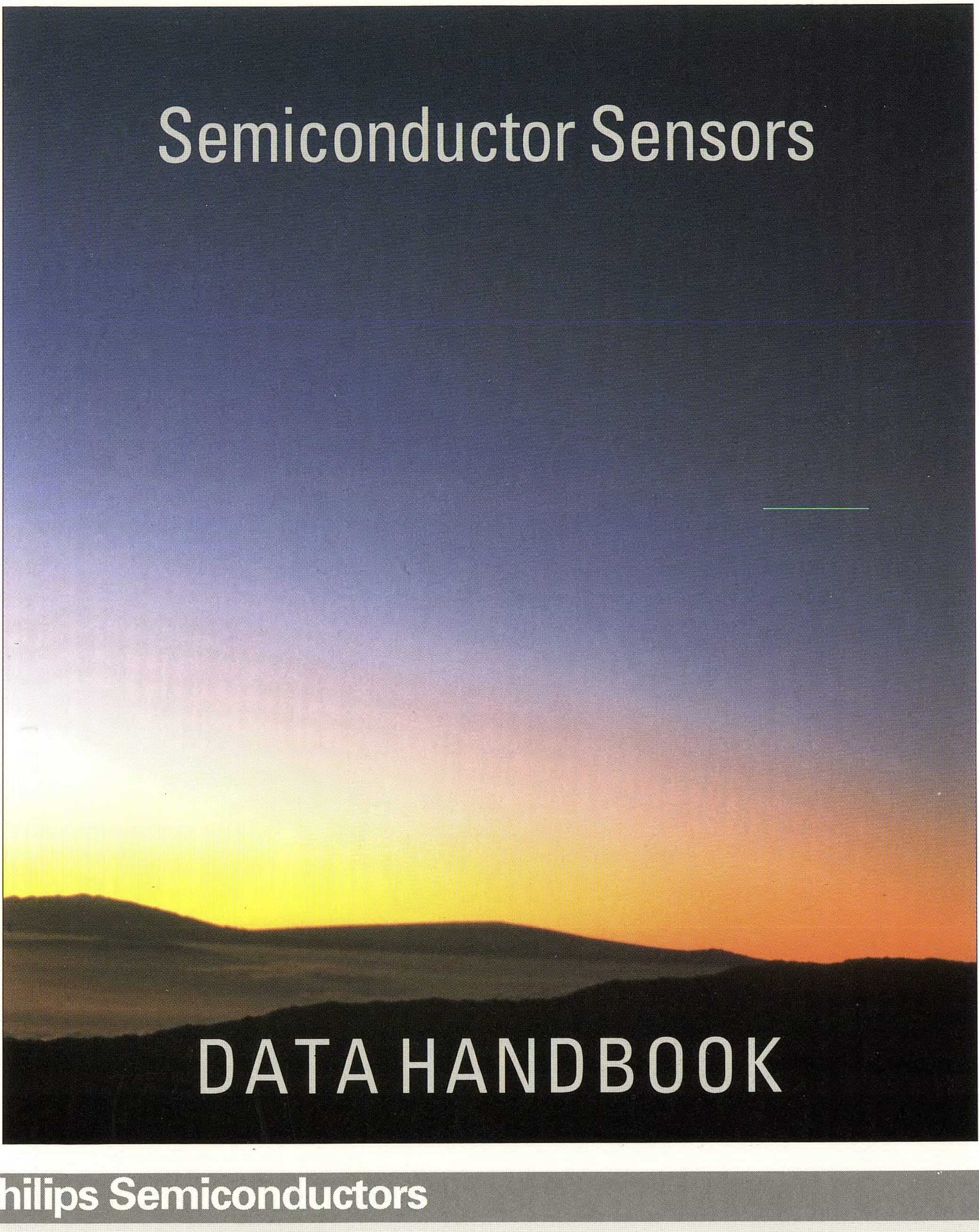
DISCRETE SEMICONDUCTORS



Semiconductor Sensors

DATA HANDBOOK

BOOK SC17 1995

Philips Semiconductors

PHILIPS

PHILIPS

QUALITY ASSURED

Our quality system focuses on the continuing high quality of our components and the best possible service for our customers. We have a three-sided quality strategy: we apply a system of total quality control and assurance; we operate customer-oriented dynamic improvement programmes; and we promote a partnering relationship with our customers and suppliers.

PRODUCT SAFETY

In striving for state-of-the-art perfection, we continuously improve components and processes with respect to environmental demands. Our components offer no hazard to the environment in normal use when operated or stored within the limits specified in the data sheet.

Some components unavoidably contain substances that, if exposed by accident or misuse, are potentially hazardous to health. Users of these components are informed of the danger by warning notices in the data sheets supporting the components. Where necessary the warning notices also indicate safety precautions to be taken and disposal instructions to be followed. Obviously users of these components, in general the set-making industry, assume responsibility towards the consumer with respect to safety matters and environmental demands.

All used or obsolete components should be disposed of according to the regulations applying at the disposal location. Depending on the location, electronic components are considered to be 'chemical', 'special' or sometimes 'industrial' waste. Disposal as domestic waste is usually not permitted.

Semiconductor Sensors

CONTENTS

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). 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.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

LIFE SUPPORT APPLICATIONS

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

ALPHANUMERIC INDEX

Alphanumeric index

Types added to the range since the last issue of Handbook SC17 (1993 issue) are shown in bold print.

SELECTION GUIDE

MAGNETIC FIELD SENSORS

Sensors for contactless rotational speed/position sensing

TYPE[1]	FIELD RANGE (kA/m)	SENSITIVITY $\frac{mV/V}{kA/m}$	BRIDGE RESISTANCE (kΩ)	PACKAGE	PAGE
KM110B/1; note 2	−2.0 to +2.0	1.7	2.1	SOT195	39
KM110B/2; note 3	−2.2 to +2.2	3.6	2.1	SOT195	43
KM110B/4; note 2	−2.0 to +2.0	1.85	2.1	SOT195	47
KMZ10A	−0.5 to +0.5	16.0	1.2	SOT195	51
KMZ10A1; note 4	−0.05 to +0.05	22.0	1.3	SOT195	56
KMZ10B	−2.0 to +2.0	4.0	2.1	SOT195	61
KMZ10C	−7.5 to +7.5	1.5	1.4	SOT195	65
KMZ11B1	−2.0 to +2.0	4.0	2.1	SOT96	70

Notes

1. In air, 1 kA/m corresponds to 1.25 mT.
2. KMZ10B with magnet to generate measurement and auxiliary field.
3. KMZ10B with magnet for auxiliary field.
4. Field range and sensitivity with switched H_x-field for detection of low magnetic fields.

SENSOR HYBRID MODULES

Sensors for contactless rotational speed measurement and reference-/mark detection

TYPE	SENSING DISTANCE (mm)	FREQUENCY RANGE (Hz)	MOUNTING DIRECTION	DIRECTIONAL SENSING	PACKAGE	PAGE
KM110BH/11	2.5	0 to 3000	tangential	no	hybrid	118
KM110BH/12	3.5	1 to 3000	tangential	no	hybrid	118
KM110BH/13	2.5	0 to 3000	radial	no	hybrid	123
KM110BH/14	3.5	1 to 3000	radial	no	hybrid	123
KM110BH/31	3.0	2 to 50000	radial	yes	hybrid	128
KM110BH/32	2.5	0 to 25000	radial	yes	hybrid	134
KMI10/1	2.5	0 to 25000	tangential/ radial	no	SOT312	100
KMI10/4	2.0	0 to 25000	tangential/ radial	no	SOT312	109

SENSOR HYBRID MODULES

Sensors for contactless angular position measurement

TYPE	ANGLE RANGE (DEG)	OUTPUT			PACKAGE	PAGE
		VALUE	TYPE	UNIT		
KM110BH/2130	30	0.5 to 4.5	linear	V	hybrid	155
KM110BH/2190	90	0.5 to 4.5	sinusoidal	V	hybrid	155
KM110BH/2270	70	4 to 20	sinusoidal	mA	hybrid	161
KM110BH/2390	90	0.5 to 4.5	linear	V	hybrid	170
KM110BH/2430	30	0.5 to 4.5	linear	V	hybrid	176
KM110BH/2470	70	0.5 to 4.5	sinusoidal	V	hybrid	176
KMA10/70	70	4 to 20	sinusoidal	mA	packaged	185
KMA20/30	30	0.5 to 4.5	linear	V	packaged	194
KMA20/70	70	0.5 to 4.5	sinusoidal	V	packaged	194
KMA20/90	>90	0.5 to 4.5	linear	V	packaged	204

TEMPERATURE SENSORS

TYPE	TEMPERATURE RANGE (°C)	RESISTANCE		SENSOR ACCURACY		PACKAGE	PAGE
		R (Ω)	at T_{amb} (°C)	°C	at T_{amb} (°C)		
KTY81-110	–55 to +150	990 to 1010	25	±1.3	25	SOD70	236
KTY81-120	–55 to +150	980 to 1020	25	±2.5	25	SOD70	236
KTY81-121	–55 to +150	980 to 1000	25	±1.3	25	SOD70	236
KTY81-122	–55 to +150	1000 to 1020	25	±1.3	25	SOD70	236
KTY81-150	–55 to +150	950 to 1050	25	±6.3	25	SOD70	236
KTY81-151	–55 to +150	950 to 1000	25	±3.2	25	SOD70	236
KTY81-152	–55 to +150	1000 to 1050	25	±3.2	25	SOD70	236
KTY81-210	–55 to +150	1980 to 2020	25	±1.3	25	SOD70	240
KTY81-220	–55 to +150	1960 to 2040	25	±2.5	25	SOD70	240
KTY81-221	–55 to +150	1960 to 2000	25	±1.3	25	SOD70	240
KTY81-222	–55 to +150	2000 to 2040	25	±1.3	25	SOD70	240
KTY81-250	–55 to +150	1900 to 2100	25	±6.3	25	SOD70	240
KTY81-251	–55 to +150	1900 to 2000	25	±3.2	25	SOD70	240
KTY81-252	–55 to +150	2000 to 2100	25	±3.2	25	SOD70	240
KTY82-110	–55 to +150	990 to 1010	25	±1.3	25	SOT23	244
KTY82-120	–55 to +150	980 to 1020	25	±2.5	25	SOT23	244
KTY82-121	–55 to +150	980 to 1000	25	±1.3	25	SOT23	244
KTY82-122	–55 to +150	1000 to 1020	25	±1.3	25	SOT23	244
KTY82-150	–55 to +150	950 to 1050	25	±6.3	25	SOT23	244
KTY82-151	–55 to +150	950 to 1000	25	±3.2	25	SOT23	244
KTY82-152	–55 to +150	1000 to 1050	25	±3.2	25	SOT23	244

Selection guide

TYPE	TEMPERATURE RANGE (°C)	RESISTANCE		SENSOR ACCURACY		PACKAGE	PAGE
		R (Ω)	at T_{amb} (°C)	°C	at T_{amb} (°C)		
KTY82-210	–55 to +150	1980 to 2020	25	±1.3	25	SOT23	251
KTY82-220	–55 to +150	1960 to 2040	25	±2.5	25	SOT23	251
KTY82-221	–55 to +150	1960 to 2000	25	±1.3	25	SOT23	251
KTY82-222	–55 to +150	2000 to 2040	25	±1.3	25	SOT23	251
KTY82-250	–55 to +150	1900 to 2100	25	±6.3	25	SOT23	251
KTY82-251	–55 to +150	1900 to 2000	25	±3.2	25	SOT23	251
KTY82-252	–55 to +150	2000 to 2100	25	±3.2	25	SOT23	251
KTY83-110	–55 to +175	990 to 1010	25	±1.3	25	SOD68	258
KTY83-120	–55 to +175	980 to 1020	25	±2.6	25	SOD68	258
KTY83-121	–55 to +175	980 to 1000	25	±1.3	25	SOD68	258
KTY83-122	–55 to +175	1000 to 1020	25	±1.3	25	SOD68	258
KTY83-150	–55 to +175	950 to 1050	25	±6.6	25	SOD68	258
KTY83-151	–55 to +175	950 to 1000	25	±3.3	25	SOD68	258
KTY83-152	–55 to +175	1000 to 1050	25	±3.3	25	SOD68	258
KTY84-130	–40 to +300	970 to 1030	100	±4.8	100	SOD68	262
KTY84-150	–40 to +300	950 to 1050	100	±8.0	100	SOD68	262
KTY84-151	–40 to +300	950 to 1000	100	±4.0	100	SOD68	262
KTY84-152	–40 to +300	1000 to 1050	25	±4.0	100	SOD68	262
KTY85-110	–40 to +125	990 to 1010	25	±1.3	25	SOD80	267
KTY85-120	–40 to +125	980 to 1020	25	±2.6	25	SOD80	267
KTY85-121	–40 to +125	980 to 1000	25	±1.3	25	SOD80	267
KTY85-122	–40 to +125	1000 to 1020	25	±1.3	25	SOD80	267
KTY85-150	–40 to +125	950 to 1050	25	±6.6	25	SOD80	267
KTY85-151	–40 to +125	950 to 1000	25	±3.3	25	SOD80	267
KTY85-152	–40 to +125	1000 to 1050	25	±3.3	25	SOD80	267
KTY86-205	–40 to +150	1990 to 2010	25	±0.7	25	SOD103	272
KTY87-205	–40 to +125	1990 to 2010	25	±0.7	25	SOD103	277
		3327 to 3361	100	±0.8	100		

PROXIMITY DETECTORS

T_{amb} = – 40 to 85 °C.

TYPE	SWITCHING DISTANCE (mm)			SUPPLY VOLTAGE (V)		MAXIMUM OUTPUT CURRENT			PAGE
						I_o (mA)	at V_B (V)		
	MIN.	TYP.	MAX.	MIN.	MAX.		MIN.	MAX.	
OM386B	1	–	5	10	30	250	10	30	285
OM387B	1	–	5	–10	–30	250	–10	–30	
OM386M	1	–	5	10	30	250	10	30	291
OM387M	1	–	5	–10	–30	250	–10	–30	
OM388B	2	–	5	10	30	250	10	30	297
OM389B	2	–	5	–10	–30	250	–10	–30	
OM390	2	–	5	10	30	250	10	30	303
OM391	2	–	5	–10	–30	250	–10	–30	
OM2860	0.8	–	5	4.7	30	250	24	24	309
OM2870	0.8	–	5	–4.7	–30	250	–24	–24	
OM3105N	–	0.8	–	6	35	250	6	35	313
OM3105P	–	0.8	–	6	35	250	6	35	317

MAGNETIC FIELD SENSORS

INTRODUCTION

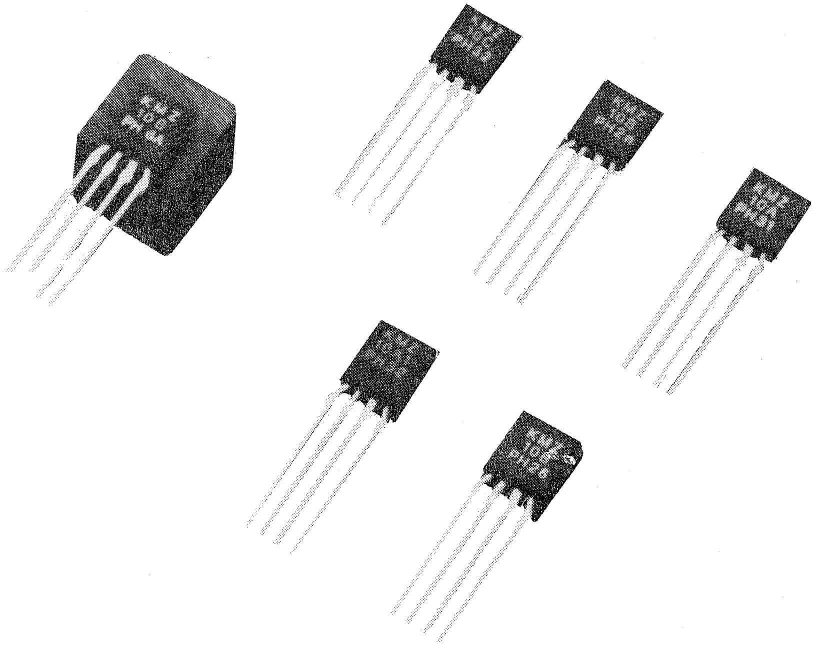


Fig.1 The KMZ magnetoresistive sensors.

The KMZ range of magnetoresistive sensors is characterized by high sensitivity, a wide operating temperature range, a low and stable offset and low sensitivity to mechanical stress. They therefore provide an excellent means of measuring both linear and angular displacement under extreme environmental conditions. This is because a quite small movement of actuating components in e.g. cars or machinery (gear wheels, metal rods, cogs, cams, etc.) can create measurable changes in magnetic field. Another typical application of magnetoresistive sensors is current measurement.

Examples where their properties can be put to good effect can be found in automotive applications, e.g. wheel speed sensors for ABS systems and position sensors for chassis position, throttle and pedal position measurement. Other examples include instrumentation and control equipment, which often require position sensors capable of detecting displacements in the region of tenths of a millimetre (or even less) and in electronic ignition systems, which must be able to determine the angular position of an internal combustion engine with great accuracy.

In many of the above mentioned applications it is advantageous to have the required magnet already glued onto the sensor. With the KM110B series Philips Semiconductors offers a number of sensor-magnet combinations which simplify the use of magnetoresistive sensors in many applications.

Finally, because of their high sensitivity, magnetoresistive sensors can measure very weak magnetic fields and are thus ideal for application in electronic compasses.

If the KMZ sensors are to be used to maximum advantage, however, it is important to have a clear understanding of their operating principles and characteristics, and of how their behaviour may be affected by external influences and by their magnetic history.

Table 1 The KMZ10 range of magnetic field sensors

PARAMETER	KMZ10A	KMZ10A1	KMZ10B	KMZ10C	KMZ11B1	UNIT
Measurement range; note 1	±0.5	±0.05	±2.0	±7.5	±2.0	kA/m
Auxiliary field; note 1	0.5	note 2	3.0	3.0	3.0	kA/m
Open circuit sensitivity	16	22.0	4.0	1.5	4.0	$\frac{\text{mV/V}}{\text{kA/m}}$
Bridge resistance	1.2	1.3	2.2	1.4	2.3	kΩ

Notes

1. In air, 1 kA/m corresponds to approximately 1.25 mT.
2. With switched auxiliary field.

OPERATING PRINCIPLES

The KMZ and KM110B make use of the magnetoresistive effect, the property of a current-carrying magnetic material to change its resistivity in the presence of an external magnetic field. The basic operating principle is shown in Fig.2.

Figure 2 shows a strip of ferromagnetic material, called permalloy (20% Fe, 80% Ni). Assume that, when no external magnetic field is present, the permalloy has an internal magnetization vector which is parallel to the current flow (shown to flow through the permalloy from left to right). If an external magnetic field H, parallel to the plane of the permalloy, but perpendicular to the current flow, is switched on, the internal magnetization vector of the permalloy will rotate around an angle α. As a consequence the resistance R of the permalloy will change as a function of the rotation angle α and is given by:

$$R = R_0 + \Delta R_0 \cos^2\alpha .$$

It can be shown, that:

$$\sin^2\alpha = \frac{H^2}{H_0^{\,2}} \qquad \text{for: } H \le H_0$$

$$\sin^2\alpha = 1 \qquad \text{for: } H > H_0$$

where H_0 can be regarded as a material constant comprising the so called demagnetizing and anisotropic fields.

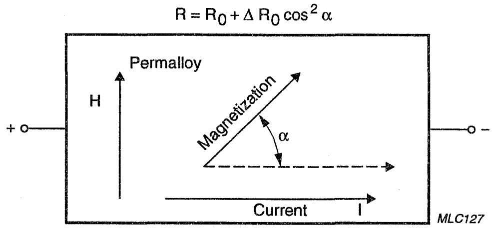
And so:

$$R = R_0 + \Delta R_0\left(1 - \frac{H^2}{H_0^{\,2}}\right) \qquad \text{for: } H \le H_0$$

and:

$$R = R_0 \qquad \text{for: } H > H_0$$

It is obvious from this quadratic expression, that the resistance/magnetic field characteristic is non-linear and, what's more, each value of R is not necessarily associated with a unique value of H (see Fig.3).



The external magnetic field H causes a rotation of the internal magnetization of the permalloy around an angle α, which results in a change in resistance. Note, that H is normal to the current I and parallel to the plane of the permalloy.

Fig.2 The magnetoresistive effect in permalloy.

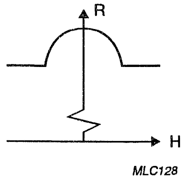


Fig.3 The resistance of the permalloy as a function of the external field H (see Fig.2).

The magnetoresistive effect can be linearized, however, by depositing aluminium stripes (Barber poles), on top of the permalloy strip at an angle of 45° to the strip axis (see Fig.4). As Al has a much higher conductivity than permalloy, the effect of the Barber poles is to rotate the current direction through 45° (the current flow assumes a 'saw-tooth' shape), i.e. to change the rotation angle of the magnetization relative to the current from α to $\alpha - 45°$. The resistance/magnetic field characteristic can easily be derived to:

$$R = R_0 + \frac{\Delta R_0}{2} + \Delta R_0 \left(\frac{H}{H_0}\right) \sqrt{1 - \frac{H^2}{H_0^2}}$$

and is shown in Fig.4. The characteristics are now linear around $\frac{H}{H_0} = 0$.

Strong magnetic fields ($H > H_0$), causing a 90° rotation of the magnetization, produce a change in resistance R between 2 and 3%.

When Barber poles are arranged at an angle of −45° to the strip axis the following expression for the sensor characteristic can be applied:

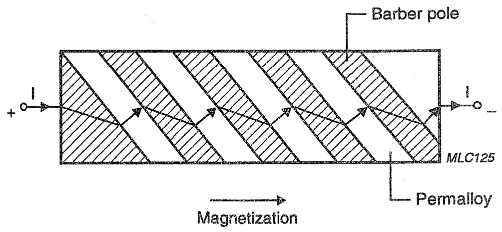
$$R = R_0 + \frac{\Delta R_0}{2} - \Delta R_0 \left(\frac{H}{H_0}\right) \sqrt{1 - \frac{H^2}{H_0^2}}.$$

It is the mirror image of the characteristic as shown in Fig.5.

In the sensors of the KMZ series four permalloy strips are arranged in a meander pattern on a silicon substrate (see Fig.7) and connected to form the four arms of a Wheatstone bridge (see Fig.6). In one pair of diagonally opposed elements the Barber poles are at +45° to the strip axis, in the other pair at −45°. A resistance increase in one pair of elements due to an external magnetic field is 'matched' by a decrease of resistance by an equal amount in the other pair. The resulting bridge imbalance is then a linear function of the amplitude of the external magnetic field in the plane of the permalloy strips normal to the strip axis.

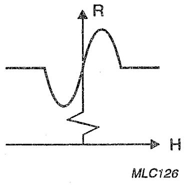
The diagram in Fig.6 contains two further resistors R_T. These are trimming resistors for trimming the sensor offset down to (almost) zero during the production process.

The main characteristics of the KMZ10 and KMZ11 sensors are given in Table 2. The outline of the KMZ10 sensor is shown in Fig.8, the outline of the KMZ11B1 in Fig.9.



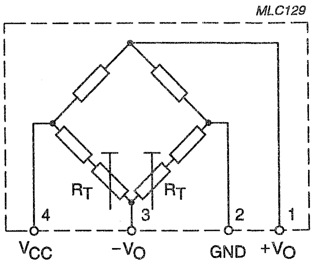
The aluminium Barber poles cause the current to flow in a saw-tooth shape.

Fig.4 Linearization of the magnetoresistive effect.



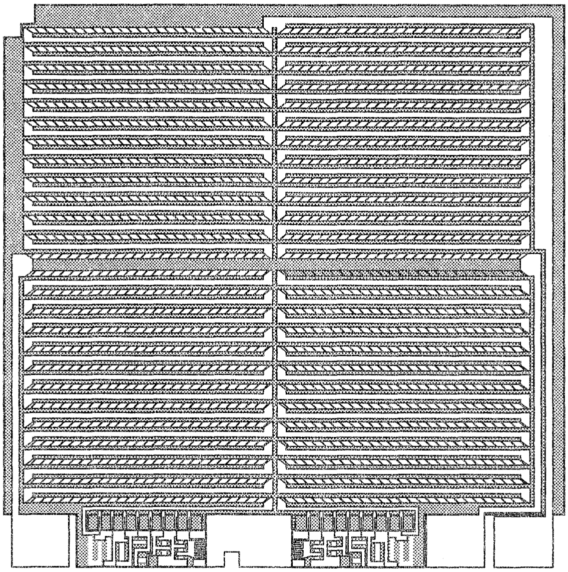
Around H = 0 the magnetoresistive effect has been linearized.

Fig.5 The resistance of the permalloy as a function of the external field H (see Fig.4).



V_{CC} = supply voltage; GND = ground; V_O = output voltage.

Fig.6 KMZ10 and KMZ11 bridge configuration with offset trimmed to zero, by resistors R_T.



The chip incorporates special resistors that are trimmed during manufacture to give zero offset at 25 °C.

Fig.7 KMZ10 chip structure.

Table 2 Main characteristics

SENSOR TYPE[1]	FIELD RANGE (kA/m)[2]	V_{CC} (V)	S $\left(\frac{mV/V}{kA/m}\right)$	R_{bridge} (kΩ)	APPLICATION EXAMPLES
KMZ10A	−0.5 to +0.5	≤9	16.0	1.2	compass, navigation, metal detection, traffic control
KMZ10A1; note 3	−0.05 to +0.05	≤9	22.0	1.3	
KMZ10B	−2.0 to +2.0	≤12	4.0	2.1	wheel speed, angular and linear position, current measurement, reference mark detection
KMZ11B1	−2.0 to +2.0	≤12	4.0	2.1	
KMZ10C	−7.5 to +7.5	≤10	1.5	1.4	
KM110B/1	KMZ10B plus operating FXD100 magnet (8 × 8 × 4.35 mm³)				wheel speed, reference mark detection
KM110B/2	KMZ10B plus auxiliary FXD100 magnet (4 × 2.3 × 0.6 mm³)				current measurement
KM110B/4	KMZ10B plus operating FXD100 magnet (5 × 5 × 3 mm³)				wheel speed, reference mark detection

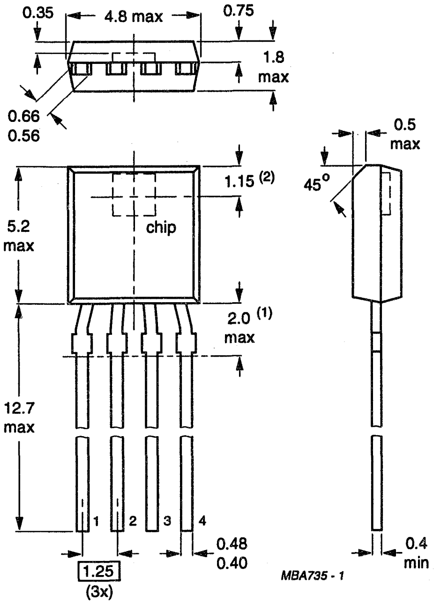
Notes

1. All sensors are supplied in SOT195 package except the KMZ11B1 which is supplied in the surface mounted SO8 (SOT96) package.
2. In air, 1 kA/m corresponds to approximately 1.25 mT.
3. Data given for operation with switched auxiliary field.

PACKAGE OUTLINES

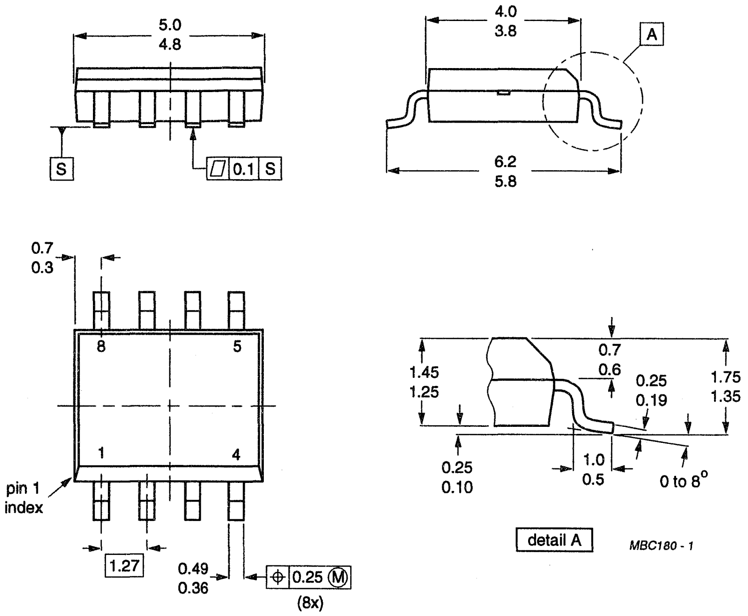
Pinning for the KMZ sensor

PIN	SYMBOL	DESCRIPTION
1	$+V_O$	output voltage
2	GND	ground
3	$-V_O$	output voltage
4	$+V_{CC}$	supply voltage



Dimensions in mm.

Fig.8 Outline of KMZ10 (SOT195).



Dimensions in mm.

Fig.9 Outline of KMZ11B1 (SOT96; SO8).

CHARACTERISTIC BEHAVIOUR

During manufacture, a strong magnetic field is applied parallel to the strip axis. This field imparts a preferred magnetization direction to the permalloy strips. Therefore, even in the absence of an external magnetic field, the magnetization will always tend to align with the strips.

The internal magnetization of the sensor strips, therefore, has two stable positions, so if for any reason the sensor is influenced by a powerful magnetic field opposing the internal aligning field, the magnetization may flip from one position to the other, and the strips become magnetized in the opposite direction (from, for example, the '+x' to the '–x' direction). As demonstrated in Fig.10, this can lead to drastic changes in sensor characteristics.

The field (e.g. '$-H_x$') needed to flip the sensor magnetization, and hence the characteristic, depends on the magnitude of the transverse field 'H_y': the greater the field 'H_y', the smaller the field '$-H_x$'. This is perfectly reasonable, since the greater the field 'H_y', the closer the magnetization's rotation approaches 90°, and hence the easier it will be to flip it into a corresponding stable position in the '–x' direction.

Looking at the curve in Fig.11 where $H_y = 0.5$ kA/m: for such a low transverse field, the sensor characteristic is stable for all positive values of H_x, and a reverse field of ≈1 kA/m is required before flipping occurs. At $H_y = 4$ kA/m however, the sensor will flip even at positive values of 'H_x' (at approximately 1 kA/m).

Figure 11 also illustrates that the flipping itself is not instantaneous; this is because not all the permalloy strips flip at the same rate. The hysteresis effect exhibited by the sensor is also shown by Fig.11. Finally, Figs 11 and 12 show that the sensitivity of the sensor falls with increasing 'H_x'. Again, this is perfectly reasonable, since the moment imposed on the magnetization by H_x directly opposes that imposed by 'H_y', thereby reducing the degree of bridge imbalance and hence the output signal for a given value of 'H_y'.

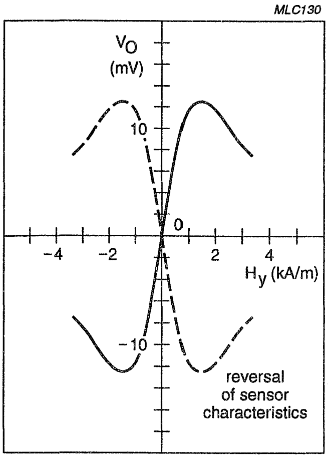
The following general recommendations for operating the KMZ10 can be applied:

- To ensure stable operation, avoid operating the sensor in an environment where it is likely to be subjected to negative external fields ('$-H_x$'). Preferably, apply a positive auxiliary field ('H_x') of sufficient magnitude to prevent any likelihood of flipping within the intended operating range (i.e. the range of 'H_y').
- Use the minimum auxiliary field that will ensure stable operation. Remember, the larger the auxiliary field, the lower the sensitivity. For the KMZ10B sensor, a minimum auxiliary field of approximately 1 kA/m is recommended.
- Finally, before using the sensor for the first time, apply a positive auxiliary field of at least 3 kA/m; this will effectively erase the sensor's history and will ensure that no residual hysteresis remains (see Fig.12). To guarantee stable operation, the sensor should in fact be operated in an auxiliary field of 3 kA/m.

The above mentioned recommendations (particularly the first one) define a kind of safe operating area (SOAR) for the sensors. This can be seen from Fig.13, which is an example (for the KMZ10B sensor) of the SOAR graphs to be found in our data sheets. The graph shows the SOAR of a KMZ10B as a function of auxiliary field 'H_x' and of disturbing field 'H_d' opposing 'H_x'.

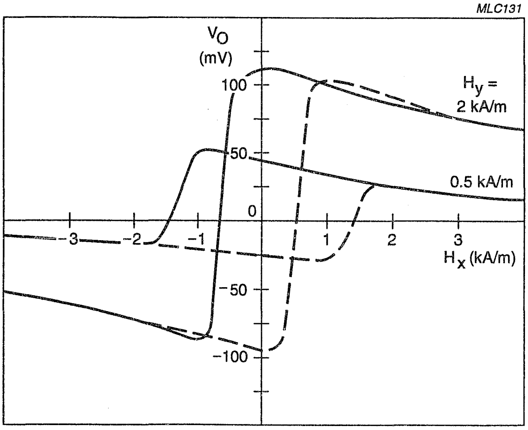
The greater the auxiliary field, the greater the disturbing field that can be tolerated before flipping occurs. For auxiliary fields above 3 kA/m, the SOAR graph shows that the sensor is completely stable, regardless of the magnitude of the disturbing field. It can also be seen from this graph that the SOAR can be extended for low values of 'H_y'. In Fig.13 (for the KMZ10B sensor), the extension for $H_y < 1$ kA/m is shown.

The KMZ10B sensor with auxiliary magnet is available as KM110B/2.



The solid line shows the characteristics of a 'perpendicular' sensor (with the magnetization oriented in the '+x' direction), and the dotted line shows the characteristic of a 'flipped' sensor (with the magnetization oriented in the '−x' direction.

Fig.10 Sensor characteristic.



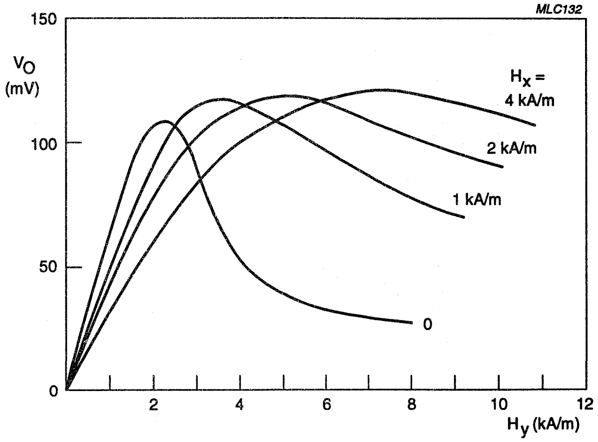
The curves illustrate three characteristics:

The sensor exhibits hysteresis.

The flipping is not instantaneous.

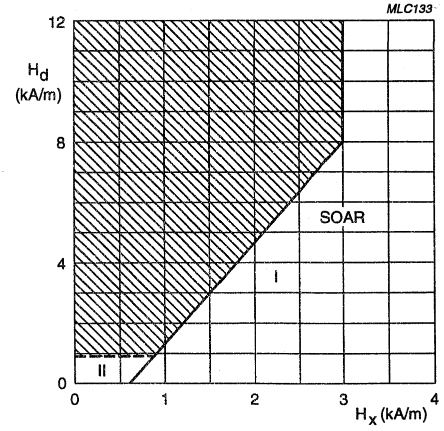
Sensitivity falls with increasing 'H_x'.

Fig.11 Sensor output 'V_O' as a function of auxiliary field 'H_x' for several values of transverse field 'H_y'.



The curves illustrate, more clearly than in Fig.11, the fall in sensitivity (i.e. initial gradient) with increasing 'H_x'.

Fig.12 Output 'V_O' as a function of transverse field 'H_y' for several values of auxiliary field 'H_x'.



The SOAR can be extended slightly (area II) for values of H_y < 1 kA/m.

Fig.13 SOAR of a KMZ10B sensor as a function of auxiliary field 'H_x' and disturbing field 'H_d' opposing 'H_x' (area I).

Effect of temperature on behaviour

Figure 14 shows that the bridge resistance increases linearly with temperature, due to the bridge resistors temperature dependency (i.e. the permalloy strips). Figure 14 shows only the variation for a typical KMZ10B sensor. The data sheets show also the spread in this variation due to manufacturing tolerances, and this should be taken into account when incorporating the sensor in practical circuits.

In addition to the bridge resistance, the sensitivity also varies with temperature. This can be seen from Fig.15, which plots output voltage against transverse field 'H_y' for various temperatures. Figure 15 shows that sensitivity falls with increasing temperature. The reason for this is quite complicated, and is related to the energy-band structure of the permalloy strips.

Figure 16 is similar to Fig.15, but with the sensor powered by a constant current supply. Figure 16 shows that with this constant current supply, the temperature dependency of sensitivity is significantly reduced. This is a direct result of the increase in bridge resistance with temperature (see Fig.14), which partly compensates the fall in sensitivity by increasing the voltage across the bridge and hence the output voltage. Figure 14 adequately demonstrates therefore the advantages of operating with constant current.

