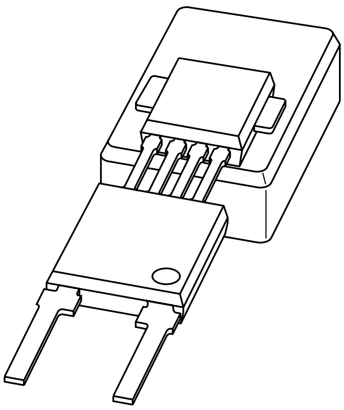
# DATA SHEET



# KMI15/1
## Integrated rotational speed sensor

Product specification
Supersedes data of 2000 Jun 26

2000 Sep 05

Philips
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## FEATURES

- Digital current output signal
- Zero speed capability
- Wide air gap
- Wide temperature range
- Insensitive to vibration
- EMC resistant.

## DESCRIPTION

The KMI15/1 sensor detects rotational speed of ferrous gear wheels and reference marks(1).
The sensor consists of a magnetoresistive sensor element, a signal conditioning integrated circuit in bipolar technology and a magnetized ferrite magnet.
The frequency of the digital current output signal is proportional to the rotational speed of a gear wheel.

| CAUTION |
|---|
| Do not press two or more products together against their magnetic forces. |

(1) The sensor contains a customized integrated circuit. Usage in hydraulic brake systems and in systems with active brake control is forbidden. For all other applications, higher temperature versions of up to 150 °C are available on request.

## PINNING

| PIN | DESCRIPTION |
|---|---|
| 1 | $V_{CC}$ |
| 2 | V– |

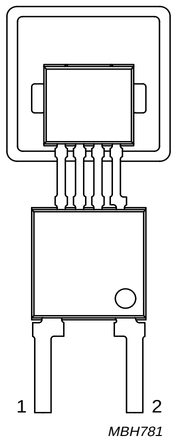



Fig.1 Simplified outline (SOT453B).

## QUICK REFERENCE DATA

| SYMBOL | PARAMETER | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_{CC}$ | DC supply voltage | – | 12 | – | V |
| $I_{CC\ (low)}$ | current output signal low | – | 7 | – | mA |
| $I_{CC\ (high)}$ | current output signal high | – | 14 | – | mA |
| d | sensing distance | 0 to 2.5 | 0 to 2.9 | – | mm |
| $f_t$ | operating tooth frequency | 0 | – | 25000 | Hz |
| $T_{amb}$ | ambient operating temperature | –40 | – | +85 | °C |

## LIMITING VALUES

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

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_{CC}$ | DC supply voltage | $T_{amb}$ = –40 to +85 °C; $R_L$ = 115 Ω | –0.5 | +16 | V |
| $T_{stg}$ | storage temperature | | –40 | +150 | °C |
| $T_{amb}$ | ambient operating temperature | | –40 | +85 | °C |
| $T_{sld}$ | soldering temperature | t ≤ 10 s | – | 260 | °C |
| | output short-circuit duration to GND | | continuous | | |

## CHARACTERISTICS

$T_{amb}$ = 25 °C; $V_{CC}$ = 12 V; d = 2.1 mm; $f_t$ = 2 kHz; test circuit: see Fig.7; $R_L$ = 115 Ω; sensor positioning: see Fig.15; gear wheel: module 2 mm; material 1.0715; unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $I_{CC\ (low)}$ | current output signal low | see Figs 6 and 8 | 5.6 | 7 | 8.4 | mA |
| $I_{CC\ (high)}$ | current output signal high | see Figs 6 and 8 | 11.2 | 14 | 16.8 | mA |
| $t_r$ | output signal rise time | $C_L$ = 100 pF; see Fig.9; 10 to 90% value | – | 0.5 | – | µs |
| $t_f$ | output signal fall time | $C_L$ = 100 pF; see Fig.9; 10 to 90% value | – | 0.7 | – | µs |
| $t_d$ | switching delay time | between stimulation pulse (generated by a coil) and output signal | – | 1 | – | µs |
| $f_t$ | operating tooth frequency | for both rotation directions | 0 | – | 25000 | Hz |
| d | sensing distance | see Fig.15 and note 1 | 0 to 2.5 | 0 to 2.9 | – | mm |
| δ | duty cycle | see Fig.6 | 30 | 50 | 70 | % |

**Note**

1. High rotational speeds of wheels reduce the sensing distance due to eddy current effects (see Fig.17).

## FUNCTIONAL DESCRIPTION

The KMI15/1 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 KMI15/1 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 (Figs 4 and 5).
The digital output signal level (see Fig.6) is independent of the sensing distance within the measuring range (Fig.14).
A (2-wire) output current enables safe transfer of the sensor signal to the detecting circuit (see Fig.7).
The integrated circuit housing is separated from the sensor element housing to optimize the sensor behaviour at high temperatures.

