TLE4921-5U

Dynamic Differential Hall Effect Sensor IC

Sensors

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TLE4921-5U

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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Dynamic Differential Hall Effect Sensor IC   **TLE4921-5U**

Bipolar IC

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
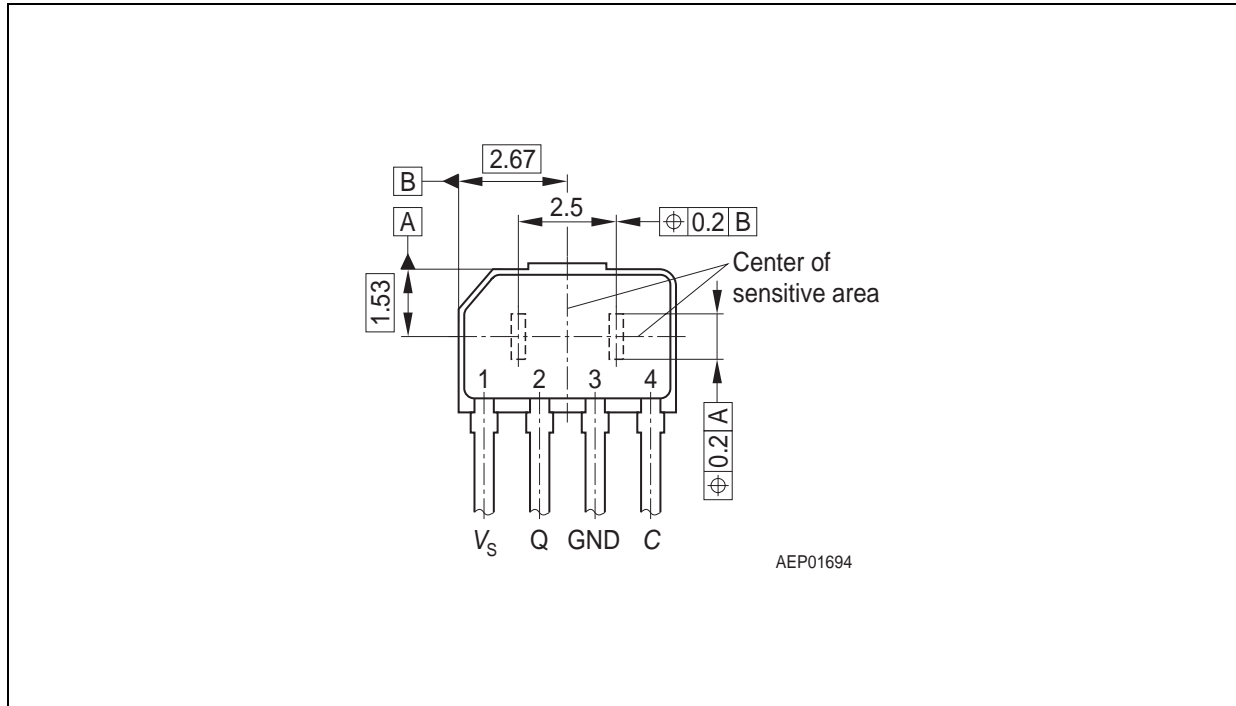- Output protection against electrical disturbances
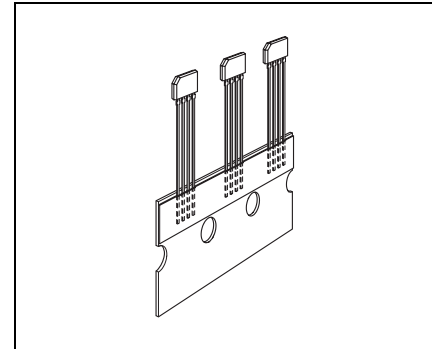
The differential Hall Effect sensor TLE4921-5U provides a high sensitivity and a superior stability over temperature and symmetrical thresholds in order to achieve a stable duty cycle. TLE4921-5U is particularly suitable for rotational speed detection and timing applications of ferromagnetic toothed 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

Data Sheet   5   V 1.1, 2008-01

1.2 Pin Configuration
(view on branded side of component)

Figure showing pin configuration with dimensions:
- 2.67
- 2.5
- ⊕ 0.2 B
- 1.53
- B, A reference markers
- Center of sensitive area
- Pins labeled 1, 2, 3, 4
- ⊕ 0.2 A
- V_S Q GND C
- AEP01694

Figure 1

Table 1   Pin Definitions and Functions

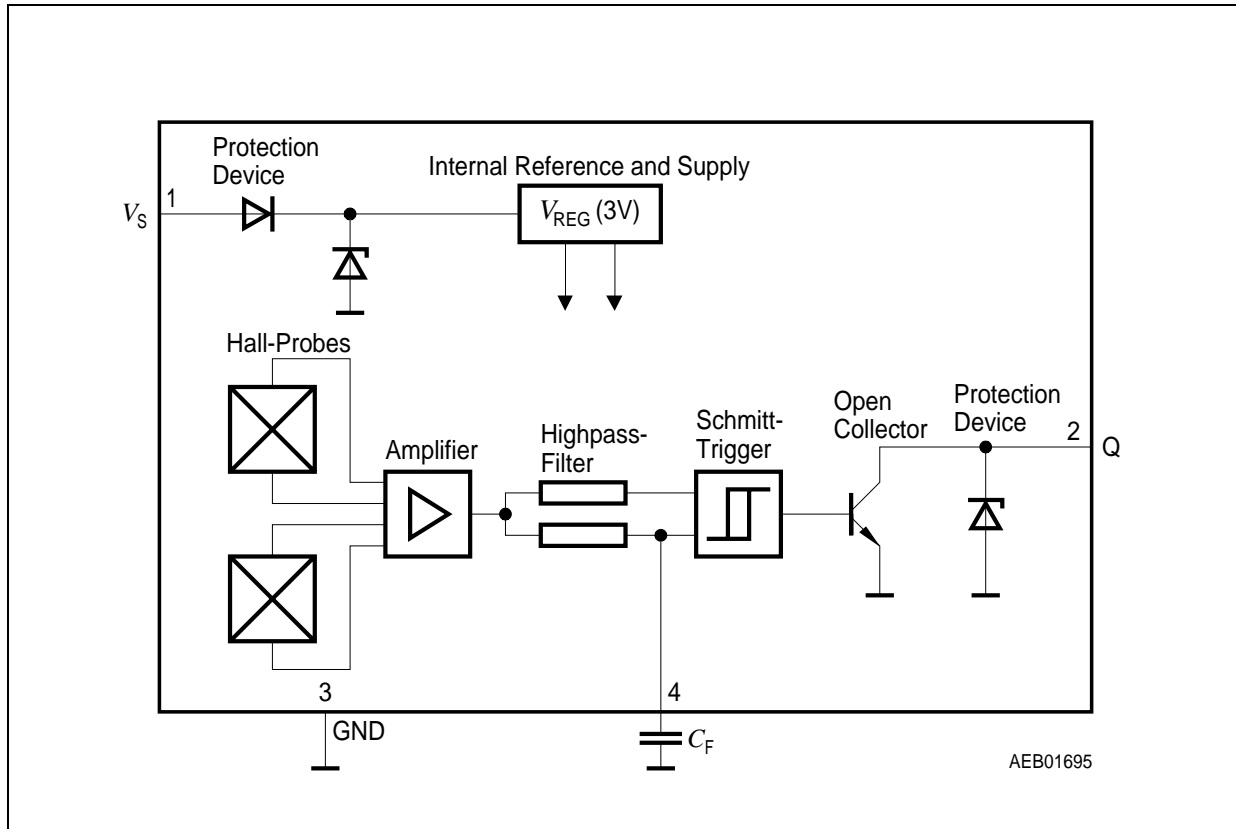| Pin No.	Symbol	Function
1	V_S	Supply voltage
2	Q	Output
3	GND	Ground
4	C	Capacitor

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°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

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.

