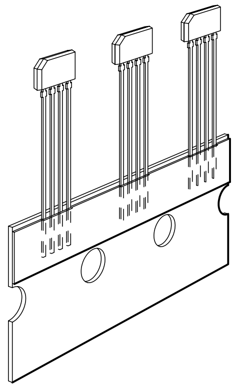
SIEMENS

Static Differential Hall Effect Sensor IC — TLE 4974

Preliminary Data — **Bipolar IC**

Features

- Static operation (zero speed)
- Digital output signal
- Two-wire and three-wire configuration possible
- Large temperature range
- Protection against overvoltage
- Protection against reversed polarity
- Output protection against electrical disturbances



P-SSO-4-1

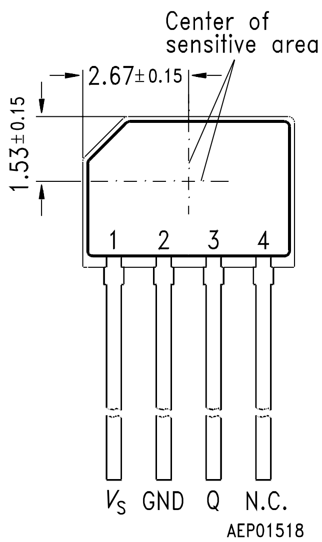
Type	Ordering Code	Package
TLE 4974 U	Q67006-A9133	P-SSO-4-1

The TLE 4974 U is a differential Hall effect sensor designed for rotational speed and timing applications using ferromagnetic toothed wheels and slotted shafts such as camshafts, crankshafts, transmissions, and ABS/TCS systems.

Since the TLE 4974 U can detect zero rotation speed, it is applicable to position sensing as well.

The TLE 4974 U 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.

Pin Configuration
(top view)



Pin Definitions and Functions

Pin	Symbol	Function
1	V_S	Supply voltage
2	GND	Ground
3	Q	Output
4	N.C.	Not connected

Functional Description

The differential Hall sensor IC detects the motion of, and static 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 (a magnet attached to the back, unmarked, side of the IC package).

Circuit Description (see Figure 1 and 2)

The TLE 4974 U is comprised of a supply voltage reference, a pair of Hall probes spaced at 2.5 mm, differential amplifier, Schmitt trigger, an open collector output.

Protection is provided at the input/supply (pin 1) for overvoltage and reverse polarity and against overstress such as load dump, etc., in accordance with ISO-TR 7637 and DIN 40839. The output (pin 3) is protected against voltage peaks and electrical disturbances.

Operation

For ease of explanation the probes will be referred to as sensor 1 and sensor 2, and assumes that the Hall IC is back-biased using the south (positive) pole. Operation is reversed, with respect to the active sensor, if back-biasing uses the north (negative) pole.

Applications using a, front (marked side of the IC package) passing, magnet wheel is identical with respect to the Hall sensor operation. Please refer to **figure 9** System Operation.

As a magnetic source, or target pass in front of sensor 2 the magnetic field or field density creates a positive differential at the input of the differential amplifier, resulting in a proportional output to the Schmitt trigger, and a triggered output to the open collector driver.

When the source or target pass in front of sensor 1 (both probes are now influenced by the source/target) the amplifier inputs are in zero differential state and the output remains “on”.

As the source or target move past sensor 2 (sensor 1 active) the amplifier inputs are in a negative differential state and the Schmitt trigger remains in the "off" state.

When the source or target moves past probe 1 (both probes not influenced by source/target) the amplifier is again in the zero differential state and the output remains in "off" condition, and the cycle repeats.

Rotation Sensing Cycle

1. Sensor 2 active (over target) - Output triggered "on"
2. Sensor 1 and 2 active (both probes over target) - Output remains “on”.
   Note:
   This is not guaranteed over temperature.
3. Sensor 2 inactive (over space), sensor 1 active (over target) - Negative differential mode - Output triggered "off".
4. Sensor 1 and 2 inactive (both probes over space) - Output remains "off".

For applications which require larger airgaps (3 mm +) and do not require zero (static) speed sensing, the TLE 4921-2U (dynamic-active high output) should be used.