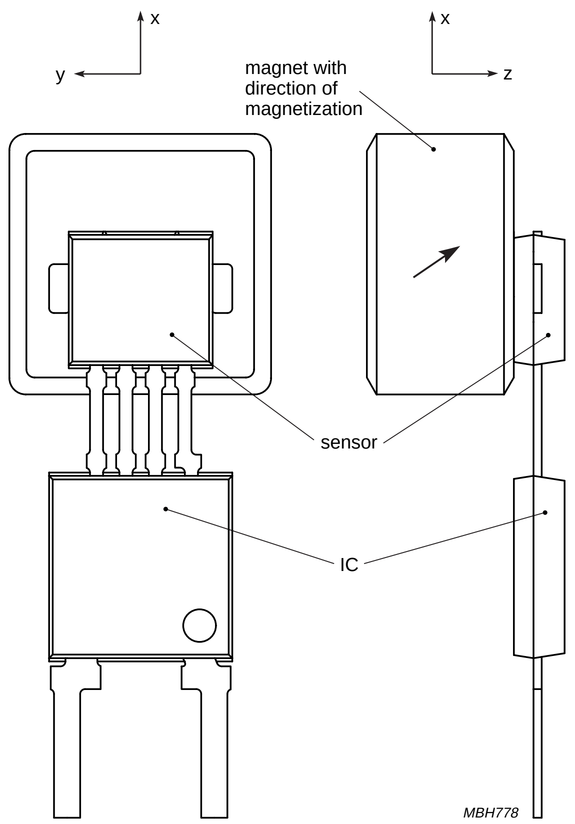



Fig.2 Component detail of the KMI15/1.

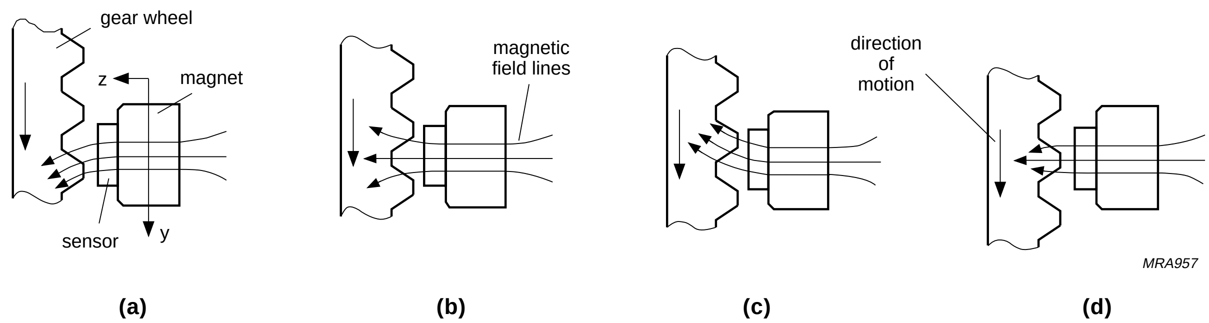



Fig.3 Functional principle.

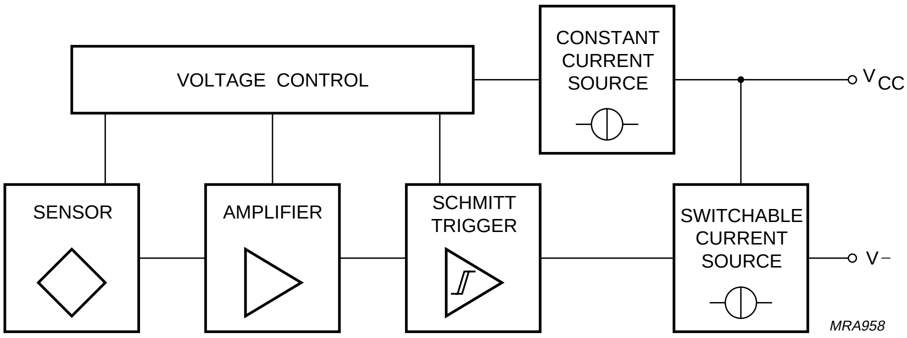



Fig.4 Block diagram.

