HEF4521B

24-stage frequency divider and oscillator

Rev. 7 — 30 March 2016 | 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 °C to +85 °C
- Complies with JEDEC standard JESD 13-B

3. Ordering information

Table 1. Ordering information

All types operate from –40 °C to +85 °C.

Type number	Package		
	Name	Description	Version
HEF4521BT	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

4. Functional diagram

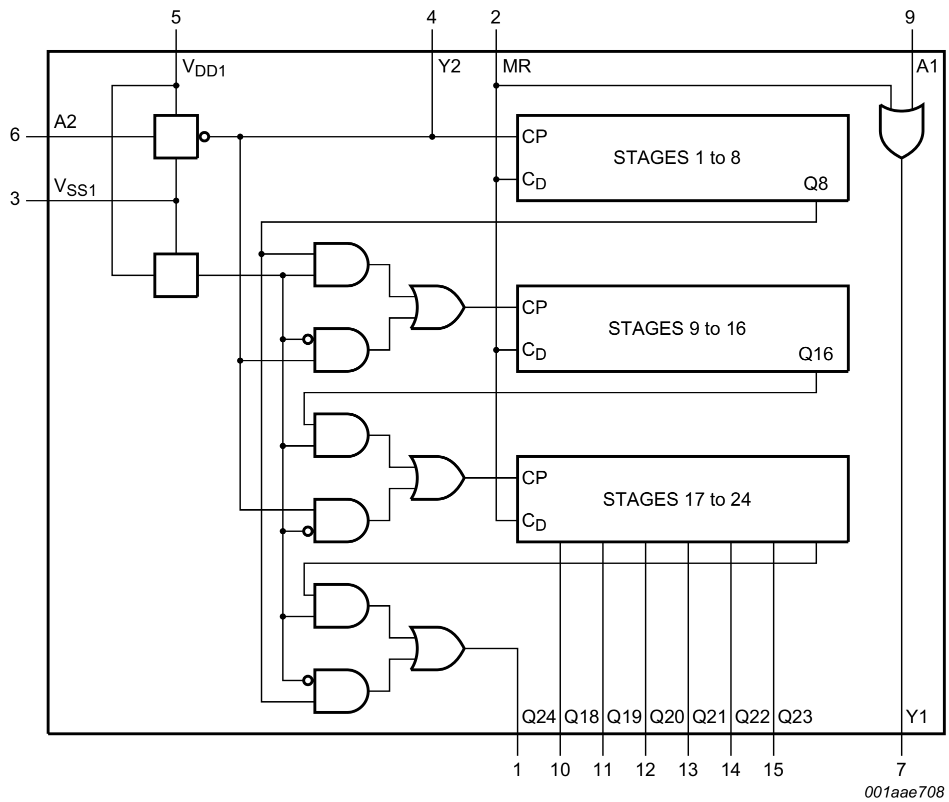


Fig 1. Functional diagram

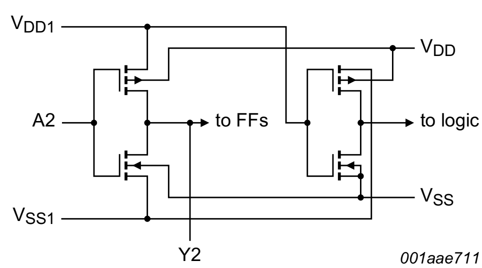


Fig 2. Schematic diagram of clock input circuitry

