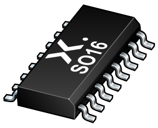

HEF4521B-Q100

24-stage frequency divider and oscillator

Rev. 1 — 19 October 2023 Product data sheet

1. General description

The HEF4521B-Q100 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-Q100 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.

This product has been qualified to the Automotive Electronics Council (AEC) standard Q100 (Grade 3) and is suitable for use in automotive applications.

2. Features and benefits

- Automotive product qualification in accordance with AEC-Q100 (Grade 3)
  - Specified from -40 °C to +85 °C
- 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 JESD22-A114F exceeds 2000 V
  - MM JESD22-A115-A exceeds 200 V

3. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
HEF4521BT-Q100	-40 °C to +85 °C	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

nexperia

4. Functional diagram

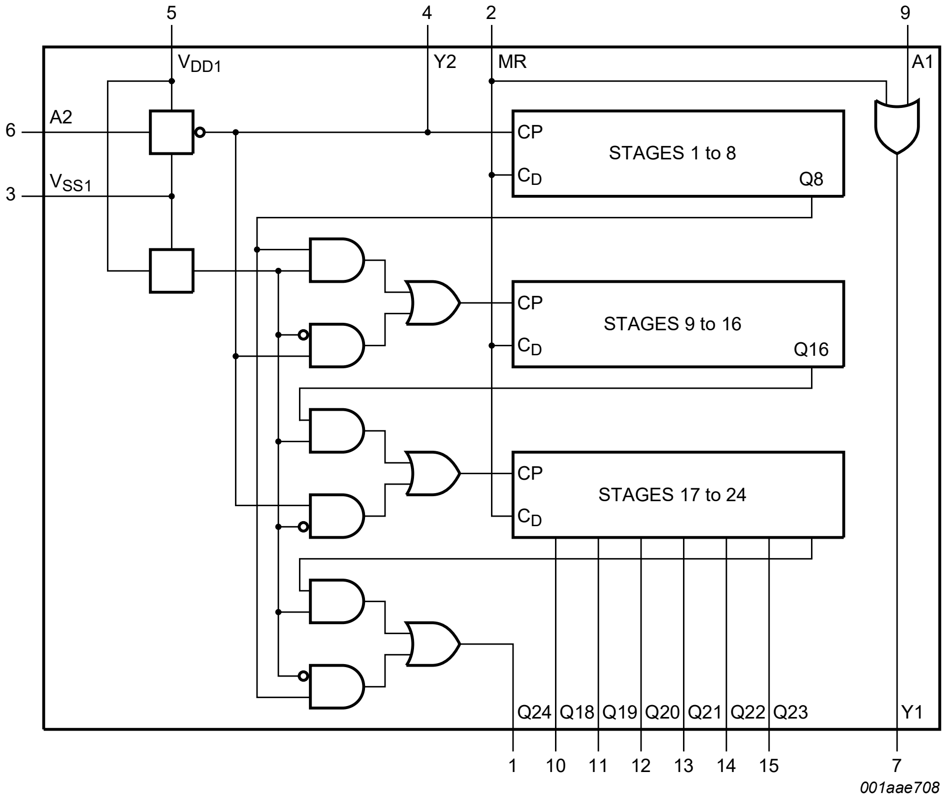

Fig. 1. Functional diagram

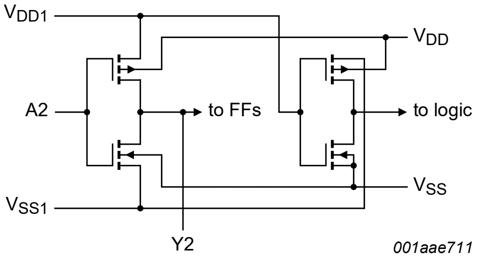

Fig. 2. Schematic diagram of clock input circuitry

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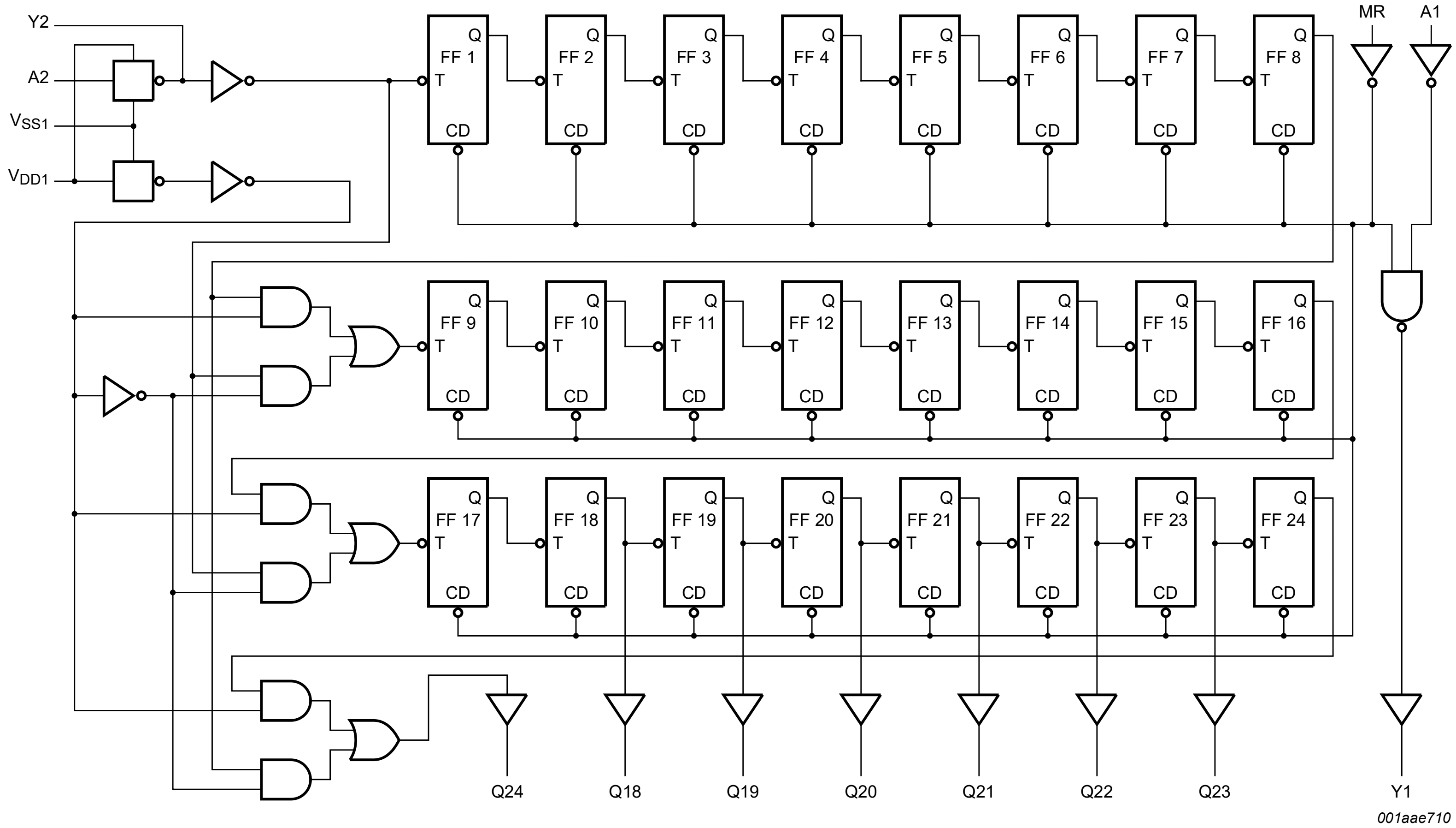

Fig. 3. Logic diagram

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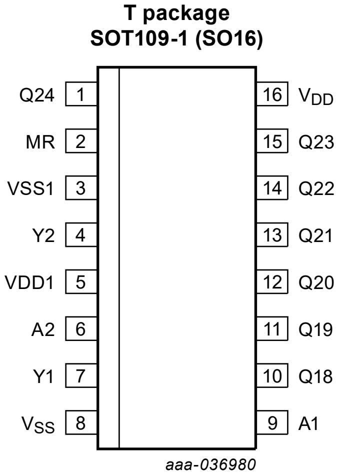
5. Pinning information

