# HEF4060B

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

Rev. 10 — 8 November 2021 Product data sheet

## 1. General description

The HEF4060B 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 $V_{DD}$.

## 2. Features and benefits

- 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:
  - HBM JESD22-A114F exceeds 2000 V
  - MM JESD22-A115-A exceeds 200 V
- Specified from -40 ° C to +85 °C

## 3. Ordering information

**Table 1. Ordering information**

| Type number | Package | | | |
|---|---|---|---|---|
| | Temperature range | Name | Description | Version |
| HEF4060BT | -40 °C to +85 °C | SO16 | plastic small outline package; 16 leads; body width 3.9 mm | SOT109-1 |
| HEF4060BTT | -40 °C to +85 °C | TSSOP16 | plastic thin shrink small outline package; 16 leads; body width 4.4 mm | SOT403-1 |

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# 4. Functional diagram

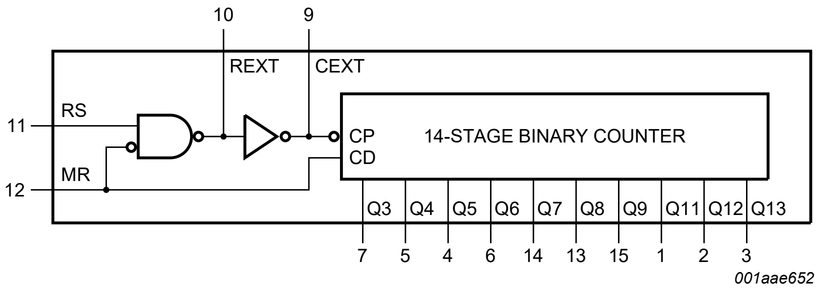



**Fig. 1. Functional diagram**

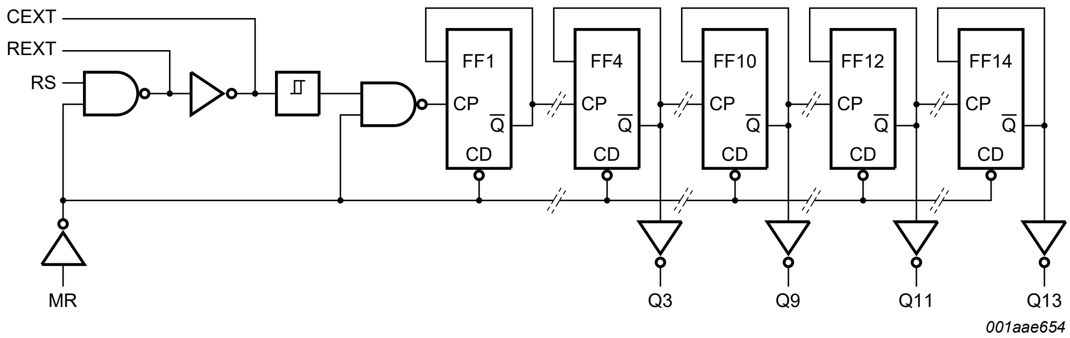



**Fig. 2. Logic diagram**

# 5. Pinning information

## 5.1. Pinning

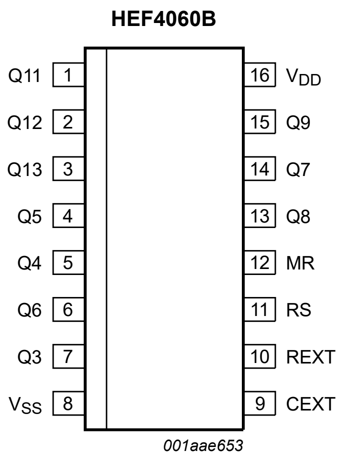



**Fig. 3. Pin configuration SOT109-1 (SO16)**

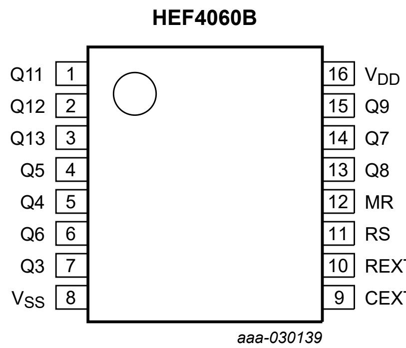



**Fig. 4. Pin configuration SOT403-1 (TSSOP16)**

### 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 | - | 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. 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 $t_{TLH}$.