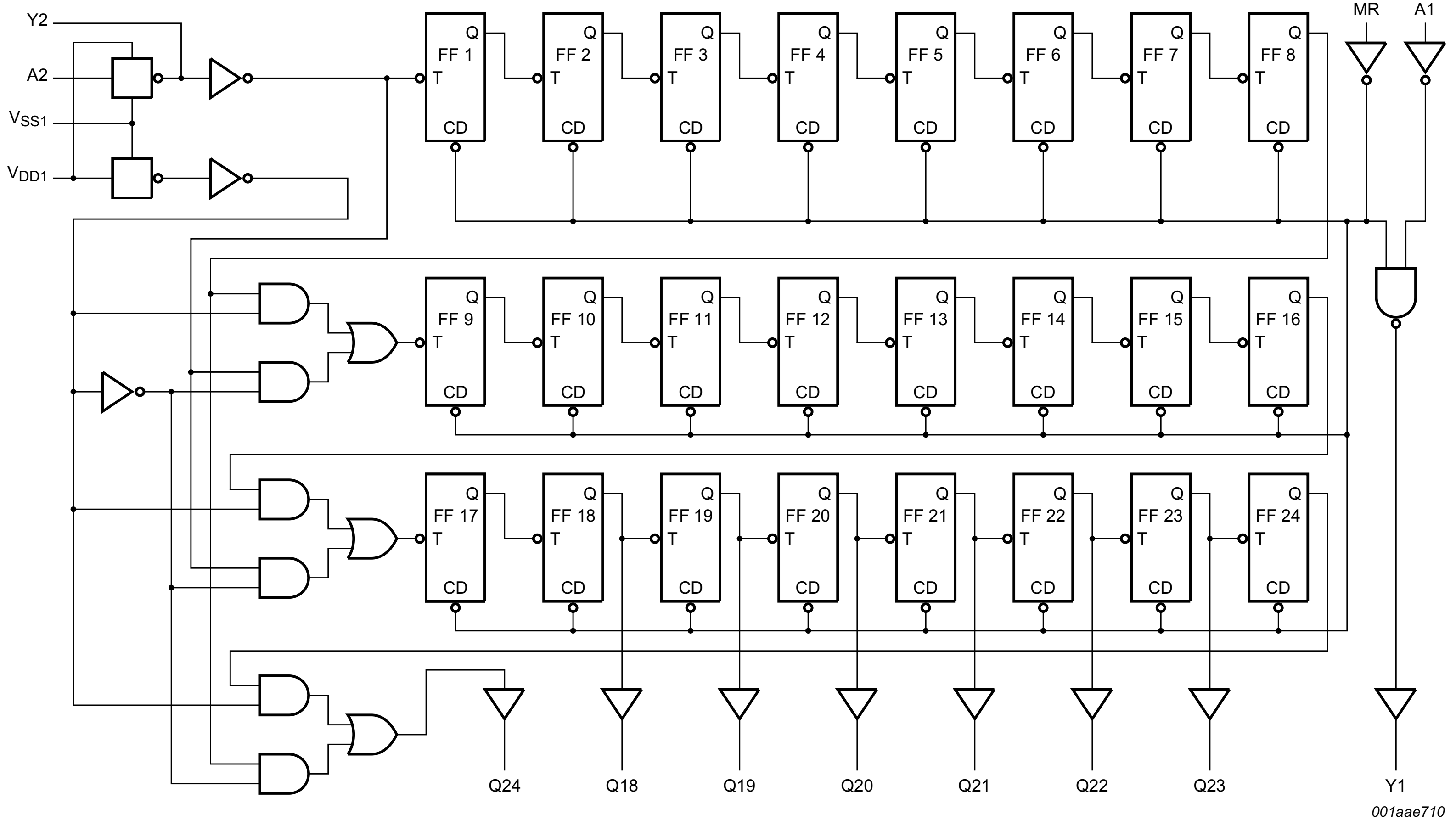


Fig 3. Logic diagram

5. Pinning information

5.1 Pinning

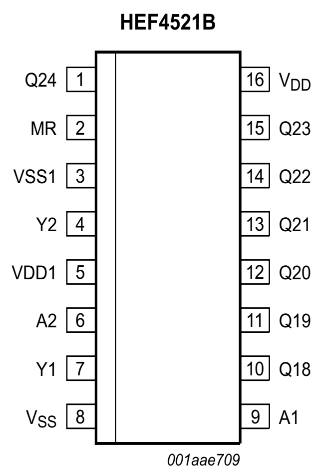


Fig 4. Pin configuration

5.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
MR	2	master reset input
V_{SS1}	3	ground supply voltage 1
V_{DD1}	5	supply voltage 1
Y1, Y2	7, 4	external oscillator connection
V_{SS}	8	ground supply voltage
A1, A2	9, 6	external oscillator connection
Q18 to Q24	10, 11, 12, 13, 14, 15, 1	output
V_{DD}	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[1]

