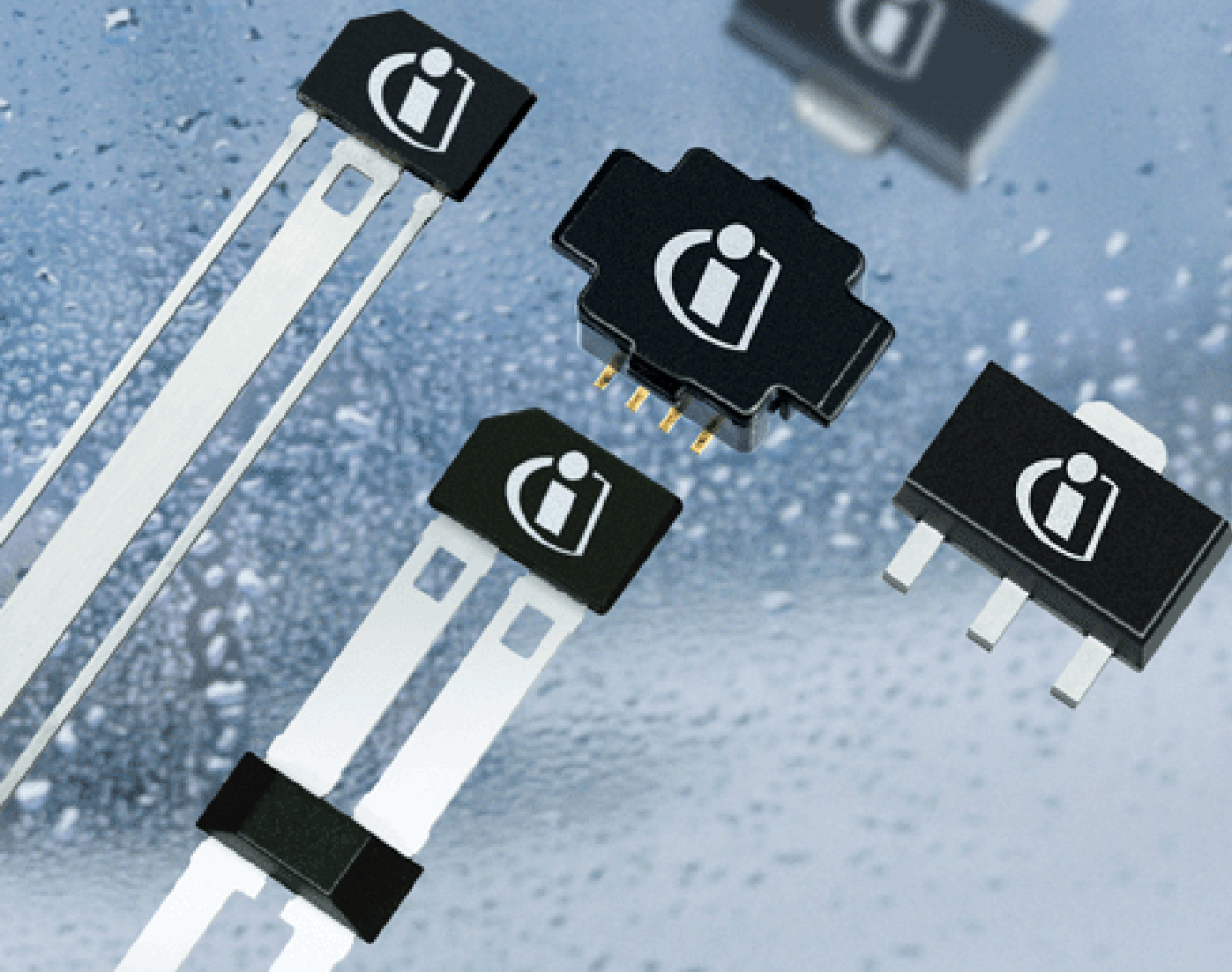


TLE4921-5U

Dynamic Differential Hall Effect Sensor IC



Sensors



Never stop thinking.

Edition 2008-01

**Published by Infineon Technologies AG,
St.-Martin-Strasse 53,
81669 München, Germany**

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Revision History: **2008-01**

V 1.1

Previous Version: V1.0

| Page | Subjects (major changes since last revision) |
|------|--|
| 5 | Ordering Code changed |
| 11 | “Output leakage current” unit corrected |
| 20 | Figures “Delay Time between Switching Threshold” exchanged and corrected |
| 21 | Figure “Delay Time versus Differential Field” corrected |
| | |

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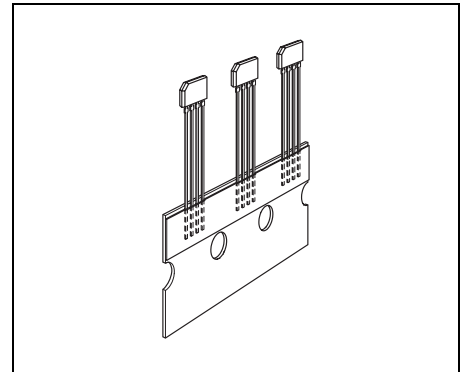


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1 Overview

1.1 Features

- Advanced performance
- High sensitivity
- Symmetrical thresholds
- High piezo resistivity
- Reduced power consumption
- South and north pole pre-induction possible
- AC coupled
- Digital output signal
- Two-wire and three-wire configuration possible
- Large temperature range
- Large airgap
- Low cut-off frequency
- Protection against overvoltage
- Protection against reversed polarity
- Output protection against electrical disturbances



The differential Hall Effect sensor TLE4921-5U provides a high sensitivity and a superior stability over temperature and symmetrical thresholds in order to achieve a stable duty cycle. TLE4921-5U is particularly suitable for rotational speed detection and timing applications of ferromagnetic toothed wheels such as anti-lock braking systems, transmissions, crankshafts, etc. The integrated circuit (based on Hall effect) provides a digital signal output with frequency proportional to the speed of rotation. Unlike other rotational sensors differential Hall ICs are not influenced by radial vibration within the effective airgap of the sensor and require no external signal processing.

| Type | Marking | Ordering Code | Package |
|------------|---------|---------------|------------|
| TLE4921-5U | 215U | SP000013593 | PG-SSO-4-1 |

1.2 Pin Configuration (view on branded side of component)

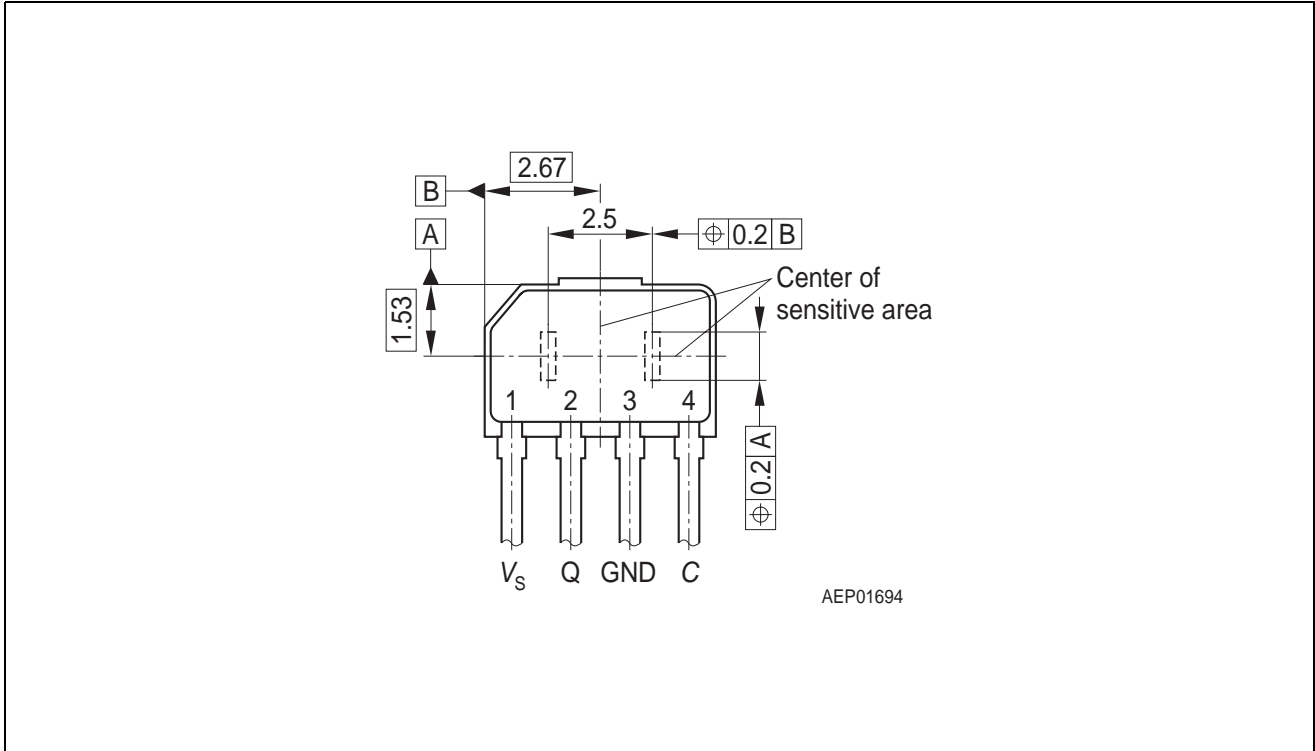


Figure 1

Table 1 Pin Definitions and Functions

| Pin No. | Symbol | Function |
|---------|--------|----------------|
| 1 | V_S | Supply voltage |
| 2 | Q | Output |
| 3 | GND | Ground |
| 4 | C | Capacitor |

