 6.2 Pin description

**Table 2. Pin description**

Symbol	Pin	Description
PL	1	parallel load input (active HIGH)
D0 to D3	4, 12, 13, 3	parallel input
$\overline{CE}$	5	count enable input (active LOW)
Q0 to Q3	6, 11, 14, 2	parallel output
V <sub>SS</sub>	8	ground supply voltage
$\overline{TC}$	7	terminal count output (active LOW)
MR	9	master reset input
UP/ $\overline{DN}$	10	up/down count control input
CP	15	clock pulse input (LOW to HIGH, edge triggered)
V <sub>DD</sub>	16	supply voltage

## 7. Functional description

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

MR	PL	UP/DN	$\overline{CE}$	CP	MODE
L	H	X	X	X	parallel load
L	L	X	H	X	no change
L	L	L	L	↑	count down
L	L	H	L	↑	count up
H	X	X	X	X	reset

[1] H = HIGH voltage level; L = LOW voltage level; X = don't care; ↑ = positive-going transition.

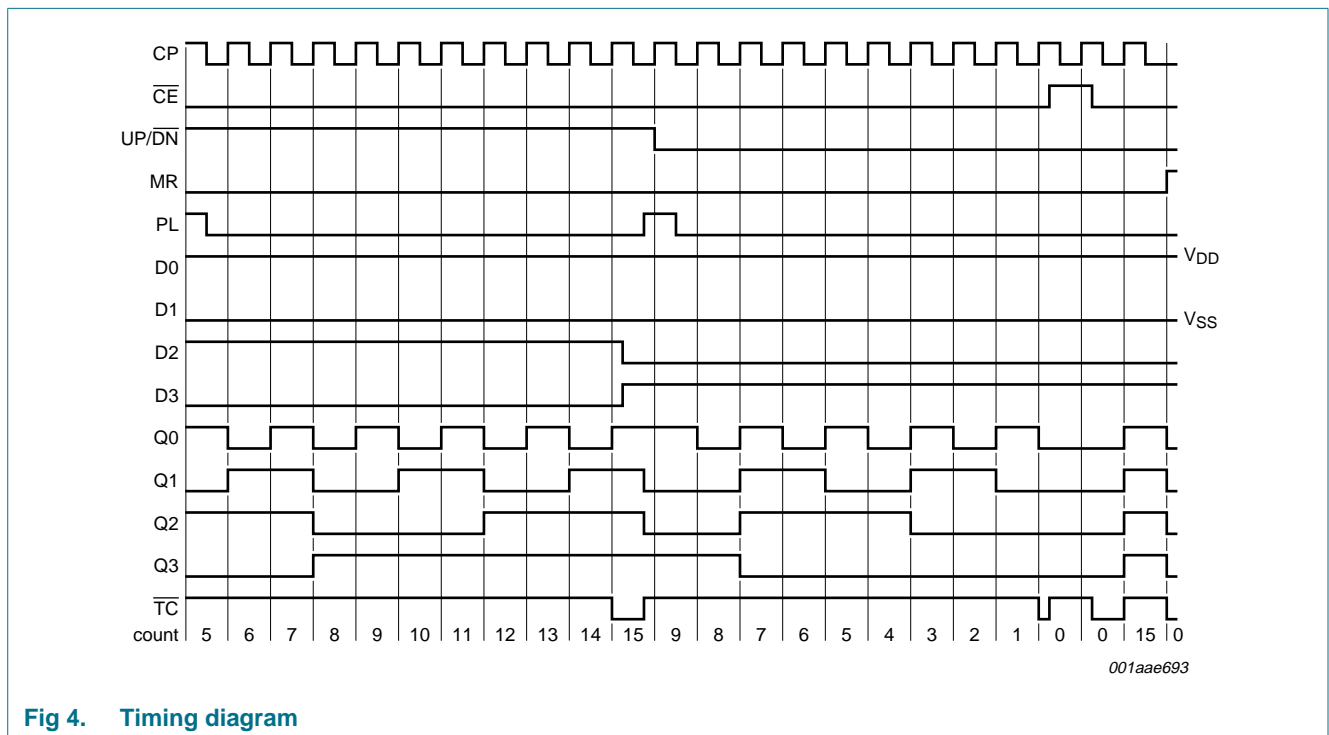
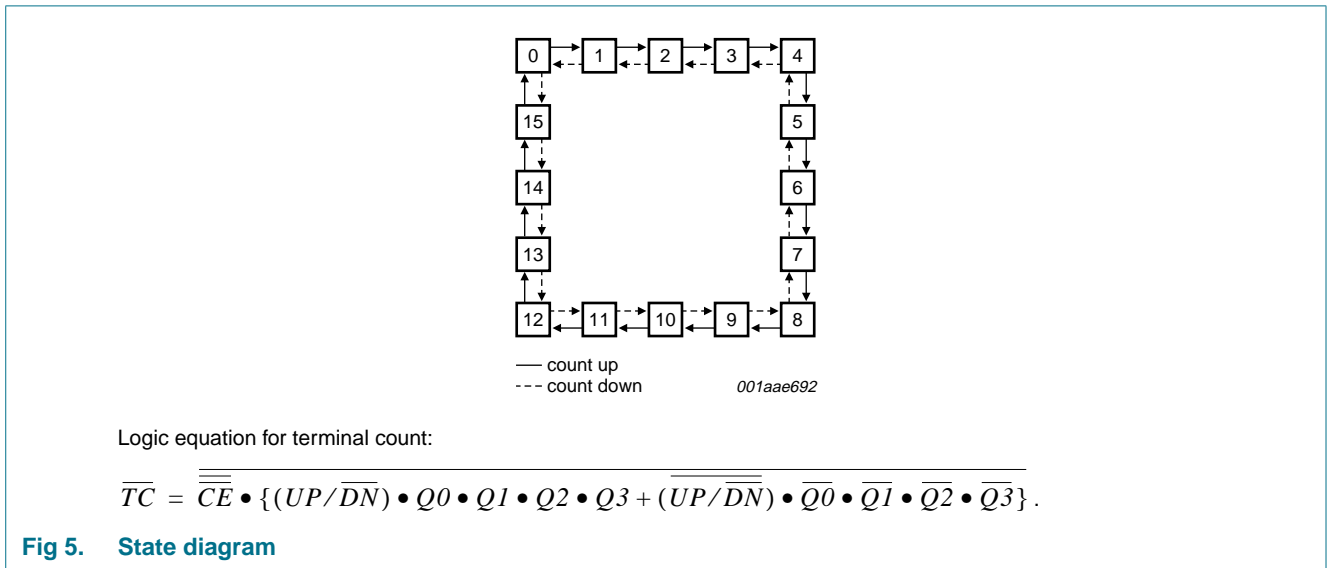