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^{24} 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	$V_I < -0.5$ V or $V_I > V_{DD} + 0.5$ V	-	±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	-	±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	SO16 package [1]	-	500	mW
P	power dissipation	per output	-	100	mW

[1] 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 V	-	-	3.75	μs/V
		V_{DD} = 10 V	-	-	0.5	μs/V
		V_{DD} = 15 V	-	-	0.08	μs/V

10. Static characteristics

Table 7. 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	$\lvert I_O \rvert$ < 1 μA	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	$\lvert I_O \rvert$ < 1 μA	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	$\lvert I_O \rvert$ < 1 μA	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	$\lvert I_O \rvert$ < 1 μA	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 V	5 V	-	–1.7	-	–1.4	-	–1.1	mA
		V_O = 4.6 V	5 V	-	–0.52	-	–0.44	-	–0.36	mA
		V_O = 9.5 V	10 V	-	–1.3	-	–1.1	-	–0.9	mA
		V_O = 13.5 V	15 V	-	–3.6	-	–3.0	-	–2.4	mA
I_{OL}	LOW-level output current	V_O = 0.4 V	5 V	0.52	-	0.44	-	0.36	-	mA
		V_O = 0.5 V	10 V	1.3	-	1.1	-	0.9	-	mA
		V_O = 1.5 V	15 V	3.6	-	3.0	-	2.4	-	mA
I_I	input leakage current		15 V	-	±0.3	-	±0.3	-	±1.0	μA
I_{DD}	supply current	I_O = 0 A	5 V	-	20	-	20	-	150	μA
			10 V	-	40	-	40	-	300	μA
			15 V	-	80	-	80	-	600	μA
C_I	input capacitance		-	-	-	-	7.5	-	-	pF

11. Dynamic characteristics

Table 8. Dynamic characteristics

V_{SS} = 0 V; T_{amb} = 25 °C; for test circuits see Figure 6; unless otherwise specified.

Symbol	Parameter	Conditions	V_{DD}		Extrapolation formula	Min	Typ	Max	Unit
t_{PHL}	HIGH to LOW propagation delay	A2 to Q18; see Figure 5	5 V	[1]	923 ns + (0.55 ns/pF)C_L	-	950	1900	ns
			10 V		339 ns + (0.23 ns/pF)C_L	-	350	700	ns
			15 V		212 ns + (0.16 ns/pF)C_L	-	220	440	ns
		Qn to Qn + 1; see Figure 5	5 V		13 ns + (0.55 ns/pF)C_L	-	40	80	ns
			10 V		4 ns + (0.23 ns/pF)C_L	-	15	30	ns
			15 V		2 ns + (0.16 ns/pF)C_L	-	10	20	ns
		MR to Qn	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
		A1 to Y1; see Figure 5	5 V		63 ns + (0.55 ns/pF)C_L	-	90	180	ns
			10 V		24 ns + (0.23 ns/pF)C_L	-	35	70	ns
			15 V		17 ns + (0.16 ns/pF)C_L	-	25	50	ns
t_{PLH}	LOW to HIGH propagation delay	A2 to Q18; see Figure 5	5 V	[1]	923 ns + (0.55 ns/pF)C_L	-	950	1900	ns
			10 V		339 ns + (0.23 ns/pF)C_L	-	350	700	ns
			15 V		212 ns + (0.16 ns/pF)C_L	-	220	440	ns
		Qn to Qn + 1; see Figure 5	5 V		13 ns + (0.55 ns/pF)C_L	-	40	80	ns
			10 V		4 ns + (0.23 ns/pF)C_L	-	15	30	ns
			15 V		2 ns + (0.16 ns/pF)C_L	-	10	20	ns
		A1 to Y1; see Figure 5	5 V		33 ns + (0.55 ns/pF)C_L	-	60	120	ns
			10 V		19 ns + (0.23 ns/pF)C_L	-	30	60	ns
			15 V		12 ns + (0.16 ns/pF)C_L	-	20	40	ns
t_t	transition time	Qn; see Figure 5	5 V	[1]	10 ns + (1.00 ns/pF)C_L	-	60	120	ns
			10 V		9 ns + (0.42 ns/pF)C_L	-	30	60	ns
			15 V		6 ns + (0.28 ns/pF)C_L	-	20	40	ns
t_W	pulse width	A2 HIGH; minimum width; see Figure 5	5 V			80	40	-	ns
			10 V			40	20	-	ns
			15 V			30	15	-	ns
		MR HIGH; minimum width; see Figure 5	5 V			70	35	-	ns
			10 V			40	20	-	ns
			15 V			30	15	-	ns
t_{rec}	recovery time	MR; see Figure 5	5 V			+20	−10	-	ns
			10 V			+15	−5	-	ns
			15 V			15	0	-	ns
f_{max}	maximum frequency	A1; see Figure 5	5 V			6	12	-	MHz
			10 V			12	25	-	MHz
			15 V			17	35	-	MHz

