

# TLE4921-5U

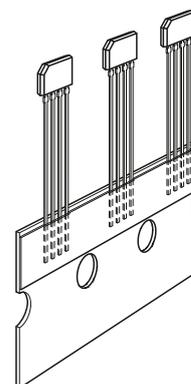
## Dynamic Differential Hall Effect Sensor IC Detection

### 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

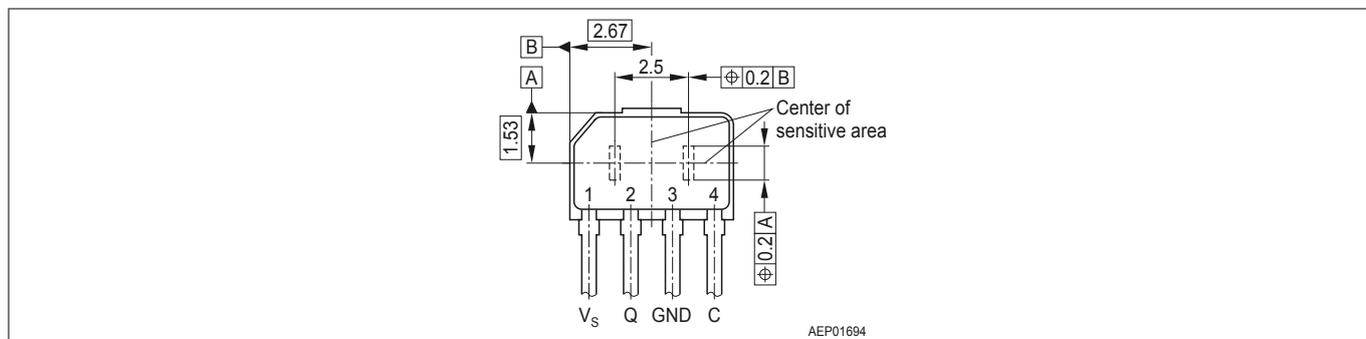
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**1 General**

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**1.1 Pin Configuration (view on branded side of component)**

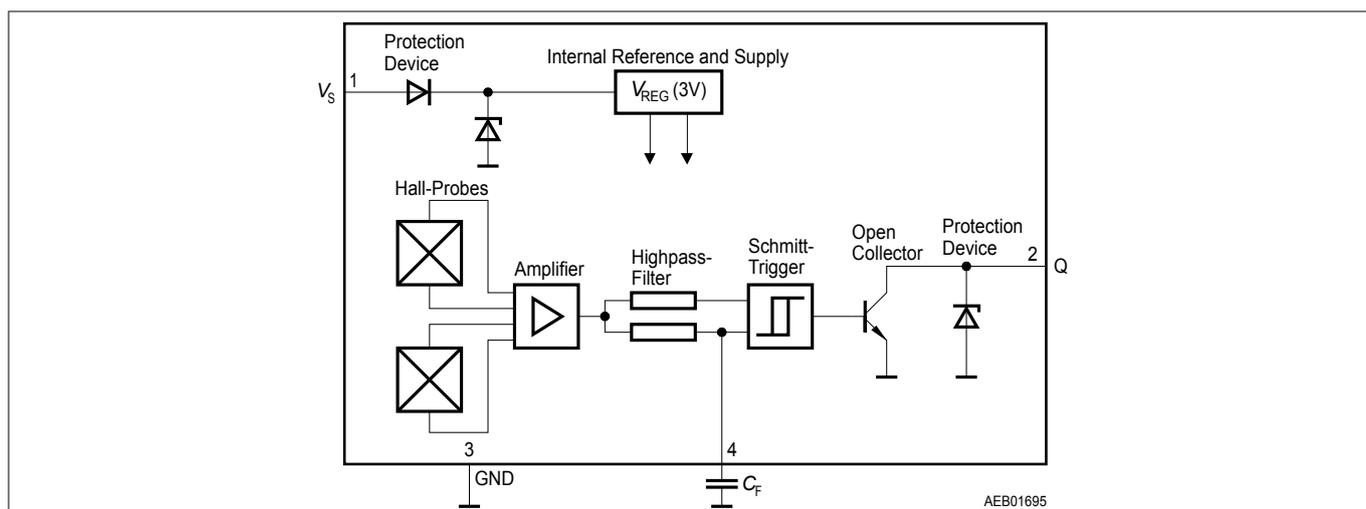


**Figure 1**

**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 General**

### **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-wire configuration.

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  $\pm 80$  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**

**2 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 <sup>(1)</sup>	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**

**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	$V_{ESD}$	-	$\pm 2$	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	$\Delta B$	-80	-	80	mT	

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

**4 Electrical and magnetic parameters**

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**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	$V_Q = \text{high}$ $I_Q = 0 \text{ mA}$	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	$\mu\text{A}$	$V_Q = 24 \text{ V}$	1
Center of switching points: $(\Delta B_{OP} + \Delta B_{RP}) / 2$	$\Delta B_m$	-1	0	1	mT	$-20 \text{ mT} < \Delta B < 20 \text{ mT}^{(1) (2)}$ $f = 200 \text{ Hz}$	2
Operate point	$\Delta B_{OP}$	-	-	0	mT	$f = 200 \text{ Hz}$ , $\Delta B = 20 \text{ mT}$	2
Release point	$\Delta B_{RP}$	0	-	-	mT	$f = 200 \text{ Hz}$ , $\Delta B = 20 \text{ mT}$	2
Hysteresis	$\Delta B_H$	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	$\mu\text{s}$	$I_Q = 40 \text{ mA}$ $C_L = 10 \text{ pF}$	1
Output fall time	$t_f$	-	-	0.5	$\mu\text{s}$	$I_Q = 40 \text{ mA}$ $C_L = 10 \text{ pF}$	1
Delay time	$t_{dop}$	-	-	25	$\mu\text{s}$	$f = 10 \text{ kHz}$ $\Delta B = 5 \text{ mT}$	2
	$t_{drp}$	-	-	10	$\mu\text{s}$		
	$t_{dop} - t_{drp}$	-	0	15	$\mu\text{s}$		
Filter input resistance	$R_C$	35	43	52	k $\Omega$	$25^\circ\text{C} \pm 2^\circ\text{C}$	1
Filter sensitivity to $\Delta B$	$S_C$	-	-5	-	mV/ mT	-	1
Filter bias voltage	$V_C$	1.6	2	2.4	V	$\Delta B = 0$	1
Frequency	$f$	<sup>(3)</sup>	-	2000	Hz	$\Delta B = 5 \text{ mT}$	2
Resistivity against mechanical stress (piezo)	$\Delta B_m$	-0.1	-	0.1	mT	$F = 2 \text{ N}$	<sup>(4)</sup>
	$\Delta B_H$	-0.1	-	0.1	mT		

(1) The Current consumption characteristic will be different and the specified values can slightly change

**4 Electrical and magnetic parameters**

(2) Leakage currents at pin 4 should be avoided. The bias shift of  $B_m$  caused by a leakage current  $I_L$  can be calculated by:

$$\Delta B_m = \frac{I_L \times R_C(T)}{S_C(T)}$$

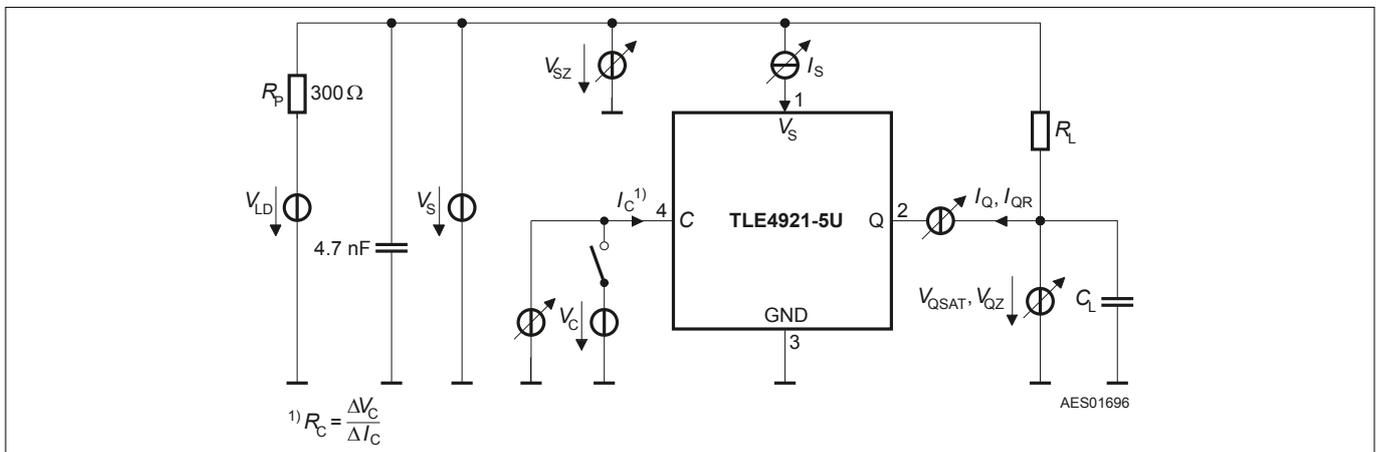
(3) For higher  $\Delta B$  the values may exceed the limits like following  $|\Delta B_m| < |0.05 \times \Delta B|$

(4) Depends on filter capacitor  $C_F$ . The cut-off frequency is given by

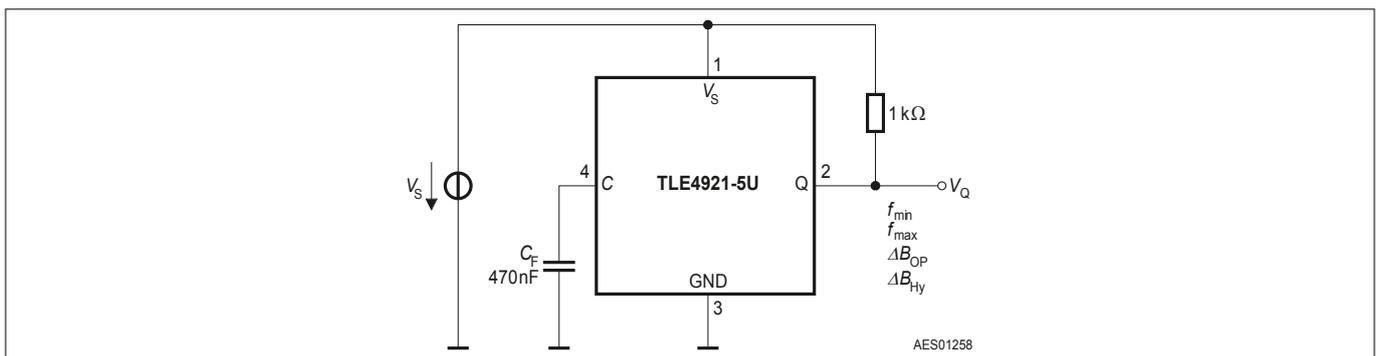
$$f = \frac{1}{2\pi \times R_C \times C_F}$$

. 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.*



**Figure 3 Test circuit 1**



**Figure 4 Test circuit 2**

**5 Application configurations**

**5 Application configurations**

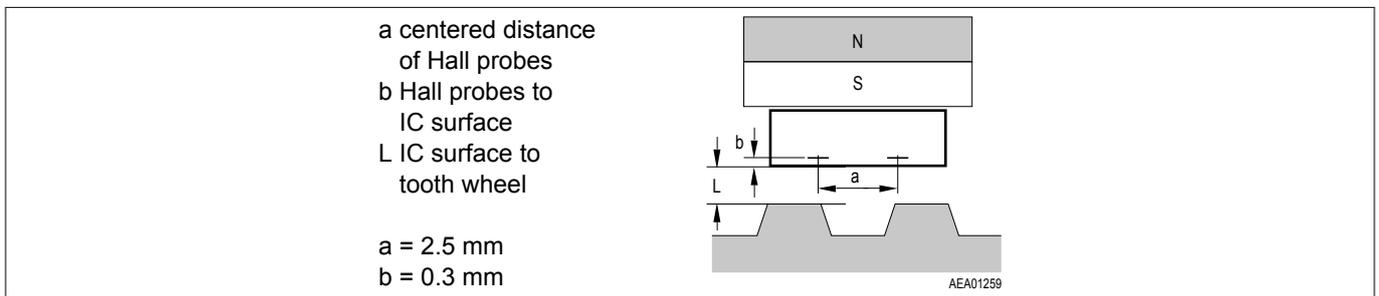
Two possible applications are shown in Figure 7 and Figure 8 (Toothed and Magnet Wheel). The difference between two-wire and three-wire application is shown in Figure 9.

**Gear Tooth Sensing**

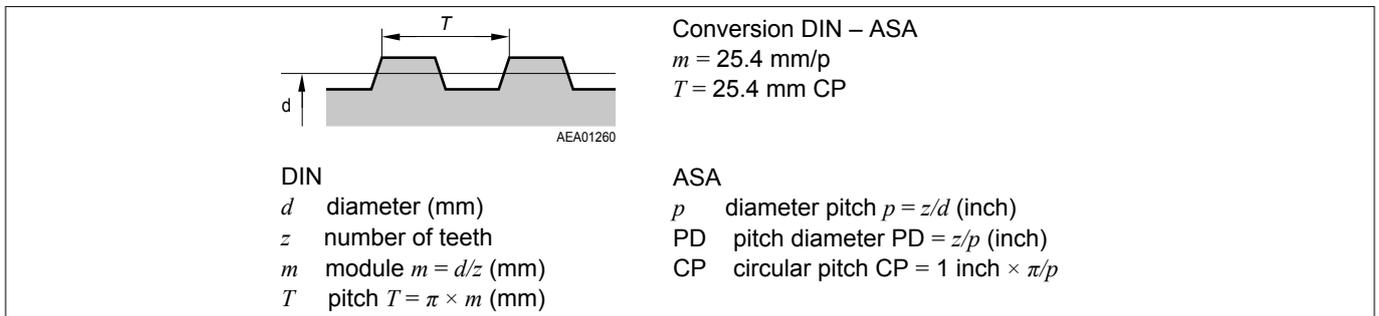
In the case of ferromagnetic toothed wheel application the IC has to be biased by the south or north pole of a permanent magnet (e.g. SmCO<sub>5</sub> (Vacuumschmelze VX145)) with the dimensions 8 mm × 5 mm × 3 mm) which should cover both Hall probes.

The maximum air gap depends on:

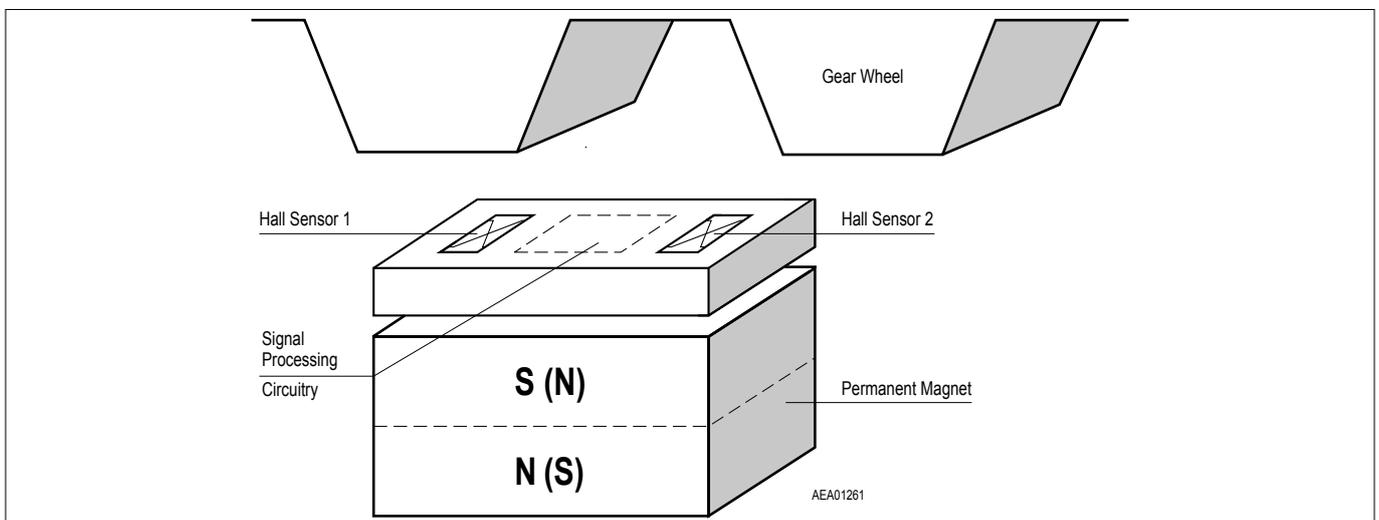
- the magnetic field strength (magnet used; pre-induction) and
- the toothed wheel that is used (dimensions, material, etc.; resulting differential field)



