HEF4060B-Q100

14-stage ripple-carry binary counter/divider and oscillator

Rev. 3 — 8 November 2021 | Product data sheet

1. General description

The HEF4060B-Q100 is a 14-stage ripple-carry counter/divider and oscillator with three oscillator terminals (RS, REXT and CEXT), ten buffered parallel outputs (Q3 to Q9 and Q11 to Q13) and an overriding asynchronous master reset (MR). The oscillator configuration allows design of either RC or crystal oscillator circuits. The oscillator may be replaced by an external clock signal at input RS. In this case, keep the oscillator pins (REXT and CEXT) floating. The counter advances on the HIGH-to-LOW transition of RS. A HIGH level on MR clears all counter stages and forces all outputs LOW, independent of the other input conditions. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of V_{DD}.

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
- Complies with JEDEC standard JESD 13-B
- Tolerant of slow clock rise and fall times
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- ESD protection:
  - MIL-STD-883, method 3015 exceeds 2000 V
  - HBM JESD22-A114F exceeds 2000 V
  - MM JESD22-A115-A exceeds 200 V (C = 200 pF, R = 0 Ω)

3. Ordering information

Table 1. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
HEF4060BT-Q100	-40 °C to +85 °C	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

nexperia

4. Functional diagram

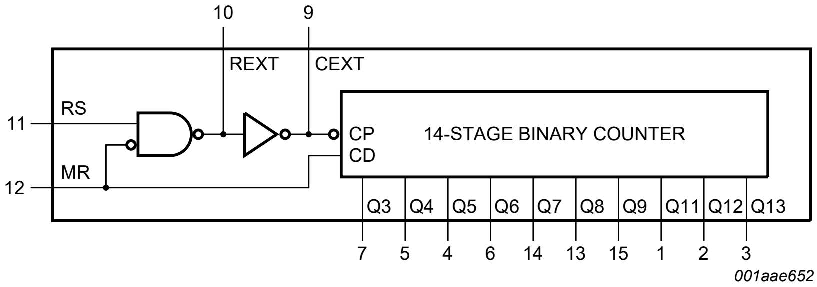


Fig. 1. Functional diagram

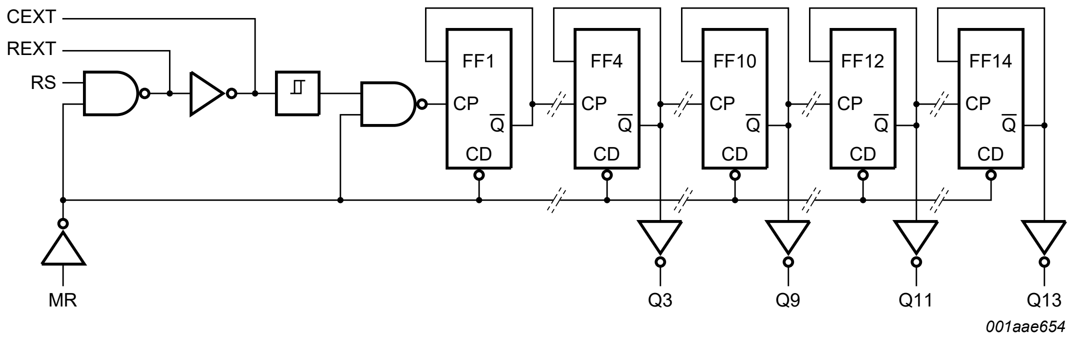


Fig. 2. Logic diagram

5. Pinning information

5.1. Pinning

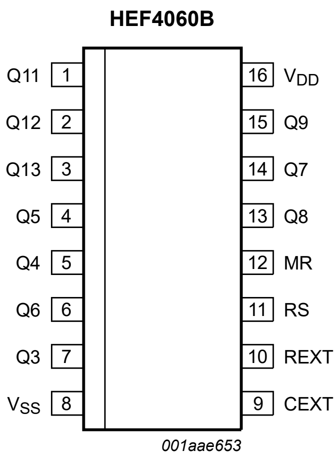


Fig. 3. Pin configuration SOT109-1 (SO16)

5.2. Pin description

Table 2. Pin description

Symbol	Pin	Description
Q11 to Q13	1, 2, 3	counter output
Q3 to Q9	7, 5, 4, 6, 14, 13, 15	counter output
V_{SS}	8	ground supply voltage
CEXT	9	external capacitor connection
REXT	10	oscillator pin
RS	11	clock input/oscillator pin
MR	12	master reset
V_{DD}	16	supply voltage