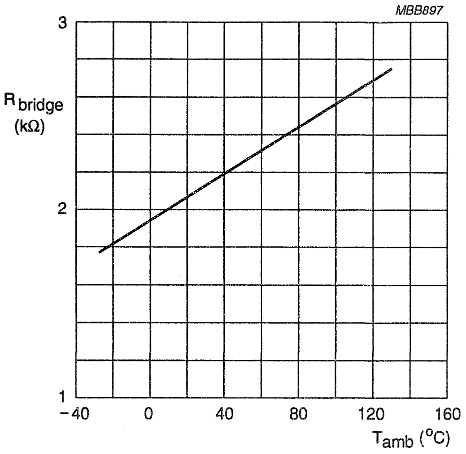
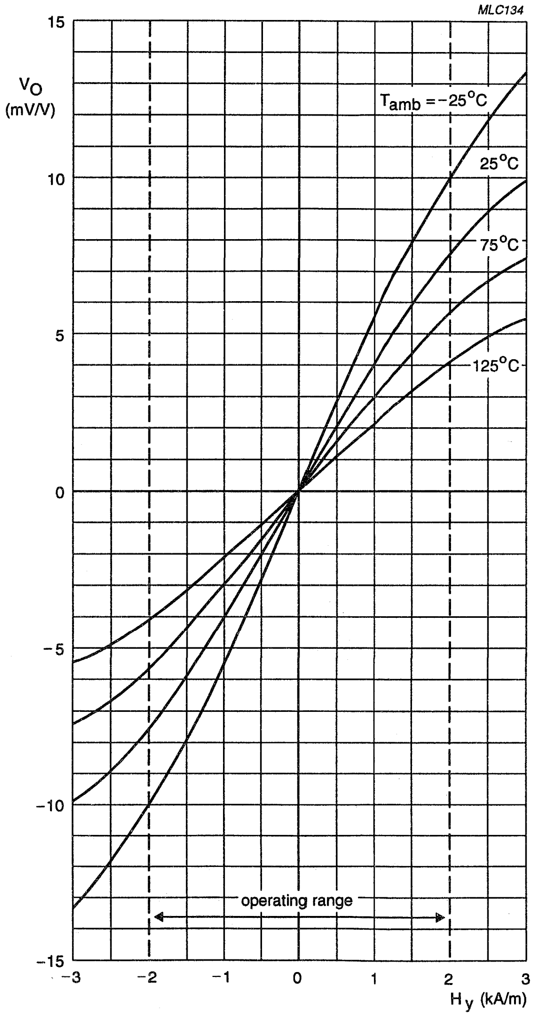
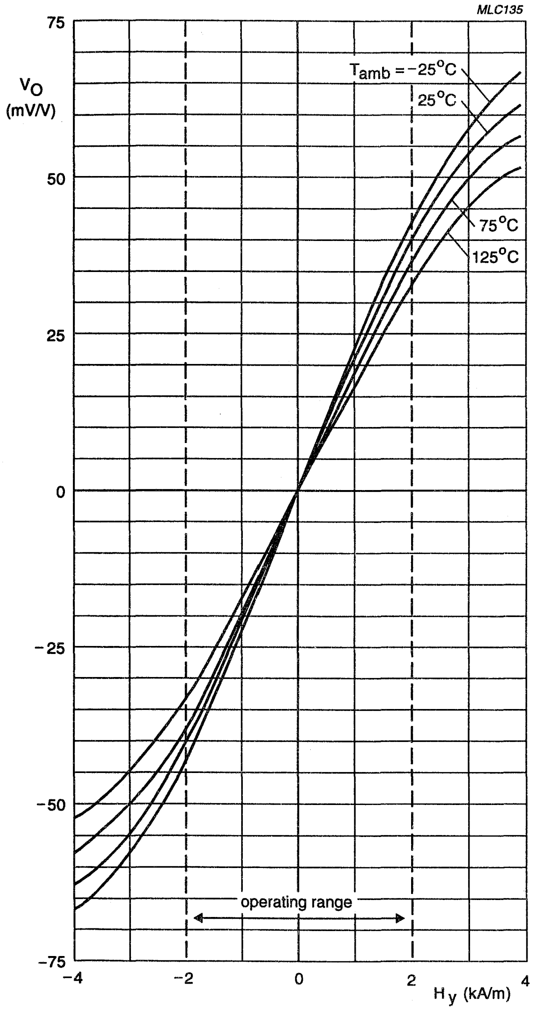


Fig.14 Bridge resistance of a KMZ10B sensor as a function of ambient temperature.



The graph illustrate that sensitivity falls with increasing temperature.

Fig.15 Output voltage 'V$_O$' as a fraction of the supply voltage of a KMZ10B sensor as a function of transverse field 'H$_y$' for several temperatures.



The reduction in temperature dependence of sensitivity is a result of the increase in bridge resistance with temperature, which increases the bridge voltage, to partly compensate the fall in sensitivity.

Fig.16 Output voltage 'V_O' of a KMZ10B sensor as a function of transverse field 'H_y' for several temperatures.

USING THE KMZ/KM110B SENSORS

The excellent properties of the KMZ magnetoresistive sensors, like high sensitivity, low and stable offset, wide operating temperature and frequency ranges and robustness, make them highly suitable for use in a wide range of e.g. automotive and industrial applications.

KMZ based products for rotational speed sensing and angular position measurement are extensively discussed in subsequent chapters. In the following sections we will concentrate on several other applications in which our magnetoresistive sensors are currently being used and discuss general application circuitry.

Linear position measurement using permanent magnets

Figures 17 and 18 show one of the simplest arrangements for using a sensor/permanent magnet combination for measuring linear displacement, and illustrates some of the problems likely to be encountered if proper account is not taken of the effects previously described.

When the sensor is placed in the field of a permanent magnet, it is exposed to magnetic fields in both the 'x' and 'y' directions. If the magnet is oriented with its axis parallel to the sensor strips (i.e. in the 'x' direction), as shown in Fig.17a, 'H_x' then provides the auxiliary field and the variation in 'H_y' can be used as a measure of 'x' displacement. Figure 17b shows how both 'H_x' and 'H_y' vary with 'x', and Fig.17c shows the corresponding output signal as a function of 'x'.

In the example shown in Fig.17, 'H_x' never exceeds '$\pm\hat{H}_x$' (the field that can cause flipping of the sensor) and the sensor characteristic remains stable throughout the measuring range.

Consider the example shown in Fig.18. In this example, for certain values of 'x', 'H_x' exceeds '$\pm\hat{H}_x$' (Fig.18b). This could occur if, for example, the magnet were powerful or if the sensor should pass close to the magnet, and as Fig.18c shows, the effects on the output can be drastic.

Assuming the sensor is initially on the transverse axis of the magnet (i.e. x = 0). 'H_y' will be zero and 'H_x' will be at its maximum value ($>\hat{H}_x$) . Therefore, the sensor will be oriented in the '+x' direction and the output voltage 'V_O' will vary as in Fig.17c.

As the sensor moves in the '+x' direction, 'H_y' (and hence 'V_O') increases, and 'H_x' falls to zero and then increases negatively until it exceeds '$-\hat{H}_x$'. At this point, the sensor characteristic flips and the output voltage reverses, moving from 'A' to 'B' in Fig.18c. Any further increase in 'x' causes the sensor voltage to move along 'BE'. However, if the sensor is moved in the opposite direction, 'H_x' increases until it exceeds '$\hat{H}_x$' and 'V_O' moves from 'B' to 'C'. At this point, the sensor characteristic flips again and 'V_O' moves from 'C' to 'D'.

Under these conditions, the sensor characteristic will trace the hysteresis loop 'ABCD', and a similar loop in the '−x' direction. Fig.18c is in fact an idealized situation and the reversals are never as abrupt as shown. It does however illustrate the effects that can occur if the sensor is placed close to a powerful magnet.

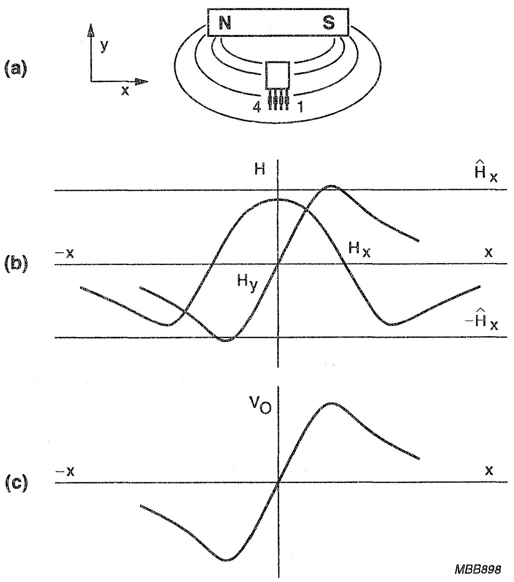
Under certain circumstances, particularly where there are likely to be temporary or fluctuating external fields, it may be advantageous to operate under these conditions, since over the region DD' the field of the permanent magnet will have a stabilizing effect upon the sensor (i.e. it will have to correct any flipping of the sensor due to transient magnetic fields). Note that reversal of the permanent magnet will give rise to the same sensor characteristic as shown in Figs 17c and 18c (i.e. with positive slope), since the sensor will then be forced to operate in its flipped state.

Figure 19 shows the sensor characteristic at distances of 10 mm and 20 mm from a permanent magnet, and amply illustrates the effects shown in Figs 17 and 18.

One-point measurement with the KM110B/1

Figure 20a shows how a KM110B/1 sensor may be used to make position measurements of a metal object, for example a steel plate (alternatively the KM110B/4, with its smaller magnet, may be used). The sensor is located in front of the plate, the magnet's magnetization is perpendicular to the axis of the plate (note that this is a schematic drawing only; in fact the sensor leads are attached on the right-hand side of the sensor package, but are not shown here). A discontinuity in the plate's structure, such as a hole or region of non-magnetic material, will disturb the magnetic field and produce a variation in the output signal from the sensor.

This is shown in Fig.20b, which gives the sensor output signal as a function of hole/sensor offset 'x', for two values of magnet/plate spacing 'd'. The interesting feature of Fig.20 is that the crossover point (i.e. the point where the hole and the sensor precisely coincide) is independent of 'd'. The obvious advantage of this set-up is that precise location of the sensor/magnet combination is unimportant for one-point measurements, so simplifying adjustment procedures. Although not shown in Fig.20b, the crossover point is also independent of the temperature, since it is effectively a null measurement. This is a major advantage of magnetoresistive sensors in this application.



The magnet provides both the auxiliary and transverse fields. In the example shown, the auxiliary field is always less than the field that will cause flipping. Note the pinning arrangement, which indicates that the sensor is viewed from the rear. Reversal of the sensor relative to the permanent magnet will reverse the characteristic.

Fig.17 Sensor output in the field of a permanent magnet as a function of its displacement 'x' parallel to the magnetic axis.

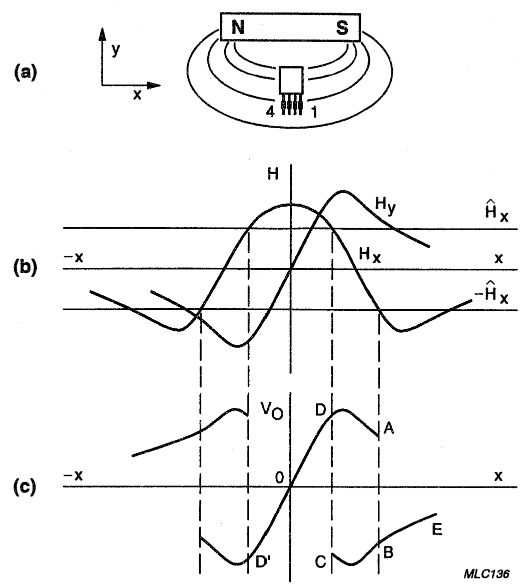
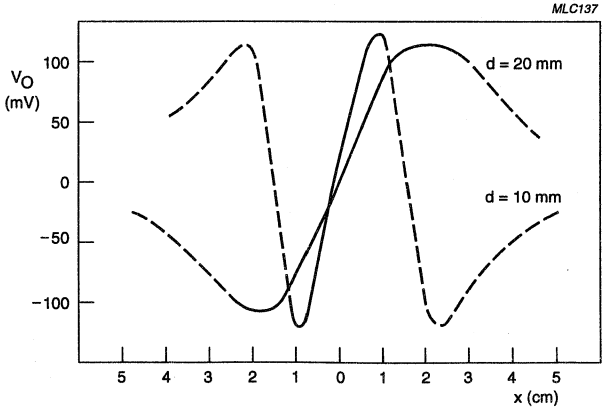


Fig.18 Sensor output in the set-up of Fig.17, but in which the auxiliary field sometimes exceeds '$\hat{H}_x$'.



Sensor distances 'd' of 10 mm and 20 mm from a permanent magnet.

Fig.19 Measured sensor output as a function of displacement 'x' parallel to the magnetic axis.

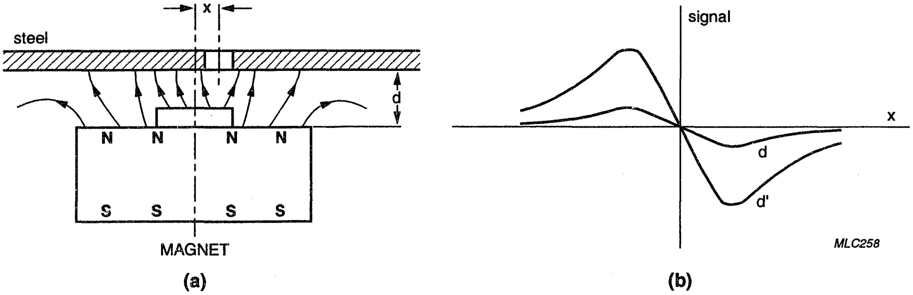


Fig.20 One-point measurement with the KM110B/1.

Current measurement with the KM110B/2

Figures 21 and 22 show two ways in which the KM110B/2 can be used to measure electric current. This could be useful, for example, in headlamp failure systems in automobiles or in clamp-on (non-contacting) meters, as used in the power industry.

Figure 22 is a fairly simple set-up, in which the sensor measures the magnetic field generated by the current-carrying wire. Figure 21 is a more sophisticated arrangement, in which the magnetic field generated by the current-carrying wire is compensated by a secondary circuit wrapped around a ferrite core. At the null-field point (detected by a KM110B/2 sensor located in the air gap between the ends of the core) the magnitude of the current in the secondary circuit is a measure of the current in the main circuit. This arrangement provides a more accurate measurement in precision applications. Note that both examples allow current measurement without any break in or interference with the circuit. In this way, they provide a distinct advantage over thermistor based systems.

Evaluation circuitry for analog signals

For applications in which analog signals are measured, for example in angular position, linear position, one-point and current measurement as shown in Fig.21, a good evaluation circuit should allow for temperature drift compensation and for offset and sensitivity adjustment.

The circuit in Fig.23 fulfils these requirements. In the first stage the sensor signal is pre-amplified, offset is adjusted and temperature drift of the sensitivity is compensated.

For temperature compensation the silicon temperature sensor KTY82/210 in surface mount SOT23 package is used (a leaded alternative is the KTY81/210 sensor in SOT54 package). The grade of compensation can be controlled with the two resistors R7 and R8. Smaller values increase the compensation factor.

In a second stage the final amplification and sensitivity adjustment take place. The output is able to approximately realize a rail to rail output voltage, if the load resistance exceeds 10 kΩ.

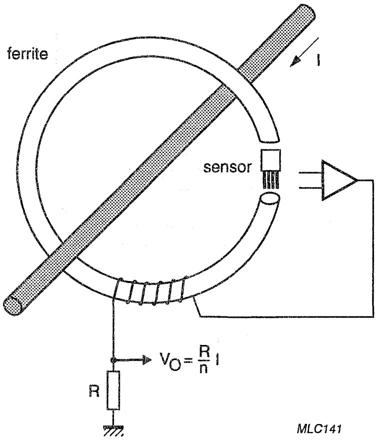
This basic circuit can be extended with additional components to meet specific EMC requirements or can be modified to obtain customized output characteristics (e.g. a different output voltage range or a current output signal).

A more detailed discussion on the subject of temperature compensation in signal conditioning circuitry for magnetoresistive sensors is given in the "*General section for Temperature Sensors*".

Using the magnetoresistive sensor with a compensation coil

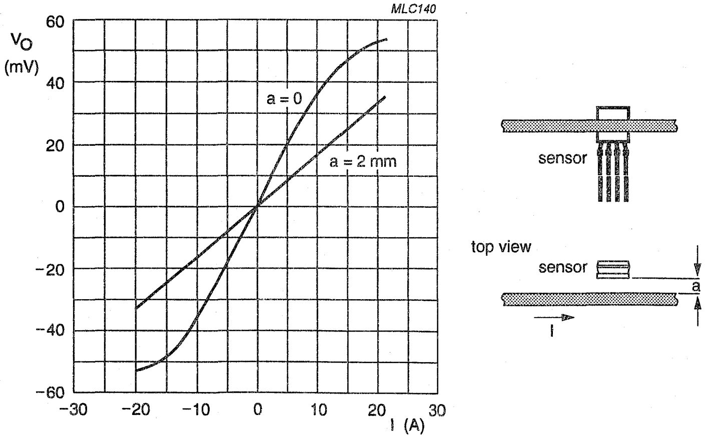
For general magnetic field or current measurements (see Fig.22), it is useful to apply the 'null-field' method, in which an opposite field (generated by a current carrying coil) is compensating the unknown field. The current through the coil is a measure of the magnetic field amplitude. The advantage is that inaccuracies as result of tolerances, temperature drift and slight non-linearities in the sensor characteristics are insignificant.

For the sensor the KM110B/2 is chosen, which includes a small auxiliary magnet. The circuit is shown in Fig.24. With zero external field applied to the sensor bridge the offset is initially set by potentiometer 'R1' to $V_O = 0$. When an external field is applied to the sensor, the resulting output causes the first op-amp to generate a current which passes through 'L1'. As a result a magnetic feedback is produced, in which the unknown magnetic field is almost compensated. The output voltage 'V_O' is thus a direct measure of the magnetic field generated by the coil and hence of the external magnetic field to be measured. The sensitivity can be calibrated by means of 'R4'.



In this set-up, a current-carrying wire is wrapped around a ferrite core, with the KM110B/2 sensor located in the air gap between its ends.

Fig.21 Current measurement with the KM110B/2 sensor.



The sensor measures the magnetic field generated by a current-carrying wire.

Fig.22 Simple set-up for measuring current using the KM110B/2 sensor.

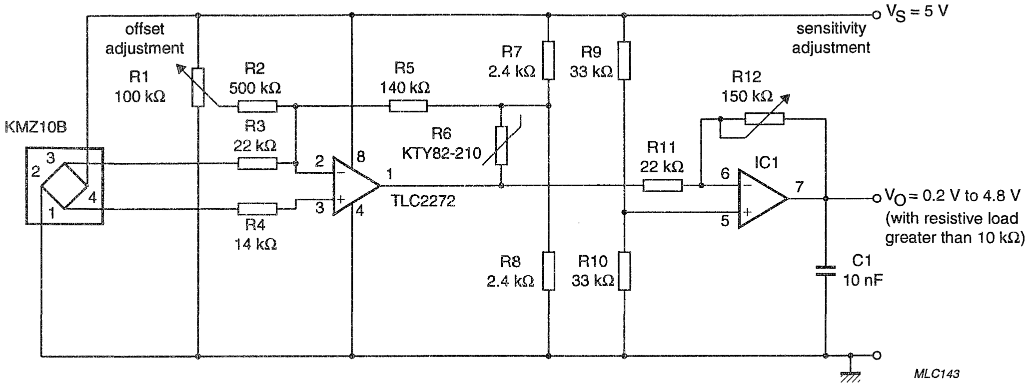
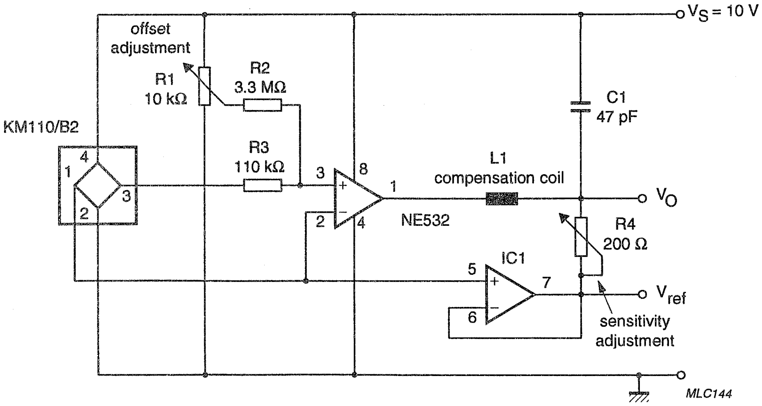


Fig.23 Evaluation circuit for analog signals.



Data for the coil: coil former catalogue number 4322 021 30240,
365 turns, diameter of the Cu wire 0.1 mm.

Fig.24 Signal conditioning circuitry for magnetoresistive sensors in combination with a compensation coil.

USING THE KMZ10A1 TO MEASURE WEAK MAGNETIC FIELDS

Magnetoresistive sensors

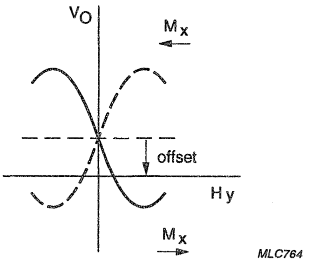
The KMZ10 sensor makes use of the magnetoresistive effect to change its resistivity in the presence of an external magnetic field. It consists of four permalloy strips which are arranged in a meander pattern to minimize undesirable temperature influences and maximize sensitivity to the magnetoresistive effect. On the sensor chip the four resistors are connected to form the arms of a Wheatstone bridge. The degree of bridge imbalance is then used to indicate the magnetic field strength, or more precisely, the variation in magnetic field in the plane of the permalloy strips normal to the direction of current.

This is in contrast to the Hall-effect sensors which are sensitive to the magnetic fields perpendicular to the sensor surface. The magnetoresistive sensors are also more sensitive, less temperature dependent and can operate at much higher frequencies compared to the Hall-effect sensors.

Principle of measuring weak magnetic fields

The Wheatstone bridge inside the sensor delivers an output voltage corresponding to the strength and direction of the magnetic field in the sensor's plane. As far as strong magnetic fields are concerned the sensor's output could be directly used to obtain the direction of the field. Problems occur when weak magnetic fields such as the earth's magnetic field have to be measured. The precision is limited by the sensitivity and the offset voltage drift of the sensor caused by a change in ambient temperature. This change can cause a higher offset drift than the measured signal. The inaccuracy in the output signal as result of the offset can be removed using the sensor's sensitivity in two directions by reversing the external field. During the manufacture of the sensor an external strong magnetic field parallel to the permalloy strips ensures that they remain premagnetized when the external magnetic field has disappeared. This ensures a stable sensor characteristic.

There are two stable premagnetization directions possible, due to the crystal's structure of the permalloy strips. One has the opposite direction to that given in the manufacturing process. Consequently there are also two stable sensor output characteristics corresponding to the external field direction (see Fig.25).



Solid line: normal sensor.
Dotted line: flipped sensor

Fig.25 Sensor output.

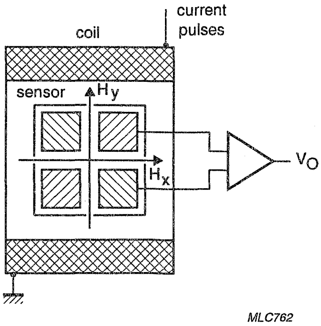


Fig.26 Flipping coil.

When placed into a controlled reversable external magnetic field, the polarity of the premagnetization can be switched between the two characteristics. The sensor is said to be 'flipped' (see Fig.25). Flipping the sensor causes a change in the output signal of the sensor which can be used to separate the offset signal from the measured signal. By measuring the unknown field twice, both in the flipped and normal state, two different values are obtained symmetrically positioned towards the offset value (the cross section of both characteristics). Subtracting both values eliminates the offset resulting in twice the value representing the unknown field strength.

The flipping process is achieved by putting the sensor inside a coil which is powered with positively and negatively alternating pulses (see Fig.26). The principle is shown by the pulse waveforms in Fig.27. The information corresponding to the measured field is contained in the amplitude and phase of the square wave. The unwanted temperature dependent offset voltage, however, remains as a DC voltage which can simply be removed by passing the output signal through a capacitor (filter).

Apart from bridge resistance variations, the sensitivity also varies with temperature. This drift is of greater concern, as it is not eliminated by the flipping process. The output voltage can change with a change in temperature although the magnetic field is still the same. This error is compensated for by using electric-magnetic feedback.

A second coil, the compensation coil, is wound around the sensor perpendicular to the flipping coil (see Fig.28). The magnetic field axis of the compensation coil lies in the same plane as the earth's magnetic field. Should the measured magnetic field vary, the sensor's output voltage will deviate from the measured value. The voltage deviation is then converted into a current by an integral controller and supplies the compensation coil. The coil itself then produces a magnetic field which is proportional to the output voltage deviation caused by the measured field. The magnetic field produced by the compensation coil is then added to the measured field and therefore compensates for the deviation in the output signal and thus for varying magnetic field. This principle is called current compensation. The advantage of this principle is the independence to sensitivity and sensitivity drift of the sensor over temperature, because the sensor is always used at its 'zero point'. The information of the magnetic signal is given in the current of the compensation coil. The integral controller can be realized with two operational amplifiers. The time constant of the controller is not critical, it depends on the application. It is a compromise between the speed of measurement and the quality of the output signal.

There will be an integrated sensor available shortly, containing the two sensors, the compensation coils and the flipping coil in one package.

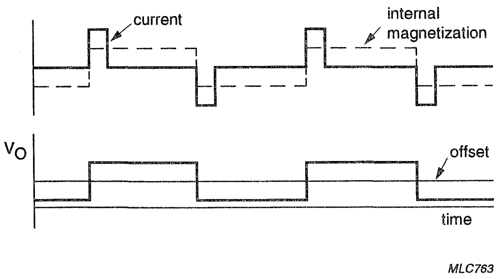


Fig.27 Pulse diagram.

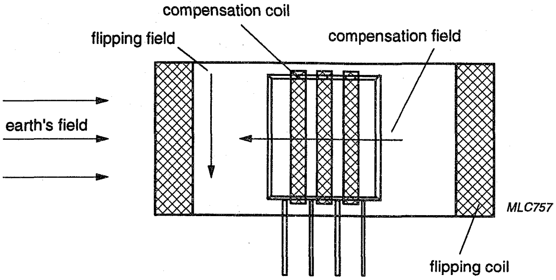


Fig.28 Magnetic field directions.

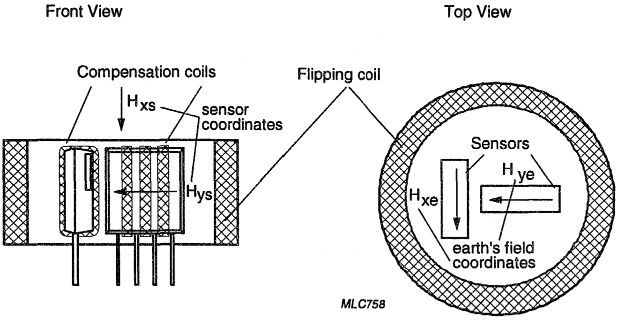


Fig.29 Compass sensor system.

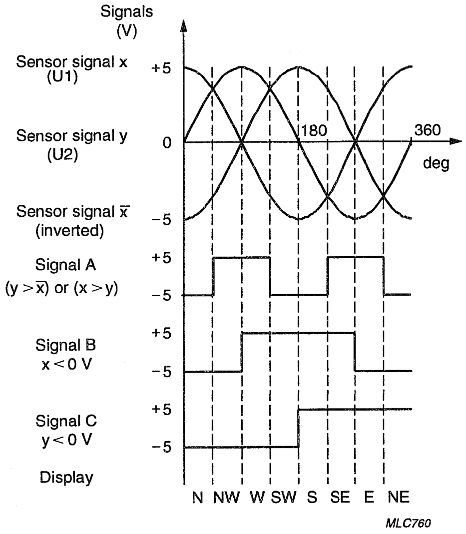


Fig.30 Evaluated signals.

Using the KMZ10A1 in a compass application

The compass is one example of using the KMZ10 sensor for measuring weak magnetic fields. In a two dimensional compass application two sensors are needed, one for the x-direction and one for the y-direction. The sensitivity axes of the sensors are arranged in the same plane but with a 90° angle displacement to one another (see Fig.29). Only one flipping coil is needed to flip both sensors but each sensor needs its own compensation coil.

Each of the two sensors delivers a single sinewave when the sensor system (see Fig.29) is rotated in the earth's field, the sinewaves shifted by 90° corresponding to the sensor arrangement. When having a simple compass where only eight directions have to be displayed, the two sensor output signals can be compared with each other to achieve three digital signals as shown in Fig.30. For the comparison the two sensor signals together with one inverted sensor signal are used, in order to determine whether the sensor signal is changing positively or negatively. This is necessary to distinguish between eight positions when the compass is rotated through 360°. Simple comparators can be used to obtain the three digital signals from the sensors, shown in the lower half of Fig.30. The digital signals can now be used to drive a display unit via a multiplexer.

Calibrating the compass for influence magnetic fields

Influence fields are the magnetic fields surrounding the compass which do not belong to the earth's field, such as screws from the casing or the dashboard of the car where the compass is placed. Every magnetic material has its own weak magnetic field. These fields are mostly strong enough to severely affect the accuracy of the compass placed inside them. Using the KMZ10A1 with current compensation additionally gives the opportunity to compensate for the influence magnetic fields. The influence field which is always turned together with the compass can therefore be considered as a constant. Taking the two dimensional compass as an example the magnetic field components can be understood as vectors in a two dimensional vector space (see Fig.31).

The task is to determine the x- and y-components of the influence field and to compensate for them. The compensation itself is very simple if the x- and y-part of the influence field is known, only an additional current has to be injected into the corresponding compensation coil of the sensor. There are many different ways for determining the influence field components, the easiest way without the need of any additional calibration devices is by using the **bidirectional calibration**. Applying this method the compass has to be arranged in two different positions, shifted by 180°, and two measurements have to be taken. The principle is explained in Fig.32.

To eliminate the interference field vector the mean value of the measurements between the two positions is calculated to determine each coordinate. These mean values are identical to the coordinates of the interference field vector and therefore they only have to be compensated by an appropriately synthesized field.

Using the sensor for a high resolution compass

In the previous example the sensors were used for a compass with a resolution for displaying eight directions. It is of course possible to increase the resolution by adapting the evaluation circuit. In this case it is advisable to evaluate the sensor signals by using a microcontroller. The microcontroller can then calculate the arctan function of the ratio of the two sensor signals to acquire the angle. The resolution then depends on the ADC used and the microcontroller. An analogue structure, extending the first model would cause a disproportionate expenditure and would not be precise enough. Using a microcontroller has the additional advantage that it is easier to implement more functions for the compass such as a memory to store a definite direction as a reference pointer. Also an automatic calibration can be realized with the help of a microcontroller. The aim is that the user does not have to perform any calibration procedures and that no external calibration instruments are needed. The principle is that the evaluation system continuously stores the magnetic field strength vectors, as with the **bidirectional calibration** described earlier, and also registers when the compass has completed a 180° turn. The microcontroller then calculates the correction vector and compensates for the influence field. This feature is quite useful for an automotive compass, where the influence field is dependent on the load of the vehicle, and therefore a manual calibration would have to be repeated.

Higher resolution, however, can cause some problems. The higher the resolution of the compass the more sensitive it gets for an angle between the earth's surface and the measuring plane of the two sensors. Normally the sensors are aligned with the earth's field which means that the angle between the compass and the surface of the earth is zero. A deviation in that angle inevitably changes the alignment between the sensors sensitivity axes and the earth's field. This means that the output signals of the sensors will change although the compass still faces in the same direction. The compass will not function accurately in this instance. This could occur when the vehicle is travelling uphill or downhill. To compensate this sort of error it is necessary to measure the third magnetic dimension and to use a gravity sensor.

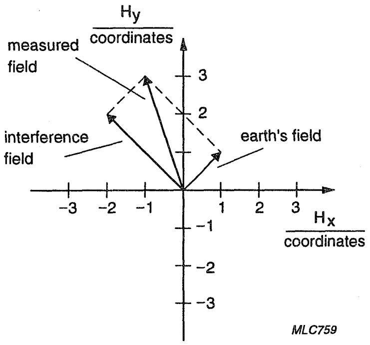
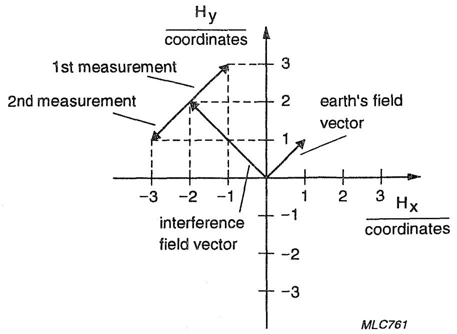


Fig.31 Two dimensional vector space.



$$H_x = \frac{\text{1st measurement} + \text{2nd measurement}}{2} = \frac{-3 + (-1)}{2} = -2$$

$$H_y = \frac{\text{1st measurement} + \text{2nd measurement}}{2} = \frac{3 + 1}{2} = 2$$

Fig.32 Measured fields in vector space.

Using the KMZ10A1 as a traffic sensor

The traffic sensor is another example of the suitability of the KMZ10A1 to measure weak magnetic fields. Traffic sensors are used for example to detect vehicles on a road in order to control traffic lights or speed limits dependent on the traffic. This way of traffic control is becoming more and more important today to regulate traffic and to protect the environment. Until now inductor coils beneath the road were mostly used to detect the traffic. Detection being related to a change in the inductance of the coil. This is of course not an ideal method. The inductor coil is permanently supplied with current, and consumes considerable amounts of energy. The method is also more costly and less reliable. Large inductor coils have to be directly built into the tarmac and are subject to mechanical stress due to changes in the ambient temperature. Additionally the conductors can snap requiring the road to be reopened.

All vehicles which are in use today contain considerable amounts of ferromagnetic material. This material generates a magnetic field which is detectable by highly sensitive magnetic field sensors like the KMZ10A1 developed by Philips Semiconductors. Even if the vehicle is demagnetized or the engine is built from aluminium, its disturbance of the earth's magnetic field will be seen by the sensors. The principle of operation is the same as with the compass. The sensors are flipped in order to achieve the highest sensitivity without any offset drift. In laboratory experiments it was shown that different vehicles could be distinguished. Even bicycles were detectable. All experiments were based on three dimensional measurements by using a third sensor for the z-component. The sensor signal evaluation circuit is similar to the one used in the compass, except that an additional flipping coil has to be implemented for the third sensor.

Magnetic field sensor KM110B/1

DESCRIPTION

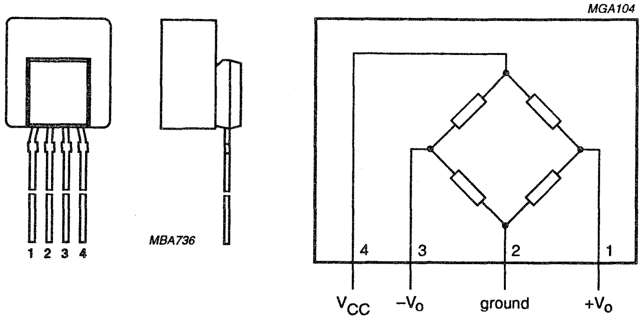
The KM110B/1 is a sensitive magnetic field sensor, employing the magneto-resistive effect of thin film permalloy.

The combination of a KMZ10B with a Ferroxdure 100 magnet and a special 30 ° magnetization enables the sensor to be used as a revolution sensor or proximity detector. The offset voltage of the KM110B/1 is magnetically trimmed during the magnetization process.

PINNING

PIN	DESCRIPTION
1	output voltage (+)
2	ground
3	output voltage (–)
4	supply voltage (V_{CC})

PIN CONFIGURATION



Marking: KMZ10B PHDxx.

Fig.1 Simplified outline and circuit configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
V_{off}	offset voltage	–0.5	–	+0.5	mV/V
R_{bridge}	bridge resistance	1.6	2.1	2.6	kΩ
T_{bridge}	bridge operating temperature range	–40	–	150	°C
H_y	operating range of magnetic field	–2	–	+2	kA/m

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage		–	12	V
P_{tot}	total power dissipation	up to T_{amb} = 130 °C	–	120	mW
T_{stg}	storage temperature range		–40	150	°C
T_{bridge}	bridge operating temperature range	note 1	–40	150	°C
$T_{bridge\ peak}$	peak bridge operating temperature	max. 3 times ≤ 15 min during lifetime notes 1 and 2	–	190	°C
H_D	external disturbing field	note 3	–	32	kA/m

Notes

1. Maximum operating temperature of the thin film permalloy.
2. Maximum temperature gradient: 5 °C/min.
3. It is not permitted to press two sensors together **against** the magnetic forces, due to their own magnetic field (H ≥ 50 kA/m close to the magnetic poles).

THERMAL RESISTANCE

SYMBOL	PARAMETER	THERMAL RESISTANCE
$R_{th\ j\text{-}a}$	from junction to ambient in free air	180 K/W

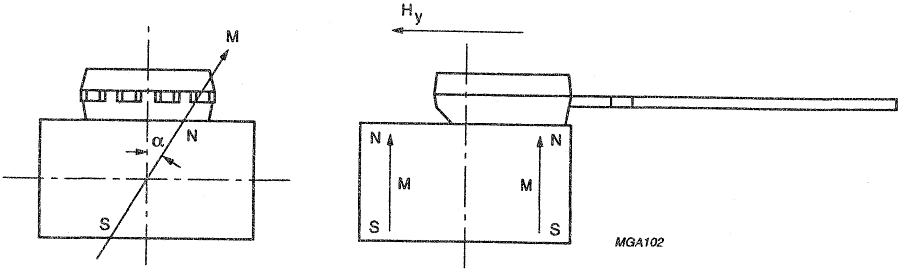
CHARACTERISTICS

T_{bridge} = 25 °C and V_{CC} = 5V unless otherwise stated.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
R_{bridge}	bridge resistance		1.6	2.6	kΩ
V_{off}	offset voltage	notes 1 and 4	−0.5	+0.5	mV/V
S	sensitivity	notes 2 and 4	1.4	2.3	$\frac{mV/V}{kA/m}$
f	operating frequency	note 3	0	1	MHz
TCV_{off}	temperature coefficient of offset voltage	temperature range = –25 to 100 °C; note 1	–5	+5	$\frac{\mu V/V}{K}$
TCR_{bridge}	temperature coefficient of bridge resistance	temperature range = –25 to 100 °C; note 1	–	0.4	%K
TCS	temperature coefficient of sensitivity	temperature range = –25 to 100 °C; note 1	0.25	0.31	%K
H_y	operating range of magnetic field		–2	+2	kA/m

Notes

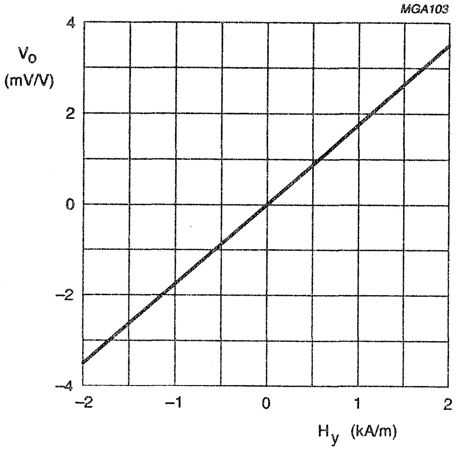
1. Measured in an environment without external magnetic fields and ferromagnetic materials.
2. $S = \{V_O(H_y = 1.6\ kA/m) - V_O(0\ kA/m)\} / \{1.6 \times V_{CC}\}$.
3. Only sensor bridge response. When sensing high speed rotation, the operating frequency may be reduced to eddy current effects.
4. The output voltage is ratiometric to the supply.



M = direction of magnetization.

N,S = magnetic poles.