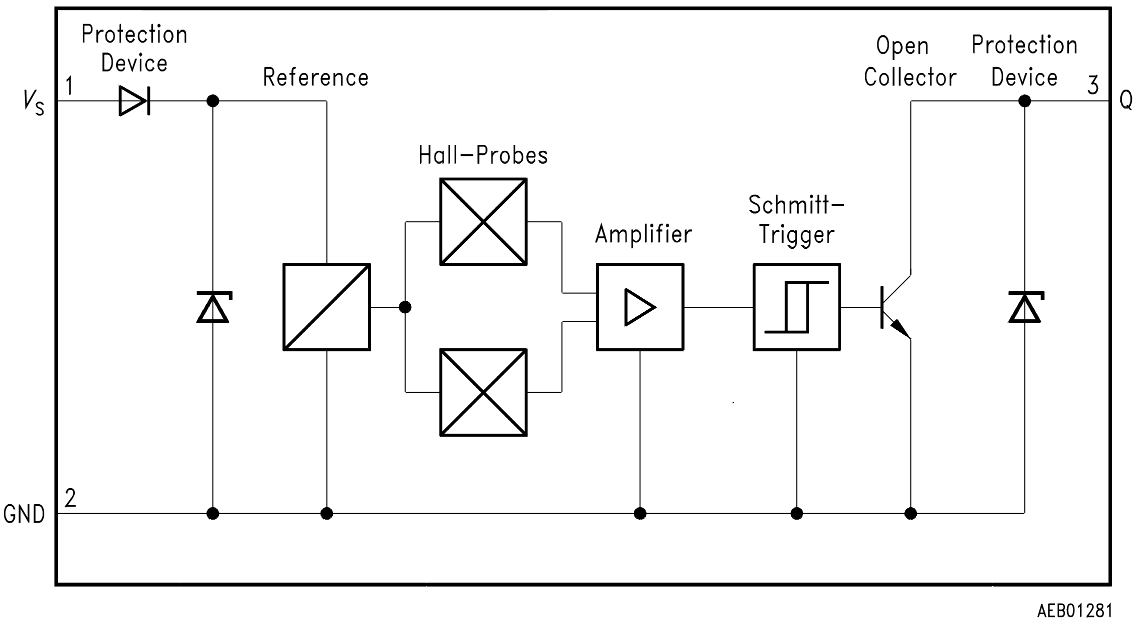


Figure 1
Block Diagram 1

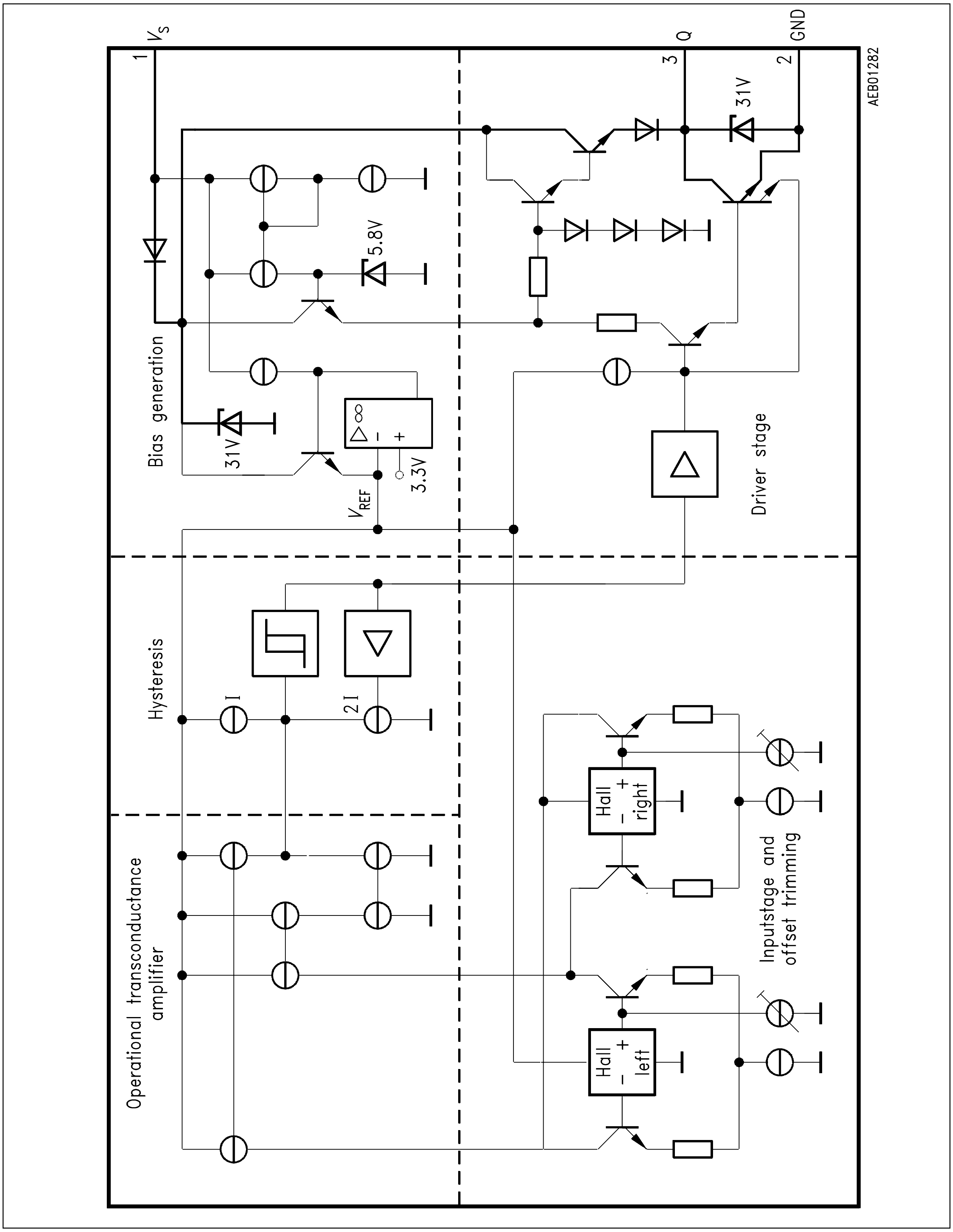


Figure 2
Block Diagram 2

Absolute Maximum Ratings
T_j = – 40 to 150 ˚C

Parameter	Symbol	Limit Values		Unit	Remarks
		min.	max.		
Supply voltage	V_S	– 40	30	V	–
Output voltage	V_Q	– 0.7	30	V	–
Output current	I_Q	–	50	mA	–
Output reverse current	$-I_Q$	–	50	mA	–
Junction temperature	T_j	–	150	˚C	–
Junction temperature	T_j	–	170	˚C	1000 h
Junction temperature	T_j	–	210	˚C	40 h
Storage temperature	T_{stg}	– 40	150	˚C	–
Thermal resistance	$R_{th\ JA}$	–	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	200	mA	t < 2 ms; v = 0.1

