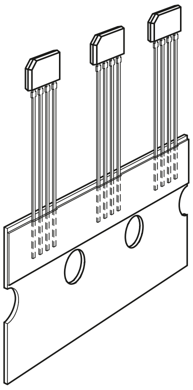
TLE4921-5U

Dynamic Differential Hall Effect Sensor IC Detection

About this document

Overview

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

Target applications

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.

Product type	Marking	Ordering code	Package
TLE4921-5U	215U	SP000013593	PG-SSO-4-1

Please read the Important Notice and Warnings at the end of this document

Table of contents

1 General

1.1 Pin Configuration (view on branded side of component)

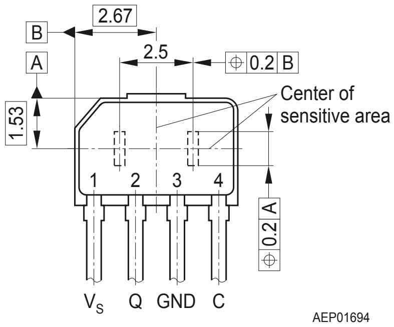


Figure 1

Table 1 **Pin definitions and functions**

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

1.2 Block diagram

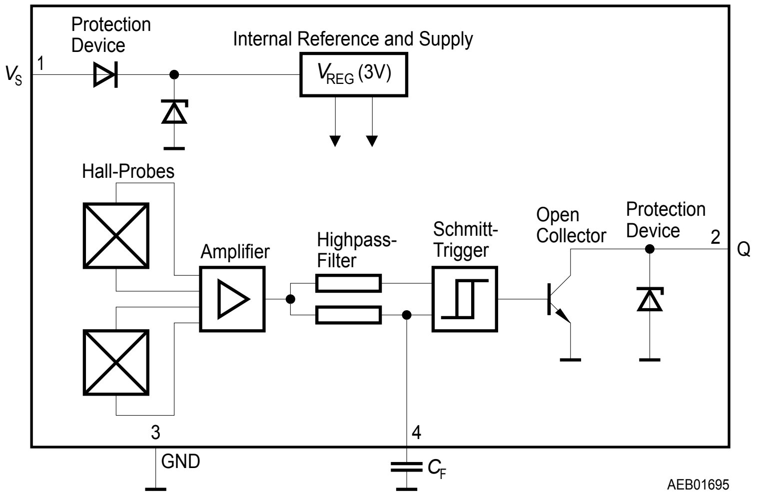


Figure 2 Block diagram

1.3 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 Schmitttrigger 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-wireconfiguration.

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

1.4 Circuit description

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.

2 Maximum ratings

Table 2 Absolute maximum ratings

T_j = -40°C to 150°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	$t < 2$ ms; $v = 0.1$
Current through output-protection device	I_{QZ}	–	200	mA	$t < 2$ ms; $v = 0.1$

(1) Reverse current < 10 mA

3 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.

4 Electrical and magnetic parameters

Table 5 Electrical Characteristics table template

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 = high I_Q = 0 mA	1
		4.3	5.9	8.8	mA	V_Q = low I_Q = 40 mA	1
Output saturation voltage	V_{QSAT}	–	0.25	0.6	V	I_Q = 40 mA	1
Output leakage current	I_{QL}	–	–	50	µA	V_Q = 24 V	1
Center of switching points: $(\Delta B_{OP} + \Delta B_{RP}) / 2$	ΔB_m	-1	0	1	mT	-20 mT < ΔB < 20 mT(1) (2) f = 200 Hz	2
Operate point	ΔB_{OP}	–	–	0	mT	f = 200 Hz, ΔB = 20 mT	2
Release point	ΔB_{RP}	0	–	–	mT	f = 200 Hz, ΔB = 20 mT	2
Hysteresis	ΔB_H	0.5	1.5	2.5	mT	f = 200 Hz, ΔB = 20 mT	2
Overvoltage protection at supply voltage at output	V_{SZ}	27	–	35	V	I_S = 16 mA	1
	V_{QZ}	27	–	35	V	I_Q = 16 mA	1
Output rise time	t_r	–	–	0.5	µs	I_Q = 40 mA C_L = 10 pF	1
Output fall time	t_f	–	–	0.5	µs	I_Q = 40 mA C_L = 10 pF	1
Delay time	t_{dop}	–	–	25	µs	f = 10 kHz ΔB = 5 mT	2
	t_{drp}	–	–	10	µs		
	$t_{dop} - t_{drp}$	–	0	15	µs		
Filter input resistance	R_C	35	43	52	kΩ	25°C ±2°C	1
Filter sensitivity to ΔB	S_C	–	-5	–	mV/mT	–	1
Filter bias voltage	V_C	1.6	2	2.4	V	ΔB = 0	1
Frequency	f	(3)	–	2000	Hz	ΔB = 5 mT	2
Resistivity against mechanical stress (piezo)	ΔBm	-0.1	–	0.1	mT	F = 2 N	2(4)
	ΔBH	-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 Bm caused by a leakage current IL can be 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°C and the given supply voltage.*

