

# HEF4541B

## Programmable timer

Rev. 6 — 25 November 2021

Product data sheet

## 1. General description

The HEF4541B is a programmable timer. It consists of a 16-stage binary counter, an integrated oscillator to be used with external timing components, an automatic power-on reset and output control logic. The external components  $R_{TC}$  and  $C_{TC}$  determines the frequency of the oscillator within the frequency range 1 Hz to 100 kHz. An external clock signal at input RS can replace the oscillator. The timer advances on the positive-going transition of RS. A LOW on the auto reset input (AR) and a LOW on the master reset input (MR) enables the internal power-on reset. A HIGH level at input MR resets the counter independent on all other inputs. Resetting, disables the oscillator to provide no active power dissipation.

A HIGH at input AR turns off the power-on reset to provide a low quiescent power dissipation of the timer. The 16-stage counter divides the oscillator frequency by  $2^8$ ,  $2^{10}$ ,  $2^{13}$  or  $2^{16}$  depending on the state of the address inputs (A0, A1). The divided oscillator frequency is available at output O. The phase input (PH) features a complementary output signal. When the mode select input (MODE) is LOW the timer is a single transition timer and when HIGH the timer is a  $2^n$  frequency divider.

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
- 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
- Specified from -40 °C to +85 °C and from -40 °C to +125 °C

## 3. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
HEF4541BT	-40 °C to +125 °C	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1