Fig 4. Timing diagram



## 8. 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
V <sub>I</sub>	input voltage		-0.5	V <sub>DD</sub> + 0.5	V
I <sub>I/O</sub>	input/output current		-	±10	mA
T <sub>stg</sub>	storage temperature		-65	+150	°C
T <sub>amb</sub>	ambient temperature		-40	+85	°C
P <sub>tot</sub>	total power dissipation	DIP16 package	[1] -	750	mW
		SO16 package	[2] -	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.

## 9. 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	-	+85	°C
Δt/ΔV	input transition rise and fall rate	V <sub>DD</sub> = 5 V	-	-	3.75	ns/V
		V <sub>DD</sub> = 10 V	-	-	0.5	ns/V
		V <sub>DD</sub> = 15 V	-	-	0.08	ns/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	$V_{DD}$	$T_{amb} = -40\text{ }^{\circ}\text{C}$		$T_{amb} = 25\text{ }^{\circ}\text{C}$		$T_{amb} = 85\text{ }^{\circ}\text{C}$		Unit
				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	-	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\text{ }\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\text{ }\mu\text{A}$ ; $V_I = V_{SS}$ 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\text{ }\mu\text{A}$ ; $V_I = V_{SS}$ 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
$I_{OH}$	HIGH-level output current	$V_O = 2.5\text{ V}$	5 V	-1.7	-	-1.4	-	-1.1	-	mA
			5 V	-0.52	-	-0.44	-	-0.36	-	mA
			10 V	-1.3	-	-1.1	-	-0.9	-	mA
			15 V	-3.6	-	-3.0	-	-2.4	-	mA
$I_{OL}$	LOW-level output current	$V_O = 0.4\text{ V}$	5 V	0.52	-	0.44	-	0.36	-	mA
			10 V	1.3	-	1.1	-	0.9	-	mA
			15 V	3.6	-	3.0	-	2.4	-	mA
$I_I$	input leakage current	$V_{DD} = 15\text{ V}$	15 V	-	$\pm 0.3$	-	$\pm 0.3$	-	$\pm 1.0$	$\mu\text{A}$
$I_{DD}$	supply current	$I_O = 0\text{ A}$ ; $V_I = V_{SS}$ or $V_{DD}$	5 V	-	20	-	20	-	150	$\mu\text{A}$
			10 V	-	40	-	40	-	300	$\mu\text{A}$
			15 V	-	80	-	80	-	600	$\mu\text{A}$
$C_I$	input capacitance		-	-	-	-	7.5	-	-	pF

