



**THE DATASHEET OF  
HEF4521BT,652**





# HEF4521B

## 24-stage frequency divider and oscillator

Rev. 9 — 19 August 2024

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

- Wide supply voltage range from 3.0 V to 15.0 V
- CMOS low power dissipation
- High noise immunity
- Low power crystal oscillator operation
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Complies with JEDEC standard JESD 13-B
- ESD protection:
  - HBM: ANSI/ESDA/JEDEC JS-001 class 2 exceeds 2000 V
  - CDM: ANSI/ESDA/JEDEC JS-002 class C3 exceeds 1000 V
- Specified from -40 °C to +85 °C

### 3. Ordering information

Table 1. Ordering information

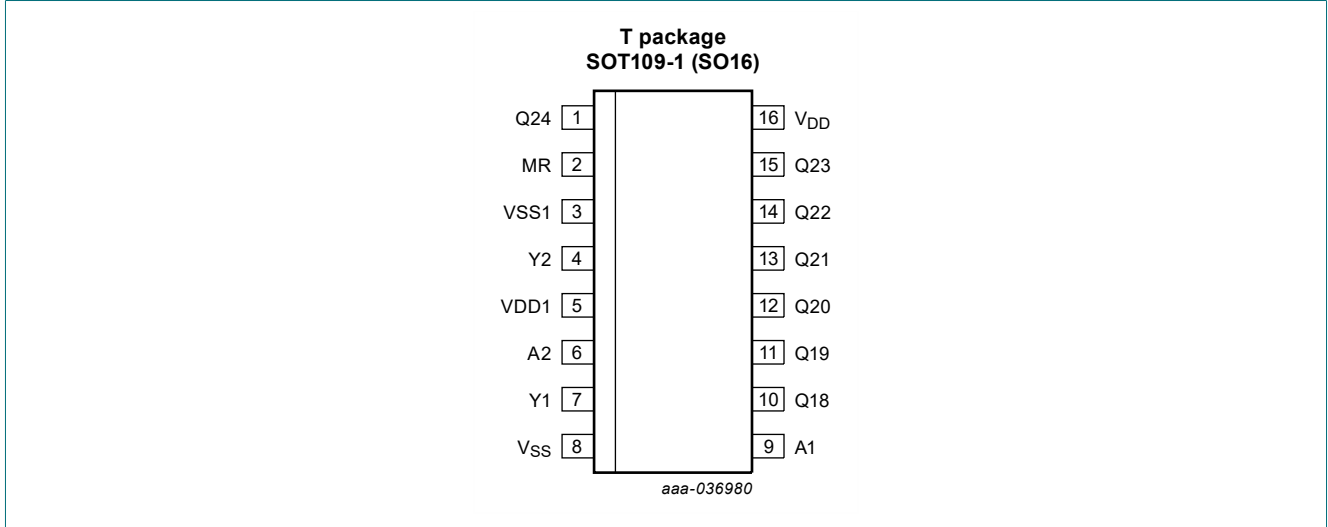
Type number	Package			
	Temperature range	Name	Description	Version
<a href="#">HEF4521BT</a>	-40 °C to +85 °C	SO16	plastic small outline package; 16 leads; body width 3.9 mm	<a href="#">SOT109-1</a>





## 5. Pinning information

### 5.1. Pinning



### 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, Q19, Q20, Q21, Q22, Q23, 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	$2^{18} = 262144$
Q19	$2^{19} = 524288$
Q20	$2^{20} = 1048576$
Q21	$2^{21} = 2097152$
Q22	$2^{22} = 4194304$
Q23	$2^{23} = 8388608$
Q24	$2^{24} = 16777216$

## 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**

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

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	[1]	[1]	$V_{DD}$	$V_{SS}$	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 $2^{24}$ mode.
L	↓		$V_{SS}$	$V_{DD}$	L	Counter ripples from an all HIGH state to an all LOW state.

[1] 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	$T_{amb} -40\text{ °C}$ to $+85\text{ °C}$	-	500	mW
P	power dissipation	per output	-	100	mW

## 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**

$V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ °C}$  unless otherwise specified; for test circuit see Fig. 5.