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

Testpulse 1	V_{LD}	– 100	–	V	t_d = 2 ms
Testpulse 2	V_{LD}	–	100	V	t_d = 0.05 ms
Testpulse 3a	V_{LD}	– 150	–	V	t_d = 0.1 µs
Testpulse 3b	V_{LD}	–	100	V	t_d = 0.1 µs
Testpulse 4	V_{LD}	– 7	–	V	$t_d \leq$ 20 s
Testpulse 5	V_{LD}	–	120	V	t_d = 400 ms; R_p = 450 Ω

Operating Range

Supply voltage	V_S	4.5	24	V	–
Junction temperature	T_j	– 40	150	˚C	–
Junction temperature	T_j	– 40	170	˚C	threshold may exceed the limits
Pre-induction	B_O	– 500	500	mT	–

AC/DC Characteristics

4.5 V ≤ V_S ≤ 24 V; – 40 ˚C ≤ T_j ≤ 150 ˚C

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			
Supply current						V_Q = high, I_Q = 0 mA	
	I_S	3.0	8	12	mA	V_S = 4.5 V	1
	I_S	3.5	8.5	13.5	mA	V_S ≥ 7 V	1
						V_Q = low, I_Q = 40 mA	
	I_S	3.5	8.5	12.5	mA	V_S = 4.5 V	1
	I_S	4.0	9	14.5	mA	V_S ≥ 7 V	1
Output saturation voltage	V_{QSat}	–	0.25	0.6	V	I_Q = 40 mA	1
Output leakage current	I_{QL}	–	–	10	µA	V_Q = 24 V	1
Switching frequency	f	0	–	20	kHz	ΔB = 20 mT	2
Switching flux density	ΔB_{OP}	– 6	2.5	17	mT	–	2
Hysteresis	ΔB_{Hy}	3	5	10	mT	–	2
Overvoltage protection							
– at supply voltage	V_{SZ}	27	–	35	V	I_S = 16 mA	1
– at output	V_{QZ}	27	–	35	V	I_S = 16 mA	1

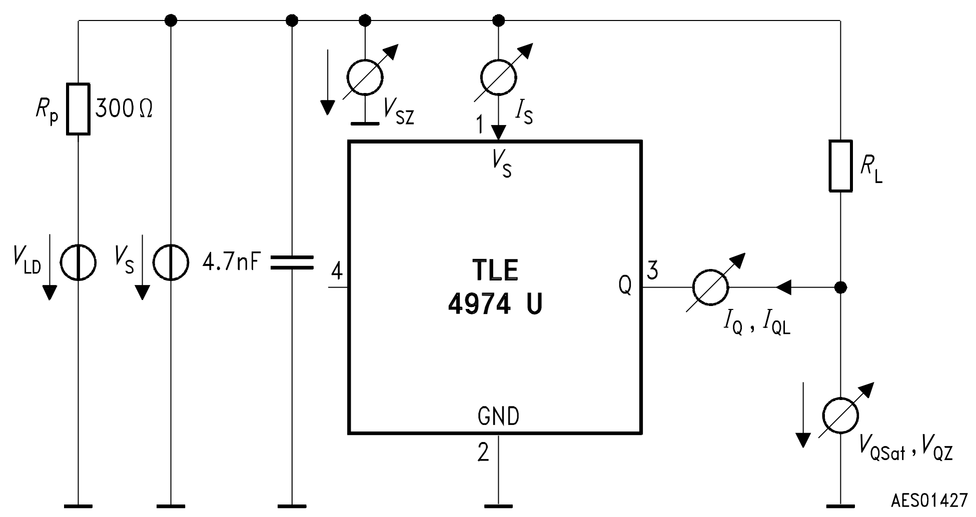


Figure 3
Test Circuit 1

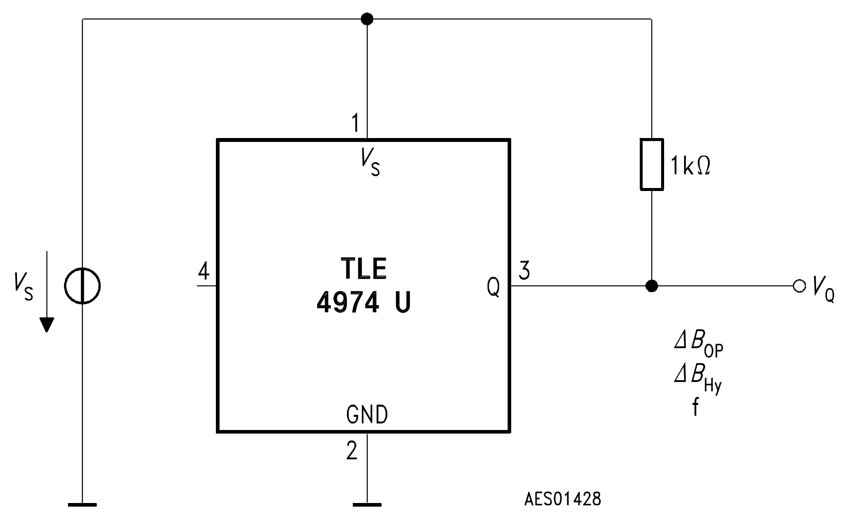


Figure 4
Test Circuit 2

– B_O = 100 mT;
– tooth wheel with module m = 2 mm
– Distance IC-object L = 1 mm
– Southpole at back of IC

Application Notes

Two possible applications are shown in **figure 7 and 8** (Tooth and Magnet Wheel).