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 = 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} V_{QZ}	27 27	– –	35 35	V V	I_S = 16 mA I_Q = 16 mA	1 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} t_{drp} $t_{dop} - t_{drp}$	– – –	– – 0	25 10 15	µs µs µs	f = 10 kHz ΔB = 5 mT	2
Filter input resistance	R_C	35	43	52	kΩ	25°C ±2°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	$\Delta B = 5$ mT	2
Resistivity against mechanical stress (piezo)	ΔB_m ΔB_H	-0.1 -0.1	– –	0.1 0.1	mT mT	F = 2 N	2 4)

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

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

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 $f = \dfrac{1}{2\pi \times R_C \times C_F}$. 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.
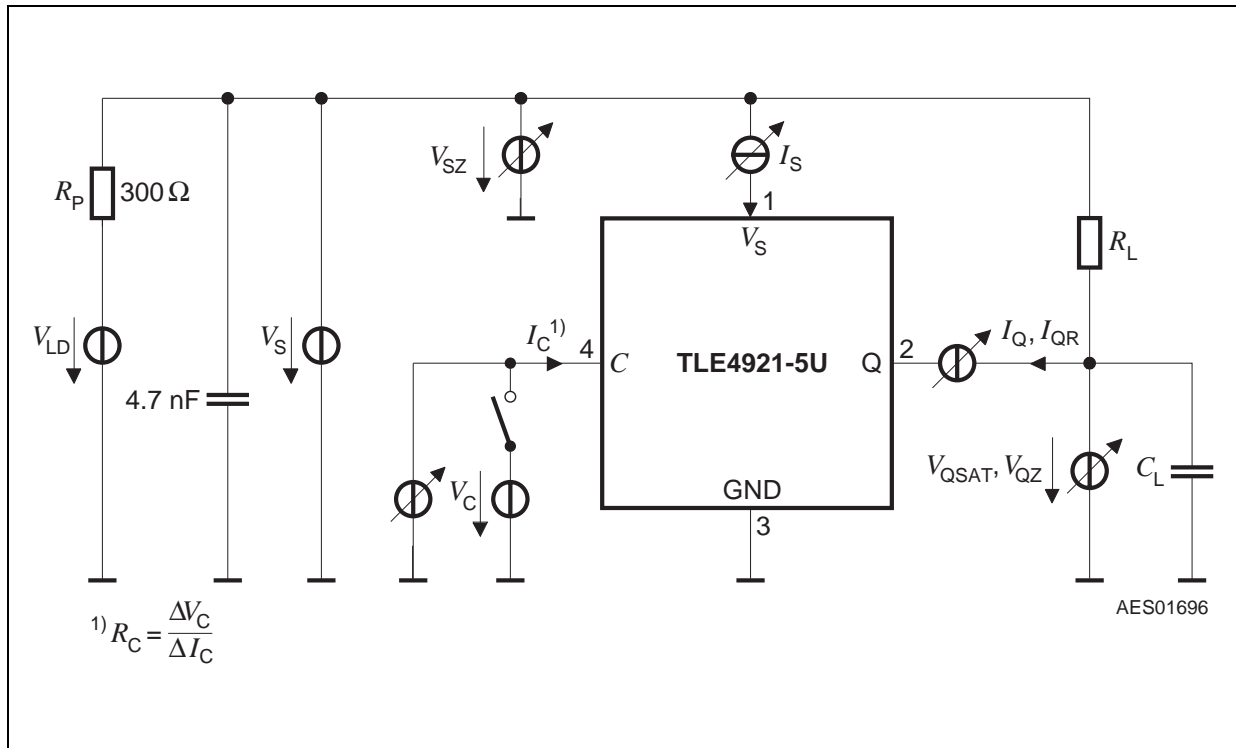
Figure 3   Test Circuit 1
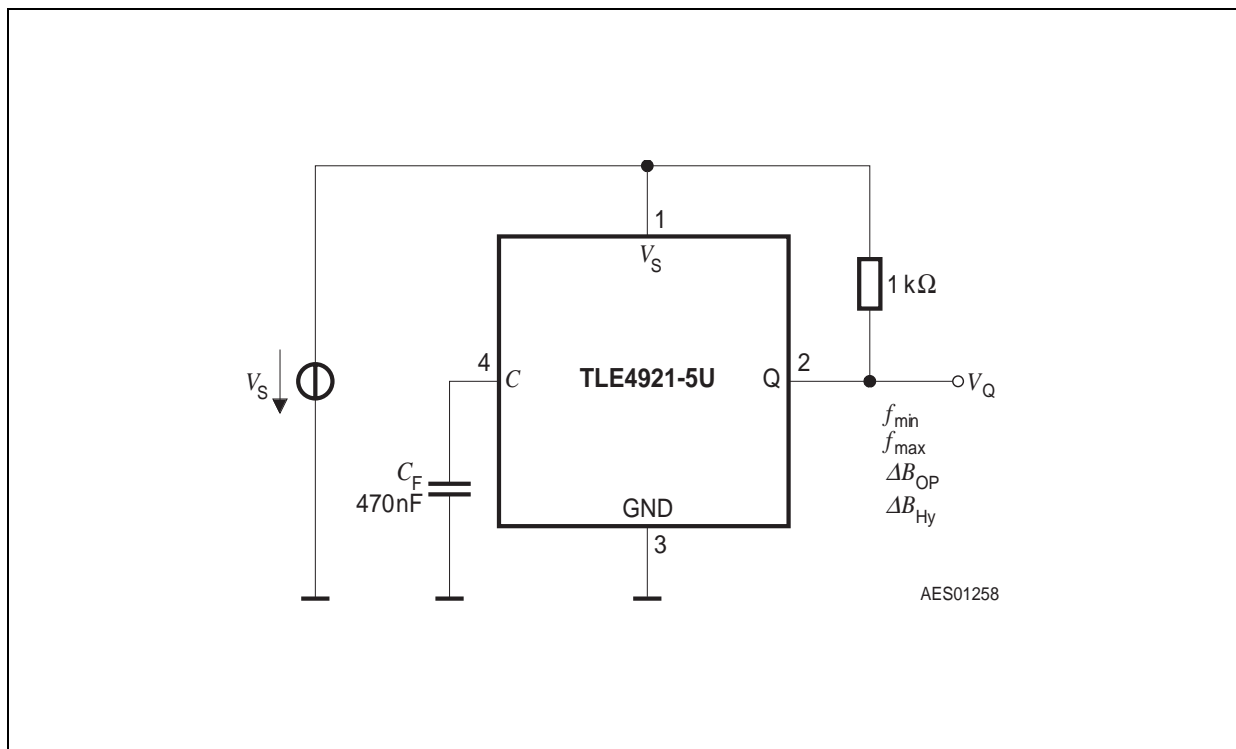
Figure 4   Test Circuit 2

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. $SmCO_5$ (Vacuumschmelze VX145)) with the dimensions 8 mm $\times$ 5 mm $\times$ 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

