

# HEF4060B-Q100

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

Rev. 2 — 9 September 2014

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  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$
- 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-883, method 3015 exceeds 2000 V
  - ◆ HBM JESD22-A114F exceeds 2000 V
  - ◆ MM JESD22-A115-A exceeds 200 V ( $C = 200\text{ pF}$ ,  $R = 0\ \Omega$ )
- Complies with JEDEC standard JESD 13-B

## 3. Ordering information

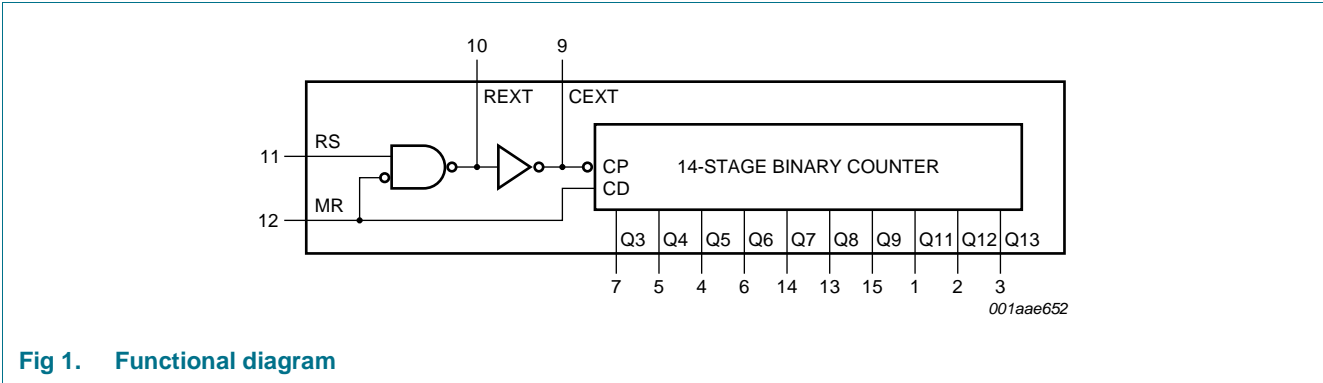
**Table 1. Ordering information**

All types operate from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$ .

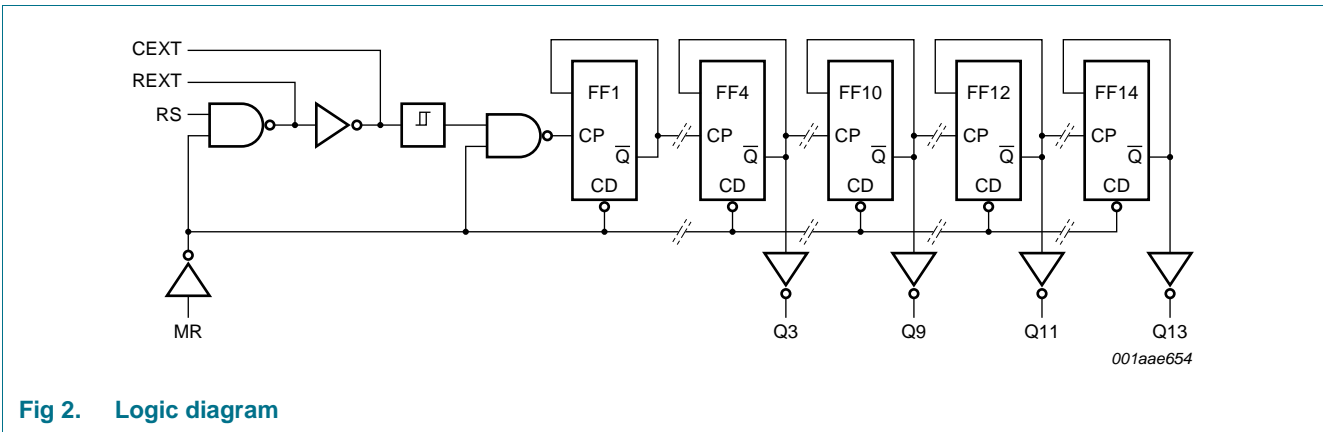
Type number	Package		Version
	Name	Description	
HEF4060BT-Q100	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1



