HEF4060B-Q100

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

Rev. 1 — 28 February 2013 Product data sheet

1. General description

The HEF4060B-Q100 is a 14-stage ripple-carry binary counter/divider and oscillator. It has three oscillator terminals (RS, REXT and CEXT) and ten buffered outputs (Q3 to Q9 and Q11 to Q13). It also has an overriding asynchronous master reset input (MR).

The oscillator configuration allows the design of either RC or crystal oscillator circuits. An external clock signal at input RS can replace the oscillator. The Schmitt trigger action of the clock makes it highly tolerant to slower clock rise and fall times. The counter advances on the negative-going transition of RS. A HIGH level on MR resets the counter (Q3 to Q9 and Q11 to Q13 = LOW), independent of other input conditions.

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
- Tolerant of slow clock rise and fall times
- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Inputs and outputs are protected against electrostatic effects
- ESD protection:
  - MIL-STD-833, method 3015 exceeds 2000 V
  - HBM JESD22-A114F exceeds 2000 V
  - MM JESD22-A115-A exceeds 200 V (C = 200 pF, R = 0 Ω)
- 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
HEF4060BT-Q100	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

4. Functional diagram

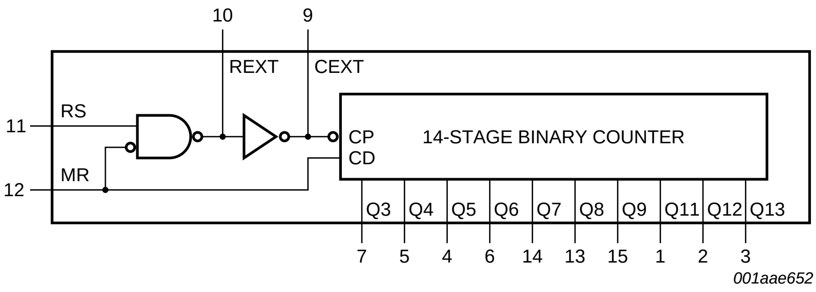


Fig 1. Functional diagram

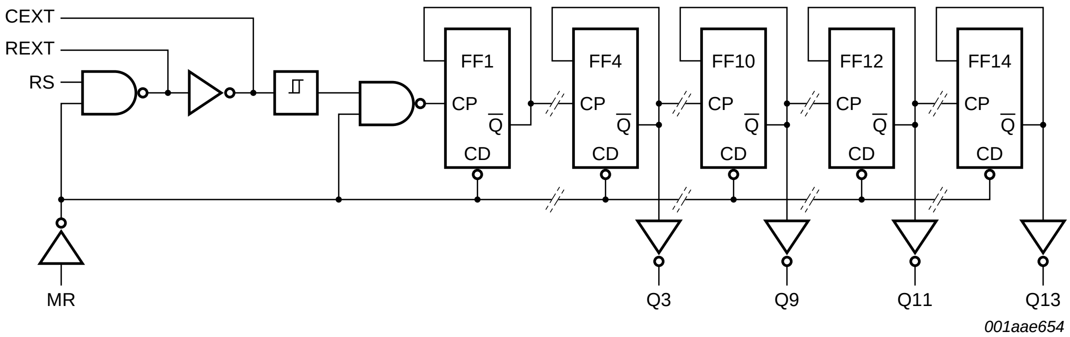


Fig 2. Logic diagram

5. Pinning information

5.1 Pinning

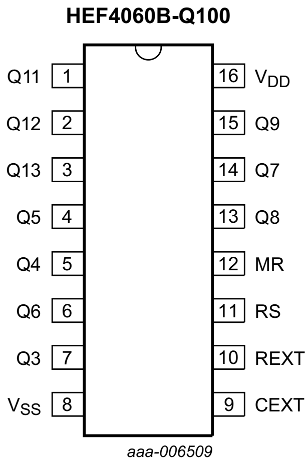


Fig 3. Pin configuration

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[1]

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

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

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 [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.