5.1. Pinning



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, Q19, Q20, Q21, Q22, Q23, 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

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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	$V_I < -0.5$ 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	T_{amb} -40 °C to +85 °C	-	500	mW
P	power dissipation	per output	-	100	mW

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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
Δt/ΔV	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	$\|I_O\|$ < 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	$\|I_O\|$ < 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	$\|I_O\|$ < 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	$\|I_O\|$ < 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

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11. Dynamic characteristics

Table 8. Dynamic characteristics

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

Symbol	Parameter	Conditions	V_{DD}	Extrapolation formula[1]	Min	Typ	Max	Unit
t_{PHL}	HIGH to LOW propagation delay	A2 to Q18; see Fig. 4	5 V	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 Fig. 4	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 Fig. 4	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 Fig. 4	5 V	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 Fig. 4	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 Fig. 4	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 Fig. 4	5 V	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 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_{rec}	recovery time	MR; see Fig. 4	5 V		+20	-10	-	ns
			10 V		+15	-5	-	ns
			15 V		15	0	-	ns
f_{max}	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_L in pF).

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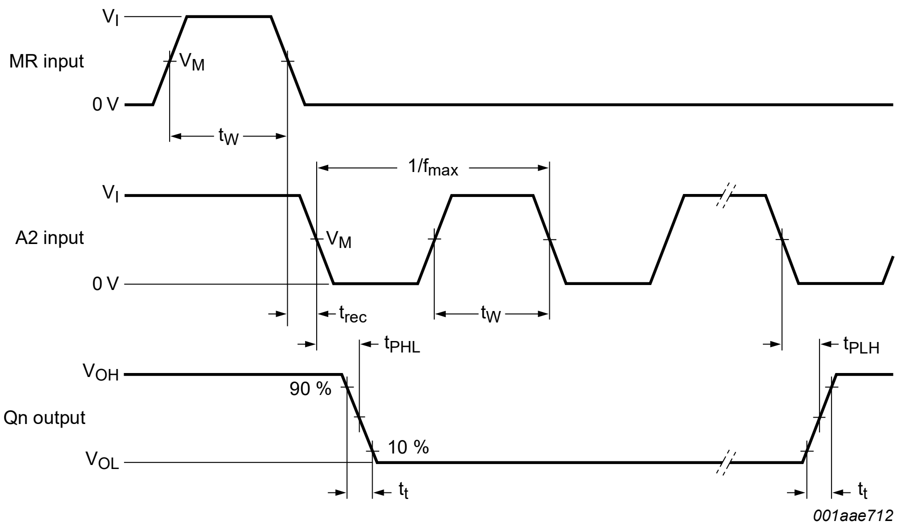
Table 9. Dynamic power dissipation P_D

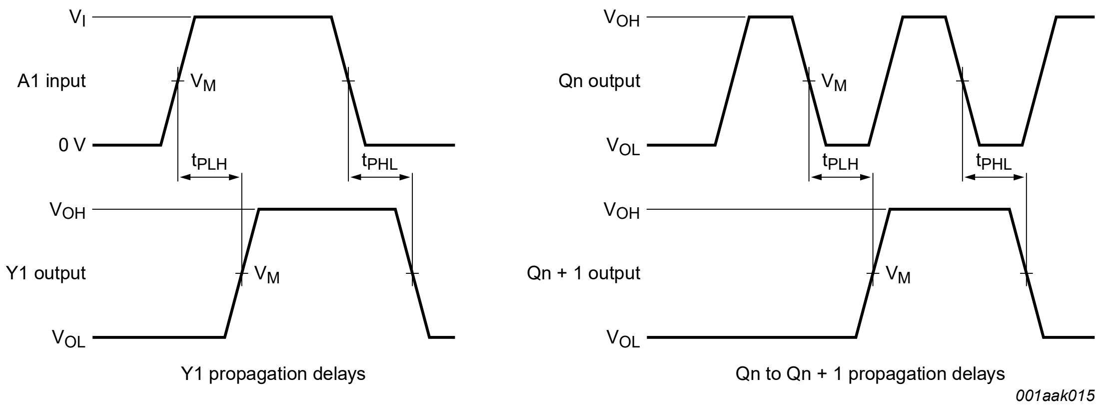
P_D can be calculated from the formulas shown. V_{SS} = 0 V; $t_r = t_f \leq$ 20 ns; T_{amb} = 25 °C.