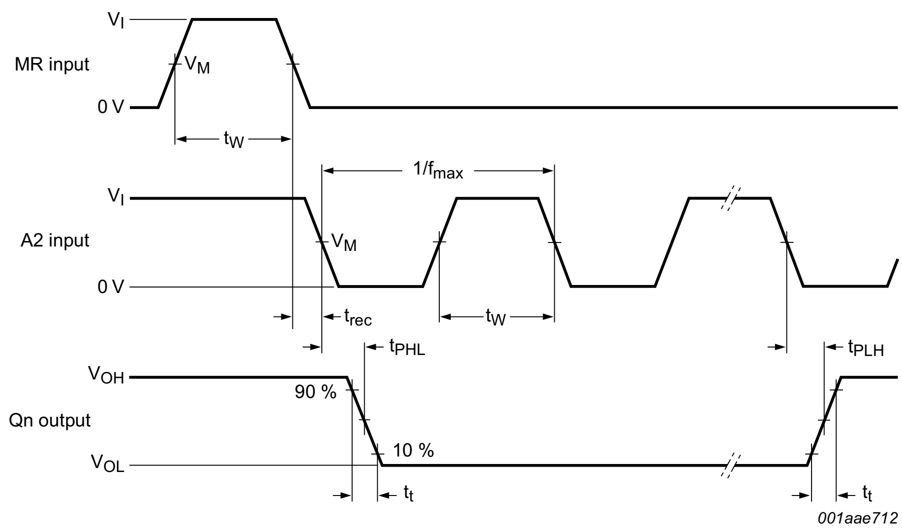
[1] The typical values of the propagation delay and transition times are calculated from the extrapolation formulas shown (C_L in pF).

Table 9. Dynamic power dissipation P_D

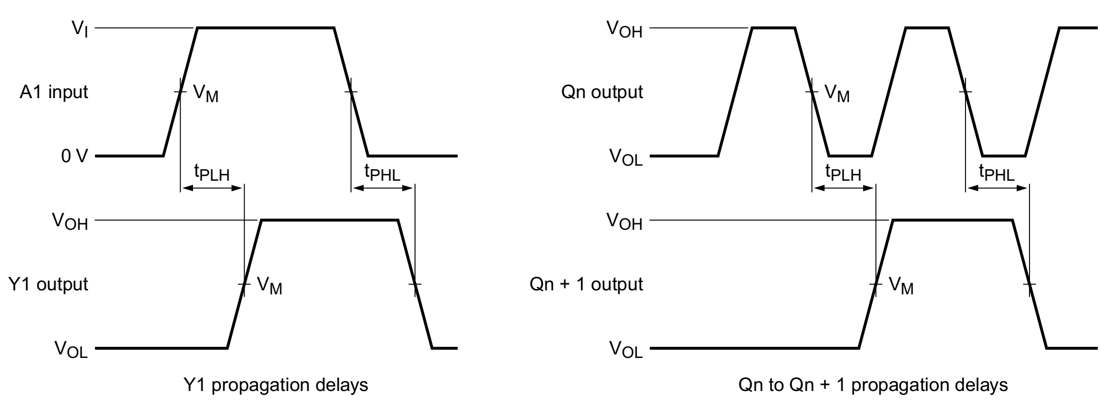
P_D can be calculated from the formulas shown. V_{SS} = 0 V; $t_r = t_f \leq 20$ ns; T_{amb} = 25 °C.