2 General

2.1 Block Diagram

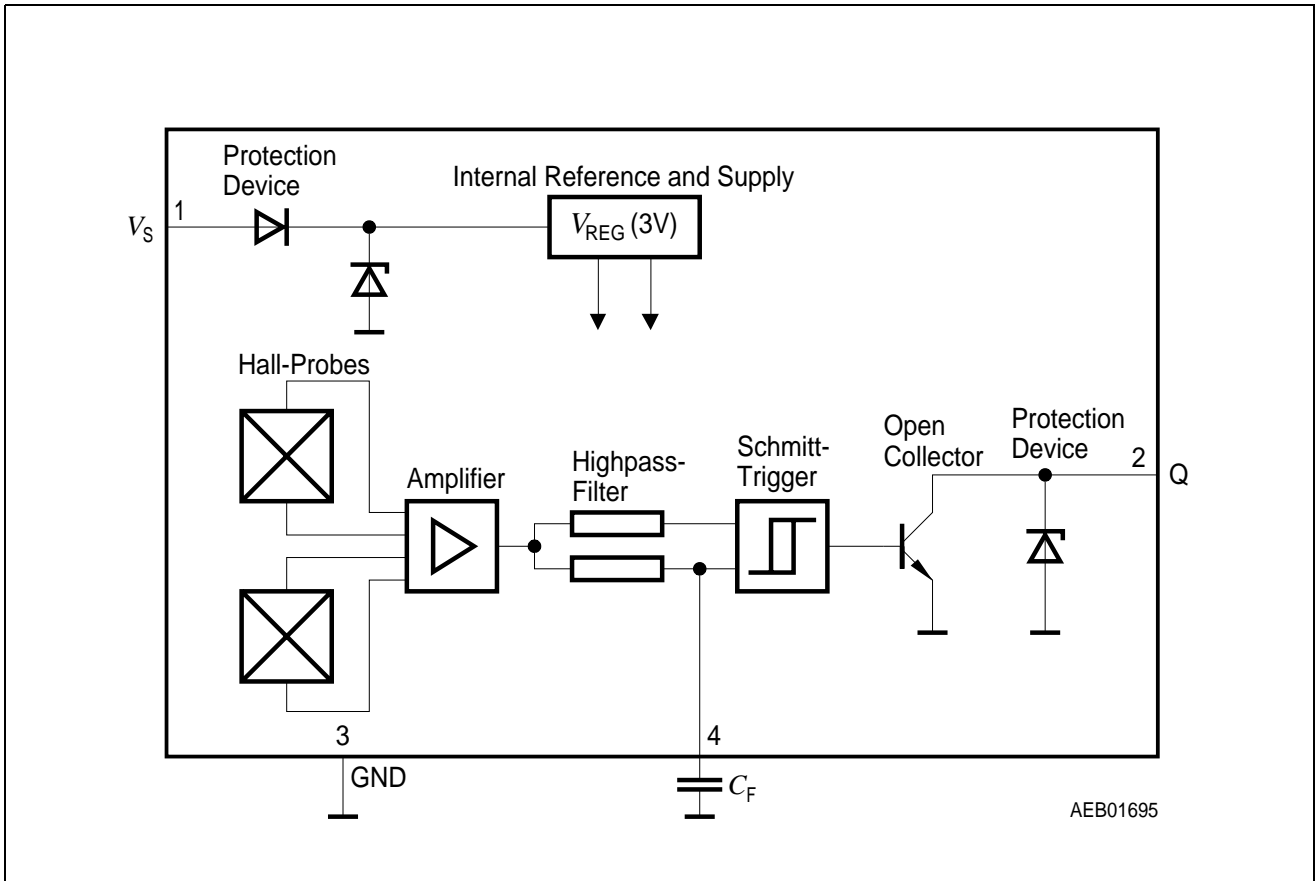


Figure 2 Block Diagram

2.2 Functional Description

The Differential Hall Sensor IC detects the motion and position of ferromagnetic and permanent magnet structures by measuring the differential flux density of the magnetic field. To detect ferromagnetic objects the magnetic field must be provided by a back biasing permanent magnet (**south or north** pole of the magnet attached to the rear unmarked side of the IC package).

Using an external capacitor the generated Hall voltage signal is slowly adjusted via an active high pass filter with a low cut-off frequency. This causes the output to switch into a biased mode after a time constant is elapsed. The time constant is determined by the external capacitor. Filtering avoids ageing and temperature influence from Schmitt-trigger input and eliminates device and magnetic offset.

The TLE4921-5U can be exploited to detect toothed wheel rotation in a rough environment. Jolts against the toothed wheel and ripple have no influence on the output signal.

Furthermore, the TLE4921-5U can be operated in a two-wire as well as in a three-wire-configuration.

The output is logic compatible by high/low levels regarding on and off.

2.3 Circuit Description (see [Figure 2](#))

The TLE4921-5U is comprised of a supply voltage reference, a pair of Hall probes spaced at 2.5 mm, differential amplifier, filter for offset compensation, Schmitt trigger, and an open collector output.

The TLE4921-5U was designed to have a wide range of application parameter variations. Differential fields up to ± 80 mT can be detected without influence to the switching performance. The pre-induction field can either come from a magnetic south or north pole, whereby the field strength up to 500 mT or more will not influence the switching points. The improved temperature compensation enables a superior sensitivity and accuracy over the temperature range. Finally the optimized piezo compensation and the integrated dynamic offset compensation enable easy manufacturing and elimination of magnet offsets.

Protection is provided at the input/supply (pin 1) for overvoltage and reverse polarity and against over-stress such as load dump, etc., in accordance with ISO-TR 7637 and DIN 40839. The output (pin 2) is protected against voltage peaks and electrical disturbances.

3 Maximum Ratings

Table 2 Absolute Maximum Ratings
 $T_j = -40^{\circ}\text{C to } 150^{\circ}\text{C}$

| Parameter | Symbol | Limit Values | | Unit | Remarks |
|--|------------|-------------------|------|------|-----------------------------|
| | | min. | max. | | |
| Supply voltage | V_S | -35 ¹⁾ | 30 | V | |
| Output voltage | V_Q | -0.7 | 30 | V | |
| Output current | I_Q | – | 50 | mA | |
| Output reverse current | $-I_Q$ | – | 50 | mA | |
| Capacitor voltage | V_C | -0.3 | 3 | V | |
| Junction temperature | T_j | – | 150 | °C | 5000 h |
| | | – | 160 | | 2500 h |
| | | – | 170 | | 1000 h |
| | | – | 210 | | 40 h |
| Storage temperature | T_S | -40 | 150 | °C | |
| Thermal resistance PG-SSO-4-1 | R_{thJA} | – | 190 | K/W | |
| Current through input-protection device | I_{SZ} | – | 200 | mA | $t < 2 \text{ ms}; v = 0.1$ |
| Current through output-protection device | I_{QZ} | – | 200 | mA | $t < 2 \text{ ms}; v = 0.1$ |

1) Reverse current < 10 mA

4 Operating Range

Table 3 ESD Protection
Human Body Model (HBM) tests according to:
Standard EIA/JESD22-A114-B HBM

| Parameter | Symbol | Limit Values | | Unit | Remarks |
|------------------|-----------|--------------|---------|------|---------|
| | | min. | max. | | |
| ESD - protection | V_{ESD} | – | ± 2 | kV | |

Table 4 Operating Range

| Parameter | Symbol | Limit Values | | | Unit | Remarks |
|------------------------|------------|--------------|------|------|------|--|
| | | min. | typ. | max. | | |
| Supply voltage | V_S | 4.5 | – | 24 | V | |
| Junction temperature | T_j | -40 | – | 150 | °C | 5000 h |
| | | – | – | 160 | | 2500 h |
| | | – | – | 170 | | 1000 h |
| Pre-induction | B_0 | -500 | – | 500 | mT | at Hall probe; independent of magnet orientation |
| Differential induction | ΔB | -80 | – | 80 | mT | |

Note: In the operating range the functions given in the circuit description are fulfilled.

Electrical and Magnetic Parameters
5 Electrical and Magnetic Parameters
Table 5 Electrical Characteristics

| Parameter | Symbol | Limit Values | | | Unit | Test Condition | Test Circuit |
|--|---------------------|--------------|------|------|---------------|---|--------------|
| | | min. | typ. | max. | | | |
| Supply current | I_S | 3.8 | 5.3 | 8.0 | mA | $V_Q = \text{high}$ $I_Q = 0 \text{ mA}$ | 1 |
| | | 4.3 | 5.9 | 8.8 | mA | $V_Q = \text{low}$ $I_Q = 40 \text{ mA}$ | 1 |
| Output saturation voltage | V_{QSAT} | – | 0.25 | 0.6 | V | $I_Q = 40 \text{ mA}$ | 1 |
| Output leakage current | I_{QL} | – | – | 50 | μA | $V_Q = 24 \text{ V}$ | 1 |
| Center of switching points: ($\Delta B_{OP} + \Delta B_{RP}$) / 2 | ΔB_m | -1 | 0 | 1 | mT | $-20 \text{ mT} < \Delta B < 20 \text{ mT}^{1) 2)}$ $f = 200 \text{ Hz}$ | 2 |
| Operate point | ΔB_{OP} | – | – | 0 | mT | $f = 200 \text{ Hz}$, $\Delta B = 20 \text{ mT}$ | 2 |
| Release point | ΔB_{RP} | 0 | – | – | mT | $f = 200 \text{ Hz}$, $\Delta B = 20 \text{ mT}$ | 2 |
| Hysteresis | ΔB_H | 0.5 | 1.5 | 2.5 | mT | $f = 200 \text{ Hz}$, $\Delta B = 20 \text{ mT}$ | 2 |
| Overvoltage protection at supply voltage at output | V_{SZ} | 27 | – | 35 | V | $I_S = 16 \text{ mA}$ | 1 |
| | V_{QZ} | 27 | – | 35 | V | $I_Q = 16 \text{ mA}$ | 1 |
| Output rise time | t_r | – | – | 0.5 | μs | $I_Q = 40 \text{ mA}$ $C_L = 10 \text{ pF}$ | 1 |
| Output fall time | t_f | – | – | 0.5 | μs | $I_Q = 40 \text{ mA}$ $C_L = 10 \text{ pF}$ | 1 |
| Delay time | t_{dop} | – | – | 25 | μs | $f = 10 \text{ kHz}$ $\Delta B = 5 \text{ mT}$ | 2 |
| | t_{drp} | – | – | 10 | μs | | |
| | $t_{dop} - t_{drp}$ | – | 0 | 15 | μs | | |
| Filter input resistance | R_C | 35 | 43 | 52 | k Ω | $25^\circ\text{C} \pm 2^\circ\text{C}$ | 1 |

Electrical and Magnetic Parameters
Table 5 Electrical Characteristics (cont'd)

| Parameter | Symbol | Limit Values | | | Unit | Test Condition | Test Circuit |
|---|--------------|---------------|------|-------|-------|---------------------------|-----------------|
| | | min. | typ. | max. | | | |
| Filter sensitivity to ΔB | S_C | – | -5 | – | mV/mT | – | 1 |
| Filter bias voltage | V_C | 1.6 | 2 | 2.4 | V | $\Delta B = 0$ | 1 |
| Frequency | f | ³⁾ | – | 20000 | Hz | $\Delta B = 5 \text{ mT}$ | 2 |
| Resistivity against mechanical stress (piezo) | ΔB_m | -0.1 | – | 0.1 | mT | F = 2 N | 2 ⁴⁾ |
| | ΔB_H | -0.1 | – | 0.1 | mT | | |

- 1) The Current consumption characteristic will be different and the specified values can slightly change
 2) Leakage currents at pin 4 should be avoided. The bias shift of B_m caused by a leakage current I_L can be

$$\text{calculated by: } \Delta B_m = \frac{I_L \times R_C(T)}{S_C(T)}$$

- 3) For higher ΔB the values may exceed the limits like following $|\Delta B_m| < |0.05 \times \Delta B|$
 4) Depends on filter capacitor C_F . The cut-off frequency is given by $f = \frac{1}{2\pi \times R_C \times C_F}$. The switching points are

guaranteed over the whole frequency range, but amplitude modification and phase shift due to the 1st order highpass filter have to be taken into account.