6. Functional description

Table 3. Function table

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

Input		Output
RS	**MR**	**Q3 to Q9 and Q11 to Q13**
↑	L	no change
↓	L	count
X	H	L

7. Limiting values

Table 4. 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		-	50	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

8. Recommended operating conditions

Table 5. 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	input MR				
		V_{DD} = 5 V	-	-	3.75	µs/V
		V_{DD} = 10 V	-	-	0.5	µs/V
		V_{DD} = 15 V	-	-	0.08	µs/V

9. Static characteristics

Table 6. 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

10. Dynamic characteristics

Table 7. Dynamic characteristics

T_{amb} = 25 °C; V_{SS} = 0 V; C_L = 50 pF; t_r = t_f ≤ 20 ns; unless otherwise specified.

Symbol	Parameter	Conditions	V_{DD}	Extrapolation formula[1]	Min	Typ	Max	Unit
t_{pd}	propagation delay	RS → Q3; see Fig. 4	5 V [2]	183 ns + (0.55 ns/pF) C_L	-	210	420	ns
			10 V	69 ns + (0.23 ns/pF) C_L	-	80	160	ns
			15 V	42 ns + (0.16 ns/pF) C_L	-	50	100	ns
		Qn → Qn + 1; see Fig. 4	5 V	-	-	25	50	ns
			10 V	-	-	10	20	ns
			15 V	-	-	6	12	ns
		MR → Qn; HIGH to LOW see Fig. 4	5 V	73 ns + (0.55 ns/pF) C_L	-	100	200	ns
			10 V	29 ns + (0.23 ns/pF) C_L	-	40	80	ns
			15 V	22 ns + (0.16 ns/pF) C_L	-	30	60	ns
t_t	transition time	see Fig. 4	5 V [3]	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	minimum width; RS HIGH; see Fig. 4	5 V		120	60	-	ns
			10 V		50	25	-	ns
			15 V		30	15	-	ns
		minimum width; MR HIGH; see Fig. 4	5 V		50	25	-	ns
			10 V		30	15	-	ns
			15 V		20	10	-	ns
t_{rec}	recovery time	input MR; see Fig. 4	5 V		160	80	-	ns
			10 V		80	40	-	ns
			15 V		60	30	-	ns
f_{max}	maximum frequency	input RS; see Fig. 4	5 V		4	8	-	MHz
			10 V		10	20	-	MHz
			15 V		15	30	-	MHz

[1] The typical values of the propagation delay and transition times are calculated from the extrapolation formulas shown (C_L in pF).
[2] t_{pd} is the same as t_{PHL} and t_{PLH}.
[3] t_t is the same as t_{THL} and t_{TLH}.

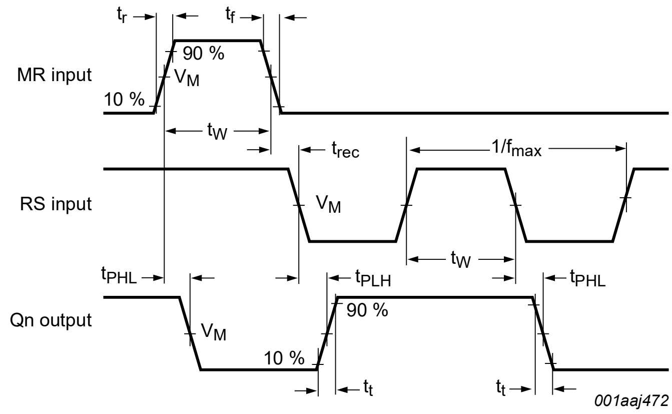
Table 8. Power dissipation

Dynamic power dissipation P_D and total power dissipation P_{tot} can be calculated from the formulas shown. T_{amb} = 25 °C.