**Figure 5 Sensor Spacing**

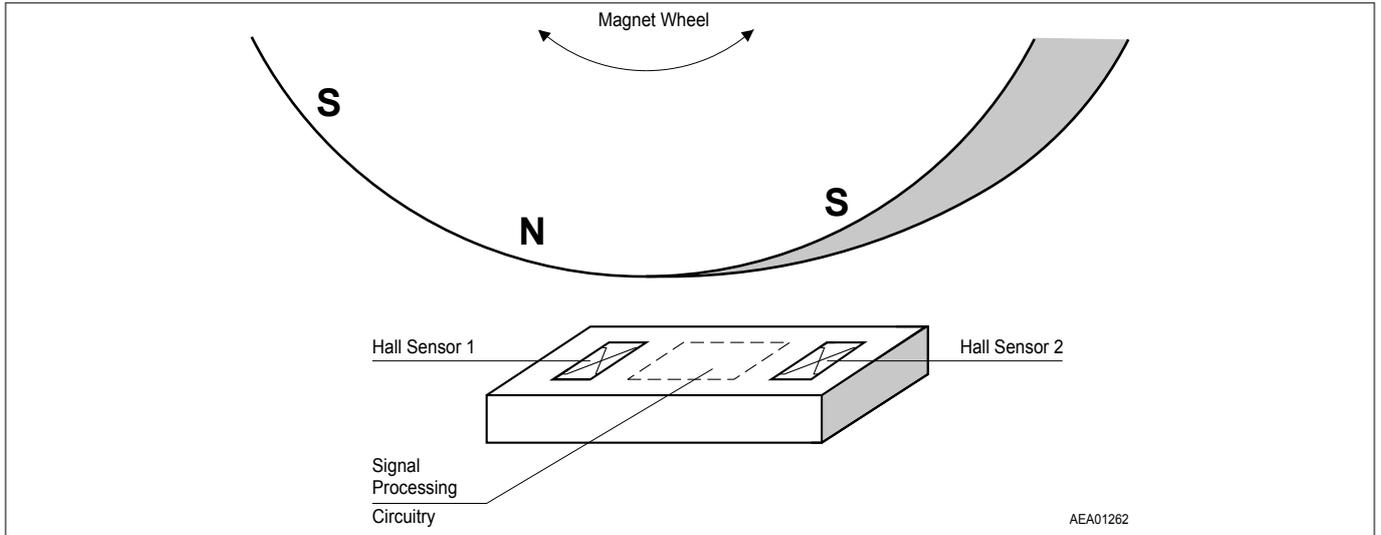


**Figure 6 Tooth Wheel Dimensions**

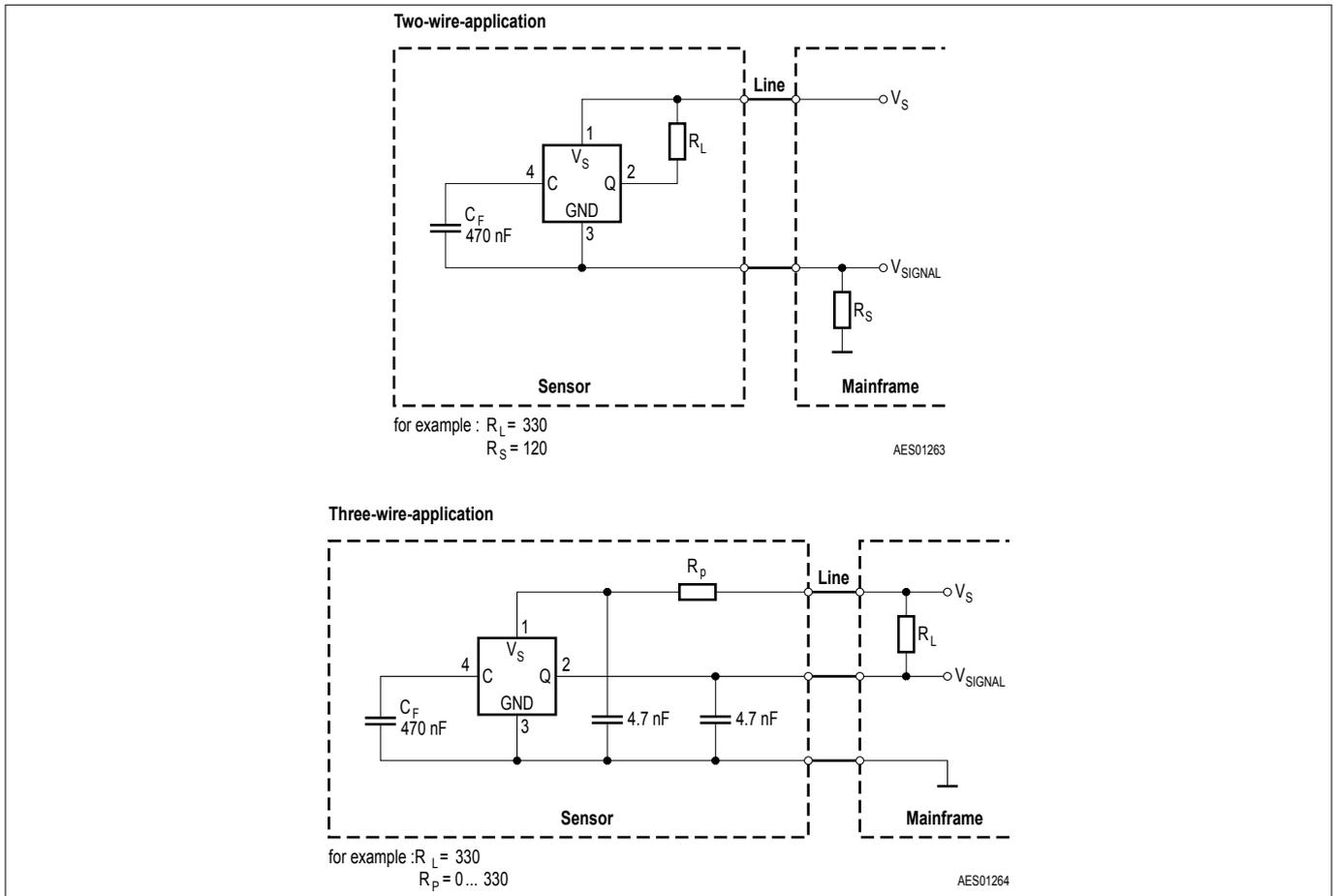


**Figure 7 TLE4921-5U, with Ferromagnetic Toothed Wheel**

**5 Application configurations**

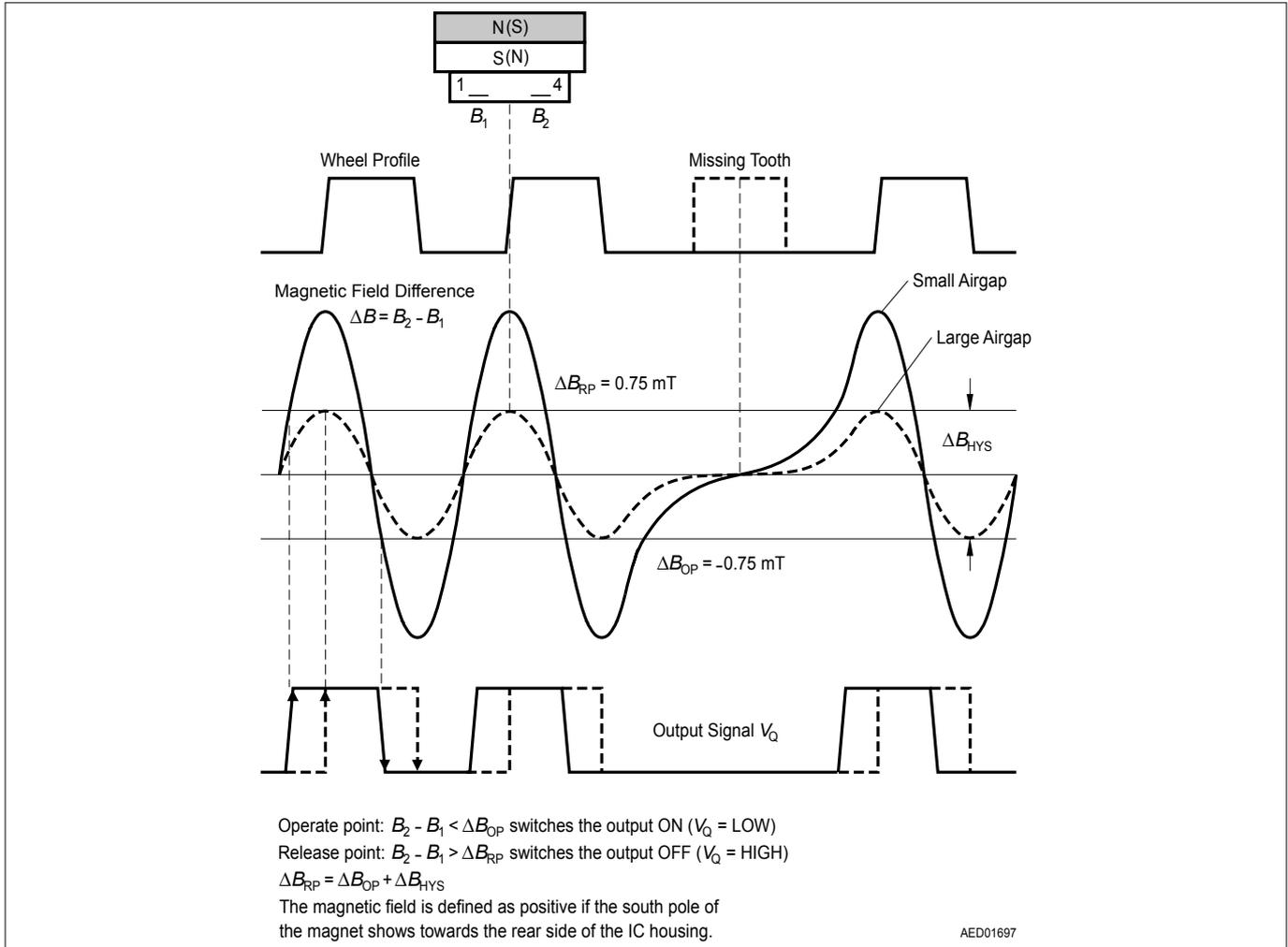


**Figure 8**      **TLE4921-5U, with Magnet Wheel**



**Figure 9**      **Application Circuits**

**5 Application configurations**

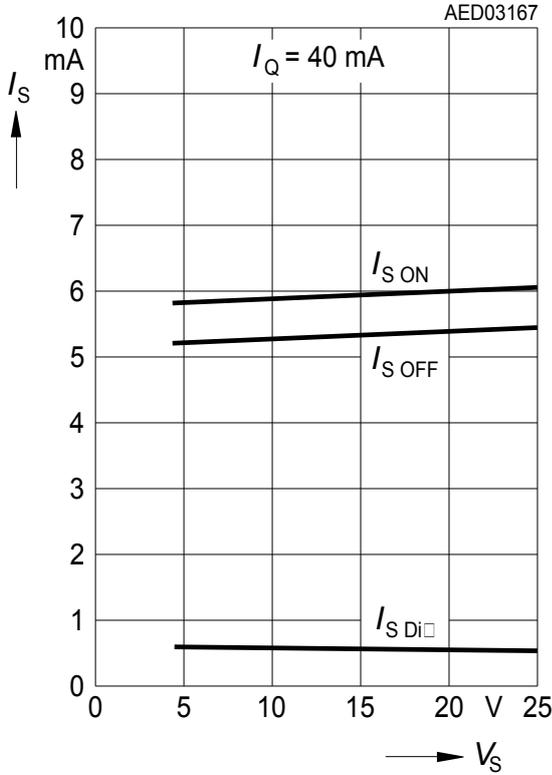


**Figure 10**      **System Operation**

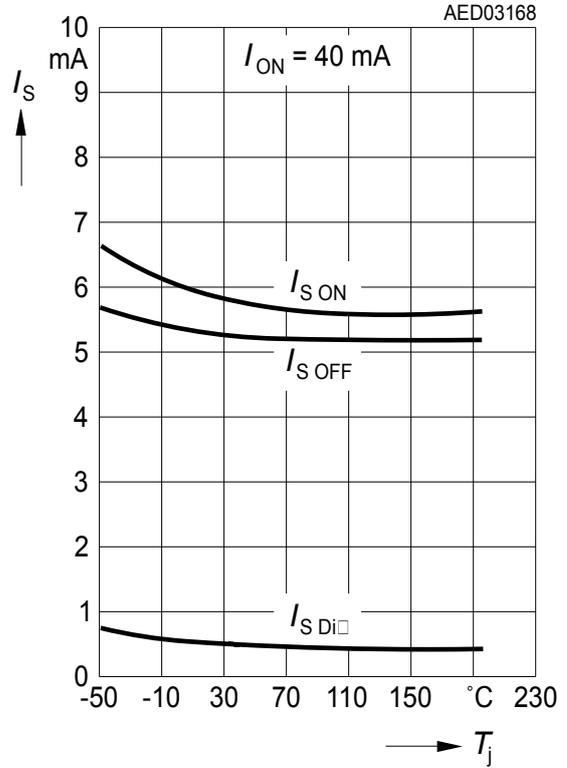
**6 Typical performance characteristics**

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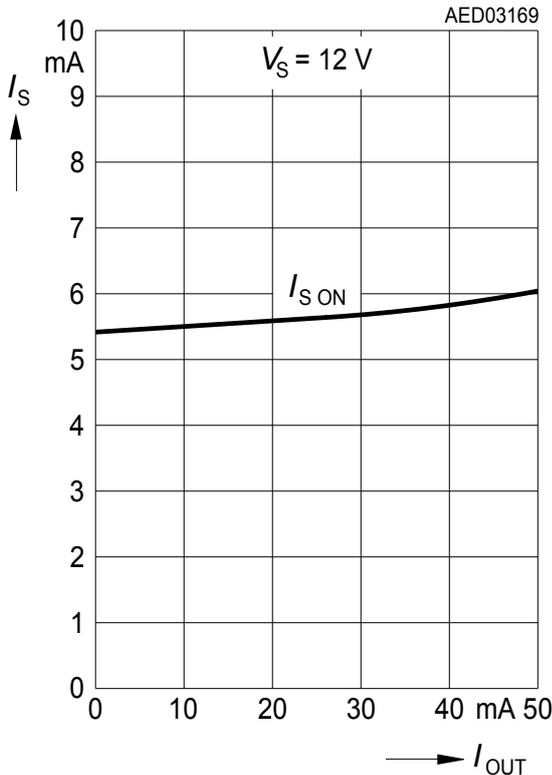
Quiescent Current versus Supply Voltage



