

# HEF4521B

## 24-stage frequency divider and oscillator

Rev. 6 — 21 November 2011

Product data sheet

### 1. General description

The HEF4521B consists of a chain of 24 toggle flip-flops with an overriding asynchronous master reset input (MR), and an input circuit that allows three modes of operation. The single inverting stage (A2 to Y2) functions as: a crystal oscillator, an input buffer for an external oscillator or in combination with A1 as an RC oscillator. The crystal oscillator operates in Low-power mode when pins  $V_{SS1}$  and  $V_{DD1}$  are supplied via external resistors.

Each flip-flop divides the frequency of the previous flip-flop by two, consequently the HEF4521B counts up to  $2^{24} = 16777216$ . The counting advances on the HIGH-to-LOW transition of the clock (A2). The outputs from each of the last seven stages ( $2^{18}$  to  $2^{24}$ ) are available for additional flexibility.

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

- Low power crystal oscillator operation
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Specified from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$
- Complies with JEDEC standard JESD 13-B

### 3. Ordering information

**Table 1. Ordering information**

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

Type number	Package		Version
	Name	Description	
HEF4521BP	DIP16	plastic dual in-line package; 16-leads (300 mil)	SOT38-4
HEF4521BT	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1



4. Functional diagram

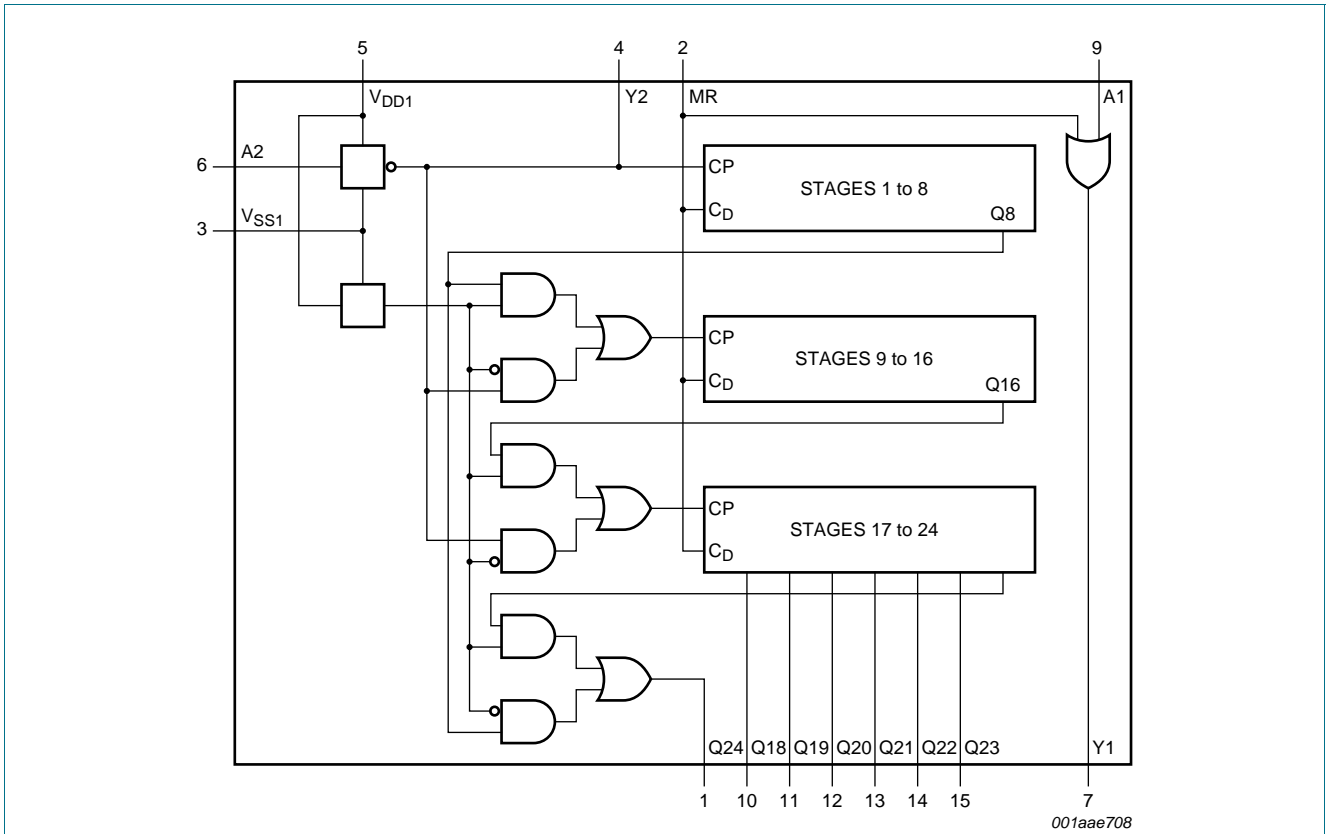


Fig 1. Functional diagram

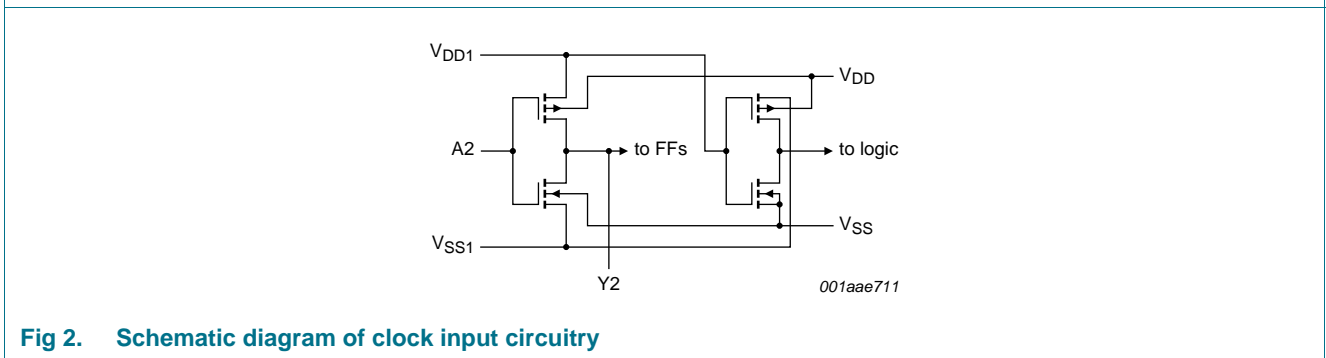


Fig 2. Schematic diagram of clock input circuitry

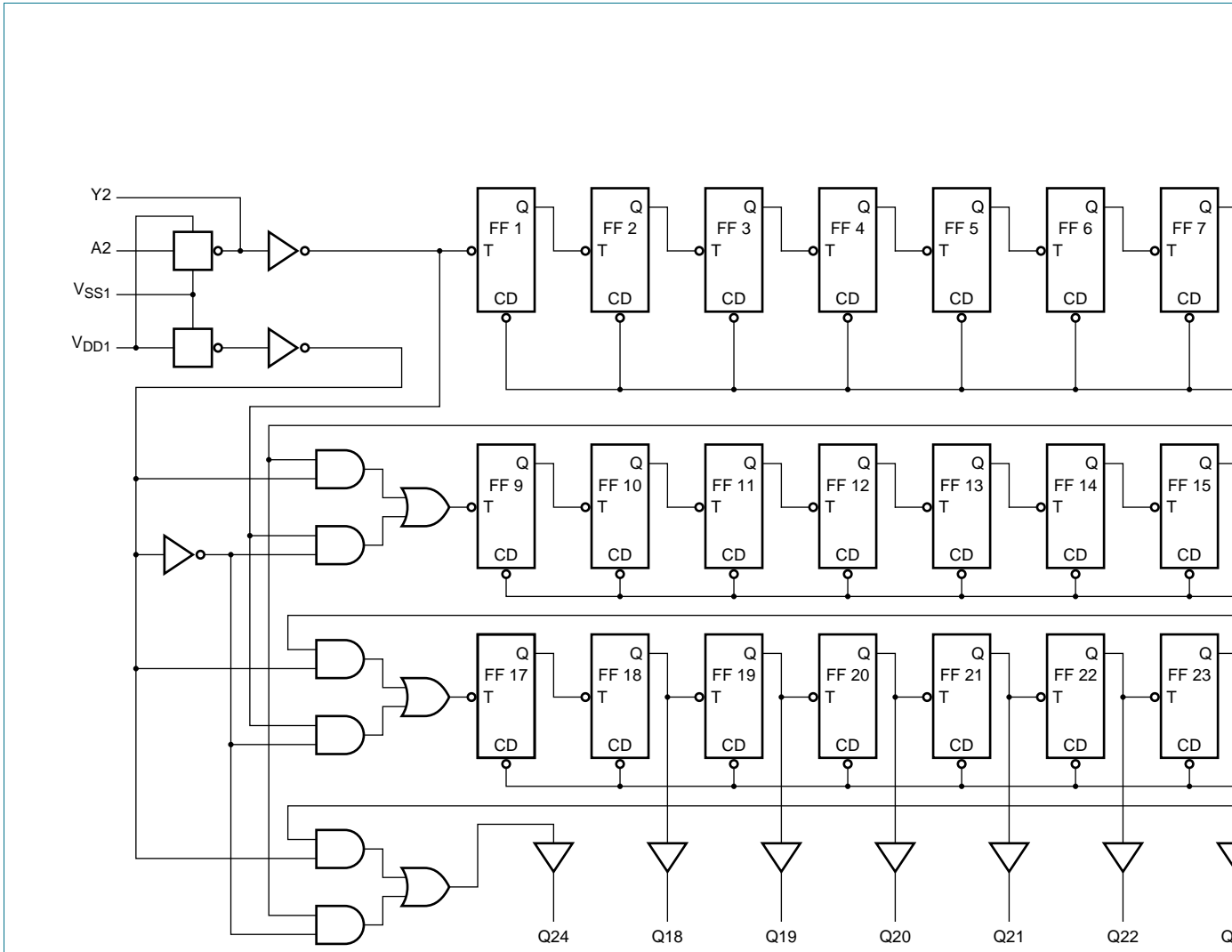


Fig 3. Logic diagram