Symbol	Parameter	Conditions	V <sub>DD</sub>	Extrapolation formula[1]	Min	Typ	Max	Unit		
t <sub>PHL</sub>	HIGH to LOW propagation delay	A2 to Q18; see Fig. 4	5 V	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 Fig. 4	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 Fig. 4	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 Fig. 4	5 V	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 Fig. 4	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 Fig. 4	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 Fig. 4	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	A2 HIGH; minimum width; see Fig. 4	5 V		80	40	-	ns		
			10 V		40	20	-	ns		
			15 V		30	15	-	ns		
		MR HIGH; minimum width; see Fig. 4	5 V		70	35	-	ns		
			10 V		40	20	-	ns		
			15 V		30	15	-	ns		
t <sub>rec</sub>	recovery time	MR; see Fig. 4	5 V		+20	-10	-	ns		
			10 V		+15	-5	-	ns		
			15 V		15	0	-	ns		
f <sub>max</sub>	maximum frequency	A1; see Fig. 4	5 V		6	12	-	MHz		
			10 V		12	25	-	MHz		
			15 V		17	35	-	MHz		

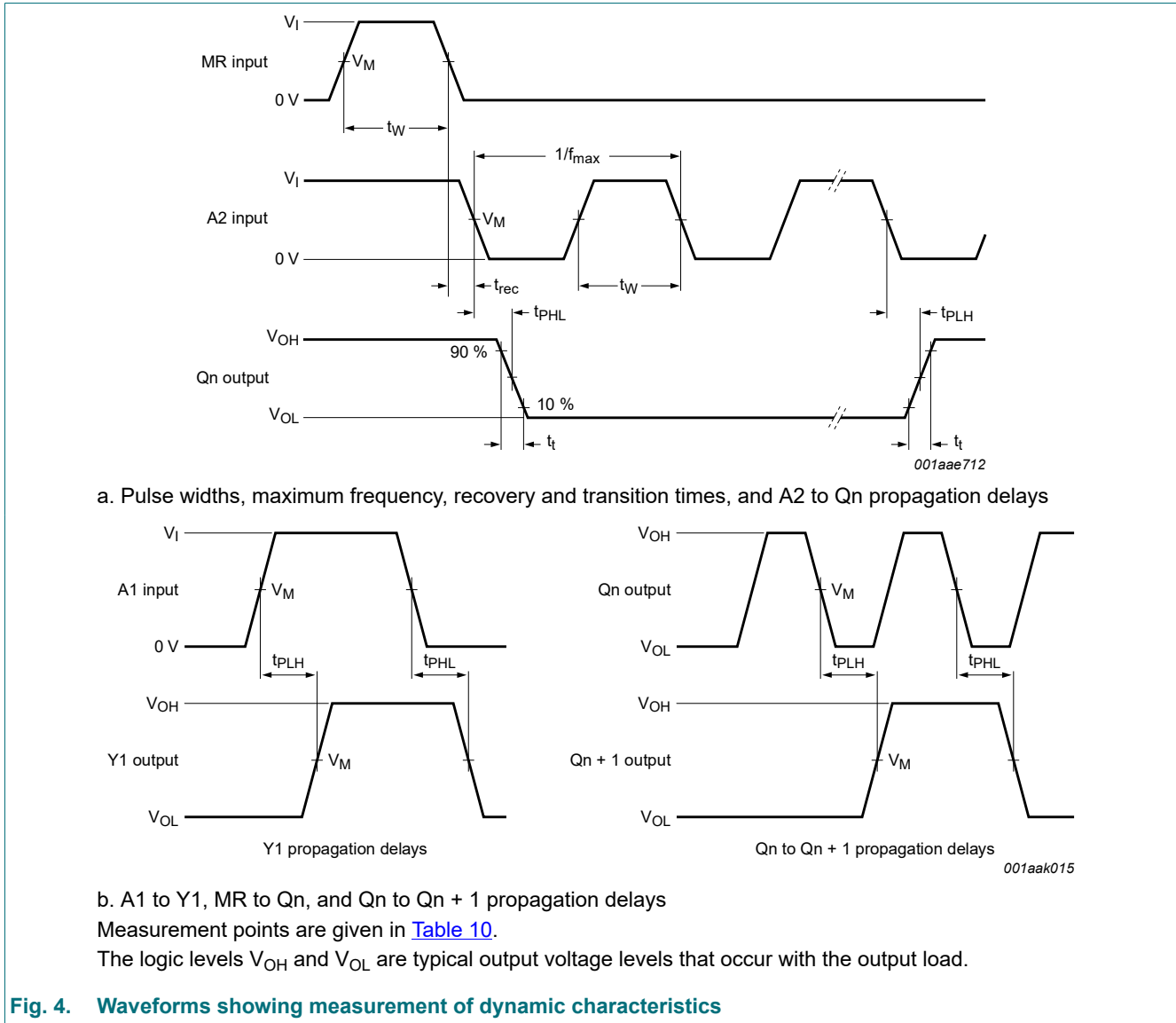
[1] The typical values of the propagation delay and transition times are calculated from the extrapolation formulas shown (C<sub>L</sub> in pF).