### 4. Functional diagram

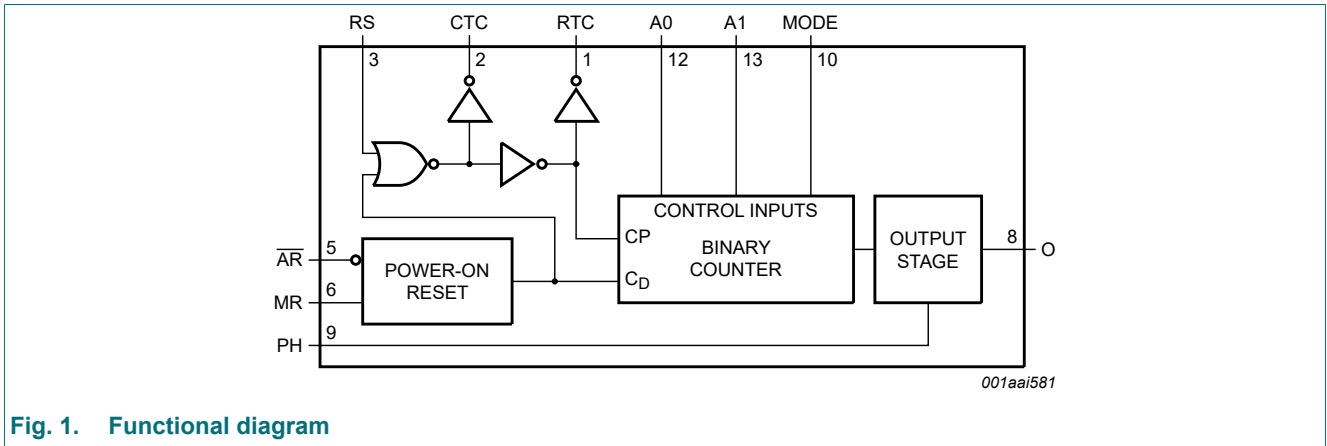


Fig. 1. Functional diagram