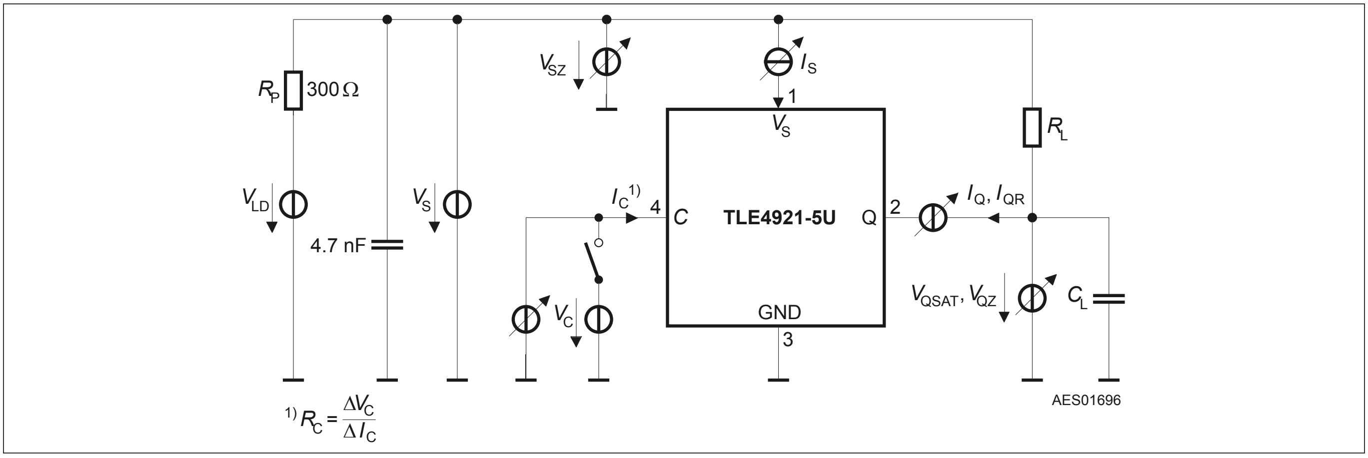


Figure 3 **Test circuit 1**

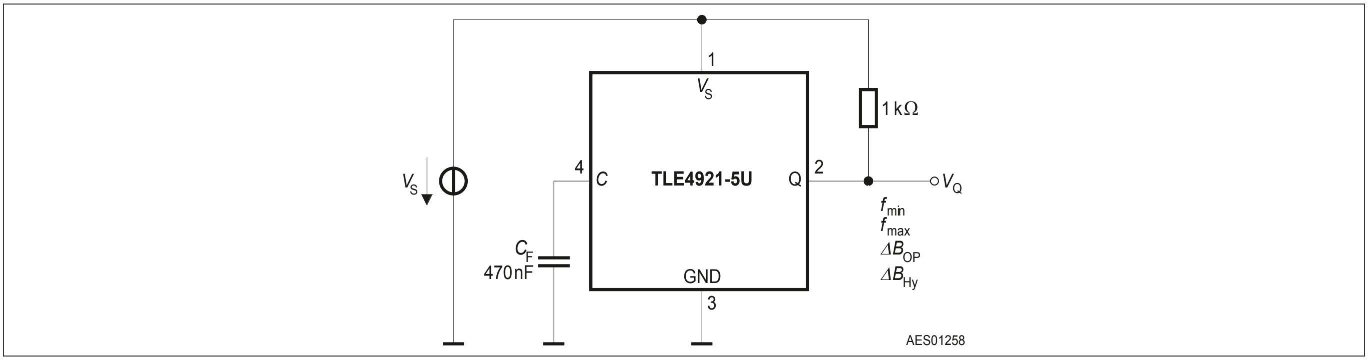


Figure 4 **Test circuit 2**

5 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. $SmCO_5$ (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)

a centered distance of Hall probes
b Hall probes to IC surface
L IC surface to tooth wheel

a = 2.5 mm
b = 0.3 mm

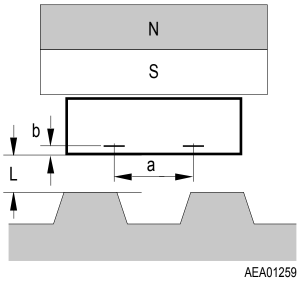
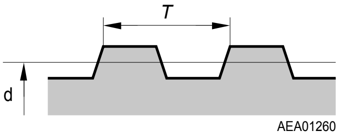


Figure 5 **Sensor Spacing**



Conversion DIN – ASA
$m = 25.4$ mm/p
$T = 25.4$ mm CP

DIN

d	diameter (mm)
z	number of teeth
m	module $m = d/z$ (mm)
T	pitch $T = \pi \times m$ (mm)

ASA

p	diameter pitch $p = z/d$ (inch)
PD	pitch diameter PD $= z/p$ (inch)
CP	circular pitch CP = 1 inch $\times \pi/p$