## 5. Pinning information

### 5.1 Pinning

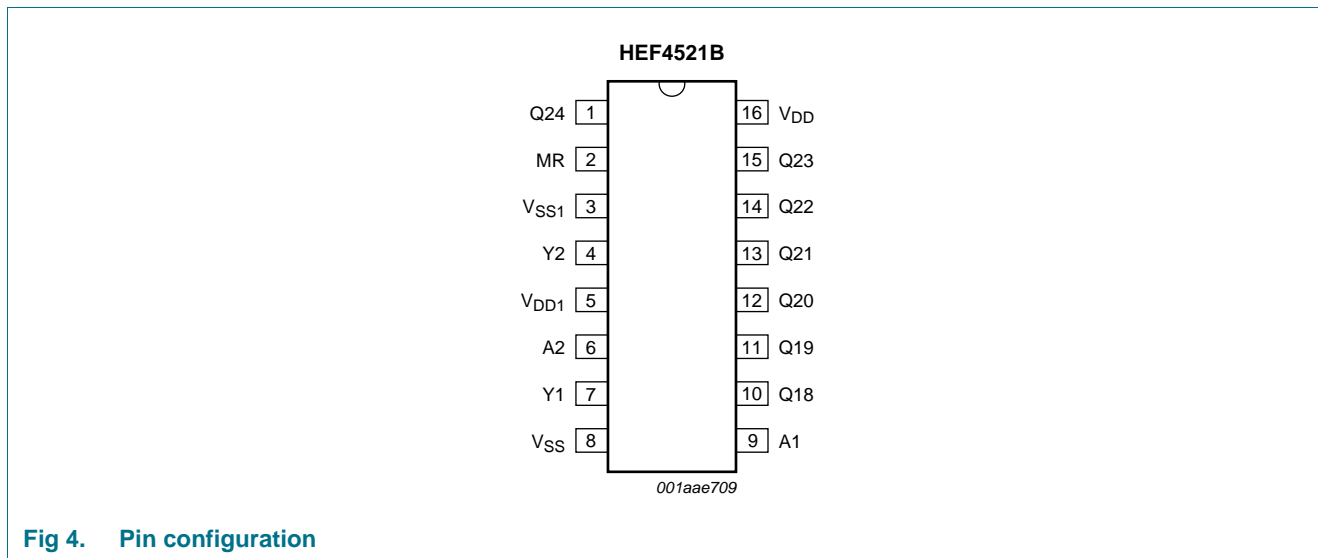


Fig 4. Pin configuration

### 5.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
MR	2	master reset input
V <sub>SS1</sub>	3	ground supply voltage 1
V <sub>DD1</sub>	5	supply voltage 1
Y1, Y2	7, 4	external oscillator connection
V <sub>SS</sub>	8	ground supply voltage
A1, A2	9, 6	external oscillator connection
Q18 to Q24	10, 11, 12, 13, 14, 15, 1	output
V <sub>DD</sub>	16	supply voltage

## 6. Count capacity

Table 3. Count capacity

Output	Count capacity
Q18	2 <sup>18</sup> = 262 144
Q19	2 <sup>19</sup> = 524 288
Q20	2 <sup>20</sup> = 1 048 576
Q21	2 <sup>21</sup> = 2 097 152
Q22	2 <sup>22</sup> = 4 194 304
Q23	2 <sup>23</sup> = 8 388 608
Q24	2 <sup>24</sup> = 16 777 216

## 7. Functional test

A test function has been included to reduce the test time required to test all 24 counter stages. This test function divides the counter into three 8-stage sections by connecting  $V_{SS1}$  to  $V_{DD}$  and  $V_{DD1}$  to  $V_{SS}$ . 255 counts are loaded into each of the 8-stage sections in parallel via A2 (connected to Y2). All flip-flops are now at a HIGH level. The counter is now returned to the normal 24-stage in series configuration by connecting  $V_{SS1}$  to  $V_{SS}$  and  $V_{DD1}$  to  $V_{DD}$ . Entering one more pulse into input A2 causes the counter to ripple from an all HIGH state to an all LOW state.

Table 4. Functional test sequence<sup>[1]</sup>

Inputs		Control terminals			Outputs	Remarks
MR	A2	Y2	$V_{SS1}$	$V_{DD1}$	Q18 to Q24	
H	L	L	$V_{DD}$	$V_{SS}$	L	counter is in three 8-stage sections in parallel mode; A2 and Y2 are interconnected (Y2 is now input); counter is reset by MR.
L	[2]	[2]	$V_{DD}$	$V_{SS}$	H	