Symbol	Parameter	V_{DD}	Typical formula for P_D (μW)	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

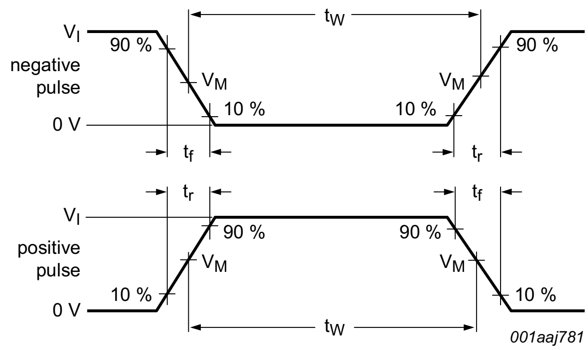


b. A1 to Y1, MR to Qn and Qn to Qn + 1 propagation delays

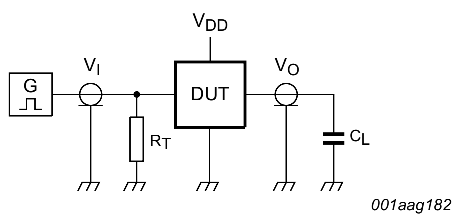
Measurement points are given in Table 10.

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;

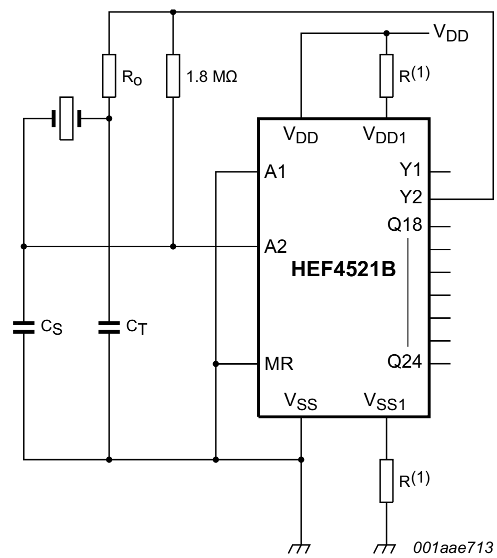
R_T = Termination resistance should be equal to output impedance Z_o of the pulse generator.

Fig 6. Test circuit for measuring switching times

Table 10. 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}	$0.5V_I$	≤ 20 ns	50 pF

13. Application information



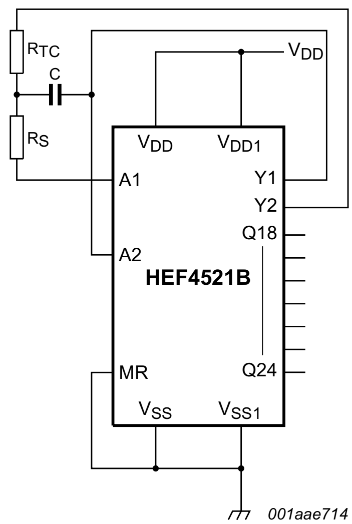
(1) Optional for low power operation.

Fig 7. Crystal oscillator circuit

Table 11. Typical characteristics for crystal oscillator

See Figure 7.

Parameter		500 kHz circuit	50 kHz circuit	Unit
Crystal characteristics				
	Resonance frequency	500	50	kHz
	Crystal cut	S	N	-
	Equivalent resistance; R_S	1	6.2	kΩ
External resistor/capacitor values				
	R_O	47	750	kΩ
	C_T	82	82	pF
	C_S	20	20	pF



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

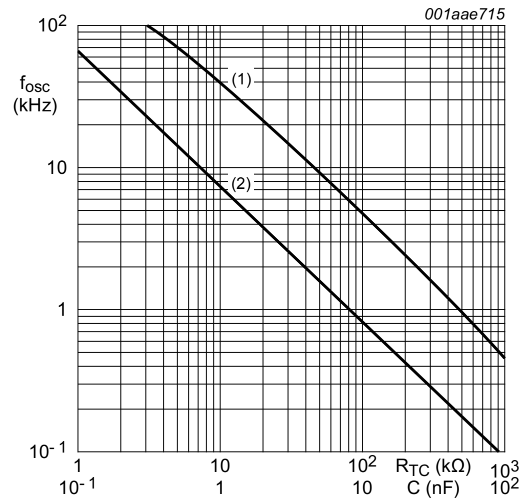
f is in Hz, R is in Ω, and C is in F.