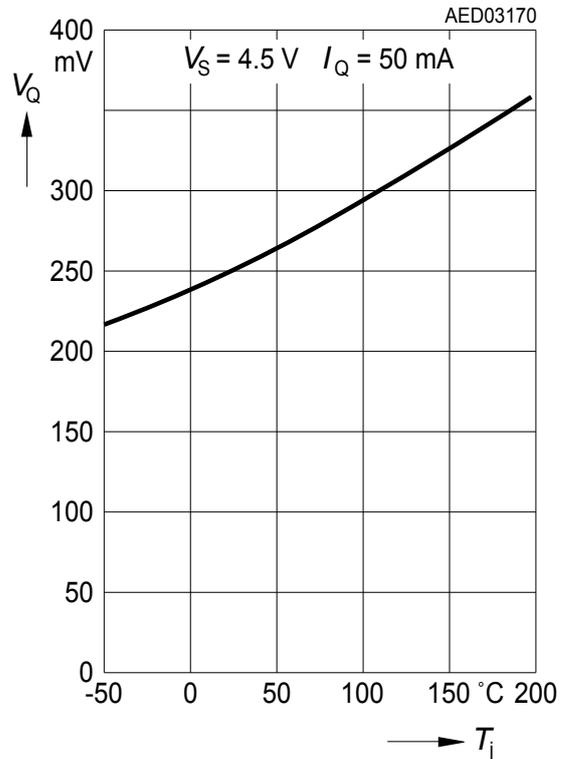
Quiescent Current versus Temperature



Quiescent Current versus Output Current

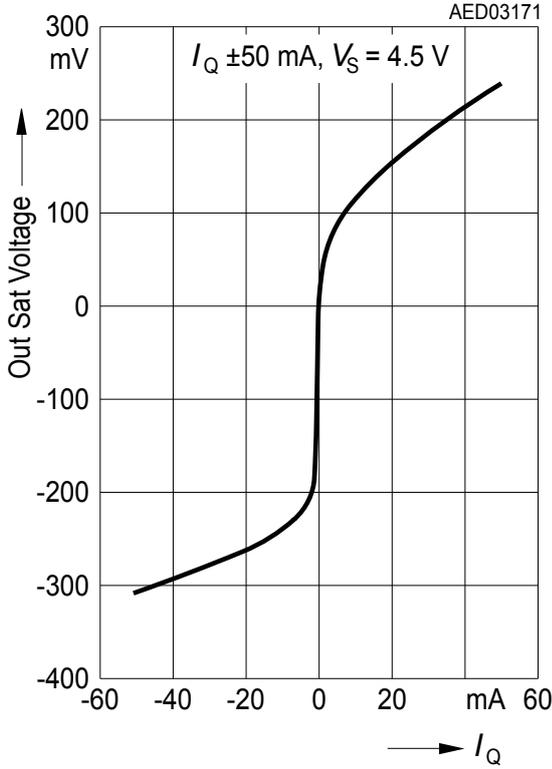


Saturation Voltage versus Temperature

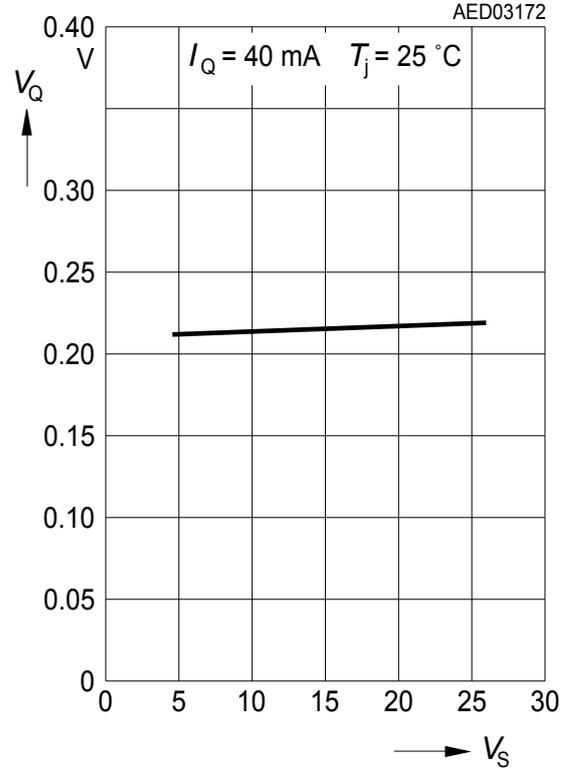


**6 Typical performance characteristics**

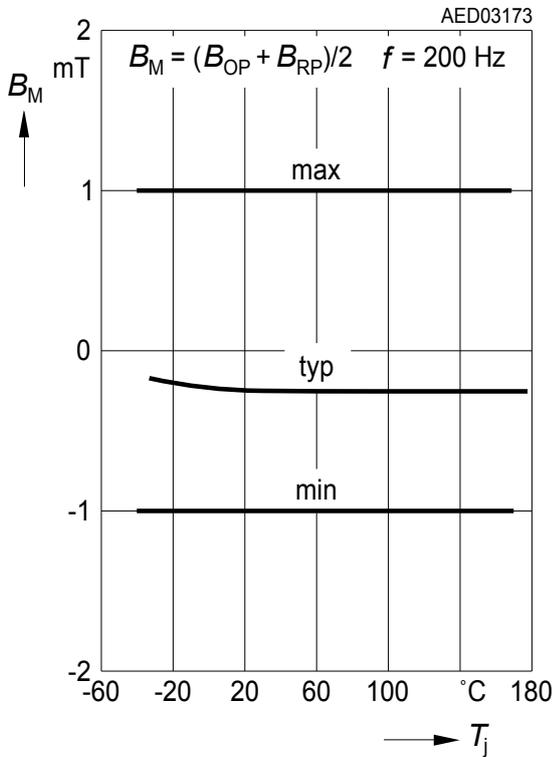
Output Saturation Voltage versus  $I_Q$  @ 25°C  $T_j$



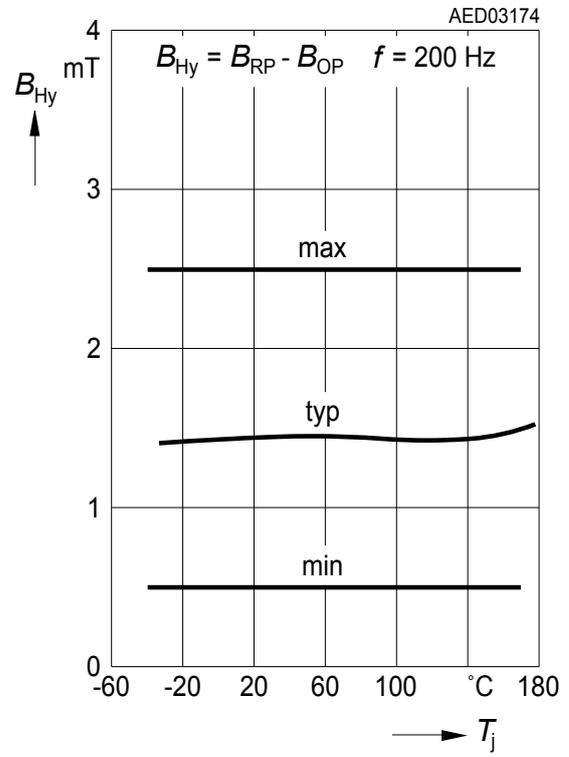
Saturation Voltage versus Supply Voltage