**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, $f_o$ = output frequency in MHz, $C_L$ = output load capacitance in pF, $V_{DD}$ = supply voltage in V, $\Sigma(C_L \times f_o)$ = sum of the outputs.
		10 V	$P_D = 5100 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	
		15 V	$P_D = 13050 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$	

**11.1. Waveforms and test circuit**



**Fig. 4. Waveforms showing measurement of dynamic characteristics**

**Table 10. Measurement points**

Supply voltage	Input	Output
$V_{DD}$	$V_M$	$V_M$
5 V to 15 V	$0.5V_{DD}$	$0.5V_{DD}$

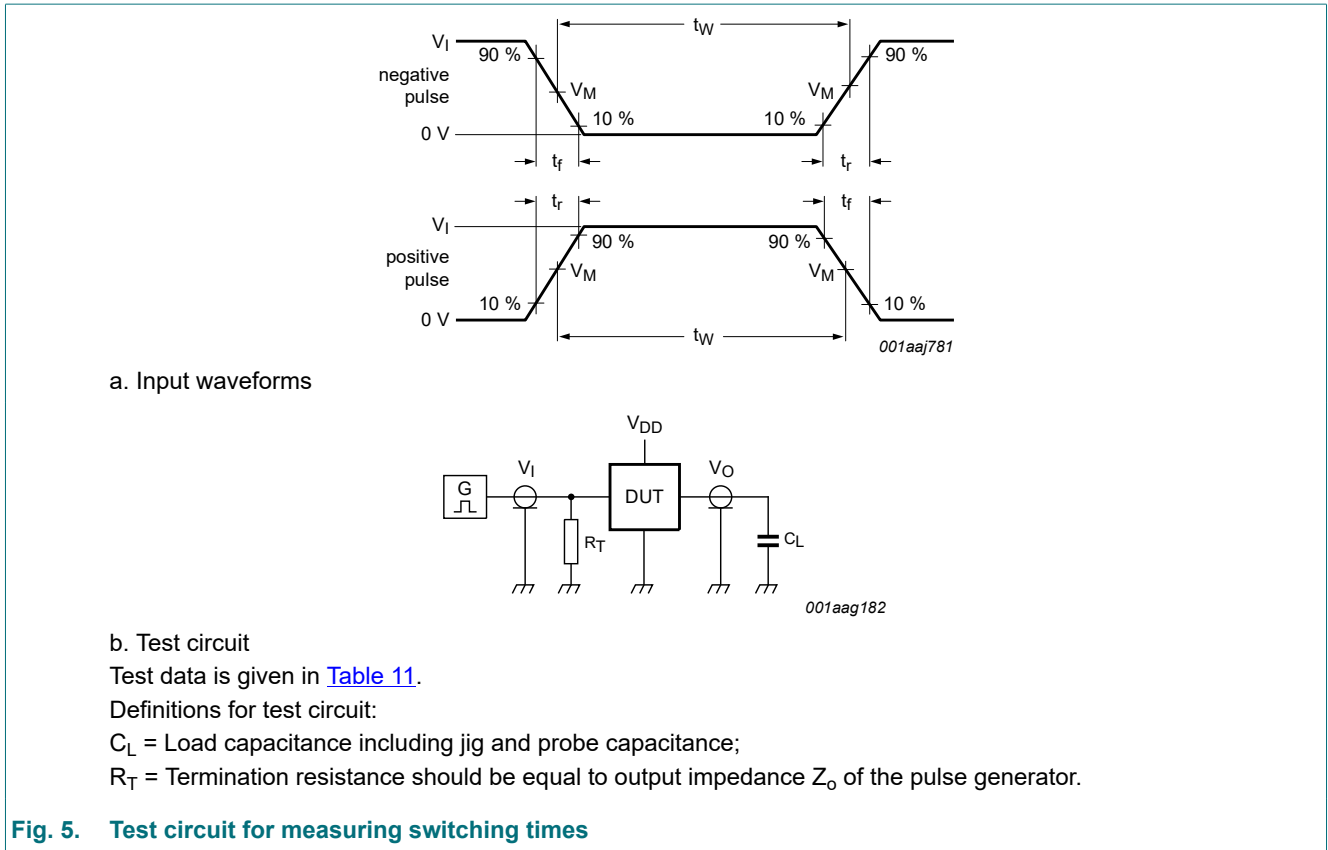


Table 11. Test data

Supply	Input	Load
$V_{DD}$	$V_I$	$C_L$
5 V to 15 V	$V_{SS}$ or $V_{DD}$	$\leq 20$ ns
		50 pF

## 12. Application information

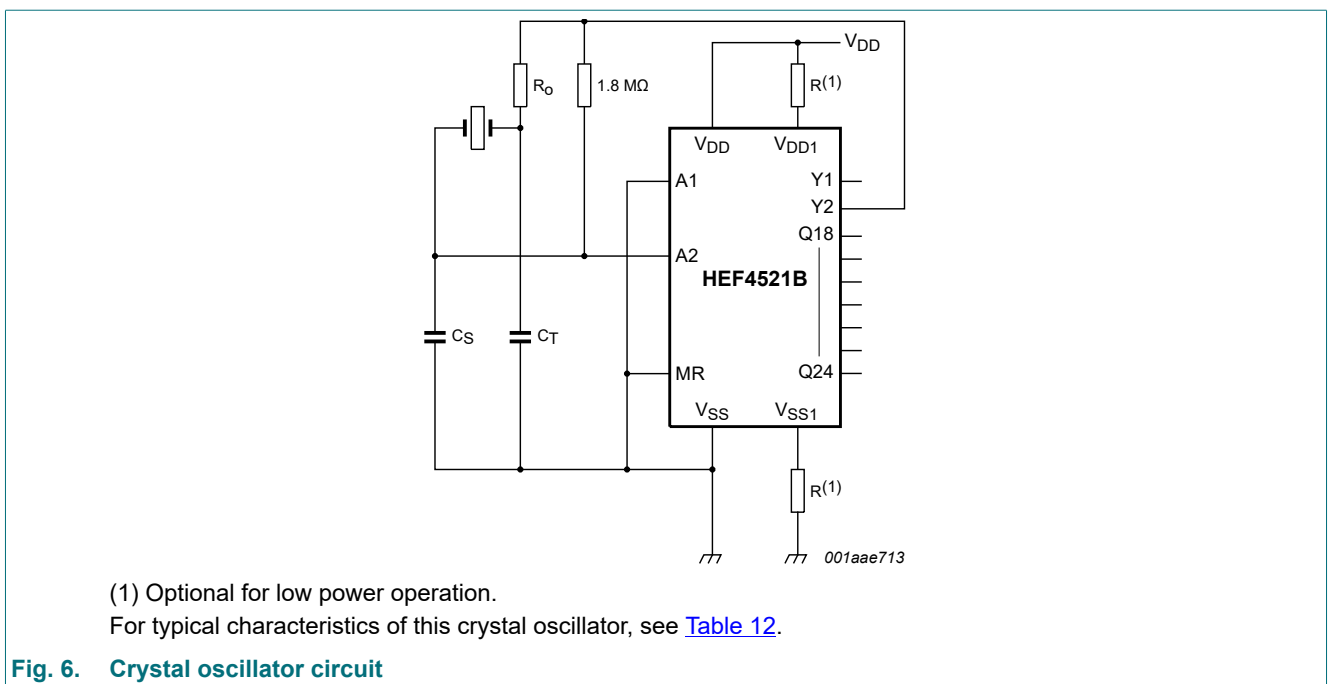


Table 12. Typical characteristics for crystal oscillator

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>			
$R_o$	47	750	k $\Omega$
$C_T$	82	82	pF
$C_S$	20	20	pF