**4. Functional diagram**



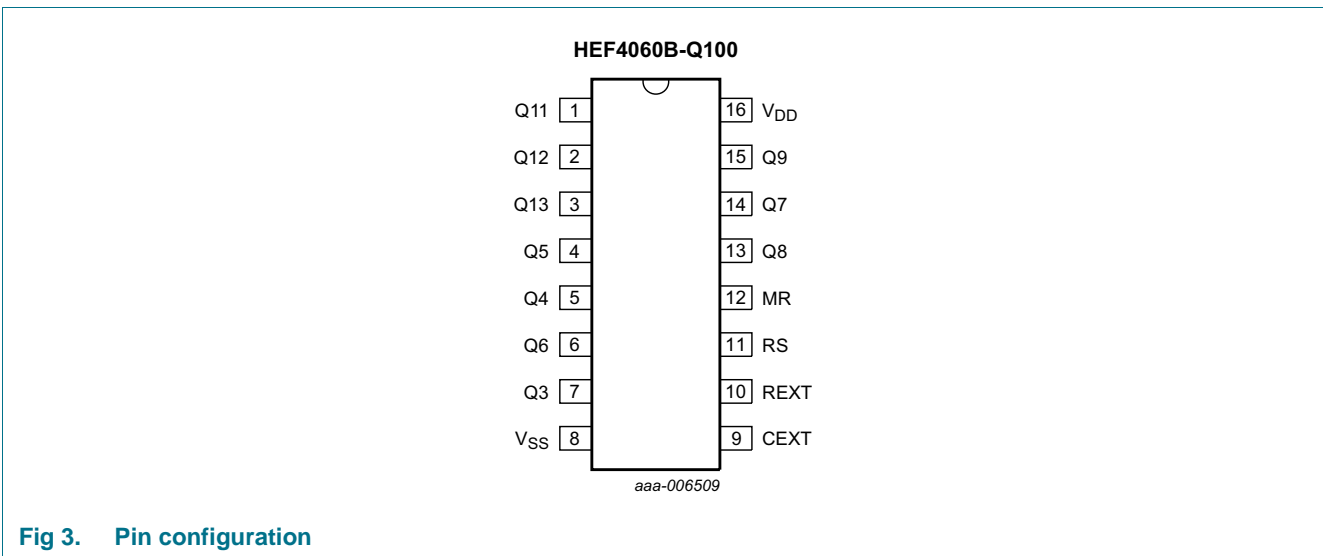
**Fig 1. Functional diagram**



**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 <sub>SS</sub>	8	ground supply voltage
CEXT	9	external capacitor connection
REXT	10	oscillator pin
RS	11	clock input/oscillator pin
MR	12	master reset
V <sub>DD</sub>	16	supply voltage

## 6. Functional description

Table 3. Function table<sup>[1]</sup>

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 <sub>DD</sub>	supply voltage		-0.5	+18	V
I <sub>IK</sub>	input clamping current	V <sub>I</sub> < -0.5 V or V <sub>I</sub> > V <sub>DD</sub> + 0.5 V	-	±10	mA
V <sub>I</sub>	input voltage		-0.5	V <sub>DD</sub> + 0.5	V
I <sub>OK</sub>	output clamping current	V <sub>O</sub> < -0.5 V or V <sub>O</sub> > V <sub>DD</sub> + 0.5 V	-	±10	mA
I <sub>I/O</sub>	input/output current		-	±10	mA
I <sub>DD</sub>	supply current		-	50	mA
T <sub>stg</sub>	storage temperature		-65	+150	°C
T <sub>amb</sub>	ambient temperature		-40	+85	°C
P <sub>tot</sub>	total power dissipation	T <sub>amb</sub> -40 °C to +85 °C	[1]	500	mW
P	power dissipation	per output	-	100	mW

[1] For SO16 package: P<sub>tot</sub> 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 <sub>DD</sub>	supply voltage		3	-	15	V
V <sub>I</sub>	input voltage		0	-	V <sub>DD</sub>	V
T <sub>amb</sub>	ambient temperature	in free air	-40	-	+85	°C
Δt/ΔV	input transition rise and fall rate	input MR				
		V <sub>DD</sub> = 5 V	-	-	3.75	μs/V
		V <sub>DD</sub> = 10 V	-	-	0.5	μs/V
		V <sub>DD</sub> = 15 V	-	-	0.08	μs/V