N
S

AEA01259

Figure 5 **Sensor Spacing**

AEA01260

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 $\times \pi/p$
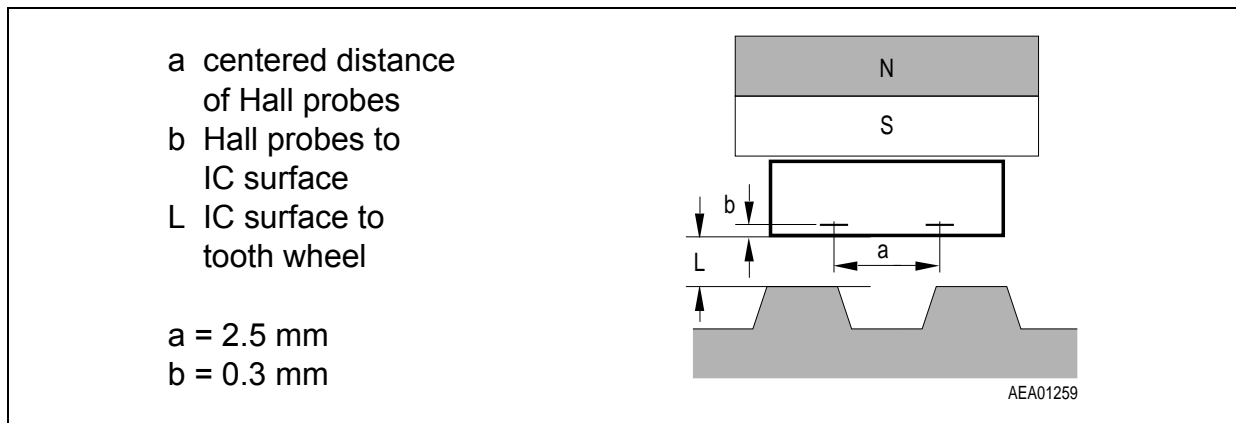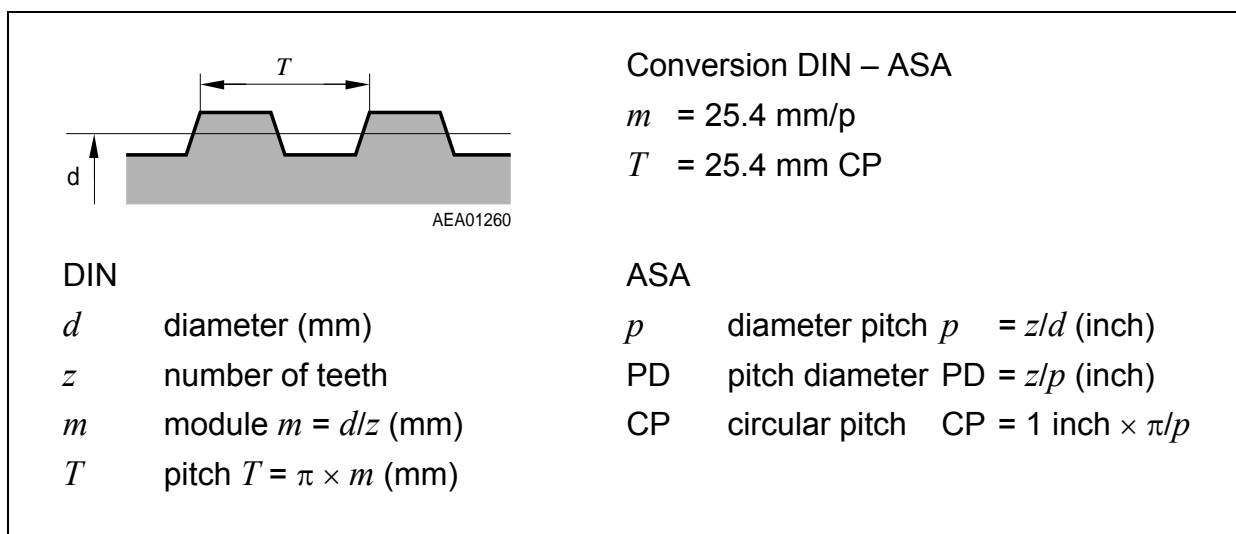
Figure 6 **Tooth Wheel Dimensions**

Figure 7   TLE4921-5U, with Ferromagnetic Toothed Wheel
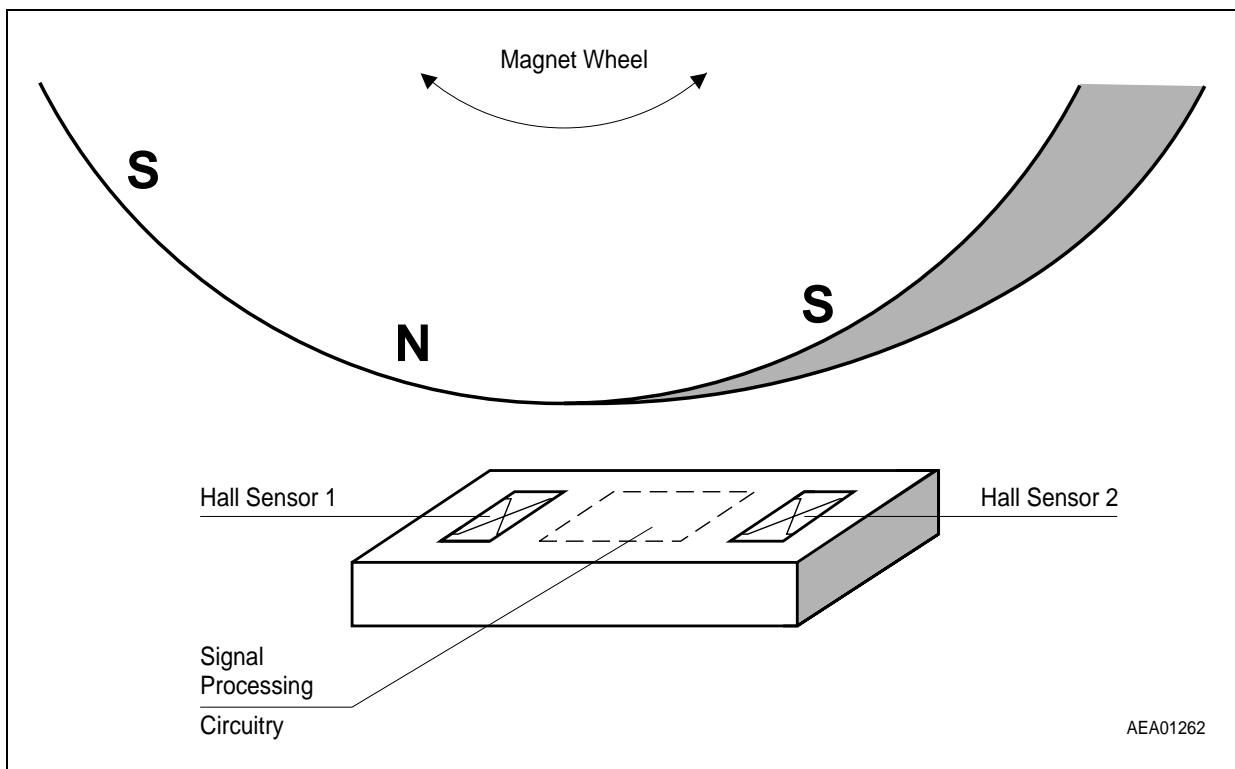
Figure 8   TLE4921-5U, with Magnet Wheel