Figure 6 **Tooth Wheel Dimensions**

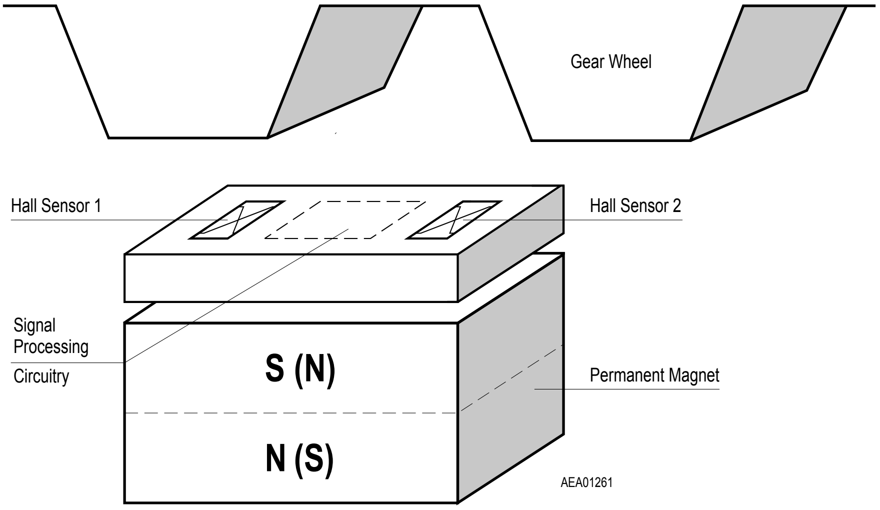


Figure 7 **TLE4921-5U, with Ferromagnetic Toothed Wheel**

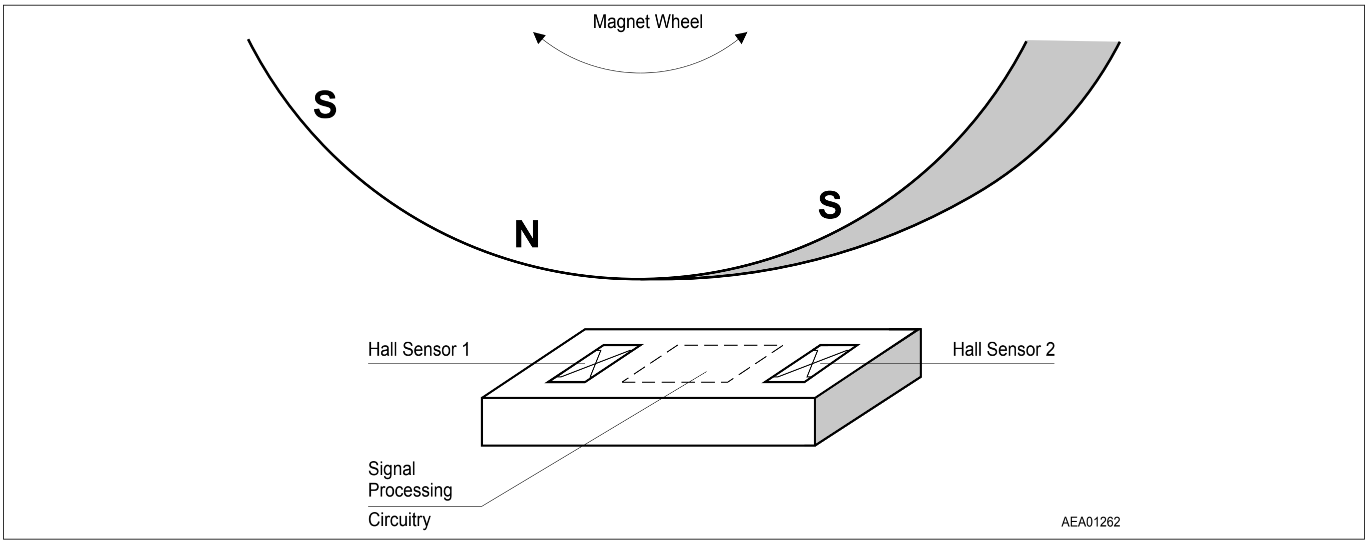


Figure 8 TLE4921-5U, with Magnet Wheel

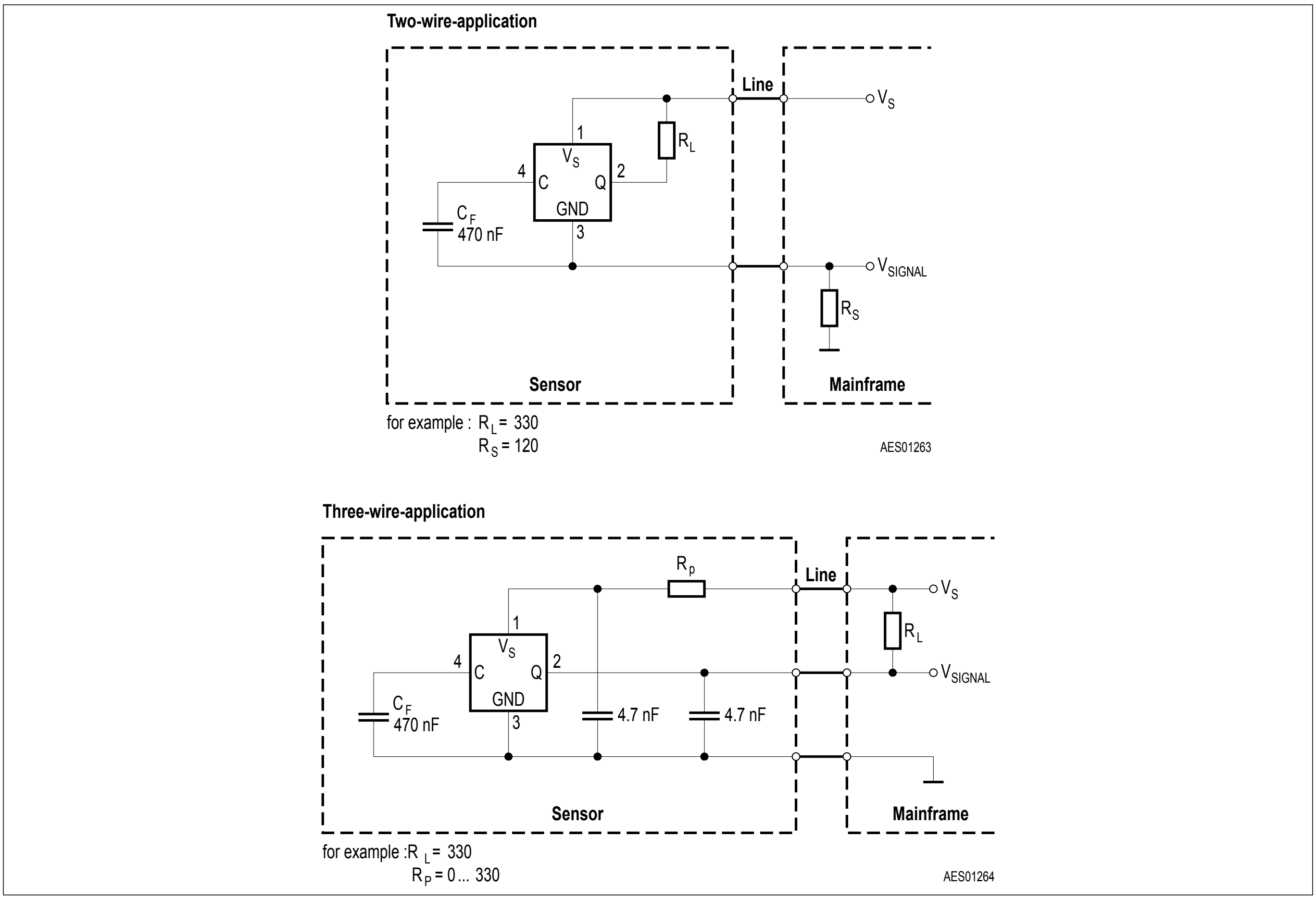
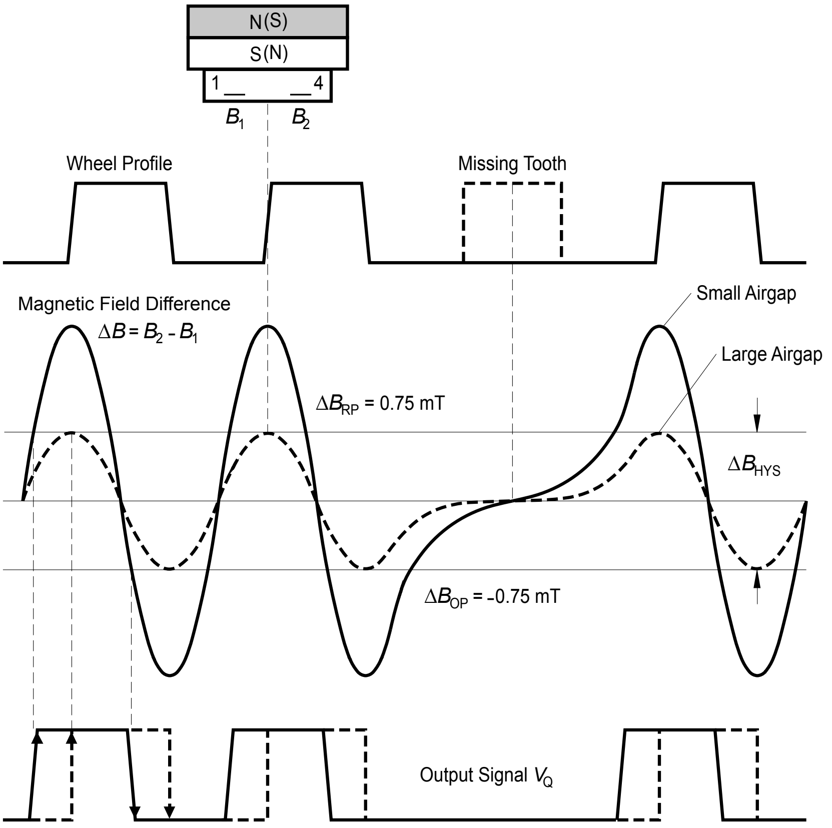


Figure 9 Application Circuits



Operate point: $B_2 - B_1 < \Delta B_{OP}$ switches the output ON (V_Q = LOW)
Release point: $B_2 - B_1 > \Delta B_{RP}$ switches the output OFF (V_Q = HIGH)
$\Delta B_{RP} = \Delta B_{OP} + \Delta B_{HYS}$
The magnetic field is defined as positive if the south pole of the magnet shows towards the rear side of the IC housing.