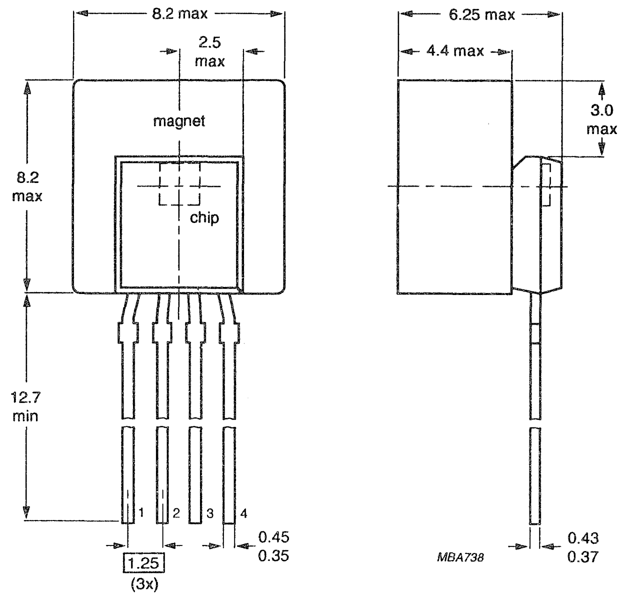
Fig.2 Principle of magnetization.



$V_{off} = 0$.

Fig.3 Sensor output characteristic.

PACKAGE OUTLINE



Dimensions in mm.

Fig.4 SOT195.

Magnetic field sensor KM110B/2

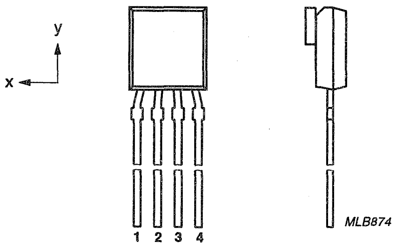
DESCRIPTION

The KM110B/2 is a sensitive magnetic field sensor, employing the magnetoresistive effect in thin-film permalloy. A Ferroxdure FXD100 magnet mounted on the back of the sensor package provides an auxiliary field of 3.6 kA/m in the x-direction of the sensor.

Typical applications for the KM110B/2 are current measurement, linear position measurement, rotational speed detection of magnetic pole wheels as well as magnetic field measurement. The sensor can be operated at any frequency between DC and 1 MHz.

PINNING

PIN	SYMBOL	DESCRIPTION
1	$+V_O$	output voltage
2	GND	ground
3	$-V_O$	output voltage
4	$+V_{CC}$	supply voltage



Marking: KMZ10B PHDxx.

Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
T_{bridge}	bridge operating temperature	–40	–	150	°C
H_y	magnetic field strength	–2.2	–	+2.2	kA/m
S	sensitivity	–	3.6	–	$\frac{mV/V}{kA/m}$
R_{bridge}	bridge resistance	1.6	2.1	2.6	kΩ
V_{offset}	offset voltage	–0.5	–	+0.5	mV/V

CIRCUIT DIAGRAM

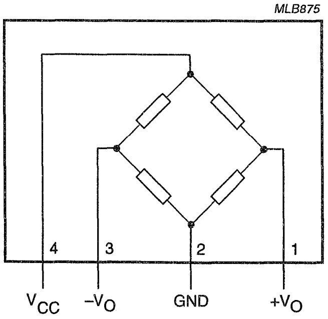


Fig.2 Simplified circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage		–	12	V
P_{tot}	total power dissipation	up to T_{amb} = 130 °C; see Fig.5	–	120	mW
T_{stg}	storage temperature	note 1	–40	+150	°C
T_{bridge}	bridge operating temperature		–40	+150	°C

Note

1. Maximum operating temperature of the thin-film permalloy.

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	180	K/W

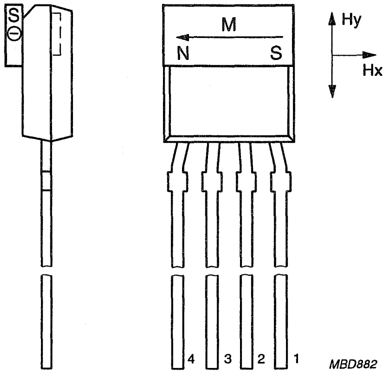
CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 5 V unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
H_y	magnetic field strength	note 1	–2.2	–	+2.2	kA/m
S	sensitivity	open circuit; notes 2 and 3	2.9	3.6.	4.4	$\frac{mV/V}{kA/m}$
TCV_O	temperature coefficient of output voltage	V_{CC} = –5 V; T_{amb} = –25 to +125 °C	–	–0.4	–	%/K
		I_{CC} = 3 mA; T_{amb} = –25 to +125 °C	–	–0.1	–	%/K
R_{bridge}	bridge resistance		1.6	–	2.6	kΩ
TCR_{bridge}	temperature coefficient of bridge resistance	T_{bridge} = –25 to +125 °C	–	0.3	–	%/K
V_{offset}	offset voltage		–0.5	–	+0.5	mV/V
TCV_{offset}	temperature coefficient of offset voltage	T_{bridge} = –25 to +125 °C	–5	±1.5	5	(µV/V)/K
FL	linearity deviation of output voltage	H_y = 0 to ±1 kA/m	–	–	0.5	%·FS
		H_y = 0 to ±1.6 kA/m	–	–	1.7	%·FS
		H_y = 0 to ±2 kA/m	–	–	2.0	%·FS
FH	hysteresis of output voltage		–	–	0.5	%·FS
f	operating frequency	note 4	0	–	1	MHz

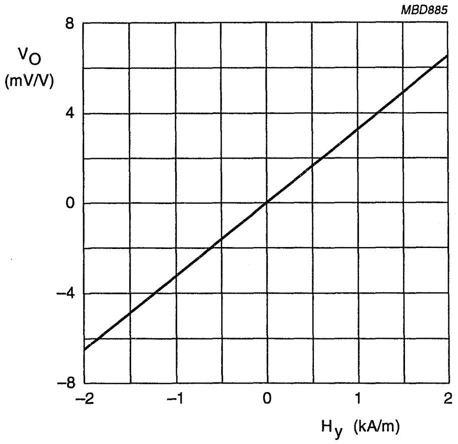
Notes to the characteristics

1. Magnet (Ferroxdure 100) delivers an auxiliary field of $H_x = 3.6$ kA/m (temperature coefficient: –0.2 %/K). Above 110 °C the auxiliary field H_x will be <3.0 kA/m; stable sensor operation may be threatened by disturbing magnetic fields.
2. $S = \frac{(V_O \text{ at } H_y = 1.6\ \text{kA/m}) - (V_O \text{ at } H_y = 0)}{1.6 \times V_{CC}}$.
3. The sensitivity increases and decreases linear with the supply voltage, thus the static output voltage is directly proportional to the supply voltage.
4. Sensor bridge response only. When sensing high speed rotation, the operating frequency may be reduced due to eddy current effects.



M = direction of magnetization.
N, S = magnetic poles.

Fig.3 Principle of magnetization.



T_{amb} = 25 °C; V_{offset} = 0.

Fig.4 Sensor output characteristic.

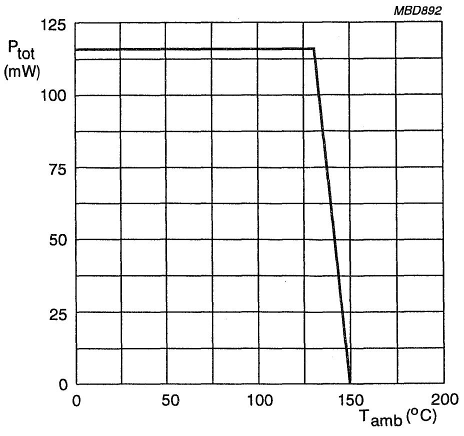
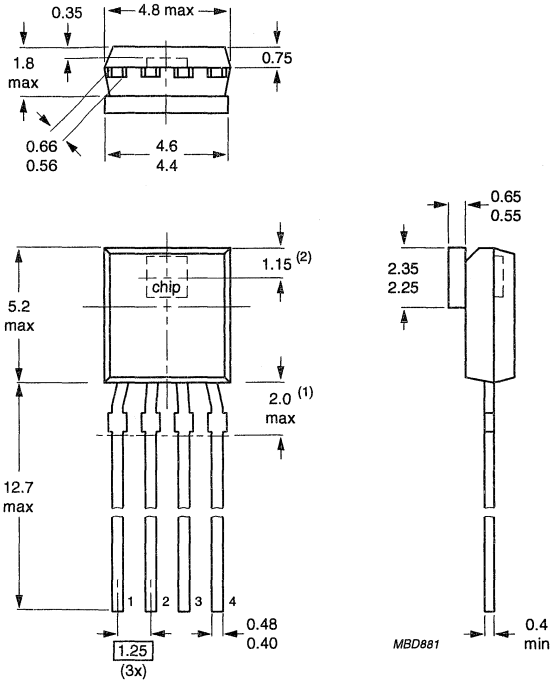


Fig.5 Power derating curve.

PACKAGE OUTLINE



Dimensions in mm.

(1) Terminal dimensions uncontrolled within this area.

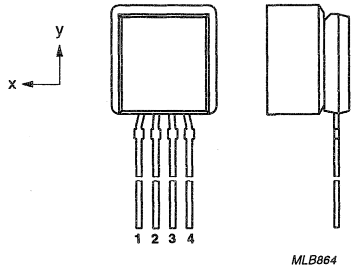
(2) Position of sensor chip.

Fig.6 Outline of KM110B/2.

Magnetic field sensor KM110B/4

DESCRIPTION

The KM110B/4 is a sensitive magnetic field sensor, employing the magnetoresistive effect of thin-film permalloy. The combination of a magnetorisistive sensor with a Ferroxdure FXD100 magnet and a special 30° magnetization enables the sensor to be used as a revolution sensor or proximity detector. The offset voltage of the KM110B/4 is magnetically trimmed during the magnetization process. The strength of the magnetic field caused by the Ferroxdure FXD100 magnet in the different sensor directions is typically: $H_x = 7$ kA/m (auxiliary field and measured at the centre of the magnetoresistive bridge). $H_z = 17$ kA/m (perpendicular to the sensor surface). H_y is zero due to the trimming process.



Marking: KMZ12B PHDxx.

Fig.1 Simplified outline.

PINNING

PIN	SYMBOL	DESCRIPTION
1	$+V_O$	output voltage
2	GND	ground
3	$-V_O$	output voltage
4	$+V_{CC}$	supply voltage

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
T_{bridge}	bridge operating temperature	–40	–	+150	°C
R_{bridge}	bridge resistance	1.6	2.1	2.6	kΩ
V_{offset}	offset voltage	–0.5	–	+0.5	mV/V

CIRCUIT DIAGRAM

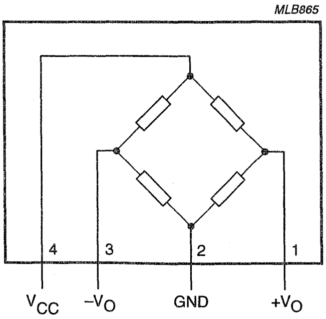


Fig.2 Simplified circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage		–	12	V
P_{tot}	total power dissipation	up to T_{amb} = 130 °C	–	120	mW
H_D	external disturbing field	see note 1	–	32	kA/m
T_{stg}	storage temperature		−40	+150	°C
T_{bridge}	bridge operating temperature	see note 2	−40	+150	°C
$T_{bridge\ peak}$	peak bridge operating temperature	max. 3 times ≤1h during lifetime; see notes 2 and 3	–	190	°C

Notes

1. It is not permitted to press two sensors together against the magnetic forces, due to their own magnetic field ($H \geq 50$ kA/m close to the magnetic poles).
2. Maximum operating temperature of the thin-film permalloy.
3. Maximum temperature gradient: 5 °C/minute.

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient in free air	180	K/W

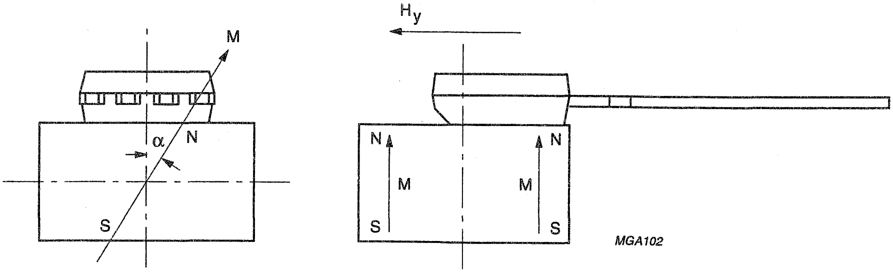
CHARACTERISTICS

T_{bridge} = 25 °C; V_{CC} = 5 V unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
R_{bridge}	bridge resistance		1.6	2.6	kΩ
V_{offset}	offset voltage	notes 1 and 4	−0.5	+0.5	mV/V
S	sensitivity	notes 2 and 4	1.5	2.2	$\frac{mV/V}{kA/m}$
f_{oper}	operating frequency	note 3	0	1	MHz
TCV_{offset}	temperature coefficient of offset voltage	T_{bridge} = −25 to + 100 °C; note 1	−5	+5	(μV/V)/K
TCR_{bridge}	temperature coefficient of bridge resistance	T_{bridge} = −25 to + 100 °C	–	0.4	%/K
TCS	temperature coefficient of sensitivity	T_{bridge} = −25 to + 100 °C	0.25	0.31	%/K

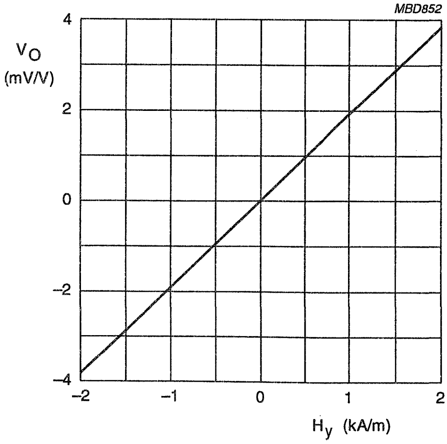
Notes

1. Measured in an environment without external fields and ferromagnetic materials.
2. $S = \frac{(V_O \text{ at } H_y = 1.6 \text{ kA/m}) - (V_O \text{ at } H_y = 0)}{1.6 \times V_{CC}}$.
3. Only sensor bridge response. When sensing high speed rotation, the operating frequency may be reduced due to eddy current effects.
4. The sensitivity increases and decreases linear with the supply voltage, thus the static output voltage is directly proportional to the supply voltage.



M = direction of magnetization.
N, S = magnetic poles.

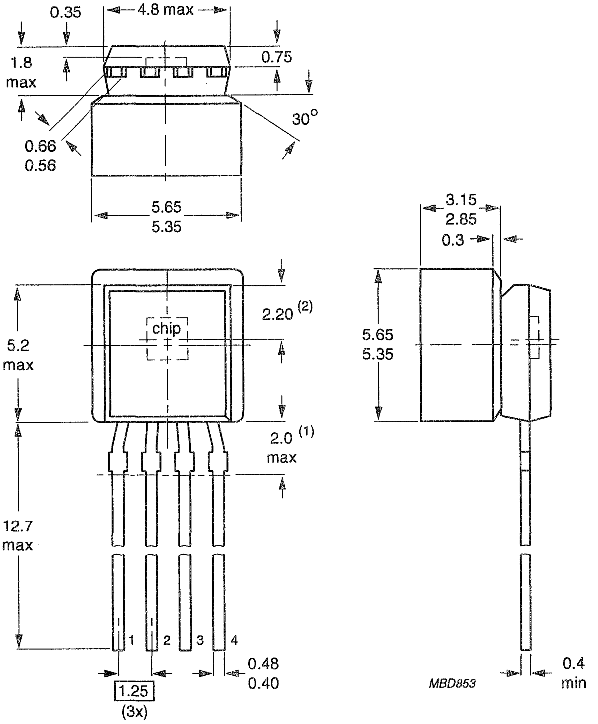
Fig.3 Principle of magnetization.



$V_{offset} = 0$.

Fig.4 Output signal as a function of the magnetic field strength.

PACKAGE OUTLINE



Dimensions in mm.

(1) Terminal dimensions uncontrolled within this area.

(2) Position of sensor chip.

Fig.5 Outline of the KM110B/4.

Magnetic field sensor | KMZ10A

DESCRIPTION

The KMZ10A is an extremely sensitive magnetic field sensor, employing the magnetoresistive effect of thin-film permalloy. Its properties enable this sensor to be used in a wide range of applications for navigation, current and field measurement, revolution counters, angular or linear position measurement and proximity detectors, etc.

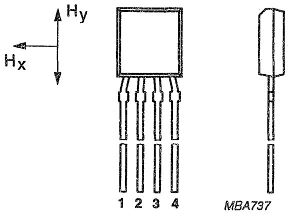


Fig.1 Simplified outline.

PINNING

PIN	SYMBOL	DESCRIPTION
1	$+V_O$	output voltage
2	GND	ground
3	$-V_O$	output voltage
4	V_{CC}	supply voltage

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
T_{bridge}	bridge operating temperature	–40	–	+150	°C
H_y	magnetic field strength	–0.5	–	+0.5	kA/m
H_x	auxiliary field	–	0.5	–	kA/m
S	sensitivity	–	16	–	$\frac{mV/V}{kA/m}$
R_{bridge}	bridge resistance	0.8	–	1.6	kΩ
V_{offset}	offset voltage	–1.5	–	+1.5	mV/V

CIRCUIT DIAGRAM

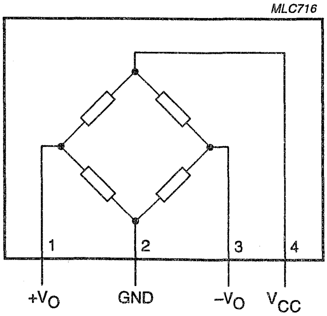


Fig.2 Simplified circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage		–	9	V
P_{tot}	total power dissipation	up to T_{amb} = 134 °C	–	90	mW
T_{stg}	storage temperature	note 1	–65	+150	°C
T_{bridge}	bridge operating temperature		–40	+150	°C

Note

1. Maximum operating temperature of the thin-film permalloy.

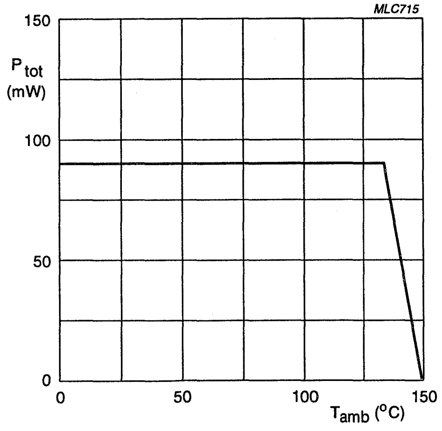


Fig.3 Power derating curve.

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	180	K/W

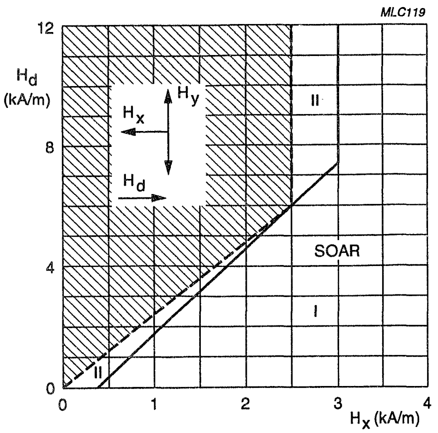
CHARACTERISTICS

T_{amb} = 25 °C; H_x = 0.5 kA/m; notes 1 and 2; V_{CC} = 5 V unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
H_y	magnetic field strength	note 2	−0.5	–	+0.5	kA/m
S	sensitivity	notes 2 and 3	13	–	19	$\frac{mV/V}{kA/m}$
TCV_O	temperature coefficient of output voltage	V_{CC} = 5 V; T_{amb} = −25 to +125 °C	–	−0.4	–	%/K
		I_{CC} = 3 mA; T_{amb} = −25 to +125 °C	–	−0.15	–	%/K
R_{bridge}	bridge resistance		0.8	–	1.6	kΩ
TCR_{bridge}	temperature coefficient of bridge resistance	T_{bridge} = −25 to +125 °C	–	0.25	–	%/K
V_{offset}	offset voltage		−1.5	–	+1.5	mV/V
TCV_{offset}	temperature coefficient of offset voltage	T_{bridge} = −25 to +125 °C	−6	–	+6	(μV/V)/K
FL	linearity deviation of output voltage	H_y = 0 to ±0.25 kA/m	–	–	0.8	%·FS
		H_y = 0 to ±0.4 kA/m	–	–	2.5	%·FS
		H_y = 0 to ±0.5 kA/m	–	–	4.0	%·FS
FH	hysteresis of output voltage		–	–	0.5	%·FS
f	operating frequency		0	–	1	MHz

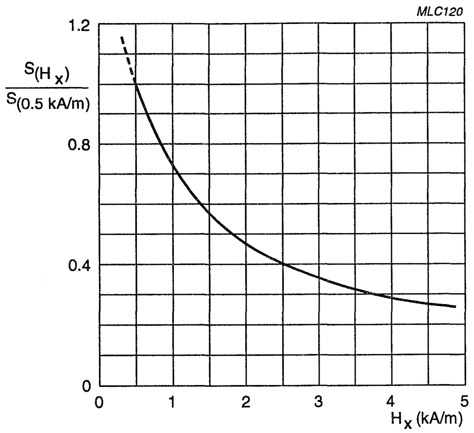
Notes

1. Before first operation or after operation outside the SOAR (Fig.4) the sensor has to be reset by application of an auxiliary field H_x = 3 kA/m.
2. No disturbing field (H_d) allowed; for stable operation under disturbing conditions see Fig.4 (SOAR) and see Fig.5 for decrease of sensitivity.
3. $S = \frac{(V_O \text{ at } H_y = 0.4\text{ kA/m}) - (V_O \text{ at } H_y = 0)}{0.4 \times V_{CC}}$.



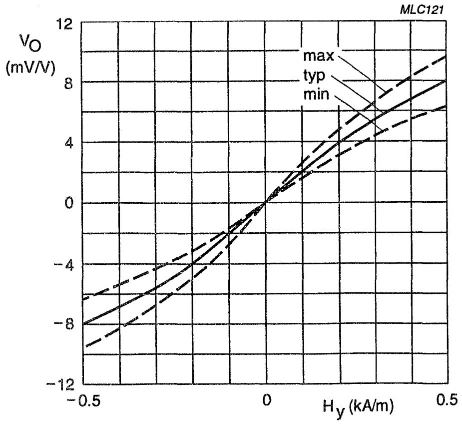
I = Region of permissible operation.
II = Permissible extension if $H_y < 0.15$ A/m.
In applications with $H_x < 3$ kA/m, the sensor has to be reset, after leaving the SOAR, by an auxiliary field of $H_x = 3$ kA/m.

Fig.4 Safe Operating Area (permissible disturbing field H_d as a component of auxiliary field H_x).



In applications with $H_x \leq 3$ kA/m, the sensor has to be reset by an auxiliary field of $H_x = 3$ kA/m before using.

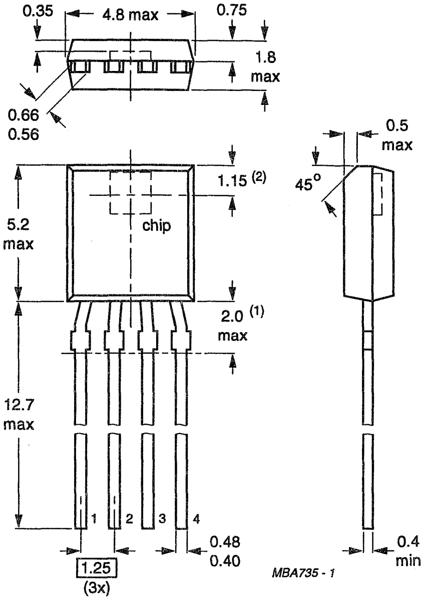
Fig.5 Relative sensitivity (ratio of sensitivity at certain H_x and sensitivity at $H_x = 0.5$ kA/m).



$H_x = 0.5$ kA/m; $T_{amb} = 25$ °C; $V_{offset} = 0$.

Fig.6 Sensor output characteristics.

PACKAGE OUTLINE



Dimensions in mm.

(1) Terminal dimensions uncontrolled within this area.

(2) Position of sensor chip.

Fig.7 Outline of KMZ10A (SOT195).

Magnetic field sensor KMZ10A1

DESCRIPTION

The KMZ10A1 is an extremely sensitive magnetic field sensor, employing the magnetoresistive effect of thin film permalloy.

Its properties enable this sensor to be used in a wide range of applications, such as navigation, current and earth magnetic field measurement, etc. The special arrangement of the sensing chip allows the constructuion of coils for switching the auxiliary field (H_X) along the length axis of the sensor.

The sensor can be operated at any frequency between DC and 1 MHz.

PINNING

PIN	DESCRIPTION
1	output voltage ($+V_O$)
2	ground
3	output voltage ($-V_O$)
4	supply voltage V_{CC}

PIN CONFIGURATION

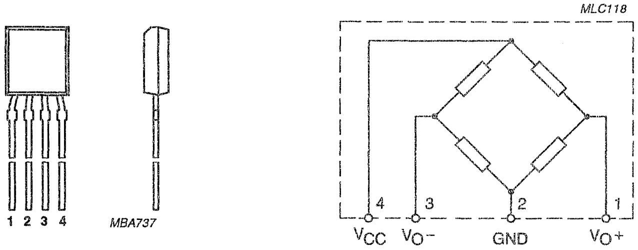


Fig.1 Simplified outline and circuit configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_B	operating voltage	–	5	–	V
H_y	operating range	– 0.5	–	0.5	kA/m
H_x	auxiliary field	–	0.5	–	kA/m
S	sensitivity	–	14	–	$\frac{mV/V}{kA/m}$
S_s	sensitivity (with switched H_x)	–	22	–	$\frac{mV/V}{kA/m}$
V_{off}	offset voltage	–1.5	–	1.5	mV/V
R_{bridge}	bridge resistance	0.85	–	1.75	kΩ

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_B	operating voltage		–	9	V
P_{tot}	total power dissipation	up to T_{amb} = 132 °C	–	100	mW
T_{stg}	storage temperature range		–65	150	°C
T_{bridge}	bridge operating temperature range		–40	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	THERMAL RESISTANCE
$R_{th\ j\text{-}a}$	from junction to ambient	180 K/W

CHARACTERISTICS

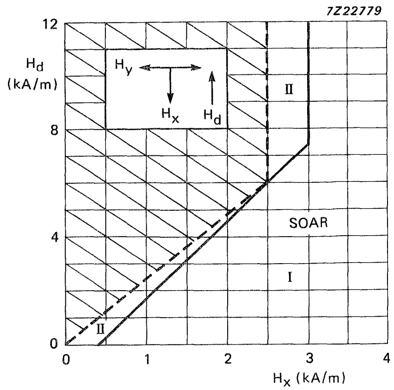
T_{amb} = 25 °C and H_x = 0.5 kA/m, unless otherwise specified; see note 1.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_B	bridge supply voltage		–	5	–	V
H_y	operating range (note 1)		– 0.5	–	0.5	kA/m
S	open circuit sensitivity	notes 1 and 2	11	–	17	$\frac{mV/V}{kA/m}$
TCV_O	temperature coefficient of output voltage at constant supply voltage	V_B = 5 V; T_j = –25 to 125 °C	–	– 0.4	–	%/K
VCV_O	temperature coefficient of output voltage at constant supply current	I_B = 3 mA; T_j = –25 to 125 °C	–	– 0.15	–	%/K
R_{bridge}	bridge resistance		0.85	–	1.75	kΩ
TCR_{bridge}	temperature coefficient of bridge resistance	resistance at T_j = –25 to 125 °C	–	0.25	–	%/K
V_{off}	offset voltage		–1.5	–	1.5	mV/V
TCV_{off}	temperature coefficient of offset voltage	at T_{bridge} = –25 to 125 °C	–6	–	6	$\frac{\mu V/V}{K}$
FL	linearity deviation of output voltage	H_y = 0 to ±0.25 kAm^{-1}	–	–	0.8	%FS
		H_y = 0 to ±0.4 kAm^{-1}	–	–	2.5	%FS
		H_y = 0 to ±0.5 kAm^{-1}	–	–	4.0	%FS
FH	hysteresis of output voltage		–	–	0.5	%FS
f	operating frequency		–	–	1	MHz
Characteristics with H_x = 0 (switched H_x, see note 3) (T_{amb} = 25 °C; V_B = 5 V)						
H_y	operating range (note 1)		– 0.05	–	0.05	kA/m
S_s	sensitivity (slope between H_y = 0 and H_y = 40 A/m)		14	–	27	$\frac{mV/V}{kA/m}$

Notes

Before first operation or after operation outside the SOAR (see Fig.2), the sensor must be reset by application of an auxiliary field H_x = 3 kA/m.

1. No disturbing field (H_d) allowed; for stable operation under disturbing conditions, see Fig.2 for SOAR and Fig.4 for decrease of sensitivity.
2. Sensitivity measured as $\Delta V_O/\Delta H_y$ between H_y = 0 and H_y = 0.4 kA/m.
3. See **APPLICATION INFORMATION**.

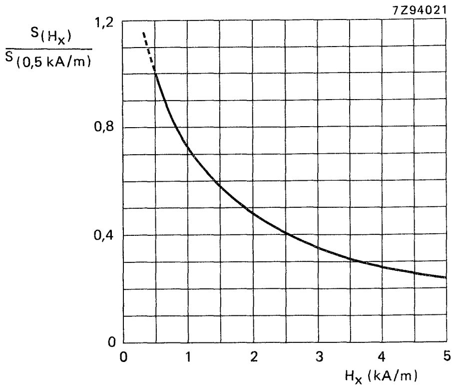


(I) Region of permissible operation.

(II)Permissible extension if $H_y < 0.05$ kA/m.

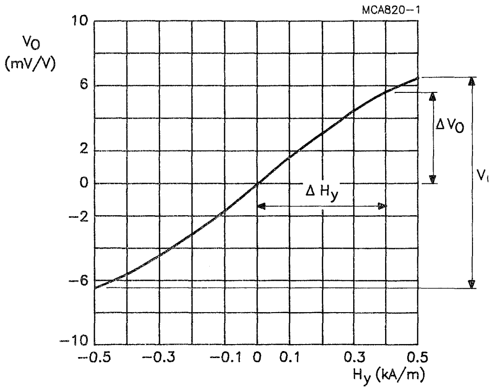
In applications with $H_x < 3$ kA/m, the sensor must be reset after leaving the SOAR by an auxiliary field of $H_x = 3$ kA/m.

Fig.2 Safe operating area (permissible disturbing field H_d as a component of auxiliary field H_x).



In applications with $H_x \leq 3$ kA/m, the sensor must be reset by an auxiliary field of $H_x = 3$ kA/m before use.

Fig.3 Relative sensitivity (ratio of sensitivity at fixed H_X and sensitivity at $H_X = 0.5$ kA/m).



$H_x = 0.5$ kA/m; $T_{amb} = 25$ °C; $V_{off} = 0$; $S = \Delta V_O/\Delta H_y$.

Fig.4 Sensor output characteristic.

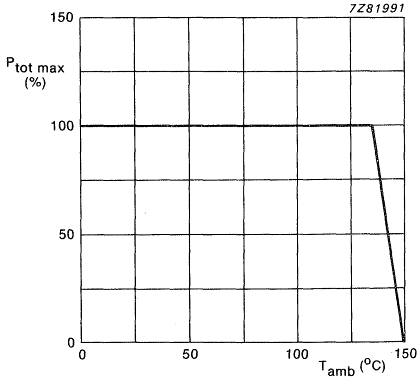
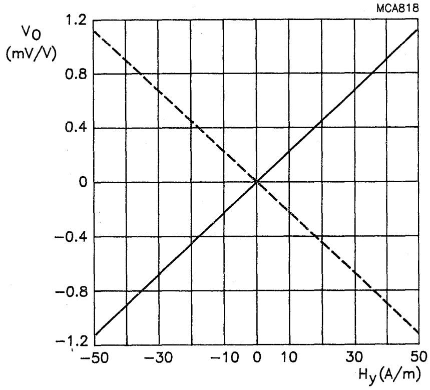


Fig.5 Power derating curve.



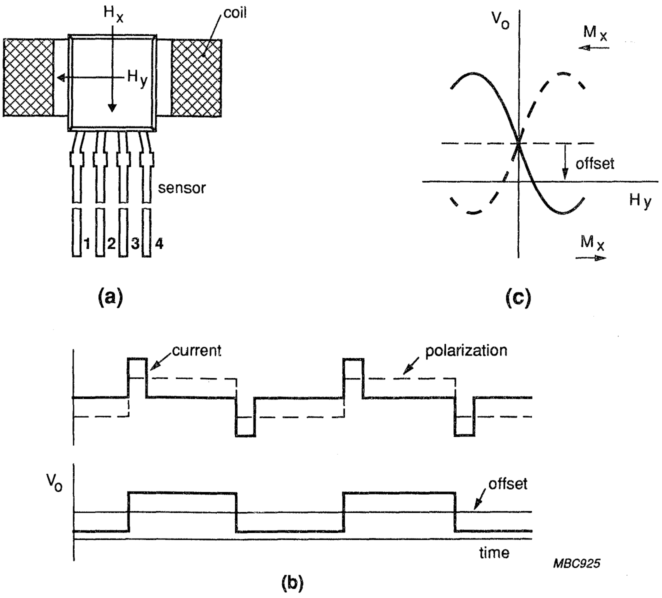
Solid line: sensor reset with H_x = 3 kA/m.
Dotted line: sensor reset with H_x = −3 kA/m.

Fig.6 Output characteristic with H_x = 0 (switched H_x).

APPLICATION INFORMATION

A problem of measuring weak magnetic fields is that precision is limited by drift in both the sensor and amplifier offset. In these instances, it is possible to take advantage of the 'flipping' characteristics of the KMZ10 series to generate an output that is independent of offset.

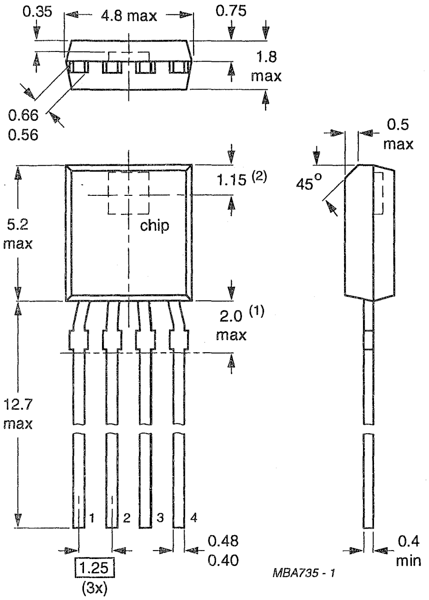
The sensor, located in a coil connected to a current pulse generator producing magnetic field pulses periodically reversed by alternate positive and negative current going pulses, is continually flipped from its normal to its reversed polarity and back again. The polarity of the offset, however, remains unchanged, so the offset itself can be eliminated by passing the output signal through a filter circuit.



(a) Set- up.
(b) Pulse diagram.
(c) Sensor output characteristics.

Fig.7 Measuring weak magnetic fields with the KMZ10A1.

PACKAGE OUTLINE



Dimensions in mm.

(1) Terminal dimensions uncontrolled within this area.

(2) Position of sensor chip.

Fig.8 SOT195.

Magnetic field sensor KMZ10B

DESCRIPTION

The KMZ10B is a sensitive magnetic field sensor, employing the magnetoresistive effect of thin film permalloy.

Its properties enable this sensor to be used in a wide range of applications for current and field measurement, revolution counters, angular or linear position measurement, proximity detectors, etc.

PINNING

PIN	DESCRIPTION
1	output voltage (+V_O)
2	ground
3	output voltage (−V_O)
4	supply voltage V_{CC}

PIN CONFIGURATION

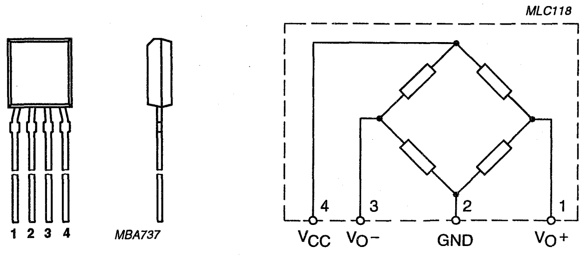


Fig.1 Simplified outline and circuit configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_B	operating voltage	–	5	–	V
H_y	operating range	−2	–	2	kA/m
H_x	auxiliary field	–	3	–	kA/m
S	sensitivity	–	4	–	$\frac{mV/V}{kA/m}$
V_{off}	offset voltage	−1.5	–	+1.5	mV/V
R_{bridge}	bridge resistance	1.6	–	2.6	kΩ

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_B	operating voltage		–	12	V
P_{tot}	total power dissipation	up to T_{amb} = 130 °C	–	120	mW
T_{stg}	storage temperature range		–65	150	°C
T_{bridge}	bridge operating temperature range		–40	150	°C

THERMAL RESISTANCE

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j\text{-}a}$	from junction to ambient	180	K/W

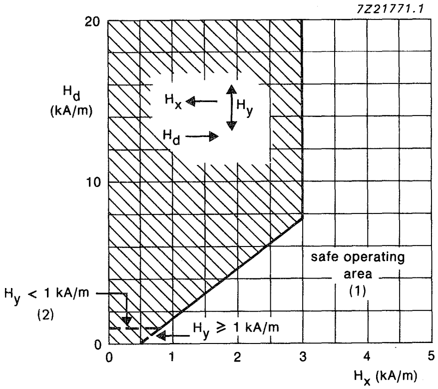
CHARACTERISTICS

T_{amb} = 25 °C and H_x = 3 kA/m. In applications with H_x < 3 kA/m, the sensor has to be reset before first operation of an auxiliary field H_x = 3 kA/m.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_B	operating voltage		–	5	–	V
H_y	operating range of magnetic field		–2	–	2	kA/m
S	sensitivity (notes 1,2)	open circuit	3.2	–	4.8	$\frac{mV/V}{kA/m}$
TCV_o	temperature coefficient of output voltage	V_B = 5 V; T_j = –25 to 125 °C	–	–0.4	–	%/K
		I_B = 3 mA; T_j = –25 to 125 °C	–	–0.1	–	%/K
R_{bridge}	bridge resistance		1.6	–	2.6	kΩ
TCR_{bridge}	temperature coefficient of bridge resistance	T_{bridge} = –25 to 125 °C	–	0.3	–	%/K
V_{off}	offset voltage		–1.5	–	+1.5	mV/V
TCV_{off}	temperature coefficient of offset voltage	T_j = –25 to 125 °C	–3	–	+3	$\frac{\mu V/V}{K}$
FL	linearity deviation of output voltage	H_y = 0 to ±1 kA/m	–	–	±0.5	%FS
		H_y = 0 to ±1.6 kA/m	–	–	±1.7	%FS
		H_y = 0 to ±2 kA/m	–	–	±2	%FS
V_{oH}	hysteresis of output voltage		–	–	0.5	%FS
f	operating frequency		0	–	1	MHz

Notes

1. No disturbing field (H_d) allowed; for stable operation under disturbing conditions see Fig.2 (SOAR) and see Fig.3 for decrease of sensitivity.
2. $$S = \frac{(V_O \text{ at } H_y = 1.6\text{ kA/m}) - (V_O \text{ at } H_y = 0)}{1.6 \times V_{CC}}$$

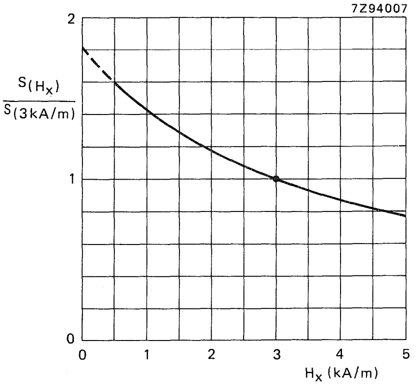


In applications with H_x < 3 kA/m, the sensor has to be reset after leaving the SOAR, by an auxiliary field of H_x = 3 kA/m.