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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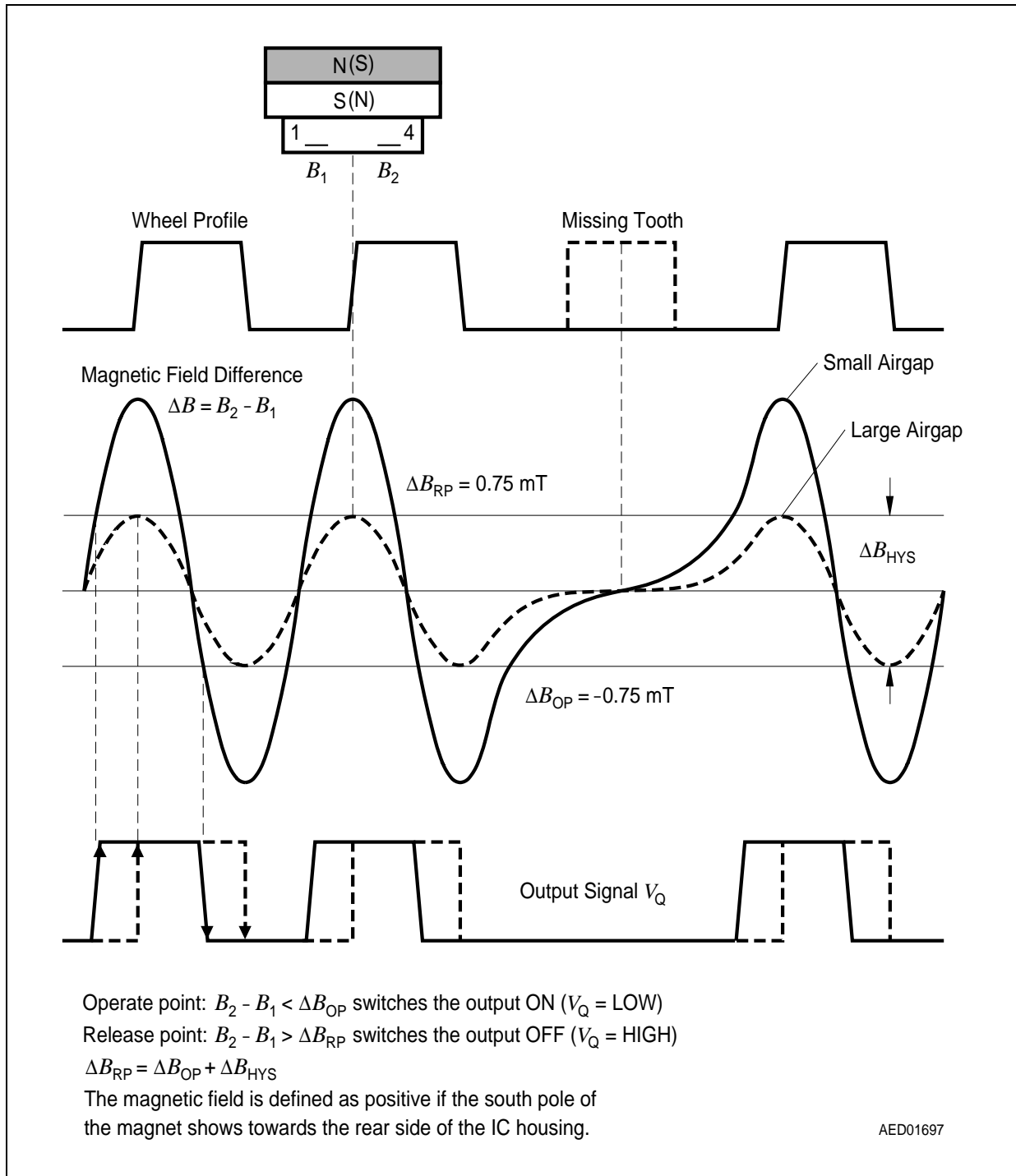
Figure 10   System Operation

7 Typical Performance Characteristics

Quiescent Current versus Supply Voltage
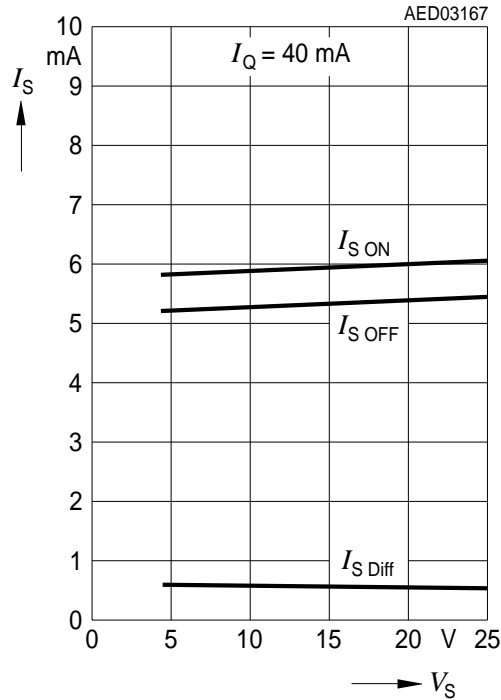
Quiescent Current versus Temperature
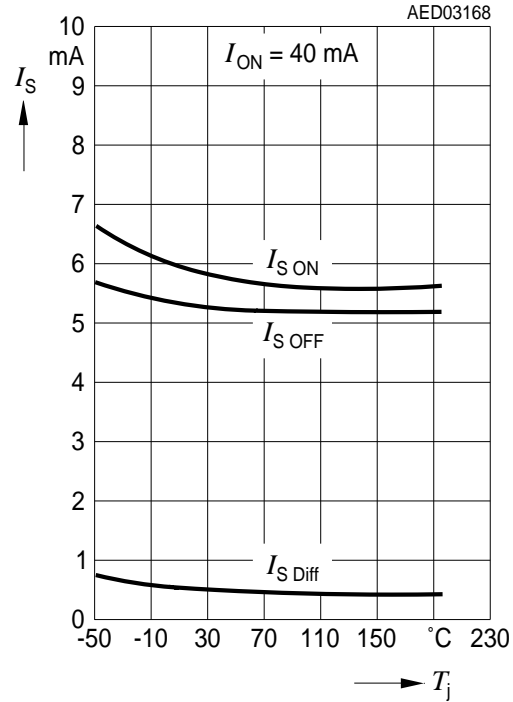
Quiescent Current versus Output Current
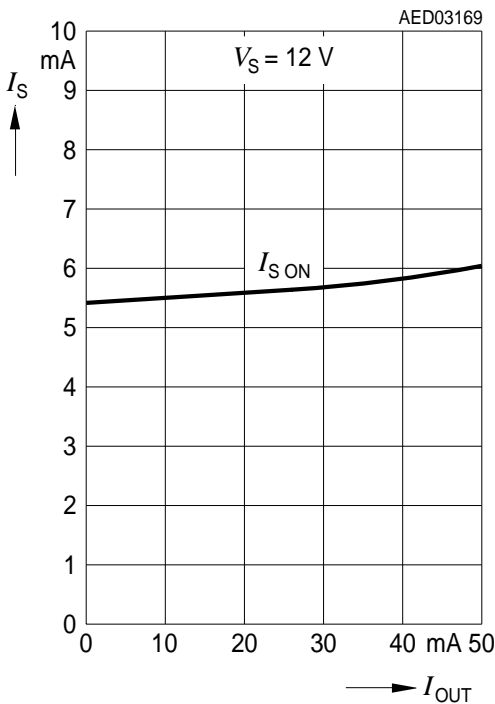
Saturation Voltage versus Temperature
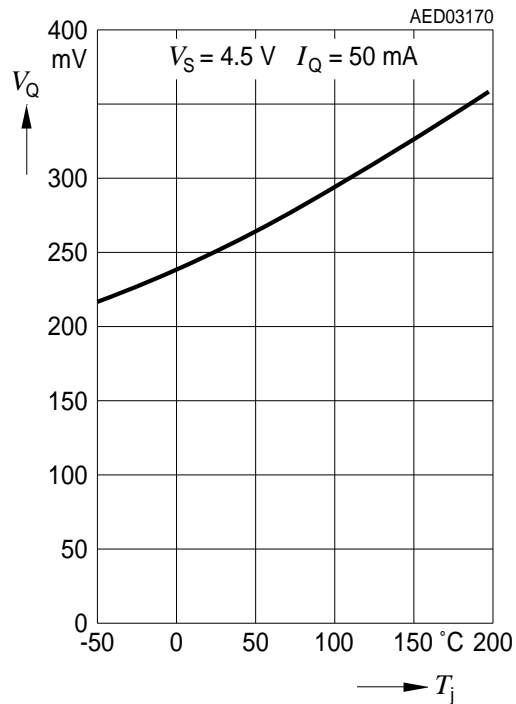
Typical Performance Characteristics

