# HEF4060B

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

**Rev. 9 — 8 July 2019** **Product data sheet**

## 1. General description

The HEF4060B is a 14-stage ripple-carry binary counter/divider and oscillator with three oscillator terminals (RS, REXT and CEXT), ten buffered outputs (Q3 to Q9 and Q11 to Q13) and an overriding asynchronous master reset input (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. The clock input' s Schmitt-trigger action 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.

## 2. Features and benefits

- 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
- Specified from -40 ° C to +85 ° C
- 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 | SO16 | plastic small outline package; 16 leads; body width 3.9 mm | SOT109-1 |
| HEF4060BTT | TSSOP16 | plastic thin shrink small outline package; 16 leads; body width 4.4 mm | SOT403-1 |

# 4. Functional diagram

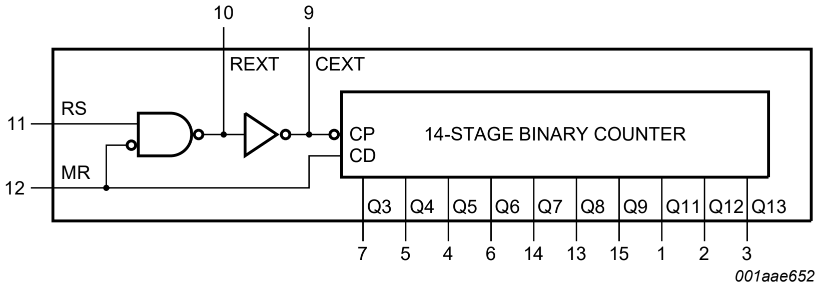



Fig. 1. Functional diagram

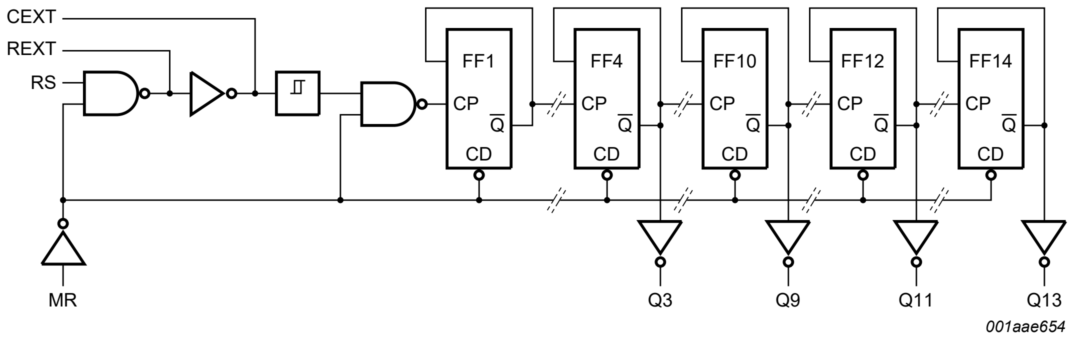



Fig. 2. Logic diagram

# 5. Pinning information

## 5.1. Pinning

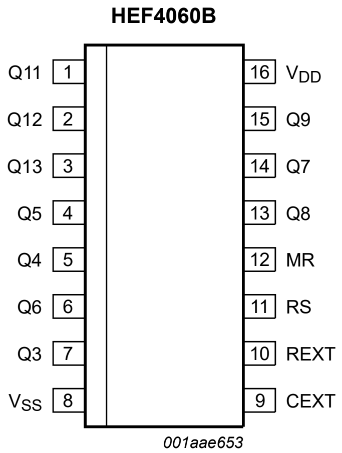



Fig. 3. Pin configuration SOT109-1 (SO16)

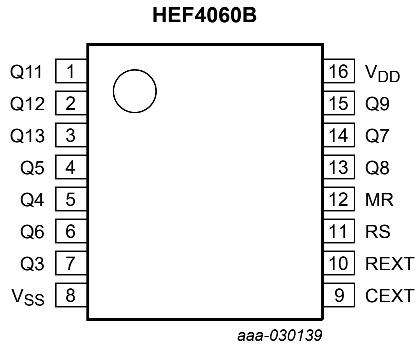



Fig. 4. Pin configuration SOT403-1 (TSSOP16)

### 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 [1] | - | 500 | mW |
| P | power dissipation | per output | - | 100 | mW |