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 Figure 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 Figure 4	5 V		-	-	25	50	ns
			10 V		-	-	10	20	ns
			15 V		-	-	6	12	ns
		MR → Qn; HIGH to LOW see Figure 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 Figure 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 Figure 4	5 V			120	60	-	ns
			10 V			50	25	-	ns
			15 V			30	15	-	ns
		minimum width; MR HIGH; see Figure 4	5 V			50	25	-	ns
			10 V			30	15	-	ns
			15 V			20	10	-	ns
t_{rec}	recovery time	input MR; see Figure 4	5 V			160	80	-	ns
			10 V			80	40	-	ns
			15 V			60	30	-	ns
f_{max}	maximum frequency	input RS; see Figure 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	$P_D = 700 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$
			10 V	$P_D = 3300 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$
			15 V	$P_D = 8900 \times f_i + \Sigma(f_o \times C_L) \times V_{DD}^2$
P_{tot}	total power dissipation	when using the on-chip oscillator	5 V	$P_{tot} = 700 \times f_{osc} + \Sigma(f_o \times C_L) \times V_{DD}^2 + 2 \times C_t \times V_{DD}^2 \times f_{osc} + 690 \times V_{DD}$
			10 V	$P_{tot} = 3300 \times f_{osc} + \Sigma(f_o \times C_L) \times V_{DD}^2 + 2 \times C_t \times V_{DD}^2 \times f_{osc} + 6900 \times V_{DD}$
			15 V	$P_{tot} = 8900 \times f_{osc} + \Sigma(f_o \times C_L) \times V_{DD}^2 + 2 \times C_t \times V_{DD}^2 \times f_{osc} + 22000 \times V_{DD}$

[1] Where:

f_i = input frequency in MHz; f_o = output frequency in MHz;

C_L = output load capacitance in pF;

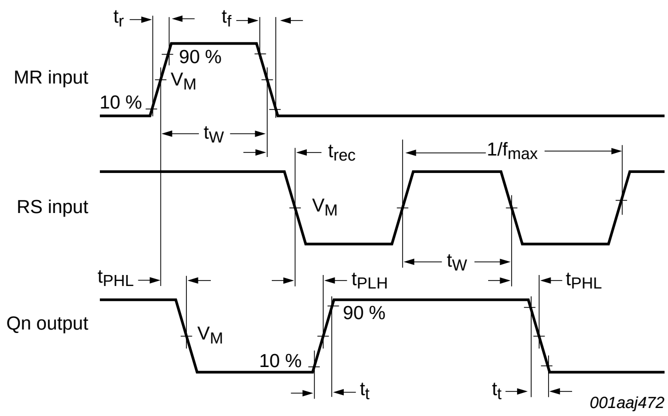
V_{DD} = supply voltage in V;

$\Sigma(f_o \times C_L)$ = sum of the outputs;

C_t = timing capacitance (pF);

f_{osc} = oscillator frequency (MHz).

11. Waveforms

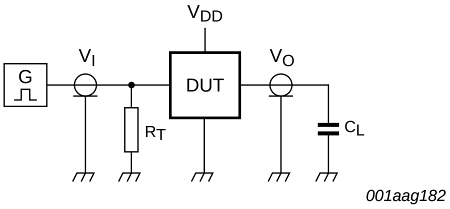


Measurement points are given in Table 9.

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;

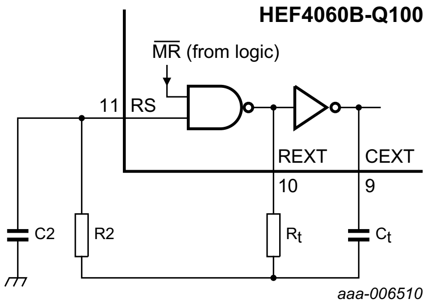
R_T = termination resistance should be equal to the output impedance Z_o of the pulse generator.

