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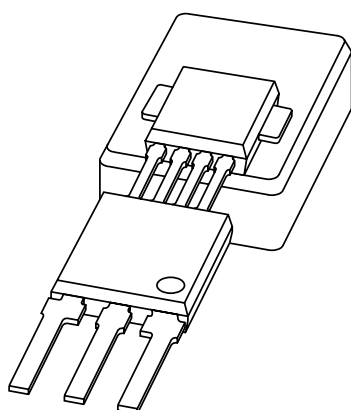
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# DATA SHEET



## **KMI16/1** Integrated rotational speed sensor

Product specification  
Supersedes data of 1998 May 15

2000 Sep 05

Integrated rotational speed sensor

KMI16/1

DESCRIPTION

The KMI16/1 sensor detects rotational speed of ferrous gear wheels and reference marks.

The sensor consists of a magnetoresistive sensor element, a signal conditioning integrated circuit in bipolar technology and a ferrite magnet.

The frequency of the digital current output signal is proportional to the rotational speed of the target wheel.

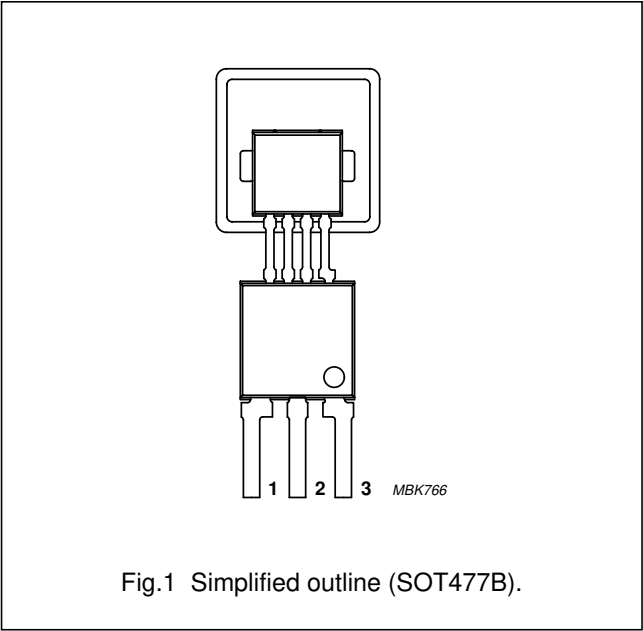
The open collector (OC) output allows for a high degree of flexibility in the design of subsequent conditioning electronics.

**CAUTION**

Do not press two or more products together against their magnetic forces. Do not expose products to strong magnetic fields of more than 30 kA/m.

PINNING

PIN	SYMBOL	DESCRIPTION
1	V <sub>CC</sub>	DC supply voltage
2	V <sub>out</sub>	open collector output
3	GND	ground



QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V <sub>CC</sub>	DC supply voltage	4.5	5	16	V
I <sub>CC</sub>	DC supply current (pin 1)	4	10	14	mA
V <sub>CEsat</sub>	OC saturation voltage	–	–	1	V
d <sub>max</sub>	maximum sensing distance	2.4	2.9	–	mm
f <sub>t</sub>	operating tooth frequency	0	–	25000	Hz
T <sub>amb</sub>	ambient operating temperature	–40	–	+150	°C