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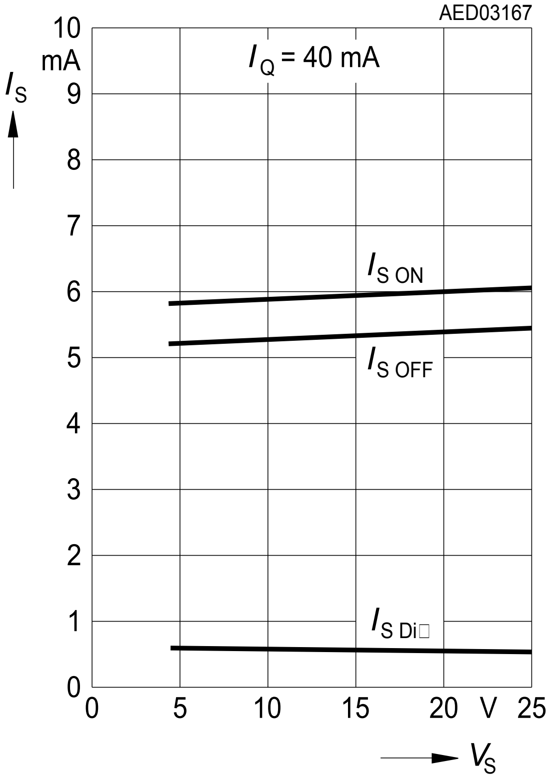
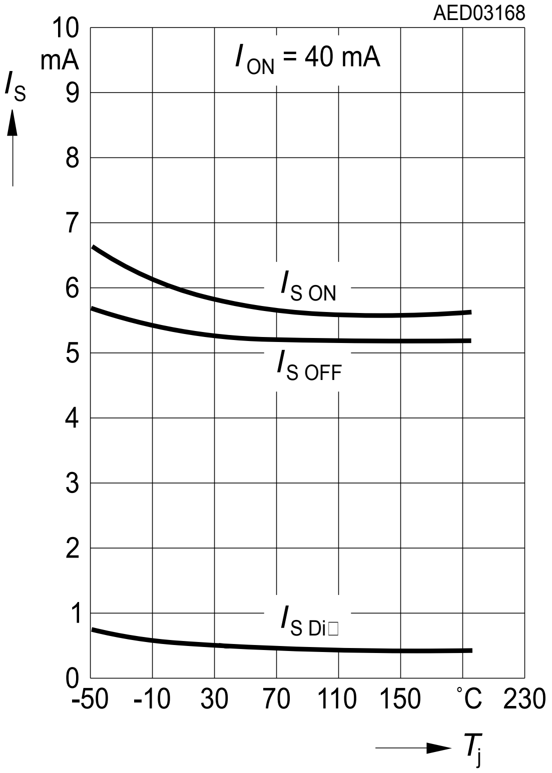
Figure 10 System Operation