Output Saturation Voltage versus I_Q @ 25°C T_j

AED03171

I_Q ±50 mA, V_S = 4.5 V

Out Sat Voltage

y-axis (mV): 300, 200, 100, 0, -100, -200, -300, -400

x-axis (I_Q, mA): -60, -40, -20, 0, 20, mA 60
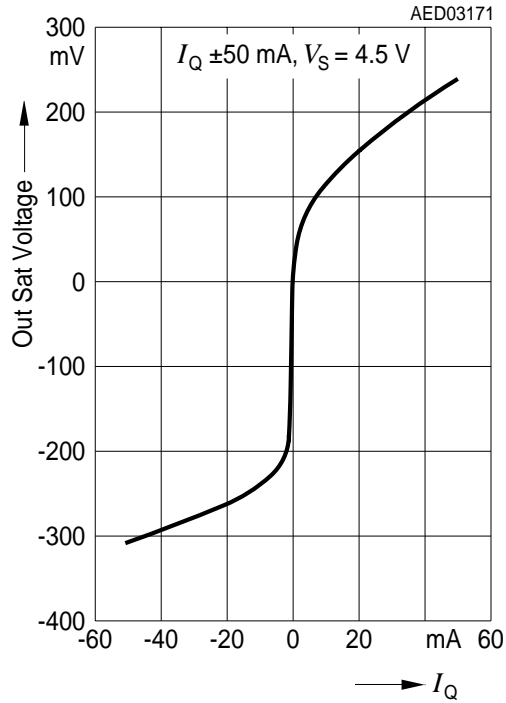
Saturation Voltage versus Supply Voltage

AED03172

I_Q = 40 mA T_j = 25 °C

V_Q

y-axis (V): 0.40, 0.30, 0.25, 0.20, 0.15, 0.10, 0.05, 0

x-axis (V_S): 0, 5, 10, 15, 20, 25, 30
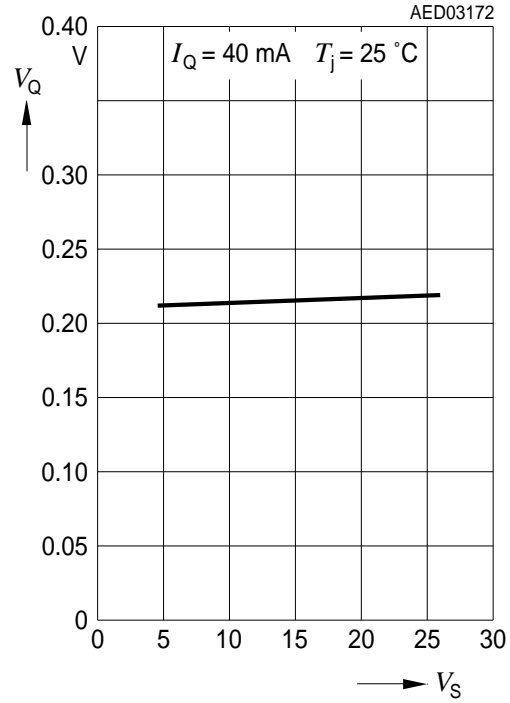
Center of Switching Points versus Temperature

AED03173

$B_M = (B_{OP} + B_{RP})/2$ f = 200 Hz

B_M (mT)

y-axis: 2, 1, 0, -1, -2

max

typ

min

x-axis (T_j, °C): -60, -20, 20, 60, 100, °C 180
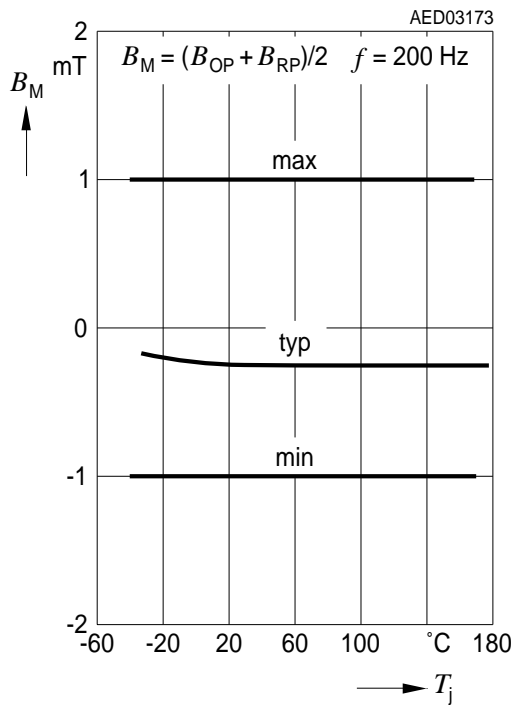
Hysteresis versus Temperature

AED03174

$B_{Hy} = B_{RP} - B_{OP}$ f = 200 Hz

B_{Hy} (mT)

y-axis: 4, 3, 2, 1, 0

max

typ

min

x-axis (T_j, °C): -60, -20, 20, 60, 100, °C 180

Data Sheet

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V 1.1, 2008-01
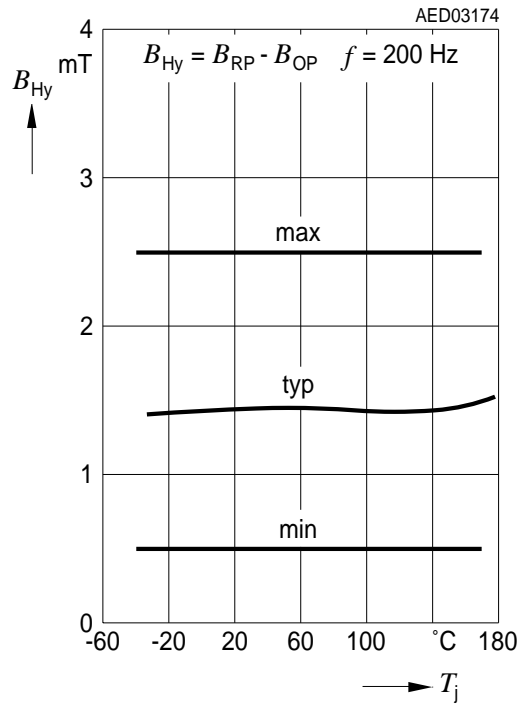
Typical Performance Characteristics

Minimum Switching Field versus Frequency
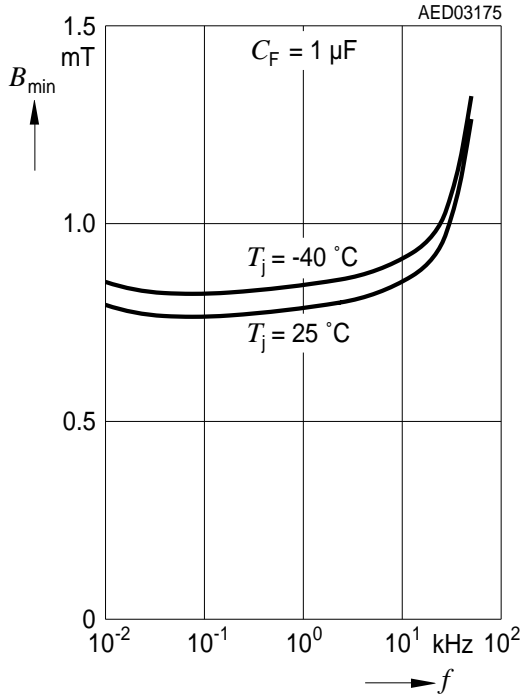
AED03175