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, 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



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. 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	$0.5V_{DD}$	$0.5V_{DD}$

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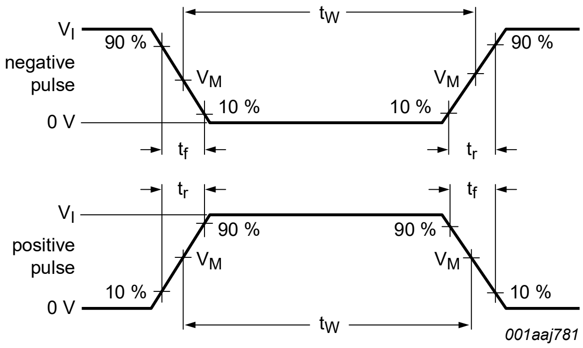
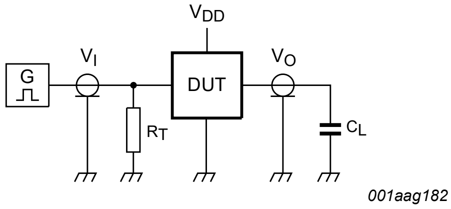


a. Input waveforms



b. Test circuit

Test data is given in Table 11.

Definitions for test circuit:

C_L = Load capacitance including jig and probe capacitance;

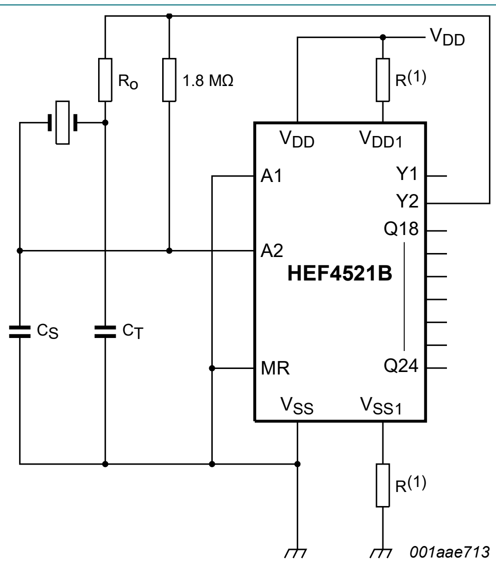
R_T = Termination resistance should be equal to output impedance Z_o of the pulse generator.

Fig. 5. Test circuit for measuring switching times

Table 11. Test data

Supply	Input		Load
V_{DD}	V_I	t_r, t_f	C_L
5 V to 15 V	V_{SS} or V_{DD}	≤ 20 ns	50 pF

12. Application information



(1) Optional for low power operation.

For typical characteristics of this crystal oscillator, see Table 12.

Fig. 6. Crystal oscillator circuit

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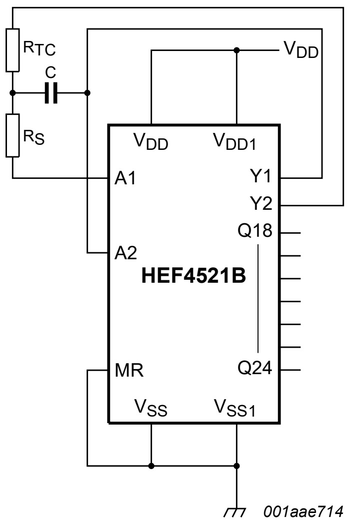
Table 12. Typical characteristics for crystal oscillator