6 Typical performance characteristics

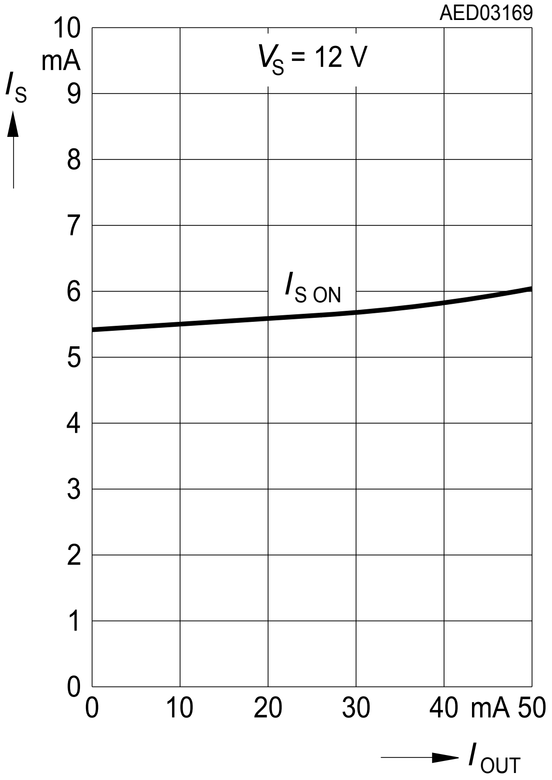
Quiescent Current versus Supply Voltage



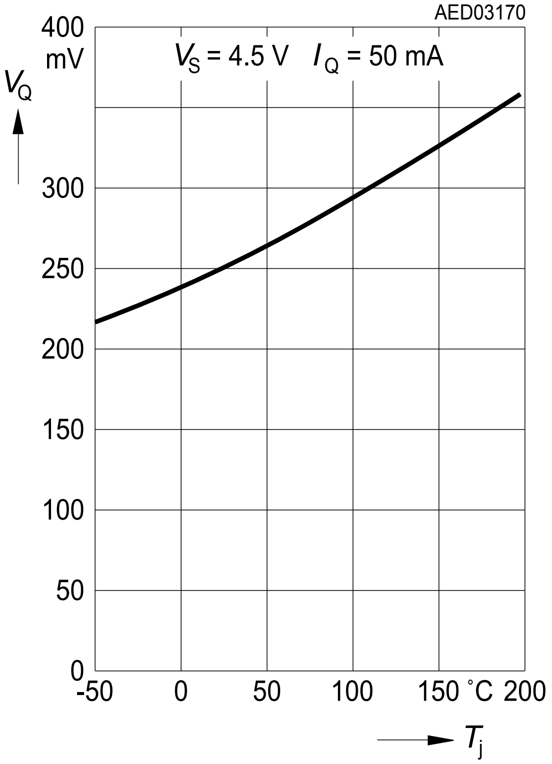
Quiescent Current versus Temperature



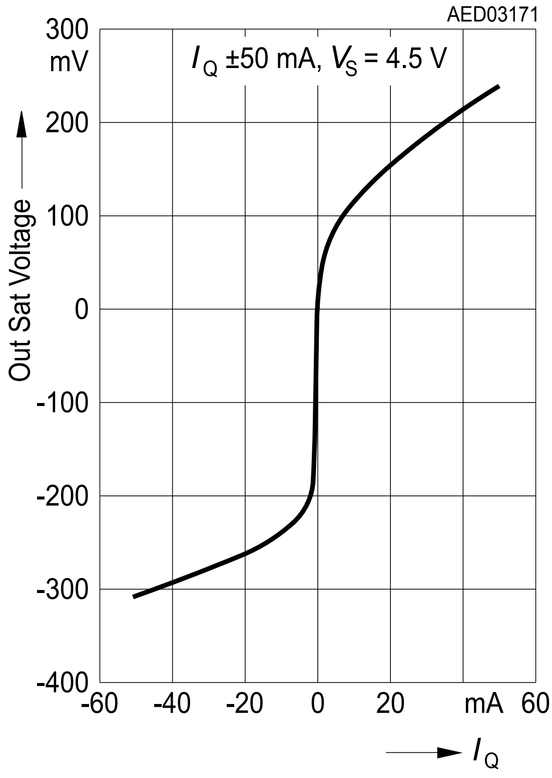
Quiescent Current versus Output Current



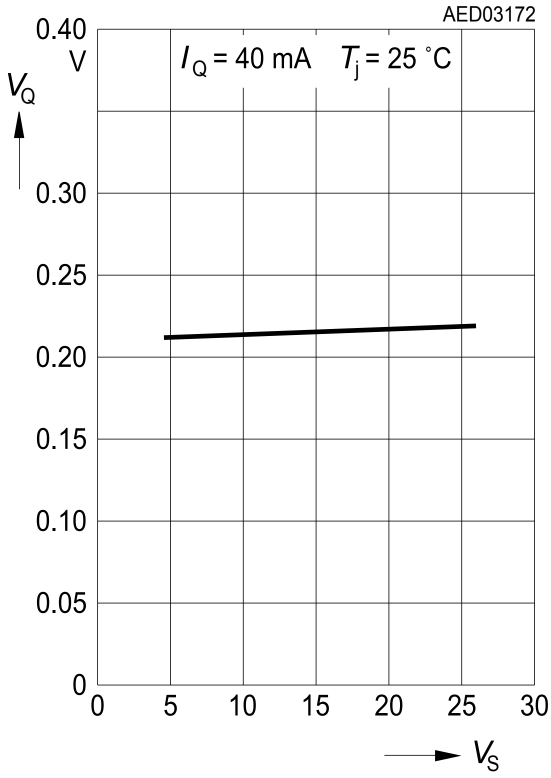
Saturation Voltage versus Temperature



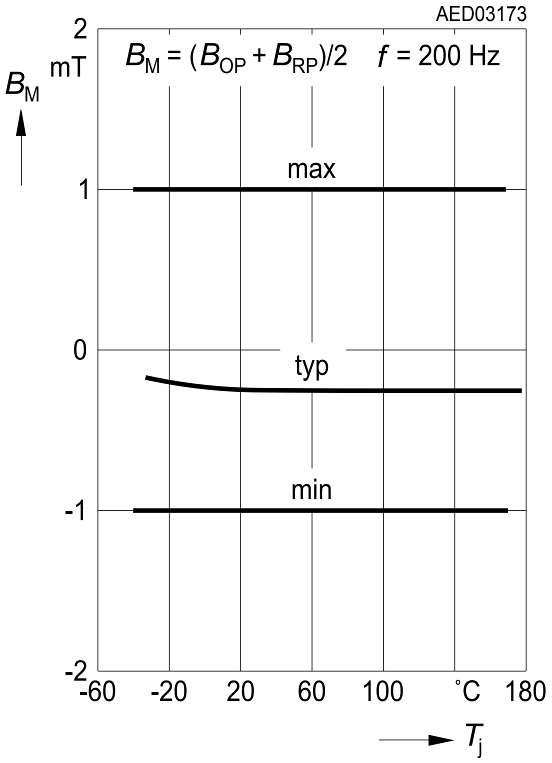
Output Saturation Voltage versus I_Q @ 25°C T_j



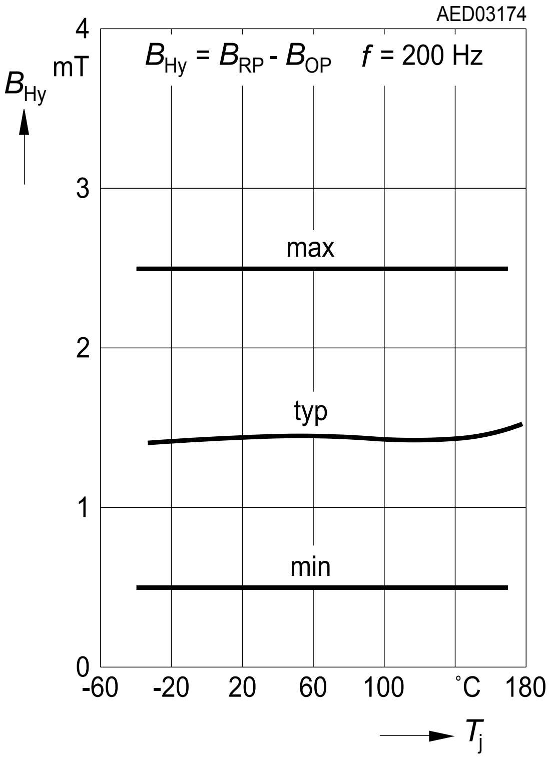
Saturation Voltage versus Supply Voltage