Note: The listed characteristics are ensured over the operating range of the integrated circuit. Typical characteristics specify mean values expected over the production spread. If not otherwise specified, typical characteristics apply at $T_j = 25^\circ\text{C}$ and the given supply voltage.

Electrical and Magnetic Parameters

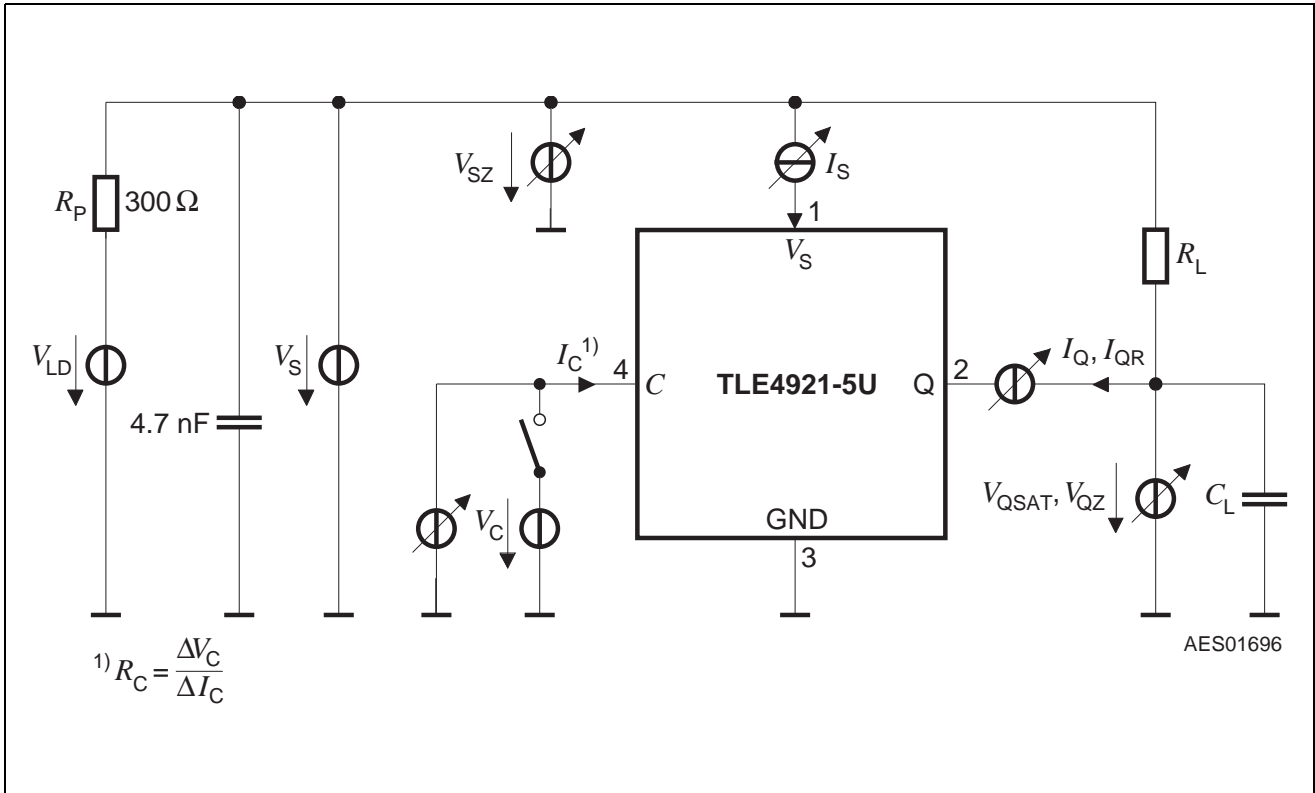


Figure 3 Test Circuit 1

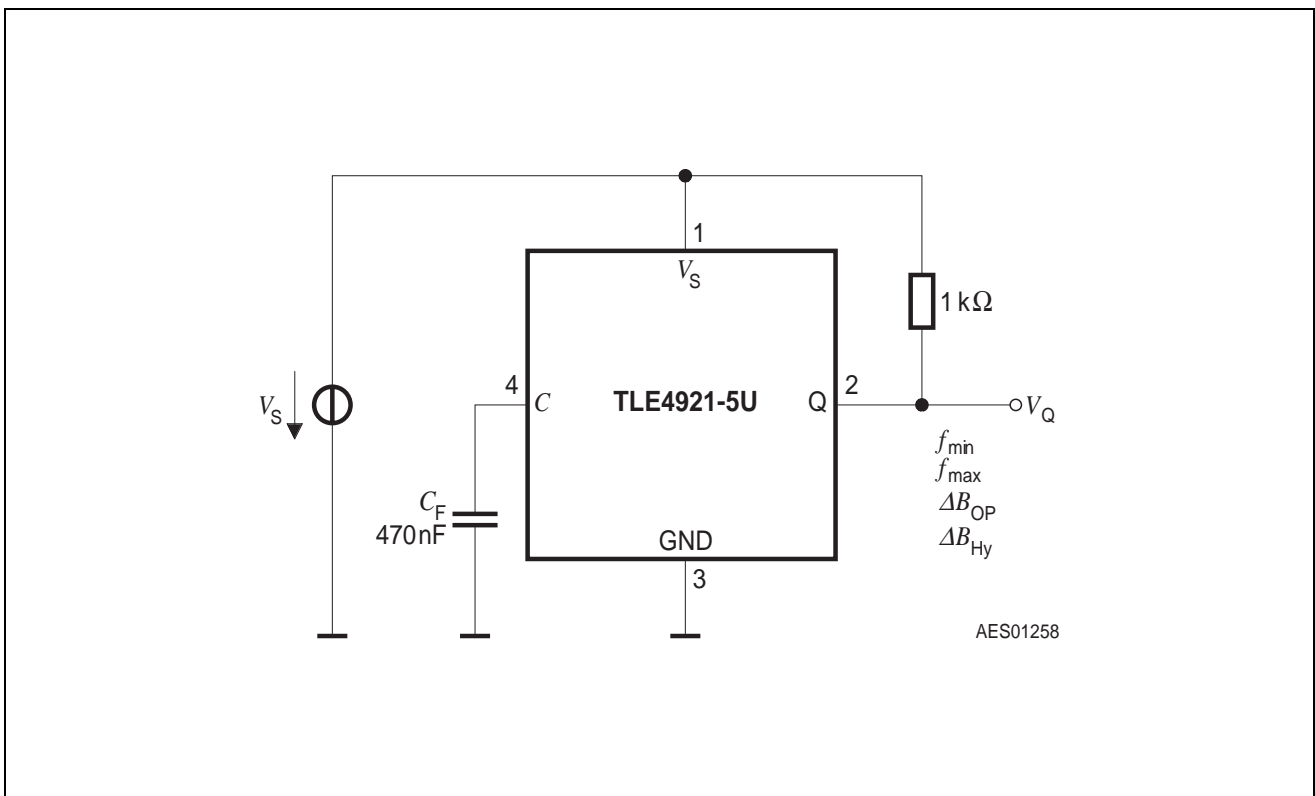


Figure 4 Test Circuit 2

6 Application Configurations

Two possible applications are shown in **Figure 7** and **Figure 8** (Toothed and Magnet Wheel). The difference between two-wire and three-wire application is shown in **Figure 9**.

Gear Tooth Sensing

In the case of ferromagnetic toothed wheel application the IC has to be biased by the south or north pole of a permanent magnet (e.g. SmCO₅ (Vacuumschmelze VX145)) with the dimensions 8 mm × 5 mm × 3 mm) which should cover both Hall probes.

The maximum air gap depends on:

- the magnetic field strength (magnet used; pre-induction) and
- the toothed wheel that is used (dimensions, material, etc.; resulting differential field)