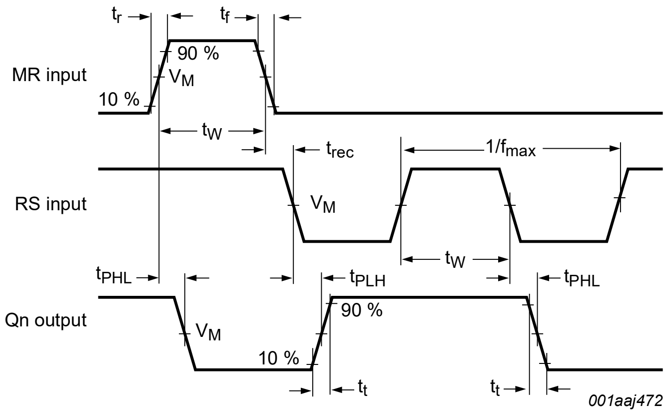
**Table 8. Power dissipation**

*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

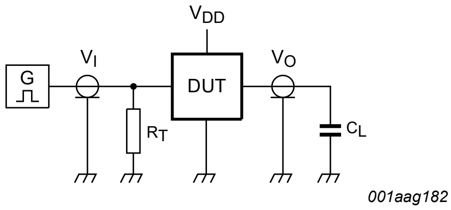



Measurement points are given in Table 9.

**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 | $0.5V_{DD}$ | $0.5V_{DD}$ |



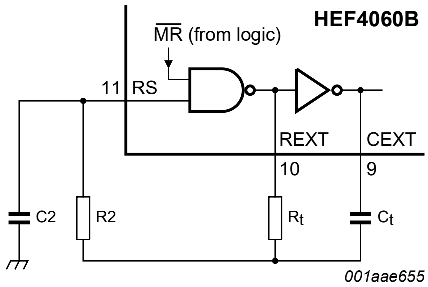

Test data is given in Table 10.
Definitions for test circuit:
DUT = Device Under Test;
$C_L$ = load capacitance including jig and probe capacitance;
$R_T$ = termination resistance should be equal to the output impedance $Z_o$ of the pulse generator.

**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.

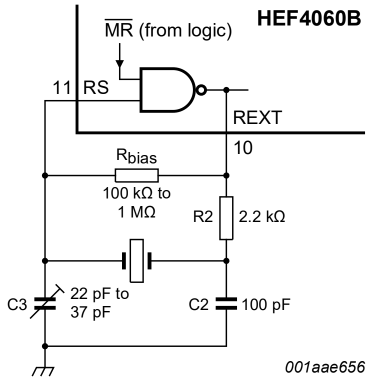
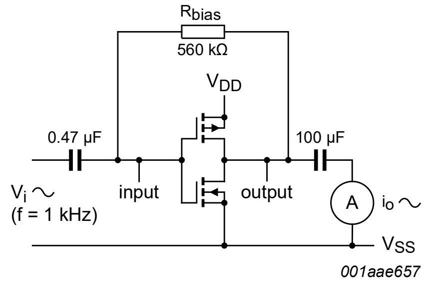
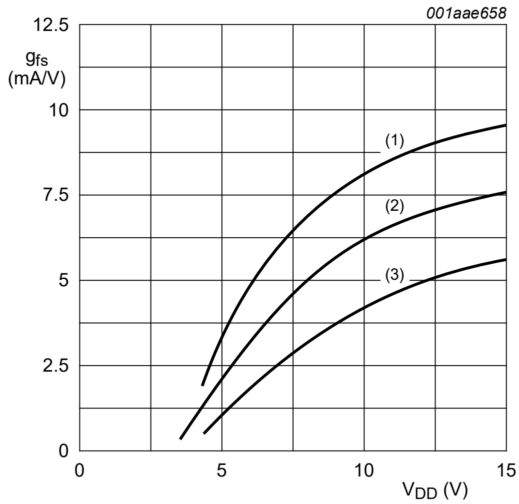



**Fig. 8. External component connection for crystal oscillator**



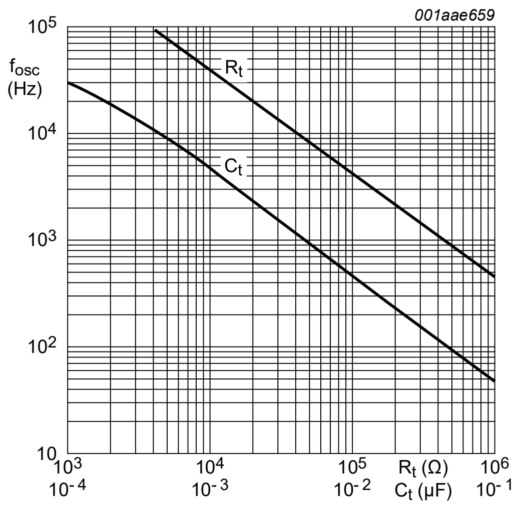

$g_{fs} = di_o/dv_i$ at $v_o$ is constant (see also Fig. 10);
MR = LOW.