(1) Region of permissible operation.

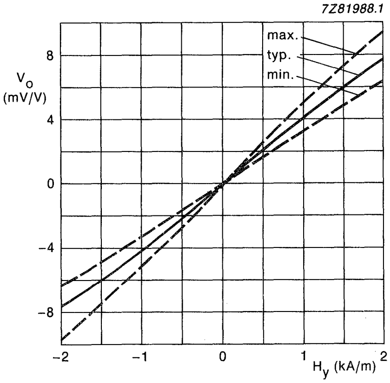
(2) Permissible extension if H_y < 1 kA/m.

Fig.2 Safe operating area (permissible disturbing field H_d as a component of auxiliary field H_x).



In applications with $H_x \leq$ 3 kA/m, the sensor has to be reset by an auxiliary field of H_x = 3 kA/m before use.

Fig.3 Relative sensitivity (ratio of sensitivity at certain H_x and sensitivity at H_x = 3 kA/m).



V_B = constant; T_{amb} = 25 °C; H_x = 3 kA/m; V_{off} = 0.

Fig.4 Sensor output characteristic.

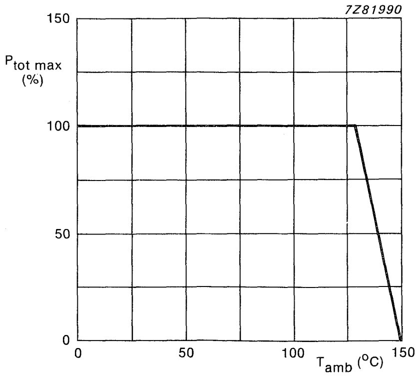
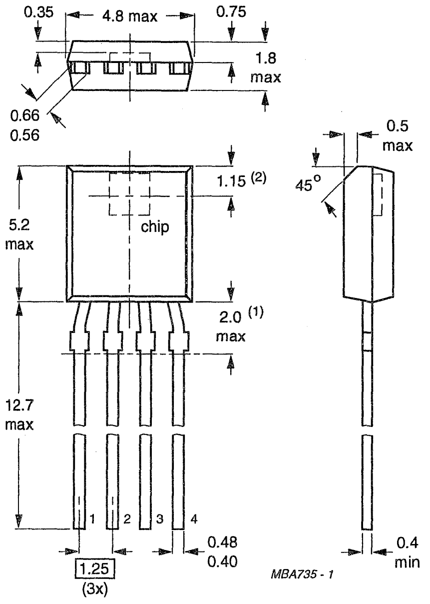


Fig.5 Power derating curve.

PACKAGE OUTLINE



Dimensions in mm.

(1) Terminal dimensions uncontrolled within this area.

(2) Position of sensor chip.

Fig.6 SOT195.

Magnetic field sensor KMZ10C

DESCRIPTION

The KMZ10C is a magnetic field sensor, employing the magnetoresistive effect of thin-film permalloy. Its properties enable this sensor to be used in a wide range of applications for current and field measurement, revolution counters, angular or linear position measurement and proximity detectors, etc.

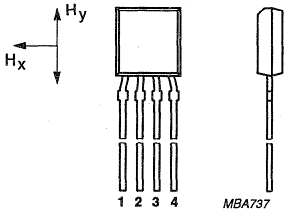


Fig.1 Simplified outline.

PINNING

PIN	SYMBOL	DESCRIPTION
1	$+V_O$	output voltage
2	GND	ground
3	$-V_O$	output voltage
4	V_{CC}	supply voltage

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
T_{bridge}	bridge operating temperature	–40	–	+150	°C
H_y	magnetic field strength	–7.5	–	+7.5	kA/m
H_x	auxiliary field	–	3	–	kA/m
S	sensitivity	–	1.5	–	$\frac{mV/V}{kA/m}$
R_{bridge}	bridge resistance	1	–	1.8	kΩ
V_{offset}	offset voltage	–1.5	–	+1.5	mV/V

CIRCUIT DIAGRAM

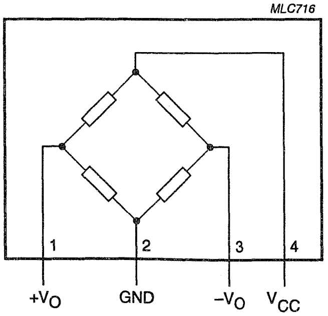


Fig.2 Simplified circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage		–	10	V
P_{tot}	total power dissipation	up to T_{amb} = 132 °C	–	100	mW
T_{stg}	storage temperature	note 1	–65	+150	°C
T_{bridge}	bridge operating temperature		–40	+150	°C

Note

1. Maximum operating temperature of the thin-film permalloy.

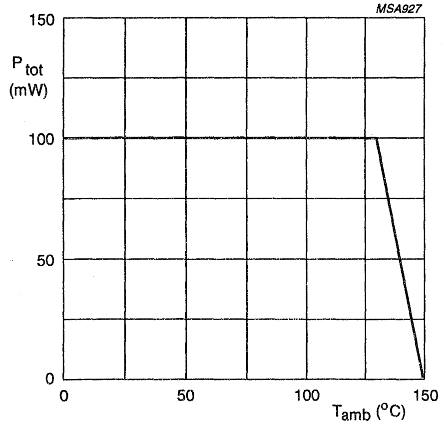


Fig.3 Power derating curve.

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	180	K/W

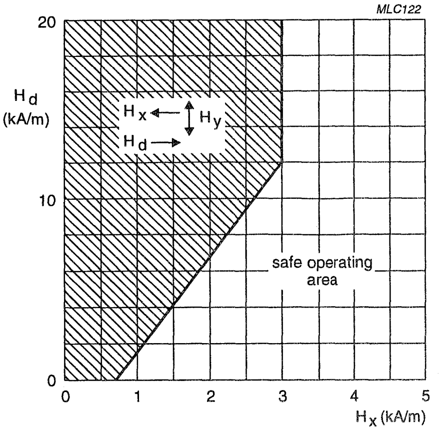
CHARACTERISTICS

T_{amb} = 25 °C; H_x = 3 kA/m; note 1; V_{CC} = 5 V unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
H_y	magnetic field strength		−7.5	−	+7.5	kA/m
S	sensitivity	notes 1 and 2	1	−	2	$\frac{mV/V}{kA/m}$
TCV_O	temperature coefficient of output voltage	V_{CC} = 5 V; T_{amb} = −25 to +125 °C	−	−0.5	−	%/K
		I_{CC} = 3 mA; T_{amb} = −25 to +125 °C	−	−0.15	−	%/K
R_{bridge}	bridge resistance		1	−	1.8	kΩ
TCR_{bridge}	temperature coefficient of bridge resistance	T_{bridge} = −25 to +125 °C	−	0.35	−	%/K
V_{offset}	offset voltage		−1.5	−	+1.5	mV/V
TCV_{offset}	temperature coefficient of offset voltage	T_{bridge} = −25 to +125 °C	−2	−	+2	(μV/V)/K
FL	linearity deviation of output voltage	H_y = 0 to ±3.75 kA/m	−	−	0.8	%·FS
		H_y = 0 to ±6.0 kA/m	−	−	2.4	%·FS
		H_y = 0 to ±7.5 kA/m	−	−	2.7	%·FS
FH	hysteresis of output voltage		−	−	0.5	%·FS
f	operating frequency		0	−	1	MHz

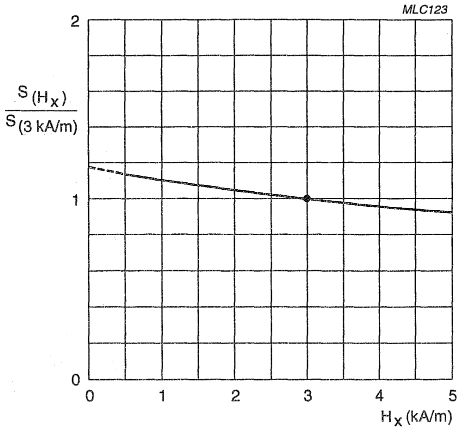
Notes

1. In applications with $H_x < 3$ kA/m the sensor has to be reset before first operation by application of an auxiliary field $H_x = 3$ kA/m.
2. $S = \frac{(V_O \text{ at } H_y = 6\text{ kA/m}) - (V_O \text{ at } H_y = 0)}{6 \times V_{CC}}$



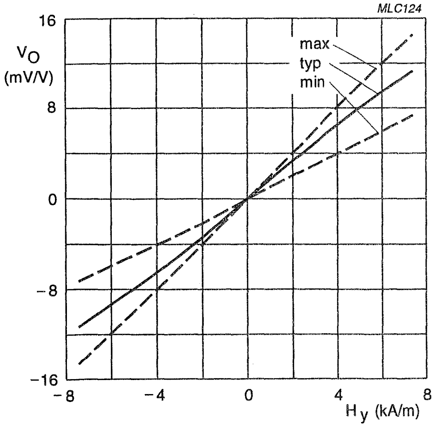
In applications with $H_x < 3$ kA/m, the sensor has to be reset, after leaving the SOAR, by an auxiliary field of $H_x = 3$ kA/m.

Fig.4 Safe Operating Area (permissible disturbing field H_d as a component of auxiliary field H_x).



In applications with $H_x \leq 3$ kA/m, the sensor has to be reset by an auxiliary field of $H_x = 3$ kA/m before using.

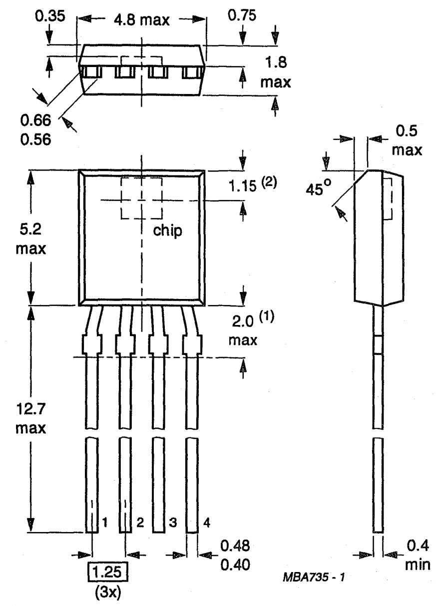
Fig.5 Relative sensitivity (ratio of sensitivity at certain H_x and sensitivity at $H_x = 3$ kA/m).



$H_x = 3$ kA/m; $T_{amb} = 25$ °C; $V_{offset} = 0$.

Fig.6 Sensor output characteristics.

PACKAGE OUTLINE



Dimensions in mm.

(1) Terminal dimensions uncontrolled within this area.

(2) Position of sensor chip.

Fig.7 Outline of KMZ10C (SOT195).

# Magnetic field sensor	KMZ11B1

DESCRIPTION

The KMZ11B1 is a sensitive magnetic field sensor, employing the magneto-resistive effect of thin film permalloy. Its properties enable this sensor to be used in a wide range of applications for current and field measurement, revolution counters, angular or linear displacement sensors, proximity detectors, etc. The sensor can be operated at any frequency between DC and 1 MHz.

PINNING

PIN	DESCRIPTION
1	output voltage (+V_o)
2	supply voltage (GND)
3	output voltage (–V_o)
4	supply voltage (V_{CC})
5 - 8	not connected

PIN CONFIGURATION

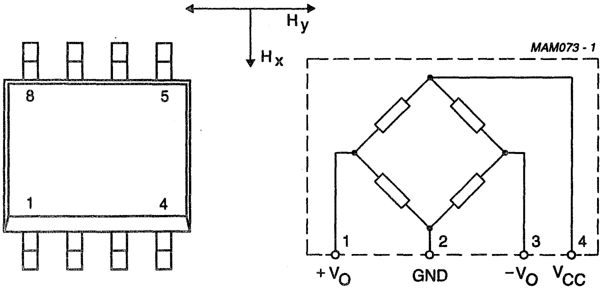


Fig.1 Simplified outline and circuit configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	supply voltage	–	5	–	V
H_y	operating range of magnetic field	–2	–	+2	kA/m
H_x	auxiliary field	–	3	–	kA/m
S	sensitivity	–	4	–	$\frac{mV/V}{kA/m}$
V_{offset}	offset voltage	–1.5	–	+1.5	mV/V
R_{bridge}	bridge resistance	1.9	–	2.9	kΩ

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage		–	12	V
P_{tot}	total power dissipation	up to T_{amb} = 130 °C	–	120	mW
T_{stg}	storage temperature		–65	+150	°C
T_{bridge}	bridge operating temperature		–40	+150	°C

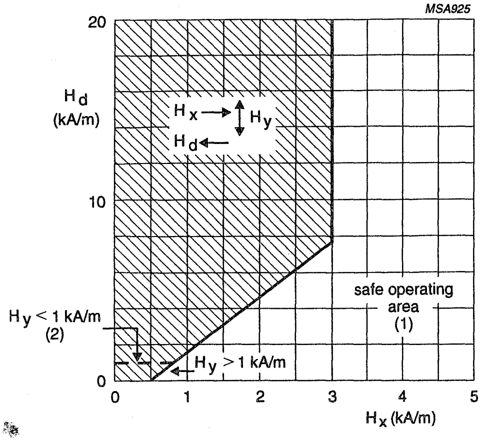
THERMAL RESISTANCE

SYMBOL	PARAMETER	THERMAL RESISTANCE
$R_{th\ j\text{-}a}$	from junction to ambient	155 K/W

CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 5 V and H_x = 3 kA/m unless otherwise specified. In applications with H_x < 3 kA/m, the sensor has to be reset by application of an auxiliary field H_x = 3 kA/m.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{CC}	supply voltage		–	5	–	V
H_y	operating range of magnetic field		–2	–	+2	kA/m
S	sensitivity	open circuit	3.2	–	4.8	$\frac{mV/V}{kA/m}$
TCV_O	temperature coefficient of output voltage	V_{CC} = 5 V; T_{amb} = –25 to +125 °C	–	–0.4	–	%/K
		I_{CC} = 3 mA; T_{amb} = –25 to +125 °C	–	–0.1	–	%/K
R_{bridge}	bridge resistance		1.9	–	2.9	kΩ
TCR_{bridge}	temperature coefficient of bridge resistance	T_{bridge} = –25 to +125 °C	–	0.3	–	%/K
V_{offset}	offset voltage		–1.5	–	+1.5	mV/V
TCV_{offset}	temperature coefficient of offset voltage	T_{bridge} = –25 to +125 °C	–3	–	+3	$\frac{\mu V/V}{K}$
FL	linearity deviation of output voltage	H_y = 0 to ±1 kA/m	–	–	±0.5	% full scale
		H_y = 0 to ±1.6 kA/m	–	–	±1.7	% full scale
		H_y = 0 to ±2 kA/m	–	–	±4.0	% full scale
FH	hysteresis of output voltage		–	–	1	% full scale
f	operating frequency		0	–	1	MHz

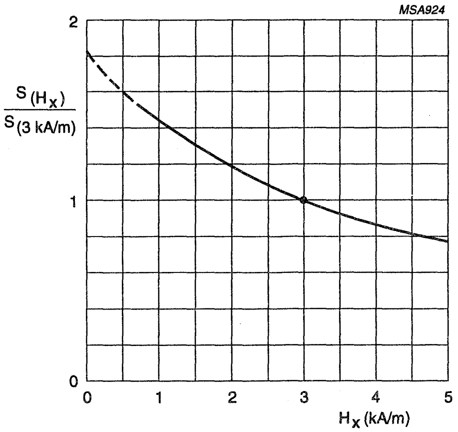


In applications with $H_x < 3$ kA/m, the sensor has to be reset after leaving the SOAR by an auxiliary field of $H_x = 3$ kA/m.

(1) Region of permissible operation.

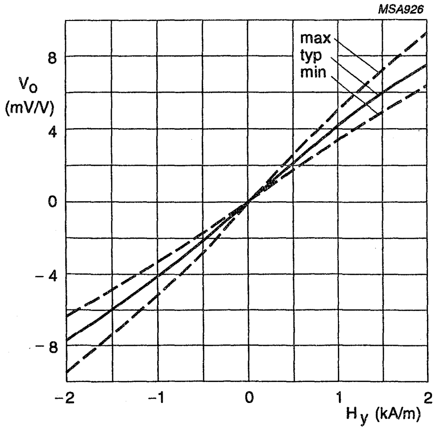
(2) Permissible extension if $H_y < 0.1$ kA/m.

Fig.2 Safe operating area (permissible disturbing field H_d as a component of auxiliary field H_x).



In applications with $H_x \leq 3$ kA/m, the sensor has to be reset by an auxiliary field of $H_x = 3$ kA/m before use.

Fig.3 Relative sensitivity (ratio of sensitivity at certain H_x and sensitivity at $H_x = 3$ kA/m).



$T_{amb} = 25$ °C; $H_x = 3$ kA/m; $V_{offset} = 0$.

Fig.4 Sensor output characteristic.

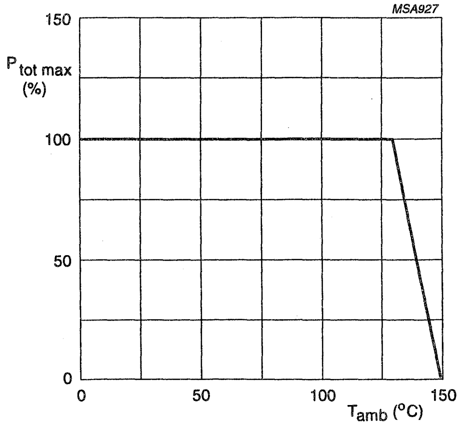


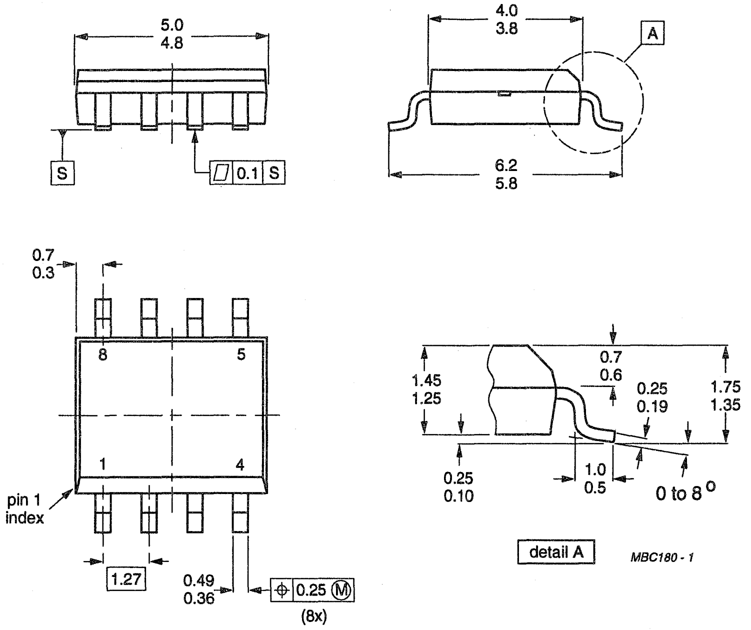
Fig.5 Power derating curve.

APPLICATION INFORMATION

The leadframe material is a copper alloy containing 2% iron. In applications with magnetic fields outside the specified operating range an increasing hysteresis effect will arise due to magnetization effects in the leadframe. However, in angular measurement applications of the KMZ11B1 in combination with strong magnetic fields H > 50 kA/m there is no additional hysteresis present.

In life support systems, the behaviour of electronic components throughout their working life can be unpredictable. The use of these devices in support systems can only be permitted when there is no danger to life caused by devices failing unexpectedly.

PACKAGE OUTLINE



Dimensions in mm.

Fig.6 SOT96 (SO8).

SENSOR HYBRID MODULES

GENERAL

The KMZ10 and KMZ11 series of magnetoresistive sensors are successfully used in a wide range of applications, due to their excellent characteristics:

- High sensitivity
- Wide operating frequency range (0 Hz (DC) to >1 MHz)
- Wide operating temperature range (−40 to +150 °C; 190 °C peak)
- Linear characteristics
- Long life
- Insensitivity to mechanical stress.

In order to assist the designer in applying KMZ sensors, Philips Semiconductors has developed a number of sensor modules for rotational speed measurement and reference mark detection in both IC and hybrid thick-film technology, containing a KMZ sensor in addition to signal conditioning circuitry. These sensor modules offer many important advantages e.g.:

- Contactless measurement, making them wear-free with a long life and high reliability
- Ready for use: all modules are trimmed; no further adjustment or trimming is required
- Shorter system-development times.

All sensor modules are offered as standard products. However, they may also serve as a starting point for the development of customized products.

The following three series of modules are described:

- KMI10 series of integrated sensors for contactless rotational speed measurement
- KM110BH/1 series of hybrid modules for contactless rotational speed measurement
- KM110BH/3 series of hybrid modules for contactless measurement of rotational speed and direction.

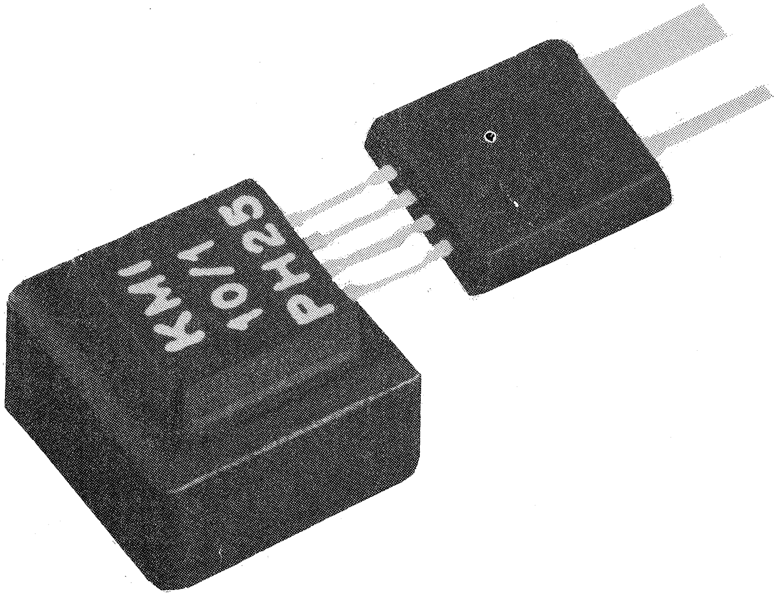


Fig.1 The KMI10/1 sensor.

THE KMI10/X INTEGRATED ROTATIONAL SPEED SENSORS

The KMI10/X sensors are designed for measuring wheel-speeds and are also suitable for reference mark, proximity switch and current detection. They comprise a KMZ10B1 magnetoresistive sensor (an adapted version of the KMZ10B sensor), a ferrite magnet and an advanced bipolar signal-conditioning IC, mounted on a single leadframe. Major features of the KMI10/X sensors are:

- Calibrated sensor, small package
- Measuring range from 0 Hz (zero speed)
- Large measuring distance (>2.5 mm)
- Digital current output signal
  - Two-lead output
- Operating temperature range up to 190 °C
- Vibration insensitive
- Wide range of gear-tooth structures possible
- EMC resistant
- Can be injection-moulded.

The data given below was measured on production-line KMI10 sensors. Both typical data and that measured beyond the allowed maximum ratings, show the sensor's excellent performance even in the most extreme environments.

Operation of the KMI10 sensors

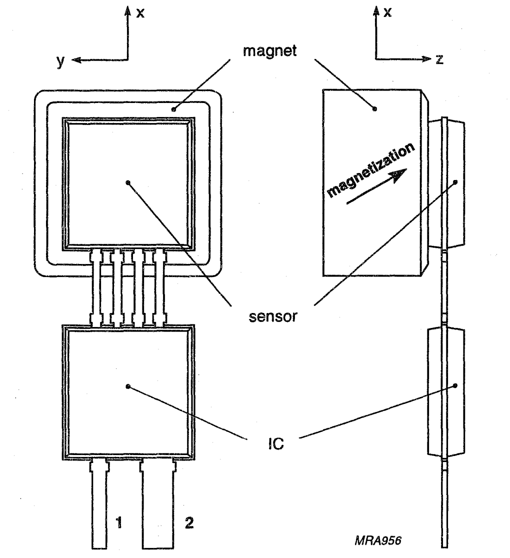
Figures 2 and 3 show the outline of the KMI10/1 and KMI10/4 sensors. The magnets are specially designed to apply a symmetrical magnetic field in the y-z plane of the sensors and a field at 30° relative to the z-axis in the x-z plane. The resulting component in the x-direction of the sensor plane stabilizes the magnetoresistive element and the symmetrical field in the y-z plane is used to detect rotational speed.

Figure 4 shows the speed detection operation. The teeth of a ferromagnetic wheel moving in the y-direction, cause a bending of the field lines which generates an output signal from the magnetoresistive sensor if the teeth have a non-symmetric position relative to the sensor. The output is always zero for symmetric positions of the teeth (i.e. either a tooth or a valley is directly in front of the sensor) and for non-symmetric positions its amplitude depends on the distance between the sensor and the wheel.

In the signal-conditioning circuit (Figs 5 and 6), the magnetoresistive sensor's output signal goes through an EMC filter and is amplified. This amplified voltage is then digitized by a comparator which contains a built-in switching hysteresis: this is realized using a Schmitt-trigger (see Section “Switching hysteresis”). A voltage-control circuit powers the sensor, the amplifier and the comparator with a stabilized 5 V supply. This circuit is in turn stabilized by a pre-stabilized bandgap-reference (GAP) diode.

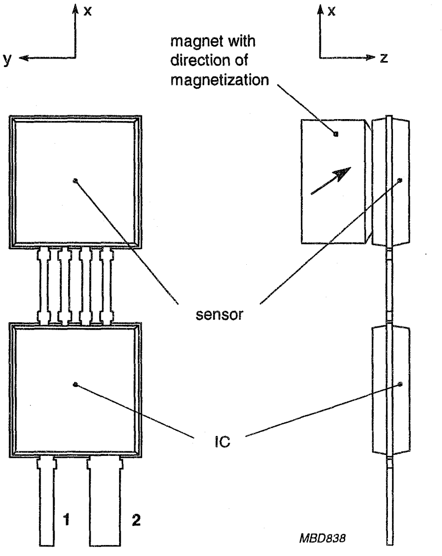
To enable The KMI10's output signal to be safely carried to a detecting circuit, the output signal is transmitted as the current (I_{CC}) in the simple two-wire supply cable. This is done using two current sources, integrated in the signal-conditioning IC. One constant current source supplies a base output current of 7 mA (which is partly used for the 5 V supply). A second, switchable, 7 mA current source is added to this when triggered by the amplified and digitized output signal of the magnetoresistive sensor. Thus, during operation, I_{CC} switches back and forth between 7 and 14 mA (see Fig.7).

The IC and magnetoresistive sensor are deliberately in separate encapsulations to optimize the KMI10's performance at high temperatures. The magnetoresistive sensor can then be exposed to higher temperatures than the IC and the IC's power dissipation will not cause inhomogeneous heating of the sensor element.



Pin 1: V_{CC} (supply voltage).
Pin 2: V– (ground).

Fig.2 Simplified outline of KMI10/1.



Pin 1: V_{CC} (supply voltage).
Pin 2: V– (ground).

Fig.3 Simplified outline of KMI10/4.

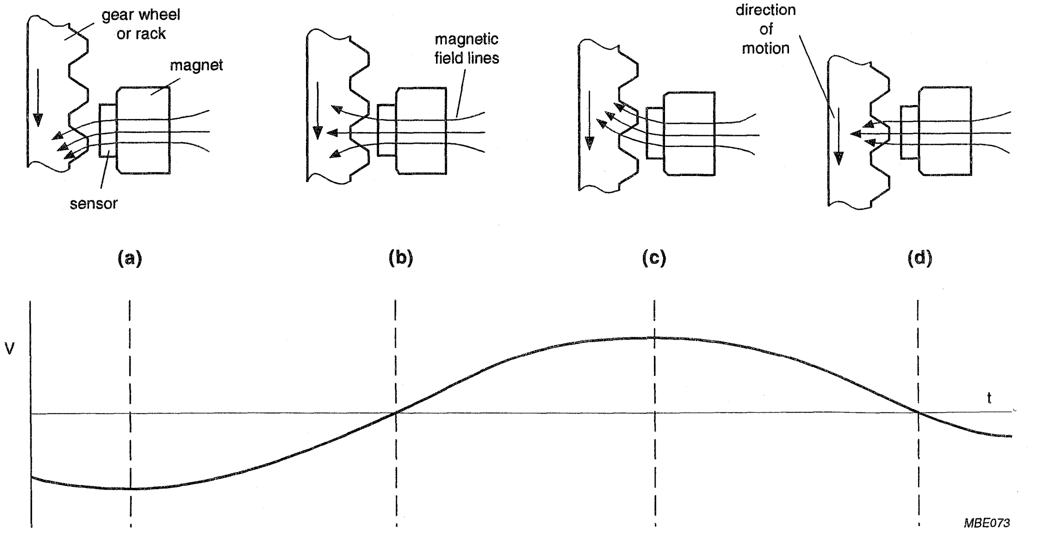


Fig.4 Speed detection using a magnetoresistive sensor.

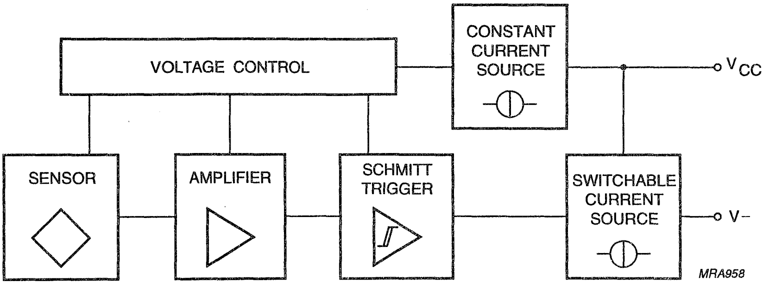


Fig.5 Block diagram of sensor and signal-conditioning circuitry.

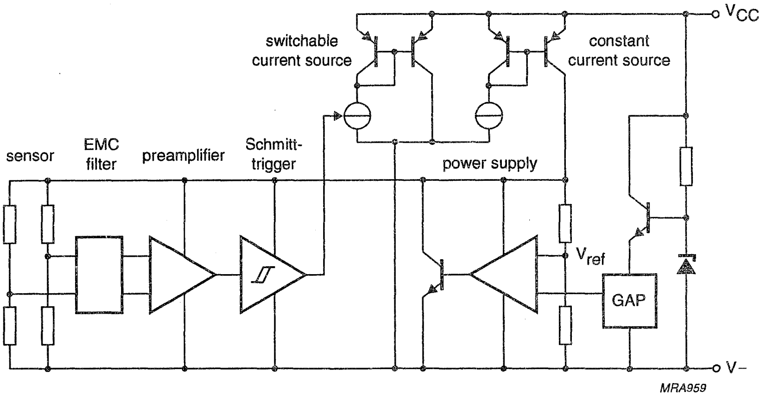


Fig.6 Sensor signal-conditioning circuit diagram.

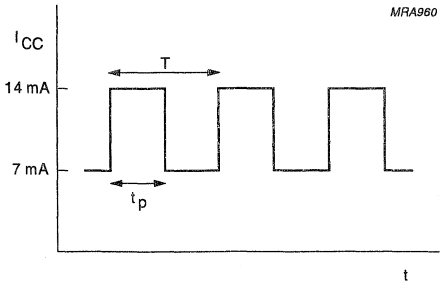


Fig.7 Current output signal.

Sensing distance

In measuring a gear wheel's rotational speed, the sensing distance is defined as the distance between the front of the magnetoresistive sensor and the tips of the teeth as measured on the central axis of the magnet (see Fig.8). The KMI10's output signal depends on the magnetic field variations at the sensor chip, generated by the rotating wheel. Beyond a certain distance 'd', I_{CC} ceases to vary between 7 and 14 mA and remains at a constant value of 7 mA. The KMI10 is optimized to deliver a stable digital output signal within a large sensing distance range and to have a sufficiently large switching hysteresis to avoid unwanted signals due to vibrations (see Section "Switching hysteresis").

The magnetoresistive effect is temperature dependent but the signal-conditioning IC largely compensates this. The residual effect on the maximum distance 'd' is shown in Fig.9.

The movement of the ferromagnetic gear wheel in the magnetic field induces eddy currents in the magnetoresistive sensor. These generate an offset voltage in the KMI10's output which linearly increases with the rotational speed. For the digital output signal to be unaffected, the maximum sensing distance is slightly shorter at higher frequencies (see Fig.9).

The magnetic field variation caused by the movement of the wheel's teeth depends on the structure of the teeth themselves. While normal and large teeth will be 'seen' very clearly by the KMI10 a smooth wheel will generate no field modulations. The variation of the maximum distance 'd' versus gear wheel module is shown in Fig.10.

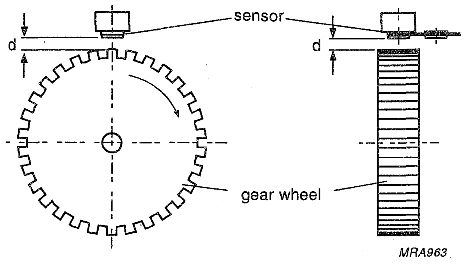
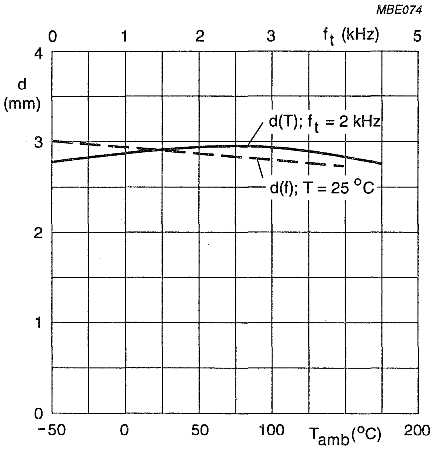


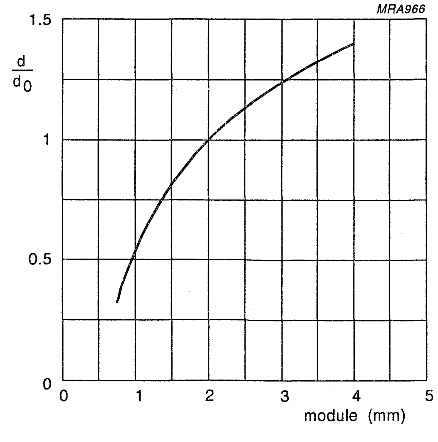
Fig.8 Sensor positioning.



The wheel's module m (in mm) = the pitch diameter of the wheel (in mm) divided by the number of the teeth: the wheel's tooth pitch (in mm) = π × m.

V_{CC} = 12 V; m = 2 mm.

Fig.9 Maximum sensing distance of the KM10/1 as a function of temperature and tooth wheel frequency.



d_0 = distance at m = 2 mm.

Fig.10 Normalized maximum sensing distance as a function of gear wheel module.

Switching hysteresis

To prevent unexpected and/or unwanted switching behaviour of the KMI10 due to mechanical vibrations (of the sensor or the gear wheel) or circuit oscillations at low rotational speeds, the signal-conditioning circuitry contains a switching hysteresis. This has a significant influence on the measuring properties of the sensor and a trade-off has been made between hysteresis and sensing distance. A large switching hysteresis ensures insensitivity to vibrations but limits the distance 'd' to short values. On the other hand, a small switching hysteresis enables a longer distance but implies a higher sensitivity to vibrations. As the switching hysteresis is very sensitive to gear wheel structure and sensing distance, these have to be carefully defined. For the KMI10/1 the maximum distance 'd' is always >2.5 mm and is typically 2.9 mm. For the KMI10/4 the maximum distance 'd' is >2.0 mm and is typically 2.3 mm (m = 2 mm).

Figure 12 shows how the switching hysteresis was measured mechanically and gives the test results as a function of sensing distance. In terms of linear movement of a gear tooth, hysteresis can be restated as follows: for a gear wheel with m = 2 mm and a sensor with d = 1.5 mm the hysteresis corresponds to a linear gear tooth movement of 0.3 mm. If the gear wheel diameter is 100 mm this hysteresis is equivalent to 0.32° of rotational distance. For other gear wheels the mechanical effects stemming from the switching hysteresis will be correspondingly different.

Temperature effects on the switching hysteresis due to changes in sensitivity or magnetic field strength are compensated in the IC. Thus the switching behaviour of the KMI10 is consistently stable across the whole temperature range.

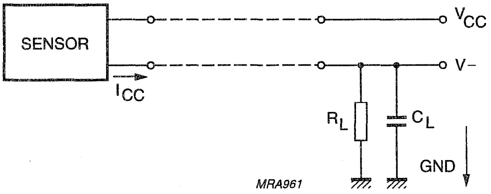


Fig.11 Test/application circuit for the KMI10.

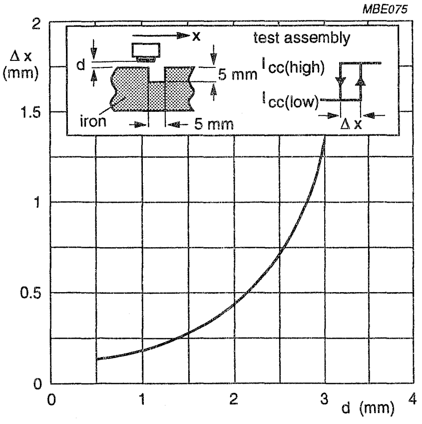


Fig.12 Mechanically measured hysteresis 'Δx' of the KMI10 as a function of sensing distance 'd' for the test assembly shown.

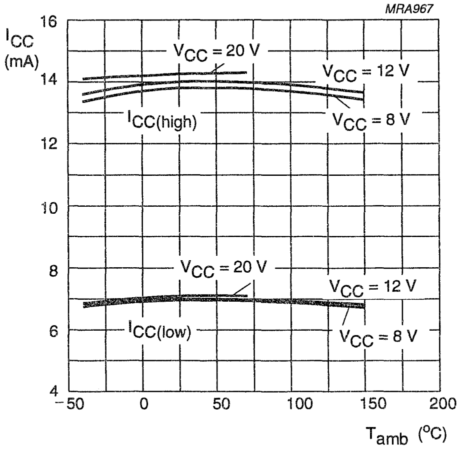
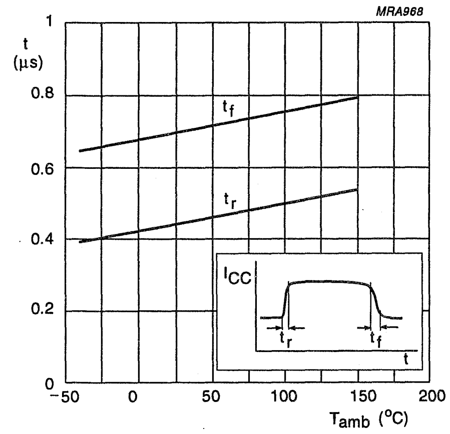


Fig.13 Output current 'I_{CC}' as a function of ambient temperature 'T_{amb}' for various supply voltages 'V_{CC}'.