Center of Switching Points versus Temperature

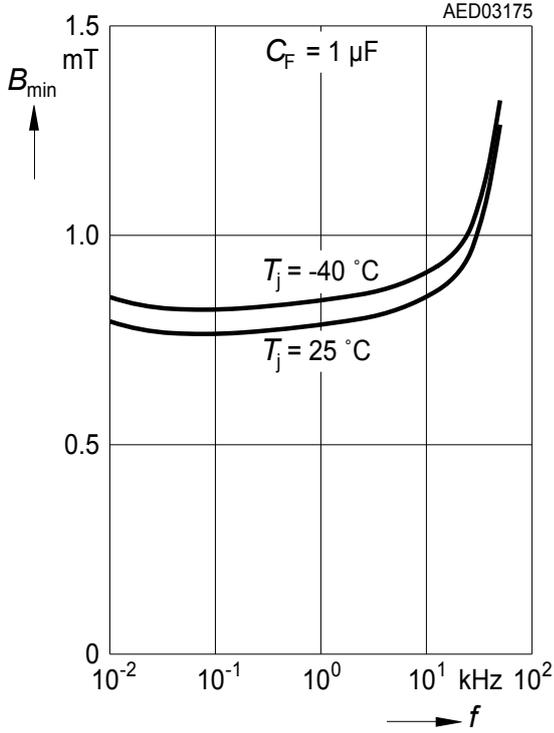


Hysteresis versus Temperature

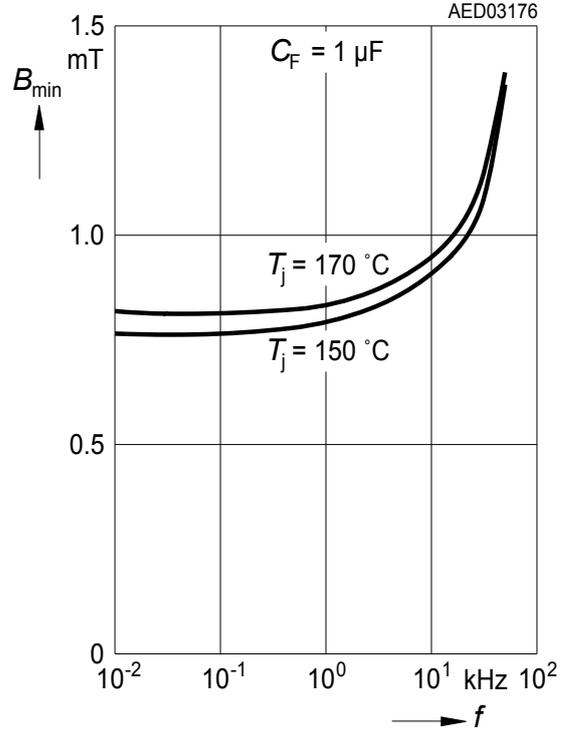


**6 Typical performance characteristics**

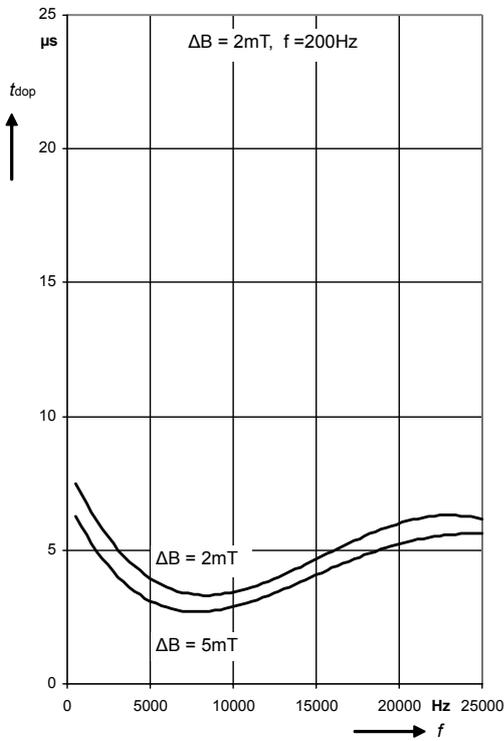
Minimum Switching Field versus Frequency



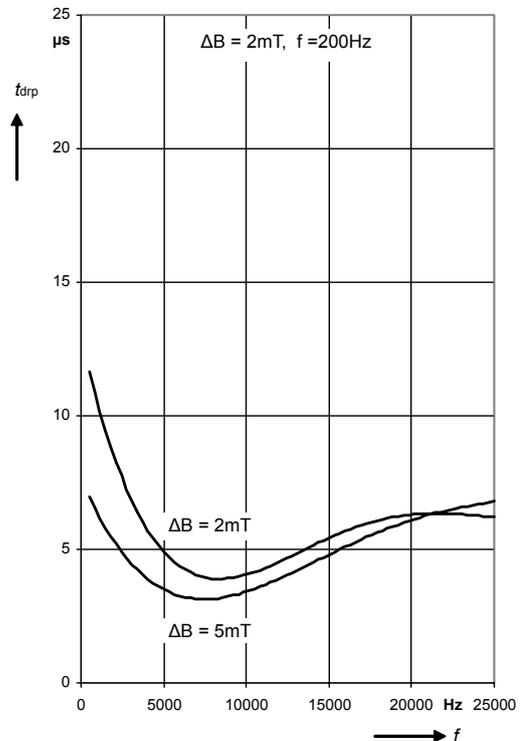
Minimum Switching Field versus Frequency



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

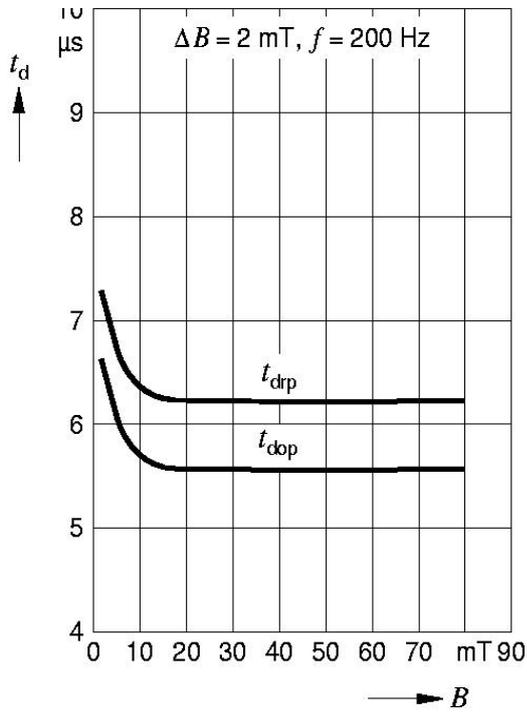


Delay Time between Switching Threshold  $\Delta B$  and Rising Edge of  $V_{OUT}$  at  $T_j = 25^\circ C$