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**LIMITING VALUES**

In accordance with the Absolute Maximum Rating System (IEC 60134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V <sub>CC</sub>	DC operating supply voltage	T <sub>amb</sub> = −40 to +150 °C	4.5	16	V
	voltage pin 1	T <sub>amb</sub> = −40 to +150 °C; no wrong polarity protection	−0.5	+16	V
V <sub>out</sub>	OC output voltage	T <sub>amb</sub> = −40 to +150 °C; no wrong polarity protection; see Fig.5	−0.5	+16	V
V <sub>out(max)</sub>	peak OC output voltage	T <sub>amb</sub> = −40 to +40 °C; no wrong polarity protection; see Fig.5	−0.5	+26.5	V
I <sub>out(max)</sub>	OC output current	T <sub>amb</sub> = −40 to +150 °C	–	20	mA
I <sub>out(off)</sub>	OC output leakage current	T <sub>amb</sub> = −40 to +150 °C	–	100	μA
P <sub>tot</sub>	total power dissipation	T <sub>amb</sub> = −40 to +150 °C	–	200	mW
T <sub>sld</sub>	soldering temperature	t ≤ 10 s	–	260	°C
T <sub>stg</sub>	storage temperature		−65	+150	°C
T <sub>amb</sub>	ambient operating temperature		−40	+150	°C

**CHARACTERISTICS**

T<sub>amb</sub> = 25 °C; V<sub>CC</sub> = 5 V; d = 1.9 mm; f<sub>t</sub> = 2 kHz; test circuit see Fig.5; gear wheel: module 2.08 mm; material 9SMnPb28k; see Fig.6; centred sensor position; see notes 1, 2 and 3; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I <sub>CC</sub>	supply current (pin 1)	T <sub>amb</sub> = −40 to +150 °C	4	10	14	mA
V <sub>out (high)</sub>	OC output voltage high	OC = off state; T <sub>amb</sub> = −40 to +150 °C	4.7	4.9	–	V
V <sub>CE sat</sub>	OC saturation voltage	OC = on state; I <sub>out</sub> = 20 mA	–	0.4	1	V
t <sub>r</sub>	output signal rise time	10% to 90%	5	12	20	μs
t <sub>f</sub>	output signal fall time	10% to 90%	0.1	0.4	10	μs
δ	duty cycle	T <sub>amb</sub> = −40 to +150 °C	30	50	70	%
d <sub>min</sub>	minimum sensing distance	T <sub>amb</sub> = −40 to +150 °C	–	0.3	0.5	mm
d <sub>max</sub>	maximum sensing distance	T <sub>amb</sub> = −40 to +150 °C	2.4	2.9	–	mm

**Notes**

1. High rotational wheel speeds reduce the maximum sensing distance because of eddy currents, depending on target wheel dimensions and materials used.
2. Output pins are designed for electrostatic sensitivity for more than 2000 V according to Human Body Model (HBM); MIL-STD-883; method 3015.
3. EMC behaviour depends greatly on design of application circuit.

# Integrated rotational speed sensor

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## FUNCTIONAL DESCRIPTION

The KMI16/1 sensor is sensitive to the motion of ferrous gear wheels or reference marks. The functional principle is shown in Fig.3. Due to the effect of flux bending, the different directions of magnetic field lines in the magnetoresistive sensor element will cause an electrical signal. Because of the chosen sensor orientation and the direction of ferrite magnetization, the KMI16/1 is sensitive to movement in the 'y' direction in front of the sensor only (see Fig.2).

The magnetoresistive sensor element signal is amplified, temperature compensated and passed to a Schmitt trigger in the conditioning integrated circuit (see Fig.4). The digital output signal level is independent of the sensing distance within the measuring range (see Fig.10). A (3-wire) output current enables safe transfer of the sensor signal to the detecting circuit (see Fig.5). The integrated circuit housing is separated from the sensor element housing to optimize the sensor behaviour at high temperatures.