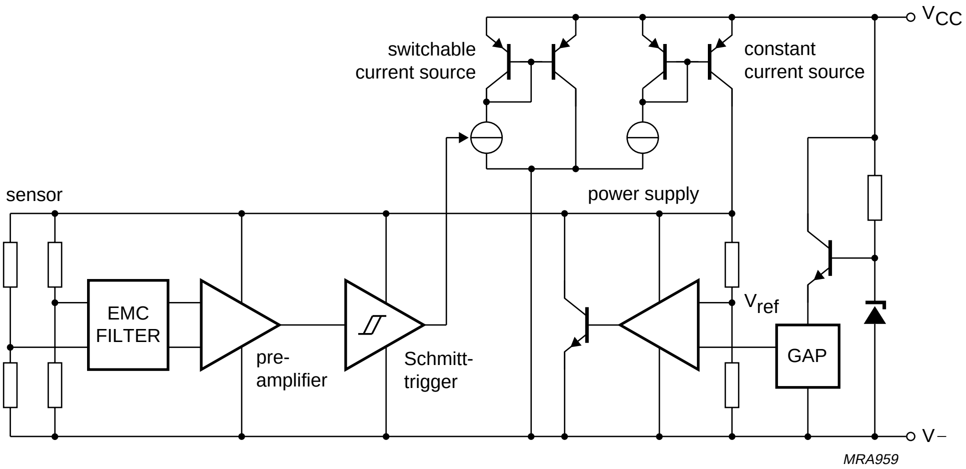
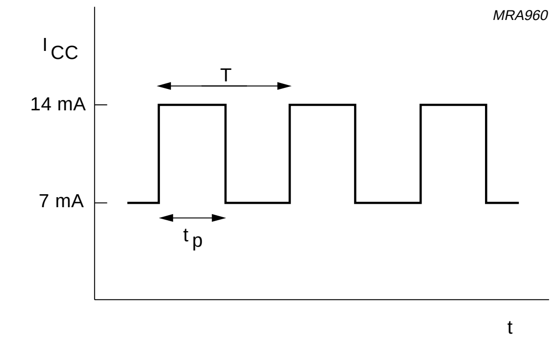



Fig.5 Simplified circuit diagram.




$\delta = \frac{t_p}{T} \times 100\%$

Fig.6 Output signal as a function of time.

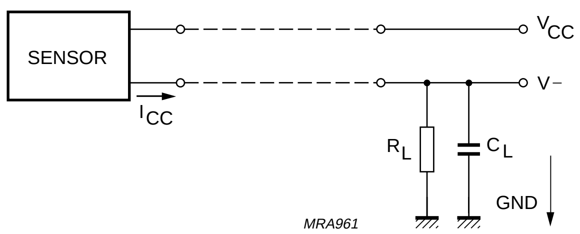



Fig.7 Test and application circuit.

## APPLICATION INFORMATION

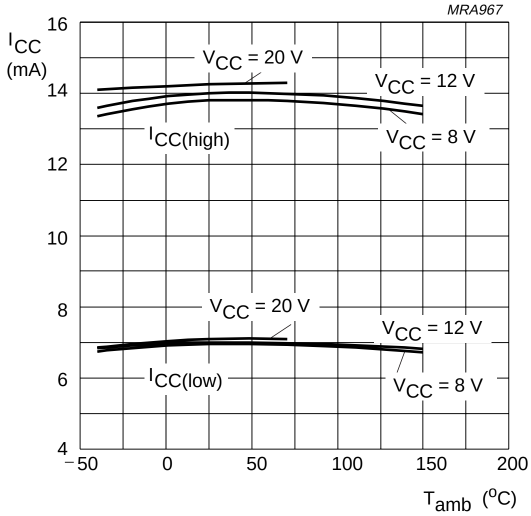
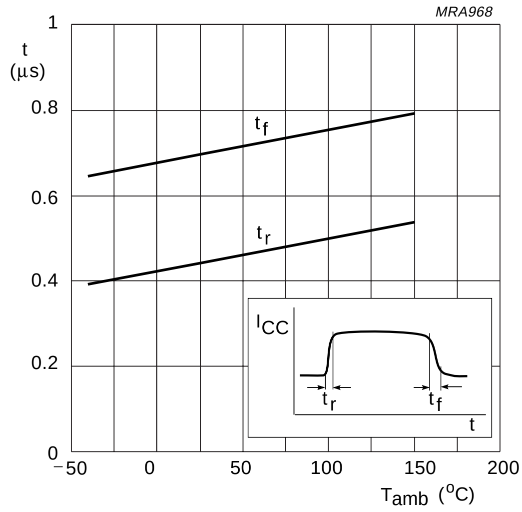