L	L	L	$V_{SS}$	$V_{SS}$	H	$V_{SS1}$ is connected to $V_{SS}$ .
L	H	L	$V_{SS}$	$V_{SS}$	H	the input A2 is made HIGH.
L	H	L	$V_{SS}$	$V_{DD}$	H	$V_{DD1}$ is connected to $V_{DD}$ ; Y2 is now made floating and becomes an output; the device is now in the 2 <sup>24</sup> mode.
L	↓		$V_{SS}$	$V_{DD}$	L	counter ripples from an all HIGH state to an all LOW state.

[1] H = HIGH voltage level; L = LOW voltage level; ↓ = HIGH to LOW transition.

[2] 255 pulses are clocked into A2, Y2. The counter advances on the LOW to HIGH transition.

## 8. Limiting values

Table 5. Limiting values

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

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{DD}$	supply voltage		-0.5	+18	V
$I_{IK}$	input clamping current	$V_I < -0.5\text{ V}$ or $V_I > V_{DD} + 0.5\text{ V}$	-	±10	mA
$V_I$	input voltage		-0.5	$V_{DD} + 0.5$	V
$I_{OK}$	output clamping current	$V_O < -0.5\text{ V}$ or $V_O > V_{DD} + 0.5\text{ V}$	-	±10	mA
$I_{I/O}$	input/output current		-	±10	mA
$I_{DD}$	supply current	to any supply terminal	-	±100	mA
$T_{stg}$	storage temperature		-65	+150	°C
$T_{amb}$	ambient temperature		-40	+85	°C
$P_{tot}$	total power dissipation	DIP16 package	[1] -	750	mW
		SO16 package	[2] -	500	mW
P	power dissipation	per output	-	100	mW

[1] For DIP16 package:  $P_{tot}$  derates linearly with 12 mW/K above 70 °C.

[2] For SO16 package:  $P_{tot}$  derates linearly with 8 mW/K above 70 °C.

## 9. Recommended operating conditions

**Table 6. 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	$V_{DD} = 5\text{ V}$	-	-	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 7. Static characteristics**

$V_{SS} = 0\text{ V}$ ;  $V_I = V_{SS}$  or  $V_{DD}$  unless otherwise specified.