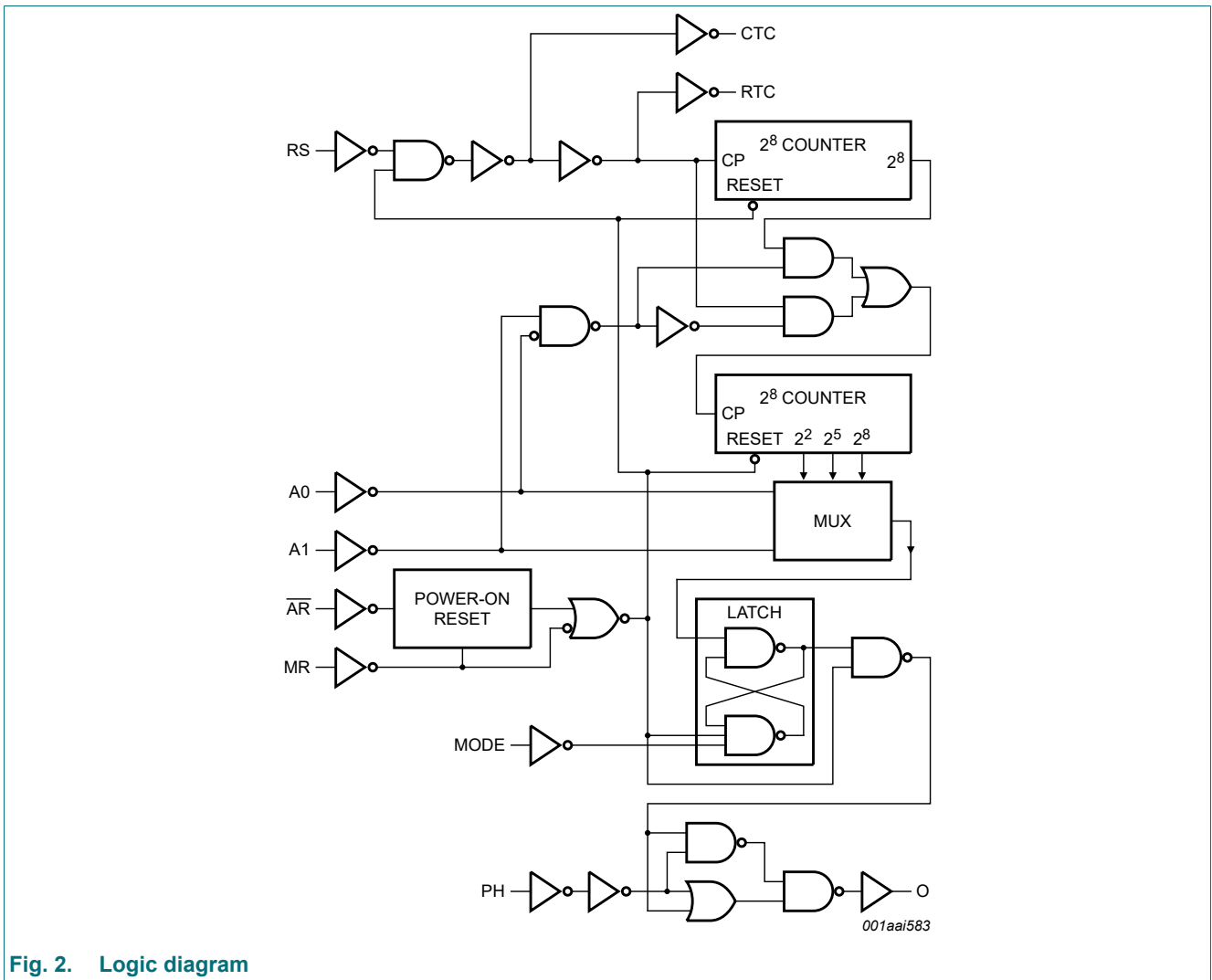
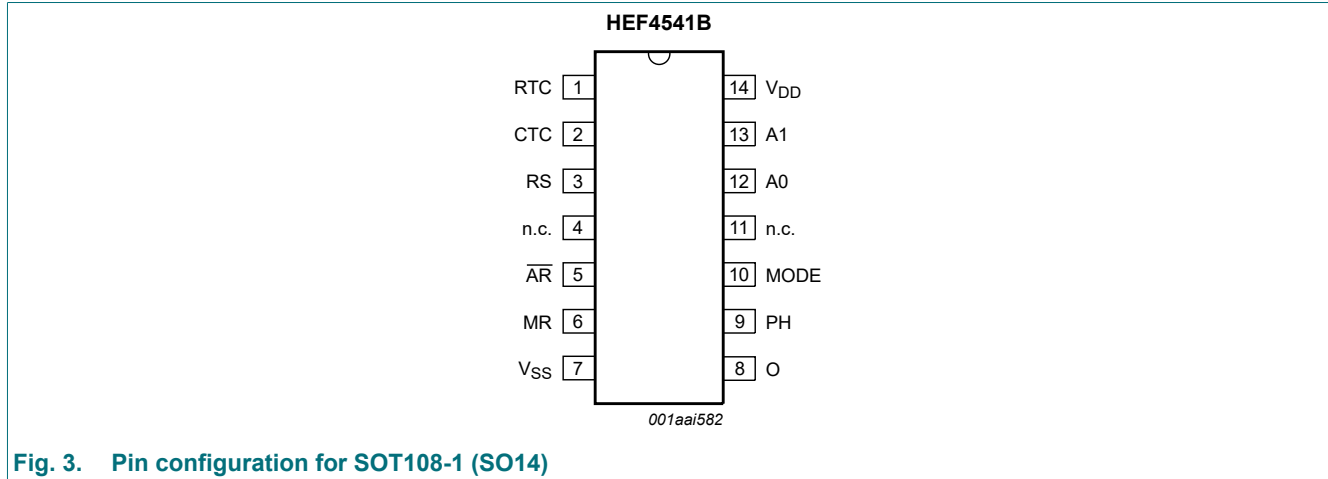