[1] For SOT109-1 (SO16) package: $P_{tot}$ derates linearly with 12.4 mW/K above 110 °C.
For SOT403-1 (TSSOP16) package: $P_{tot}$ derates linearly with 8.5 mW/K above 91 °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 | $\lvert I_O \rvert$ < 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 | $\lvert I_O \rvert$ < 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 | $\lvert I_O \rvert$ < 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 | $\lvert I_O \rvert$ < 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; $t_r = t_f \leq 20$ ns; unless otherwise specified.*

| Symbol | Parameter | Conditions | $V_{DD}$ | | Extrapolation formula[1] | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|
| $t_{pd}$ | propagation delay | RS → Q3; see Fig. 5 | 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. 5 | 5 V | | - | - | 25 | 50 | ns |
| | | | 10 V | | - | - | 10 | 20 | ns |
| | | | 15 V | | - | - | 6 | 12 | ns |
| | | MR → Qn; HIGH to LOW see Fig. 5 | 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. 5 | 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. 5 | 5 V | | | 120 | 60 | - | ns |
| | | | 10 V | | | 50 | 25 | - | ns |
| | | | 15 V | | | 30 | 15 | - | ns |
| | | minimum width; MR HIGH; see Fig. 5 | 5 V | | | 50 | 25 | - | ns |
| | | | 10 V | | | 30 | 15 | - | ns |
| | | | 15 V | | | 20 | 10 | - | ns |
| $t_{rec}$ | recovery time | input MR; see Fig. 5 | 5 V | | | 160 | 80 | - | ns |
| | | | 10 V | | | 80 | 40 | - | ns |
| | | | 15 V | | | 60 | 30 | - | ns |
| $f_{max}$ | maximum frequency | input RS; see Fig. 5 | 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 $t_{TLH}$.

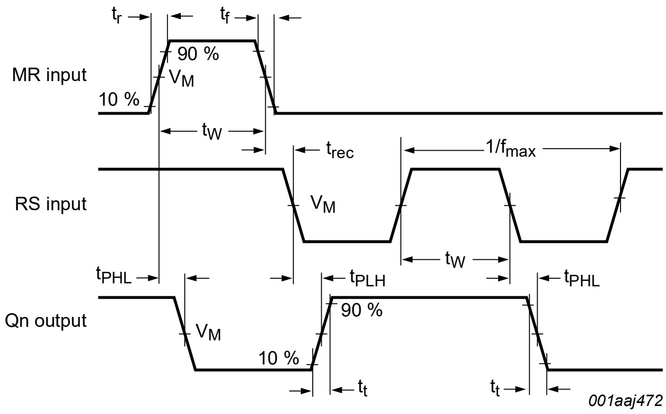
**Table 8. Power dissipation**

*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

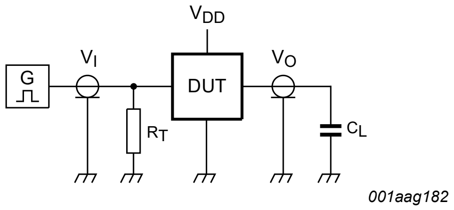



Measurement points are given in Table 9.

**Fig. 5. 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 | $0.5V_{DD}$ | $0.5V_{DD}$ |



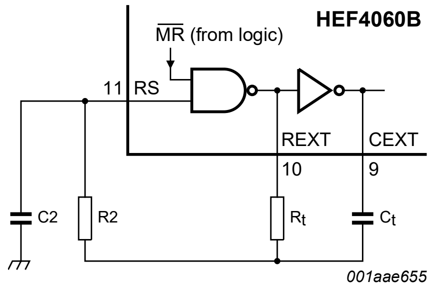

Test data is given in Table 10.
Definitions for test circuit:
DUT = Device Under Test;
$C_L$ = load capacitance including jig and probe capacitance;
$R_T$ = termination resistance should be equal to the output impedance $Z_o$ of the pulse generator.

**Fig. 6. 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. 7. 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. 8, R2 is the power limiting resistor. For starting and maintaining oscillation a minimum transconductance is necessary.