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



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

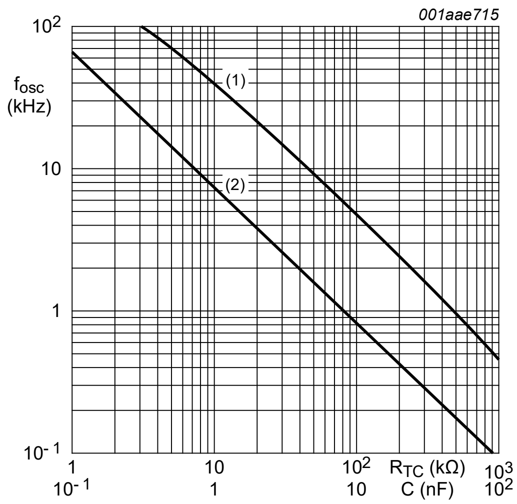
f is in Hz, R is in Ω, and C is in F.

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

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

I_I = input leakage current.

Fig. 7. RC oscillator circuit



V_{DD} = 10 V; The test circuit is shown in Fig. 7.

(1) R_{TC}; C = 1 nF; R_S » 2 R_{TC}.

(2) C; R_{TC} = 56 kΩ; R_S = 120 kΩ.

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

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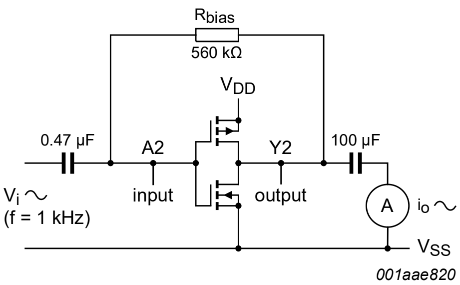
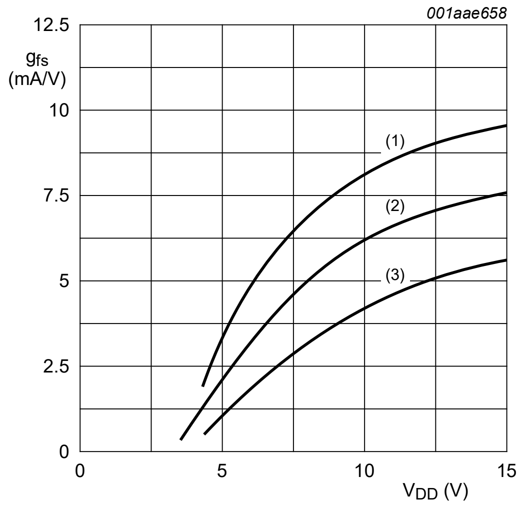


$g_{fs} = d_{io}/d_{vi}$ with v_o constant (see Fig. 10).

Fig. 9. Test setup for measuring forward transconductance



T_{amb} = 25 °C.

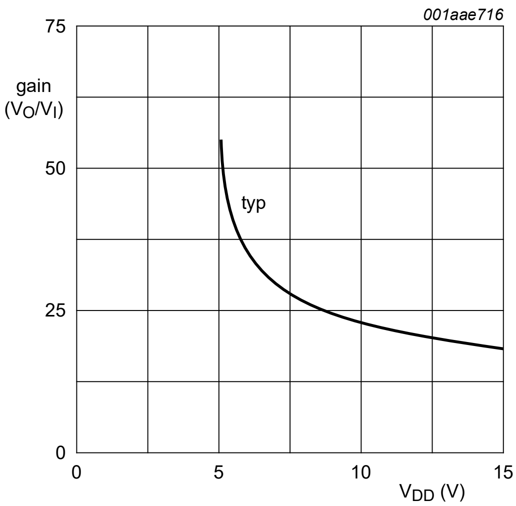
s = observed standard deviation.