The differences between two-wire and three-wire application is shown in **figure 10**.

Tothed Wheel Sensing

In the case of ferromagnetic toothed wheel application the IC has to be biased by a permanent magnet (e.g. $SECo_5$ (Vacuumschmelze VX145) with the dimensions 8 mm x 5 mm x 3 mm) which should cover both hallprobes.

The maximum air gap depends on

– the magnetic field strength (magnet used),
– the toothed wheel that is used (dimensions, material, etc),
– the ambient temperature

a	centred distance of hall probes	a = 2.5 mm
b	hall-probes to IC surface	b= 0.25 mm
L	IC surface to tooth wheel	

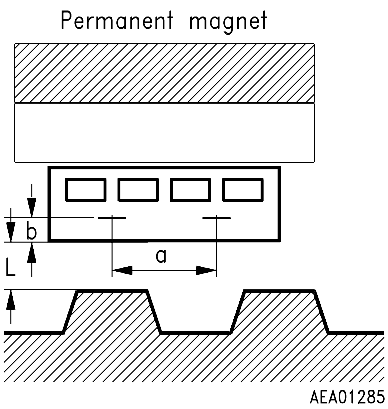
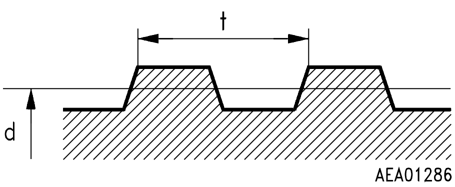


Figure 5
Sensor Spacing



Conversion DIN - ASA
m = 25.4 mm/p
t = 25.4 mm x CP

DIN

d diameter (mm)
z number of teeth
m module m = d/z (mm)
t pitch t = π x m (mm)

ASA

p diametral pitch p = z/d (inch)
PD pitch diameter PD = z/p (inch)
CP circular pitch CP = 1 inch x π /p