Fig.8 Output current levels as functions of ambient temperature; typical values.




$V_{CC}$ = 12 V; $C_L$ = 100 pF; $R_L$ = 115 Ω.

Fig.9 Output current switching times as functions of ambient temperature; typical values.

# Integrated rotational speed sensor KMI15/1

### Mounting conditions

The recommended sensor position in front of a gear wheel is shown in Fig.15. The distance 'd' is measured between the sensor front and the tip of a gear wheel tooth.
The KMI15/1 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 11, 12 and 13. The symmetrical reference axis of the sensor corresponds to the axis of the ferrite magnet.

### Environmental conditions

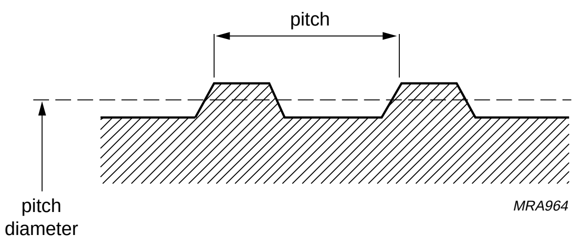
Due to eddy current effects the sensing distance depends on the tooth frequency (Fig.17). The influence of gear wheel module on the sensing distance is shown in Fig.16.

### Gear Wheel Dimensions

| SYMBOL | DESCRIPTION | UNIT |
|---|---|---|
| **German DIN** | | |
| z | number of teeth | |
| d | diameter | mm |
| m | module m = d/z | mm |
| p | pitch p = π × m | mm |
| **ASA; note** 1 | | |
| PD | pitch diameter (d in inch) | inch |
| DP | diametric pitch DP = z/PD | $inch^{-1}$ |
| CP | circular pitch CP = π/DP | inch |

**Note**

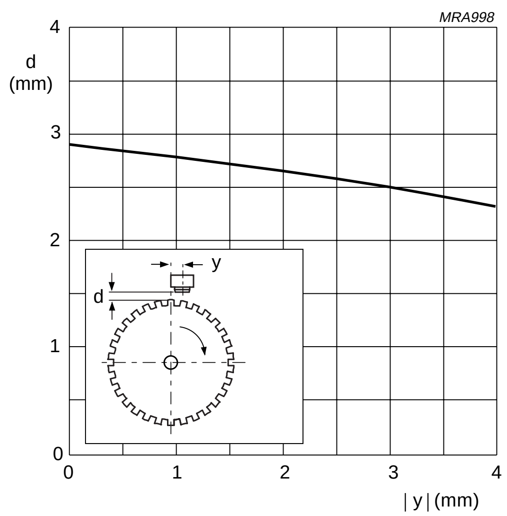
1. For conversion from ASA to DIN: m = 25.4 mm/DP; p = 25.4 mm × CP.




$$\text{module} = \frac{\text{pitch diameter}}{\text{number of teeth}}$$

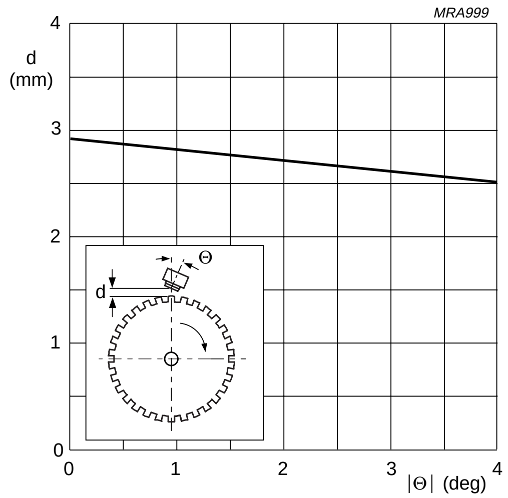
pitch = module × π

Fig.10 Gear wheel dimensions.