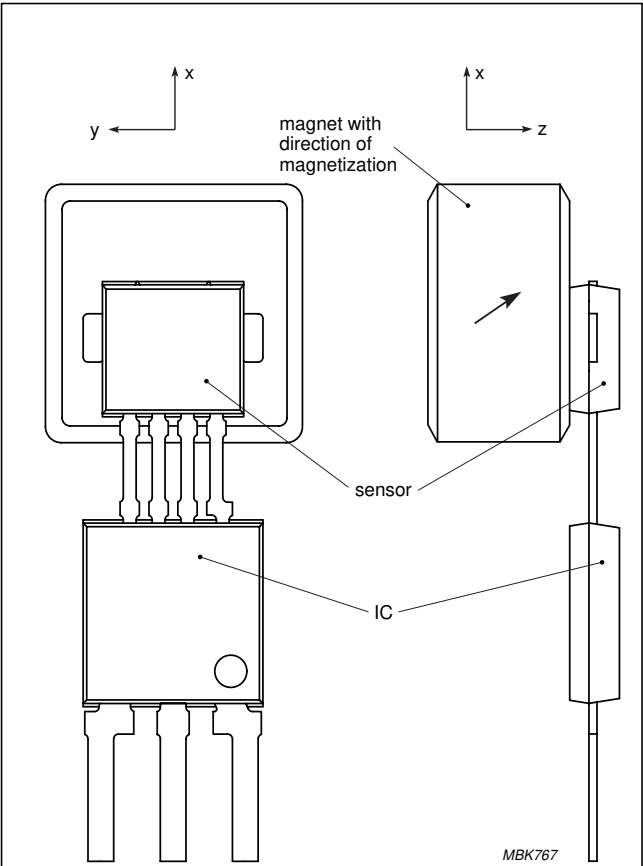


Fig.2 Component detail of the KMI16/1.

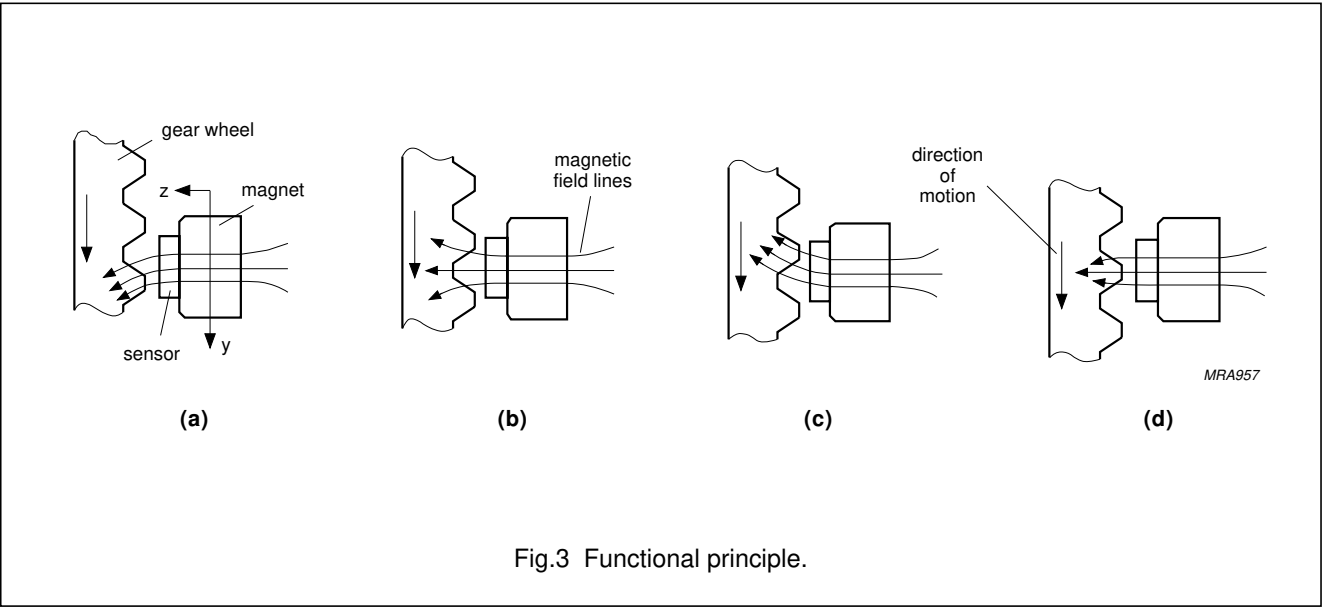


Fig.3 Functional principle.