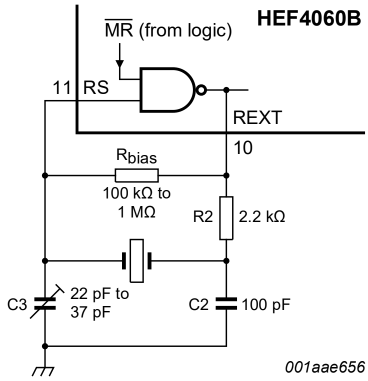
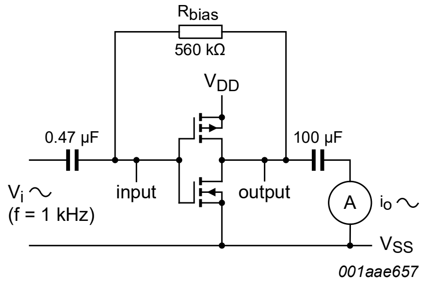
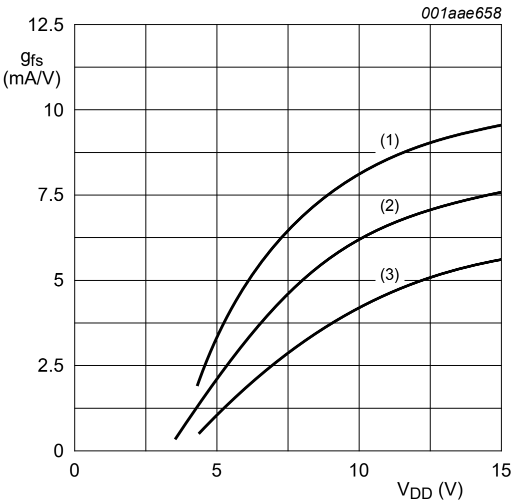



**Fig. 8. External component connection for crystal oscillator**




$g_{fs} = di_o/dv_i$ at $v_o$ is constant (see also Fig. 10); MR = LOW.

**Fig. 9. Test setup for measuring forward transconductance ($g_{fs}$)**




$T_{amb}$ = 25 °C.

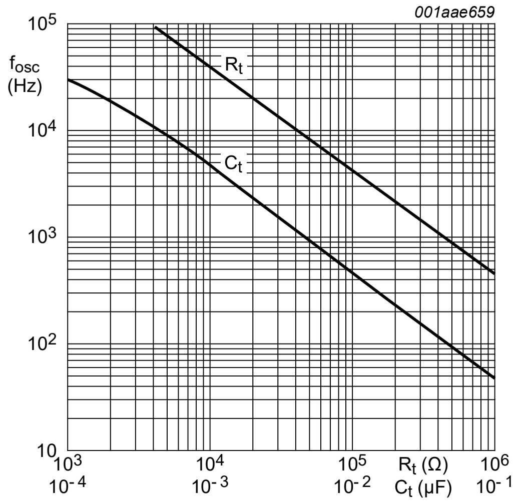
(1) Average + 2 σ.

(2) Average.

(3) Average - 2 σ.

Where ‘ σ’ is the observed standard deviation.

**Fig. 10. Typical forward transconductance $g_{fs}$ as a function of the supply voltage**

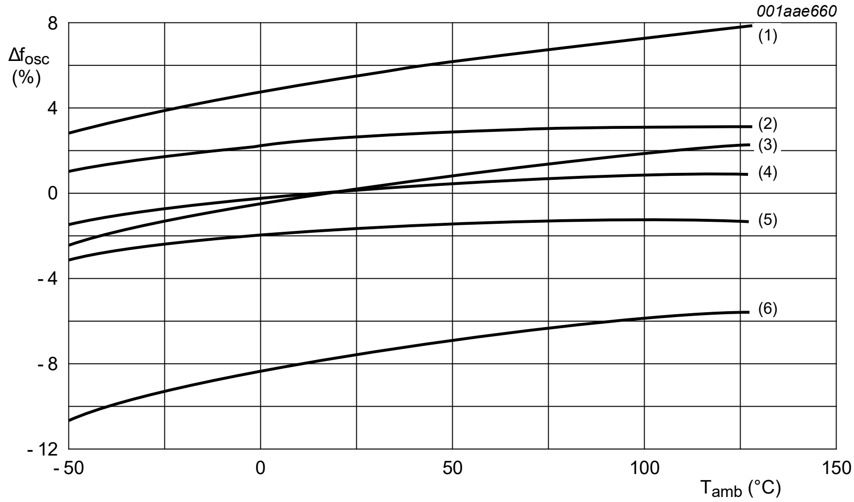



$C_t$ curve at $R_t$ = 100 kΩ; R2 = 470 kΩ.

$R_t$ curve at $C_t$ = 1 nF; R2 = 5 $R_t$.

$V_{DD}$ = 5 V to 15 V; $T_{amb}$ = 25 °C.