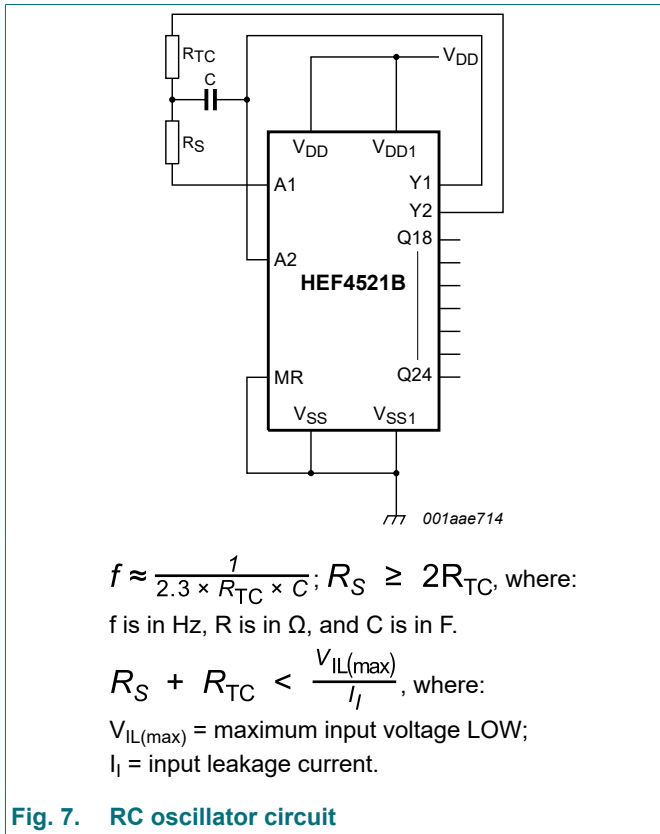


Fig. 7. RC oscillator circuit

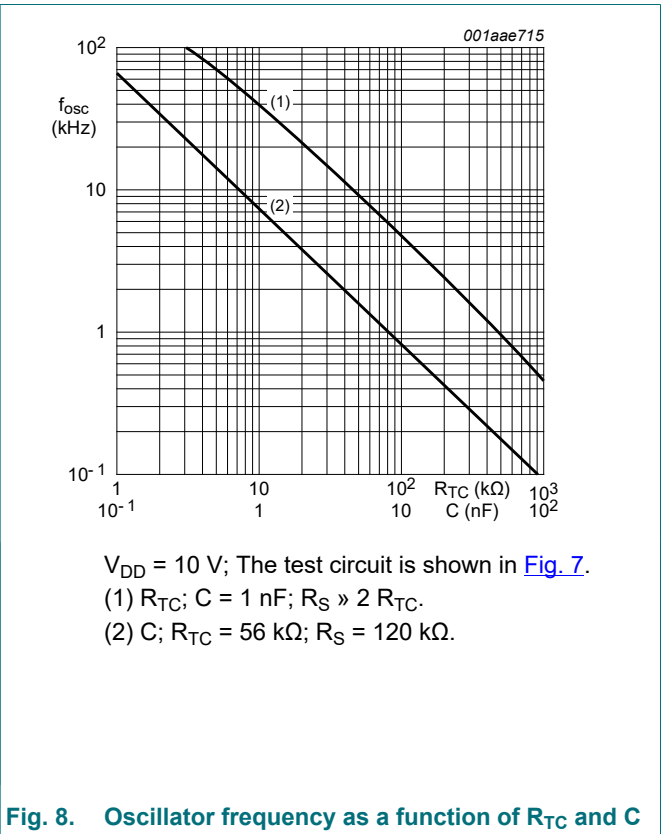
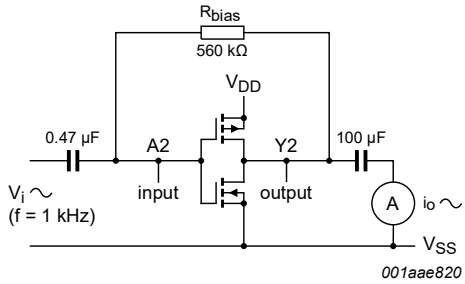
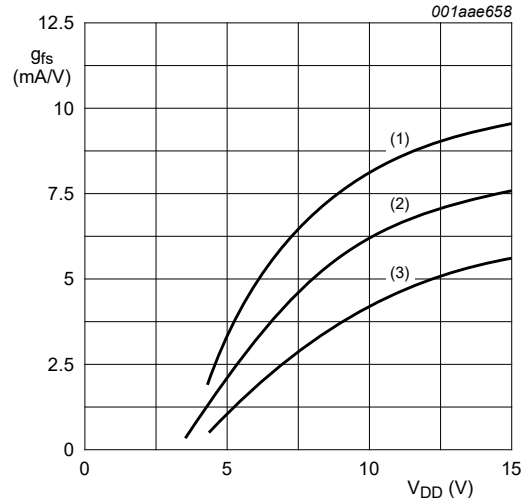