Center of Switching Points versus Temperature

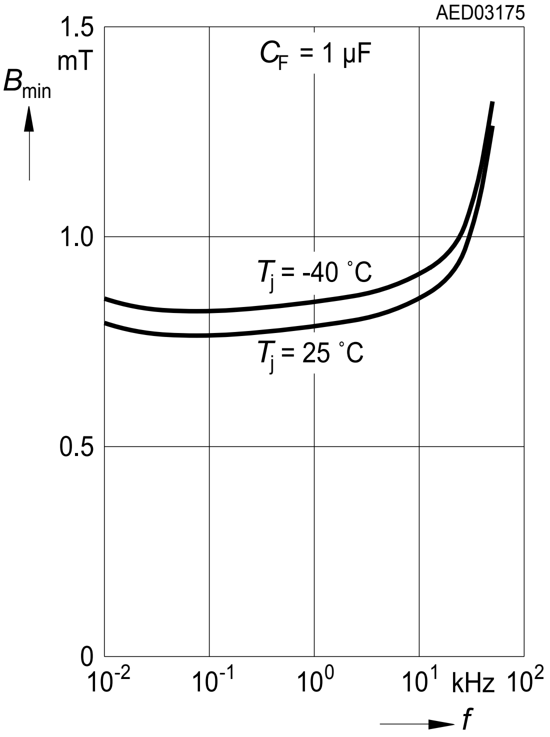


Hysteresis versus Temperature

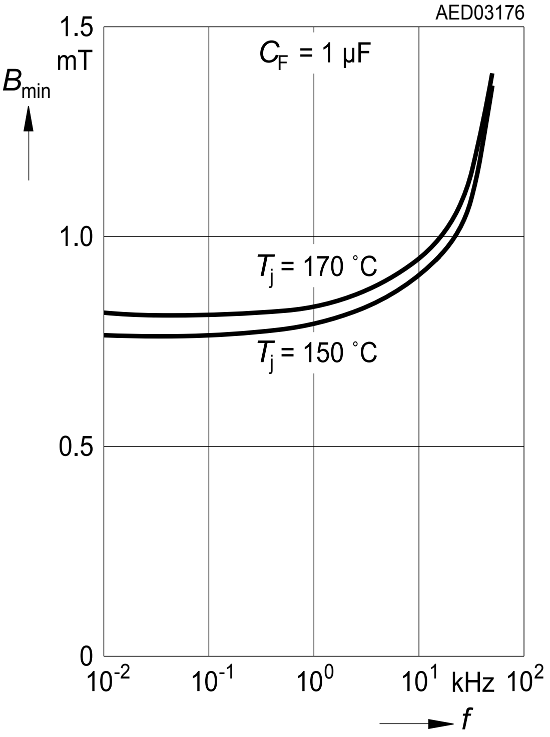


6 Typical performance characteristics

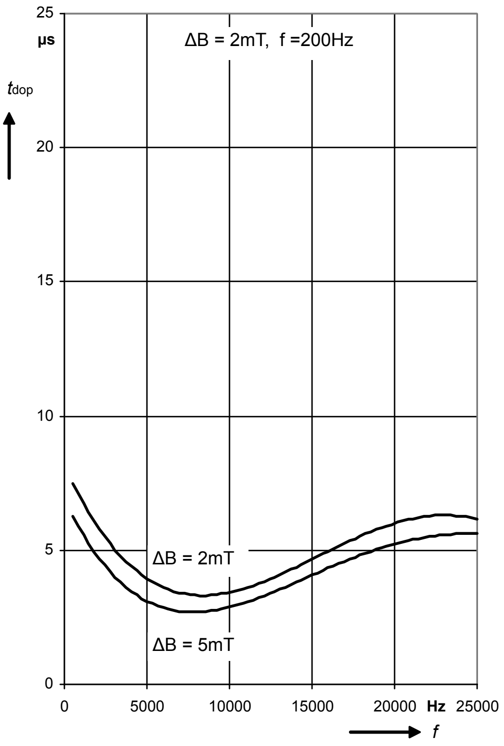
Minimum Switching Field versus Frequency



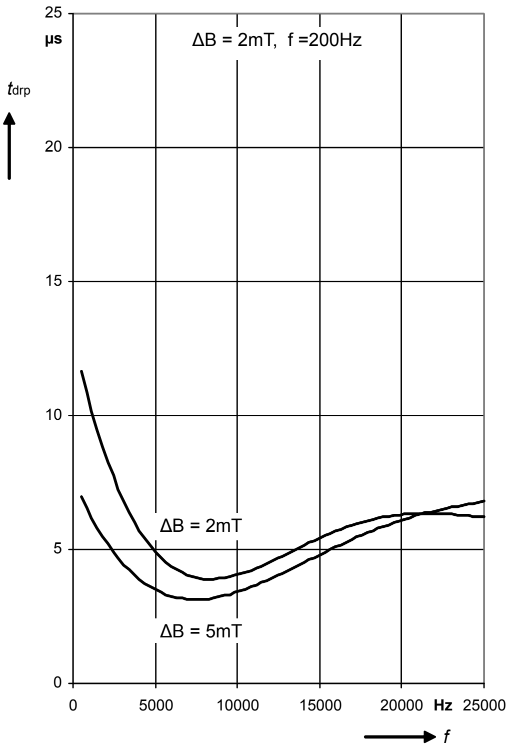
Minimum Switching Field versus Frequency



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

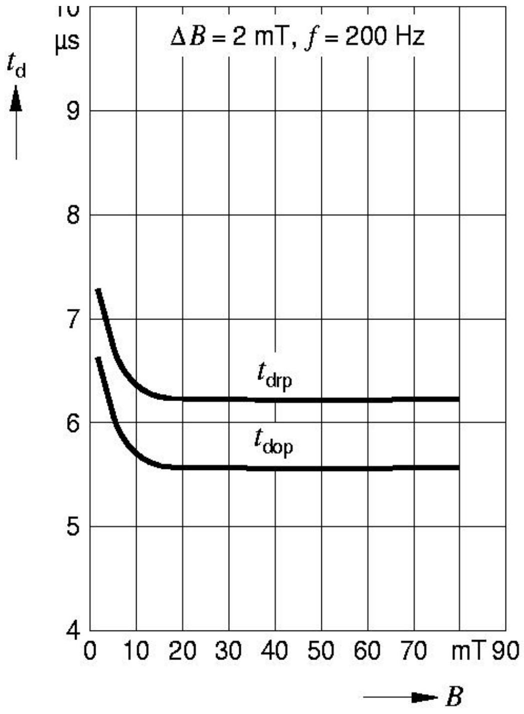


Delay Time between Switching Threshold ΔB and Rising Edge of V_{OUT} at $T_j = 25°C$