Output signal

Figure 11 shows a test/application circuit for the KMI10 (an alternative circuit is shown in Fig.15). The load resistor R_L has a specified value of 115 Ω but this can be varied provided the influence on the minimum supply voltage V_{CC} is taken into account. The output voltage V– corresponding to I_{CC} = 7 or 14 mA is about 0.8 to 1.6 V. Figure 13 shows the typical influence of supply voltage, V_{CC} and ambient temperature T_{amb}, on the current levels. The output signal's switching times (10 to 90 % definition) depend on the value of C_L introduced for noise and interference reduction. Its capacitance should be adapted to specific application requirements. Figure 14 shows the rise and fall times of the output signal for C_L = 100 pF as a function of ambient temperature.



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

Fig.14 Switching times 't_r and t_f' as functions of ambient temperature 'T_{amb}'.

EMC

Figure 15 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.

Tests for electrostatic discharge (ESD) were conducted in line with *"IEC 801-2"* to demonstrate the KMI10/1'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
Test pulse 1	V_{LD}	−100	–	t_d = 2 ms
Test pulse 2	V_{LD}	–	100	t_d = 0.2 ms
Test pulse 3a	V_{LD}	−150	–	t_d = 0.1 μs
Test pulse 3b	V_{LD}	–	100	t_d = 0.1 μs
Test pulse 4	V_{LD}	−7	–	t_d = 130 ms
Test pulse 5	V_{LD}	–	120	t_d = 400 ms

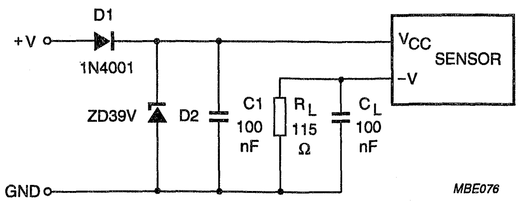


Fig.15 Test/application circuit for the KMI10.

Mounting

Figure 8 shows how the KMI10 should be mounted for measuring the rotational speed of a ferrous gear wheel. The sensor position is important since the speed sensing takes place in one direction only (along the y-axis, in both directions).

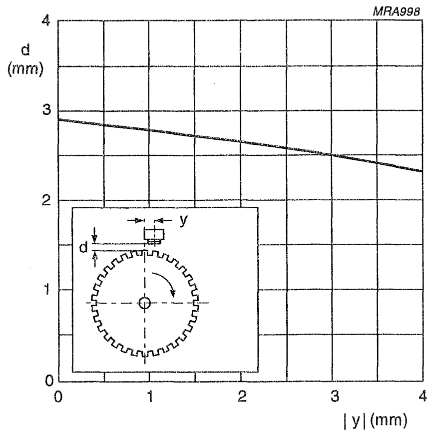
When mounting the KMI10 there are two factors shown in Figs 16 and 17 that may affect performance:

- The angle Θ between the symmetry axes of sensor and the wheel (in the y-z plane)
- The horizontal shift 'y' relative to the optimum sensor position.

These must be minimized. Recommended tolerances for optimum conditions are $|\Theta| \leq 1°$ and $|y| \leq 0.5$ mm.

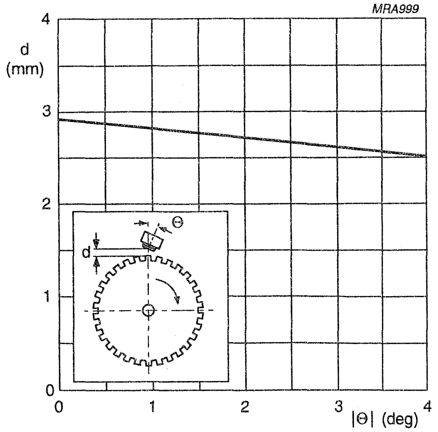
A shift in position in the x-direction is not critical to the KMI10's performance. The magnet's field component in the x-direction means that an x-shift has a non-symmetrical behaviour (see Fig.18).

A tilt in the x-z plane has a negligible influence on the optimum sensing distance for angles <4°.



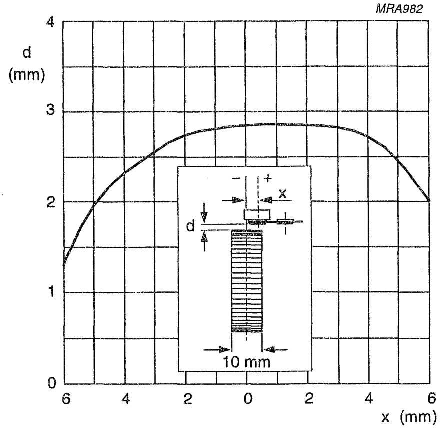
V_{CC} = 12 V; f = 2 kHz; m = 2 mm; pitch diameter = 100 mm.

Fig.16 Influence of position tolerance '| y |' on maximum sensing distance 'd'.



V_{CC} = 12 V; f = 2 kHz; m = 2 mm.

Fig.17 Influence of angular tolerance '|Θ|' on maximum sensing distance 'd'.



V_{CC} = 12 V; f = 2 kHz; m = 2 mm.

Fig.18 Influence of position tolerance 'x' on maximum sensing distance 'd'.

Encapsulation

When designing an encapsulation for the KMI10 sensors, the following should be noted:

- Both the KMI10/1 and KMI10/4 can be injection moulded. Contacting and intermittent problems, as are occasionally observed with inductive sensors, do not occur.
- The encapsulated material should be non-magnetic.
- The part of the encapsulation directly in front of the magnetoresistive sensor element should be as thin as possible to operate the KMI10/X at the longest possible distance from the object to be measured.

Applications and specifications

Although the KMI10/X was developed for wheel speed measurement, it can also be used for detecting reference marks, currents and proximity switching. Information on these applications is available on request.

The main characteristics for the KMI10/1 and KMI10/4 are given in Table 2.

Table 2 Main characteristics

SYMBOL	DESCRIPTION	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{CC}	supply voltage:					
	KMI10/1	$T_{amb} \leq 60° C$	7.5	–	20	V
	KMI10/4	$T_{amb} \leq 150° C$	7.5	–	16	V
d	sensing distance:	m = 2 for wheel module				
	KMI10/1		0	–	2.9	mm
	KMI10/4		0	–	2.3	mm
f_t	tooth wheel frequency		0	–	25000	Hz
$I_{CC(high)}$	output current high		–	14	–	mA
$I_{CC(low)}$	output current low		–	7	–	mA
T_{amb}	operating ambient temperature		−40	–	150	°C
T_{peak}	peak temperature		–	–	190	°C

KM110BH/1 MODULE SERIES FOR MAGNETORESISTIVE SENSING OF ROTATION AND REFERENCE MARK DETECTION

The KM110BH/1 series consists of four hybrid modules for measuring rotational speed or detecting reference marks. In contrast to the KMI10 series, the KM110BH/1X modules have a digital voltage output. They can operate:

- Quasi-statically (0 Hz frequency)
- At large distance from the objects to be measured
- From −40 to +125 °C (190 °C peak)
- Without external magnets.

For new design-ins it is recommended to consider the integrated sensors KMI10/1 and KMI10/4 instead of the KM110BH/11 and KM110BH/13 modules. When very large measuring distances are required (up to 3.5. mm) the KM110 BH /12 and KM110BH/14 are the obvious choices.

Sensor module

The module is based on thick-film technology using a ceramic substrate. Two versions are available, with circuitry optimized for specific application areas:

- A quasi-static module for slow movement sensing (i.e. speed measurements down to zero)
- A module with a high-pass filter for use at large measuring distances and speeds above zero.

The position of the sensor can also be selected, as the module is supplied with the sensor either radially or tangentially arranged. Figure 20 shows both mechanical arrangements, set to measure the rotation of a toothed wheel. The data for this set-up and the type range are given in Table 3. Table 4 gives the main characteristics of the module.

The circuit and sensor position options enable the module to be used in many applications, e.g.:

- Incremental measurement can be performed easily and at low cost
- The module can be used as the first stage when customizing speed sensing equipment.

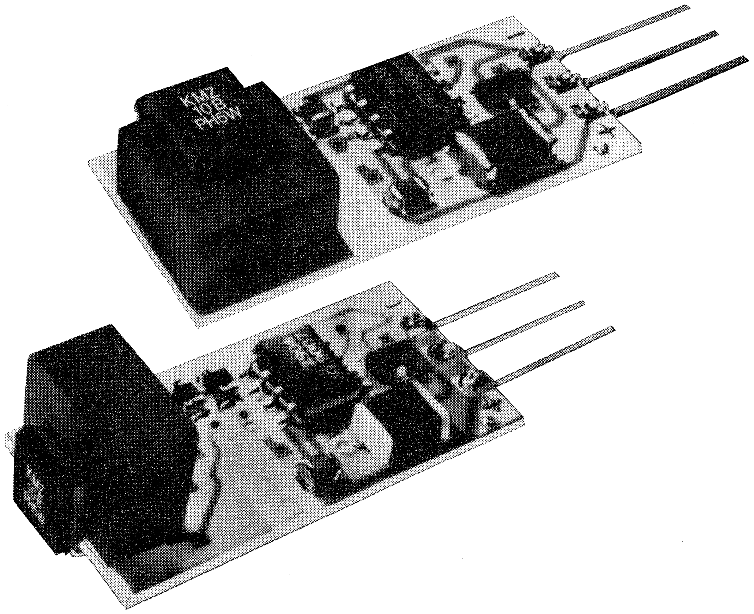


Fig.19 The KM110BH/1 series.

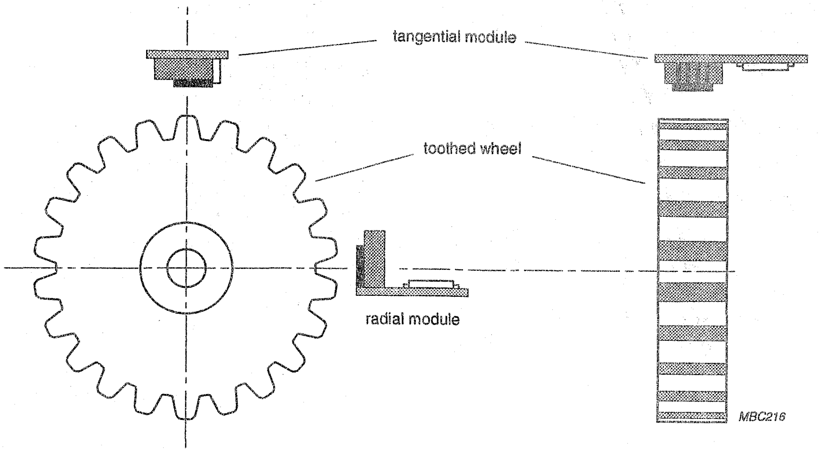


Fig.20 Radial and tangential versions of the module, arranged for rotation measurement of a toothed wheel.

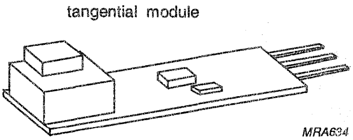


Fig.21 Tangential module (KM110BH/11 and KM110BH/12).

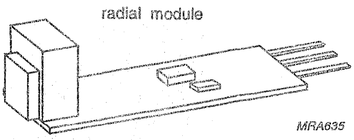


Fig.22 Radial module (KM110BH/13 and KM110BH/14).

Table 3 Philips' magnetoresistive sensor modules

SYMBOL	PARAMETER	KM110BH/11(1)(3)	KM110BH/12(2)(3)	KM110BH/13(1)(4)	KM110BH/14(2)(4)	UNIT
f_t	tooth wheel frequency	0 to 3000	1 to 3000	0 to 3000	1 to 3000	Hz
d	maximum sensing distance to tooth wheel	2.5	3.5	2.5	3.5	mm

Notes

1. Without filter.
2. With filter.
3. See Fig.21.
4. See Fig.22.

Table 4 Main characteristics

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{CC}	supply voltage	note 1	4	5	10	V
$V_{O(rel)}$	relative digital output signal		0	–	5	V
T_{oper}	operating temperature		–40	–	+125(2)	°C
d	measuring distance	without filter; note 3	0	–	2.5	mm
		with filter; note 3	0	–	3.5	mm
f_t	tooth wheel frequency	without filter	0	–	3000	Hz
		with filter	1	–	3000	Hz

Notes

1. Maximum ripple for filter version is 50 mV.
2. During 500 hours maximum 150 °C.
3. Gear wheel dimensions: diameter = 104 mm; width = 10 mm; 50 teeth; m = 2.05; material: 9SMnPb28k.

Module circuit

Figure 23 shows the sensor module circuit. The circuit amplifies the sensor signal (IC1) and then digitizes it using a comparator (IC2) to provide the digital output signal (V_O). For good switching performance (especially at low frequencies) and to suppress small noise signals, the comparator has a built-in switching hysteresis. The hysteresis has a defined temperature drift to compensate the temperature dependent sensor signal.

In the module for quasi-static operation, the bridge connectors BR1 and BR2 are open. In the version that uses the filter, these connectors are closed.

The recommended supply is 5 V, but values in the range of ≈4 to ≈10 V are also possible. If the filter versions of the modules are used (KM110BH/12 or KM110BH/14), the ripple on the supply voltage should not exceed 50 mV; this prevents unwanted switching of the comparator. The output can withstand short-circuiting to the two supply levels. Normally, the external load should be ≥100 kΩ, but with an additional external pull-up resistor, a lower value may be used. The values of internal resistors R18 and R19 are 10 kΩ and 100 Ω respectively. Since a protection diode is not provided on the substrate, care should be taken to ensure the correct supply polarity.

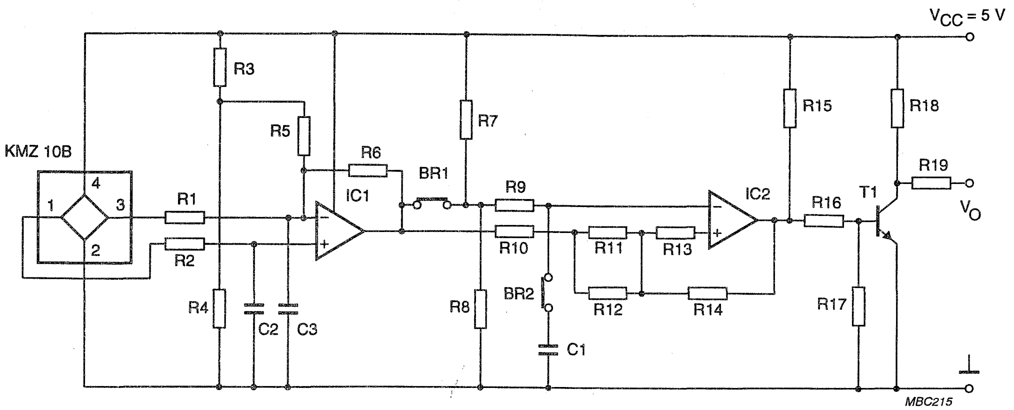


Fig.23 Sensor module circuit.

Mounting

The module's magnetoresistive sensor operates as a magnetic Wheatstone bridge, measuring non-symmetrical magnetic conditions such as metal teeth or pins in front of the sensor. Figure 20 shows how the module should be mounted for measuring the rotation of a ferrous pulse wheel. The sensor position is important, since sensing is not symmetrical around the module's symmetrical axis.

When mounting the module, there are two factors, shown in Fig.24, that may affect the performance of the module:

- The angle 'γ' between the symmetry axes of the sensor module and the wheel
- The vertical shift 'y' relative to the optimum sensor position.

These two factors must be minimized, especially when using the modules without filter (types KM110BH/11 and KM110BH/13). Recommended tolerances for normal conditions are: $\gamma < 1°$, $y < 0.5$ mm.

The sensor's symmetry axis corresponds to that of the module's magnet (the crystal is not mounted in the centre of the sensor encapsulation).

Module encapsulation

When designing a module encapsulation, the following considerations should be borne in mind:

- The encapsulation material should be non-magnetic
- To operate the module at large distance from the object to be measured, the part of the encapsulation directly in front of the sensor element should be as thin as possible
- No components should be located near the sides of the module; 0.8 mm of substrate edge is available to allow the module to be securely mounted into grooves (see Figs 25 and 26)

When potting hybrid modules, it is strongly recommended to do this in two steps.

During the first step the module should be covered by an elastic layer This absorbs mechanical stress caused by varying expansion coefficients of the different materials used, as well as thermally generated stress. The following materials are suggested:

Dow Corning, silicone coating, type HIPEC Q1-9224

Dexter-Hysol, semiconductor encapsulant, type 4323.

During the second step a potting material has to be used, that supplies the necessary mechanical stability needed for successful mounting; for example:

Grace-Emerson, Stycast 2651-40.

Temperature range

The front of the module (sensor and magnet) can withstand temperatures up to 190 °C provided the duration is limited to a few hours over the module's lifetime. The integrated circuit, however, should not operate in environments above 125 °C.

Performance

The maximum measuring distance depends upon the structure of the wheel and, for modules without filter, also on the accuracy of mounting. If the wheel structures differ greatly from the example shown, the range has to be found by measurement.

With high rotational speeds, eddy current signals are generated that reduce the performance of the modules without filter.

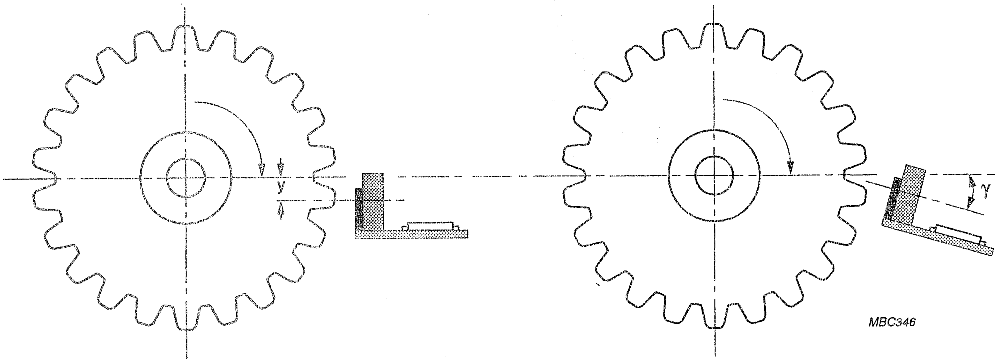
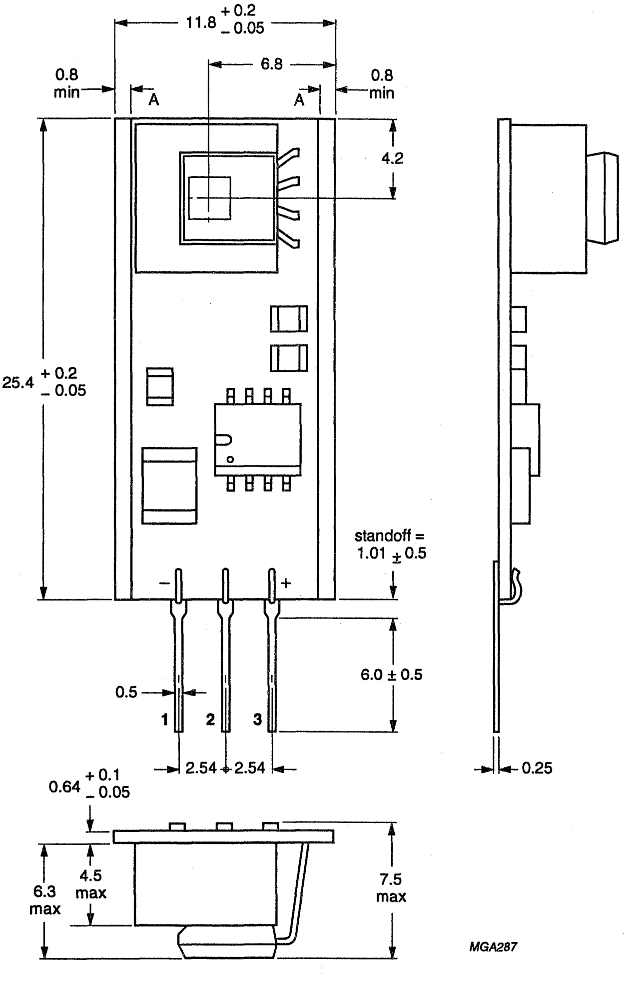
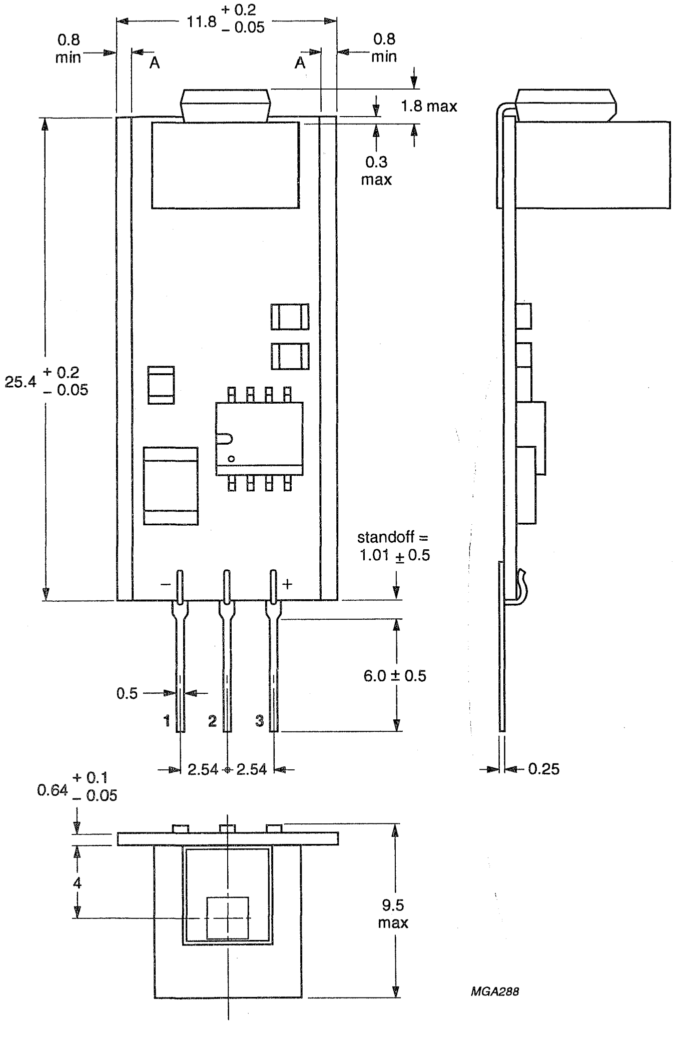


Fig.24 Sensor position tolerances.



Pin 1: ground
Pin 2: V_O
Pin 3: V_{CC}
Dimensions in mm.

Fig.25 Module dimensions: KM110BH/11 and KM110BH/12.



Pin 1: ground
Pin 2: V_O
Pin 3: V_{CC}
Dimensions in mm.

Fig.26 Module dimensions: KM110BH/13 and KM110BH/14.

THE KM110BH/31 MODULE FOR MAGNETORESISTIVE SENSING OF ROTATIONAL SPEED AND DIRECTION

Based around the KMZ10B magnetoresistive sensor, the KM110BH/3 series extends the successful KMI10 and KM110BH/1 families of sensor modules for contactless rotational speed sensing. In addition, the KM110BH/3 series uses a circuit which enables it to indicate **rotational direction**, as well as accurately measure rotational speeds. The KM110BH/3X sensors can operate:

From 2 Hz (10 Hz for the KM110BH/32) to 20 kHz at a large distance from the object to be measured.

From −40 to +125 °C (150 °C peak).

With a wide range of toothed wheels.

The sensors are available in two versions. The KM110BH/31 has a digital **voltage** output and the KM110BH/32 has a digital **current** output.

Direction indication with magnetoresistive sensors

Until recently, two magnetic sensors were needed to indicate the rotational direction of a toothed wheel. The technique required placing the sensors around the wheel with a specific distance between one another to ensure that the two sensor output signals were optimally phase-shifted by 90°. The distance, of course, varied with the module (m)[1] of the specific toothed wheel used. However, with filters to suppress offset signals, it was possible to vary the distance between the sensors and thus use different wheels.

The single-sensor technique used in the KM110BH/3X sensor is based on separate signal-processing for the sensor's two half-bridge signals. As the bridge geometry is fixed within the sensor chip, there is an optimum wheel module (of e.g. m = 0.8 mm for the KM110BH/31). Nevertheless it operates successfully using toothed wheels with a wide range of pitches. Although the stability of the two half bridges is reduced with non-optimal pitches, filtering compensates for this and allows the KM110BH/3X sensors to operate at long distances from the wheel. Without filtering, the circuit could indicate zero speed, and be capable of incremental counting, but the operating range would be limited.

Mounting

The sensor operates like a magnetic Wheatstone bridge, measuring non-symmetric magnetic conditions, as when teeth or pins move in front of the sensor. The KM110BH/31 can sense this movement in two possible directions (shown in Fig.27). The mounting position, therefore, is very important for accurate measurements. Two types of mounting error affect the KM110BH/31's performance:

- Allowing an angle between the sensor's symmetry axis (the centre line in Fig.27), and that of the toothed wheel
- Vertical shifting of the sensor away from the optimum position shown in Fig.27.

The sensor's symmetry axis corresponds with that of the built-in magnet: the chip is not mounted in the centre of the sensor encapsulation.

Circuit

Figure 28 shows a block diagram of the KM110BH/31 circuit with separate signal processing for each half of the bridge. The digital output signals (V_{O1} and V_{O2}) are connected directly to the output pins. The circuit design enables evaluation of the output signals by a microcontroller. Figures 30 and 31 show that both output signals vary with rotational direction. If desired, the two output signals may be connected to a flip-flop for a direct indication of rotation (see Fig.29).

Since a protection diode is not included in the KM110BH/31, care should be taken to ensure the correct supply polarity (V_{CC}). The recommended supply is 5 V, but operation is possible with supplies from 4 to 10 V. The supply ripple should not exceed 40 mV to prevent unwanted switching of the comparator.

Both output pins can withstand short-circuiting to the supply lead (V_{CC}). Normally the external load should be ≥100 kΩ, but with an additional external pull-up resistor, this value can be reduced. The output resistance is 100 Ω when the signal is LOW and 10 kΩ when HIGH.

---

(1) $m = \frac{\text{pitch diameter}}{\text{number of teeth}}$; $\text{pitch} = m \times \pi$

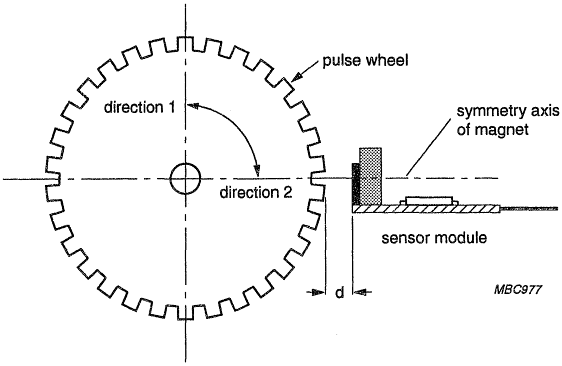


Fig.27 Optimum operating position.

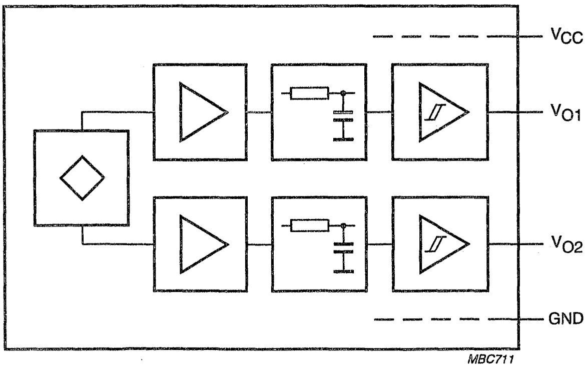


Fig.28 Block diagram of module circuit.

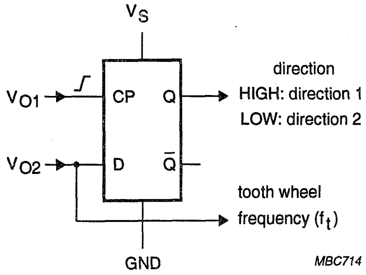


Fig.29 Circuit for rotation indication.

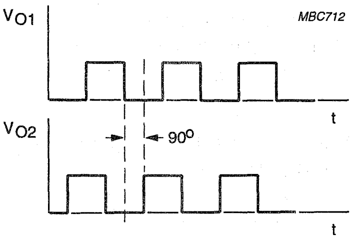


Fig.30 Output signals (direction 1).

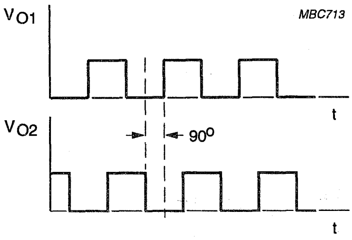


Fig.31 Output signals (direction 2).

Encapsulation

When designing a module encapsulation, the following considerations should be borne in mind:

- The encapsulation material should be non-magnetic
- To operate the module at large distance from the object to be measured, the part of the encapsulation directly in front of the sensor element should be as thin as possible
- No components should be located near the sides of the module; 0.8 mm of substrate edge is available to allow the module to be securely mounted into grooves (see Figs 32 and 33).

When potting hybrid modules, it is strongly recommended to do this in two steps.

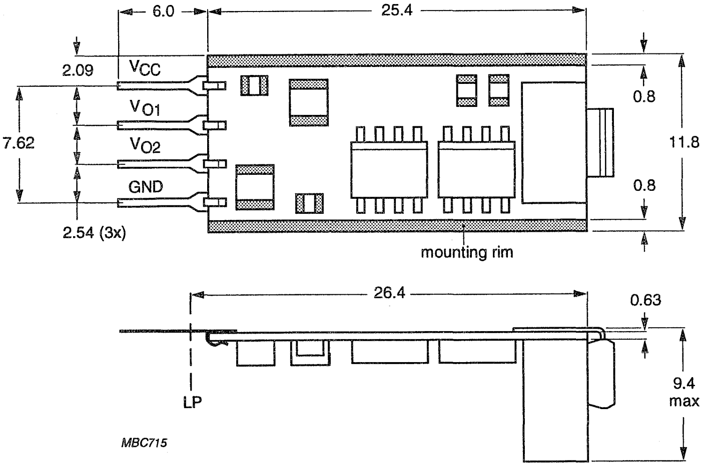
During the first step the module should be covered by an elastic layer. This absorbs mechanical stress caused by varying expansion coefficients of the different materials used, as well as thermally generated stress. The following materials are suggested:

Dow Corning, silicone coating, type HIPEC Q1-9224

Dexter-Hysol, semiconductor encapsulant, type 4323.

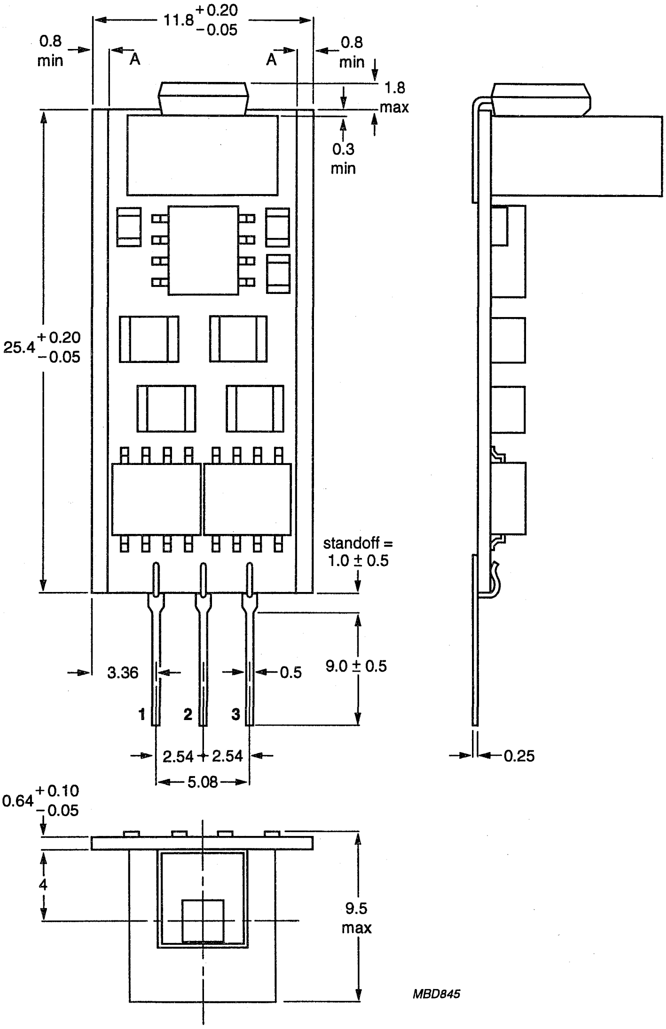
During the second step a potting material has to be used that supplies the necessary mechanical stability needed for successful mounting; for example:

Grace-Emerson, Stycast 2651-40.



Dimensions in mm.

Fig.32 Module dimensions: KM110BH/31.



Pin 1: ground
Pin 2: V_{CC1}
Pin 3: V_{CC2}
Dimensions in mm.

Fig.33 Module dimensions: KM110BH/32.

Temperature range

The front of the KM110BH/3X sensors (i.e. sensor and magnet) can withstand temperatures up to 150 °C provided the duration is limited to a few hours over the module's lifetime. The integrated circuits, however, should not operate in environments above 125 °C.

Performance

The distance range depends on the structure of the toothed wheel and also on the accuracy of mounting. The latter may influence the output signal form and cause an effective phase shift if the measuring distance is very small.

If different wheel modules (m) are used form the range given in Fig.34, the measuring distance range has to be found by measurement.

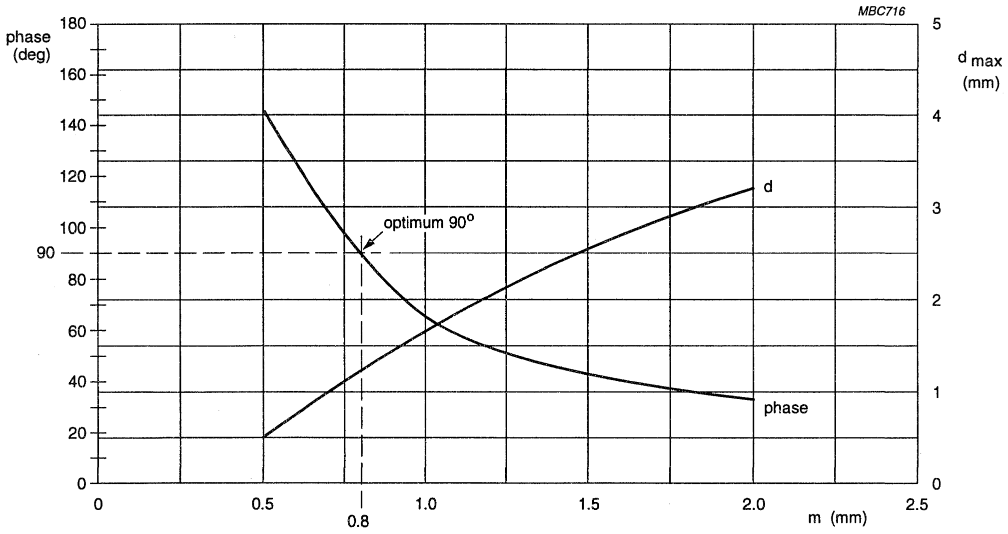


Fig.34 Effect of different toothed wheel structures on the KM110BH/31.

Table 5 Characteristics of the KM110BH/31 and KM110BH/32

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	supply voltage (note 1):				
	KM110BH/31	4	5	10	V
	KM110BH/32	7.5	–	16	V
V_{O1}; V_{O2}	digital output signals (note 2):				
	KM110BH/31 (low)	–	–	0.4	V
	KM110BH/31 (high)	4.3	–	–	V
I_{O1}; I_{O2}	output signals:				
	KM110BH/32 (low)	–	7	–	mA
	KM110BH/32 (high)	–	14	–	mA
T_{oper}	operating temperature:				
	KM110BH/31	–40	–	+125	°C
	KM110BH/32	–40	–	+125	°C
T_{peak}	peak temperature:				
	KM110BH/31	–	150	–	°C
	KM110BH/32	–	150	–	°C
d	measuring distance (see Fig.34):				
	KM110BH/31	0	–	3	mm
	KM110BH/32	0	–	3	mm
f_t	tooth wheel frequency:				
	KM110BH/31	2	–	20000	Hz
	KM110BH/32	10	–	20000	Hz
R_L	external load resistor:				
	KM110BH/31	100	–	–	kΩ
	KM110BH/32	–	120	–	Ω

Notes

1. Maximum ripple is 40 mV.
2. The peak voltage is relative to V_{CC}.

Integrated rotational speed sensor KMI10/1

FEATURES

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

DESCRIPTION

The KMI10/1 sensor detects rotational speed of ferrous gear wheels and reference marks (note 1). The sensor consists of a magnetoresistive sensor element, a signal conditioning IC 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.

Note 1

The sensor contains a customized IC. Passenger car Anti Blocking Systems (ABS) applications restricted, other applications free.

Caution

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

PINNING

PIN	DESCRIPTION
1	V_{CC}
2	V–

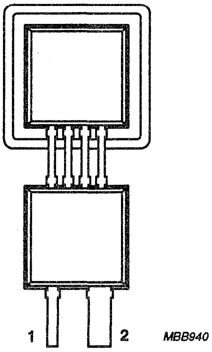


Fig.1 Simplified outline.

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	operating frequency	0	–	25 000	Hz
T_{amb}	ambient operating temperature	–40	–	150	°C

LIMITING VALUES

In accordance with Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage	T_{amb} = –40 to 60 °C T_{amb} = –40 to 150 °C	7.5 7.5	20 16	V V
T_{stg}	storage temperature		–40	150	°C
T_{amb}	ambient operating temperature	note 1	–40	150	°C
T_{peak}	peak temperature	sensor front only, 3 x 1 h over lifetime	–	190	°C
T_{sld}	soldering temperature	$t \leq 10$ s	–	260	°C
	output short-circuit duration to GND		continuous, (note 2)		

Notes

1. The ambient operating temperature of the module can be extended up to +175 °C for a limited time. This will be monitored by environmental quality tests up to 100 h of operation at +175 °C under characteristic conditions.
2. With R_L = 115 Ω the device is continuously protected against wrong polarity of DC supply voltage (V_{CC}) to GND (see Fig.7).

CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 12 V; d = 2.1 mm; f = 2 kHz; test circuit: see Fig.7; R_L = 115 Ω; sensor position: see Fig.9; 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 16	5.6	7	8.4	mA
$I_{CC\ high}$	current output signal high	see Figs 6 and 16	11.2	14	16.8	mA
t_r	output signal rise time	see Fig.17; C_L = 100 pF; 10% to 90% value	–	0.5	–	µs
t_f	output signal fall time	see Fig.17; C_L = 100 pF; 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	operating frequency	for both rotation directions	0	–	25 000	Hz
d	sensing distance	see Fig.9 and note 1	0 to 2.5	0 to 2.9	–	mm
t_1/T	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.14).

FUNCTIONAL DESCRIPTION

The KMI10/1 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 KMI10/1 is sensitive to movement in 'y' direction in front of the sensor only (see Fig.2). The magnetoresistive sensor element signal is amplified, temperature compensated and given to a Schmitt trigger in the conditioning IC (Figs 4 and 5). The digital output signal level (Fig.6) is within the measuring range independent of the sensing distance (Fig.8). A current (2-wire) output signal enables safe sensor signal transport to the detecting circuit (Fig.7). The IC housing is deliberately separated from the sensor element housing to optimize the sensor behaviour at high temperatures.

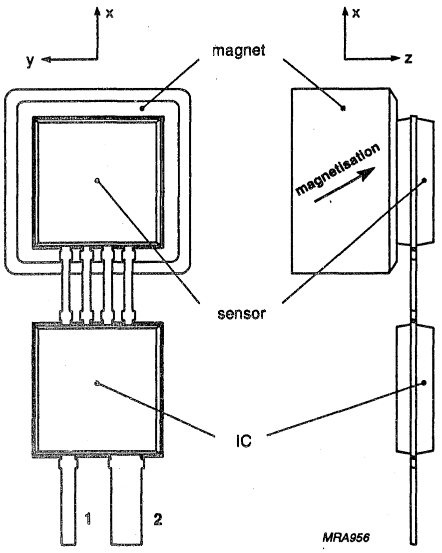


Fig.2 Component detail of the KMI10/1.

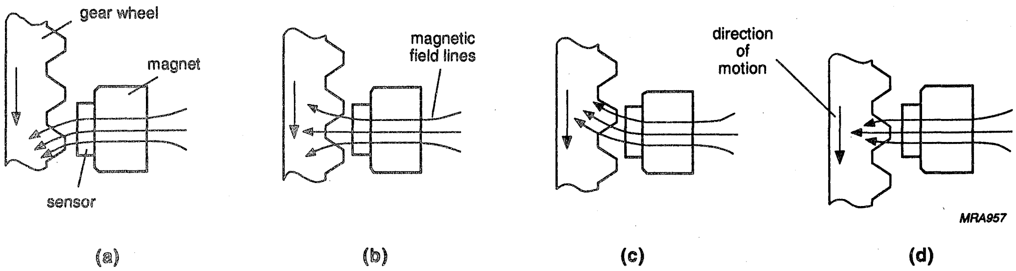


Fig.3 Functional principle of KMI10/1.

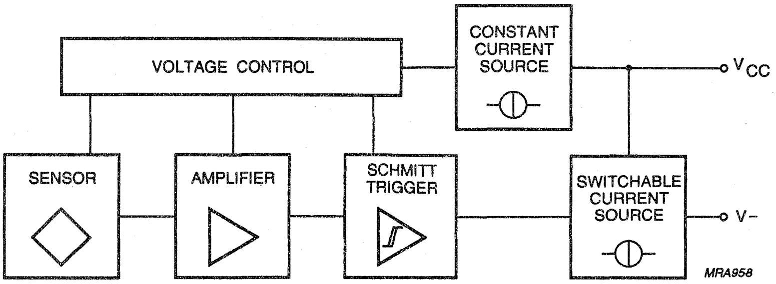


Fig.4 Block diagram 1.

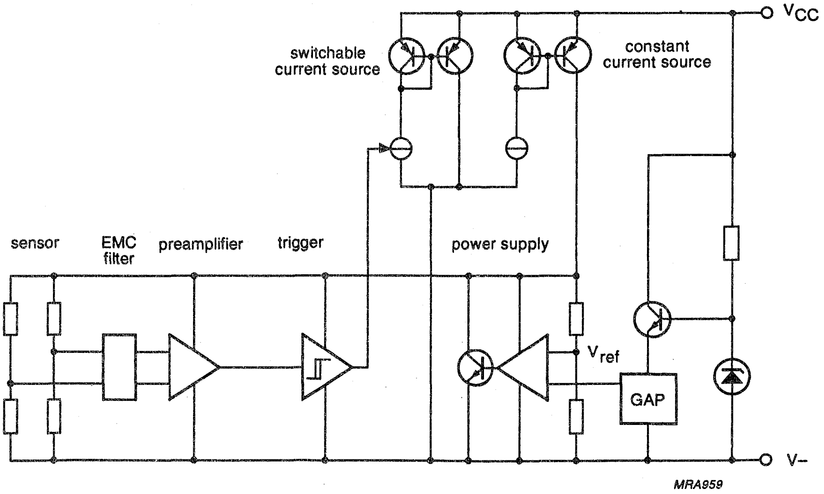


Fig.5 Block diagram 2.

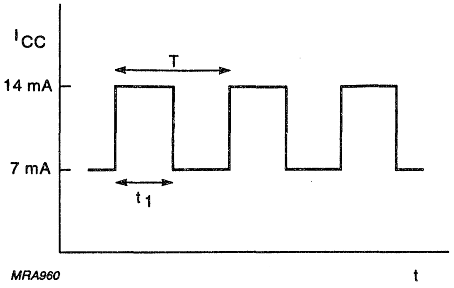


Fig.6 Output signal of KMI10/1.

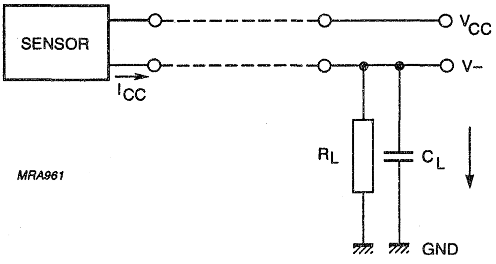
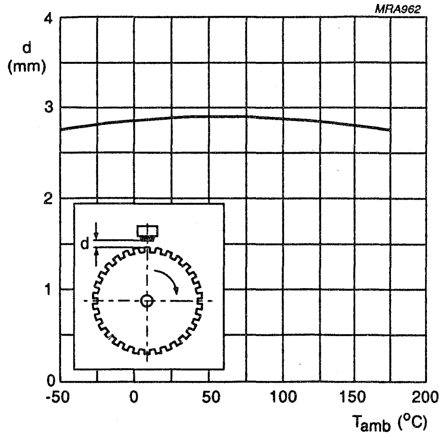


Fig.7 Test and application circuit.



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

Fig.8 Typical sensing distance.

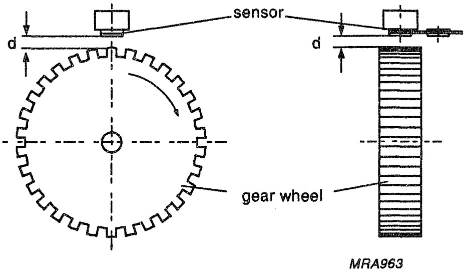


Fig.9 Sensor position.

Mounting conditions

The recommended sensor position in front of a gear wheel is shown in Fig.9. The distance 'd' is measured between the sensor front and the tip of a gear wheel tooth. The KMI10/1 senses ferrous indicators like gear wheels in ±'y' direction (Fig.2) only (no rotational symmetry of the sensor). 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.14). The influence of gear wheel module on the sensing distance is shown in Fig.15.

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 x 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 x CP.

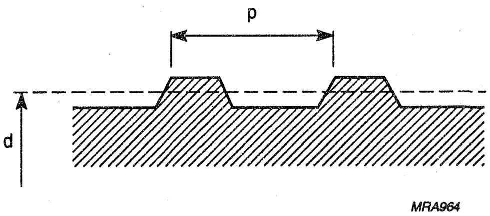
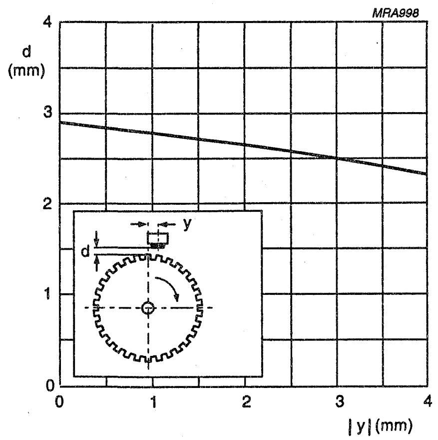
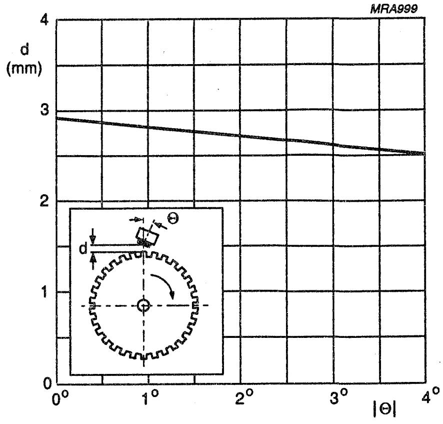


Fig.10 Gear wheel dimensions.



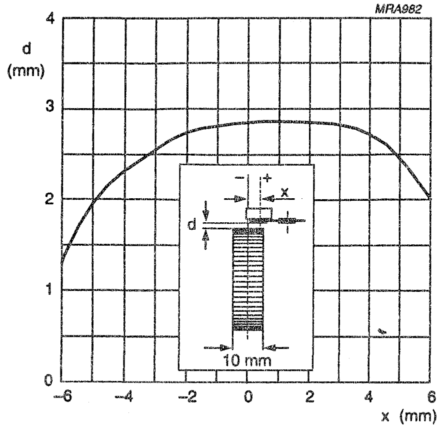
V_{CC} = 12 V; f = 2 kHz; module = 2 mm; pitch diameter = 100 mm.

Fig.11 Position tolerance 'y'.



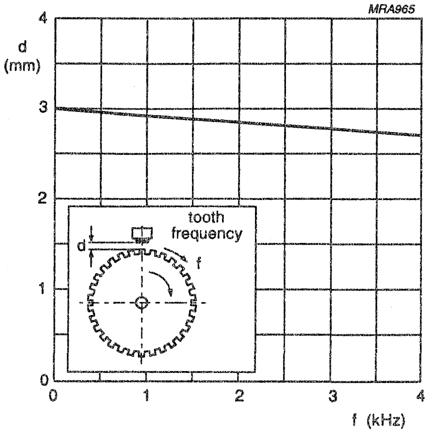
V_{CC} = 12 V; f = 2 kHz; module = 2 mm.

Fig.12 Position tolerance θ.



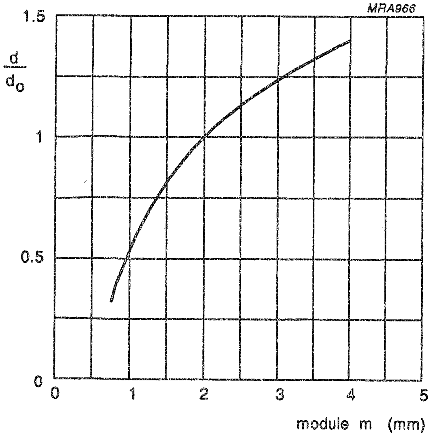
V_{CC} = 12 V; f = 2 kHz; module = 2 mm.

Fig.13 Position tolerance x.



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

Fig.14 Tooth frequency dependence.



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

Fig.15 Normalized maximum sensing distance as a function of gear wheel module.

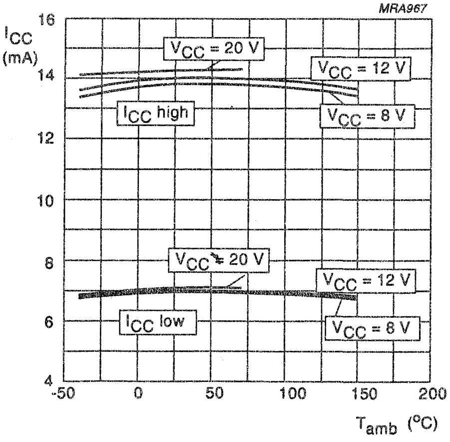
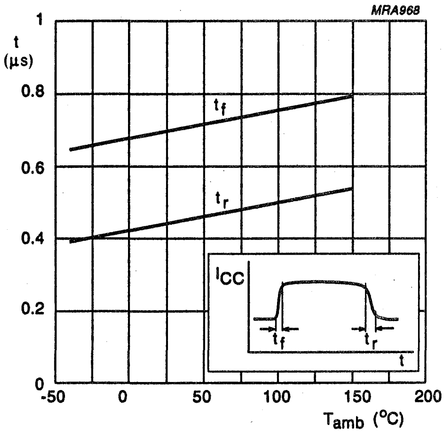


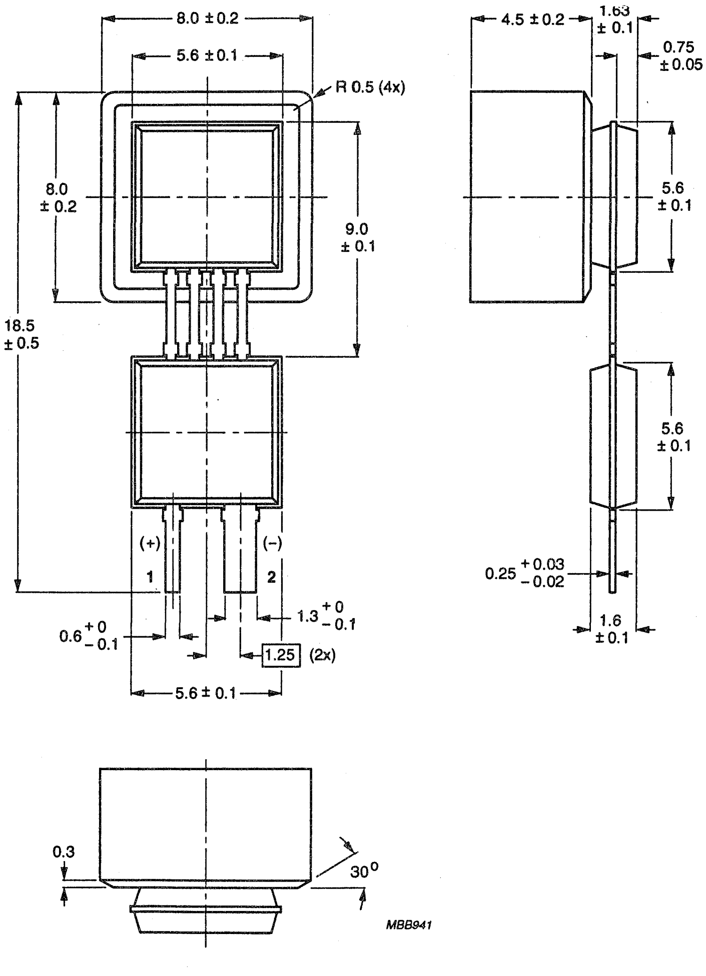
Fig.16 Output current levels.



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

Fig.17 Switching time.

PACKAGE OUTLINE



Dimensions in mm.

Fig.18 KMI10/1.

Rotational speed sensor KMI10/4

FEATURES

- Digital current output signal
- Zero speed capability
- Wide air gap
- Wide temperature range
- Vibration insensitive
- EMC resistant.

DESCRIPTION

The KMI10/4 sensor detects rotational speed of ferrous gear wheels and reference marks(1). The sensor comprises a magnetoresistive sensor element, a signal conditioning circuit in bipolar technology and a ferrite magnet. The frequency of the digital current output signal is proportional to the rotational speed of a gear wheel.

PINNING

PIN	DESCRIPTION
1	V_{CC}
2	V–

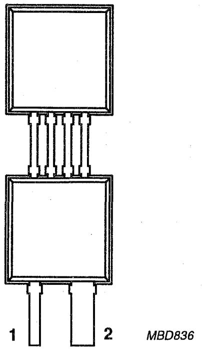


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	12	–	V
T_{amb}	operating ambient temperature	–40	–	+150	°C
$I_{CC(low)}$	output current low	–	7	–	mA
$I_{CC(high)}$	output current high	–	14	–	mA
$f_{t(oper)}$	operating tooth frequency	0	–	25000	Hz
d	sensing distance	0 to 2.0	0 to 2.3	–	mm

---

(1) The sensor contains a customized integrated circuit. Automotive Anti Blocking Systems (ABS) applications are restricted, other applications are free.

FUNCTIONAL DESCRIPTION

The KMI10/4 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 KMI10/4 is sensitive to movement in ‘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 IC (see Figs 4 and 5). The digital output signal (see Fig.6) is at a fixed level independent of the sensing distance. A (2-wire) output current ensures safe sensor signal transport to the detecting circuit (see Fig.7). The IC housing is deliberately separated from the sensor element housing to optimize the sensor behaviour at high temperatures.

The strength of the magnetic field caused by the Ferroxdure 100 magnet in the different sensor directions, measured at the centre of the magnetoresistive bridge, is typically: H_x = 7 kA/m (auxiliary field) and H_z = 17 kA/m (perpendicular to the sensor surface). H_y is zero due to the trimming process.

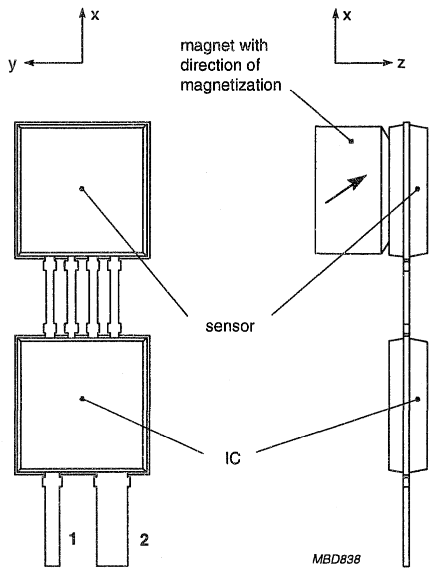
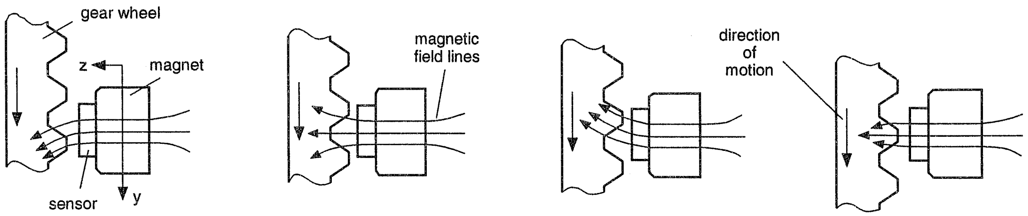


Fig.2 Component detail of the KMI10/4.



(a) (b) (c) (d)

Fig.3 Functional principle.

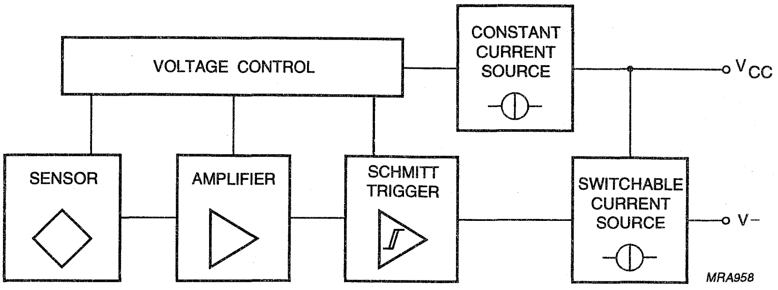


Fig.4 Block diagram.

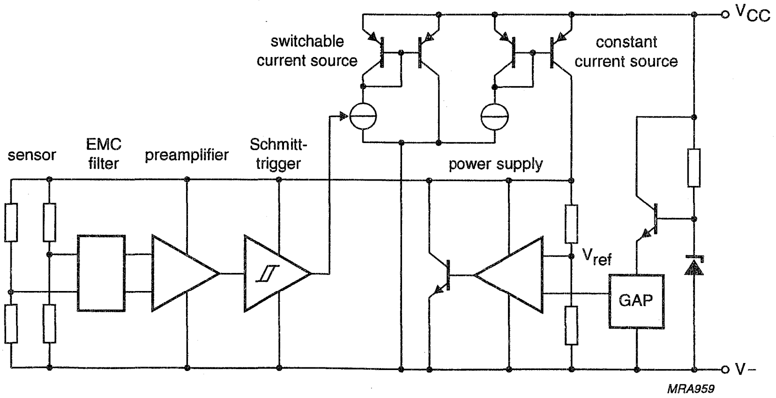


Fig.5 Simplified circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage	T_{amb} = –40 to +60 °C	7.5	20	V
		T_{amb} = –40 to +150 °C	7.5	16	V
T_{stg}	storage temperature		–40	+150	°C
T_{amb}	operating ambient temperature		–40	+150(1)	°C
T_{peak}	peak temperature	sensor front only, 3 × 1 h over lifetime	–	190	°C
T_{sld}	soldering temperature	$t \leq 10$ s	–	260	°C
	output short-circuit duration to GND		continuous, note 2		

Notes

1. The ambient operating temperature range of the module can be extended up to +175 °C for a limited time.
2. With $R_L = 115\ \Omega$, the device is continuously protected against wrong polarity of DC supply voltage V_{CC} to GND (see Fig.7).

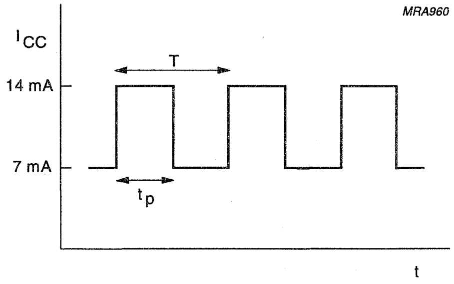
CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 12 V; d = 1.5 mm; f = 2 kHz; test circuit: see Fig.7; R_L = 115 W; test arrangement: see Fig.15; gear wheel: module 2 mm; material 1.0715; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$I_{CC(low)}$	output current low	see Figs 6 and 8	5.6	7	8.4	mA
$I_{CC(high)}$	output current high	see Figs 6 and 8	11.2	14	16.8	mA
t_r	output current rise time	C_L = 100 pF; see Fig.9; 10% to 90% value	–	0.5	–	µs
t_f	output current 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
$f_{t(oper)}$	operating tooth frequency	for both rotation directions	0	–	25000	Hz
δ	duty cycle	see Fig.6	20	50	80	%
d	sensing distance	see Fig.15; note 1	0 to 2.0	0 to 2.3	–	mm

Note

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



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

Fig.6 Output signal as a function of time.

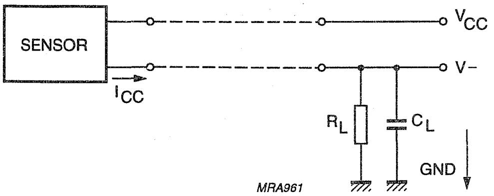


Fig.7 Test and application circuit.

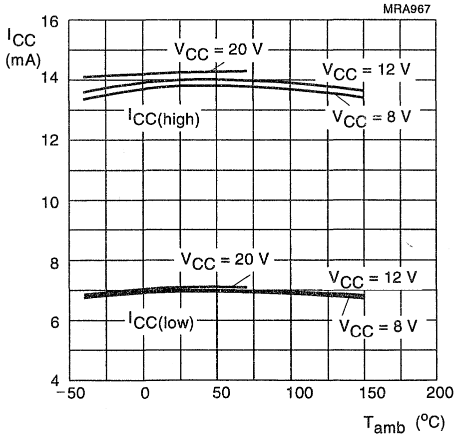


Fig.8 Output current levels as functions of ambient temperature.

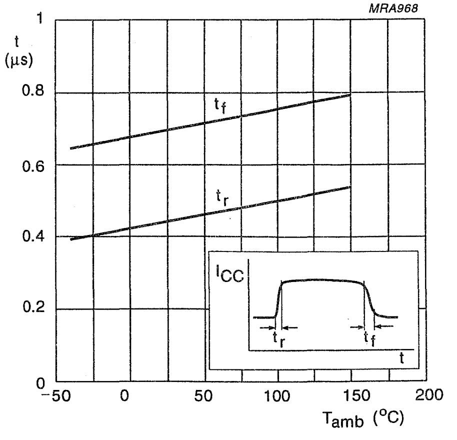


Fig.9 Output current switching times as functions of ambient temperature.

APPLICATION INFORMATION

Mounting conditions

The recommended sensor position in front of a gear wheel is shown in Fig.15. Distance 'd' is measured between the sensor front and the tip of a gear wheel tooth. The KMI10/4 senses ferrous indicators like gear wheels in ± 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

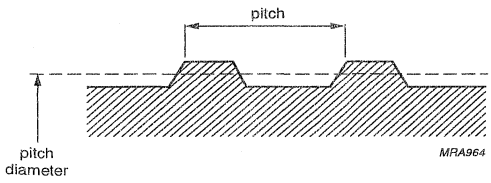
Due to eddy current effects the sensing distance depends on the tooth frequency (see Fig.17). The influence of gear wheel module on the sensing distance is shown in Fig.16.

Gear wheel dimensions

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

Note

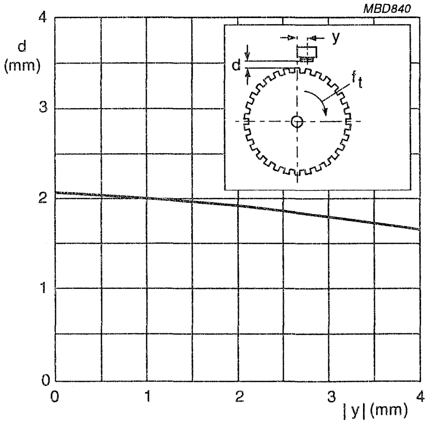
1. For conversion from ASA to DIN: m = 25.4 mm/DP; p = 25.4 mm × CP.



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

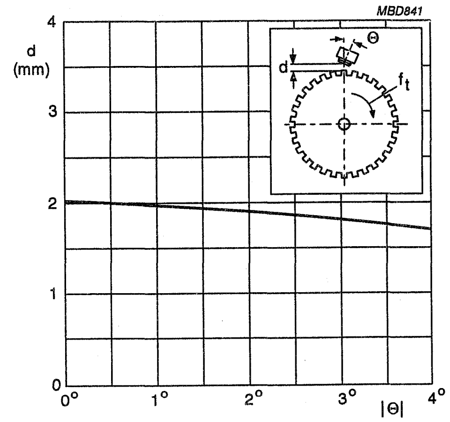
$$\text{pitch} = \text{module} \times \pi$$

Fig.10 Gear wheel definitions.



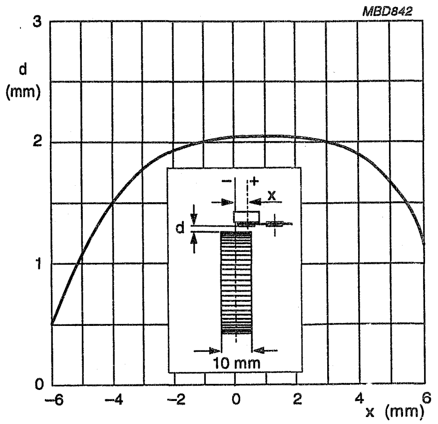
V_{CC} = 12 V; f_t = 2 kHz; module = 2 mm; pitch diameter = 100 mm.

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



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

Fig.12 Sensing distance as a function of positional tolerance.



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.

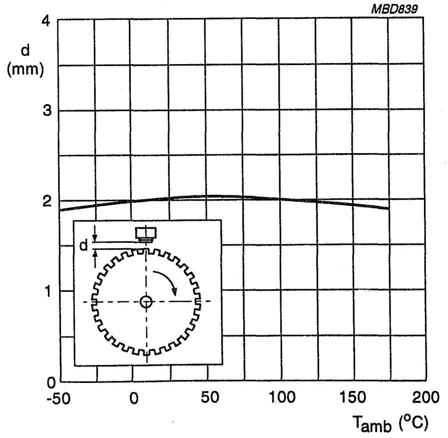


Fig.14 Typical sensing distance as a function of ambient temperature.

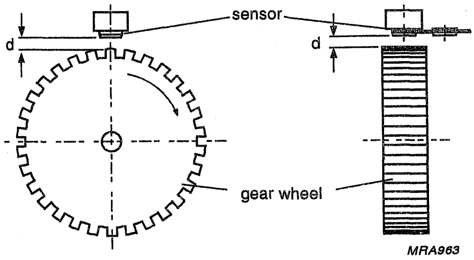
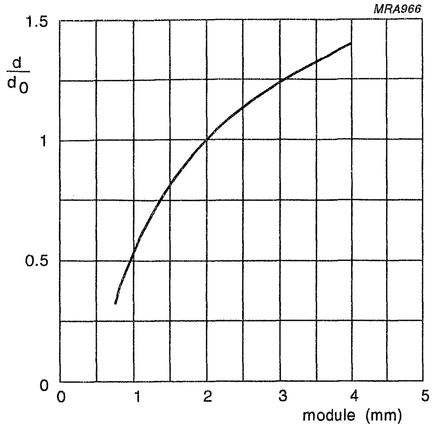
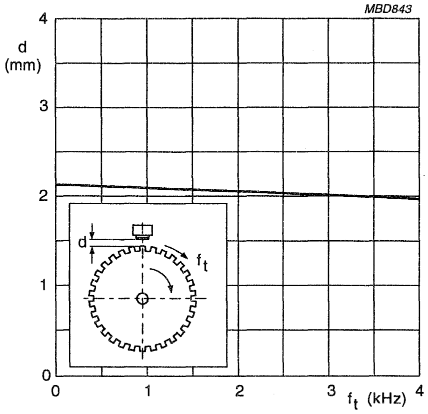


Fig.15 Sensor positioning.



d_0 = sensing distance for gear wheel with module = 2 mm.

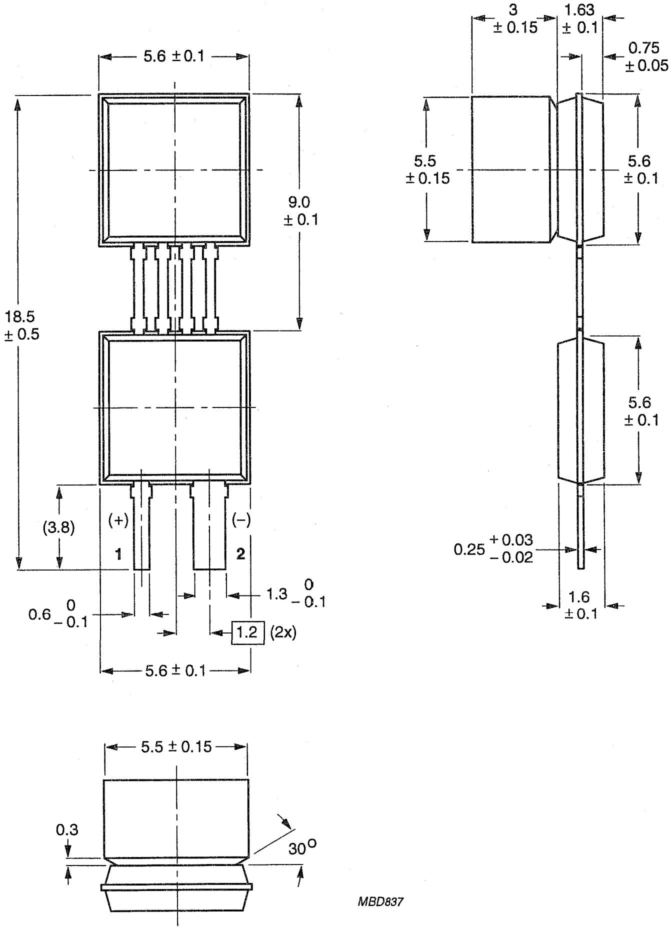
Fig.16 Normalized maximum sensing distance as a function of a gear wheel module.



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

Fig.17 Sensing distance as a function of tooth frequency.

PACKAGE OUTLINE



Dimensions in mm.

Fig.18 Outline of KMI10/4.

Revolution sensors KM110BH/11; KM110BH/12

DESCRIPTION

Sensor modules used for the detection of rotation and markings. The module is a combination of a magnetoresistive sensor, a permanent magnet and a signal conditioning circuit in hybrid technology. The module delivers a ratiometric digital output signal with short-circuit protection.

The KM110BH/11 is the DC coupled version, which allows revolution sensing beginning at 0 Hz. It is not intended for new design-ins; use KMI10/1 or KMI10/4 instead.

The AC coupled KM110BH/12 starts at 1 Hz for increased sensing distance.

PINNING

PIN	DESCRIPTION
1	ground
2	V_{OUT}
3	V_{CC}

PIN CONFIGURATION

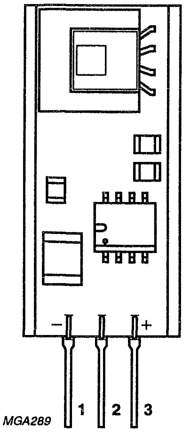


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
V_{OL}	output signal LOW	–	–	0.4	V
V_{OH}	output signal HIGH	4.3	–	–	V
d	sensing distance	–	–	3.5	mm
f	operating frequency range	0	–	3000	Hz
T_{op}	operating temperature range	−40	–	125	°C

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage		4	10	V
V_{ripple}	ripple voltage supply	KM110BH/12 only	–	50	mV
I	supply current		–	14	mA
T_{stg}	storage temperature range		−40	125	°C
T_{op}	operating temperature range	note 1	−40	125	°C
$T_{op\ sens}$	peak temperature	note 2	–	190	°C
	output short-circuit duration to ground	permanent (note 3)			

Notes

1. The operating temperature range of the module can be extended up to +150 °C for a limited time. This will be monitored by environmental quality tests up to 500 hours of operation at +150 °C under characteristic conditions.
2. This value applies to the sensor only, for a period not exceeding 1 hour.
3. If pin 3 is shorted to either pin 1 or pin 2, current may flow permanently, without damage to the device.

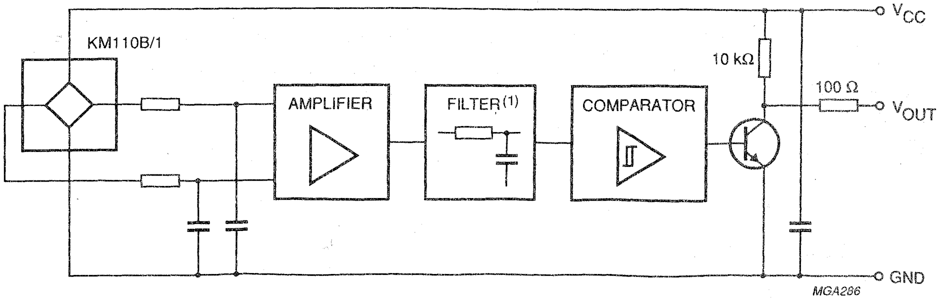
CHARACTERISTICS

T_{amb} = 25 °C; f = 2 kHz; V_{CC} = 5 V unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{OL}	output signal LOW		–	0.4	V
V_{OH}	output signal HIGH		4.3	–	V
t_r	output signal rise time	$C_L \leq 50$ pF	–	10	µs
t_f	output signal fall time	$C_L \leq 50$ pF	–	10	µs
f	operating frequency range	for both directions of rotation			
	KM110BH/11 (note 1)		0	3000	Hz
	KM110BH/12		1	3000	Hz
R_L	load resistance	note 2	100	–	kΩ
d	sensing distance	note 3 see Fig.3			
	KM110BH/11		–	2.5	mm
	KM110BH/12		–	3.5	mm
y	linear position error	see Fig.4	–	0.5	mm
θ	angle error	see Fig.4	–	1	deg

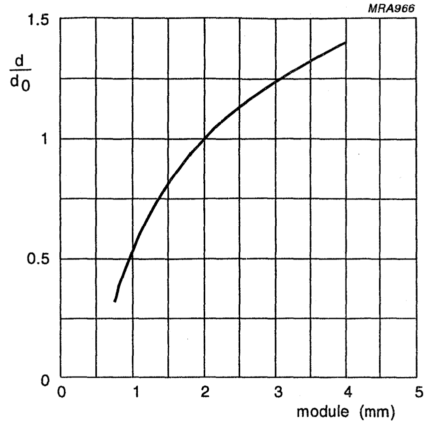
Notes

1. High rotation speeds of wheels reduce the range of the KMB110H/11, due to eddy currents. This causes a reduction in sensing distance.
2. $R_L \leq 100$ kΩ possible with external pull-up resistor.
3. Gear wheel dimensions: diameter = 104 mm; width = 10 mm; 50 teeth; module 2.08; material 9SMnPb28k.



(1) KM110BH/12 only.

Fig.2 Circuit diagram.



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

Fig.3 Normalized measuring distance as a function of gear wheel module.

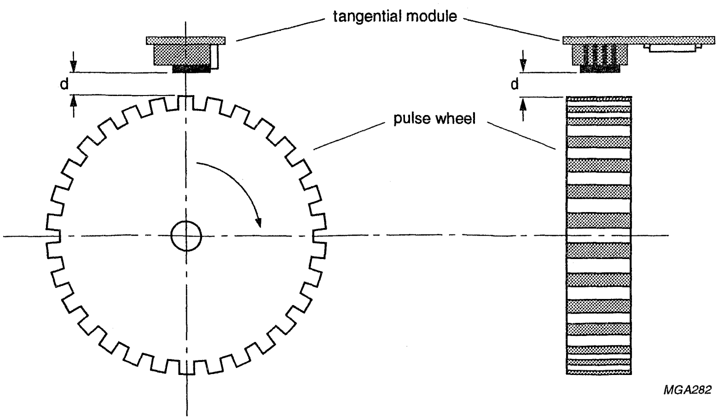


Fig.4 Optimal sensor position.

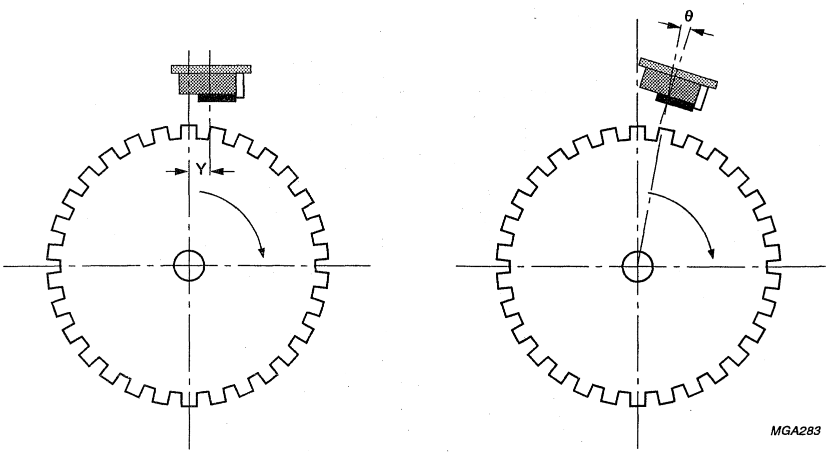


Fig.5 Sensor position with tolerances.