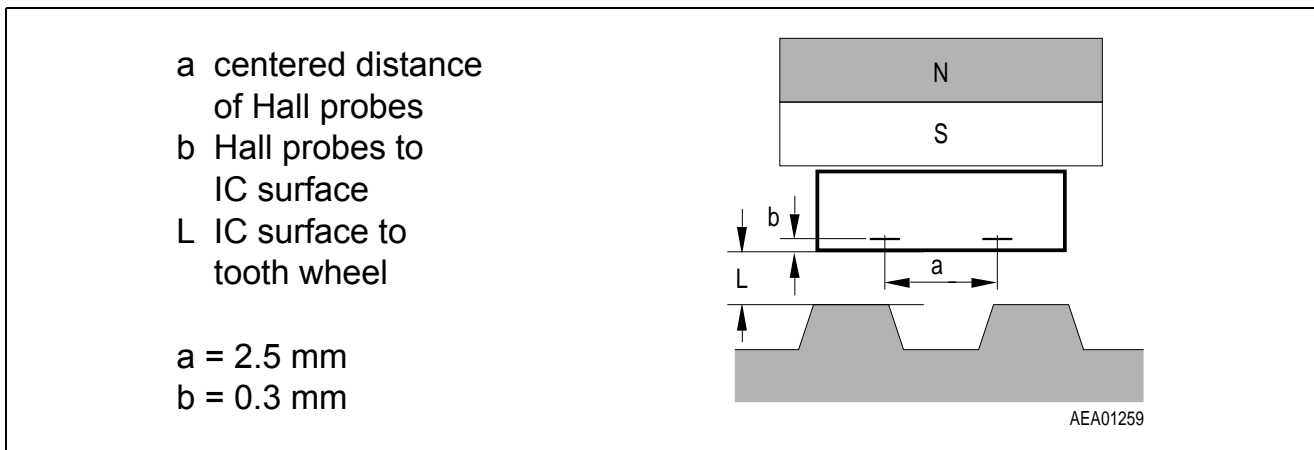


Figure 5 Sensor Spacing

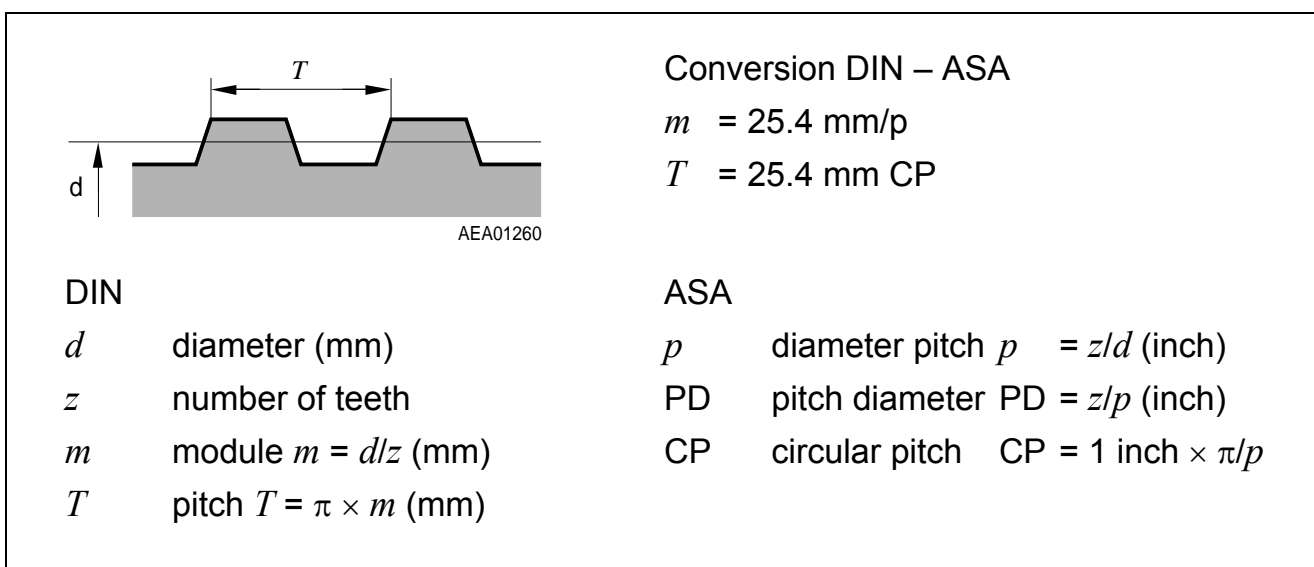


Figure 6 Tooth Wheel Dimensions

Application Configurations

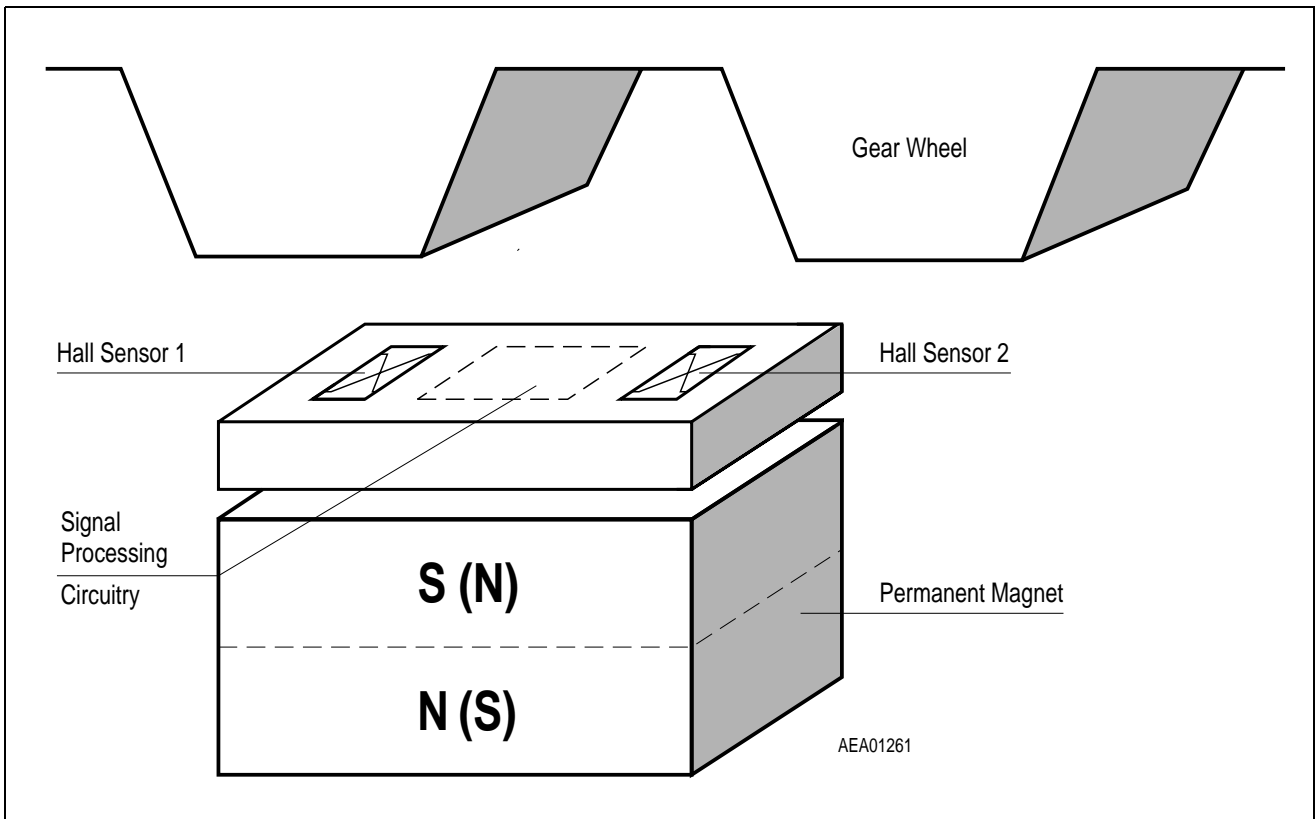


Figure 7 TLE4921-5U, with Ferromagnetic Toothed Wheel