Symbol	Parameter	Conditions	$V_{DD}$	$T_{amb} = -40\text{ °C}$		$T_{amb} = 25\text{ °C}$		$T_{amb} = 85\text{ °C}$		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}$	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}$	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
		$V_O = 4.6\text{ V}$	5 V	-	-0.52	-	-0.44	-	-0.36	mA
		$V_O = 9.5\text{ V}$	10 V	-	-1.3	-	-1.1	-	-0.9	mA
		$V_O = 13.5\text{ V}$	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
		$V_O = 0.5\text{ V}$	10 V	1.3	-	1.1	-	0.9	-	mA
		$V_O = 1.5\text{ V}$	15 V	3.6	-	3.0	-	2.4	-	mA
$I_I$	input leakage current		15 V	-	$\pm 0.3$	-	$\pm 0.3$	-	$\pm 1.0$	$\mu\text{A}$
$I_{DD}$	supply current	$I_O = 0\text{ A}$	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 8. Dynamic characteristics**

$V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ °C}$ ; for test circuits see [Figure 6](#); 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	A2 to Q18; see <a href="#">Figure 5</a>	5 V	[1] 923 ns + (0.55 ns/pF)C <sub>L</sub>	-	950	1900	ns	
			10 V	339 ns + (0.23 ns/pF)C <sub>L</sub>	-	350	700	ns	
			15 V	212 ns + (0.16 ns/pF)C <sub>L</sub>	-	220	440	ns	
		Qn to Qn + 1; see <a href="#">Figure 5</a>	5 V	13 ns + (0.55 ns/pF)C <sub>L</sub>	-	40	80	ns	
			10 V	4 ns + (0.23 ns/pF)C <sub>L</sub>	-	15	30	ns	
			15 V	2 ns + (0.16 ns/pF)C <sub>L</sub>	-	10	20	ns	
		MR to Qn	5 V	93 ns + (0.55 ns/pF)C <sub>L</sub>	-	120	240	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	80	ns	
	A1 to Y1; see <a href="#">Figure 5</a>	5 V	63 ns + (0.55 ns/pF)C <sub>L</sub>	-	90	180	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	A2 to Q18; see <a href="#">Figure 5</a>	5 V	[1] 923 ns + (0.55 ns/pF)C <sub>L</sub>	-	950	1900	ns
				10 V	339 ns + (0.23 ns/pF)C <sub>L</sub>	-	350	700	ns
				15 V	212 ns + (0.16 ns/pF)C <sub>L</sub>	-	220	440	ns
Qn to Qn + 1; see <a href="#">Figure 5</a>			5 V	13 ns + (0.55 ns/pF)C <sub>L</sub>	-	40	80	ns	
			10 V	4 ns + (0.23 ns/pF)C <sub>L</sub>	-	15	30	ns	
			15 V	2 ns + (0.16 ns/pF)C <sub>L</sub>	-	10	20	ns	
A1 to Y1; see <a href="#">Figure 5</a>			5 V	33 ns + (0.55 ns/pF)C <sub>L</sub>	-	60	120	ns	
			10 V	19 ns + (0.23 ns/pF)C <sub>L</sub>	-	30	60	ns	
			15 V	12 ns + (0.16 ns/pF)C <sub>L</sub>	-	20	40	ns	
t <sub>t</sub>		transition time	Qn; see <a href="#">Figure 5</a>	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
t <sub>W</sub>		pulse width	A2 HIGH; minimum width; see <a href="#">Figure 5</a>	5 V		80	40	-	ns
				10 V		40	20	-	ns
				15 V		30	15	-	ns
	MR HIGH; minimum width; see <a href="#">Figure 5</a>		5 V		70	35	-	ns	
			10 V		40	20	-	ns	
			15 V		30	15	-	ns	
t <sub>rec</sub>	recovery time	MR; see <a href="#">Figure 5</a>	5 V		+20	-10	-	ns	
			10 V		+15	-5	-	ns	
			15 V		15	0	-	ns	
f <sub>max</sub>	maximum frequency	A1; see <a href="#">Figure 5</a>	5 V		6	12	-	MHz	
			10 V		12	25	-	MHz	
			15 V		17	35	-	MHz	

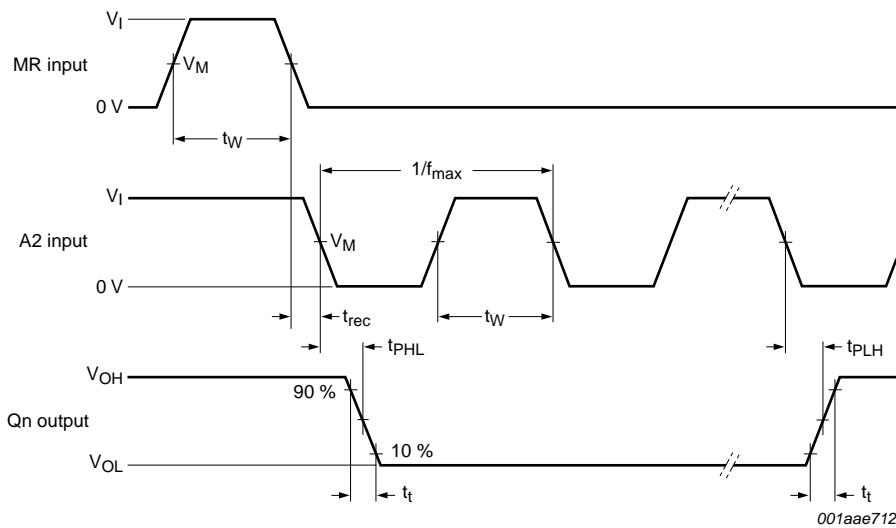
[1] The typical values of the propagation delay and transition times are calculated from the extrapolation formulas shown (C<sub>L</sub> in pF).