## 11. Dynamic characteristics

**Table 7. Dynamic characteristics**

$V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ; for test circuit see [Figure 8](#); unless otherwise specified.

Symbol	Parameter	Conditions	V <sub>DD</sub>	Extrapolation formula	Min	Typ	Max	Unit
t <sub>PHL</sub>	HIGH to LOW propagation delay	CP to Qn	5 V	<sup>[1]</sup> 118 ns + (0.55 ns/pF) C <sub>L</sub>	-	145	290	ns
			10 V	49 ns + (0.23 ns/pF) C <sub>L</sub>	-	60	120	ns
			15 V	37 ns + (0.16 ns/pF) C <sub>L</sub>	-	45	90	ns
		CP to $\overline{\text{TC}}$	5 V	233 ns + (0.55 ns/pF) C <sub>L</sub>	-	260	525	ns
			10 V	94 ns + (0.23 ns/pF) C <sub>L</sub>	-	105	210	ns
			15 V	67 ns + (0.16 ns/pF) C <sub>L</sub>	-	75	150	ns
		PL to Qn	5 V	98 ns + (0.55 ns/pF) C <sub>L</sub>	-	125	255	ns
			10 V	44 ns + (0.23 ns/pF) C <sub>L</sub>	-	55	110	ns
			15 V	32 ns + (0.16 ns/pF) C <sub>L</sub>	-	40	85	ns
		PL to $\overline{\text{TC}}$	5 V	223 ns + (0.55 ns/pF) C <sub>L</sub>	-	250	500	ns
			10 V	99 ns + (0.23 ns/pF) C <sub>L</sub>	-	110	220	ns
			15 V	72 ns + (0.16 ns/pF) C <sub>L</sub>	-	80	160	ns
		$\overline{\text{CE}}$ to $\overline{\text{TC}}$	5 V	138 ns + (0.55 ns/pF) C <sub>L</sub>	-	165	330	ns
			10 V	54 ns + (0.23 ns/pF) C <sub>L</sub>	-	65	135	ns
			15 V	42 ns + (0.16 ns/pF) C <sub>L</sub>	-	50	100	ns
		MR to Qn, $\overline{\text{TC}}$	5 V	178 ns + (0.55 ns/pF) C <sub>L</sub>	-	205	405	ns
			10 V	54 ns + (0.23 ns/pF) C <sub>L</sub>	-	65	130	ns
			15 V	37 ns + (0.16 ns/pF) C <sub>L</sub>	-	45	85	ns
t <sub>PLH</sub>	LOW to HIGH propagation delay	CP to Qn	5 V	<sup>[1]</sup> 128 ns + (0.55 ns/pF) C <sub>L</sub>	-	155	310	ns
			10 V	54 ns + (0.23 ns/pF) C <sub>L</sub>	-	65	130	ns
			15 V	37 ns + (0.16 ns/pF) C <sub>L</sub>	-	45	90	ns
		CP to $\overline{\text{TC}}$	5 V	153 ns + (0.55 ns/pF) C <sub>L</sub>	-	180	360	ns
			10 V	64 ns + (0.23 ns/pF) C <sub>L</sub>	-	75	150	ns
			15 V	47 ns + (0.16 ns/pF) C <sub>L</sub>	-	55	115	ns
		PL to Qn	5 V	143 ns + (0.55 ns/pF) C <sub>L</sub>	-	170	340	ns
			10 V	59 ns + (0.23 ns/pF) C <sub>L</sub>	-	70	140	ns
			15 V	42 ns + (0.16 ns/pF) C <sub>L</sub>	-	50	105	ns
		PL to $\overline{\text{TC}}$	5 V	223 ns + (0.55 ns/pF) C <sub>L</sub>	-	250	500	ns
			10 V	99 ns + (0.23 ns/pF) C <sub>L</sub>	-	110	220	ns
			15 V	72 ns + (0.16 ns/pF) C <sub>L</sub>	-	80	160	ns
		$\overline{\text{CE}}$ to $\overline{\text{TC}}$	5 V	118 ns + (0.55 ns/pF) C <sub>L</sub>	-	145	290	ns
			10 V	49 ns + (0.23 ns/pF) C <sub>L</sub>	-	60	125	ns
			15 V	37 ns + (0.16 ns/pF) C <sub>L</sub>	-	45	95	ns
		MR to $\overline{\text{TC}}$	5 V	198 ns + (0.55 ns/pF) C <sub>L</sub>	-	225	450	ns
			10 V	64 ns + (0.23 ns/pF) C <sub>L</sub>	-	75	150	ns
			15 V	42 ns + (0.16 ns/pF) C <sub>L</sub>	-	50	100	ns