Fig. 2. Logic diagram

## 5. Pinning information

### 5.1. Pinning



### 5.2. Pin description

**Table 2. Pin description**

Symbol	Pin	Description
RTC	1	external resistor connection
CTC	2	external capacitor connection
RS	3	external resistor connection (RS) or external clock input
n.c.	4, 11	not connected
$\overline{\text{AR}}$	5	auto reset input (active low)
MR	6	master reset input
V <sub>SS</sub>	7	ground (0 V)
O	8	timer output
PH	9	phase input
MODE	10	mode select input
A0, A1	12, 13	address inputs
V <sub>DD</sub>	14	supply voltage

## 6. Functional description

**Table 3. Function table**

H = HIGH voltage level; L = LOW voltage level; X = don't care.

Input				MODE
AR	MR	PH	MODE	
H	L	X	X	auto reset disabled
L	L	X	X	auto reset enabled[1]
X	H	X	X	master reset active
X	L	X	H	normal operation selected division to output
X	L	X	L	single-cycle mode[2]
X	L	L	X	output initially LOW after reset
X	L	H	X	output initially HIGH, after reset

- [1] For correct power-on reset, the supply voltage should be above 8.5 V. For  $V_{DD} < 8.5$  V, disable the auto reset and connect  $\overline{AR}$  to  $V_{DD}$ .  
 [2] The timer is initialized on a reset pulse and the output changes state after  $2^{n-1}$  counts and remains in that state (latched). A master reset or a LOW to HIGH transition on the MODE input, resets this latch.

**Table 4. Frequency selection table**

A0	A1	Number of counter stages n	$\frac{f_{OSC}}{f_O} = 2^n$
L	L	13	8192
L	H	10	1024
H	L	8	256
H	H	16	65536

## 7. 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	-	$\pm 10$	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	-	$\pm 10$	mA
$I_{I/O}$	input/output current	O output	-	$\pm 10$	mA
$T_{stg}$	storage temperature		-65	+150	°C
$T_{amb}$	ambient temperature		-40	+125	°C
$P_{tot}$	total power dissipation	$T_{amb} = -40$ °C to +125 °C [1]	-	500	mW
P	power dissipation		-	100	mW

- [1] For SOT108-1 (SO14) package:  $P_{tot}$  derates linearly with 10.1 mW/K above 100 °C.

## 8. Recommended operating conditions

Table 6. Recommended operating conditions

Symbol	Parameter	Conditions	Min	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	+125	°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	$\mu\text{s/V}$