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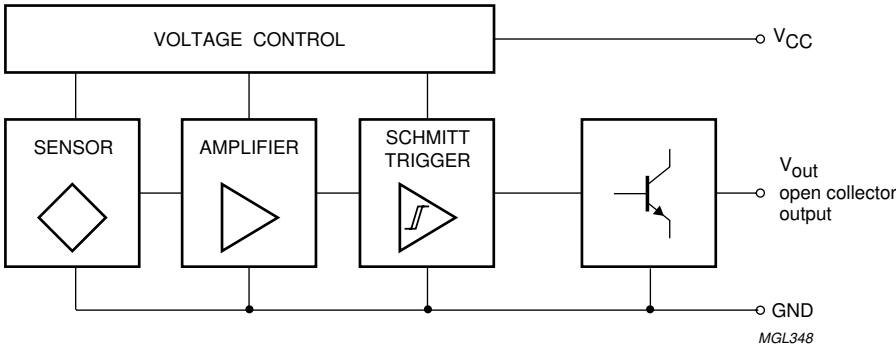


Fig.4 Block diagram.

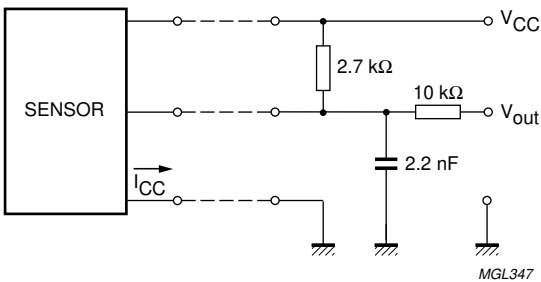


Fig.5 Test and application circuit.

Integrated rotational speed sensor

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APPLICATION INFORMATION

Mounting conditions

The recommended sensor position in front of a gear wheel is shown in Fig.11. The distance ‘d’ is measured between the sensor front and the tip of a gear wheel tooth. The KMI16/1 senses ferrous indicators like gear wheels in the ‘y’ direction only (no rotational symmetry of the sensor); see Fig.2. The effect of incorrect mounting positions on sensing distance is shown in Figs 7, 8 and 9. The symmetrical reference axis of the sensor corresponds to the axis of the ferrite magnet.

Environmental conditions

Due to eddy current effects the sensing distance depends on the tooth frequency (see Fig.13). The influence of the gear wheel module on the sensing distance is shown in Fig.12.

Gear Wheel Dimensions

SYMBOL	DESCRIPTION	UNIT
German DIN		
z	number of teeth	–
d	diameter	mm
m	module $m = d/z$	mm
p	pitch $p = \pi \times m$	mm
ASA; note 1		
PD	pitch diameter (d in inch)	inch
DP	diametric pitch $DP = z/PD$	inch <sup>-1</sup>
CP	circular pitch $CP = \pi/DP$	inch