$C_F = 1\ \mu F$

$T_j = -40\ °C$

$T_j = 25\ °C$

Minimum Switching Field versus Frequency

AED03176

$C_F = 1\ \mu F$

$T_j = 170\ °C$

$T_j = 150\ °C$
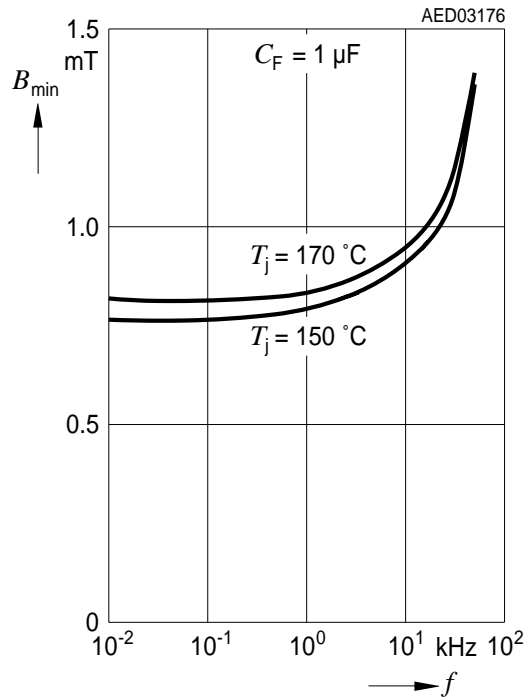
Delay Time between Switching Threshold ΔB and Falling Edge of V_{OUT} at $T_j = 25°C$

$\Delta B = 2mT,\ f = 200Hz$

$\Delta B = 2mT$

$\Delta B = 5mT$
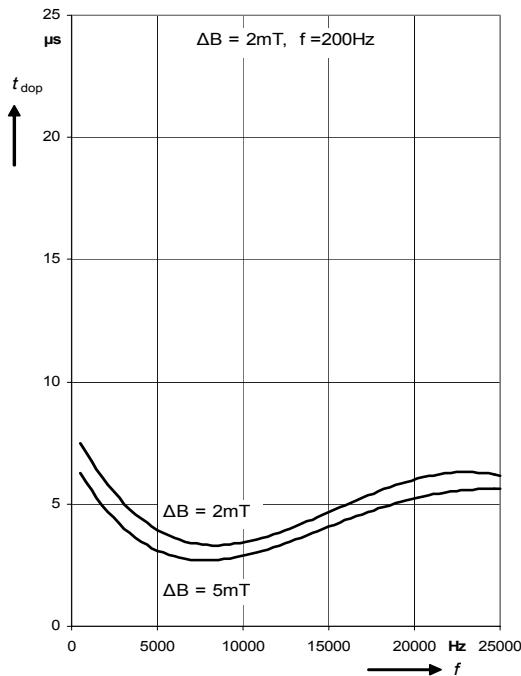
Delay Time between Switching Threshold ΔB and Rising Edge of V_{OUT} at $T_j = 25°C$

$\Delta B = 2mT,\ f = 200Hz$

$\Delta B = 2mT$

$\Delta B = 5mT$

Data Sheet

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V 1.1, 2008-01
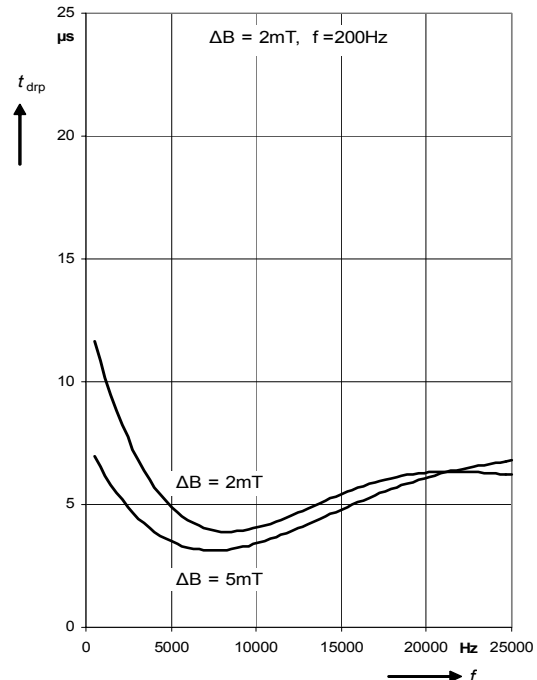
Typical Performance Characteristics

Delay Time versus Differential Field
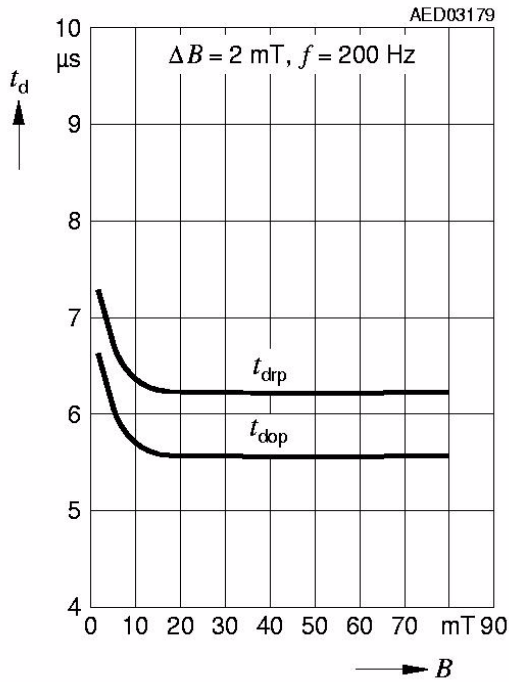
AED03179

$\Delta B = 2$ mT, $f = 200$ Hz

t_d (µs) versus B (mT)

t_{drp}

t_{dop}

Delay Time versus Temperature

AED03180

$\Delta B = 2$ mT, $f = 200$ Hz

t (µs) versus T (°C)

t_{drp}

t_{dop}

Rise and Fall Time versus Temperature

AED03181

$I_Q = 40$ mA

t (ns) versus T_j (°C)

t_r

t_f
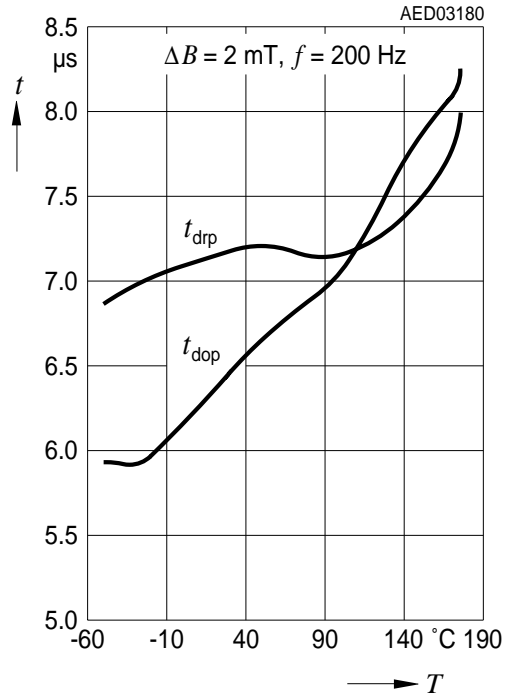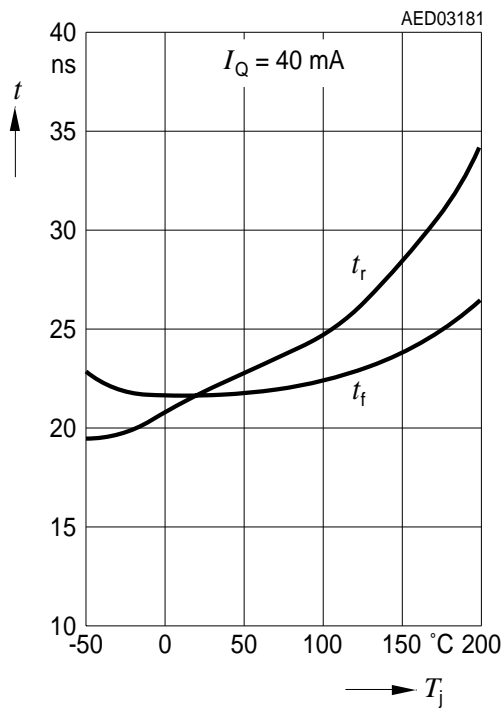
Rise and Fall Time versus Output Current