## 9. Static characteristics

Table 6. Static characteristics

V<sub>SS</sub> = 0 V; V<sub>I</sub> = V<sub>SS</sub> or V<sub>DD</sub> 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		Unit
				Min	Max	Min	Max	Min	Max	
V <sub>IH</sub>	HIGH-level input voltage	I <sub>O</sub>   < 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 <sub>IL</sub>	LOW-level input voltage	I <sub>O</sub>   < 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 <sub>OH</sub>	HIGH-level output voltage	I <sub>O</sub>   < 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 <sub>OL</sub>	LOW-level output voltage	I <sub>O</sub>   < 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 <sub>OH</sub>	HIGH-level output current	V <sub>O</sub> = 2.5 V	5 V	-	-1.7	-	-1.4	-	-1.1	mA
		V <sub>O</sub> = 4.6 V	5 V	-	-0.52	-	-0.44	-	-0.36	mA
		V <sub>O</sub> = 9.5 V	10 V	-	-1.3	-	-1.1	-	-0.9	mA
		V <sub>O</sub> = 13.5 V	15 V	-	-3.6	-	-3.0	-	-2.4	mA
I <sub>OL</sub>	LOW-level output current	V <sub>O</sub> = 0.4 V	5 V	0.52	-	0.44	-	0.36	-	mA
		V <sub>O</sub> = 0.5 V	10 V	1.3	-	1.1	-	0.9	-	mA
		V <sub>O</sub> = 1.5 V	15 V	3.6	-	3.0	-	2.4	-	mA
I <sub>I</sub>	input leakage current		15 V	-	±0.3	-	±0.3	-	±1.0	μA
I <sub>DD</sub>	supply current	I <sub>O</sub> = 0 A	5 V	-	20	-	20	-	150	μA
			10 V	-	40	-	40	-	300	μA
			15 V	-	80	-	80	-	600	μA
C <sub>I</sub>	input capacitance		-	-	-	-	7.5	-	-	pF

## 10. Dynamic characteristics

**Table 7. Dynamic characteristics**

$T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{SS} = 0\text{ V}$ ;  $C_L = 50\text{ pF}$ ;  $t_r = t_f \leq 20\text{ ns}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	V <sub>DD</sub>	Extrapolation formula <sup>[1]</sup>	Min	Typ	Max	Unit
t <sub>pd</sub>	propagation delay	RS → Q3; see <a href="#">Figure 4</a>	5 V	<sup>[2]</sup> 183 ns + (0.55 ns/pF) C <sub>L</sub>	-	210	420	ns
			10 V	69 ns + (0.23 ns/pF) C <sub>L</sub>	-	80	160	ns
			15 V	42 ns + (0.16 ns/pF) C <sub>L</sub>	-	50	100	ns
		Q <sub>n</sub> → Q <sub>n</sub> + 1; see <a href="#">Figure 4</a>	5 V	-	-	25	50	ns
			10 V	-	-	10	20	ns
			15 V	-	-	6	12	ns
		MR → Q <sub>n</sub> ; HIGH to LOW see <a href="#">Figure 4</a>	5 V	73 ns + (0.55 ns/pF) C <sub>L</sub>	-	100	200	ns
			10 V	29 ns + (0.23 ns/pF) C <sub>L</sub>	-	40	80	ns
			15 V	22 ns + (0.16 ns/pF) C <sub>L</sub>	-	30	60	ns
t <sub>t</sub>	transition time	see <a href="#">Figure 4</a>	5 V	<sup>[3]</sup> 10 ns + (1.00 ns/pF) C <sub>L</sub>	-	60	120	ns
			10 V	9 ns + (0.42 ns/pF) C <sub>L</sub>	-	30	60	ns
			15 V	6 ns + (0.28 ns/pF) C <sub>L</sub>	-	20	40	ns
t <sub>w</sub>	pulse width	minimum width; RS HIGH; see <a href="#">Figure 4</a>	5 V		120	60	-	ns
			10 V		50	25	-	ns
			15 V		30	15	-	ns
		minimum width; MR HIGH; see <a href="#">Figure 4</a>	5 V		50	25	-	ns
			10 V		30	15	-	ns
			15 V		20	10	-	ns
t <sub>rec</sub>	recovery time	input MR; see <a href="#">Figure 4</a>	5 V		160	80	-	ns
			10 V		80	40	-	ns
			15 V		60	30	-	ns
f <sub>max</sub>	maximum frequency	input RS; see <a href="#">Figure 4</a>	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<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>t</sub> is the same as t<sub>THL</sub> and t<sub>TLH</sub>.