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

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

I_I = input leakage current.

Fig 8. RC oscillator circuit

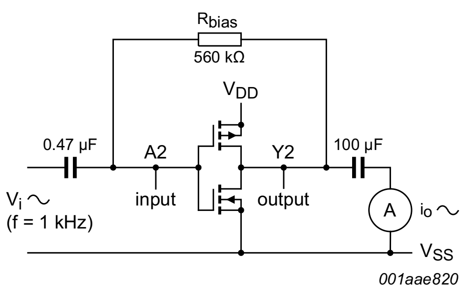


V_{DD} = 10 V; The test circuit is shown in Figure 8.

(1) R_{TC}; C = 1 nF; $R_S \approx 2\ R_{TC}$.

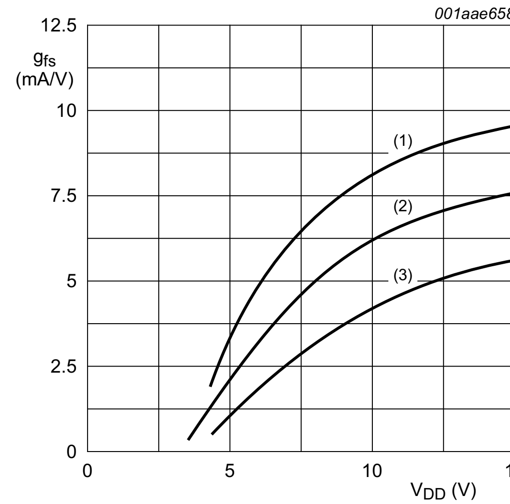
(2) C; R_{TC} = 56 kΩ; R_S = 120 kΩ.

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



$g_{fs} = d_{io}/d_{vi}$ 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 °C