Gear wheel dimensions

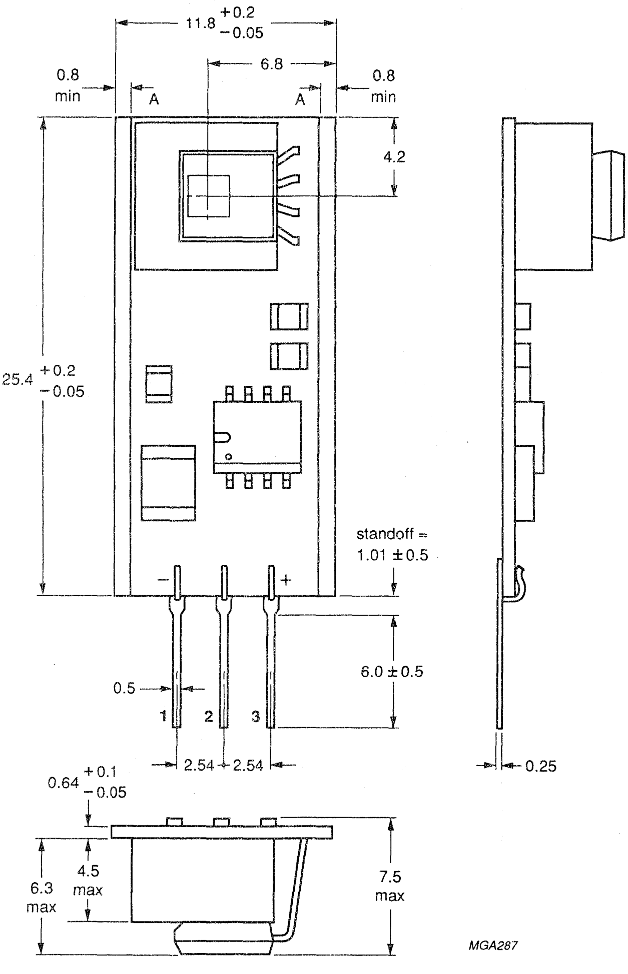
The gear wheel dimensions are specified in accordance with the German DIN standard, where:

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

Mounting conditions

Refer to Fig.4. The module senses ferrous indicators like wheels in one direction only (no rotational symmetry). The symmetrical axis of the sensor corresponds to the axis of the ferrite magnet. The crystal is not mounted in the centre of the housing.

PACKAGE OUTLINE



Dimensions in mm.

Area 'A' free of SMD devices.

Fig.5 KM110BH/11; KM110BH/12.

Revolution sensors KM110BH/13; KM110BH/14

DESCRIPTION

Sensor modules used for the detection of rotation and markings. The module is a combination of a magnetoresistive sensor, a permanent magnet and a signal conditioning circuit in hybrid technology. The module delivers a ratiometric digital output signal with short-circuit protection.

The KM110BH/13 is the DC coupled version, which allows revolution sensing beginning at 0 Hz. It is not intended for new design-ins; use KMI10/1 or KMI10/4 instead.

The AC coupled KM110BH/14 starts at 1 Hz for increased sensing distance.

PINNING

PIN	DESCRIPTION
1	ground
2	V_{OUT}
3	V_{CC}

PIN CONFIGURATION

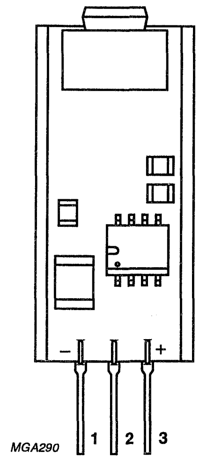


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
V_{OL}	output signal LOW	–	–	0.4	V
V_{OH}	output signal HIGH	4.3	–	–	V
d	sensing distance	–	–	3.5	mm
f	operating frequency range	0	–	3000	Hz
T_{op}	operating temperature range	–40	–	125	°C

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage		4	10	V
V_{ripple}	ripple voltage supply	KM110BH/14 only	–	50	mV
I	supply current		–	14	mA
T_{stg}	storage temperature range		–40	125	°C
T_{op}	operating temperature range	note 1	–40	125	°C
$T_{op\ sens}$	peak temperature	note 2	–	190	°C
	output short-circuit duration to ground	permanent (see note 3)			

Notes

1. The operating temperature range of the module can be extended up to +150 °C for a limited time. This will be monitored by environmental quality tests up to 500 hours of operation at +150 °C under characteristic conditions.
2. This value applies to the sensor only, for a period not exceeding 1 hour.
3. If pin 3 is shorted to either pin 1 or pin 2, current may flow permanently, without damage to the device.

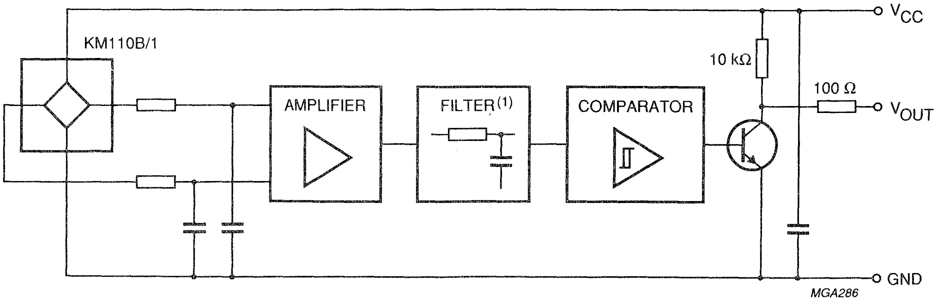
CHARACTERISTICS

T_{amb} = 25 °C; f = 2 kHz; V_{CC} = 5 V unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{OL}	output signal LOW		–	0.4	V
V_{OH}	output signal HIGH		4.3	–	V
t_r	output signal rise time	$C_L \leq 50$ pF	–	10	μs
t_f	output signal fall time	$C_L \leq 50$ pF	–	10	μs
f	operating frequency range	for both directions of rotation			
	KM110BH/13 (note 1)		0	3000	Hz
	KM110BH/14		1	3000	Hz
R_L	load resistance	note 2	100	–	kΩ
d	sensing distance	note 3 see Fig.3			
	KM110BH/13		–	2.5	mm
	KM110BH/14		–	3.5	mm
y	linear position error	see Fig.4	–	0.5	mm
θ	angle error	see Fig.4	–	1	deg

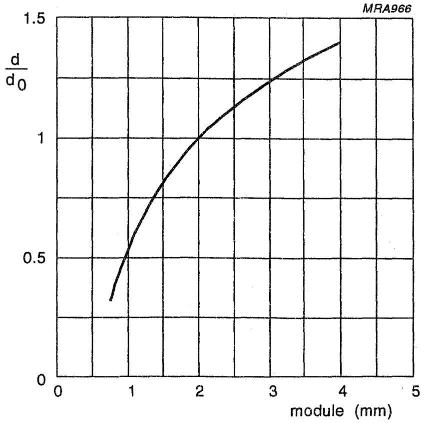
Notes

1. High rotation speeds of wheels reduce the range of the KMB110H/11, due to eddy currents. This causes a reduction in sensing distance.
2. $R_L \leq 100$ kΩ possible with external pull-up resistor.
3. Gear wheel dimensions: diameter = 104 mm; width = 10 mm; 50 teeth; module 2.08; material 9SMnPb28k.



(1) KM110BH/14 only.

Fig.2 Circuit diagram.



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

Fig.3 Normalized measuring distance as a function of gear wheel module.

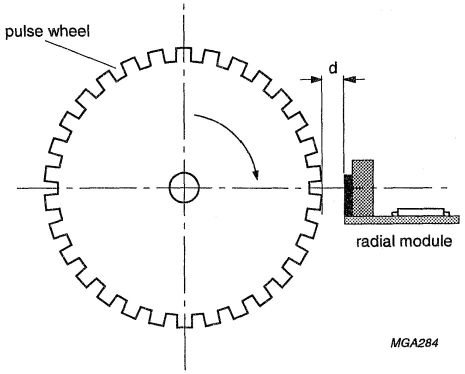


Fig.4 Optimal sensor position.

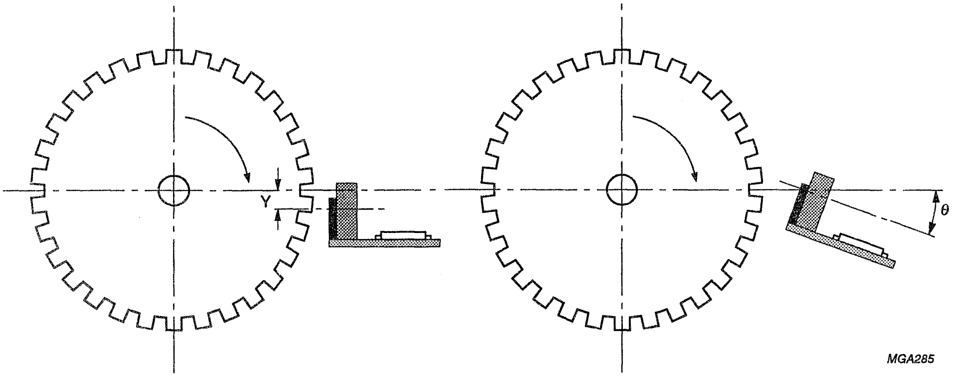


Fig.5 Sensor position with tolerances.

Gear wheel dimensions

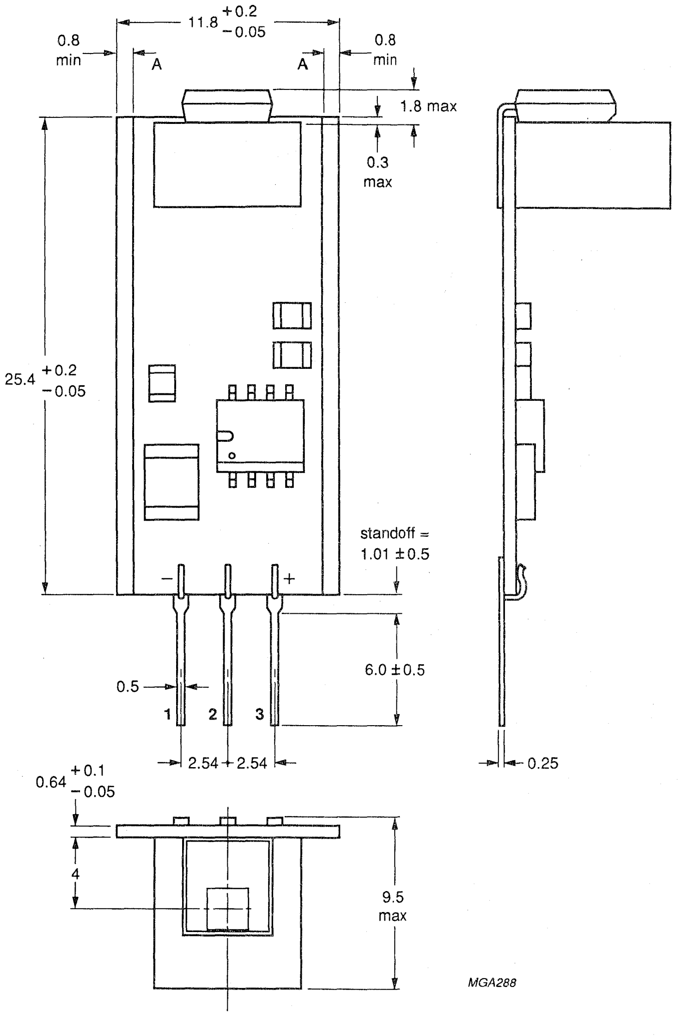
The gear wheel dimensions are specified in accordance with the German DIN standard, where:

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

Mounting conditions

Refer to Fig.4. The module senses ferrous indicators like wheels in one direction only (no rotational symmetry). The symmetrical axis of the sensor corresponds to the axis of the ferrite magnet. The crystal is not mounted in the centre of the housing.

PACKAGE OUTLINE



Dimensions in mm.
Area 'A' free of SMD devices.

Fig.5 KM110BH/13; KM110BH/14.

Rotational speed sensor with direction recognition

KM110BH/31

DESCRIPTION

Sensor module for the detection of rotational speed and its direction. The module consists of the magnetoresistive sensor KMZ10B, a permanent magnet and a signal conditioning circuit in hybrid technology. The module delivers a digital output signal with short-circuit protection.

PINNING

PIN	DESCRIPTION
1	V_{CC}
2	V_{O1}
3	V_{O2}
4	ground

PIN CONFIGURATION

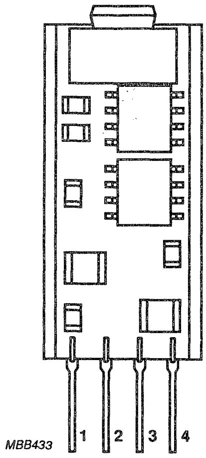


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
V_{O1L}, V_{O2L}	output signal LOW	–	–	0.4	V
V_{O1H}, V_{O2H}	output signal HIGH	4.3	–	–	V
d	sensing distance	–	–	3	mm
f	operating frequency range	2	–	50000	Hz
T_{op}	operating temperature range	–40	–	125	°C

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage		4	10	V
V_{ripple}	ripple voltage supply		–	40	mV
I_{CC}	supply current		–	14	mA
T_{stg}	storage temperature range		–40	125	°C
T_{op}	operating temperature range	note 1	–40	125	°C
$T_{op\ sens}$	peak temperature	sensor only	–	150	°C
	output short-circuit duration to ground	continuous			

Note

1. The operating temperature range of the module can be extended up to +150 °C for a limited time. This will be monitored by environmental quality tests up to 500 hours of operation at +150 °C under characteristic conditions.

CHARACTERISTICS

T_{amb} = 25 °C; f = 2 kHz; V_{CC} = 5 V unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{O1L}, V_{O2L}	output signal LOW	note 1	–	0.4	V
V_{O1H}, V_{O2H}	output signal HIGH	note 2	4.3	–	V
t_r	output signal rise time	$C_L \leq 50$ pF	–	10	µs
t_f	output signal fall time	$C_L \leq 50$ pF	–	10	µs
f	operating frequency range	for both directions of rotation	2	50 000	Hz
R_L	load resistance	note 3	100	–	kΩ
d	sensing distance	note 4 see Fig.3		3	mm
y	linear position error	see Fig.4	–	0.5	mm
θ	angle error	see Fig.4	–	1	deg

Notes

1. Refer to Figs 2, 5 and 6. The KM110BH/31 sensor is based on separated signal conditioning for two half-bridge signals. As the average distance between the two bridge-halves is fixed by the magnetoresistive sensor dimensions, the optimum structure pitch of a gear wheel should be 2.8 mm. Figures 5 and 6 show the dependence of both output signals on the direction of movement.
2. V_{O1H} and V_{O2H} are relative to V_{CC}.
3. $R_L \leq 100$ kΩ possible with external pull-up resistor.
4. Gear wheel dimensions: diameter = 104 mm; width = 10 mm; 50 teeth; module 2.08; material 9SMnPb28k.

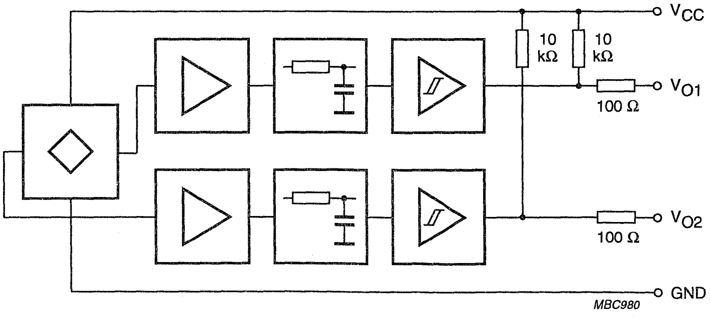


Fig.2 Circuit diagram.

Gear wheel dimensions

The gear wheel dimensions are specified in accordance with the German DIN 780 standard, where:

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

Mounting conditions

Refer to Fig.3 for the correct mounting position. The module senses ferrous indicators like wheels in one plane only (no rotational symmetry). The measuring axis of the sensor corresponds to the symmetry axis of the ferrite magnet - the crystal is not mounted in the centre of the housing.

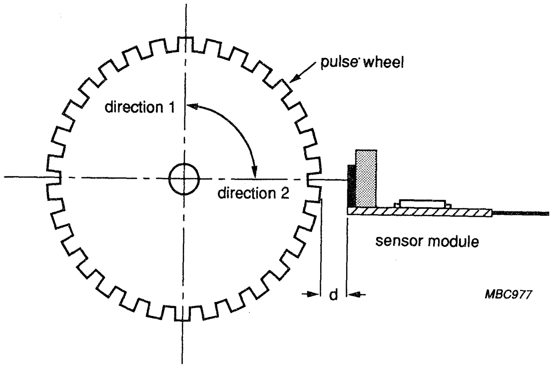


Fig.3 Optimal sensor position.

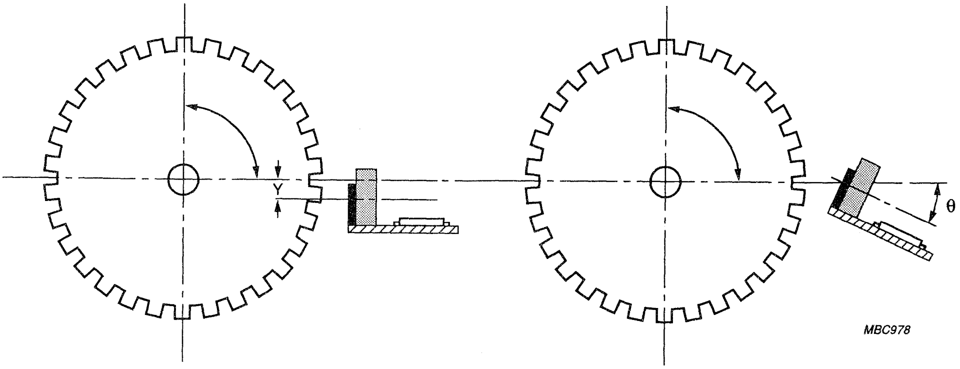


Fig.4 Sensor position with tolerances.

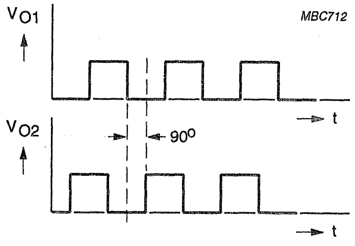


Fig.5 Output signals with gear wheel rotation in direction 1.

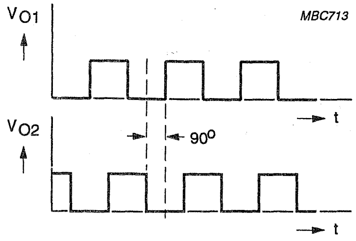


Fig.6 Output signals with gear wheel rotation in direction 2.

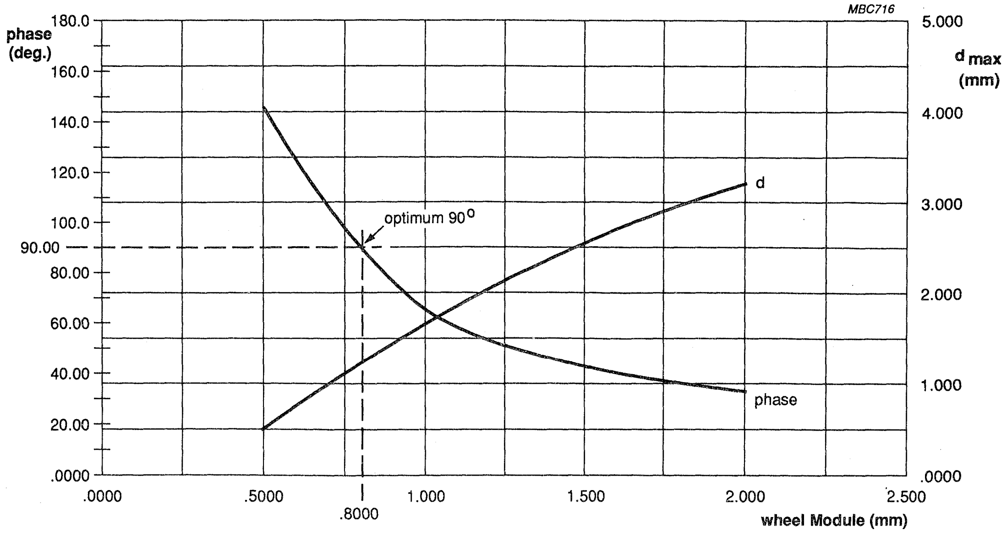


Fig.7 Phase and distance relationship for different gear wheel modules.

APPLICATION INFORMATION

Direction recognition can be achieved with a microprocessor or with a simple flip-flop circuit, see Fig.8.

In life-support systems, the behaviour of electronic components throughout their working life can be unpredictable. The use of these devices in support systems can only be permitted when there is no danger to life caused by devices failing unexpectedly.

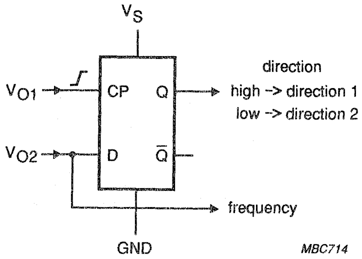
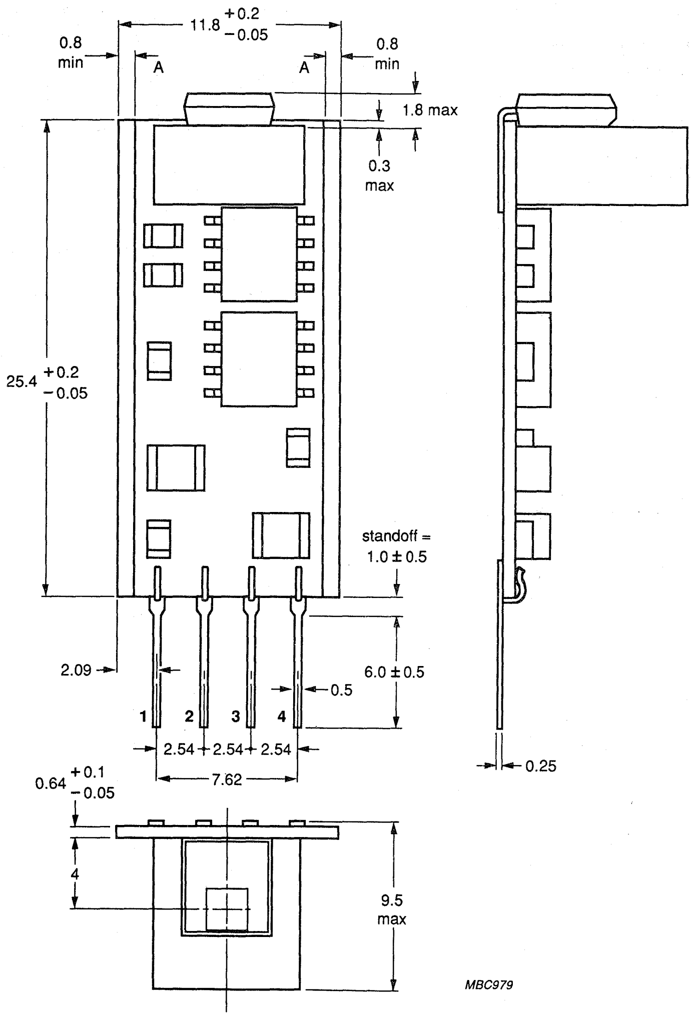


Fig.8 Interface for direction rotation.

PACKAGE OUTLINE



Dimensions in mm.

Area 'A' free of SMD devices.

Fig.9 KM110BH/31.

Rotational speed sensor with direction recognition

KM110BH/32

FEATURES

- Contactless rotational speed sensing
- Direction recognition capability
- Easy to mount, ready for use
- Digital output current signal
- Operating temperatures up to 125 °C
- EMC resistant.

DESCRIPTION

The KM110BH/32 sensor detects rotational speed and direction. The sensor comprises a magnetoresistive sensor element, KMZ10B, a signal conditioning circuit in hybrid technology and a permanent magnet. The KM110BH/32 delivers a digital current output signal with short-circuit protection.

PINNING

SYMBOL	PIN	DESCRIPTION
GND	1	ground
V_{CC1}	2	DC supply 1 voltage
V_{CC2}	3	DC supply 2 voltage

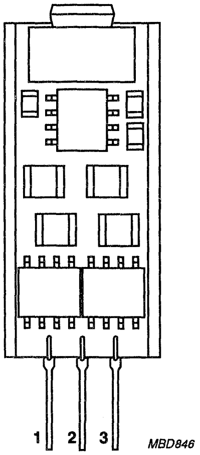


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC1}	DC supply 1 voltage	–	12	–	V
V_{CC2}	DC supply 2 voltage	–	12	–	V
$I_{CC1(low)}$	output 1 current low	–	7	–	mA
$I_{CC2(low)}$	output 2 current low	–	7	–	mA
$I_{CC1(high)}$	output 1 current high	–	14	–	mA
$I_{CC2(high)}$	output 2 current high	–	14	–	mA
$f_{t(oper)}$	operating tooth frequency	10	–	20000	Hz
d	sensing distance	–	0 to 4	–	mm
T_{amb}	operating ambient temperature	–40	–	+125	°C

BLOCK DIAGRAM

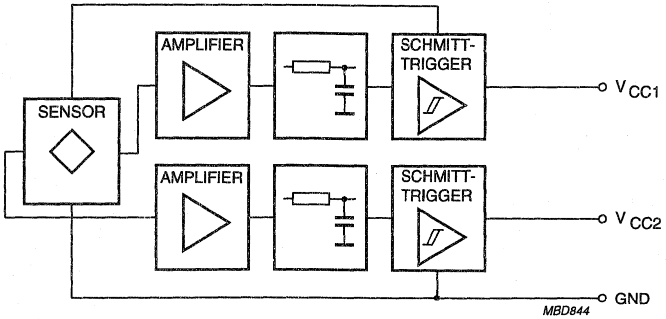


Fig.2 Block diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC1}	DC supply 1 voltage		7.5	16	V
V_{CC2}	DC supply 2 voltage		7.5	16	V
T_{stg}	storage temperature		–40	+125	°C
T_{amb}	operating ambient temperature		–40	+125(1)	°C
T_{peak}	peak temperature	sensor element only	–	150	°C

Note

1. The operating temperature range of the module can be extended up to +150 °C for a limited time.

CHARACTERISTICS

T_{amb} = 25 °C; $V_{CC1} = V_{CC2}$ = 12 V; f = 2 kHz; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$I_{CC1(low)}$	output 1 current low	note 1	5.6	–	8.4	mA
$I_{CC2(low)}$	output 2 current low	note 1	5.6	–	8.4	mA
$I_{CC1(high)}$	output 1 current high		11.2	–	16.8	mA
$I_{CC2(high)}$	output 2 current high		11.2	–	16.8	mA
t_r	output current rise time	$C_L \leq 50$ pF	–	–	10	µs
t_f	output current fall time	$C_L \leq 50$ pF	–	–	10	µs
$f_{t(oper)}$	operating tooth frequency	for both rotation directions	10	–	20000	Hz
R_L	load resistance		–	–	120	Ω
d	sensing distance	see Fig.5	–	0 to 4	–	mm
y	linear position error	see Fig.6	–	–	0.5	mm
θ	angular error	see Fig.6	–	–	1	deg

Note

1. The KM110BH/32 sensor is based on separated signal conditioning for two half-bridge signals (see Fig.2). As the average distance between the two bridge-halves is fixed by the magnetoresistive sensor dimensions, the optimum pitch of the pulse wheel should be 2.8 mm. Figures 3 and 4 show the dependency of the direction movement.

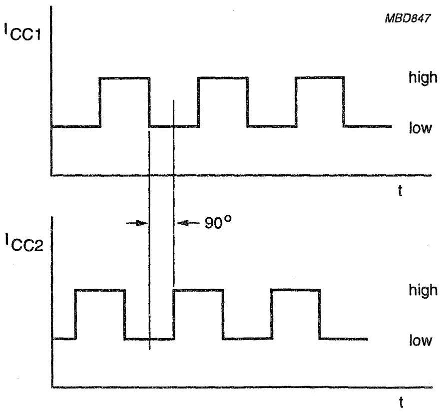


Fig.3 Output signals with pulse wheel rotation in direction 1.

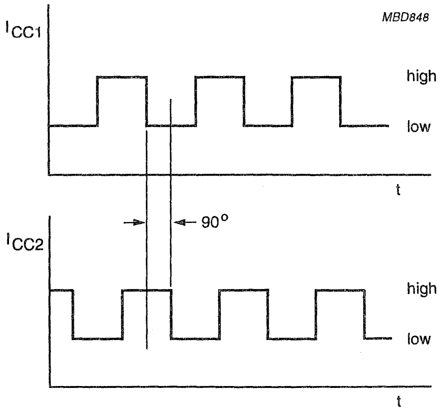


Fig.4 Output signals with pulse wheel rotation in direction 2.

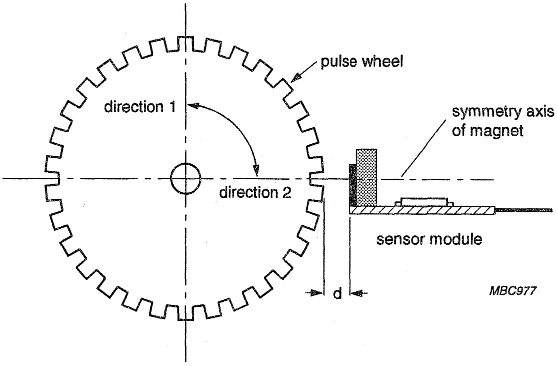


Fig.5 Sensor positioning.

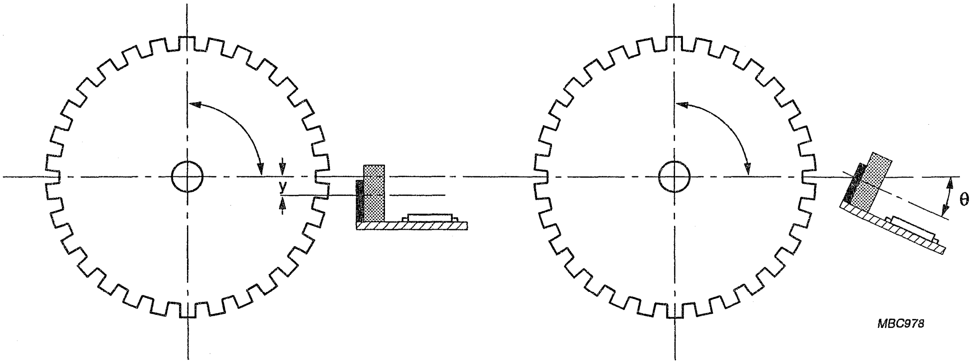


Fig.6 Sensor positional errors.

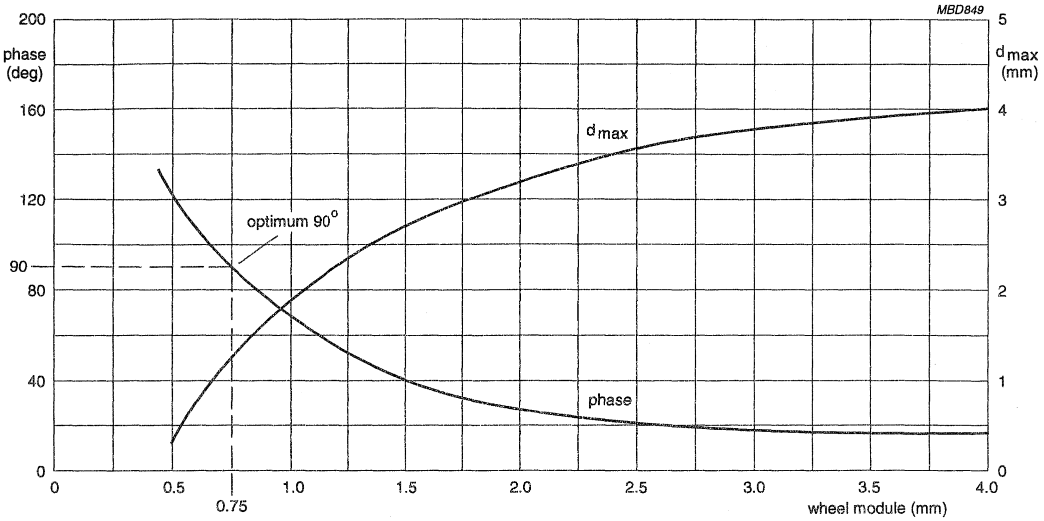
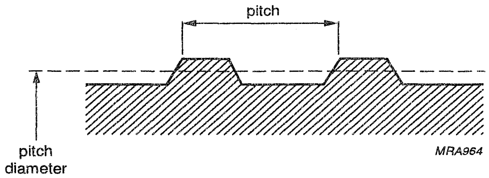


Fig.7 Phase and distance relationship for different pulse wheel modules.

APPLICATION INFORMATION

Mounting conditions

Refer to Fig.5 for the correct mounting position. The module senses ferrous indicators like pulse wheels in one plane only (no rotational symmetry). The measuring axis of the sensor corresponds to the symmetry axis of the ferrite magnet. The crystal is not mounted in the centre of the housing.



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

$$\text{pitch} = \text{module} \times \pi$$

Fig.8 Gear wheel definitions.

Signal evaluation

The two output signals from the sensor are constant current symmetrical pulses with a lead/lag difference of 90°. Ground is common to both channels. A simple two-channel current to voltage conversion is shown in Fig.9. Operation is similar for both channels. The voltage developed across a measuring resistor in the positive supply line is applied to buffer IC1. The voltage output pulse V_{O1} (V_{O2}) is referred to ground and is at a level suitable for input to subsequent digital processing circuitry.

Direction recognition can be achieved with a microcontroller or with a simple flip-flop circuit (see Fig.10).

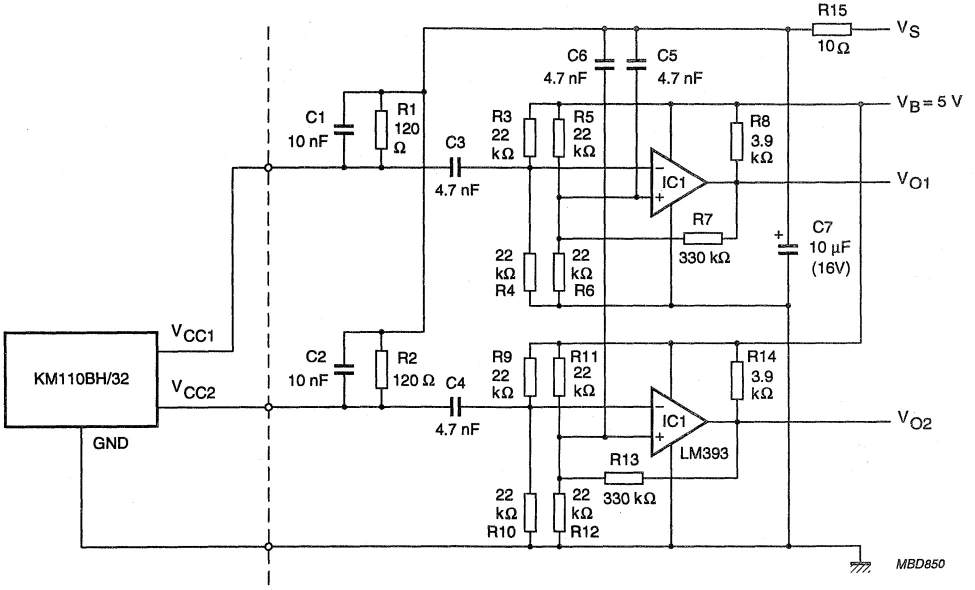


Fig.9 Output signal conversion circuit.

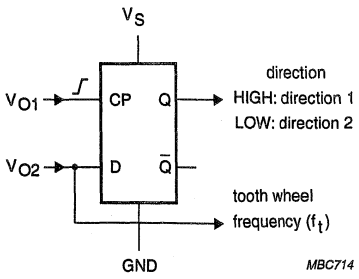
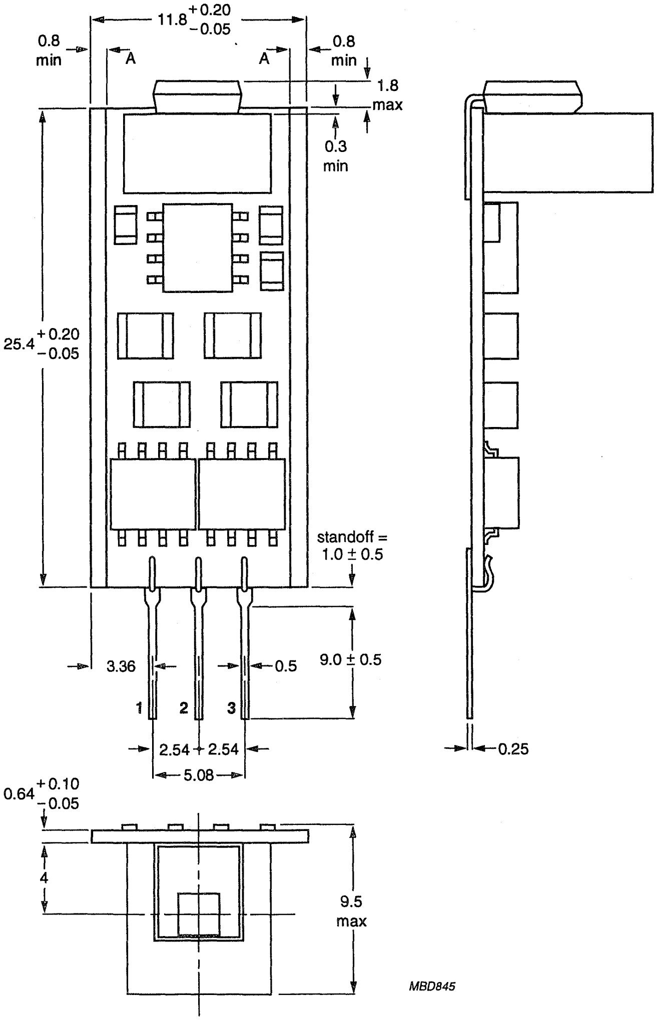


Fig.10 Interface for direction recognition.

PACKAGE OUTLINE



Dimensions in mm.
Area ‘A’ free of SMD devices.

Fig.11 Outline of KM110BH/32.