**Fig. 11. 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.

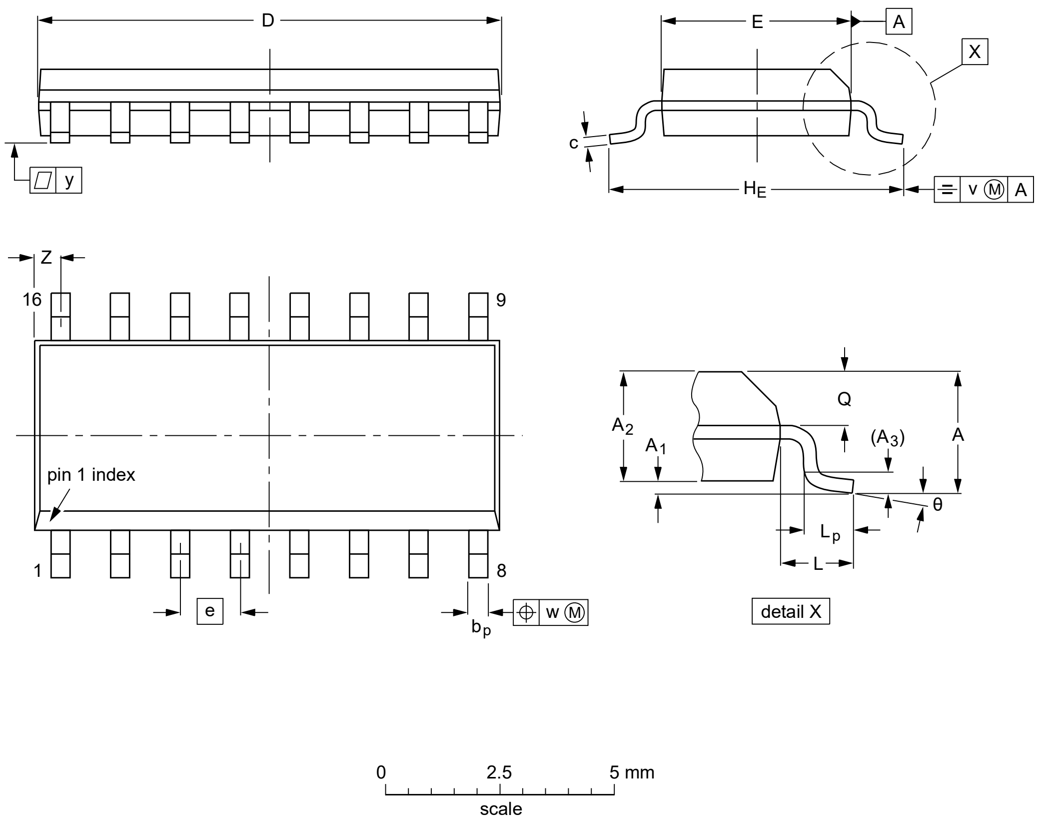
Lines (2), (4), (5): $R_t$ = 100 kΩ; $C_t$ = 1 nF; R2 = 300 kΩ.

Referenced at: $f_{osc}$ at $T_{amb}$ = 25 °C and $V_{DD}$ = 10 V.

**Fig. 12. Oscillator frequency deviation ($\Delta f_{osc}$) 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<br>0.10 | 1.45<br>1.25 | 0.25 | 0.49<br>0.36 | 0.25<br>0.19 | 10.0<br>9.8 | 4.0<br>3.8 | 1.27 | 6.2<br>5.8 | 1.05 | 1.0<br>0.4 | 0.7<br>0.6 | 0.25 | 0.25 | 0.1 | 0.7<br>0.3 | 8°<br>0° |
| inches | 0.069 | 0.010<br>0.004 | 0.057<br>0.049 | 0.01 | 0.019<br>0.014 | 0.0100<br>0.0075 | 0.39<br>0.38 | 0.16<br>0.15 | 0.05 | 0.244<br>0.228 | 0.041 | 0.039<br>0.016 | 0.028<br>0.020 | 0.01 | 0.01 | 0.004 | 0.028<br>0.012 | |