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



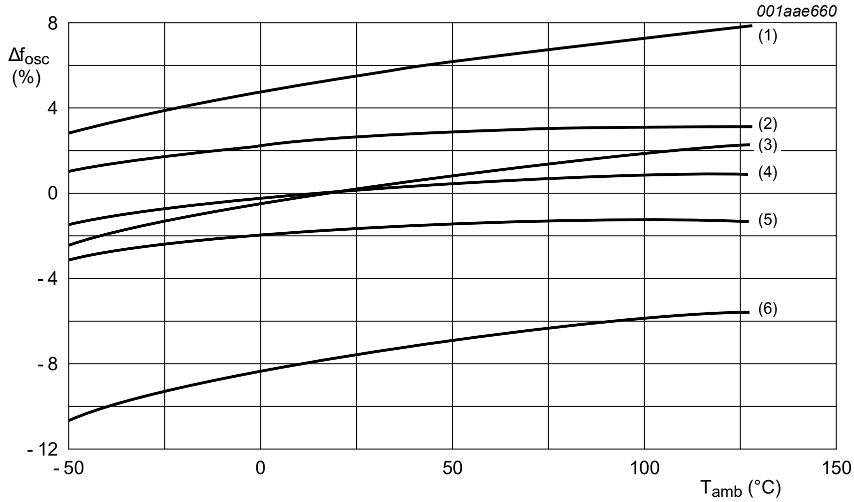

$T_{amb}$ = 25 °C.
(1) Average +2 σ.
(2) Average.
(3) Average -2 σ.
Where ‘σ’ is the observed standard deviation.