Fig. 8. Oscillator frequency as a function of  $R_{TC}$  and C



$g_{fs} = d_{i_o}/d_{v_i}$  with  $v_o$  constant (see Fig. 10).

Fig. 9. Test setup for measuring forward transconductance

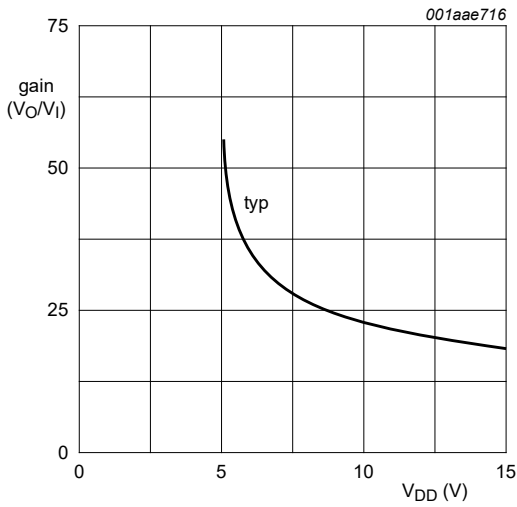


$T_{amb} = 25\text{ }^{\circ}\text{C}$ .

s = observed standard deviation.

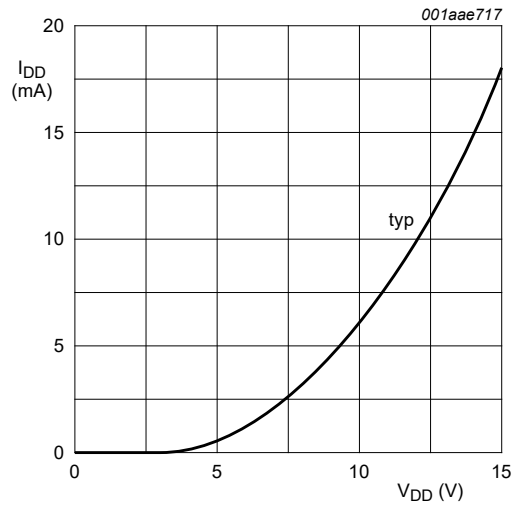
- (1) Average +2s
- (2) Average
- (3) Average -2s

Fig. 10. Typical forward transconductance  $g_{fs}$  as a function of the supply voltage



For test setup, see Fig. 13.

Fig. 11. Voltage gain  $V_o/V_i$  as a function of supply voltage



For test setup, see Fig. 13.