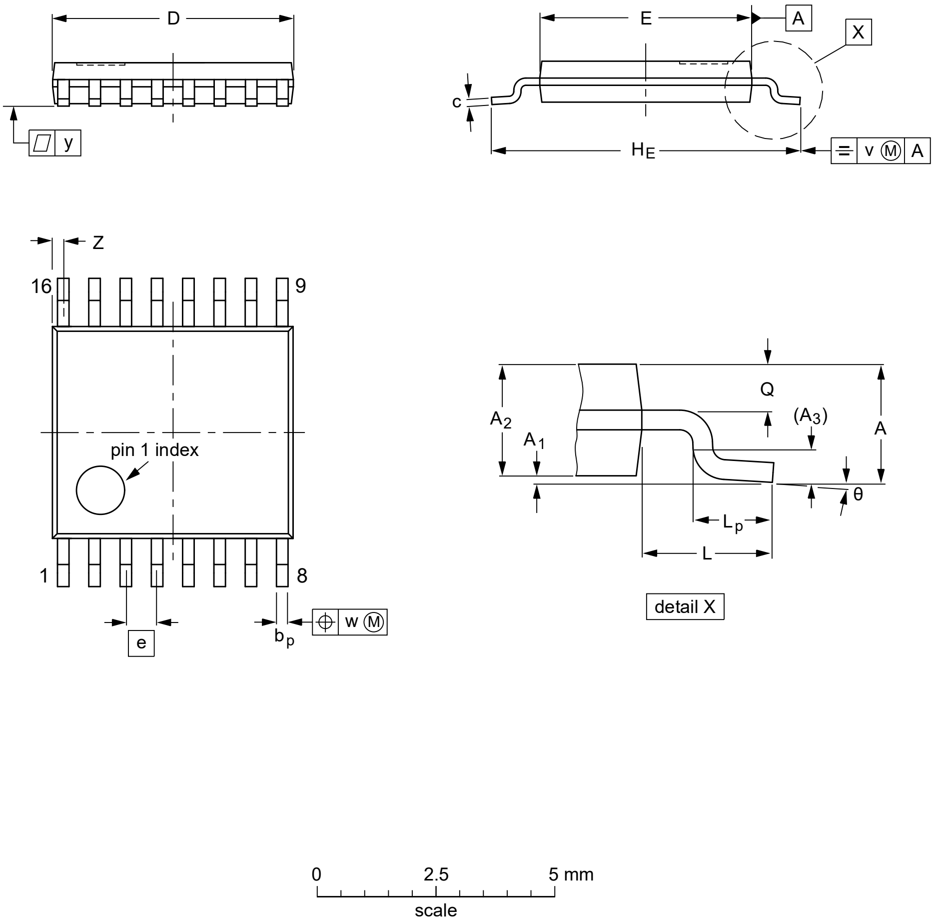
**Note**

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~~<br>03-02-19 |

**Fig. 13. Package outline SOT109-1 (SO16)**

**TSSOP16: plastic thin shrink small outline package; 16 leads; body width 4.4 mm** **SOT403-1**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A max. | $A_1$ | $A_2$ | $A_3$ | $b_p$ | c | D [(1)] | E [(2)] | e | $H_E$ | L | $L_p$ | Q | v | w | y | Z [(1)] | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.1 | 0.15<br>0.05 | 0.95<br>0.80 | 0.25 | 0.30<br>0.19 | 0.2<br>0.1 | 5.1<br>4.9 | 4.5<br>4.3 | 0.65 | 6.6<br>6.2 | 1 | 0.75<br>0.50 | 0.4<br>0.3 | 0.2 | 0.13 | 0.1 | 0.40<br>0.06 | 8°<br>0° |

**Notes**

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

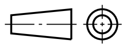
| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT403-1 | | MO-153 | | |  | ~~99-12-27~~<br>03-02-18 |

**Fig. 14. Package outline SOT403-1 (TSSOP16)**

# 13. Revision history

**Table 11. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| HEF4060B v.9 | 20190708 | Product data sheet | - | HEF4060B v.8 |
| Modifications: | • Type number HEF4060BTT (SOT403-1/TSSOP16) added. | | | |
| HEF4060B v.8 | 20160325 | Product data sheet | - | HEF4060B v.7 |
| Modifications: | • Type number HEF4060BP (SOT38-4) removed. | | | |
| HEF4060B v.7 | 20111116 | Product data sheet | - | HEF4060B v.6 |
| Modifications: | • Legal pages updated.<br>• Changes in "General description" and "Features and benefits".<br>• Section "Applications" removed. | | | |
| HEF4060B v.6 | 20110511 | Product data sheet | - | HEF4060B v.5 |
| HEF4060B v.5 | 20091127 | Product data sheet | - | HEF4060B v.4 |
| HEF4060B v.4 | 20090817 | Product data sheet | - | HEF4060B_CNV v.3 |
| HEF4060B_CNV v.3 | 19950101 | Product specification | - | HEF4060B_CNV v.2 |
| HEF4060B_CNV v.2 | 19950101 | Product specification | - | - |

# 14. 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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