**Table 8. Power dissipation**

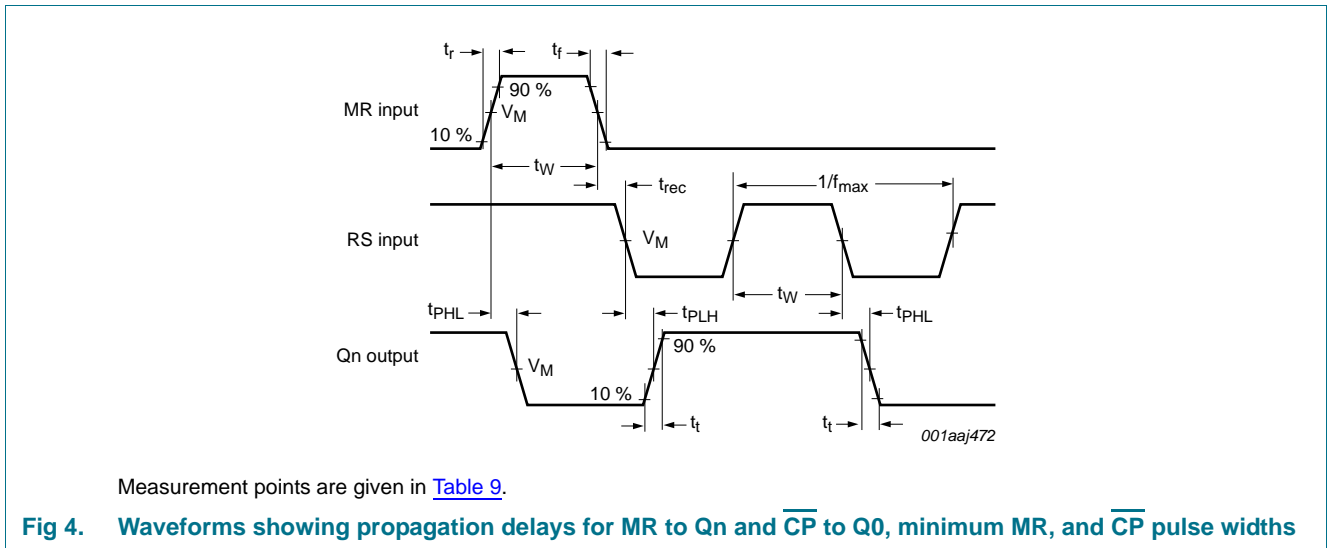
Dynamic power dissipation  $P_D$  and total power dissipation  $P_{tot}$  can be calculated from the formulas shown.  $T_{amb} = 25\text{ }^\circ\text{C}$ .

Symbol	Parameter	Conditions	$V_{DD}$	Typical formula for $P_D$ and $P_{tot}$ ( $\mu\text{W}$ ) <sup>[1]</sup>
$P_D$	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:

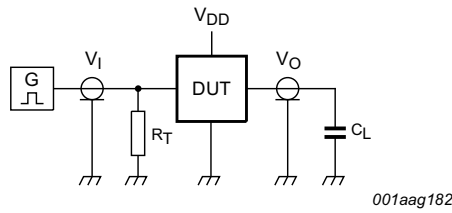
- $f_i$  = input frequency in MHz;  $f_o$  = output frequency in MHz;
- $C_L$  = output load capacitance in pF;
- $V_{DD}$  = supply voltage in V;
- $\Sigma(f_o \times C_L)$  = sum of the outputs;
- $C_t$  = timing capacitance (pF);
- $f_{osc}$  = oscillator frequency (MHz).