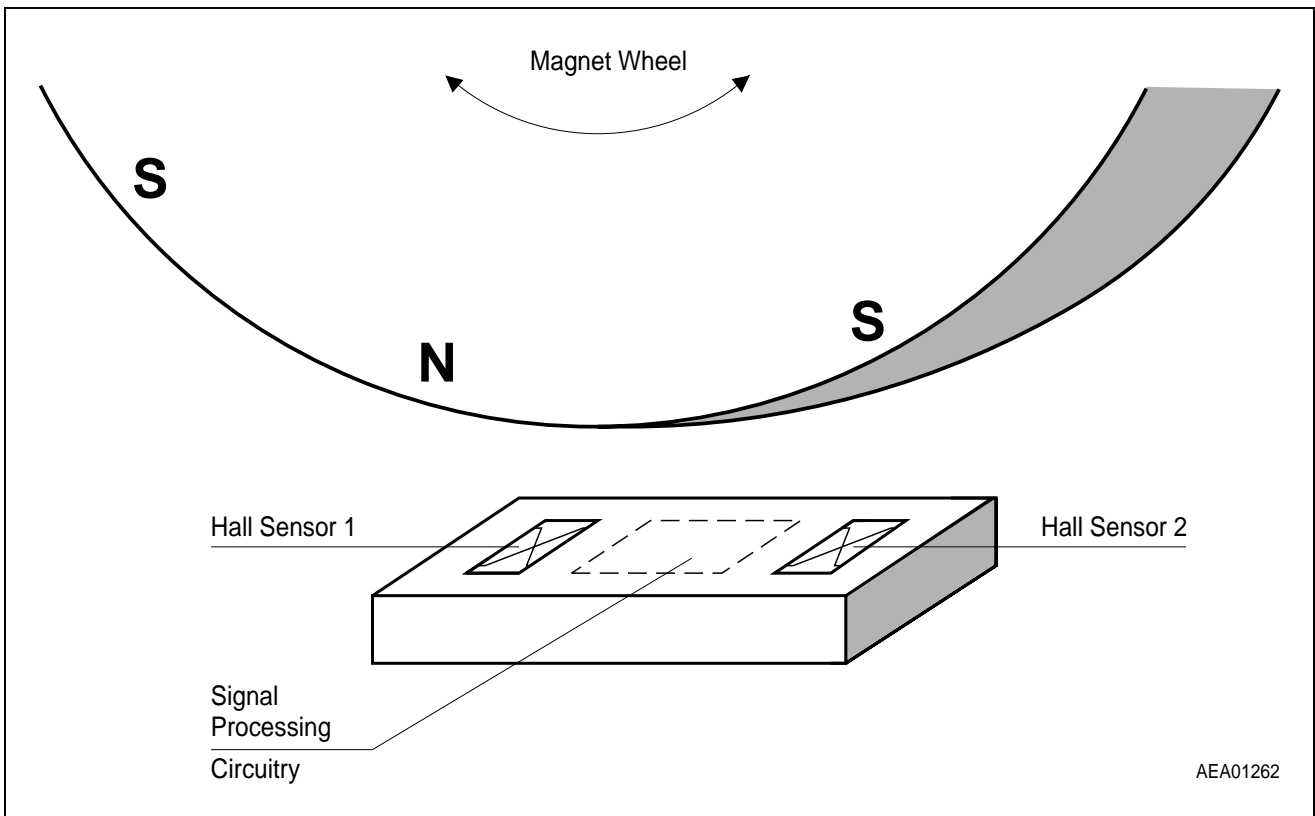


Figure 8 TLE4921-5U, with Magnet Wheel

Application Configurations

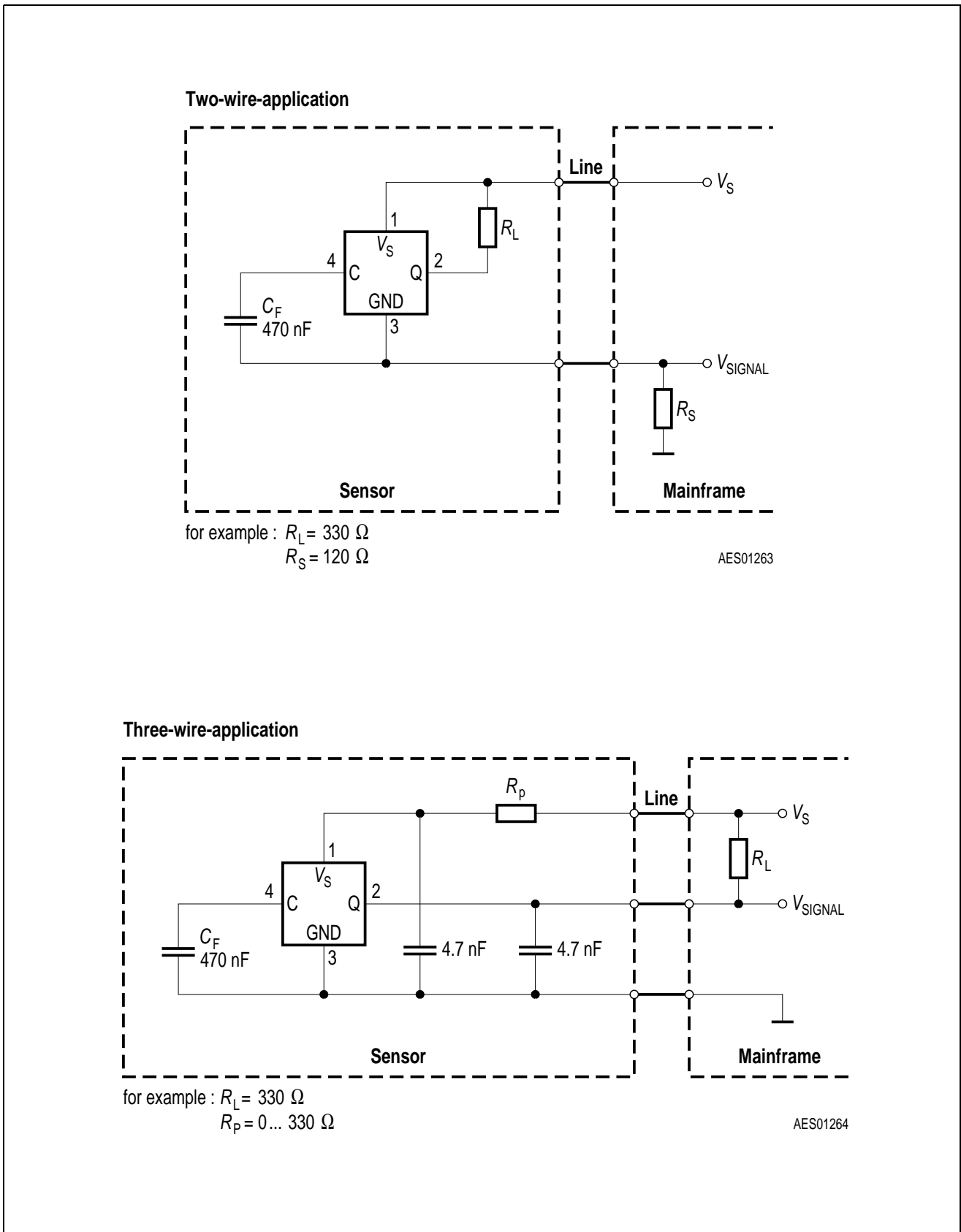


Figure 9 Application Circuits

Application Configurations

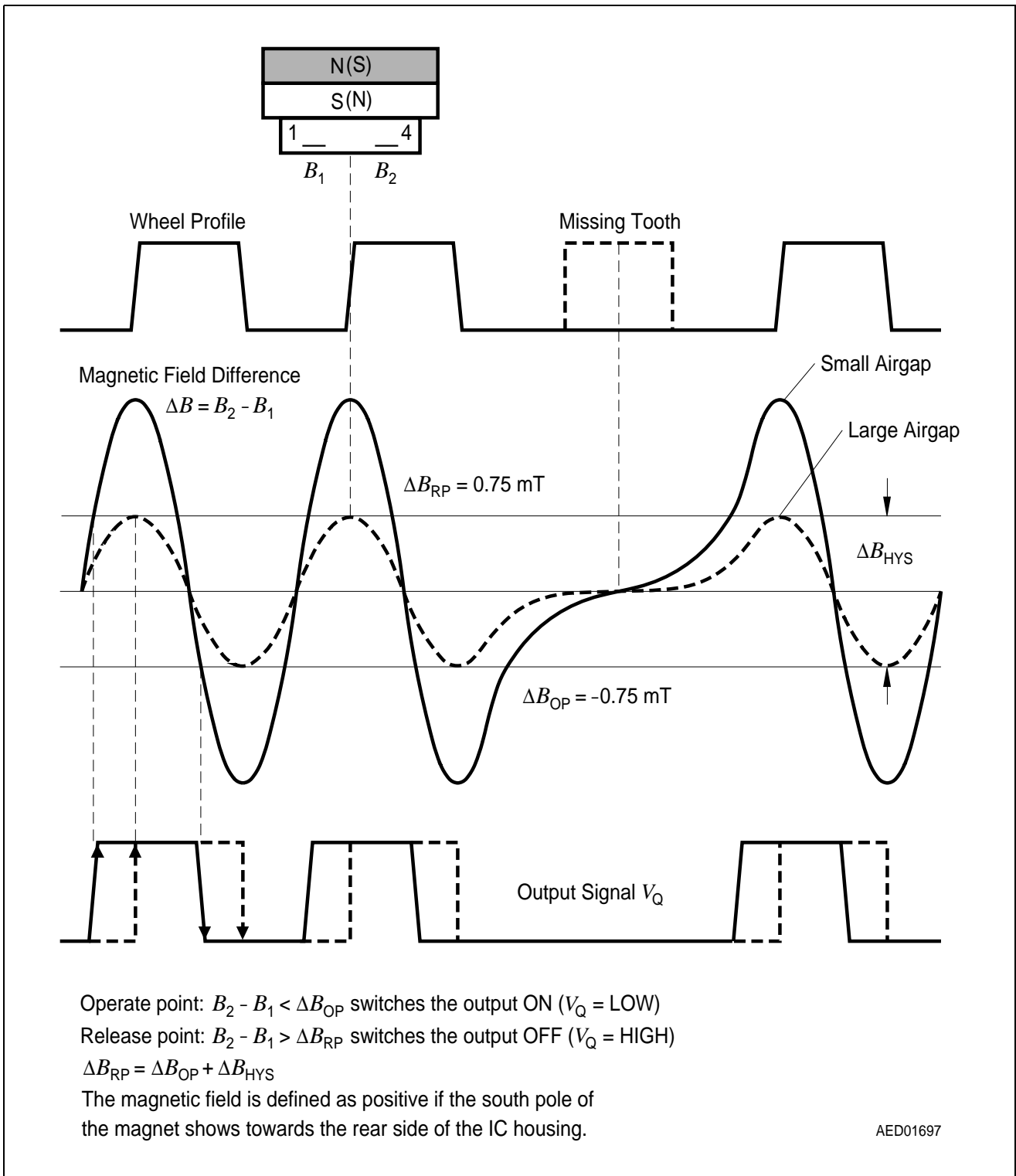
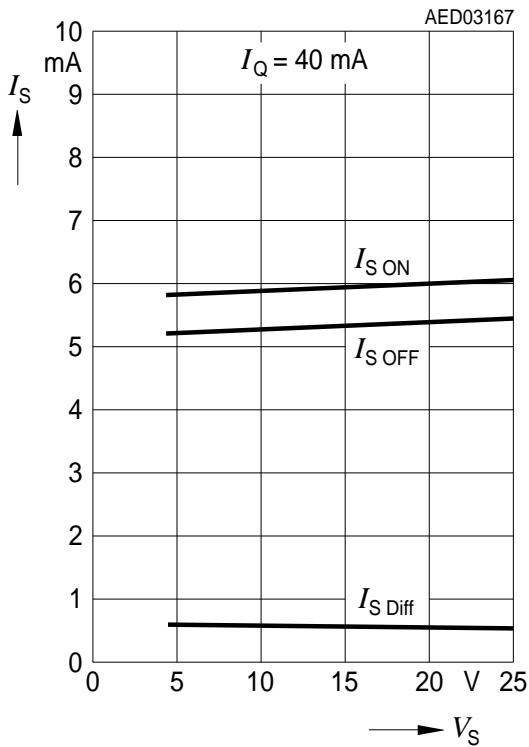