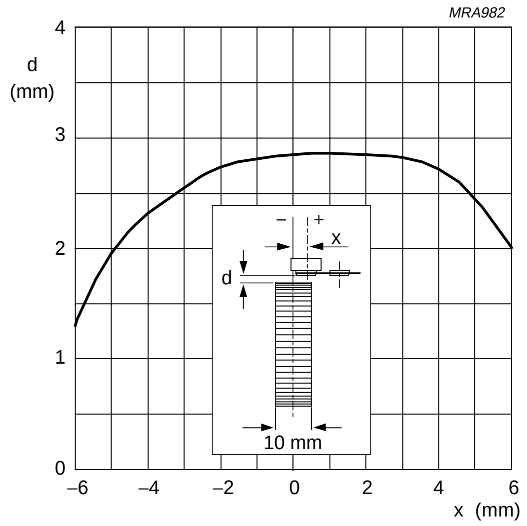

$V_{CC}$ = 12 V; $f_t$ = 2 kHz; module = 2 mm; pitch diameter = 100 mm.

Fig.11 Sensing distance as a function of positional tolerance in the y-axis; typical values.



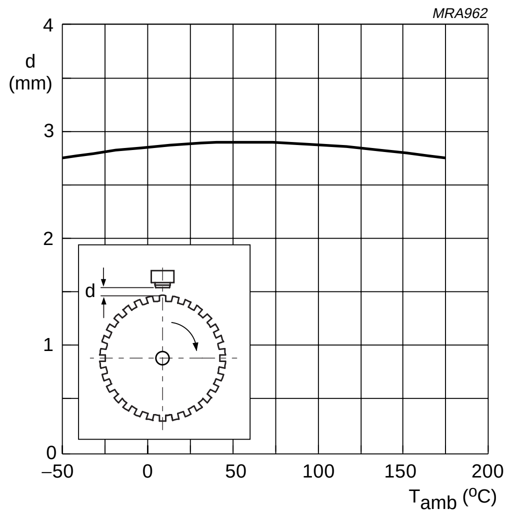

$V_{CC}$ = 12 V; $f_t$ = 2 kHz; module = 2 mm.

Fig.12 Sensing distance as a function of positional tolerance; typical values.




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

Fig.13 Sensing distance as a function of positional tolerance in the x-axis; typical values.




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

Fig.14 Sensing distance as a function of ambient temperature; typical values.

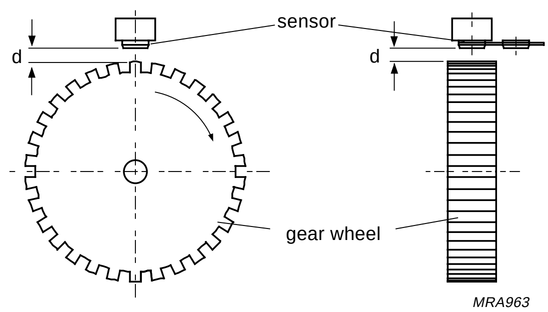
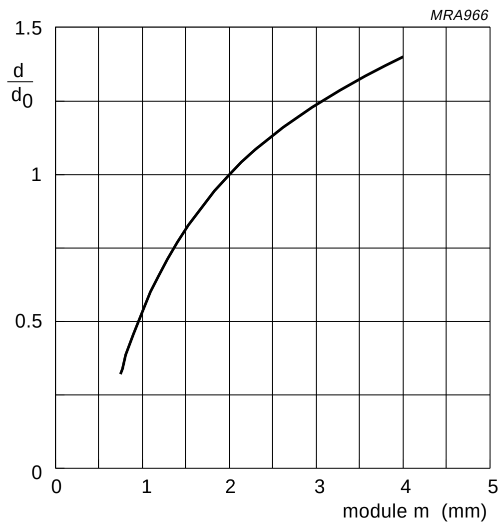
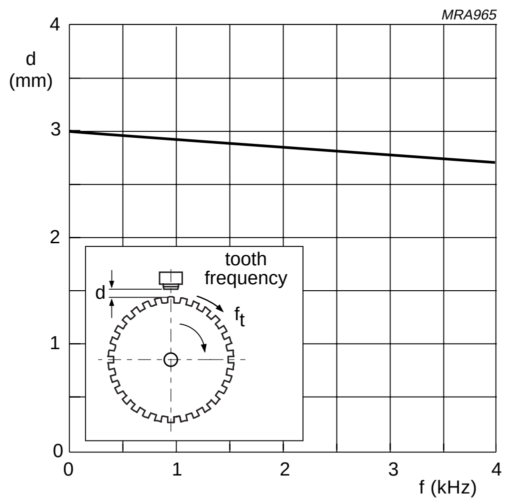