Symbol	Parameter	Conditions	V_{DD}	Typical formula for P_D and P_{tot} (μW)[1]
P_D	dynamic power dissipation	per device	5 V	$P_D = 700 \times f_i + \sum(f_o \times C_L) \times V_{DD}^2$
			10 V	$P_D = 3300 \times f_i + \sum(f_o \times C_L) \times V_{DD}^2$
			15 V	$P_D = 8900 \times f_i + \sum(f_o \times C_L) \times V_{DD}^2$
P_{tot}	total power dissipation	when using the on-chip oscillator	5 V	$P_{tot} = 700 \times f_{osc} + \sum(f_o \times C_L) \times V_{DD}^2 + 2 \times C_t \times V_{DD}^2 \times f_{osc} + 690 \times V_{DD}$
			10 V	$P_{tot} = 3300 \times f_{osc} + \sum(f_o \times C_L) \times V_{DD}^2 + 2 \times C_t \times V_{DD}^2 \times f_{osc} + 6900 \times V_{DD}$
			15 V	$P_{tot} = 8900 \times f_{osc} + \sum(f_o \times C_L) \times V_{DD}^2 + 2 \times C_t \times V_{DD}^2 \times f_{osc} + 22000 \times V_{DD}$

[1] Where:
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;
$\sum(f_o \times C_L)$ = sum of the outputs;
C_t = timing capacitance (pF);
f_{osc} = oscillator frequency (MHz).

10.1. Waveforms and test circuit

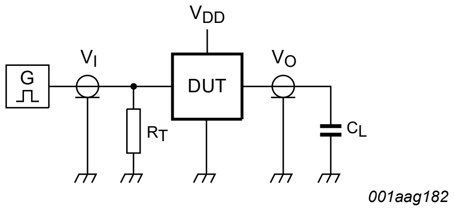


Measurement points are given in Table 9.

Fig. 4. Waveforms showing propagation delays for MR to Qn and $\overline{CP}$ to Q0, minimum MR, and $\overline{CP}$ pulse widths

Table 9. Measurement points

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



Test data is given in Table 10.

Definitions for test circuit:

DUT = Device Under Test;

C_L = load capacitance including jig and probe capacitance;

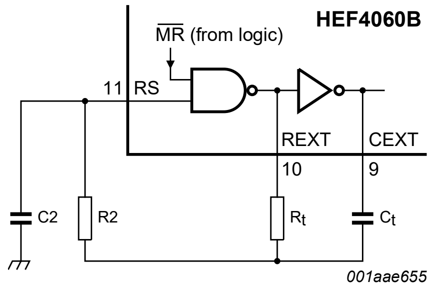
R_T = termination resistance should be equal to the output impedance Z_o of the pulse generator.

Fig. 5. Test circuit for measuring switching times

Table 10. Measurement point and test data

Supply voltage	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

11. RC oscillator



Typical formula for oscillator frequency: $f_{osc} = \frac{1}{2.3 \times R_t \times C_t}$

Fig. 6. External component connection for RC oscillator

11.1. Timing component limitations

The oscillator frequency is mainly determined by R_t x C_t, provided R_t << R2 and R2 x C2 << R_t x C_t. The influence of the forward voltage across the input protection diodes on the frequency is minimized by R2. The stray capacitance C2 should be kept as small as possible. In consideration of accuracy, C_t must be larger than the inherent stray capacitance. R_t must be larger than the LOCMOS (Local Oxidation Complementary Metal-Oxide Semiconductor) 'ON' resistance in series with it, which typically is 500 Ω at V_{DD} = 5 V, 300 Ω at V_{DD} = 10 V and 200 Ω at V_{DD} = 15 V.

The recommended values for these components to maintain agreement with the typical oscillation formula are:

- C_t ≥ 100 pF, up to any practical value,
- 10 kΩ ≤ R_t ≤ 1 MΩ.

11.2. Typical crystal oscillator circuit

In Fig. 7, R2 is the power limiting resistor. For starting and maintaining oscillation a minimum transconductance is necessary.