Note

1. For conversion from ASA to DIN:  $m = 25.4 \text{ mm}/DP$ ;  
 $p = 25.4 \text{ mm} \times CP$ .

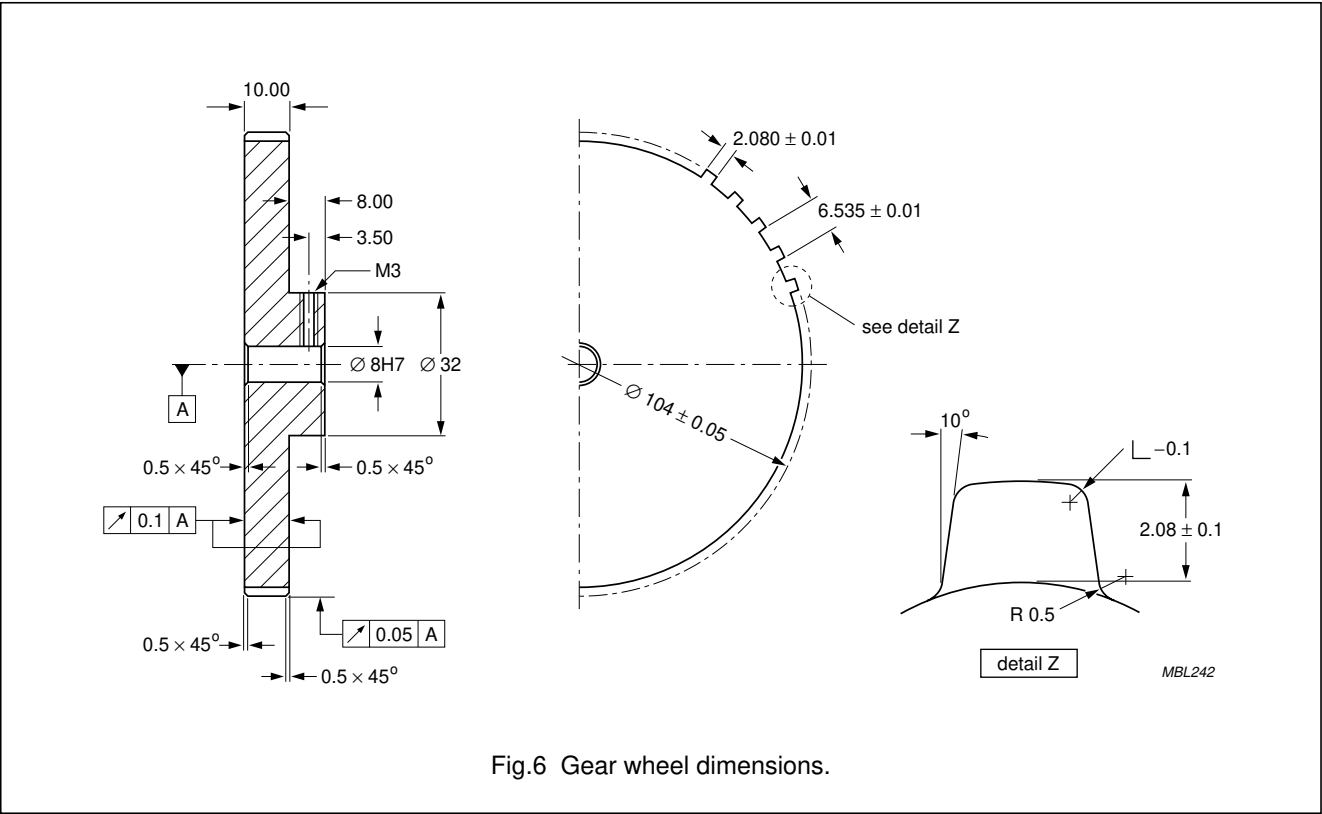
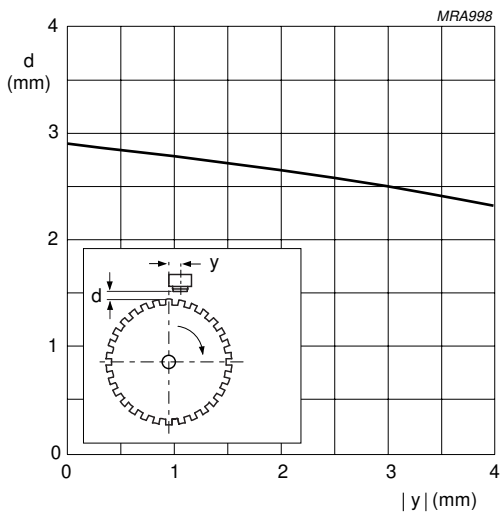


Fig.6 Gear wheel dimensions.