**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 $C_t$**

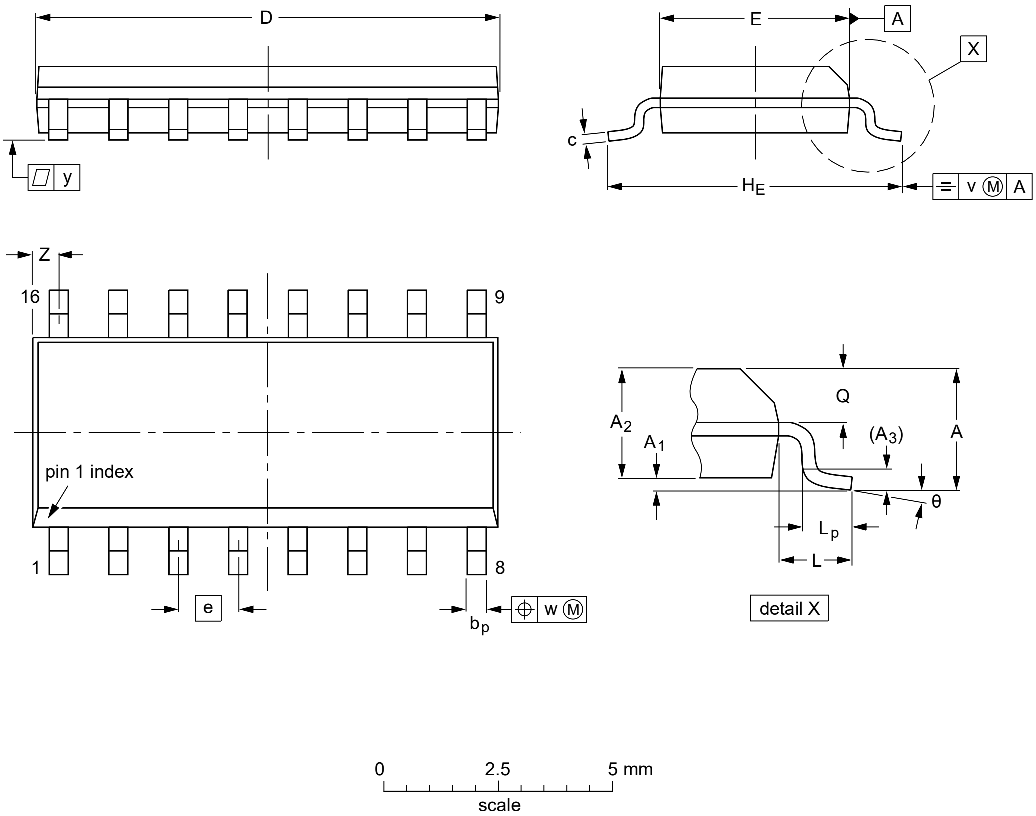



Lines (1) and (2): $V_{DD}$ = 15 V.
Lines (3) and (4): $V_{DD}$ = 10 V.
Lines (5) and (6): $V_{DD}$ = 5 V.
Lines (1), (3), (6): $R_t$ = 100 kΩ; $C_t$ = 1 nF; R2 = 0 Ω.
Lines (2), (4), (5): $R_t$ = 100 kΩ; $C_t$ = 1 nF; R2 = 300 kΩ.
Referenced at: $f_{osc}$ at $T_{amb}$ = 25 °C and $V_{DD}$ = 10 V.

**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 | |

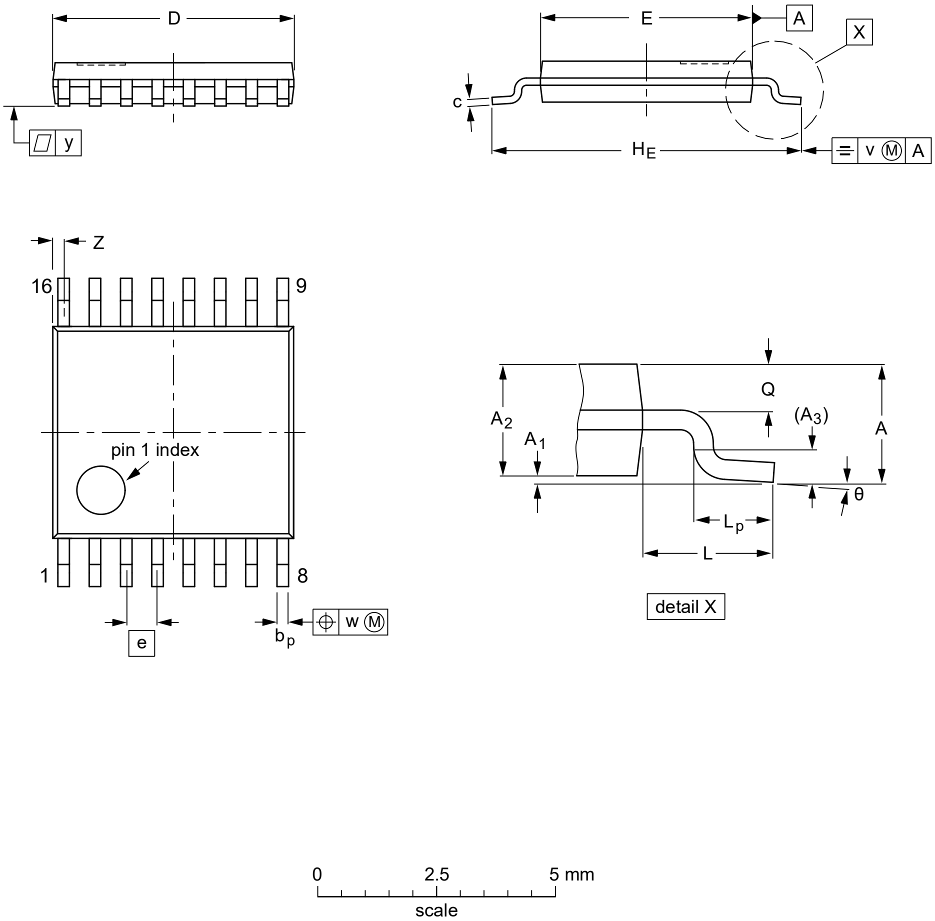
**Note**

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.

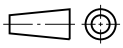
| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT403-1 | | MO-153 | | |  | ~~99-12-27~~<br>03-02-18 |

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

## 13. Abbreviations

**Table 11. Abbreviations**

| Acronym | Description |
|---|---|
| DUT | Device Under Test |
| ESD | ElectroStatic Discharge |
| HBM | Human Body Model |
| MM | Machine Model |

## 14. Revision history

**Table 12. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| HEF4060B v.10 | 20211108 | Product data sheet | - | HEF4060B v.9 |
| Modifications: | • The format of this data sheet has been redesigned to comply with the identity guidelines of Nexperia.<br>• Legal texts have been adapted to the new company name where appropriate.<br>• Section 1 and Section 2 updated. | | | |
| 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 | - | - |

# 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".
[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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