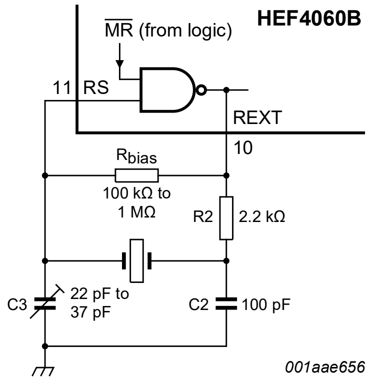
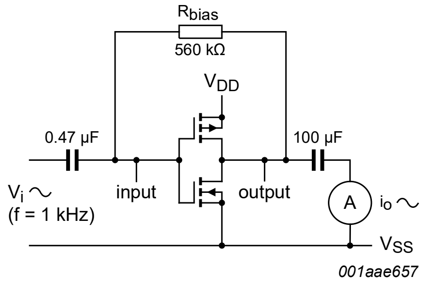
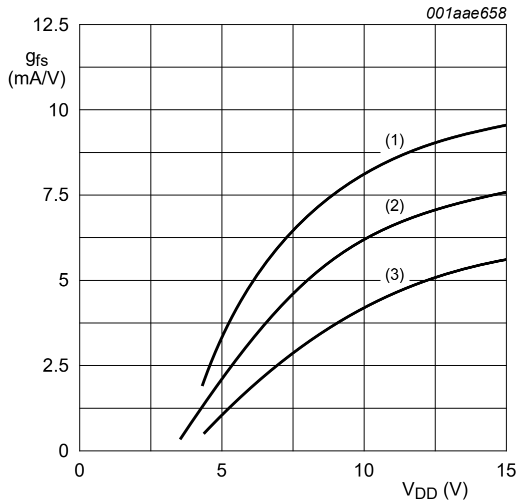


Fig. 7. External component connection for crystal oscillator



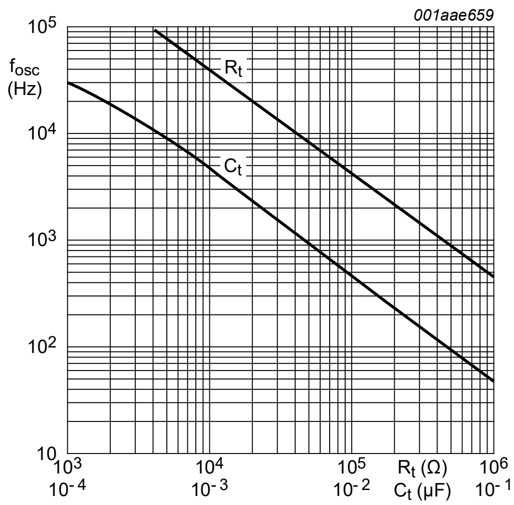
$g_{fs} = di_o/dv_i$ at v_o is constant (see also Fig. 9);
MR = LOW.

Fig. 8. Test setup for measuring forward transconductance (g_{fs})



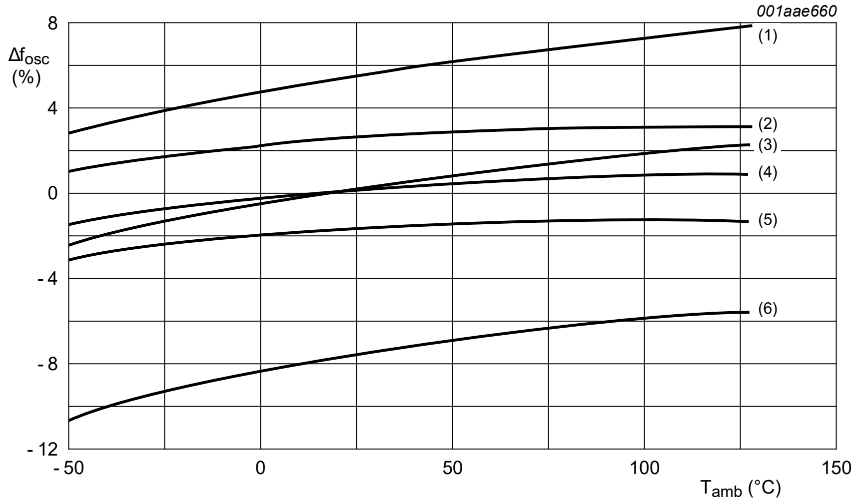
T_{amb} = 25 °C.
(1) Average +2 σ.
(2) Average.
(3) Average -2 σ.
Where ‘σ’ is the observed standard deviation.

Fig. 9. Typical forward transconductance g_{fs} as a function of the supply voltage



C_t curve at R_t = 100 kΩ; R2 = 470 kΩ.
R_t curve at C_t = 1 nF; R2 = 5 R_t.
V_{DD} = 5 V to 15 V; T_{amb} = 25 °C.