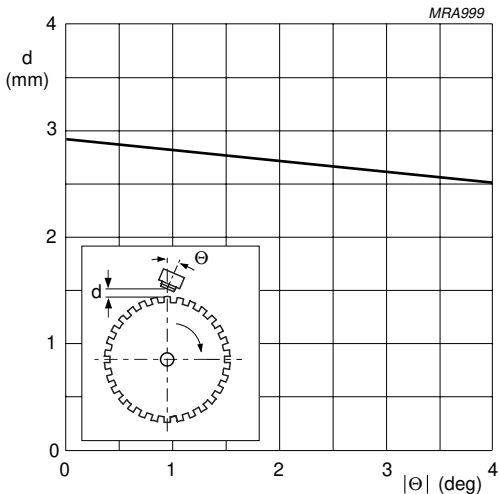
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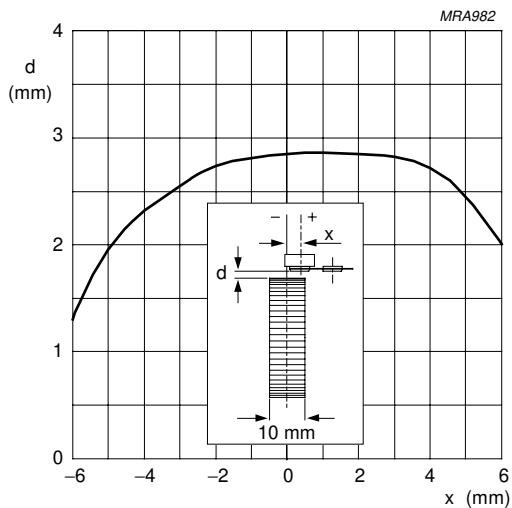
$V_{CC} = 12\text{ V}$ ;  $f_t = 2\text{ kHz}$ ; module = 2 mm; pitch diameter = 100 mm.

Fig.7 Sensing distance as a function of positional tolerance in the y-axis; typical values.



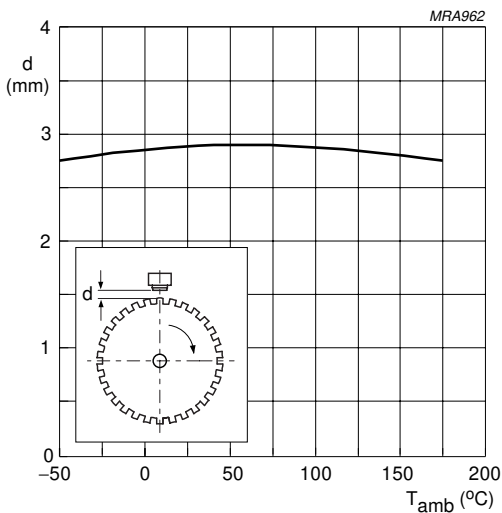
$V_{CC} = 12\text{ V}$ ;  $f_t = 2\text{ kHz}$ ; module = 2 mm.

Fig.8 Sensing distance as a function of positional tolerance; typical values.



$V_{CC} = 12\text{ V}$ ;  $f_t = 2\text{ kHz}$ ; module = 2 mm.

Fig.9 Sensing distance as a function of positional tolerance in the x-axis; typical values.



$V_{CC} = 12\text{ V}$ ;  $f_t = 2\text{ kHz}$ ; module = 2 mm.

Fig.10 Sensing distance as a function of ambient temperature; typical values.