## 9. Static characteristics

Table 7. Static characteristics

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

Symbol	Parameter	Conditions	$V_{DD}$	$T_{amb} = -40\text{ °C}$		$T_{amb} = 25\text{ °C}$		$T_{amb} = 85\text{ °C}$		$T_{amb} = 125\text{ °C}$		Unit	
				Min	Max	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	-	3.5	-	V	
			10 V	7.0	-	7.0	-	7.0	-	7.0	-	V	
			15 V	11.0	-	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	-	1.5	V	
			10 V	-	3.0	-	3.0	-	3.0	-	3.0	V	
			15 V	-	4.0	-	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	-	4.95	-	V	
			10 V	9.95	-	9.95	-	9.95	-	9.95	-	V	
			15 V	14.95	-	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	-	0.05	V	
			10 V	-	0.05	-	0.05	-	0.05	-	0.05	V	
			15 V	-	0.05	-	0.05	-	0.05	-	0.05	V	
$I_{OH}$	HIGH-level output current	CTC, RTC;	$V_O = 2.5\text{ V}$	5 V	-	-1.4	-	-1.2	-	-0.95	-	-0.95	mA
			$V_O = 4.6\text{ V}$	5 V	-	-0.5	-	-0.4	-	-0.3	-	-0.3	mA
			$V_O = 9.5\text{ V}$	10 V	-	-1.4	-	-1.2	-	-0.95	-	-0.95	mA
			$V_O = 13.5\text{ V}$	15 V	-	-4.8	-	-4.0	-	-3.2	-	-3.2	mA
		O;	$V_O = 2.5\text{ V}$	5 V	-	-1.7	-	-1.4	-	-1.1	-	-1.1	mA
			$V_O = 4.6\text{ V}$	5 V	-	-0.64	-	-0.5	-	-0.36	-	-0.36	mA
			$V_O = 9.5\text{ V}$	10 V	-	-1.6	-	-1.3	-	-0.9	-	-0.9	mA
			$V_O = 13.5\text{ V}$	15 V	-	-4.2	-	-3.4	-	-2.4	-	-2.4	mA

Symbol	Parameter	Conditions	V <sub>DD</sub>	T <sub>amb</sub> = -40 °C		T <sub>amb</sub> = 25 °C		T <sub>amb</sub> = 85 °C		T <sub>amb</sub> = 125 °C		Unit
				Min	Max	Min	Max	Min	Max	Min	Max	
I <sub>OL</sub>	LOW-level output current	CTC, RTC;										
		V <sub>O</sub> = 0.4 V	5 V	0.33	-	0.27	-	0.20	-	0.20	-	mA
		V <sub>O</sub> = 0.5 V	10 V	1.0	-	0.85	-	0.68	-	0.68	-	mA
		V <sub>O</sub> = 1.5 V	15 V	3.2	-	2.7	-	2.3	-	2.3	-	mA
		O;										
		V <sub>O</sub> = 0.4 V	5 V	0.64	-	0.5	-	0.36	-	0.36	-	mA
		V <sub>O</sub> = 0.5 V	10 V	1.6	-	1.3	-	0.9	-	0.9	-	mA
	V <sub>O</sub> = 1.5 V	15 V	4.2	-	3.2	-	2.4	-	2.4	-	mA	
I <sub>I</sub>	input leakage current		15 V	-	±0.1	-	±0.1	-	±1.0	-	±1.0	µA
I <sub>DD</sub>	supply current	I <sub>O</sub> = 0 A	5 V	-	5	-	5	-	150	-	150	µA
			10 V	-	10	-	10	-	300	-	300	µA
			15 V	-	20	-	20	-	600	-	600	µA
C <sub>I</sub>	input capacitance		-	-	-	7.5	-	-	-	-	pF	

Table 8. Reset characteristics

V<sub>SS</sub> = 0 V; V<sub>I</sub> = V<sub>SS</sub> or V<sub>DD</sub>; see Table 12 for test conditions; unless otherwise specified.

Symbol	Parameter	Conditions	V <sub>DD</sub>	T <sub>amb</sub> = -40 °C		T <sub>amb</sub> = +25 °C			T <sub>amb</sub> = +85 °C		T <sub>amb</sub> = +125 °C		Unit
				Min	Max	Min	Typ	Max	Min	Max	Min	Max	
I <sub>DD</sub>	supply current	supply current for power-on reset enable; AR = MR = 0 V; other inputs at 0 V or V <sub>DD</sub>	5 V	-	80	-	20	80	-	230	-	230	µA
			10 V	-	750	-	250	600	-	700	-	700	µA
			15 V	-	1.6	-	0.5	1.3	-	1.5	-	1.5	mA
V <sub>DD</sub>	supply voltage	supply voltage for automatic reset initialization; AR = MR = 0 V; other inputs at 0 V or V <sub>DD</sub>	-	-	-	8.5	5	-	-	-	-	-	V