## 11. Waveforms



**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;

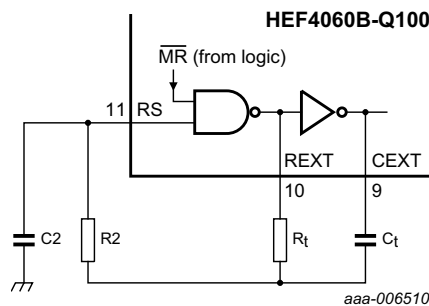
$R_T$  = termination resistance should be equal to the output impedance  $Z_o$  of the pulse generator.

**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 $V_{DD}$	$\leq 20$ ns	50 pF

## 12. 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**

### 12.1 Timing component limitations

The oscillator frequency is mainly determined by  $R_t \times C_t$ , provided  $R_t \ll R_2$  and  $R_2 \times C_2 \ll R_t \times C_t$ .  $R_2$  minimizes 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,  $C_t$  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  $\Omega$  at  $V_{DD} = 5$  V, 300  $\Omega$  at  $V_{DD} = 10$  V and 200  $\Omega$  at  $V_{DD} = 15$  V.

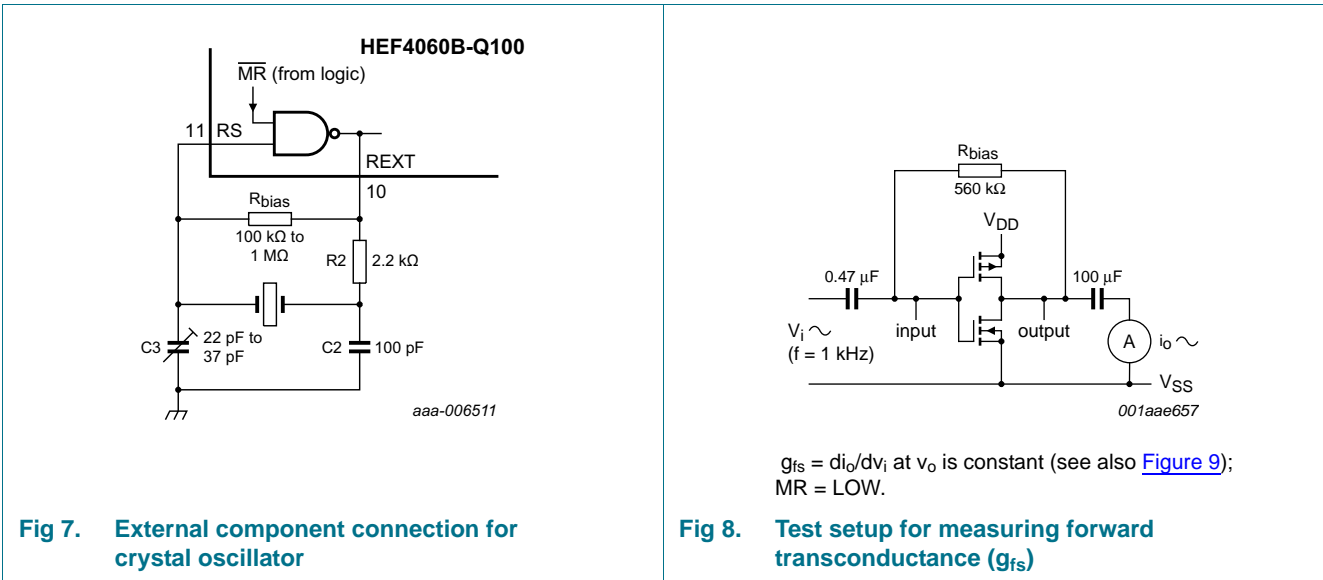
The recommended values for these components to maintain agreement with the typical oscillation formula are:

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

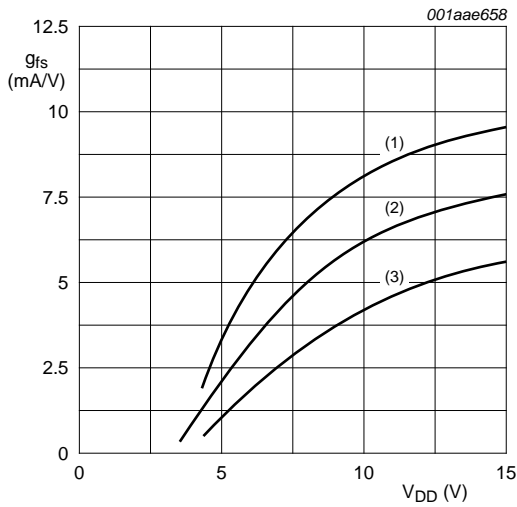
$$10 \text{ k}\Omega \leq R_t \leq 1 \text{ M}\Omega.$$