Fig 5. Test circuit for 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

12. RC oscillator



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

Fig 6. External component connection for RC oscillator

12.1 Timing component limitations

The oscillator frequency is mainly determined by $R_t \times C_t$, provided R_t << R2 and R2 × C2 << $R_t \times C_t$. R2 minimizes the influence of the forward voltage across the input protection diodes on the frequency. 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. This resistance is typically 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:

$C_t \geq 100$ pF, up to any practical value,

$10 \text{ k}\Omega \leq R_t \leq 1 \text{ M}\Omega$.

12.2 Typical crystal oscillator circuit

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

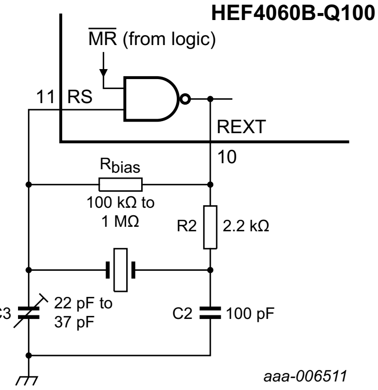
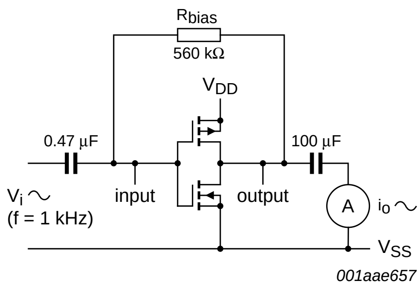
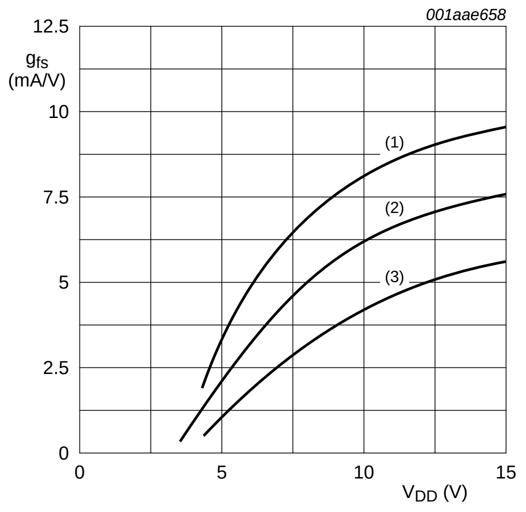


Fig 7. External component connection for crystal oscillator



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

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



T_{amb} = 25 °C.

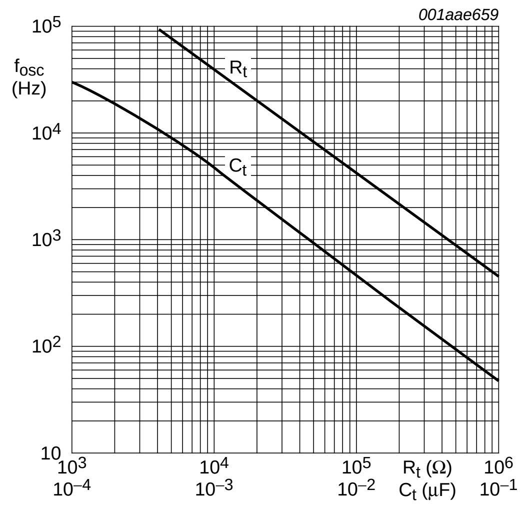
(1) Average + 2 σ.