AED03182

$T_j = 25$ °C

t (ns) versus I_{OUT} (mA)

t_r

t_f
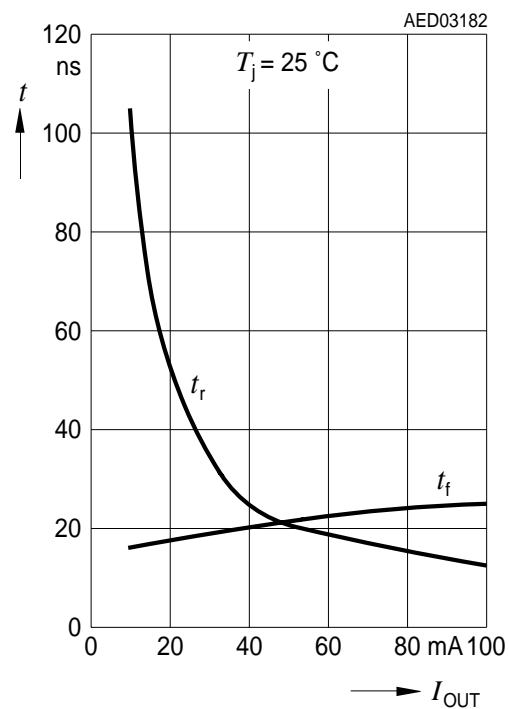
Typical Performance Characteristics

Capacitor Voltage versus Temperature

AED03183
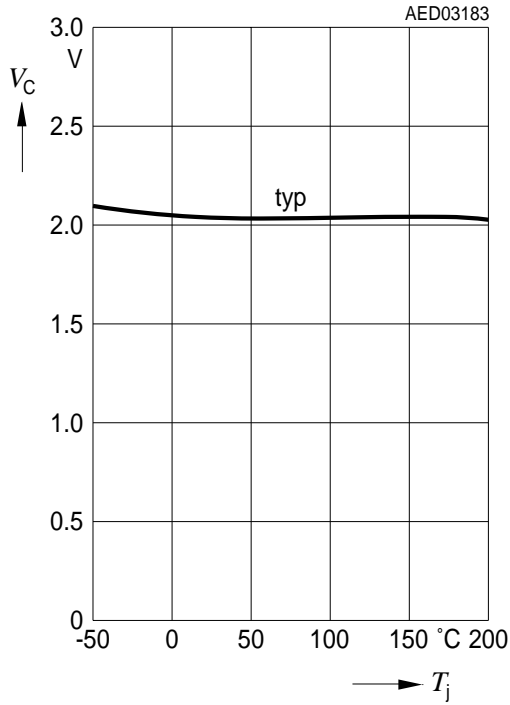
Switching Thresholds versus Mechanical Stress

AED03184
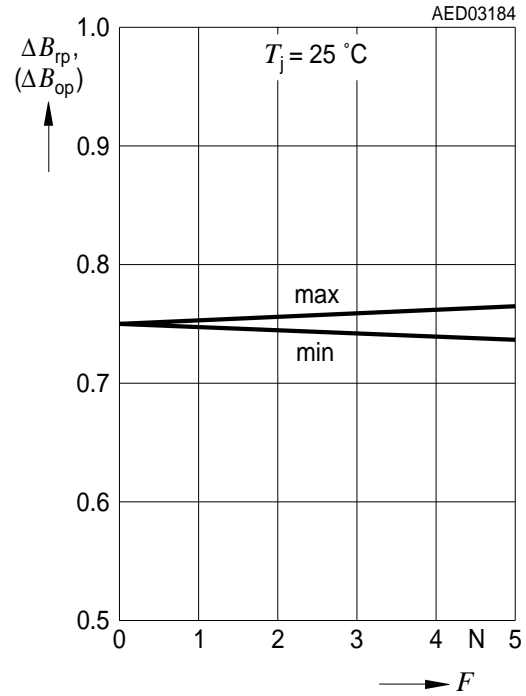
Filter Sensitivity versus Temperature

AED03185
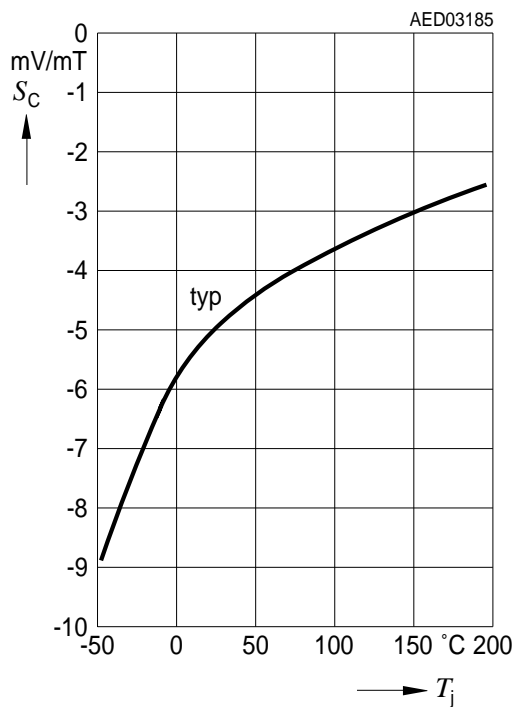
Filter Input Resistance versus Temperature

AED03186

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

Periodjitter (1σ) versus Temperature

AED03187

$@ \Delta B = 10$ mT

max
typ
min

AED03188

$f = 1$ KHz, $B_P = 5$ mT

TLE4921-5U
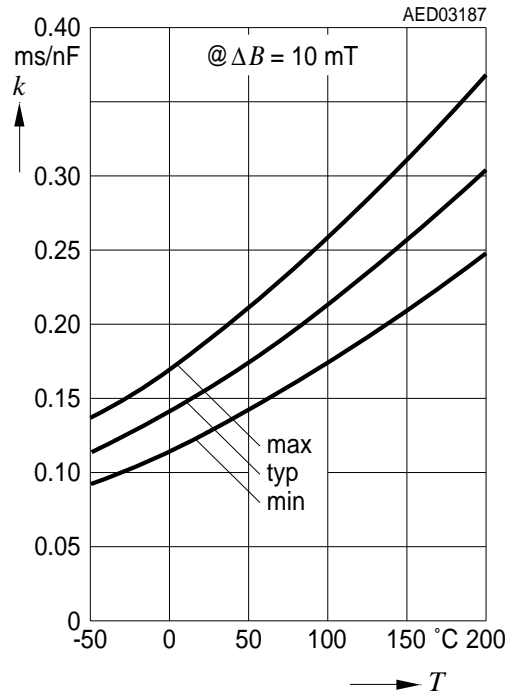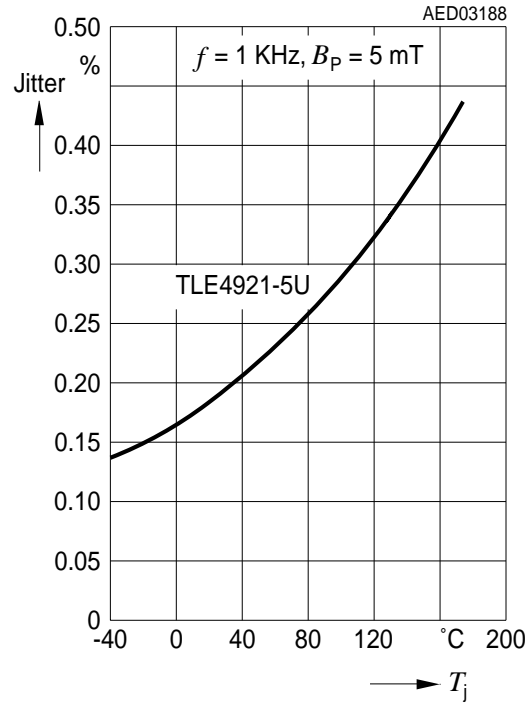
Table 6   Electro Magnetic Compatibility
ref. DIN 40839 part 1; test circuit 1