(1) Average +2s

(2) Average

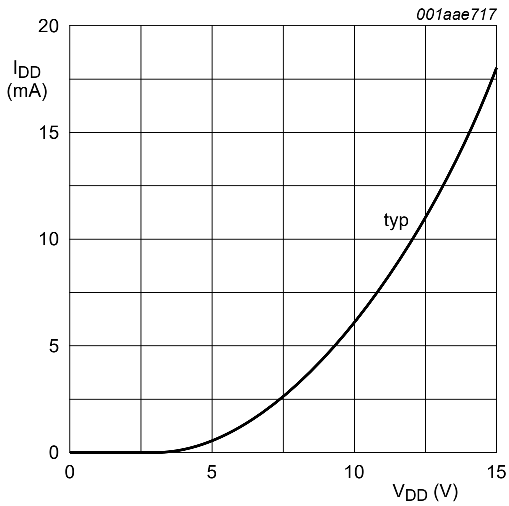
(3) Average -2s

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

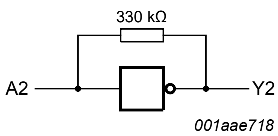


Fig. 13. Test setup for measuring the voltage gain and supply current graphs

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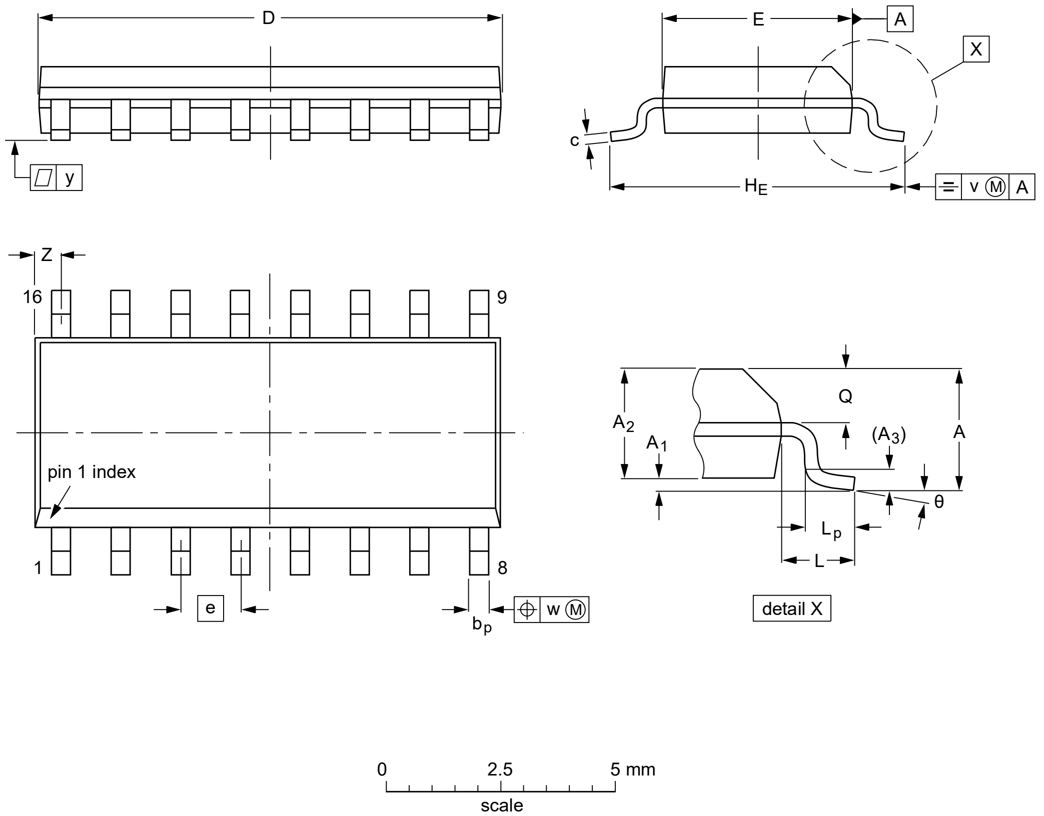
13. Package outline

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. 14. Package outline SOT109-1 (SO16)

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14. Abbreviations

Table 13. Abbreviations

Acronym	Description
CMOS	Complementary Metal Oxide Semiconductor
DUT	Device Under Test
ESD	ElectroStatic Discharge
HBM	Human Body Model
MM	Machine Model

15. Revision history

Table 14. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4521B_Q100 v.1	20231019	Product data sheet	-	-

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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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