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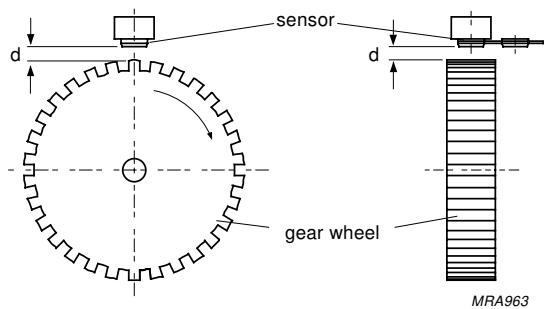
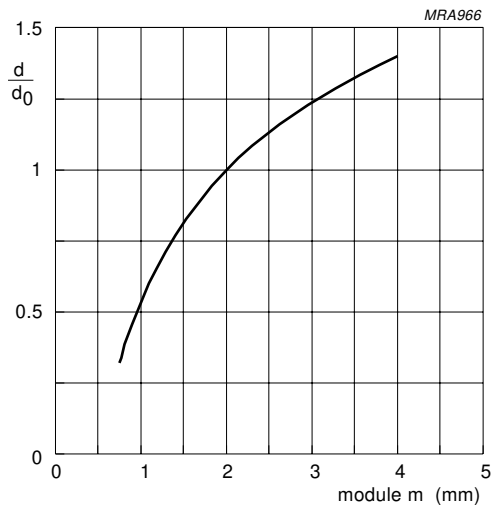
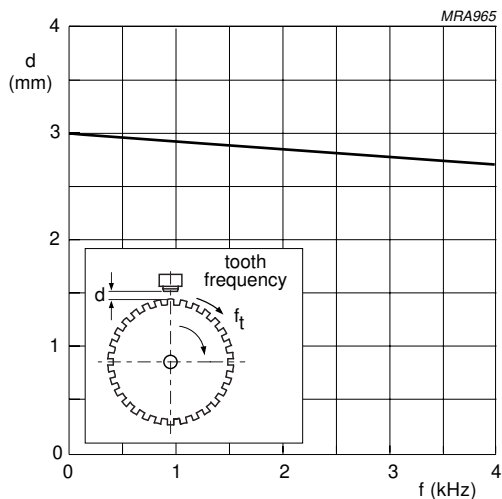


Fig.11 Sensor positioning.



$d_0$  = measuring distance for a gear wheel with module  $m = 2$  mm.

Fig.12 Normalized maximum sensing distance as a function of gear wheel module; typical values.



$V_{CC} = 12$  V; module = 2 mm.

Fig.13 Sensing distance as a function of tooth frequency; typical values.