Fig. 12. Supply current as a function of supply voltage

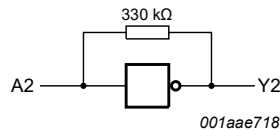


Fig. 13. Test setup for measuring the voltage gain and supply current graphs

### 13. Package outline

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

SOT109-1

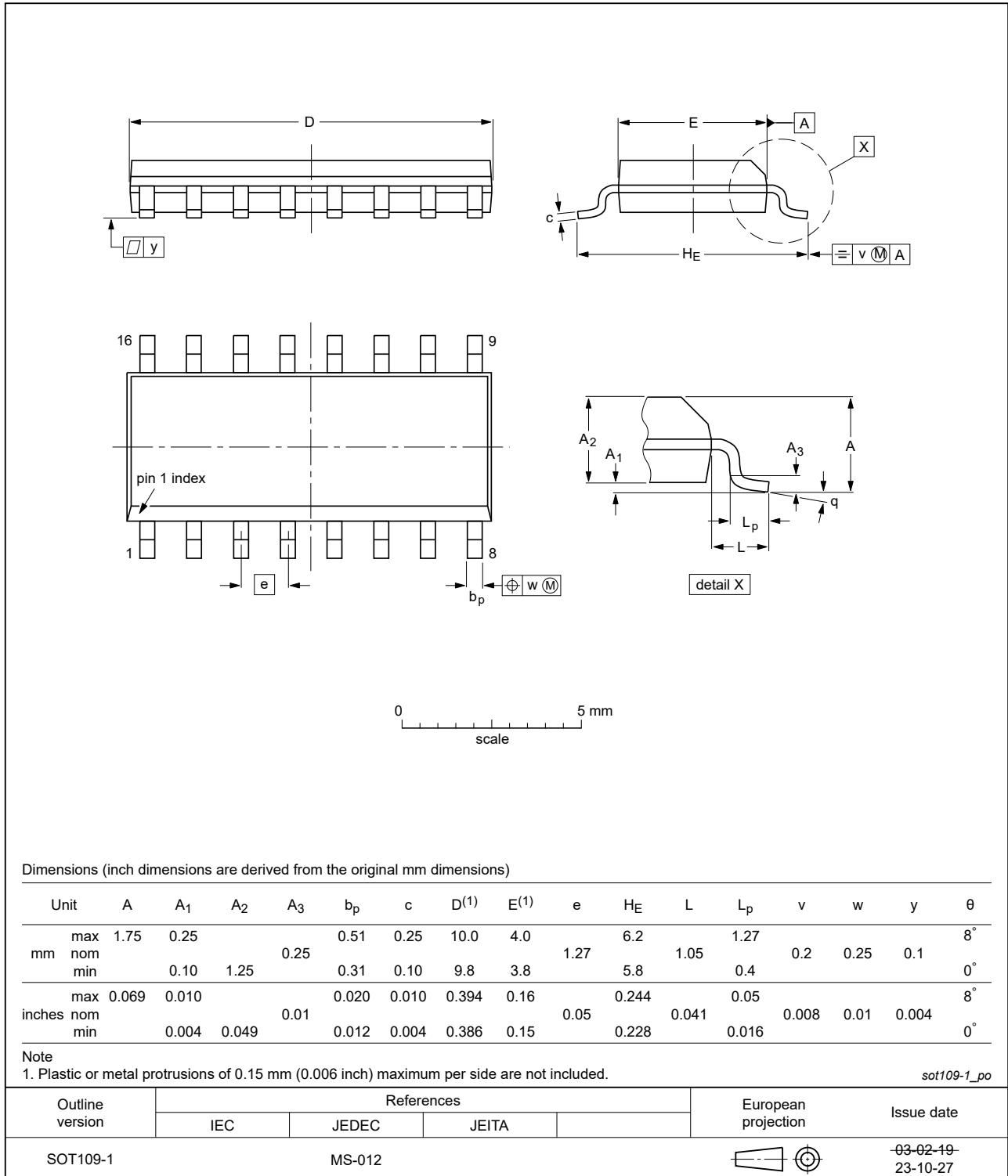


Fig. 14. Package outline SOT109-1 (SO16)

## 14. Abbreviations

Table 13. Abbreviations

Acronym	Description
ANSI	American National Standards Institute
CDM	Charged Device Model
CMOS	Complementary Metal Oxide Semiconductor
DUT	Device Under Test
ESD	ElectroStatic Discharge
ESDA	ElectroStatic Discharge Association
HBM	Human Body Model
JEDEC	Joint Electron Device Engineering Council

## 15. Revision history

Table 14. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4521B v.9	20240819	Product data sheet	-	HEF4521B v.8.1
Modifications:	<ul style="list-style-type: none"> <li>• <a href="#">Section 2</a>: ESD specification updated according to the latest JEDEC standard.</li> <li>• <a href="#">Fig. 14</a>: Aligned SO package outline drawing to JEDEC MS-012</li> </ul>			
HEF4521B v.8.1	20231019	Product data sheet	-	HEF4521B 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 2</a> updated.</li> <li>• <a href="#">Section 14</a> added.</li> </ul>			
HEF4521B v.7	20160330	Product data sheet	-	HEF4521B v.6
Modifications:	<ul style="list-style-type: none"> <li>• Type number HEF4521BP (SOT38-4) removed.</li> </ul>			
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 Table note [1] and [2]</li> <li>• <a href="#">Table 7</a>: I<sub>OH</sub> minimum values changed to maximum</li> <li>• <a href="#">Fig. 10</a>: space between "2" and "s" removed in figure notes [1] and [3]</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

### 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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