Figure 6
Toothed Wheel Dimensions

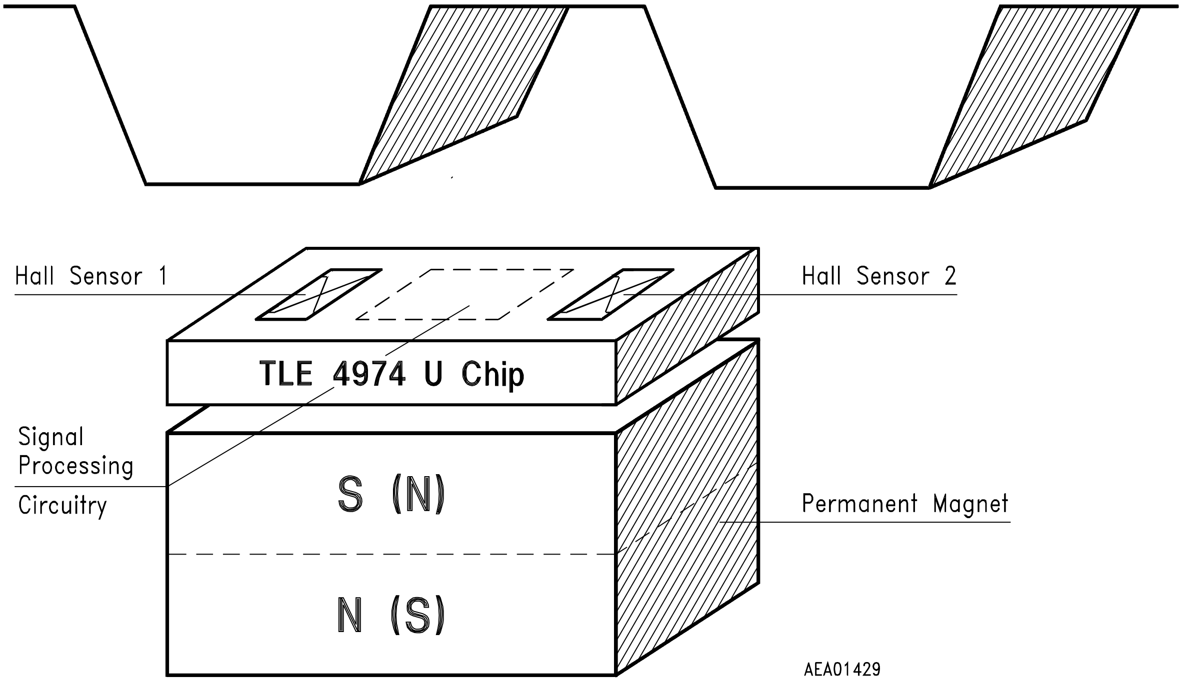


Figure 7
TLE 4974 U, with Ferromagnetic Toothed Wheel

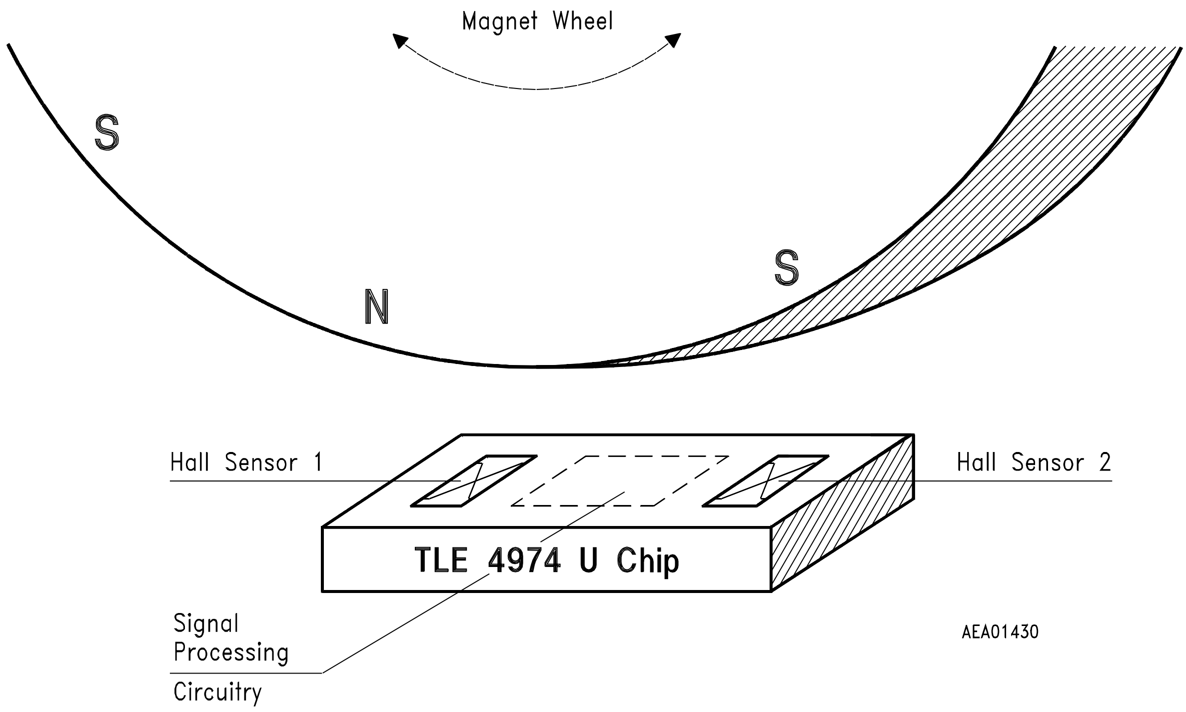
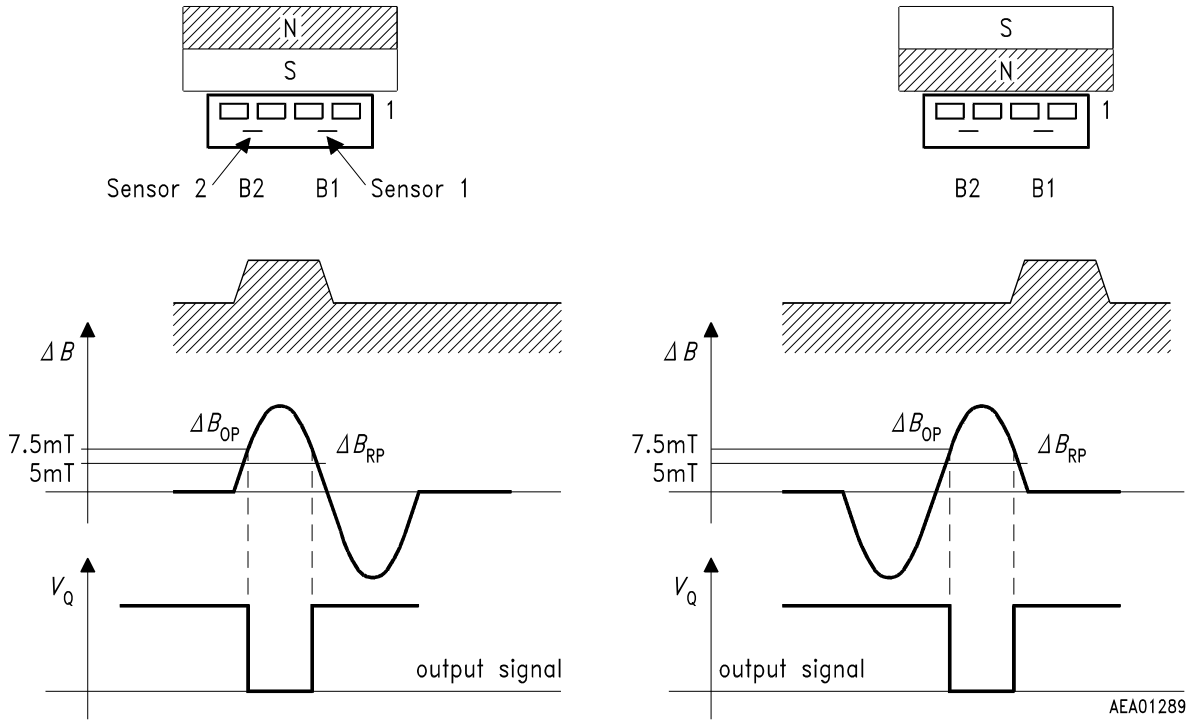