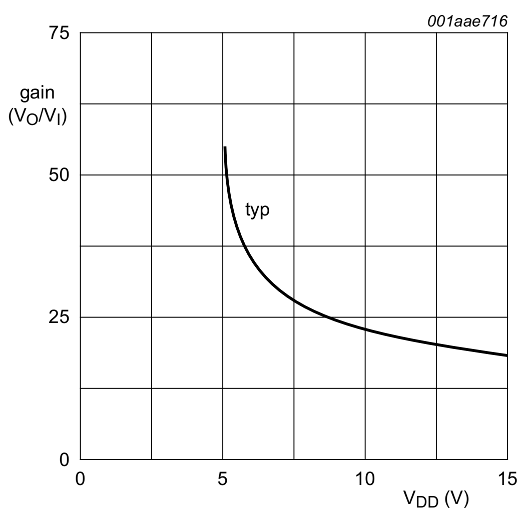


Fig 12. Voltage gain V_O/V_I as a function of supply voltage

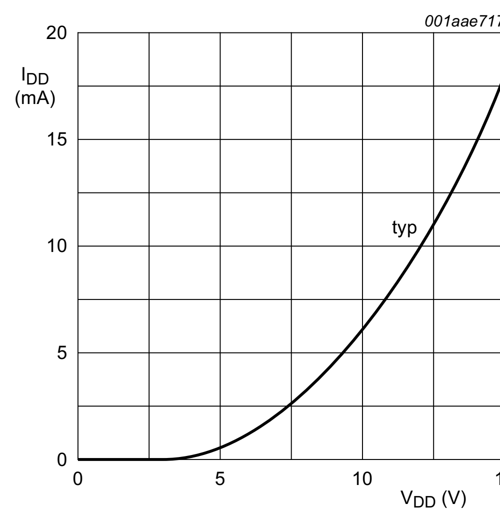


Fig 13. Supply current as a function of supply voltage

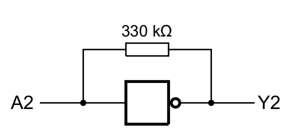
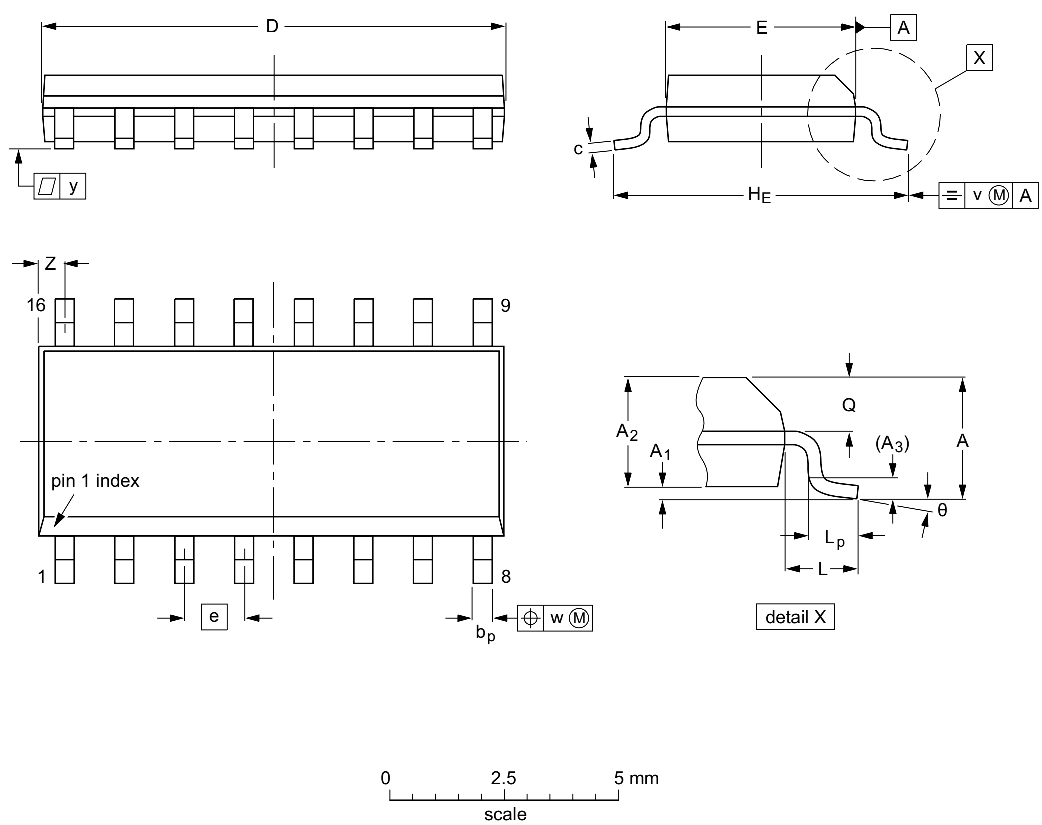


Fig 14. Test setup for measuring the Figure 12 and Figure 13 graphs

14. Package outline

SO16: plastic small outline package; 16 leads; body width 3.9 mm **SOT109-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	D(1)	E(1)	e	H_E	L	L_p	Q	v	w	y	Z(1)	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	10.0 9.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.39 0.38	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.020	0.01	0.01	0.004	0.028 0.012	

Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT109-1	076E07	MS-012				~~99-12-27~~ 03-02-19

Fig 15. Package outline SOT109-1 (SO16)

15. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4521B v.7	20160330	Product data sheet	-	HEF4521B v.6
Modifications:	• Type number HEF4521BP (SOT38-4) removed.			
HEF4521B v.6	20111121	Product data sheet	-	HEF4521B v.5
Modifications:	• Section Applications removed • Table 4: added references to Table note [1] and Table note [2] • Table 7: I_{OH} minimum values changed to maximum • Figure 11, Figure note [1] and Figure note [3]: space between ‘2’ and ‘s’ removed			
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[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 URL http://www.nexperia.com.

16.2 Definitions

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17. Contact information

For more information, please visit: **http://www.nexperia.com**

For sales office addresses, please send an email to: **salesaddresses@nexperia.com**

18. Contents

For more information, please visit: http://www.nexperia.com
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