Fig.15 Sensor positioning.




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

Fig.16 Normalized maximum sensing distance as a function of gear wheel module; typical values.




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

Fig.17 Sensing distance as a function of tooth frequency; typical values.

## EMC

Figure 18 shows a recommended application circuit for automotive applications (wheel sensing $f_t$ < 5 kHz). It provides a protection interface to meet Electromagnetic Compatibility (EMC) standards and safeguard against voltage spikes. Table 1 lists the tests which are applicable to this circuit and the achieved class of functional status. Protection against 'load dump' (test pulse 5 according to *"DIN 40839"*) means a very high demand on the protection circuit and requires a suitable suppressor diode with sufficient energy absorption capability.

The board net often contains a central load dump protection that makes such a device in the protection circuit of the sensor module unnecessary.

Tests for electrostatic discharge (ESD) were conducted in line with *"IEC 801-2"* to demonstrate the KMI15/1's handling capabilities. The *"IEC 801-2"* test conditions were: C = 150 pF, R = 150 Ω, V = 2 kV.

Electromagnetic disturbances with fields up to 150 V/m and f = 1 GHz (ref. *"DIN 40839"*) have no influence on performance.

**Table 1** EMC test results

| EMC REF. DIN 40839 | SYMBOL | MIN. (V) | MAX. (V) | REMARKS | CLASS |
|---|---|---|---|---|---|
| Test pulse 1 | $V_{LD}$ | –100 | – | $t_d$ = 2 ms | C |
| Test pulse 2 | $V_{LD}$ | – | 100 | $t_d$ = 0.2 ms | A |
| Test pulse 3a | $V_{LD}$ | –150 | – | $t_d$ = 0.1 µs | A |
| Test pulse 3b | $V_{LD}$ | – | 100 | $t_d$ = 0.1 µs | A |
| Test pulse 4 | $V_{LD}$ | –7 | – | $t_d$ = 130 ms | B |
| Test pulse 5 | $V_{LD}$ | – | 120 | $t_d$ = 400 ms | B |