**Table 7. Dynamic characteristics ...continued**  
 $V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ; for test circuit see [Figure 8](#); unless otherwise specified.

Symbol	Parameter	Conditions	V <sub>DD</sub>	Extrapolation formula	Min	Typ	Max	Unit
t <sub>t</sub>	transition time		5 V	[1] 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
f <sub>max</sub>	maximum frequency	see <a href="#">Figure 6</a>	5 V		3	6	-	MHz
			10 V		7	14	-	MHz
			15 V		9	18	-	MHz
t <sub>w</sub>	pulse width	CP input LOW; minimum width; see <a href="#">Figure 6</a>	5 V		95	45	-	ns
			10 V		35	20	-	ns
			15 V		25	15	-	ns
		PL input HIGH; minimum width; see <a href="#">Figure 7</a>	5 V		105	55	-	ns
			10 V		45	25	-	ns
			15 V		35	15	-	ns
		MR input HIGH; minimum width; see <a href="#">Figure 7</a>	5 V		120	60	-	ns
			10 V		50	25	-	ns
			15 V		40	20	-	ns
t <sub>rec</sub>	recovery time	MR input; see <a href="#">Figure 7</a>	5 V		130	65	-	ns
			10 V		45	20	-	ns
			15 V		30	15	-	ns
		PL input; see <a href="#">Figure 7</a>	5 V		150	75	-	ns
			10 V		50	25	-	ns
			15 V		30	15	-	ns
t <sub>su</sub>	set-up time	Dn to PL; see <a href="#">Figure 7</a>	5 V		100	50	-	ns
			10 V		50	25	-	ns
			15 V		40	20	-	ns
		UP/ $\overline{\text{DN}}$ to CP; see <a href="#">Figure 6</a>	5 V		250	125	-	ns
			10 V		100	50	-	ns
			15 V		75	35	-	ns
		$\overline{\text{CE}}$ to CP; see <a href="#">Figure 6</a>	5 V		120	60	-	ns
			10 V		40	20	-	ns
			15 V		25	10	-	ns
t <sub>h</sub>	hold time	Dn to PL; see <a href="#">Figure 7</a>	5 V		+10	-40	-	ns
			10 V		+5	-20	-	ns
			15 V		0	-20	-	ns
		UP/ $\overline{\text{DN}}$ to CP; see <a href="#">Figure 6</a>	5 V		+35	-90	-	ns
			10 V		+15	-35	-	ns
			15 V		+15	-25	-	ns
		$\overline{\text{CE}}$ to CP; see <a href="#">Figure 6</a>	5 V		+20	-40	-	ns
			10 V		+5	-15	-	ns
			15 V		+5	-10	-	ns