Figure 8
TLE 4974 U, with Magnet Wheel



For Southpole or Northpole at the back of the IC

release point: B2-B1 < ΔB_{RP} switches the output OFF (V_Q = HIGH)
operate point: B2-B1 > ΔB_{OP} switches the output ON (V_Q = LOW)
$\Delta B_{OP} = \Delta B_{RP} + \Delta B_{Hy}$

Figure 9
System Operation

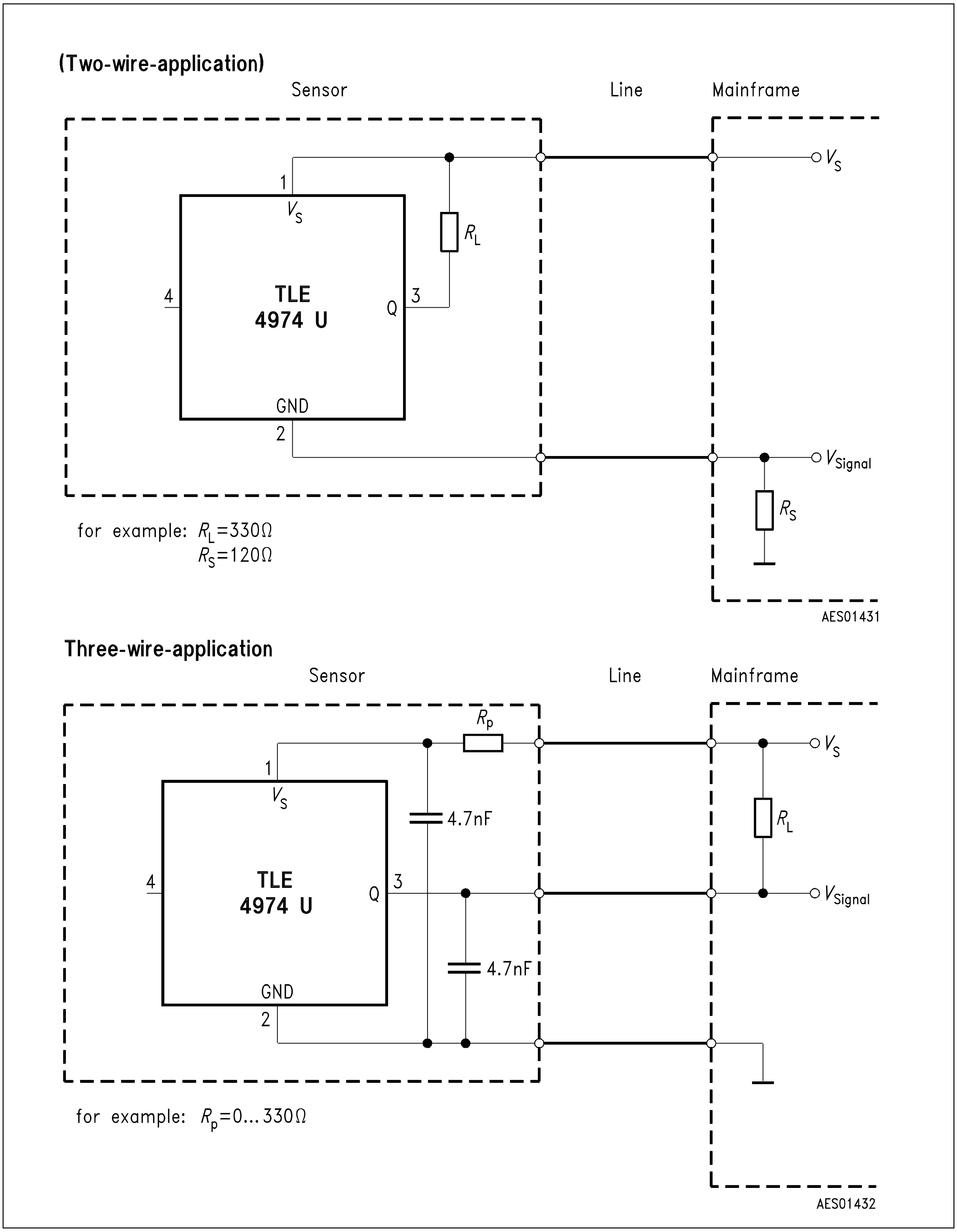
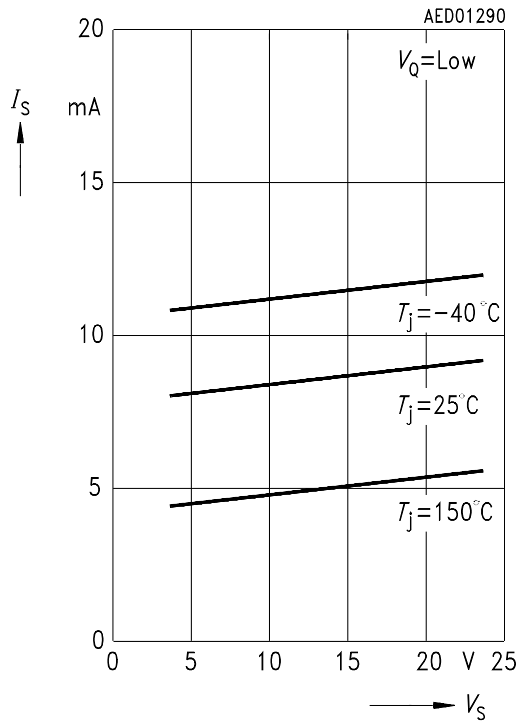
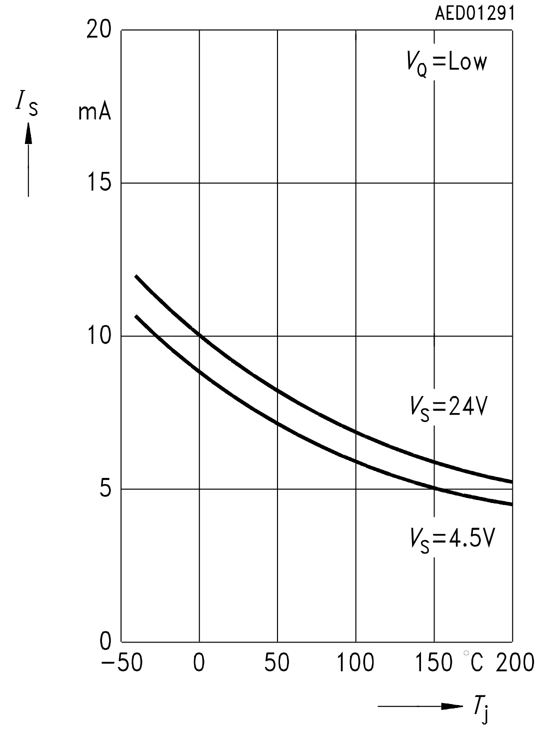