Figure 10 System Operation

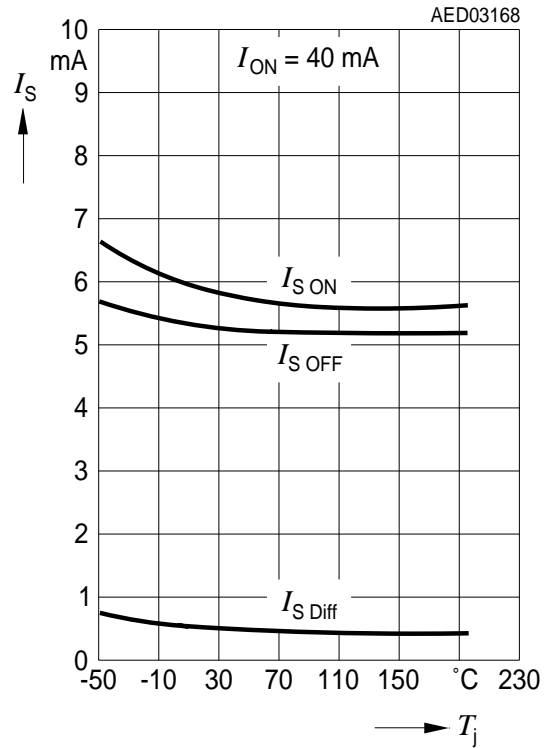
Typical Performance Characteristics

7 Typical Performance Characteristics

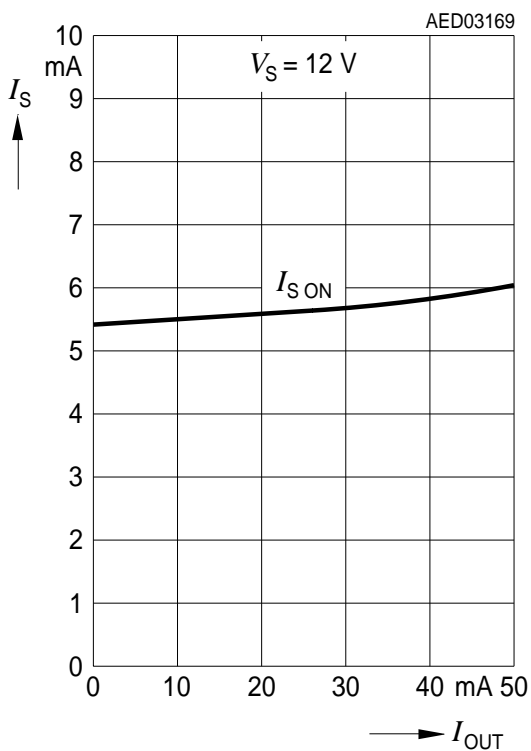
Quiescent Current versus Supply Voltage



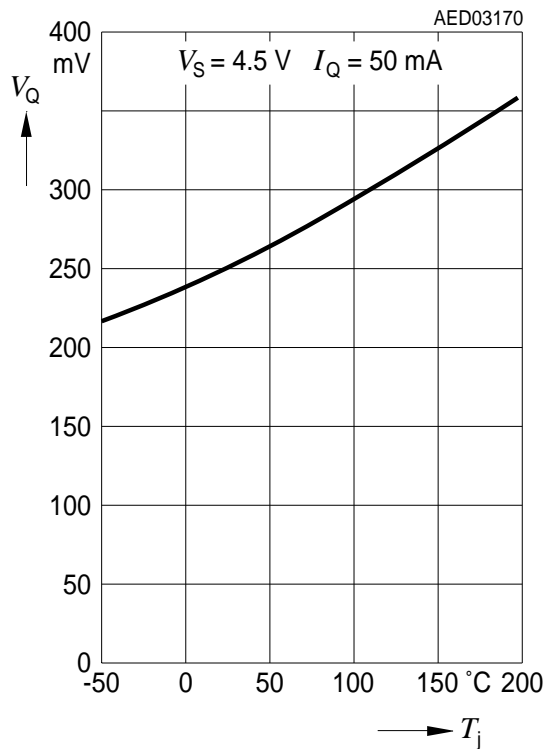
Quiescent Current versus Temperature



Quiescent Current versus Output Current

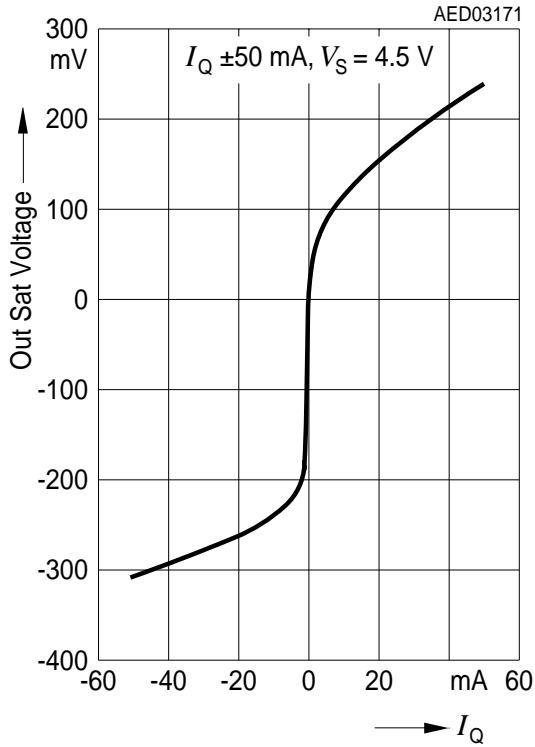


Saturation Voltage versus Temperature

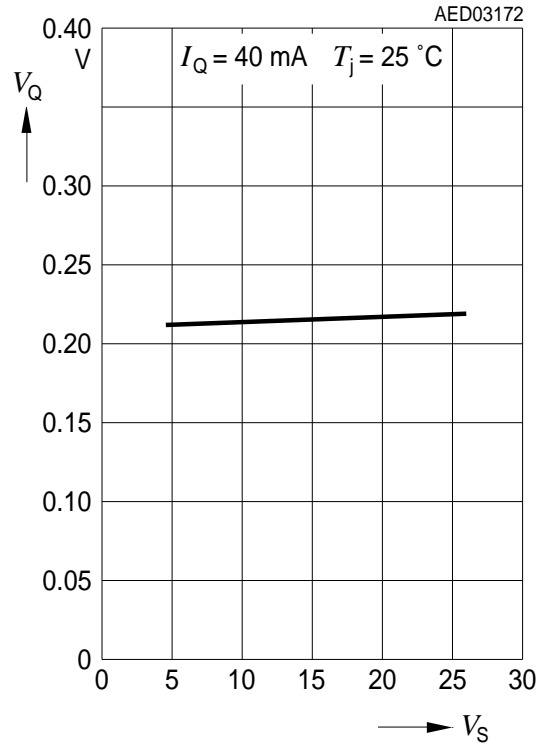


Typical Performance Characteristics

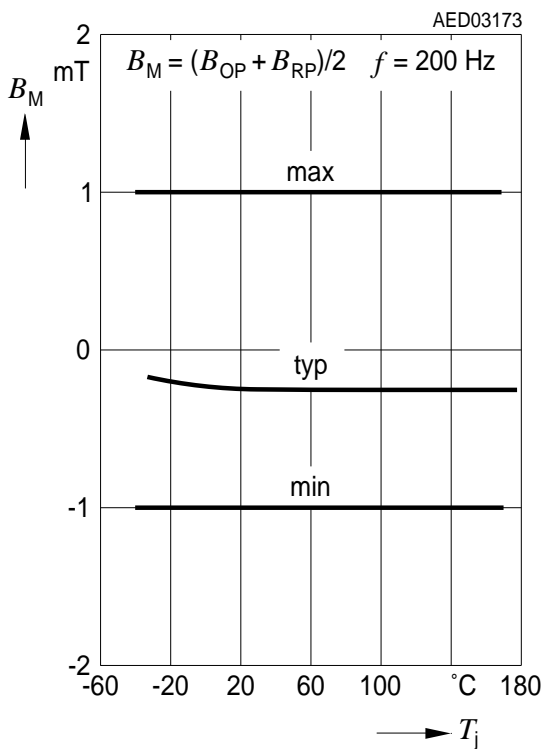
Output Saturation Voltage versus I_Q @ 25°C T_j



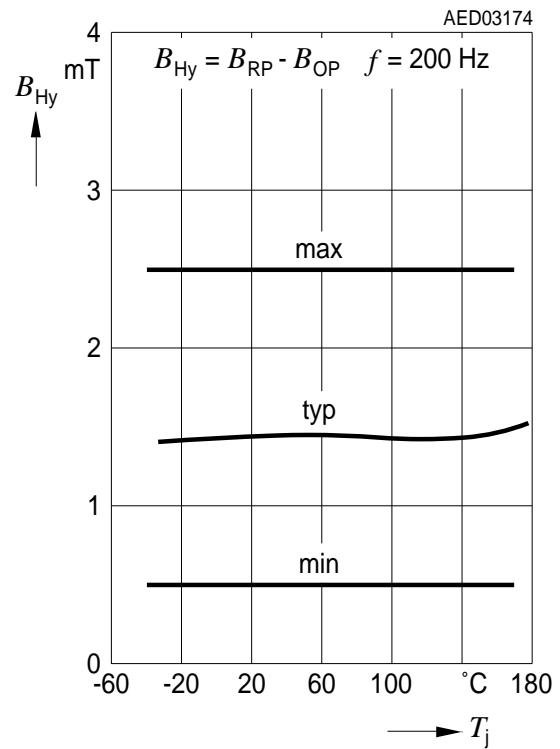
Saturation Voltage versus Supply Voltage



Center of Switching Points versus Temperature

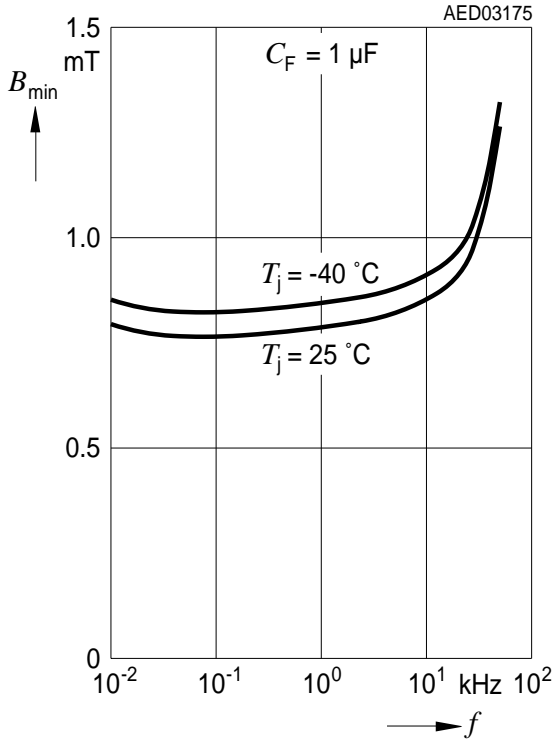


Hysteresis versus Temperature

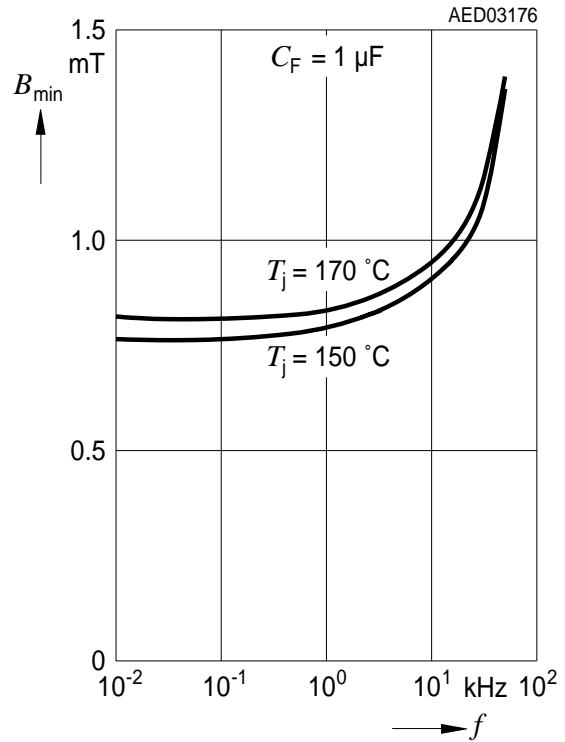


Typical Performance Characteristics

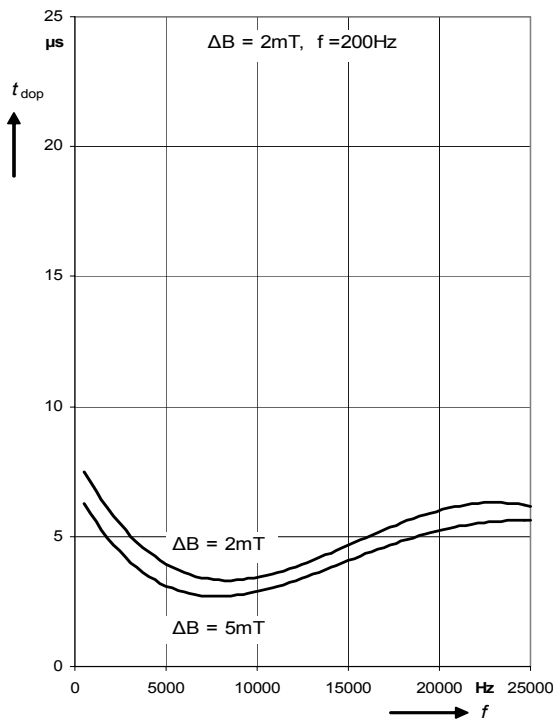
Minimum Switching Field versus Frequency



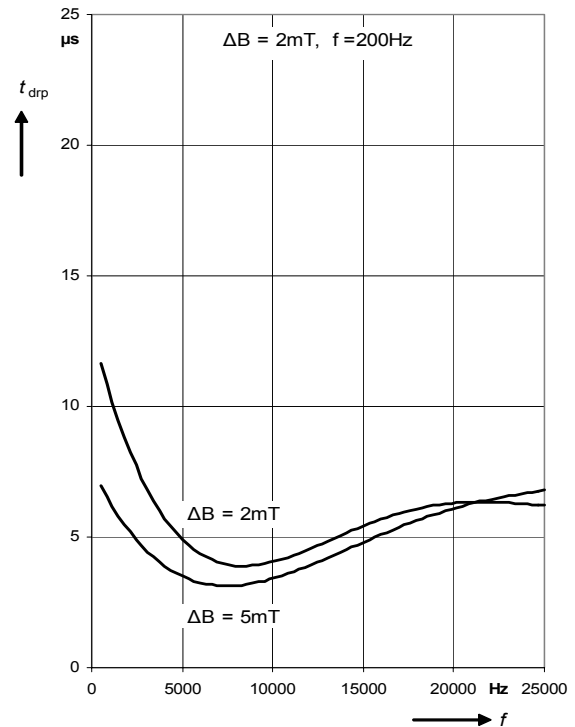
Minimum Switching Field versus Frequency



Delay Time between Switching Threshold ΔB and Falling Edge of V_{OUT} at $T_j = 25^\circ\text{C}$