**Table 9. Dynamic power dissipation  $P_D$**

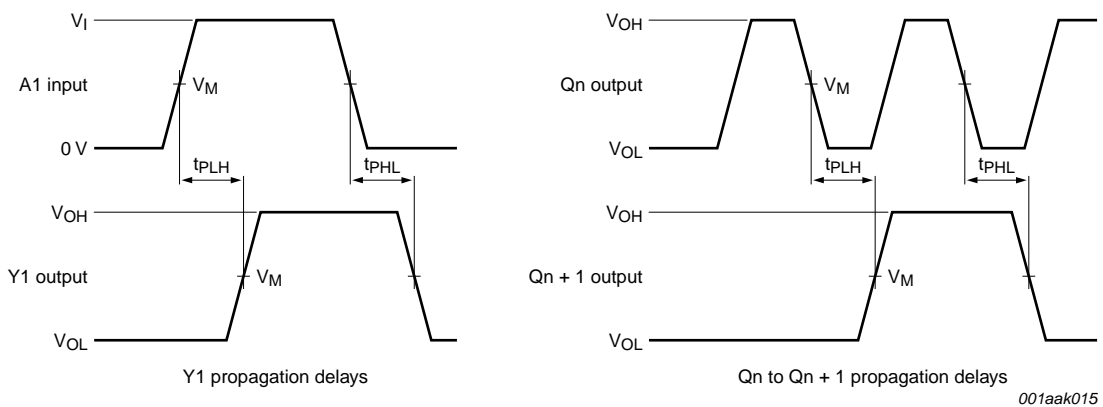
$P_D$  can be calculated from the formulas shown.  $V_{SS} = 0\text{ V}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ .

Symbol	Parameter	$V_{DD}$	Typical formula for $P_D$ ( $\mu\text{W}$ )	where:
$P_D$	dynamic power dissipation	5 V	$P_D = 1200 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$f_i$ = input frequency in MHz,
		10 V	$P_D = 5100 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$f_o$ = output frequency in MHz,
		15 V	$P_D = 13050 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	$C_L$ = output load capacitance in pF, $V_{DD}$ = supply voltage in V, $\Sigma(C_L \times f_o)$ = sum of the outputs.

## 12. Waveforms



a. Pulse widths, maximum frequency, recovery and transition times and A2 to Qn propagation delays



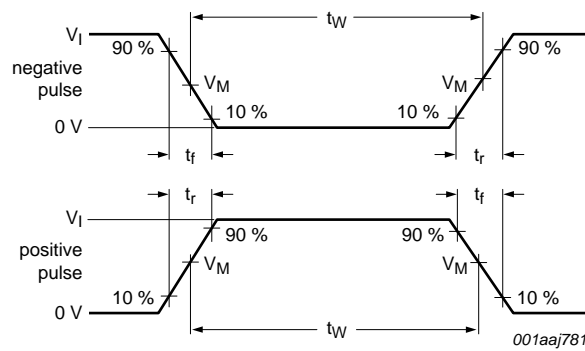
b. A1 to Y1, MR to Qn and Qn to Qn + 1 propagation delays

Measurement points are given in [Table 10](#).

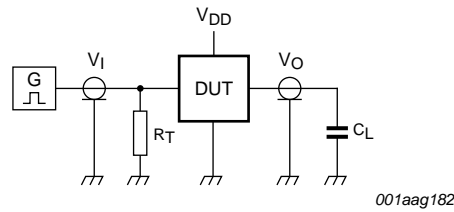
The logic levels  $V_{OH}$  and  $V_{OL}$  are typical output voltage levels that occur with the output load.

**Fig 5. Waveforms showing measurement of dynamic characteristics**





a. Input waveforms



b. Test circuit

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

Definitions for test circuit:

Device Under Test (DUT);