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.
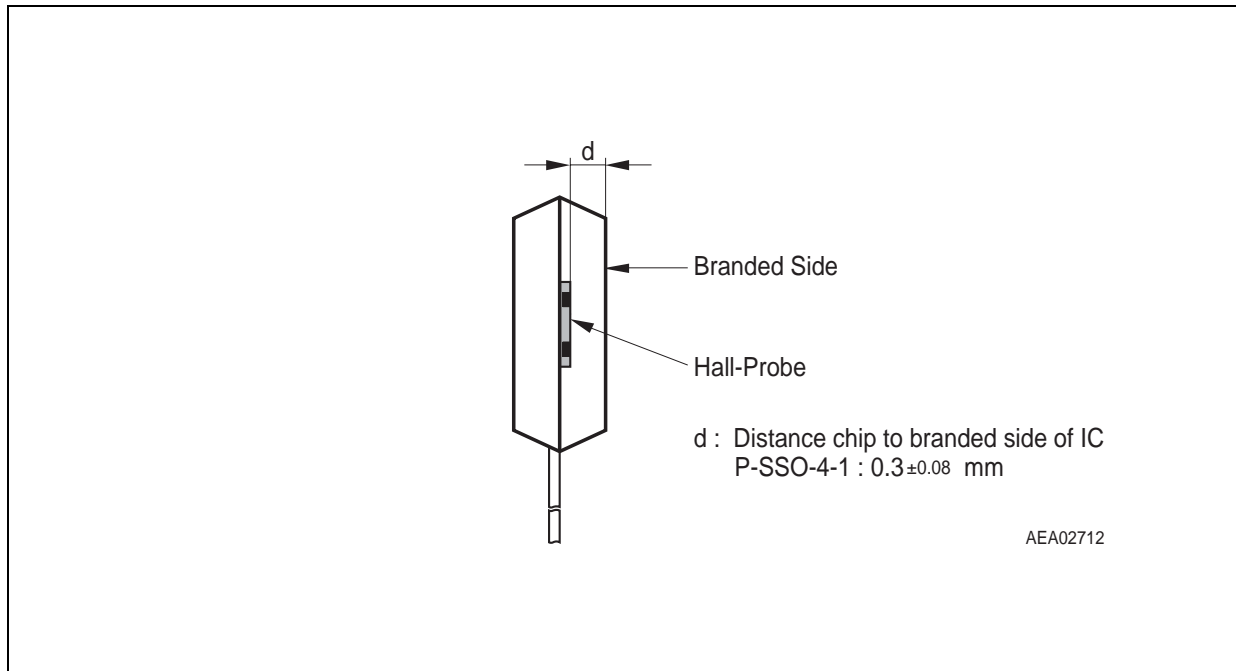
Figure 11   Distance Chip to Upper Side of IC
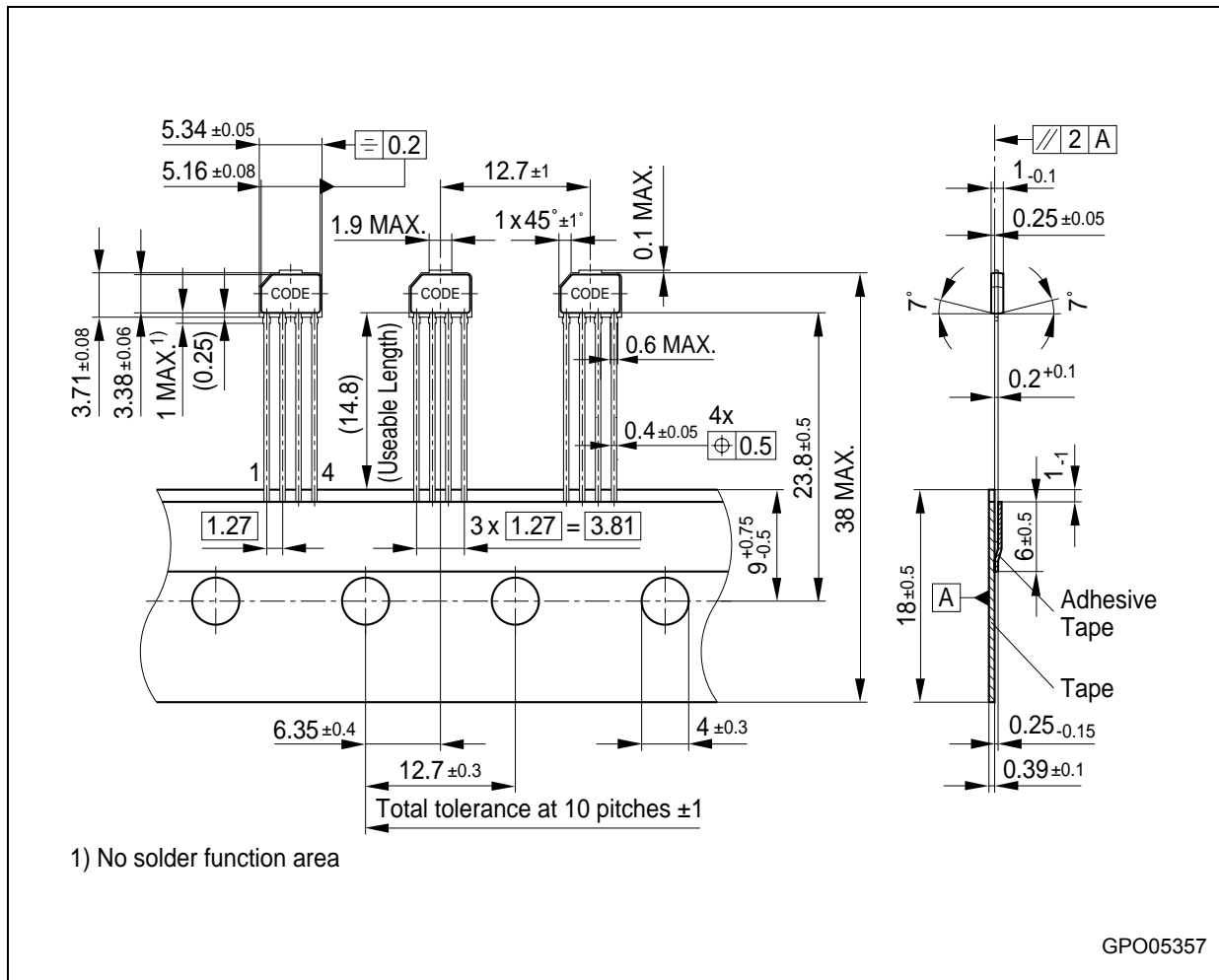
8 Package Outlines

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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