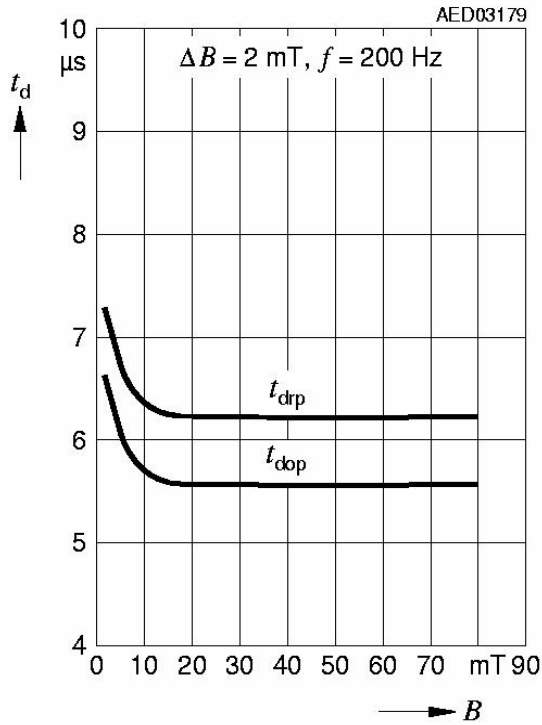


Delay Time between Switching Threshold ΔB and Rising Edge of V_{OUT} at $T_j = 25^\circ\text{C}$

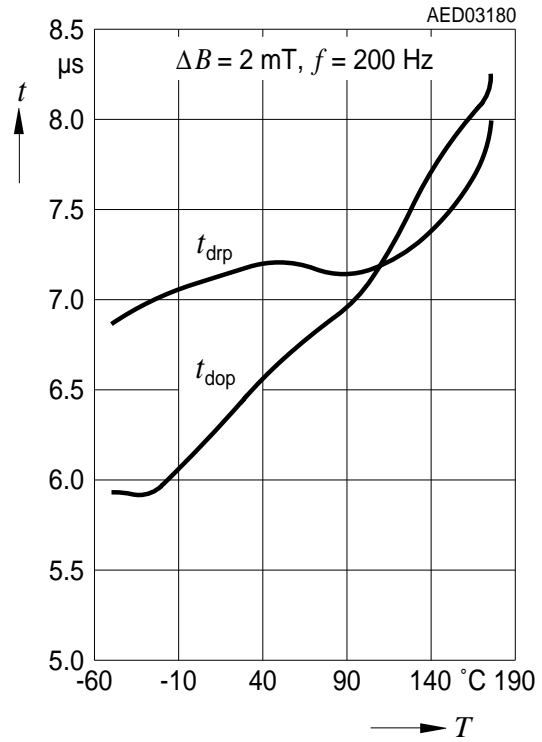


Typical Performance Characteristics

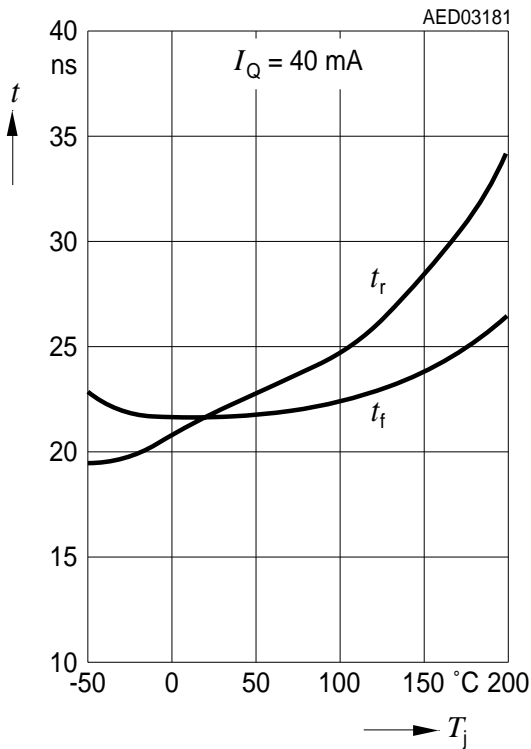
Delay Time versus Differential Field



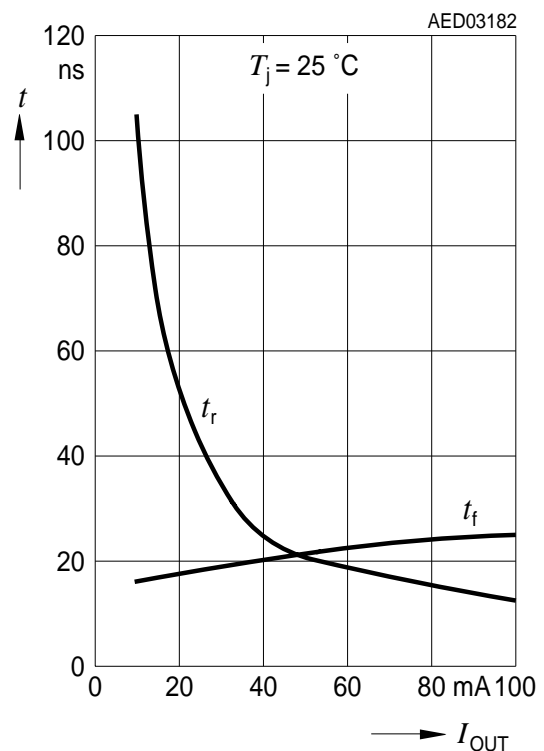
Delay Time versus Temperature



Rise and Fall Time versus Temperature

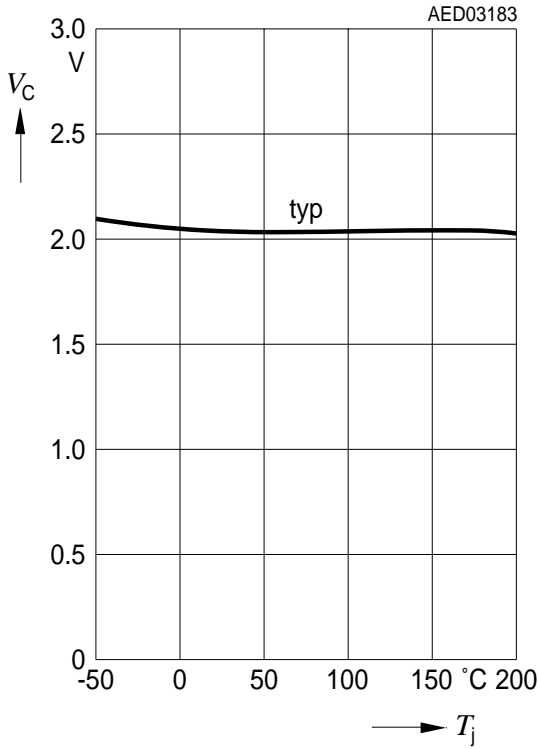


Rise and Fall Time versus Output Current

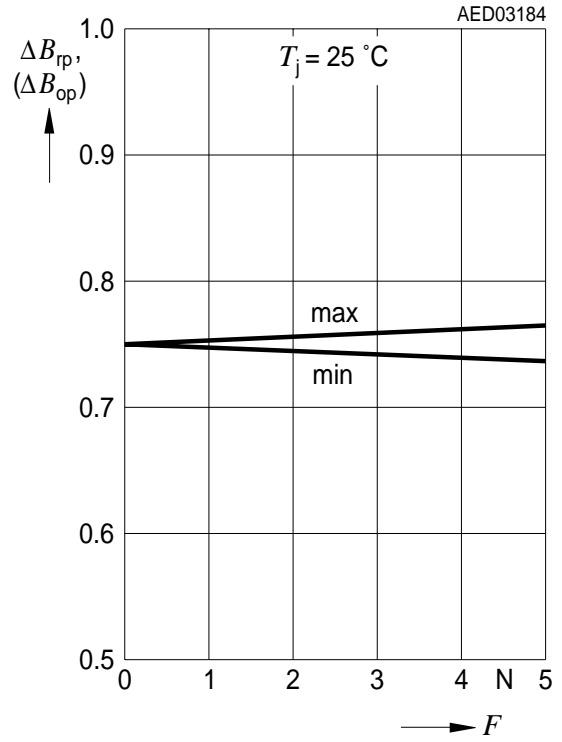


Typical Performance Characteristics

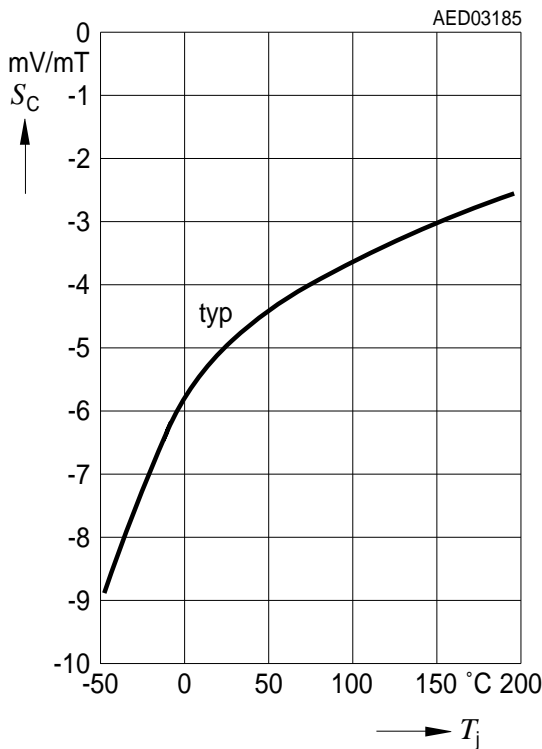
Capacitor Voltage versus Temperature



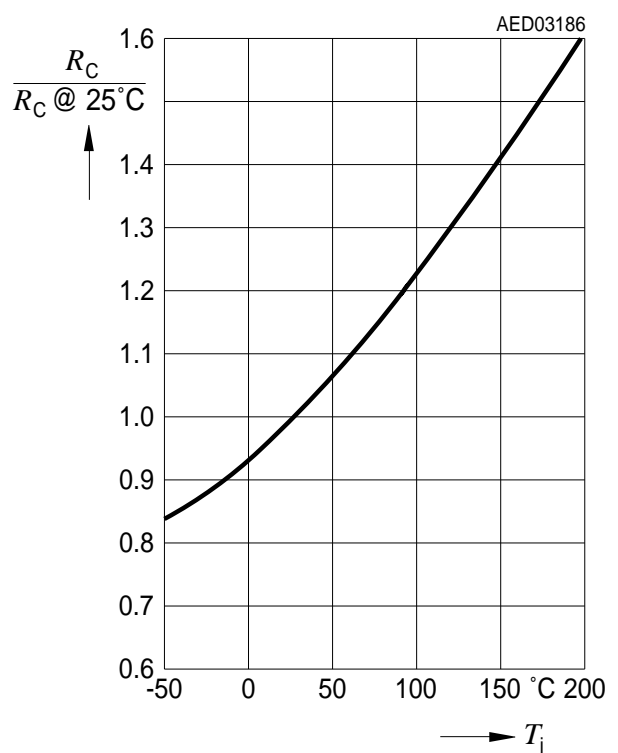
Switching Thresholds versus Mechanical Stress