$C_L$  = 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 switching times

Table 10. Measurement points and test data

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

13. Application information

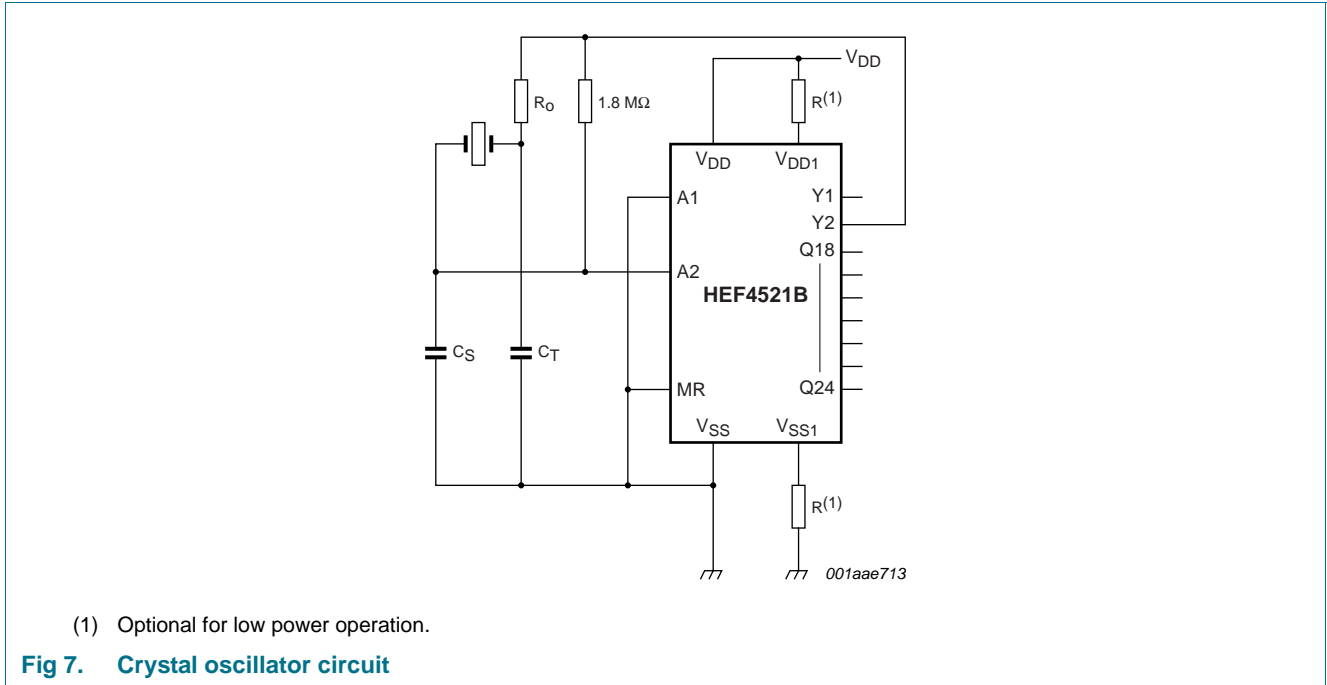
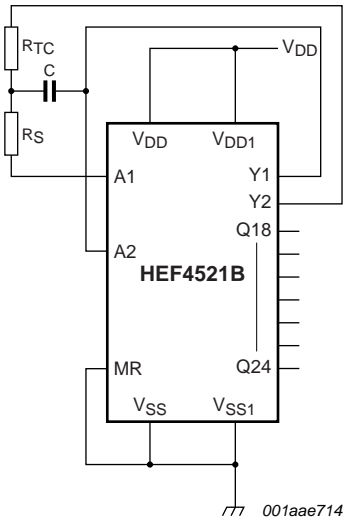


Table 11. Typical characteristics for crystal oscillator

See [Figure 7](#).

Parameter	500 kHz circuit	50 kHz circuit	Unit
<b>Crystal characteristics</b>			
Resonance frequency	500	50	kHz
Crystal cut	S	N	-
Equivalent resistance; $R_S$	1	6.2	k $\Omega$
<b>External resistor/capacitor values</b>			
$R_0$	47	750	k $\Omega$
$C_T$	82	82	pF
$C_S$	20	20	pF



$$f \approx \frac{1}{2.3 \times R_{TC} \times C} ; R_S \geq 2R_{TC} , \text{ where:}$$

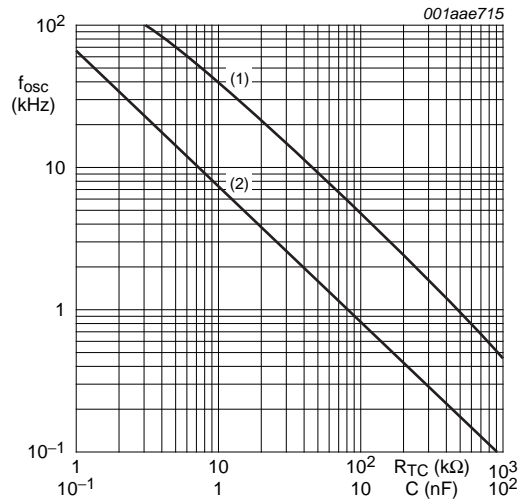
f is in Hz, R is in  $\Omega$ , and C is in F.

$$R_S + R_{TC} < \frac{V_{IL(max)}}{I_{LI}} , \text{ where:}$$

$V_{IL(max)}$  = maximum input voltage LOW; and

$I_{LI}$  = input leakage current.

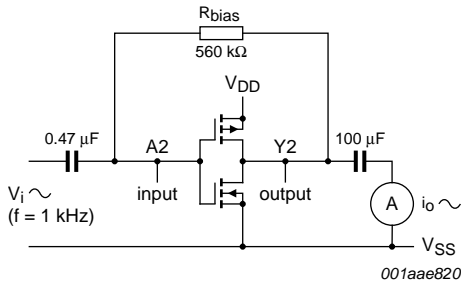
Fig 8. RC oscillator circuit



$V_{DD} = 10 \text{ V}$ ; The test circuit is shown in [Figure 8](#).

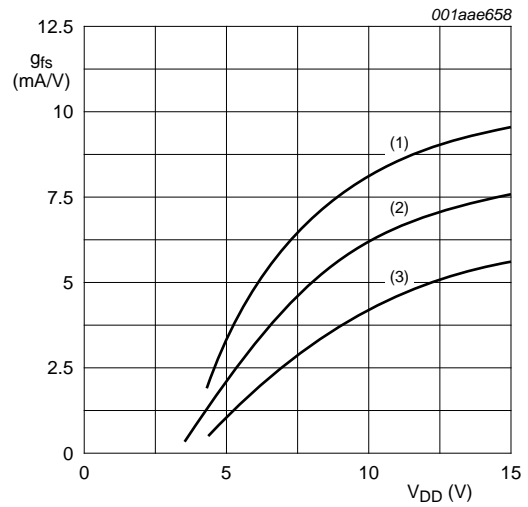
- (1)  $R_{TC}$ ;  $C = 1 \text{ nF}$ ;  $R_S \approx 2 R_{TC}$ .
- (2)  $C$ ;  $R_{TC} = 56 \text{ k}\Omega$ ;  $R_S = 120 \text{ k}\Omega$ .

Fig 9. Oscillator frequency as a function of  $R_{TC}$  and C



$g_{fs} = d_{i_o}/d_{v_i}$  with  $v_o$  constant (see Figure 11).