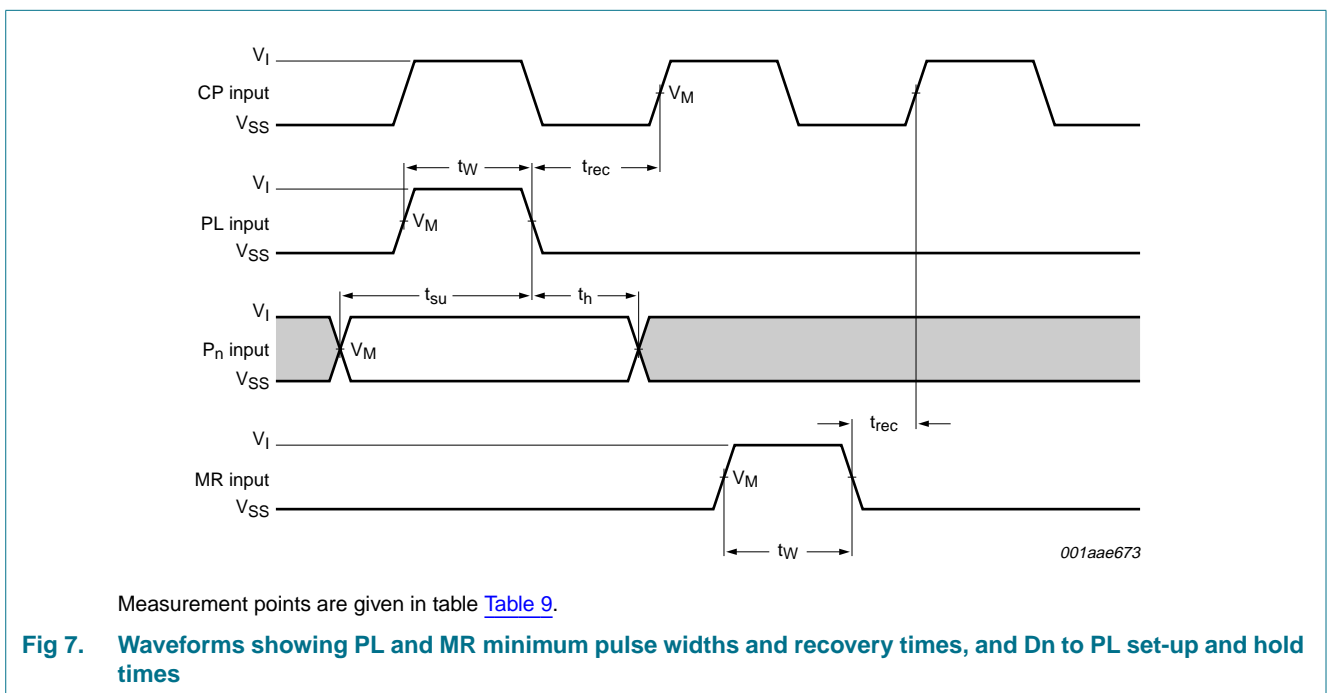
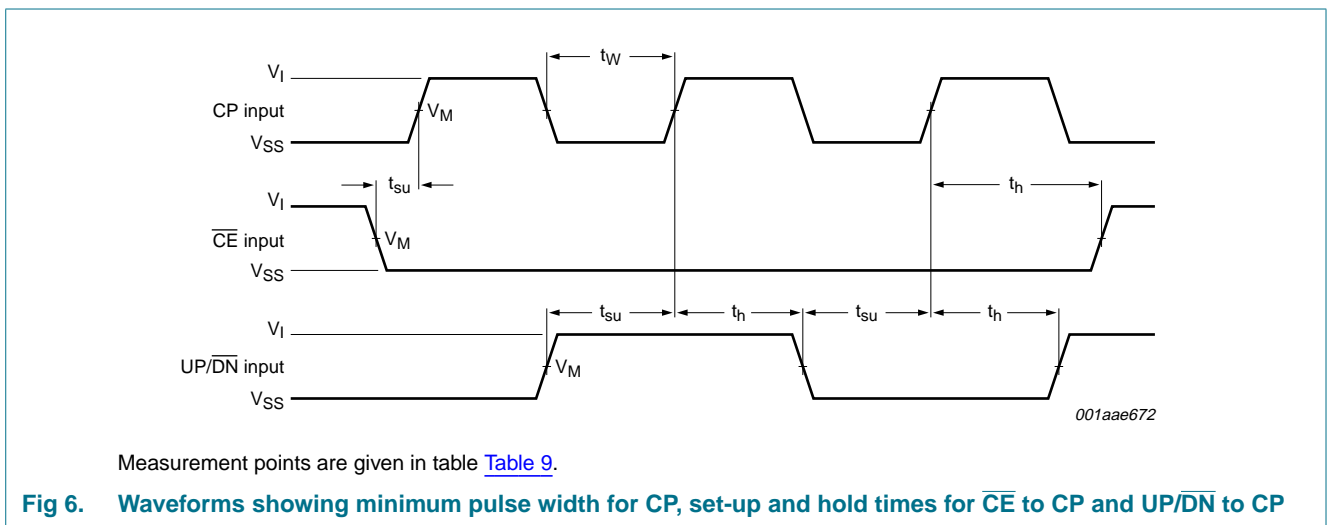
[1] The typical values of the propagation delay and transition times are calculated from the extrapolation formulas shown (C<sub>L</sub> in pF).