Filter Sensitivity versus Temperature

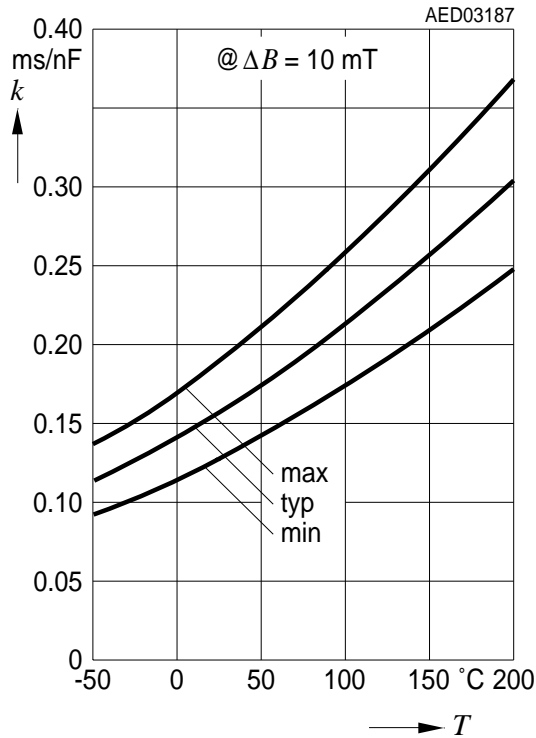


Filter Input Resistance versus Temperature



Typical Performance Characteristics

Delay Time for Power on (V_S Switching from 0 V to 4.5 V) t_{pon} versus Temp.



Periodjitter (1σ) versus Temperature

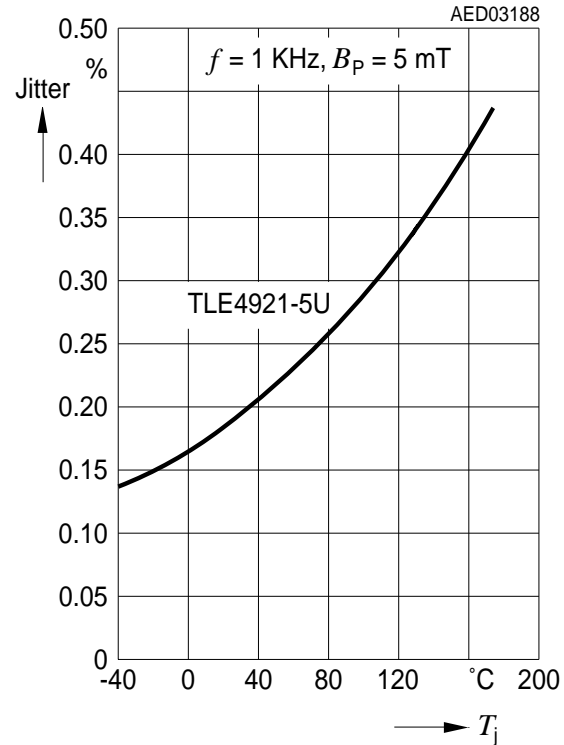


Table 6 Electro Magnetic Compatibility
ref. DIN 40839 part 1; test circuit 1

| Parameter | Symbol | Level/Typ | Status |
|--------------|----------|--------------|--------|
| Testpulse 1 | V_{LD} | IV / - 100 V | C |
| Testpulse 2 | | IV / 100 V | B |
| Testpulse 3a | | IV / - 150 V | C |
| Testpulse 3b | | IV / 100 V | C |
| Testpulse 4 | | IV / - 7 V | C |
| Testpulse 5 | | IV / 86.5 V | C |

Note: Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Typical Performance Characteristics

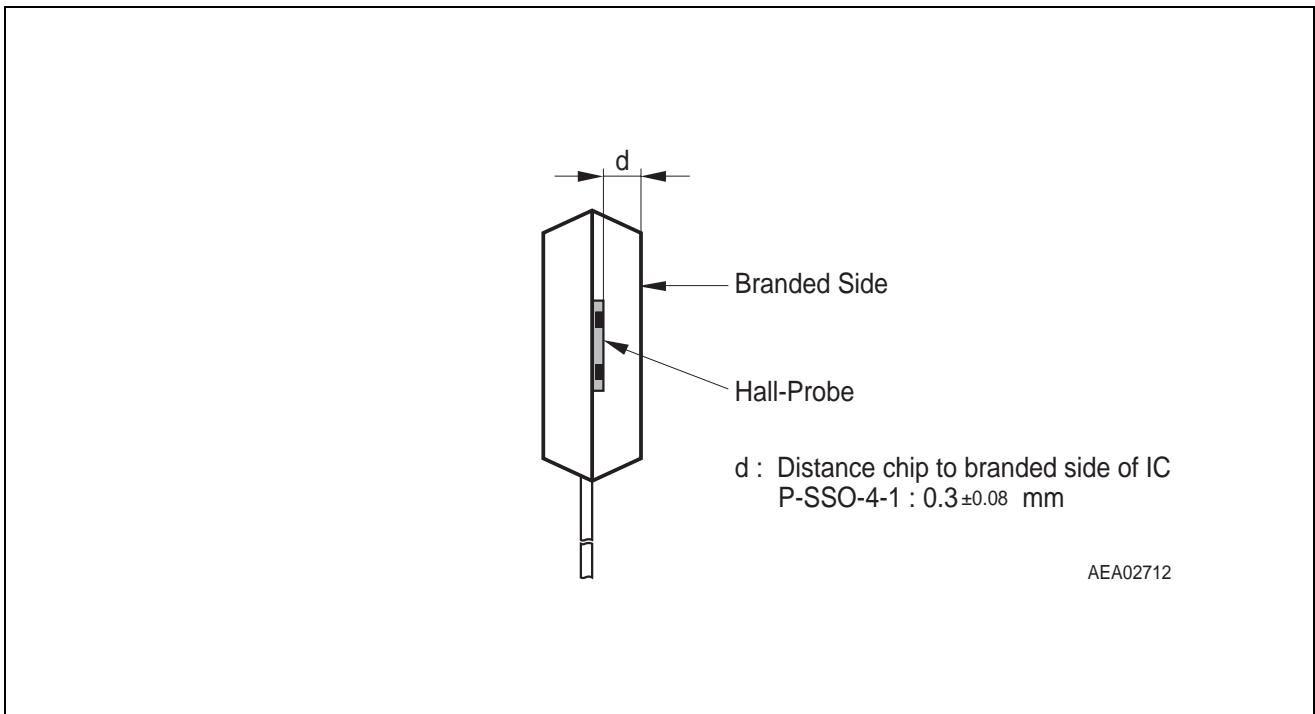


Figure 11 Distance Chip to Upper Side of IC

8 Package Outlines

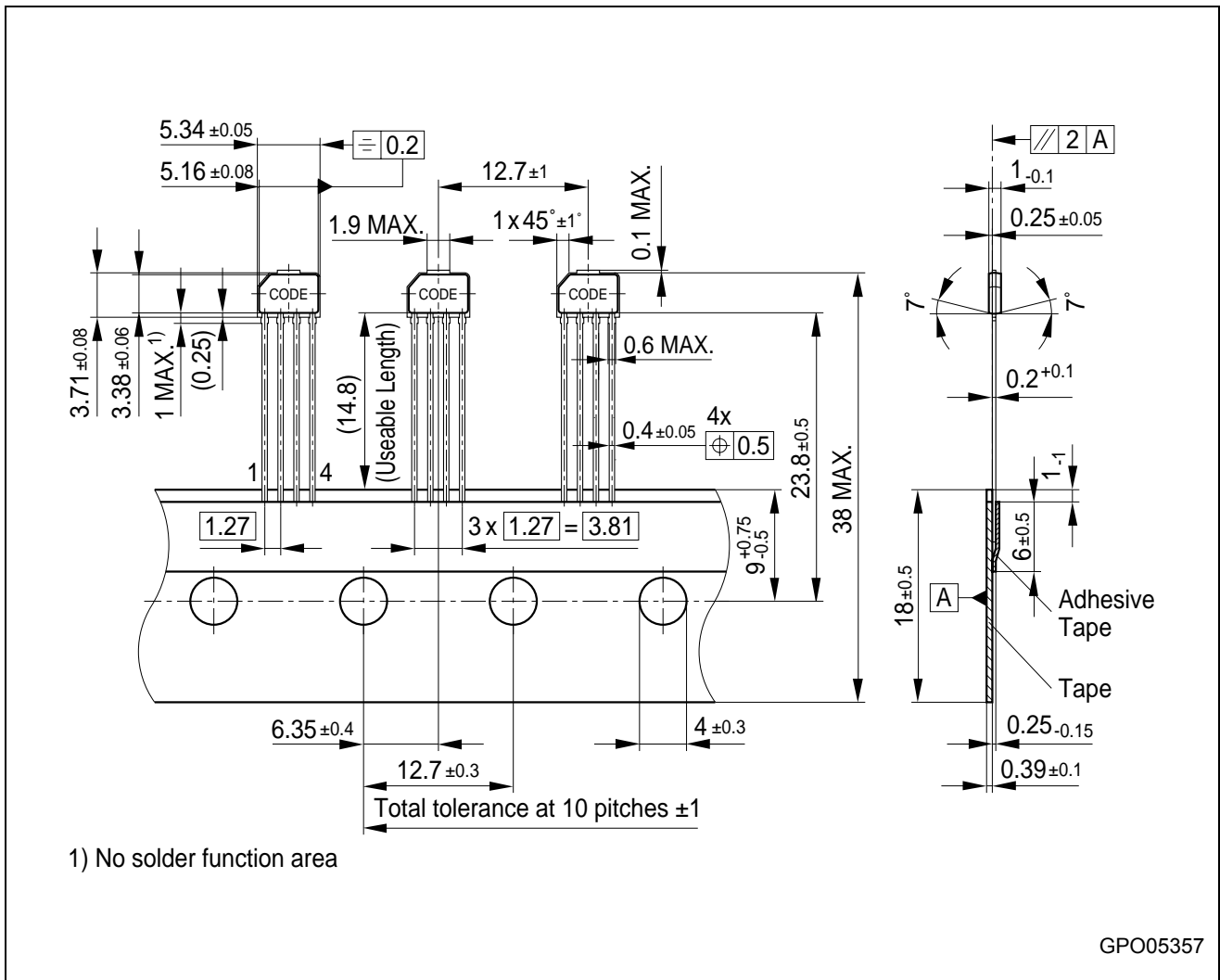


Figure 12 PG-SSO-4-1 (Plastic Single Small Outline Package)

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Dimensions in mm

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