Fig 10. Test setup for measuring forward transconductance



- (1) Average + 2s.
- (2) Average.
- (3) Average - 2s.

Where 's' is the observed standard deviation.

Fig 11. Typical forward transconductance  $g_{fs}$  as a function of the supply voltage at  $T_{amb} = 25\text{ °C}$

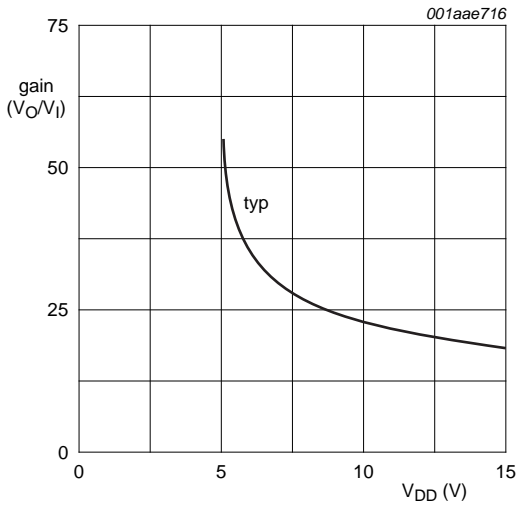


Fig 12. Voltage gain  $V_O/V_I$  as a function of supply voltage

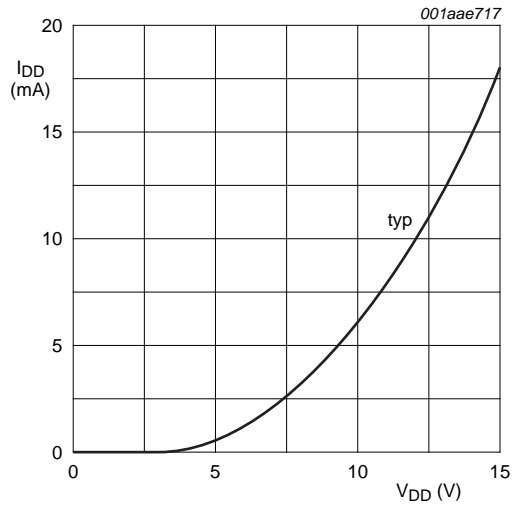


Fig 13. Supply current as a function of supply voltage

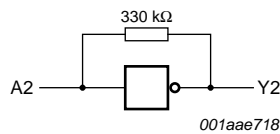


Fig 14. Test setup for measuring the Figure 12 and Figure 13 graphs

14. Package outline

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

SOT38-4

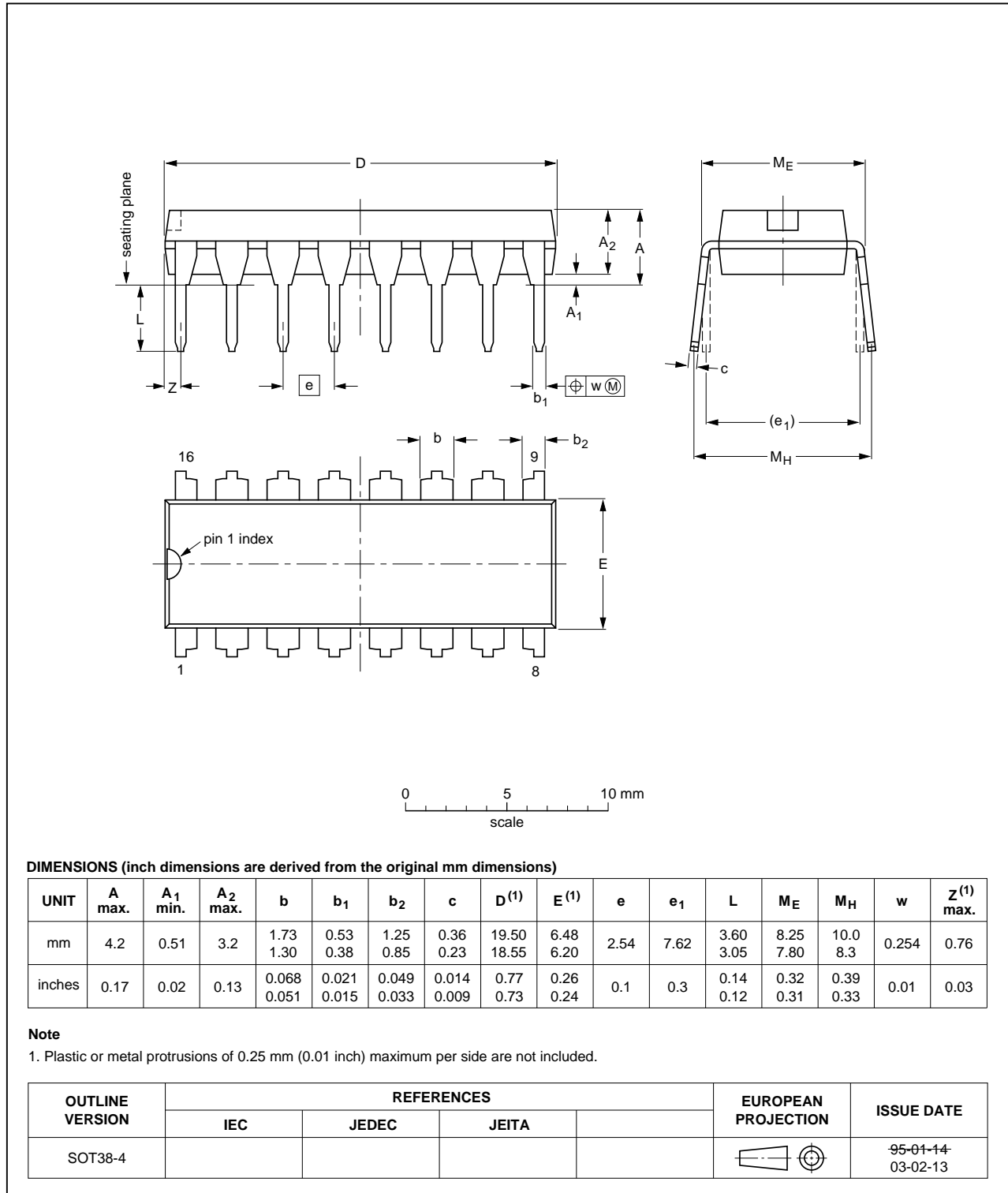


Fig 15. Package outline SOT38-4 (DIP16)