**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.

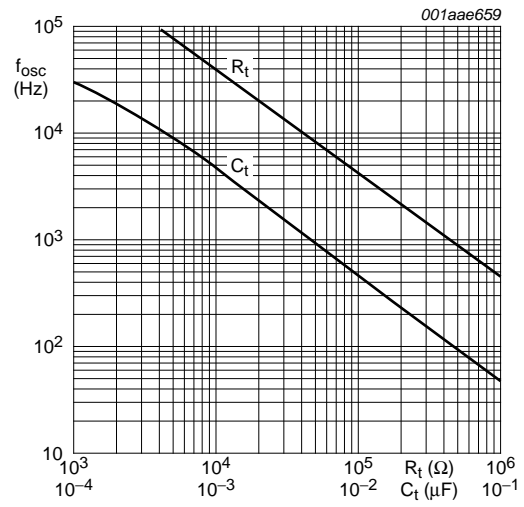






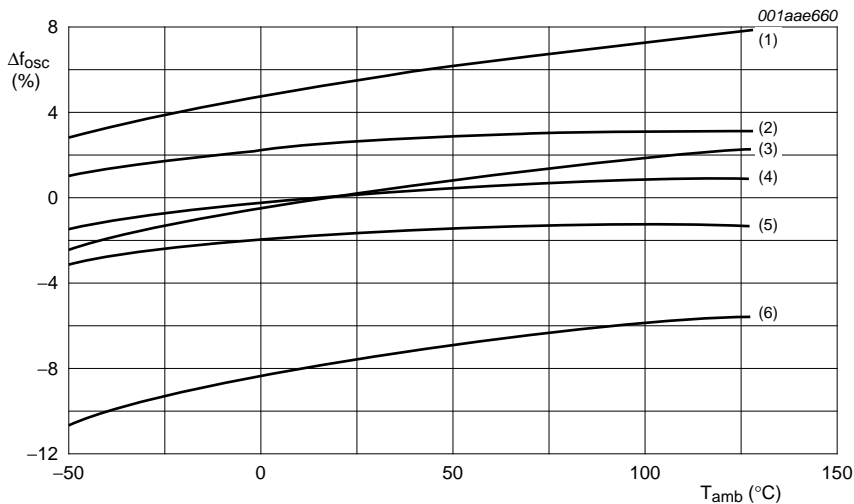
$T_{amb} = 25\text{ }^{\circ}\text{C}$ .  
 (1) Average +  $2\sigma$ .  
 (2) Average.  
 (3) Average -  $2\sigma$ .  
 Where ' $\sigma$ ' is the observed standard deviation.

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



$C_t$  curve at  $R_t = 100\text{ k}\Omega$ ;  $R_2 = 470\text{ k}\Omega$ .  
 $R_t$  curve at  $C_t = 1\text{ nF}$ ;  $R_2 = 5 R_t$ .  
 $V_{DD} = 5\text{ V to } 15\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ .

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



Lines (1) and (2):  $V_{DD} = 15\text{ V}$ .  
 Lines (3) and (4):  $V_{DD} = 10\text{ V}$ .  
 Lines (5) and (6):  $V_{DD} = 5\text{ V}$ .  
 Lines (1), (3), (6):  $R_t = 100\text{ k}\Omega$ ;  $C_t = 1\text{ nF}$ ;  $R_2 = 0\text{ W}$ .  
 Lines (2), (4), (5):  $R_t = 100\text{ k}\Omega$ ;  $C_t = 1\text{ nF}$ ;  $R_2 = 300\text{ k}\Omega$ .  
 Referenced at:  $f_{osc}$  at  $T_{amb} = 25\text{ }^{\circ}\text{C}$  and  $V_{DD} = 10\text{ V}$ .