Figure 10
Application Circuits

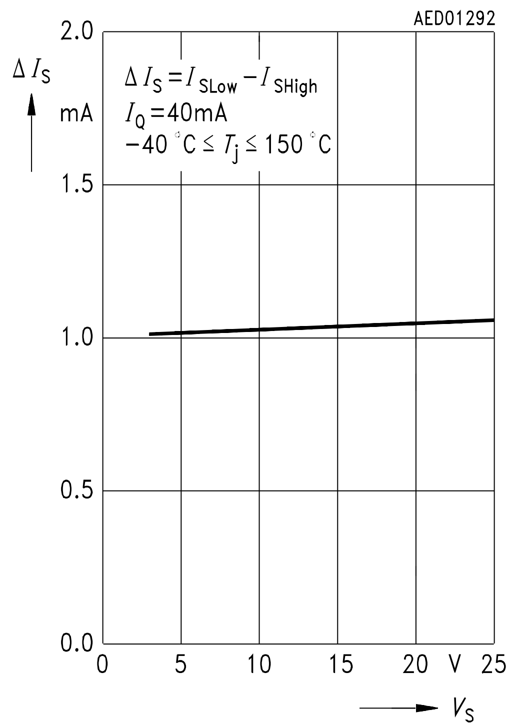
Quiescent Current versus Supply Voltage



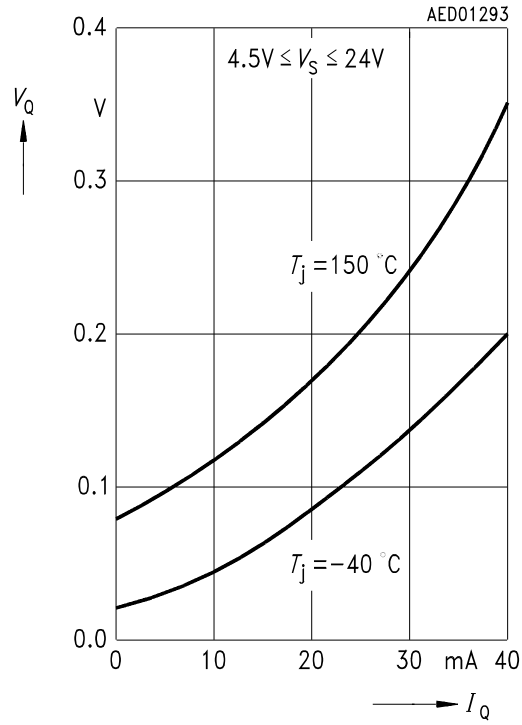
Quiescent Current versus Junction Temperature



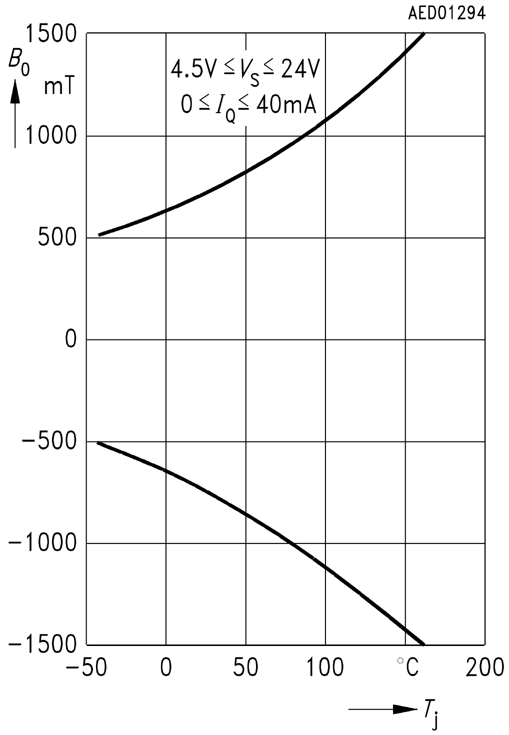
Quiescent Current Difference versus Supply Voltage