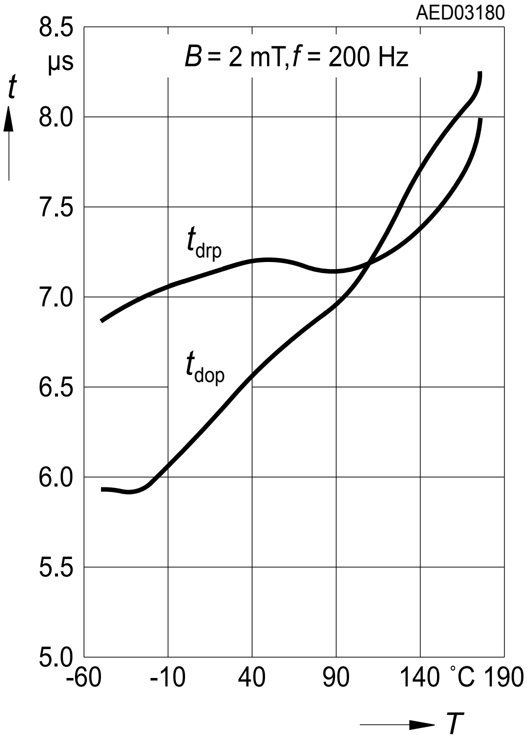


6 Typical performance characteristics

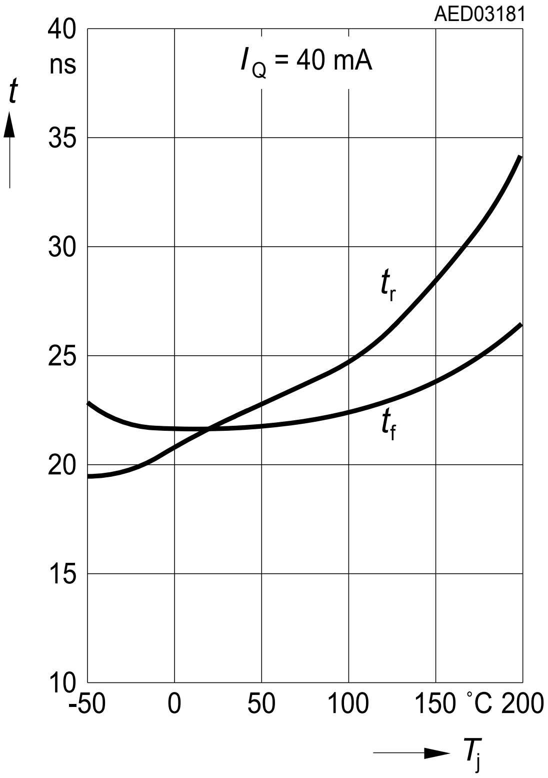
Delay Time versus Differential Field



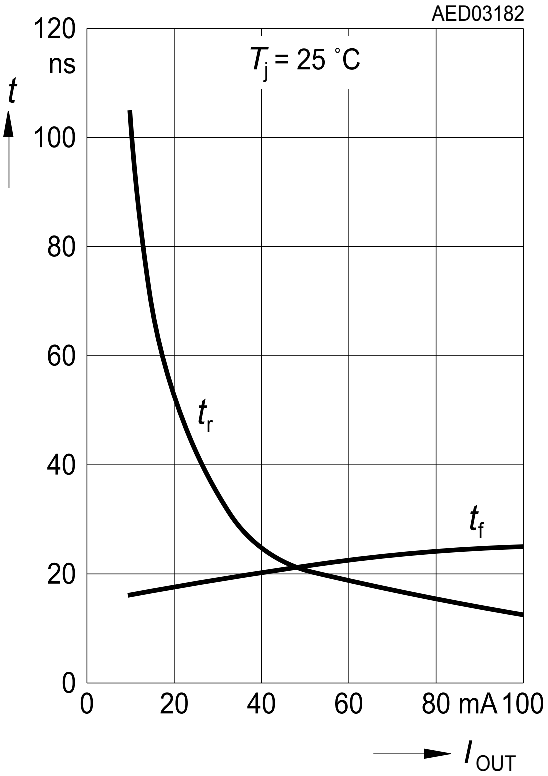
Delay Time versus Temperature



Rise and Fall Time versus Temperature

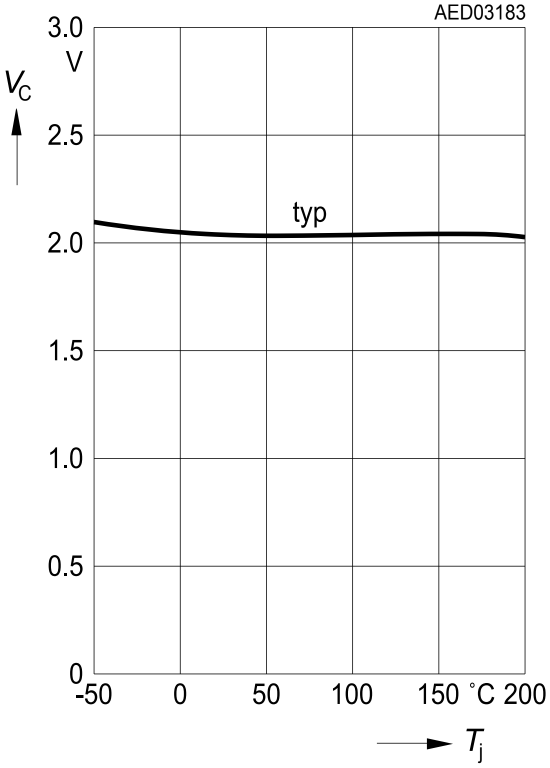


Rise and Fall Time versus Output Current

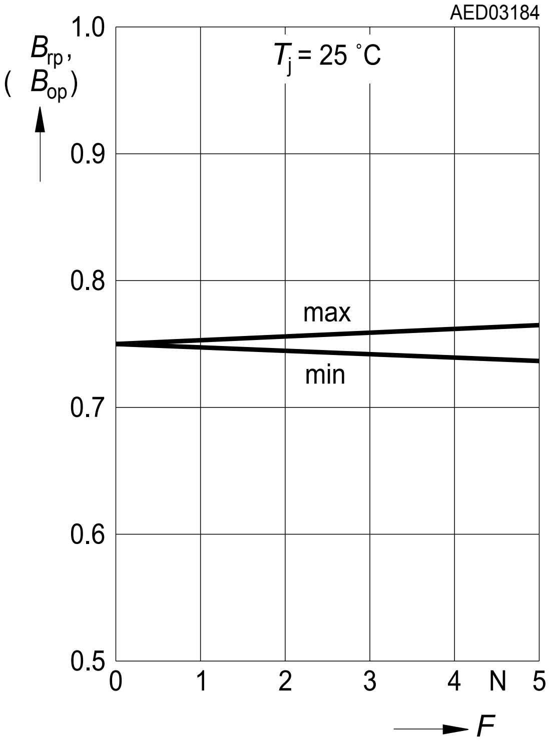


6 Typical performance characteristics

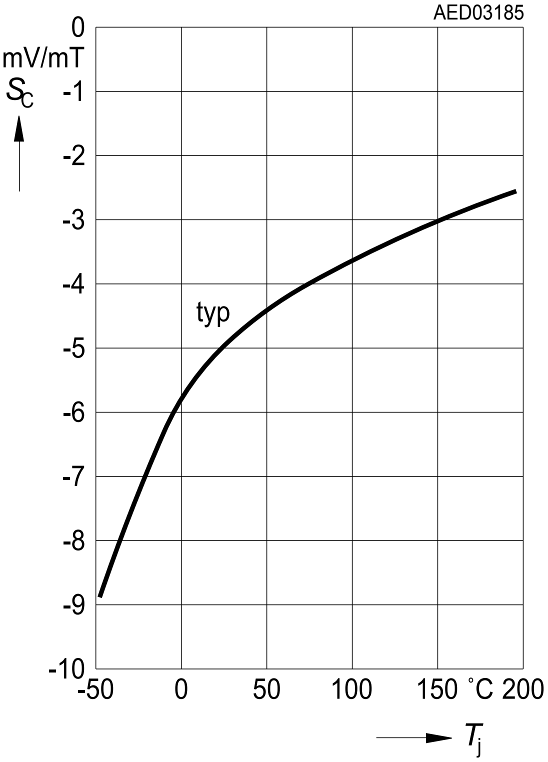
Capacitor Voltage versus Temperature



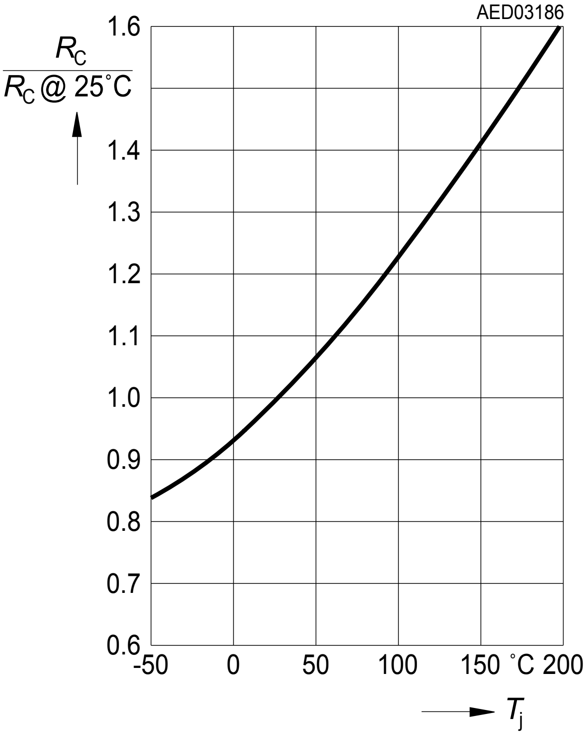
Switching Thresholds versus Mechanical Stress



Filter Sensitivity versus Temperature

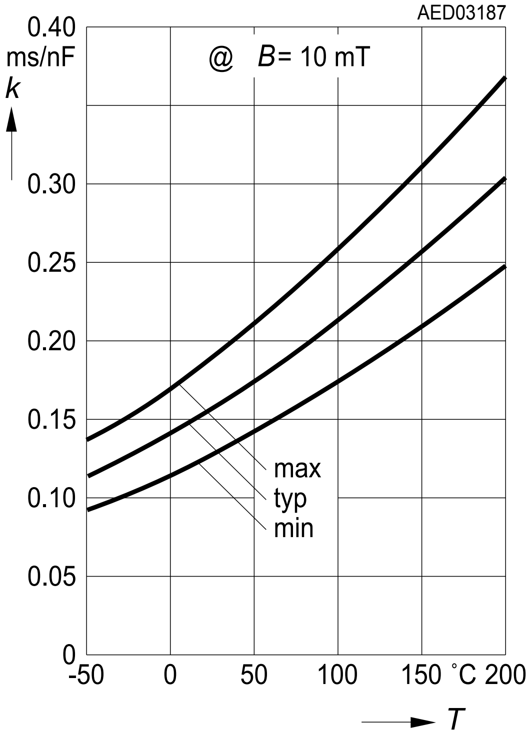


Filter Input Resistance versus Temperature



6 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

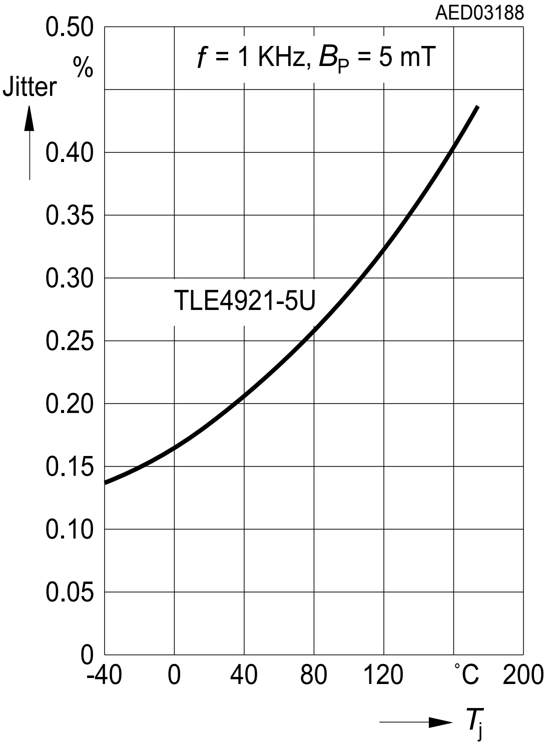