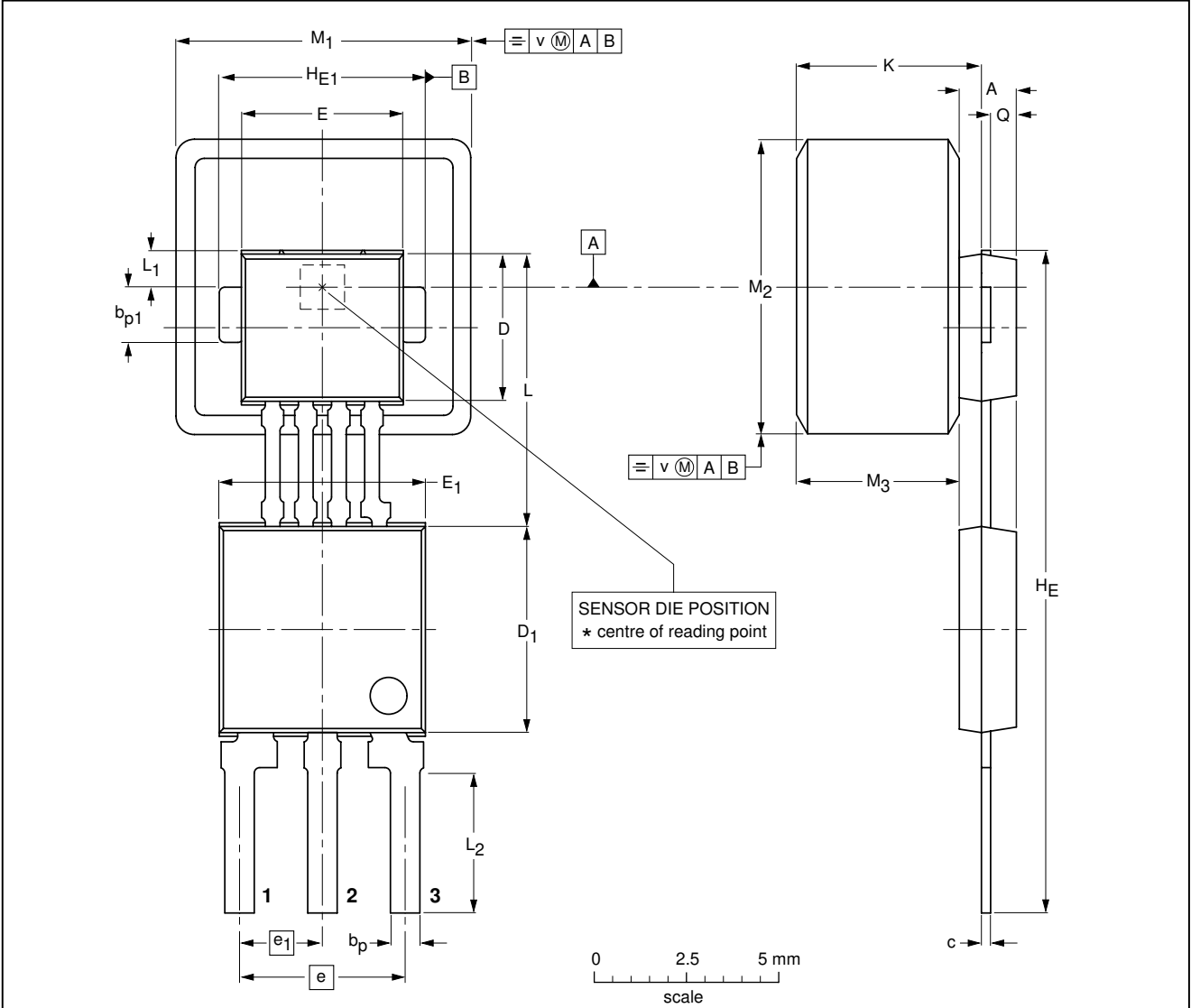
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PACKAGE OUTLINE

Plastic single-ended multi-chip package;  
magnetized ferrite magnet (8 x 8 x 4.5 mm); 4 interconnections; 3 in-line leads

SOT477B



DIMENSIONS (mm are the original dimensions)

UNIT	A <sup>(1)</sup>	b <sub>p</sub>	b <sub>p1</sub>	c	D <sup>(2)</sup>	D <sub>1</sub> <sup>(2)</sup>	E <sup>(2)</sup>	E <sub>1</sub> <sup>(2)</sup>	e	e <sub>1</sub>	H <sub>E</sub>	H <sub>E1</sub>	K <sub>max.</sub>	L	L <sub>1</sub>	L <sub>2</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub> <sup>(1)</sup>	Q	v
mm	1.7 1.4	0.8 0.7	1.57 1.47	0.3 0.24	4.1 3.9	5.7 5.5	4.5 4.3	5.7 5.5	4.6 4.4	2.35 2.15	18.2 17.8	5.6 5.5	5.37	7.55 7.25	1.2 0.9	3.9 3.5	8.15 7.85	8.15 7.85	4.7 4.3	0.75 0.65	0.25

Notes

- 1. Glue thickness not included.
- 2. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT477B						99-09-23 00-08-31

## Integrated rotational speed sensor

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## DATA SHEET STATUS

DATA SHEET STATUS	PRODUCT STATUS	DEFINITIONS <sup>(1)</sup>
Objective specification	Development	This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.
Preliminary specification	Qualification	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Product specification	Production	This data sheet contains final specifications. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.

## Note

1. Please consult the most recently issued data sheet before initiating or completing a design.

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**Limiting values definition** — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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Integrated rotational speed sensor

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