## 10. Dynamic characteristics

**Table 9. 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	Min	Typ[1]	Max	Unit
t <sub>pd</sub>	propagation delay	RS to O; 2 <sup>8</sup> selected; see Fig. 4	5 V [2]	348 ns + (0.55 ns/pF)C <sub>L</sub>	-	375	750	ns
			10 V	139 ns + (0.23 ns/pF)C <sub>L</sub>	-	150	300	ns
			15 V	102 ns + (0.16 ns/pF)C <sub>L</sub>	-	110	220	ns
		RS to O; 2 <sup>10</sup> selected; see Fig. 4	5 V	398 ns + (0.55 ns/pF)C <sub>L</sub>	-	425	850	ns
			10 V	154 ns + (0.23 ns/pF)C <sub>L</sub>	-	165	330	ns
			15 V	112 ns + (0.16 ns/pF)C <sub>L</sub>	-	120	240	ns
		RS to O; 2 <sup>13</sup> selected; see Fig. 4	5 V	483 ns + (0.55 ns/pF)C <sub>L</sub>	-	510	1020	ns
			10 V	179 ns + (0.23 ns/pF)C <sub>L</sub>	-	190	380	ns
			15 V	127 ns + (0.16 ns/pF)C <sub>L</sub>	-	135	270	ns
		RS to O; 2 <sup>16</sup> selected; see Fig. 4	5 V	548 ns + (0.55 ns/pF)C <sub>L</sub>	-	575	1150	ns
			10 V	199 ns + (0.23 ns/pF)C <sub>L</sub>	-	210	420	ns
			15 V	142 ns + (0.16 ns/pF)C <sub>L</sub>	-	150	300	ns
t <sub>w</sub>	pulse width	RS LOW; MR HIGH; see Fig. 4	5 V [3]		60	30	-	ns
			10 V		30	15	-	ns
			15 V		24	12	-	ns
f <sub>clk(max)</sub>	maximum clock frequency	RS; see Fig. 4	5 V		8	16	-	MHz
			10 V		15	30	-	MHz
			15 V		18	36	-	MHz
f <sub>osc</sub>	oscillator frequency	R <sub>t</sub> = 5 kΩ; C <sub>t</sub> = 1 nF; R <sub>s</sub> = 10 kΩ; see Fig. 6	5 V		-	90	-	kHz
			10 V		-	90	-	kHz
			15 V		-	90	-	kHz
		R <sub>t</sub> = 56 kΩ; C <sub>t</sub> = 1 nF; R <sub>s</sub> = 120 kΩ; see Fig. 6	5 V		-	8	-	kHz
			10 V		-	8	-	kHz
			15 V		-	8	-	kHz

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

[2] t<sub>pd</sub> is the same as t<sub>PHL</sub> and t<sub>PLH</sub>.

[3] t<sub>w</sub> is the same as t<sub>VL(min)</sub> and t<sub>WH(min)</sub>.

**Table 10. Dynamic power dissipation**

P<sub>D</sub> can be calculated from the formulas shown.  $V_{SS} = 0\text{ V}$ ;  $t_r = t_f \leq 20\text{ ns}$ ;  $T_{amb} = 25\text{ °C}$ .

Symbol	Parameter	V <sub>DD</sub>	Typical formula[1]
P <sub>D</sub>	dynamic power dissipation	<b>Per package</b>	
		5 V	$P_D = 1300 \times f_i + (f_o \times C_L \times V_{DD}^2) \mu\text{W}$
		10 V	$P_D = 5300 \times f_i + (f_o \times C_L \times V_{DD}^2) \mu\text{W}$
		15 V	$P_D = 12000 \times f_i + (f_o \times C_L \times V_{DD}^2) \mu\text{W}$
		<b>Total, using the on-chip oscillator</b>	
		5 V	$P_D = 1300 \times f_{osc} + f_o C_L V_{DD}^2 + 2C_{TC} V_{DD}^2 f_{osc} + 10V_{DD} \mu\text{W}$
		10 V	$P_D = 5300 \times f_{osc} + f_o C_L V_{DD}^2 + 2C_{TC} V_{DD}^2 f_{osc} + 100V_{DD} \mu\text{W}$
		15 V	$P_D = 12000 \times f_{osc} + f_o C_L V_{DD}^2 + 2C_{TC} V_{DD}^2 f_{osc} + 400V_{DD} \mu\text{W}$

[1] f<sub>i</sub> = input frequency in MHz; f<sub>o</sub> = output frequency in MHz; C<sub>L</sub> = output load capacitance in pF; V<sub>DD</sub> = supply voltage in V; f<sub>osc</sub> = oscillator frequency in MHz; C<sub>TC</sub> = timing capacitance in pF.