(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

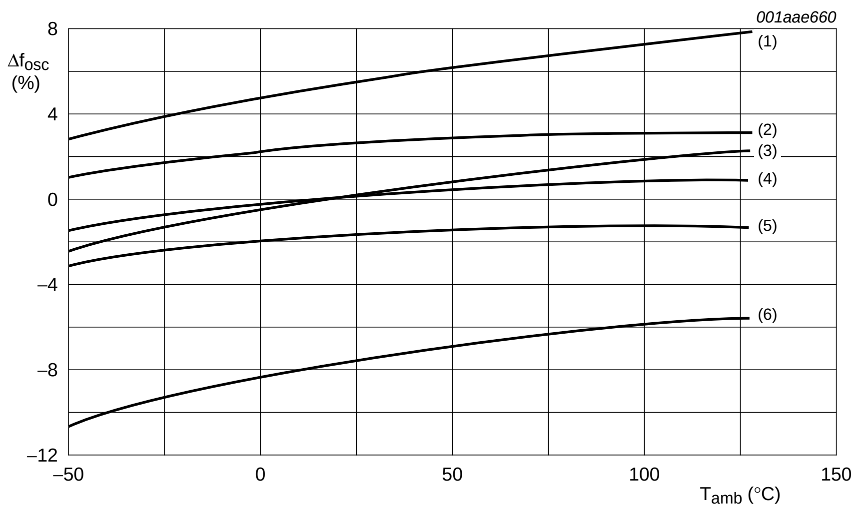


C_t curve at R_t = 100 kΩ; R2 = 470 kΩ.

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 W.

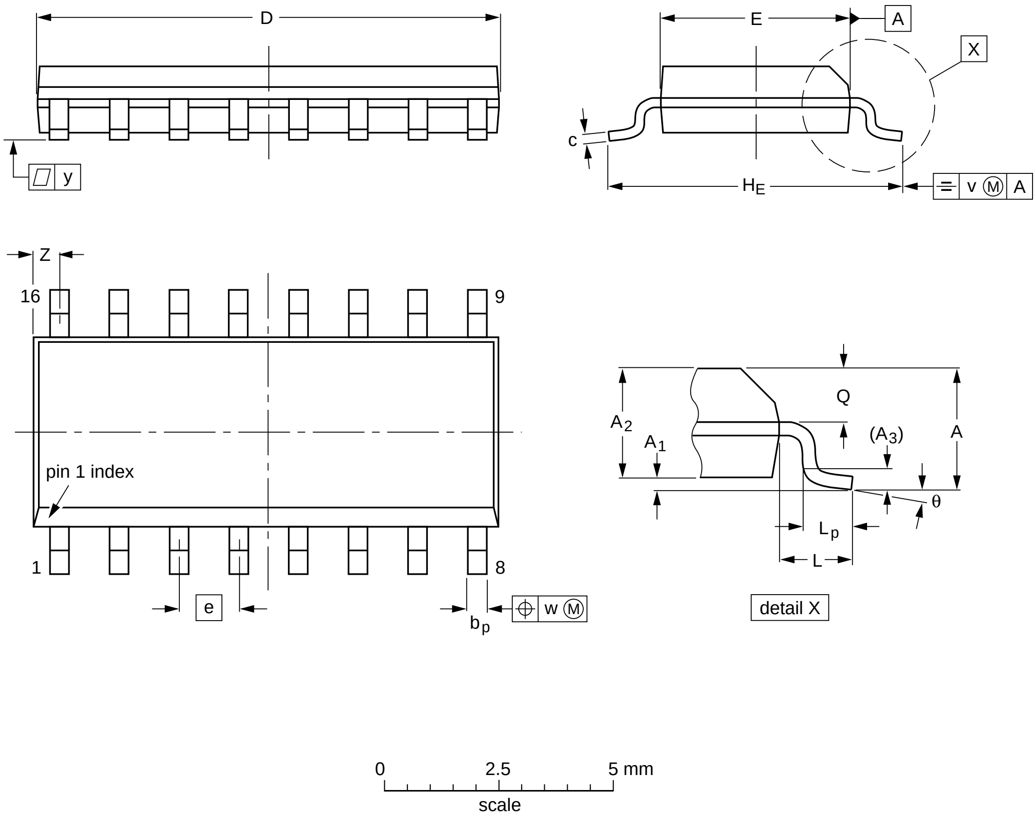
Lines (2), (4), (5): R_t = 100 kΩ; C_t = 1 nF; R2 = 300 kΩ.

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

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^o 0^o
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)

14. Abbreviations

Table 11. Abbreviations

Acronym	Description
HBM	Human Body Model
ESD	ElectroStatic Discharge
MM	Machine Model
MIL	Military

15. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
HEF4060B_Q100 v.1	20130228	Product data sheet	-	-

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.
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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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