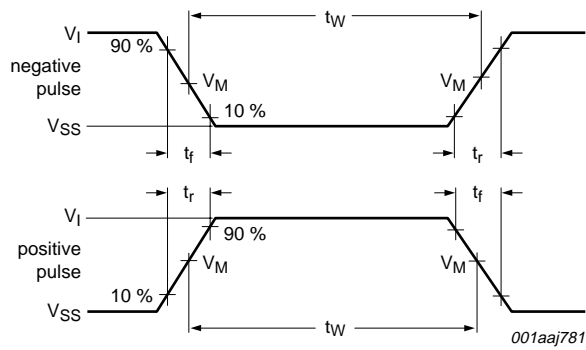
**Table 8. Dynamic power dissipation  $P_D$**

$P_D$  can be calculated from the formulas shown.  $V_{SS} = 0\text{ V}$ ;  $C_L = 50\text{ pF}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .

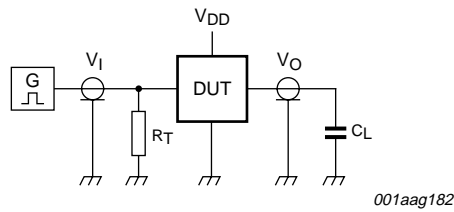
Symbol	Parameter	$V_{DD}$	Typical formula for $P_D$ ( $\mu\text{W}$ )	where:
$P_D$	dynamic power dissipation	5 V	$P_D = 1000 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$f_i$ = input frequency in MHz;
		10 V	$P_D = 4500 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$f_o$ = output frequency in MHz;
		15 V	$P_D = 11200 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$C_L$ = output load capacitance in pF;
				$V_{DD}$ = supply voltage in V;
				$\Sigma(C_L \times f_o)$ = sum of the outputs.

## 12. Waveforms





a. Input waveforms



b. Test circuit

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

Definitions for test circuit:

$R_L$  = Load resistance;

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

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

**Fig 8. Test circuit for measuring switching times**

**Table 9. Measurement points and test data**

Supply voltage	Input			Load	
	$V_I$	$V_M$	$t_r, t_f$	$C_L$	$R_L$
5 V to 15 V	$V_{DD}$	$0.5V_I$	$\leq 20$ ns	50 pF	1 k $\Omega$