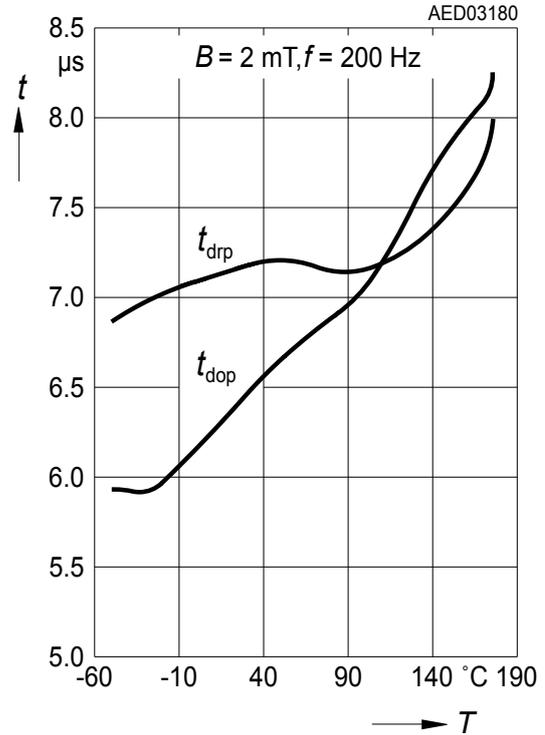


**6 Typical performance characteristics**

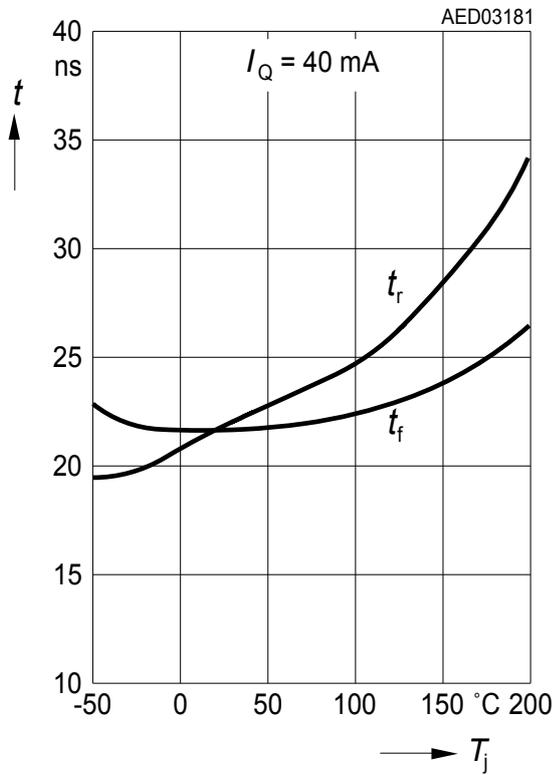
Delay Time versus Differential Field



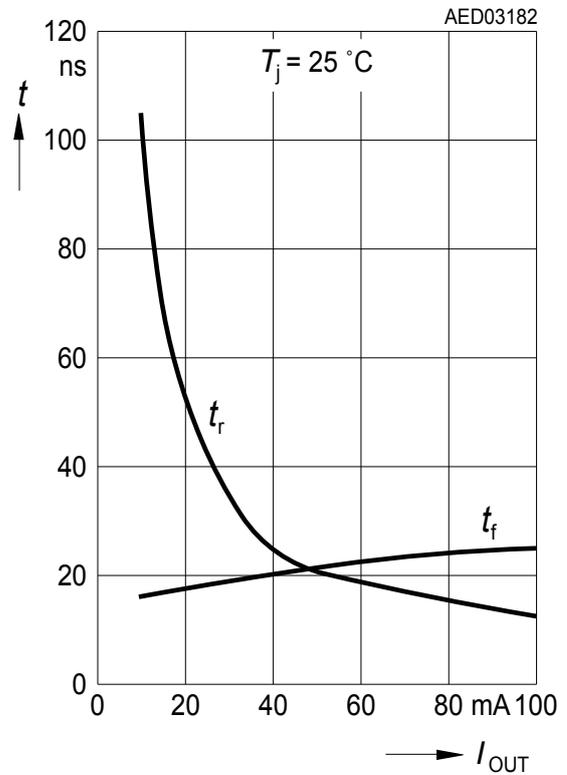
Delay Time versus Temperature



Rise and Fall Time versus Temperature

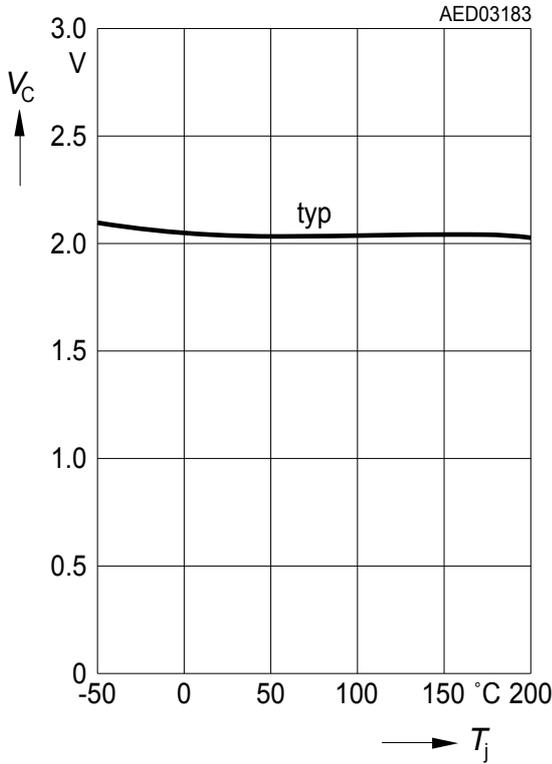


Rise and Fall Time versus Output Current

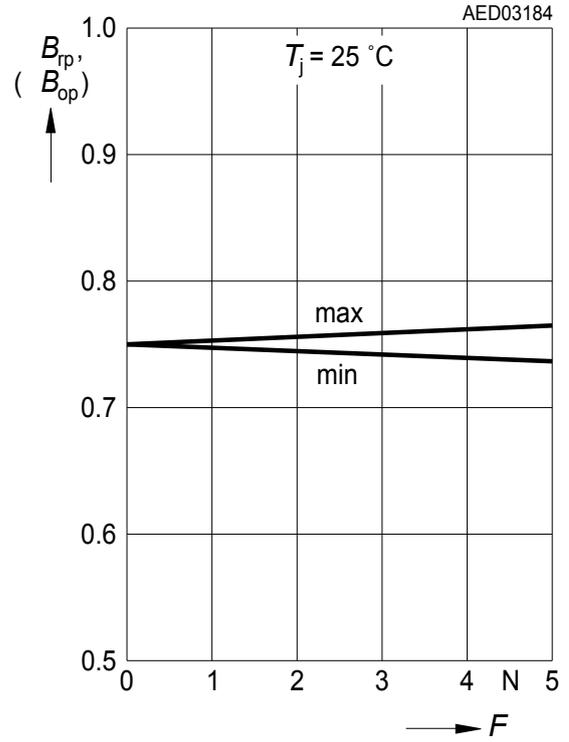


**6 Typical performance characteristics**

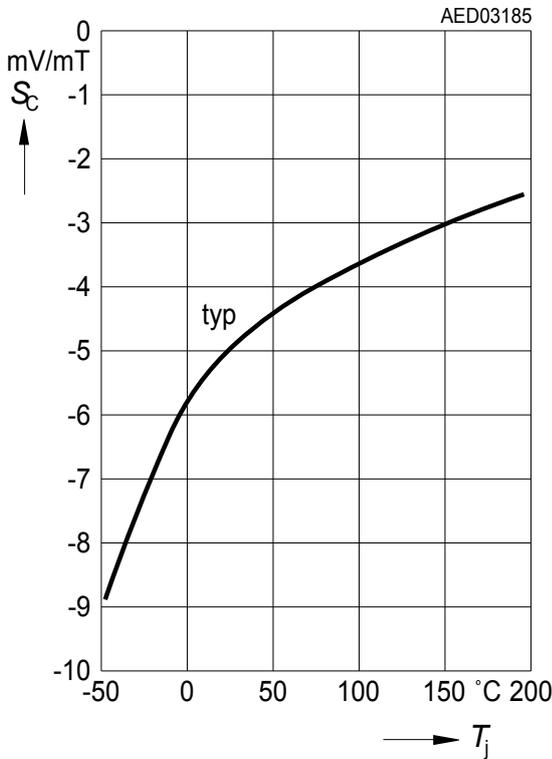
Capacitor Voltage versus Temperature



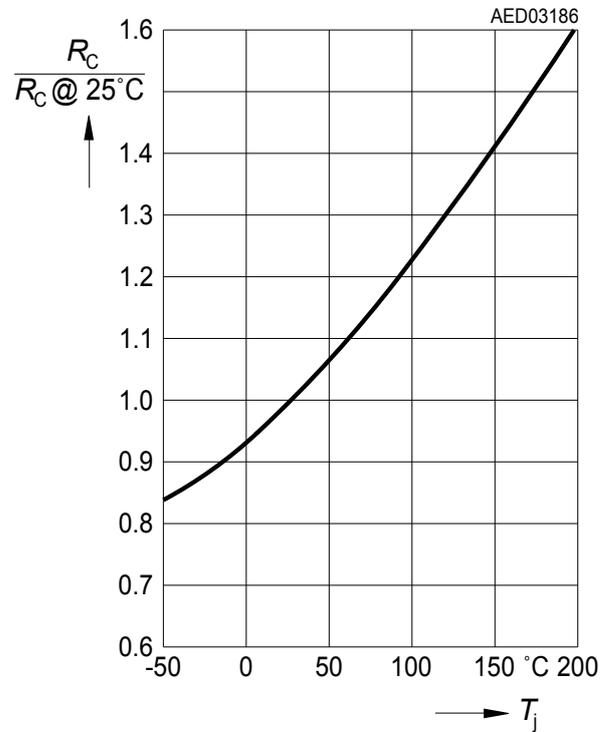
Switching Thresholds versus Mechanical Stress