Table 6 Electro magnetic compatibility

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.*

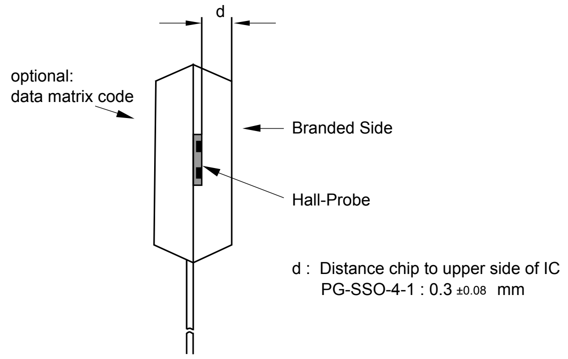
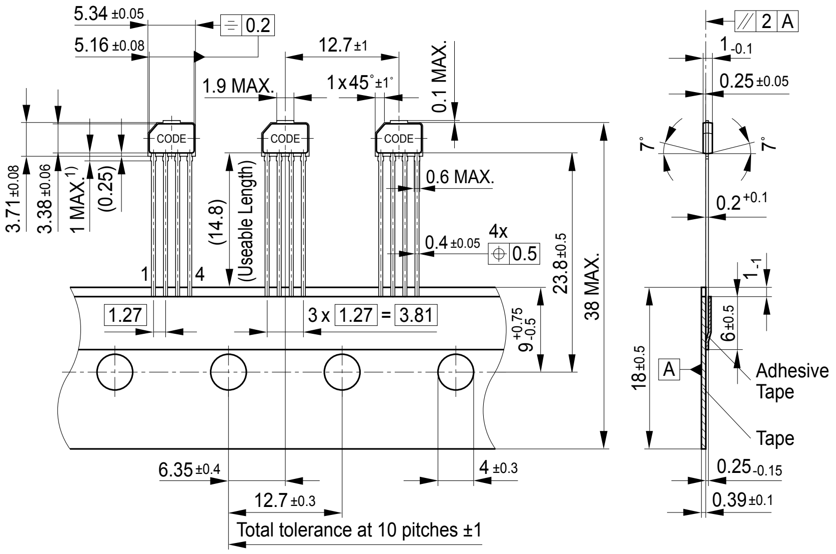


Figure 11 Distance Chip to Upper Side of IC

7 Package outlines



1) No solder function area

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

You can find all of our packages, sorts of packing and others in our Infineon Internet Page “Products”: http://www.infineon.com/products. Dimensions in mm

8 Revision history

Revision History

Page	Subjects (major changes since last revision)
Revision History: 2020-11, Rev. 1.2	
Previous Revisions: Rev. 1.1	
17	Edited figure 11 (optional: data matrix code)
Rev. 1.0	
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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