13. Package outline

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

SOT38-4

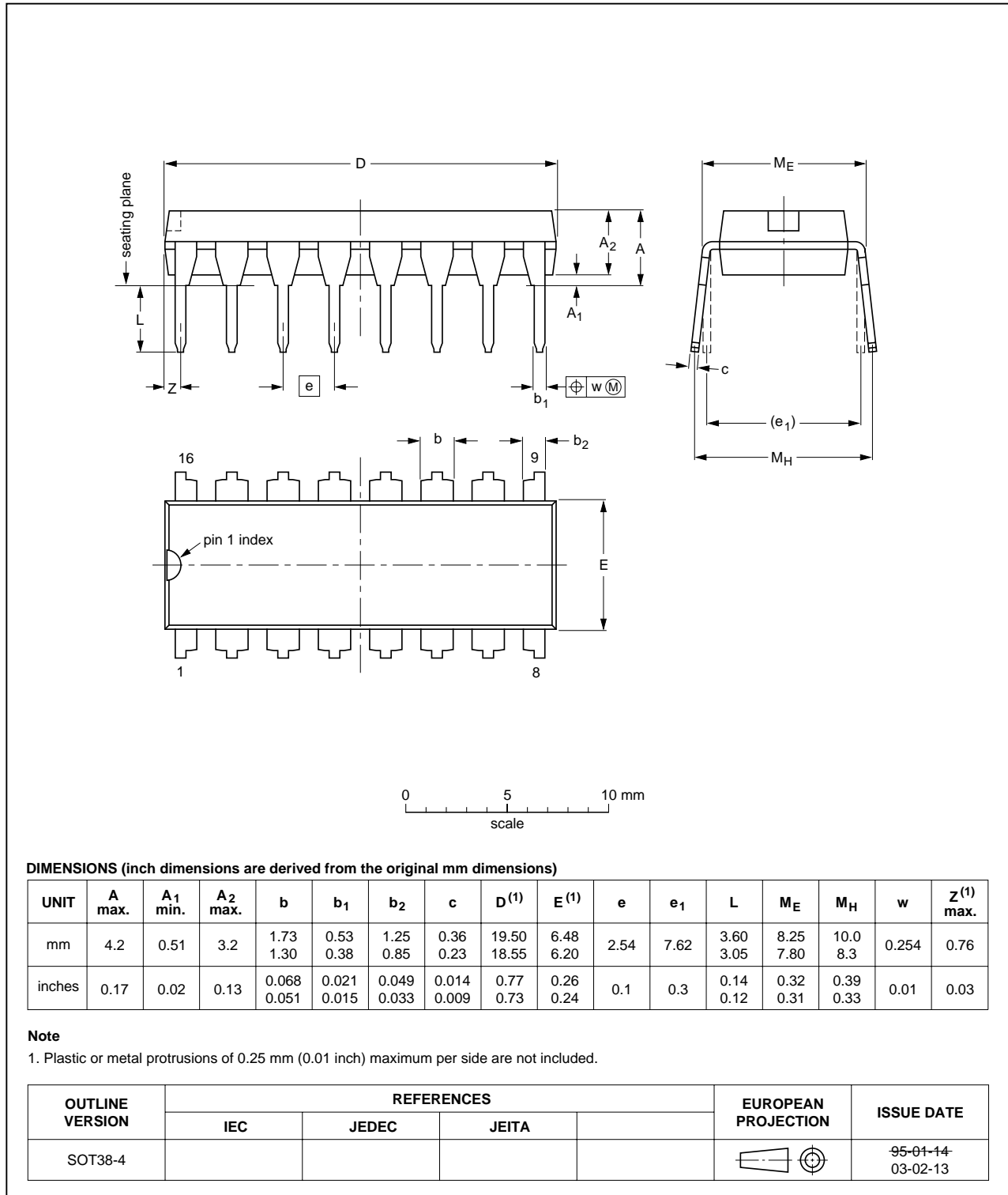


Fig 9. Package outline SOT38-4 (DIP16)