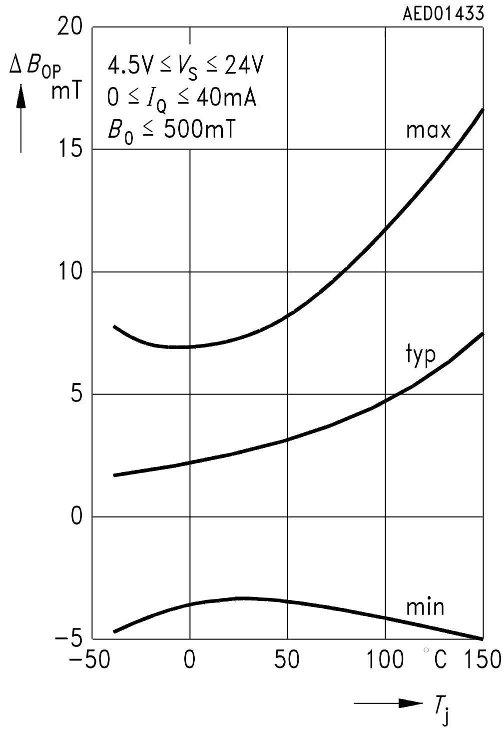
Saturation Voltage versus Output current



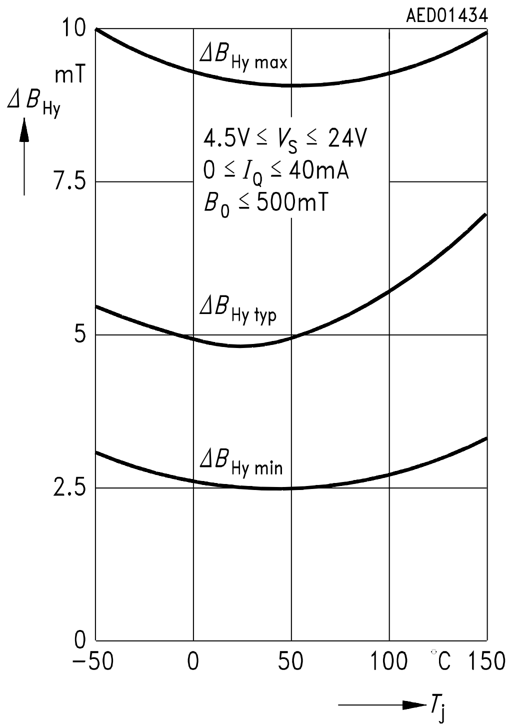
Maximum Preinduction versus Junction Temperature



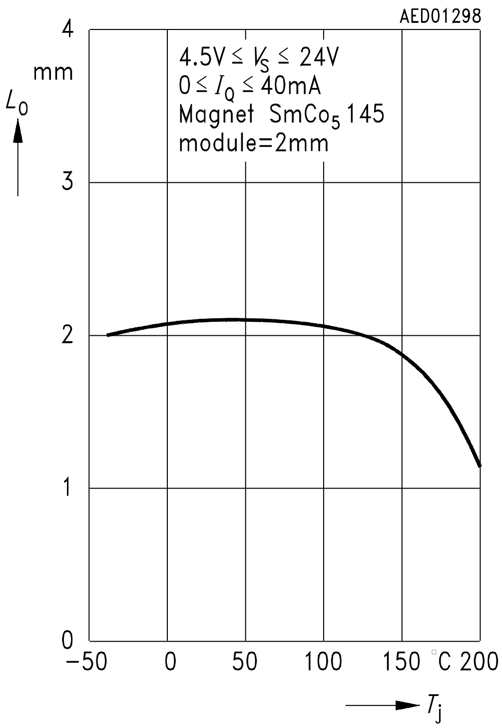
Switching Induction versus Temperature



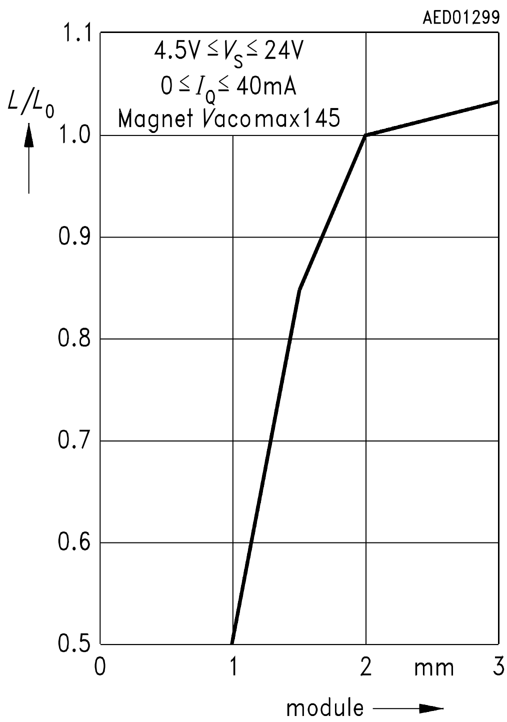
Hysteresis Induction versus Junction Temperature



Distance IC-Toothed Wheel versus Junction Temperature



Relative Distance versus Module



Fall and Rise Time versus Junction Temperature