**Fig 11. Oscillator frequency deviation ( $\Delta f_{osc}$ ) as a function of ambient temperature**

13. Package outline

SO16: plastic small outline package; 16 leads; body width 3.9 mm

SOT109-1

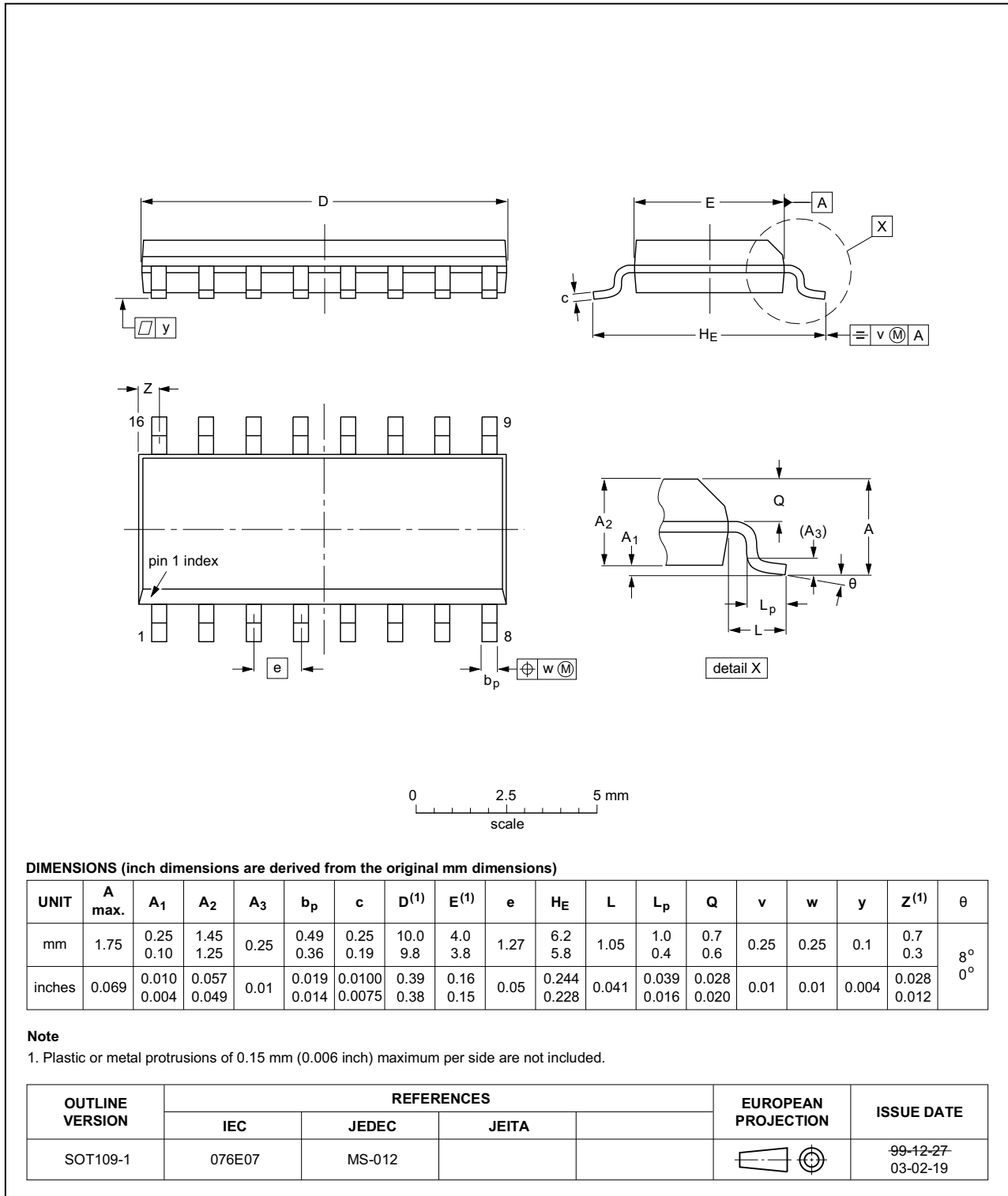


Fig 12. Package outline SOT109-1 (SO16)

## 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.2	20140909	Product data sheet	-	HEF4060B_Q100 v.1
Modifications:	• <a href="#">Section 2</a> : ESD protection: MIL-STD-833 changed to MIL-STD883			
HEF4060B_Q100 v.1	20130228	Product data sheet	-	-

## 16. Legal information

### 16.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	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.
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[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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