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

SOT109-1

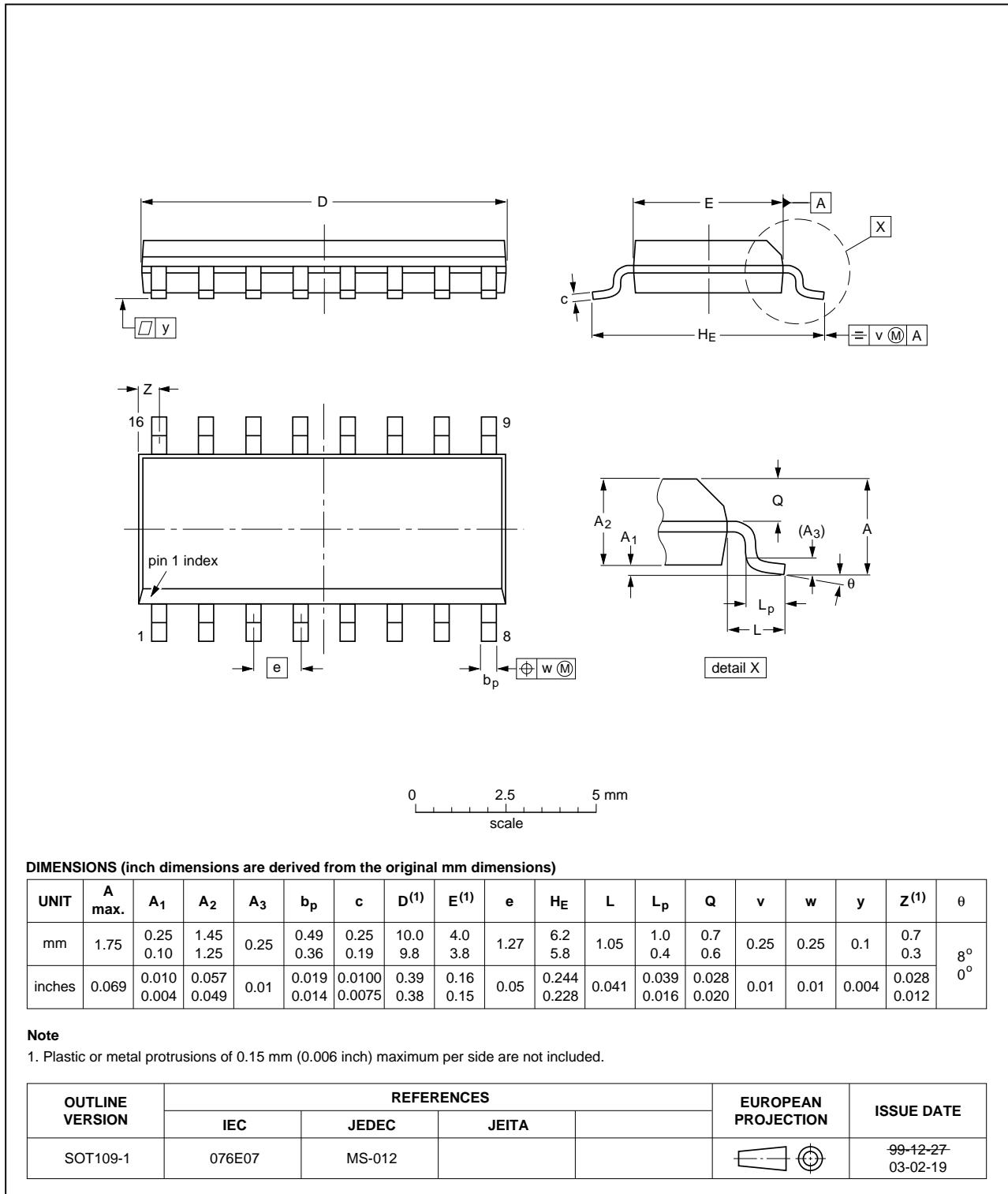


Fig 16. Package outline SOT109-1 (SO16)

## 15. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4521B v.6	20111121	Product data sheet	-	HEF4521B v.5
Modifications:	<ul style="list-style-type: none"> <li>• Section Applications removed</li> <li>• <a href="#">Table 4</a>: added references to <a href="#">Table note [1]</a> and <a href="#">Table note [2]</a></li> <li>• <a href="#">Table 7</a>: I<sub>OH</sub> minimum values changed to maximum</li> <li>• <a href="#">Figure 11</a>, <a href="#">Figure note [1]</a> and <a href="#">Figure note [3]</a>: space between '2' and 's' removed</li> </ul>			
HEF4521B v.5	20091105	Product data sheet	-	HEF4521B v.4
HEF4521B v.4	20090421	Product data sheet	-	HEF4521B_CNV v.3
HEF4521B_CNV v.3	19950101	Product specification	-	HEF4521B_CNV v.2
HEF4521B_CNV v.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>.

### 16.2 Definitions

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