10.1. Waveforms and test circuit

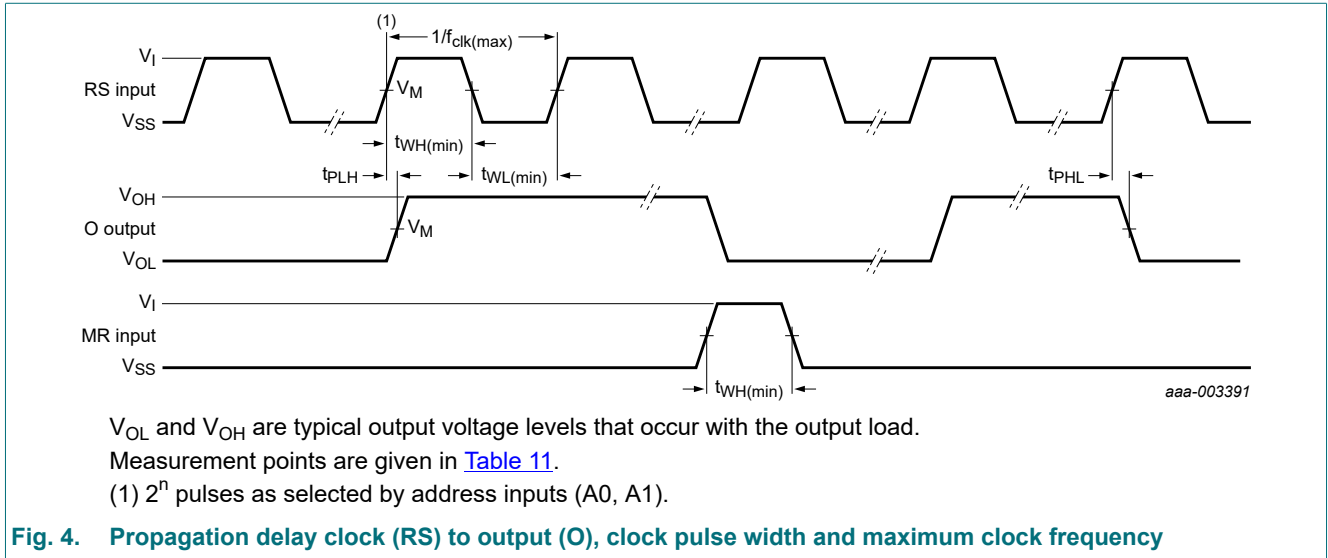


Table 11. Measurement points

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

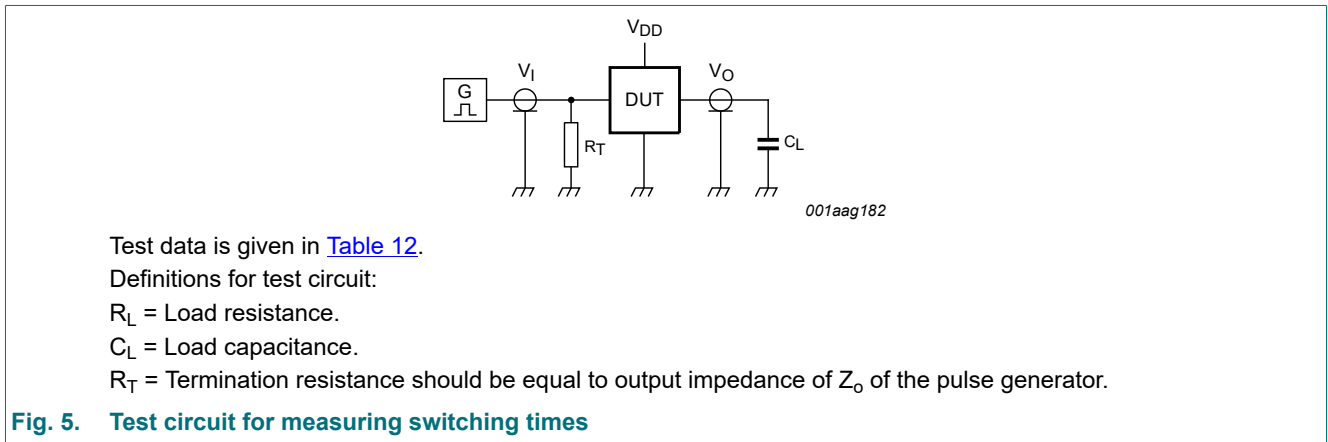


Table 12. Test data

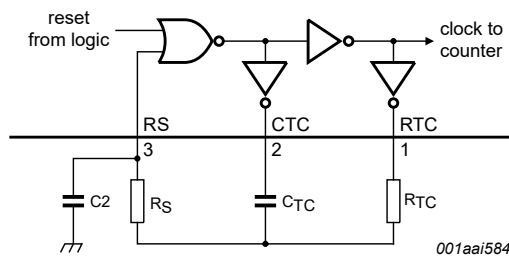
Supply	Input	Load
$V_{DD}$	$V_I$	$C_L$
5 V to 15 V	$V_{SS}$ or $V_{DD}$	$\leq 20$ ns



## 11. Application information

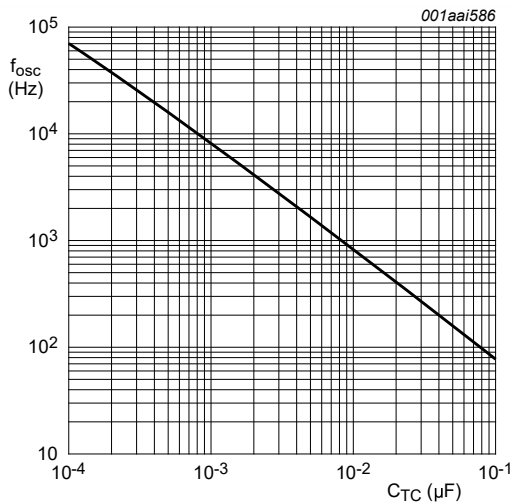
### RC oscillator timing component limitations

$R_{TC}C_{TC}$  determines the oscillator frequency, provided  $R_{TC} \ll R_S$  and  $R_S C_2 \ll R_{TC}C_{TC}$ . The function of  $R_S$  is to minimize the influence of the forward voltage across the input protection diodes on the frequency. The stray capacitance  $C_2$  should be kept as small as possible. In consideration of accuracy,  $C_{TC}$  must be larger than the inherent stray capacitance.  $R_{TC}$  must be larger than the LOCMOS 'ON' resistance in series with it, which typically is 500  $\Omega$  at  $V_{DD} = 5$  V, 300  $\Omega$  at  $V_{DD} = 10$  V and 200  $\Omega$  at  $V_{DD} = 15$  V. The recommended values for these components to maintain agreement with the typical oscillation formula are:  $C_{TC} \geq 100$  pF, up to any typical value,  $10$  k $\Omega \leq R_{TC} \leq 1$  M $\Omega$ .

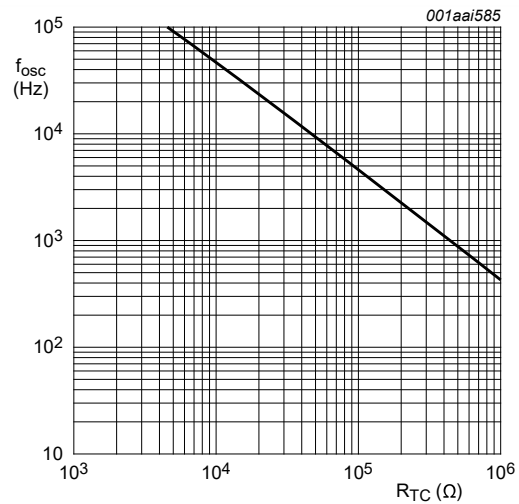


Typical formula for oscillator frequency:  $f_{osc} = \frac{1}{2.3 \times R_{TC} \times C_{TC}}$