Filter Sensitivity versus Temperature

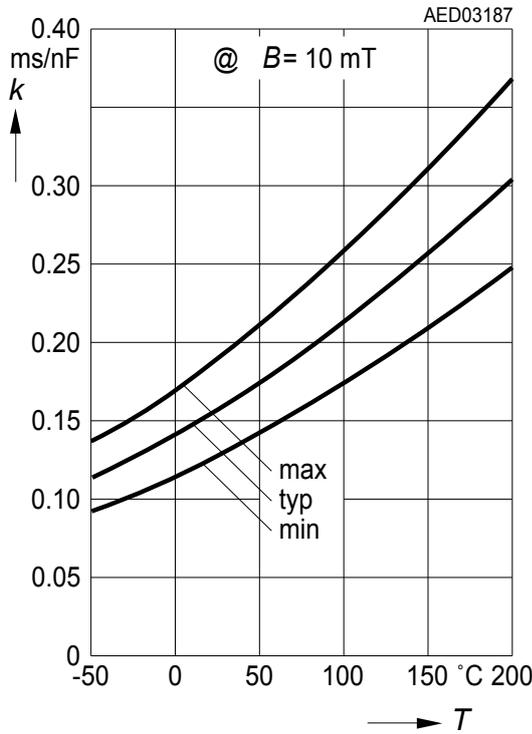


Filter Input Resistance versus Temperature

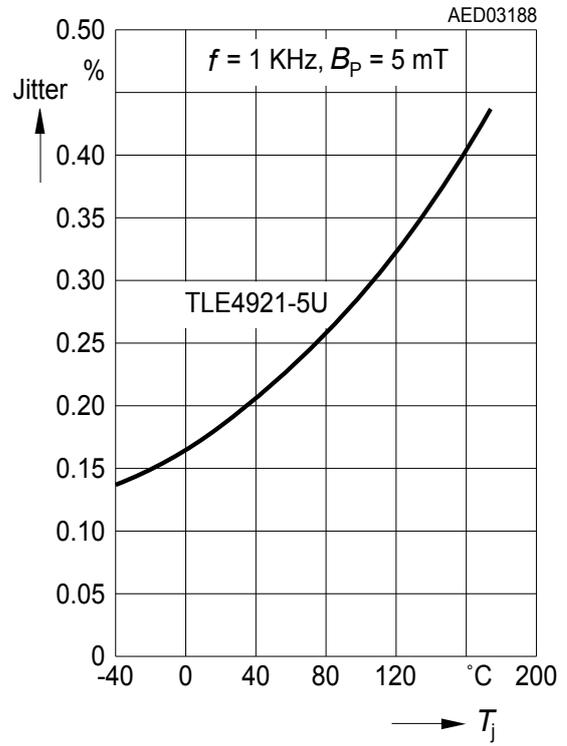


**6 Typical performance characteristics**

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



Periodjitter ( $1\sigma$ ) versus Temperature



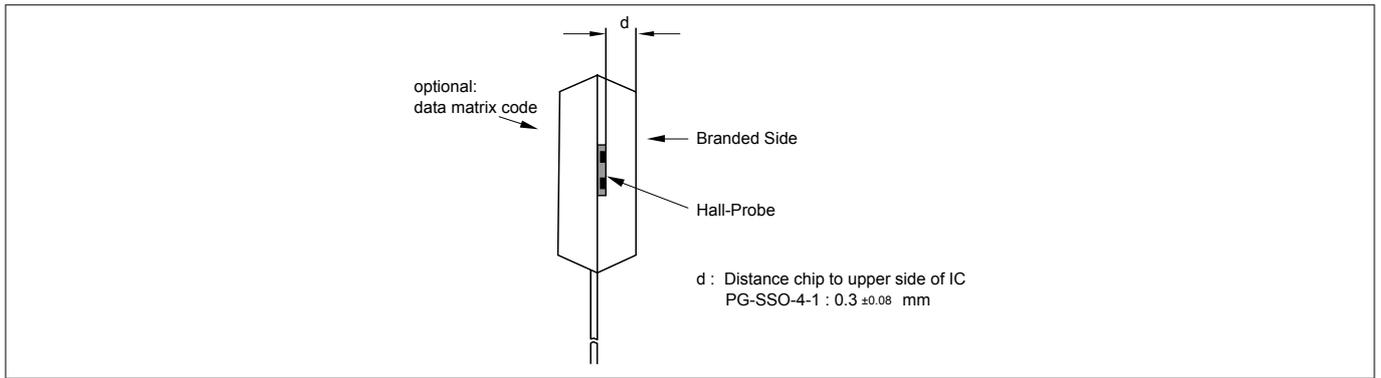
**Table 6 Electro magnetic compatibility**

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.*

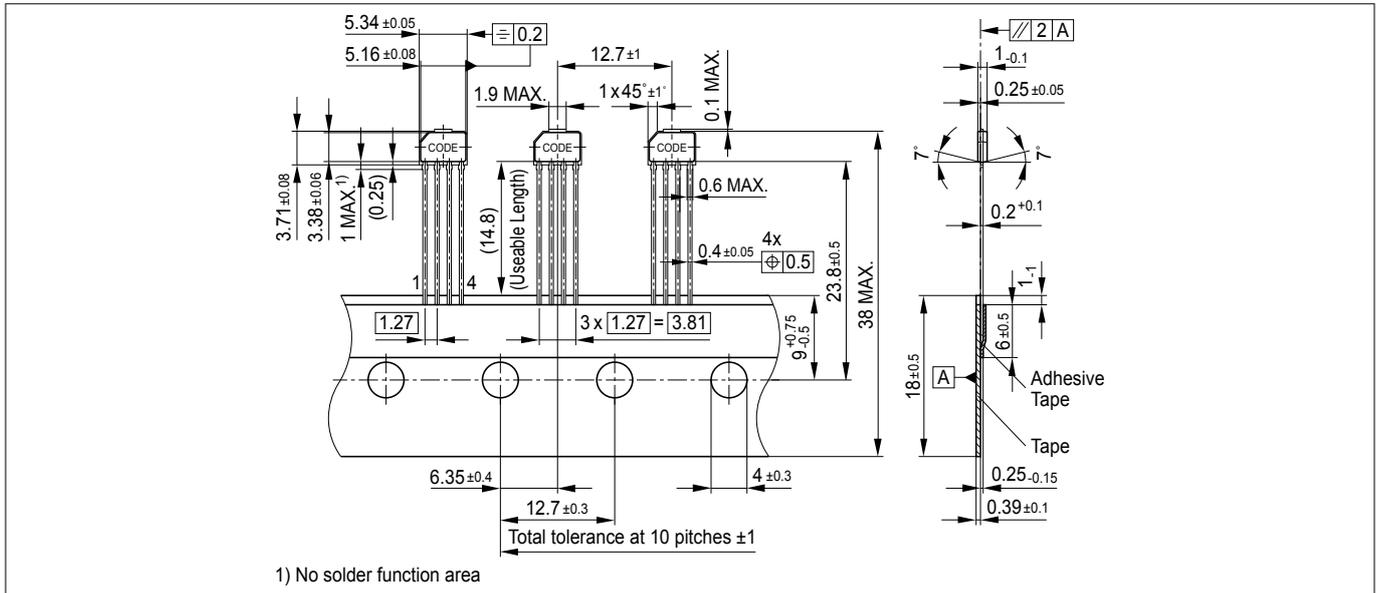
**6 Typical performance characteristics**



**Figure 11**      **Distance Chip to Upper Side of IC**

**7 Package outlines**

**7 Package outlines**



**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

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**8 Revision history**

## **8 Revision history**

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**Revision History**

<b>Page</b>	<b>Subjects (major changes since last revision)</b>
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Revision History: 2020-11, Rev. 1.2

Previous Revisions: Rev. 1.1

17	Edited figure 11 (optional: data matrix code)
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Rev. 1.0

5	Ordering Code changed
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11	“Output leakage current” unit corrected
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20	Figures “Delay Time between Switching Threshold” exchanged and corrected
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21	Figure “Delay Time versus Differential Field” corrected
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