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

SOT109-1

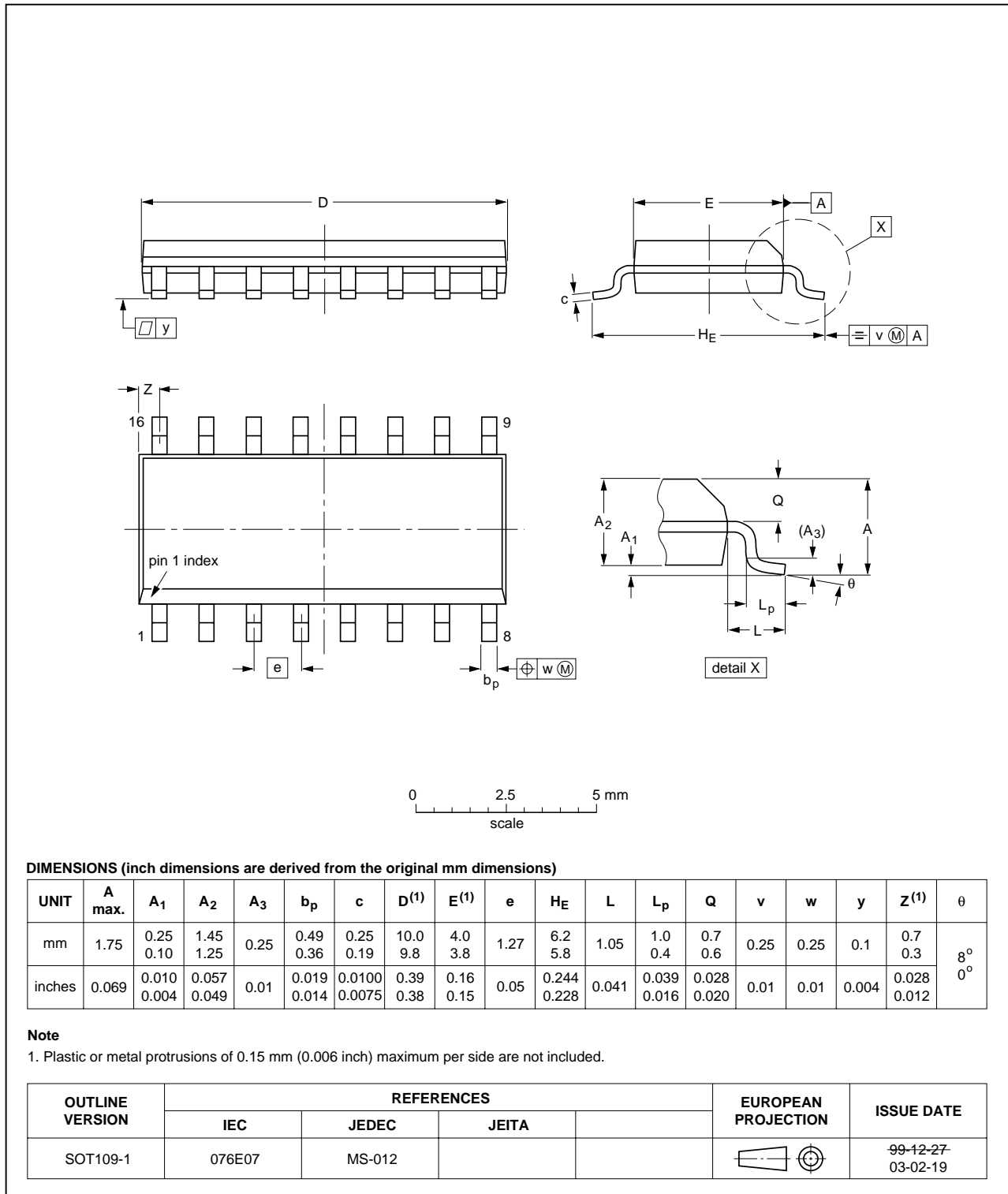


Fig 10. Package outline SOT109-1 (SO16)

## 14. Abbreviations

Table 10. Abbreviations

Acronym	Description
DUT	Device Under Test
ESD	ElectroStatic Discharge
HBM	Human Body Model
MM	Machine Model

## 15. Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4516B_4	20090312	Product data sheet	-	HEF4516B_CNV_3
Modifications:	<ul style="list-style-type: none"> <li>• The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors.</li> <li>• Legal texts have been adapted to the new company name where appropriate.</li> <li>• Pins renamed throughout.</li> <li>• <a href="#">Section 2 “Features”</a> added.</li> <li>• <a href="#">Section 3 “Applications”</a> added.</li> <li>• Package version SOT38-1 changed to SOT38-4 in <a href="#">Section 4</a>, and <a href="#">Figure 9</a>. Package SOT74 removed from <a href="#">Section 4</a>.</li> <li>• <a href="#">Table 1 “Ordering information”</a> restructured.</li> <li>• <a href="#">Section 8 “Limiting values”</a> and <a href="#">Section 10 “Static characteristics”</a> added, taken from the HE4000B Family Specifications data sheet.</li> <li>• <a href="#">Section 9 “Recommended operating conditions”</a> added.</li> <li>• <a href="#">Figure 8 “Test circuit for measuring switching times”</a> and <a href="#">Table 9 “Measurement points and test data”</a> added.</li> <li>• <a href="#">Section 14 “Abbreviations”</a> added.</li> </ul>			
HEF4516B_CNV_3	19950101	Product specification	-	HEF4516B_CNV_2
HEF4516B_CNV_2	19950101	Product specification	-	-

## 16. Legal information

### 16.1 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".

[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 URL <http://www.nxp.com>.

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