Fig. 10. RC oscillator frequency as a function of R_t and C_t

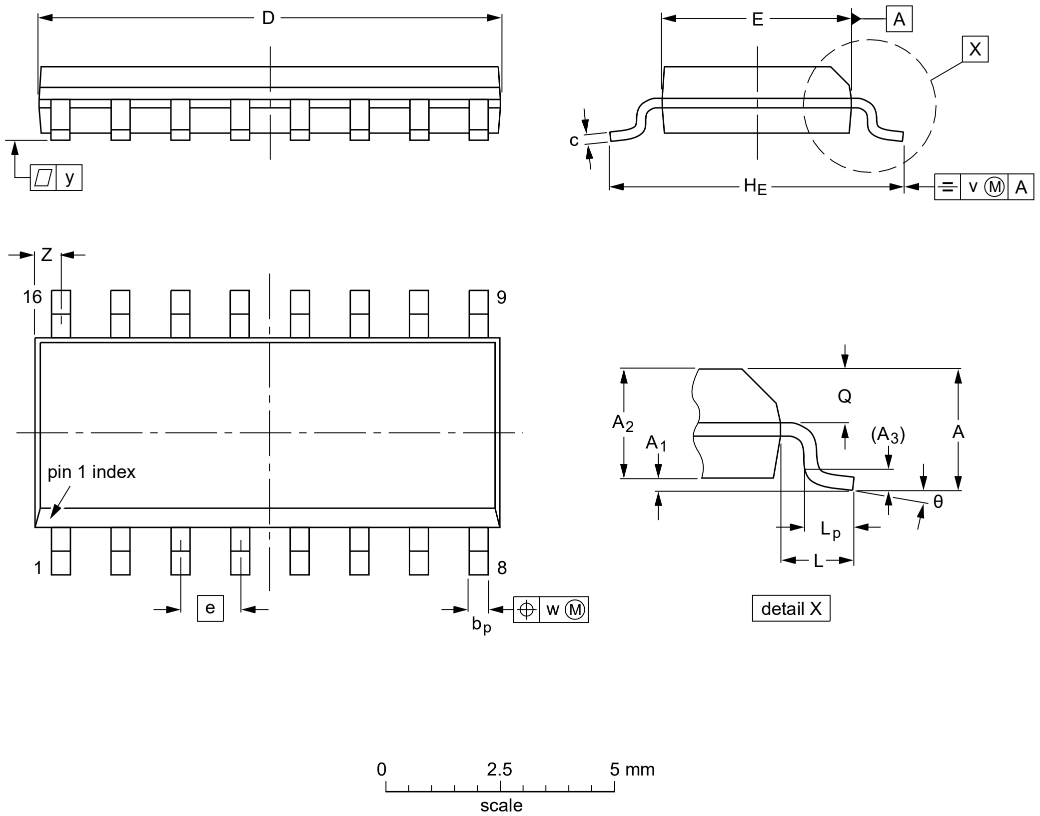


Lines (1) and (2): V_{DD} = 15 V.
Lines (3) and (4): V_{DD} = 10 V.
Lines (5) and (6): V_{DD} = 5 V.
Lines (1), (3), (6): R_t = 100 kΩ; C_t = 1 nF; R2 = 0 Ω.
Lines (2), (4), (5): R_t = 100 kΩ; C_t = 1 nF; R2 = 300 kΩ.
Referenced at: f_{osc} at T_{amb} = 25 °C and V_{DD} = 10 V.

Fig. 11. Oscillator frequency deviation (Δf_{osc}) as a function of ambient temperature

12. 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. 12. Package outline SOT109-1 (SO16)

13. Abbreviations

Table 11. Abbreviations

Acronym	Description
DUT	Device Under Test
ESD	ElectroStatic Discharge
HBM	Human Body Model
MIL	Military
MM	Machine Model

14. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4060B_Q100 v.3	20211108	Product data sheet	-	HEF4060B_Q100 v.2
Modifications:	• The format of this data sheet has been redesigned to comply with the identity guidelines of Nexperia. • Legal texts have been adapted to the new company name where appropriate. • Section 1 and Section 2 updated.			
HEF4060B_Q100 v.2	20140909	Product data sheet	-	HEF4060B_Q100 v.1
Modifications:	• Section 2: ESD protection: MIL-STD-833 changed to MIL-STD883.			
HEF4060B_Q100 v.1	20130228	Product data sheet	-	-

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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Date of release: 8 November 2021