Fig. 6. External component connection for RC oscillator;  $R_S \approx R_{TC}$

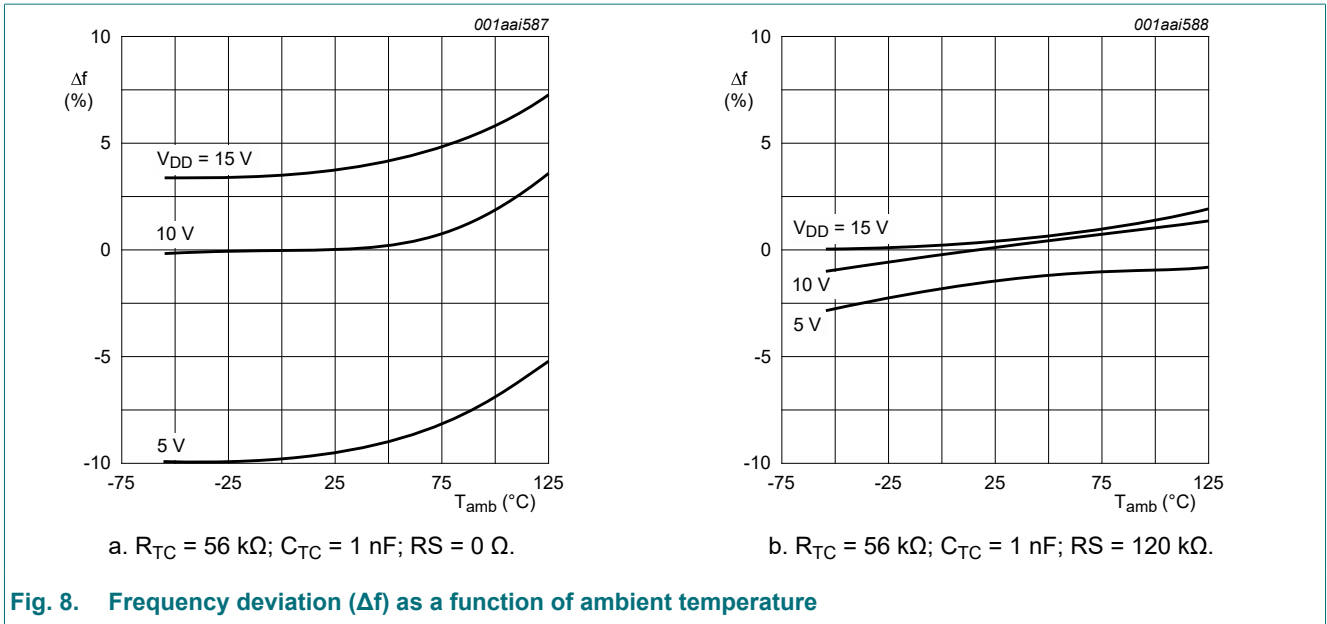


a.  $C_{TC}$  curve at  $R_{TC} = 56$  k $\Omega$ ;  $R_S = 120$  k $\Omega$ .



b.  $R_{TC}$  curve at  $C_{TC} = 1$  nF;  $R_S = 2 R_{TC}$ .

Fig. 7. RC oscillator frequency as a function of  $R_{TC}$  and  $C_{TC}$  at  $V_{DD} = 5$  V to 15 V;  $T_{amb} = 25$  °C



## 12. Package outline

SO14: plastic small outline package; 14 leads; body width 3.9 mm

SOT108-1



Fig. 9. Package outline SOT108-1 (SO14)

## 13. 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

## 14. Revision history

Table 14. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4541B v.6	20211125	Product data sheet	-	HEF4541B v.5
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>Maximum temperature changed to 125 °C throughout the data sheet.</li> <li><a href="#">Section 2</a> updated.</li> <li><a href="#">Section 7</a>: Derating values for <math>P_{tot}</math> total power dissipation have been updated.</li> </ul>			
HEF4541B v.5	20151215	Product data sheet	-	HEF4541B v.4
Modifications:	<ul style="list-style-type: none"> <li>Type number HEF4541BP (SOT27-1) removed.</li> </ul>			
HEF4541B v.4	20120625	Product data sheet	-	HEF4541B_CNV v.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><a href="#">Section 2</a> added.</li> </ul>			
HEF4541B_CNV v.3	19950101	Product specification	-	HEF4541B_CNV v.2
HEF4541B_CNV v.2	19950101	Product specification	-	-

## 15. 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".
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