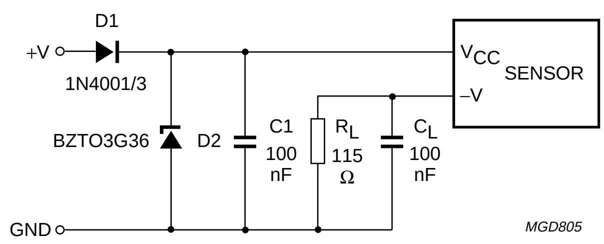
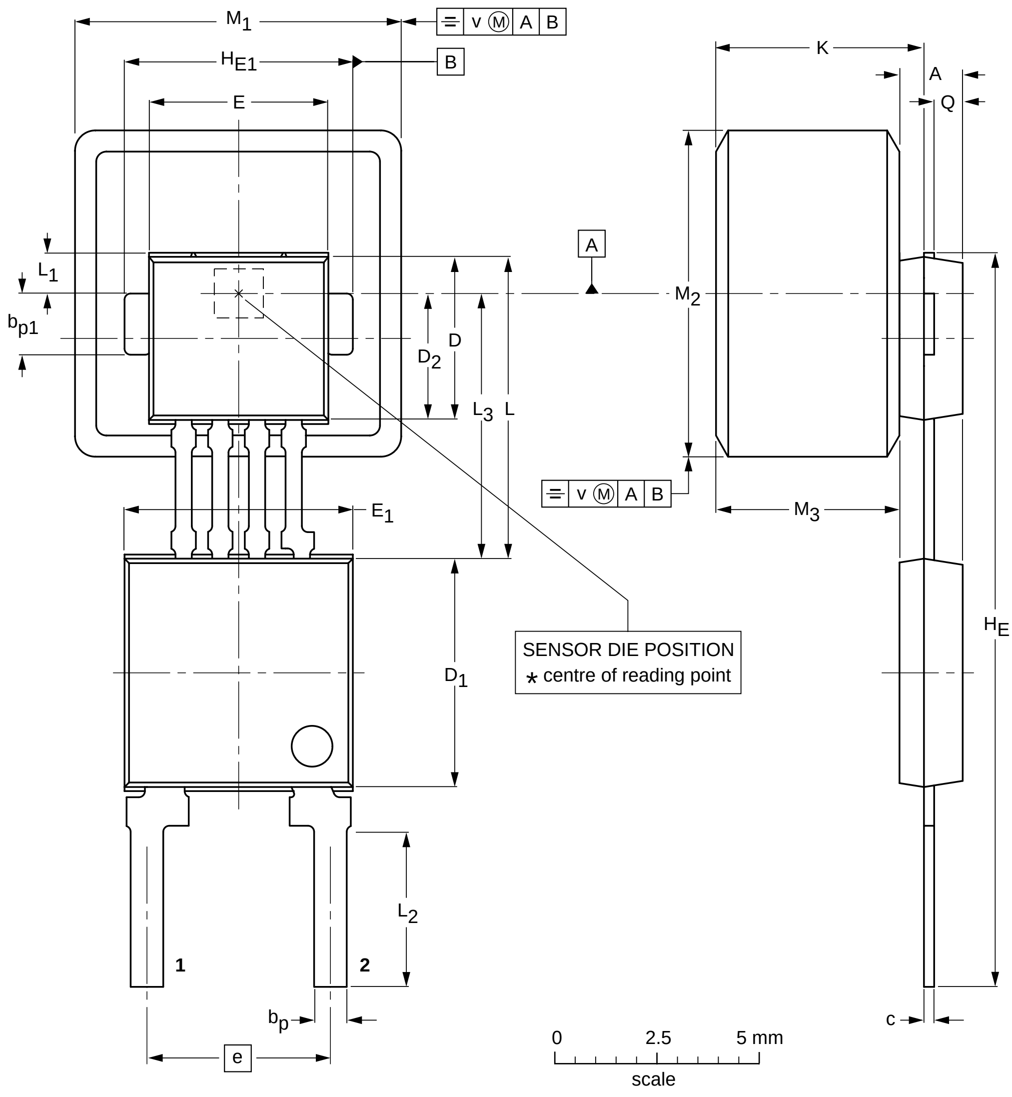



Fig.18 Test/application circuit for the KMI15/1.

## PACKAGE OUTLINE

**Plastic single-ended multi-chip package;**
**magnetized ferrite magnet (8 x 8 x 4.5 mm); 4 interconnections; 2 in-line leads** **SOT453B**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | $A^{(1)}$ | $b_p$ | $b_{p1}$ | c | $D^{(2)}$ | $D_1^{(2)}$ | $D_2^{(2)}$ | $E^{(2)}$ | $E_1^{(2)}$ | e | $H_E$ | $H_{E1}$ | K max. | L | $L_1$ | $L_2$ | $L_3$ | $M_1$ | $M_2$ | $M_3^{(1)}$ | Q | v |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.7<br>1.4 | 0.8<br>0.7 | 1.57<br>1.47 | 0.3<br>0.24 | 4.1<br>3.9 | 5.7<br>5.5 | 3.15<br>2.95 | 4.5<br>4.3 | 5.7<br>5.5 | 4.6<br>4.4 | 18.2<br>17.8 | 5.6<br>5.5 | 5.37 | 7.55<br>7.25 | 1.2<br>0.9 | 3.9<br>3.5 | 6.55<br>6.35 | 8.15<br>7.85 | 8.15<br>7.85 | 4.7<br>4.3 | 0.75<br>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 | | | |
| SOT453B | | | | | | ~~99-09-23~~<br>00-08-31 |

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| Objective specification | Development | This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice. |
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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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## NOTES

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