SENSORS FOR CONTACTLESS ANGULAR POSITION MEASUREMENT

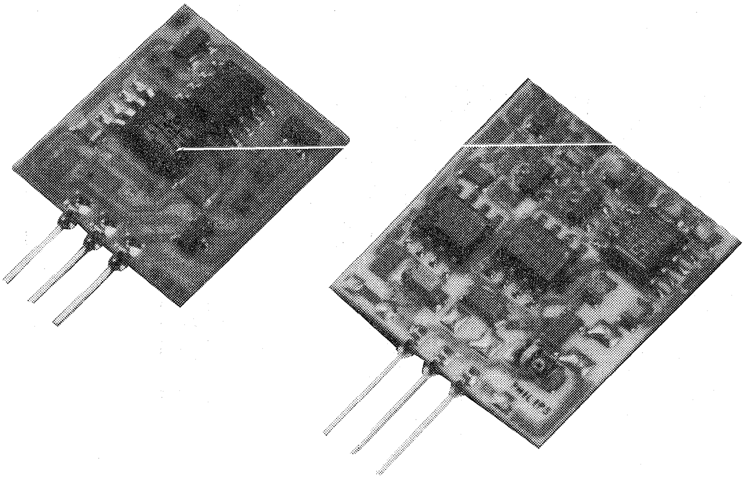


Fig.1 The KM110BH/21 sensor module.

General

Philips Semiconductors has designed a wide range of modules to meet the strong demand for contactless angular measurement systems. In the automotive field alone there are many potential applications, such as electronic control of accelerator pedal, chassis position, steering angle and throttle position.

Magnetoresistive sensors are particular suitable for angular position measurement applications, since they can be operated in such a way, that their output signal is virtually independent of:

- Magnet tolerances and magnet temperature coefficient
- Positioning tolerances and sensor-magnet distance.

Moreover, all modules are pre-calibrated for offset, sensitivity and zero point and contain integrated temperature compensation.

As a consequence, assembly of the (encapsulated) sensor is easy and calibration after assembly becomes superfluous, thus saving considerable costs. More technical details are explained in the next Section “Angular measurement with magnetoresistive sensors”.

There are two module series available. The KM110BH/2 family comprises a range of modules in hybrid thick-film technology. The circuits and the magnetic parameters of these modules have been chosen so that they can be used:

- Directly, in a wide range of applications (without further trimming or any adjustments)
- As the basis for customized modules.

The KMA family comprises a range of encapsulated angular position sensors, which are based on the KM110BH/2 hybrid sensors and the encapsulation of which has been developed in cooperation with AB Electronics of Werne, Germany.

Angular measurement with magnetoresistive sensors

With the KMZ magnetoresistive sensor, two different techniques are available for angle measurement. The first, used in most magnetic field sensor angle measurement equipment, entails measuring the **field-strength** of a rotating magnet as a function of the angle. With this technique, the field used is within the normal sensitivity range of the KMZ sensor, and angles of ±90° can be measured.

However, since the magnet's properties influence the sensor output, the measurement equipment must be calibrated after assembly. Only with a very well-defined magnetic system would a pre-calibrated circuit be possible. Defining such a system is both expensive and difficult, due to the tolerances caused by the thermal sensitivity of the magnet.

The second technique, used in our KM110BH/2 modules, requires strong magnetic fields (≥80 kA/m). The KMZ sensor operates in 'saturation mode', detecting only the **field-direction**. In the limiting event of infinite field strength, the field strength and its drift with temperature have no influence on the sensor.

Therefore, using this technique reduces measurement-system tolerances and allows pre-trimming of the sensors; the only requirement is that field directions during trimming correspond with field directions after assembly. The typical angle measurement range is from –45 to +45°, and the sensor output signal is sinusoidal. Because of this, a linear signal can be obtained in the central part of the output characteristic.

In practice, it is not necessary to use very strong and possibly expensive magnets for the sensor to operate in saturation mode. Even with readily available magnets (or field strengths), the influence of tolerances or temperature drift is minimal.

As field strengths decrease, the peak output signal remains more or less constant and the angle range increases from ±45° to a maximum of ±90° (approximately) at very low magnetic fields.

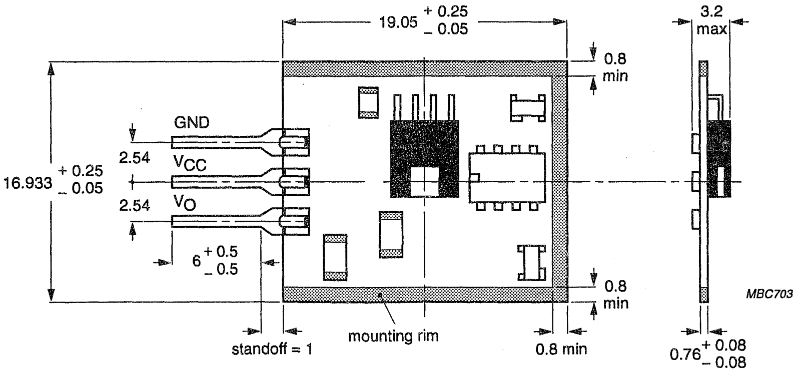
The KM110BH/21 module series

Figure 2 shows the construction of the KM110BH/21 module. It is based on the KMZ10B sensor. There are two types in the range: the KM110BH/2130 and the KM110BH/2190. They are trimmed differently, but both are based on the same circuit (see Fig.3). The KM110BH/2130 is trimmed to a higher amplification and measures angles between –15 and +15°, generating a linear output signal (non-linearity is only ≈1%).

The KM110BH/2190 measures the angle range from approximately –45 to +45°, with a sinusoidal output. Both modules have an analog voltage output signal. Figure 4 shows the output signals 'V_O' of the two modules as a function of measured angle 'α'.

Further data on the KM110BH/21 module series can be found in Table 1.

Although both modules are readily available, it is recommended to use the modules of the KM110BH/23 and/or KM110BH/24 families for new design-ins (see Table 1).



Dimensions in mm.

Fig.2 Construction of a KM110BH/21.

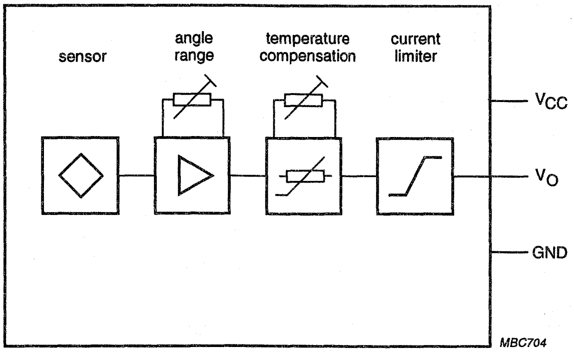
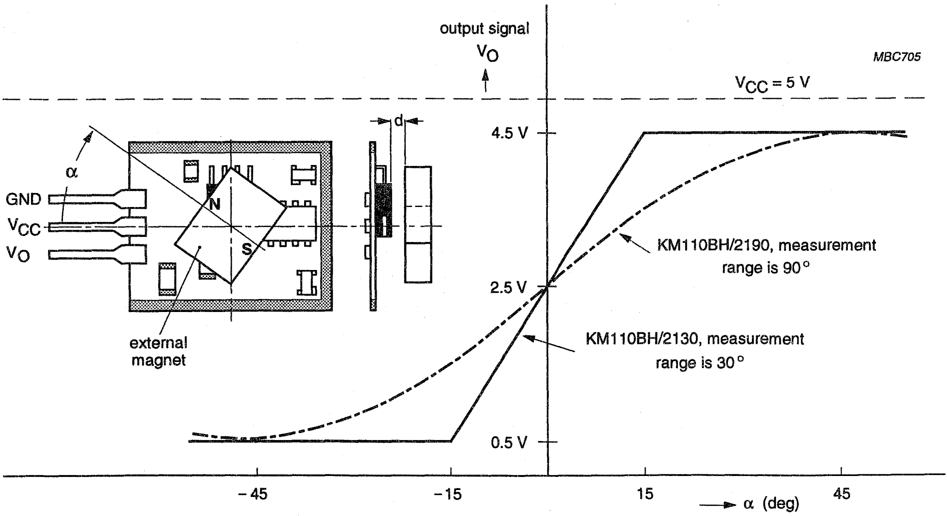


Fig.3 Block diagram of a module circuit.



Dimensions in mm.

Fig.4 Output characteristics of the KM110BH/2130 and KM110BH/2190 modules.

Table 1 Type range of contactless position sensor modules

PARAMETER	KM110BH/						UNIT
	2130(1)	2190(2)	2270	2390	2430	2470	
Angle range	30	90	70	90	30	70	deg
Output voltage(3)	0.5 to 4.5	0.5 to 4.5	–	0.5 to 4.5	0.5 to 4.5	0.5 to 4.5	V
Output current	–	–	4 to 20	–	–	–	mA
Output characteristic	linear	sinusoidal	sinusoidal	linear	linear	sinusoidal	
Supply voltage	5	5	8.5	5	5	5	V
Substrate dimensions	19.1 × 16.9	19.1 × 16.9	23.6 × 20.3	23.6 × 20.3	23.6 × 20.3	23.6 × 20.3	mm^2
Resolution	0.001	0.001	0.001	0.001	0.001	0.001	deg
Temperature range	−40 to +125	−40 to +125	−40 to +125	−40 to +125	−40 to +125	−40 to +125	°C
Production	running	running	running	12/95	8/94	8/94	

Notes

1. For new design-ins the KM110BH/2430 should be used.
2. For new design-ins the KM110BH/2470 or KM110BH/2390 should be used.
3. The output voltage is ratiometric.

The KM110BH/2270 module

The KM110BH/2270 is trimmed to an angle ranging from −35 to +35°. The outline is shown in Fig.5, a block diagram of the circuit in Fig.6. The module is based on the KMZ11B1 sensor. It contains an input voltage stabilization. In contrast to the other modules in the KM110BH/2 range the KM110BH/2270 has an analog **current** output signal (4 to 20 mA). Using a simple resistor this can be converted into a voltage signal. The output characteristic of the KM110BH/2270 is shown in Fig.7. The module contains protection circuitry to make it EMC friendly.

Both resolution and reproducibility are extremely high (better than 0.001° at $\alpha = 0°$). Hysteresis, with a typical value of 0.02° at $\alpha = 0°$, is very low.

When designing an encapsulation for the KM110BH/2270, it may be necessary to have the pins of the hybrid bent in an S-shape in order to avoid force on the solder joints. In this event the KM110BH/2270G should be ordered. Further data is supplied in Table 1.

The KM110BH/2390 module

The KM110BH/2390 module has been designed for linearly measuring angles over ranges of up to 106° (from −53 to +53°). It is based on a modified version of the KMZ11B1, especially designed for linear measurement of wide angle ranges. The outline is shown in Fig.8. The block diagram of the circuit is the same as for the KM110BH/21 module (see Fig.3).

The module has an analog voltage output signal (0.5 to 4.5 V for angles from −45 to +45°). The output characteristic is shown in Fig.9. A summary of module data can be found in Table 1.

The KM110BH/24 module

The outline of the KM110BH/24 module is shown in Fig.10. The module is based on the KMZ11B1. The block diagram of the circuit is shown in Fig.3.

The KM110BH/24 is available in 2 versions. The KM110BH/2430 is trimmed to have an angle range of 30° (−15 to +15°, non-linearity is ≈1%) and has a linear voltage output. The KM110BH/2470 has an angle range of 70° (−35 to +35°) and has a sinusoidal voltage output. The output characteristics are shown in Figs 11 and 12. The modules contain protection circuitry to make them EMC friendly.

Magnets

From a technical viewpoint, the most suitable magnet is a large and strong one; all tolerances are then negligible. However, cost and space must also be considered. The optimum size, therefore, largely depends on individual requirements. In Table 2 three different commercially available SmCo magnets are given, all suitable for angle measurement applications.

For each magnet the dimensions, the recommended measuring distance 'd', the tolerance on 'd', the eccentricity and the temperature range is given.

The magnets described have tolerances of magnetization direction affecting the angle measurement. Deviations of up to 2° are possible. This should be taken into account if no mechanical $\alpha = 0°$ calibration is possible.

The symmetry axis of the module and the rotation axis of the magnet should be identical.

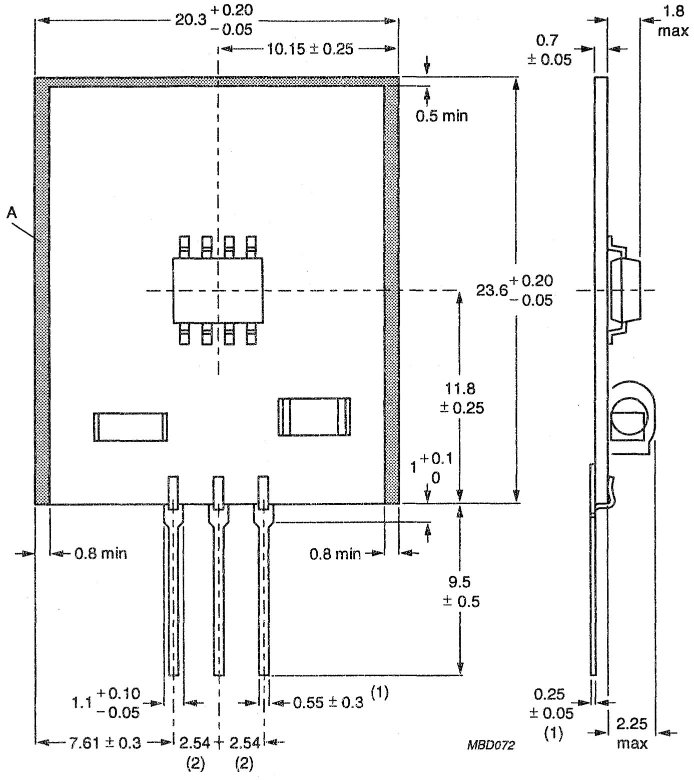
If one of the axis is shifted, the measuring system neglects this tolerance because of the parallel field lines of the magnet. Measurements with magnets 11.2 × 8 mm^2 faced to the sensor allow for eccentric tolerances of up to 0.5 mm in the event of an accepted V_O tolerance of 1% and up to 0.25 mm for an accepted V_O tolerance of 0.5% (offset, angle range). For smaller magnets, this axis tolerance should be reduced proportionally.

Table 2 Magnets for angle sensor hybrids

MATERIAL	DIMENSIONS(1) (mm)	d(2) (mm)	TOLERANCE d(3) (mm)	ECCENTRICITY(4) (mm)	T_{amb} (°C)
Sm_2Co_{17}	11.2 × 5.5 × 8	2.1	±0.30	±0.25	−55 to +125
	6 × 3 × 5	0.7	±0.15	±0.15	
	8 × 3 × 7.5	0.5	±0.30	±0.20	

Notes

1. The magnetization is always parallel to the latter dimensions given.
2. Distance 'd' between magnet and KMZ sensor front as shown in Fig.4.
3. Maximum deviation of distance 'd' for which the change in sensor output signal is smaller than 0.5% of full scale sensor signal.
4. Maximum deviation of magnet rotational axis to sensor rotational axis for which the change in sensor output signal is smaller than 0.5% of full scale sensor signal.



Dimensions in mm.

Area 'A' (shaded) free of SMD devices.

(1) Dimension before bath soldering; maximum dimension after bath soldering: 0.7 mm.

(2) Pitch tolerance: 0.2 mm.

Fig.5 Outline of the KM110BH/2270.

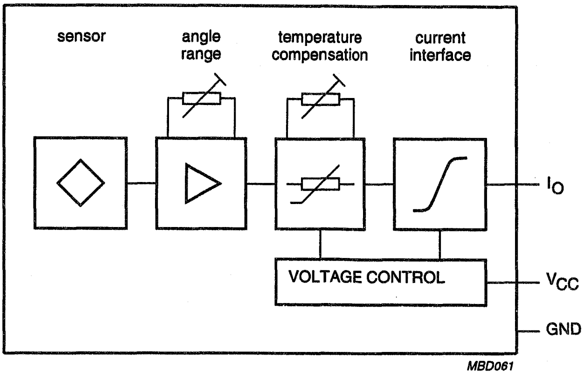


Fig.6 Block diagram of the KM110BH/2270.

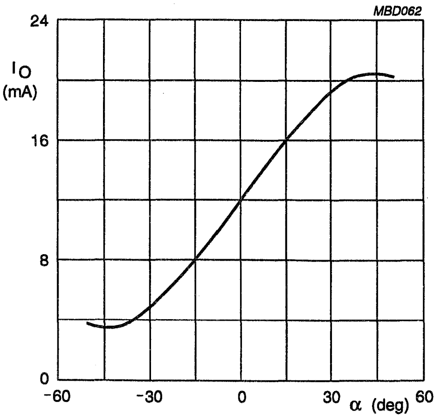
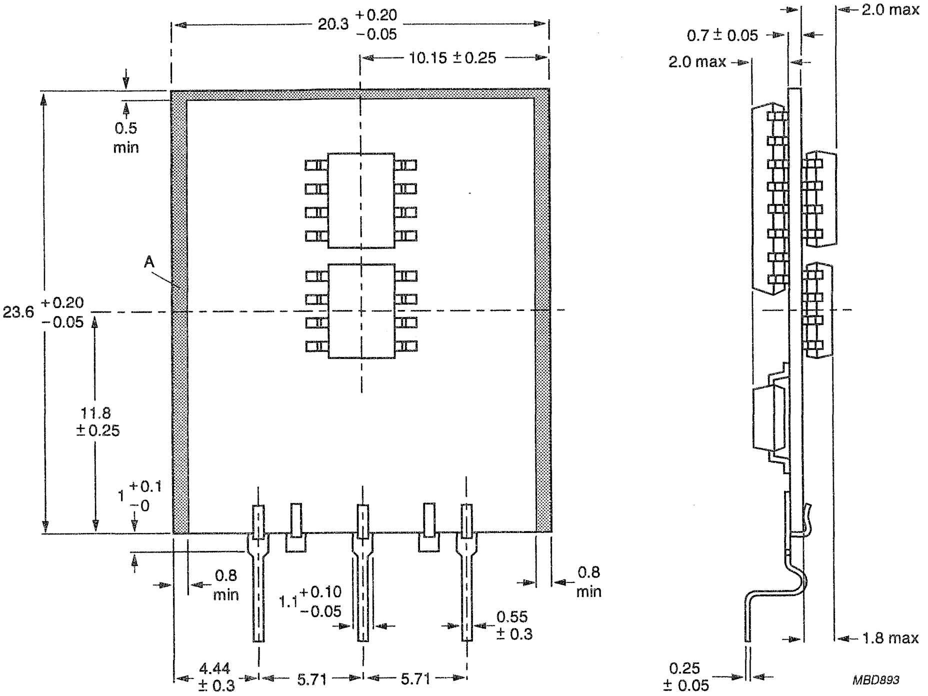


Fig.7 Output current 'I_O' as a function of angular displacement 'α' for the KM110BH/2270.



Dimensions in mm.
Area 'A' (shaded) free of SMD devices.

Fig.8 Outline of the KM110BH/2390.

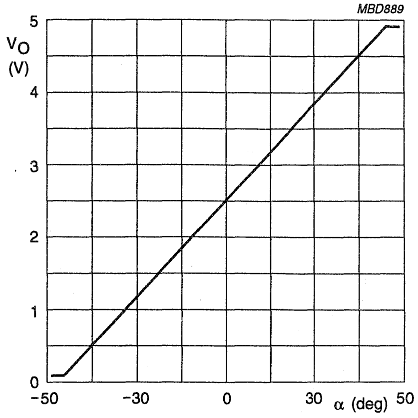
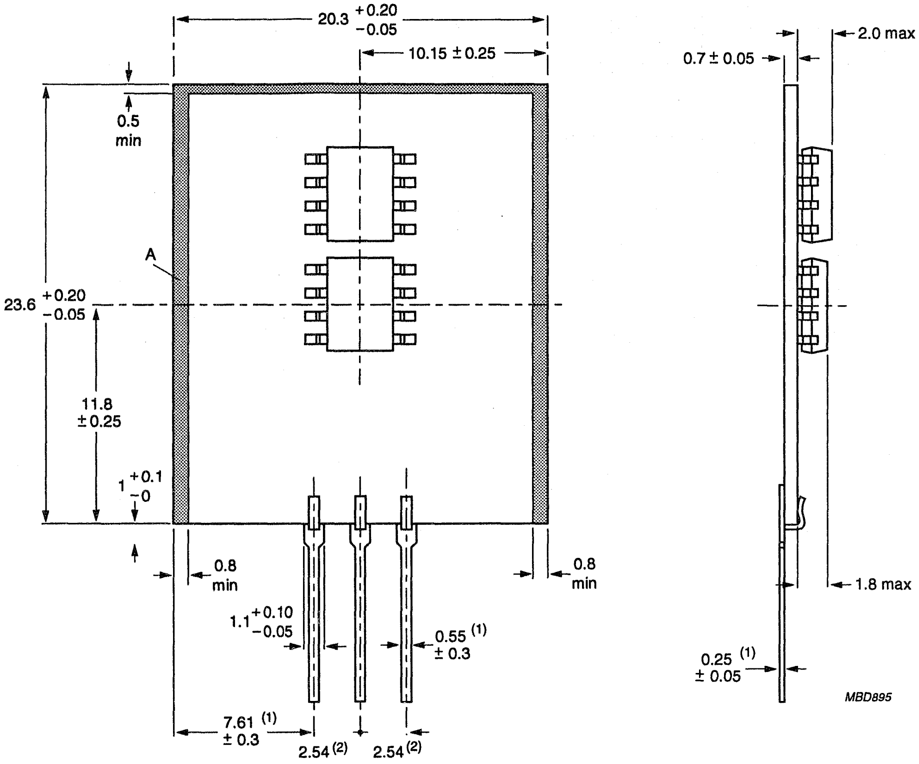


Fig.9 Output voltage ‘V_O’ as a function of angular displacement ‘α’ for the KM110BH/2390.



Dimensions in mm.

Area 'A' (shaded) free of SMD devices.

(1) Dimension before bath soldering; maximum dimension after bath soldering: 0.7 mm.

(2) Pitch tolerance: 0.2 mm.

Fig.10 Outline of the KM110BH/2430 and KM110BH/2470.

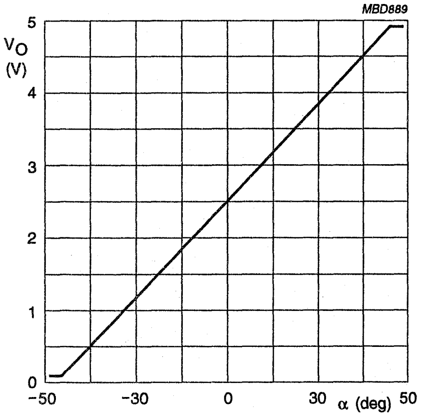


Fig.11 Output voltage 'V_O' as a function of angular displacement 'α' for the KM110BH/2430.

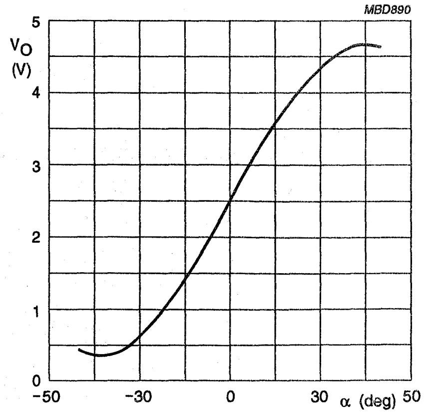


Fig.12 Output voltage 'V_O' as a function of angular displacement 'α' for the KM110BH/2470.

THE KMA10 AND KMA20 ENCAPSULATED SENSORS FOR ANGULAR POSITION MEASUREMENT

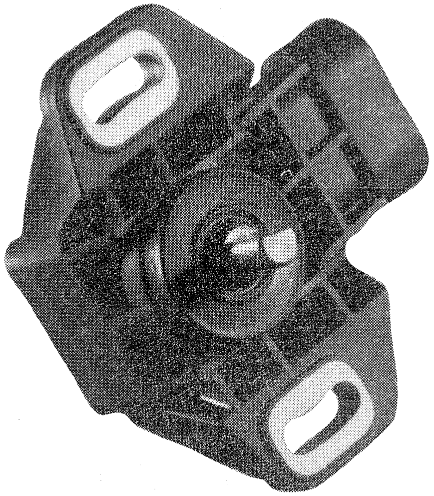


Fig.13 The KMA10 and KMA20 sensors.

The KMA10 and KMA20 are ready-to-use contactless angle sensors, designed to operate in extreme environments. The sensors are based on the KMZ11B1 magnetoresistive sensor element. They contain integrated signal conditioning electronics and are available in a hermetically-sealed, rugged encapsulation. Applications are both automotive and industrial, such as chassis position measurement and angular position measurement of accelerator pedals, control levers, operating handles, shafts, etc.

The KMA10 and KMA20 sensors, jointly developed by Philips Semiconductors and AB Electronics, offer:

- Angle measuring ranges of 30, 70 and 90°
- Contactless operation - wear-free and no microlinearity problems (output is noise-free even for small angle changes)
- Easy/mechanically-adjustable mounting - ready-for-use
- Analog current (KMA10) and voltage (KMA20) output signal
- Operation up to 125 °C
- Protection against aggressive environments
- A rugged mechanical design
- EMC-friendly operation.

The encapsulation

Figure 14 shows the encapsulation of the KMA sensors. The rugged design of the encapsulation, the AMP Superseal connector and the protection cap on the shaft ensure reliable operation under harsh environmental conditions. Thus, the KMA sensors are resistant, for example, to aggressive media and pressurized water (DIN protection class IP65). Moreover they operate at temperatures up to 125 °C and its construction enables easy mounting and connection to an external shaft or spindle.

The sensors are supplied with a 3-pin ‘AMP Superseal 1.5 series’ socket. For the recommended matching plug, the following AMP components are required:

- A plug connector, part no. 282087-1
- A receptacle contact (strip form, wire size range 1.0 to 1.5 mm^2), part no. 282110-1
- A single wire seal (yellow, insulation diameter 1.8 to 2.4 mm), part no. 281934-2.

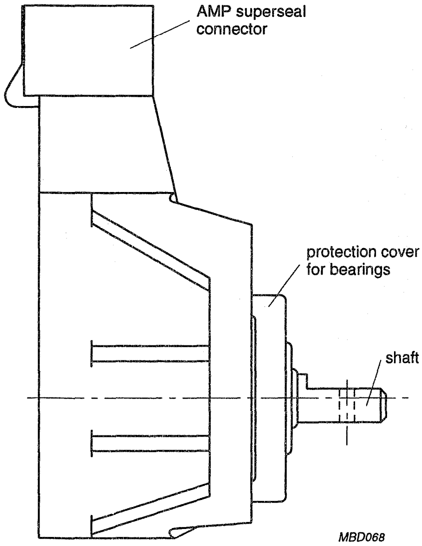


Fig.14 Encapsulation of the KMA sensors.

The KMA10/70

The KMA10 sensor is available in one version, the KMA10/70. It is based on the KM110BH/2270 hybrid and therefore has a 70° measuring range, a sinusoidal current output (see Fig.7) and operates at temperatures up to 100 °C. The maximum absolute angle error (over temperature) is shown in Fig.15.

Remark: the angle error should not be mixed up with the resolution and the reproducibility of the sensor!

The KMA20 family

The KMA20 sensors are available in three versions.

The KMA20/30 is based on the KM110BH/2430 and has a measuring range of 30°. The KMA20/70 is based on the KM110BH/2470 and has a measuring range of 70°. Both sensors have a voltage output. However, the output signal of the KMA20/30 is linear (see Fig.11) and of the KMA20/70 sinusoidal. The maximum absolute angle error (over temperature) is shown in Fig.16.

The last member in the KMA20 family is the KMA20/90, which is based on the KM110BH/2390. It has a linear voltage output signal over its angle measuring range of maximum 106° and a minimum absolute angle error of 1°.

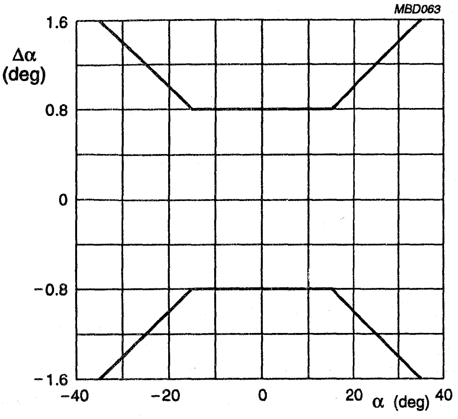
A summary of data of the KMA10 and KMA20 sensors is given in Table 3.

Table 3 Type range encapsulated angle sensors

PARAMETER	KMA10/70	KMA20/30	KMA20/70	KMA20/90	UNIT
Angle range	70	30	70	90	deg
Output voltage(1)	–	0.5 to 4.5	0.5 to 4.5	0.5 to 4.5	V
Output current range	4 to 20	–	–	–	mA
Output characteristic	sinusoidal	linear	sinusoidal	linear	
Supply voltage	8.5	5	5	5	V
Resolution	0.001	0.001	0.001	0.001	deg
Operating life	$>5 \times 10^8$	$>5 \times 10^8$	$>5 \times 10^8$	$>5 \times 10^8$	cycles
Temperature range	–40 to +100	–40 to +125	–40 to +125	–40 to +125	°C
Production	running	8/94	8/94	12/95	

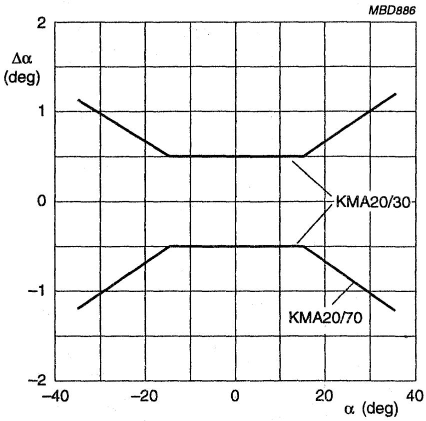
Note

1. The output voltage is ratiometric.



Temperatures between −20 and +85 °C.

Fig.15 Maximum absolute angle error of the KMA10/70.



Temperatures between −20 and +85 °C.

Fig.16 Maximum absolute angle error of the KMA20/30 and KMA20/70.

Angle sensor hybrid KM110BH/2130; KM110BH/2190

DESCRIPTION

Sensor module for contactless measurement of angular displacements of strong magnetic fields. The module is a ready-trimmed (sensitivity and zero point) combination of the magnetoresistive sensor KMZ10B and a signal conditioning circuit in hybrid technology. The KM110BH/2130 delivers a linear output signal that is proportional to the direction of the magnetic field. The KM110BH/2190 delivers a sinusoidal signal.

For new design-ins the KM110BH/23 and KM110BH/24 modules are recommended.

PINNING

PIN	DESCRIPTION
1	ground
2	V_{CC}
3	V_O

PIN CONFIGURATION

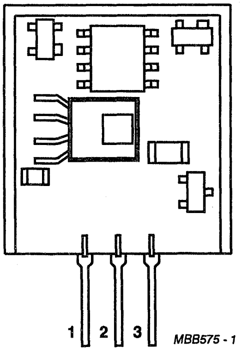


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
V_O	output voltage range	0.5	–	4.5	V
α	angle range				
	KM110BH/2130	−15	–	15	deg
	KM110BH/2190	−45	–	45	deg
T_{op}	operating temperature range	−40	–	125	°C

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{CC}	supply voltage	4.5	5.5	V
I_{CC}	supply current	–	20	mA
T_{stg}	storage temperature range	−40	125	°C
T_{op}	operating temperature range	−40	125	°C
	output short-circuit duration	permanent (see note 1)		

Note

1. If pin 3 is shorted to either pin 1 or pin 2, current may flow permanently, without damage to the device.

CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 5 V and a homogeneous magnetic field H_{ext} = 100 kA/m in the sensitive layer of the KMZ sensor unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
α	angle range (note 1)					
	KM110BH/2130		−15	−	15	deg
	KM110BH/2190	note 2	−45	−	45	deg
V_O	output voltage range					
	KM110BH/2130	linear, see Fig.4	0.5	−	4.5	V
	KM110BH/2190	sinusoidal, see Fig.5	0.5	−	4.5	V
V_{zero}	zero point voltage	$\alpha = 0$ deg	−	2.5	−	V
V_{off}	zero point offset voltage					
	KM110BH/2130		−45		+45	mV
	KM110BH/2190		−	±35	−	mV
S	sensitivity (note 3)	$\alpha = 0$ deg				
	KM110BH/2130		−	139	−	mV/deg
	KM110BH/2190		−	70	−	mV/deg
FL	deviation of linearity (note 4)					
	KM110BH/2130		−	−	±1	%/FS
	KM110BH/2190		−	−	−	%/FS
SP_{max}	maximum angular speed					
	KM110BH/2130		−	10	−	deg/ms
	KM110BH/2190		−	30	−	deg/ms
R_L	load resistance		10	−	−	kΩ
Temperature coefficients (−40 to +85 °C)						
TCV_{zero}	temperature coefficient of zero point voltage					
	KM110BH/2130		−	0.6	−	mV/K
	KM110BH/2190		−	0.3	−	mV/K
TCS	temperature coefficient of sensitivity		−	±200	−	ppm/K

Notes

1. Refer to Fig.3. The magnetic field can be achieved using the first magnet listed in Table 1. Other magnets, along with their required distances from the front of the KMZ sensor, are given in this table.
2. Valid for $H_{ext} = \infty$. The real field strength of 100 kA/m gives a slightly higher operating angle range of ±46.5 deg.
3. The sensitivity will change slightly with +0.33% per 10% magnetic field increase if H_{ext} deviates from 100 kA/m.
4. Deviation from best straight line in angle range.

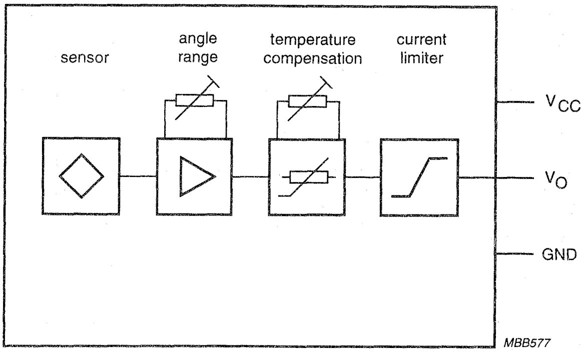


Fig.2 Circuit diagram.

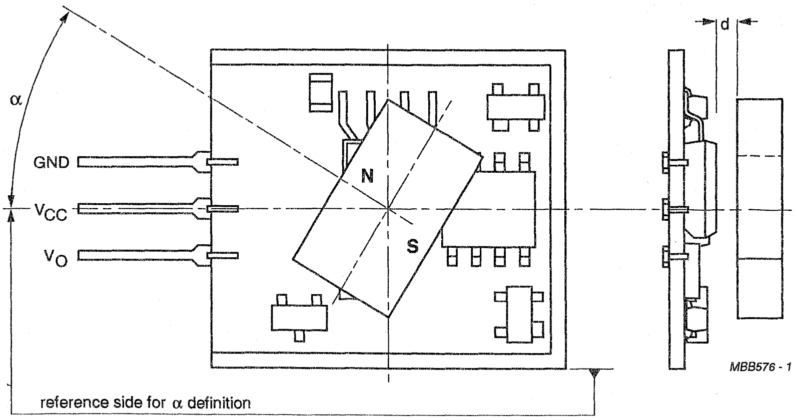


Fig.3 Optimum magnet position relative to the sensor module.

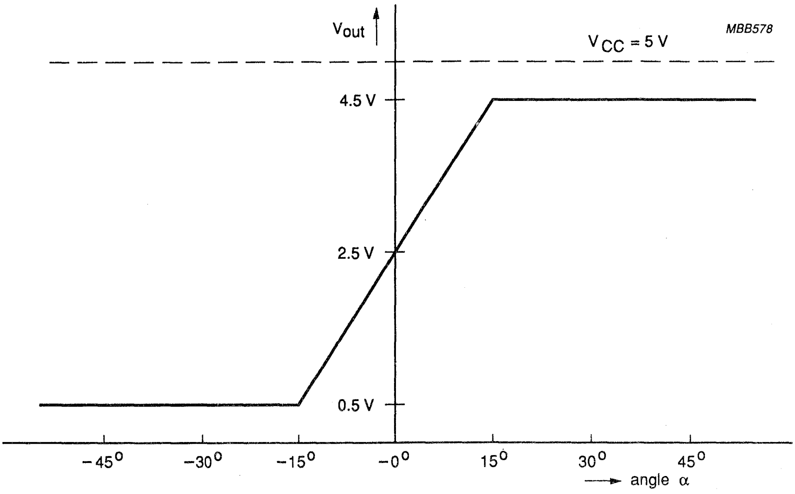


Fig.4 Output signal of KM110BH/2130.

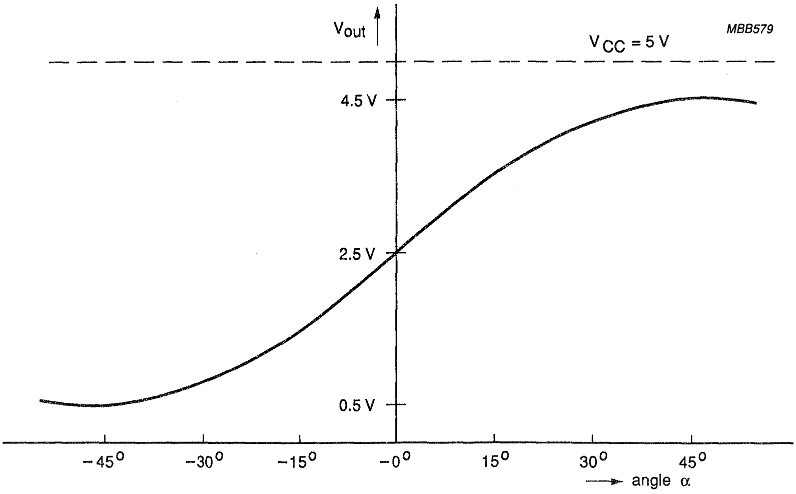


Fig.5 Output signal of KM110BH/2190.

Table 1 Magnets for angle sensor hybrids

MAGNETS			HYBRID ANGLE SENSORS			
MATERIAL	**DIMENSIONS (note 1) (mm)**	**TEMP. RANGE (°C)**	**DISTANCE d (note 2) (mm)**	**ANGLE RANGE CORRESPONDING TO V_O = 0.5 to 4.5 V**		**TEMP. RANGE (°C)**
				/2130	**/2190**	
NdFeB (note 3)	11.2 x 5.5 x 8	−55 to +110	2.5	30	93	−40 to +125
NdFeB (note 3)	6 x 3 x 5		0.8			
SmCo	11.2 x 5.5 x 8	−55 to +125	2.0	30	93	
SmCo	6 x 3 x 5		0.6			
FXD 330	10 x 7 x 8	−55 to +125	0.5	30.5	94.5	
FXD 330	7 x 5 x 4		0.2	30	93	

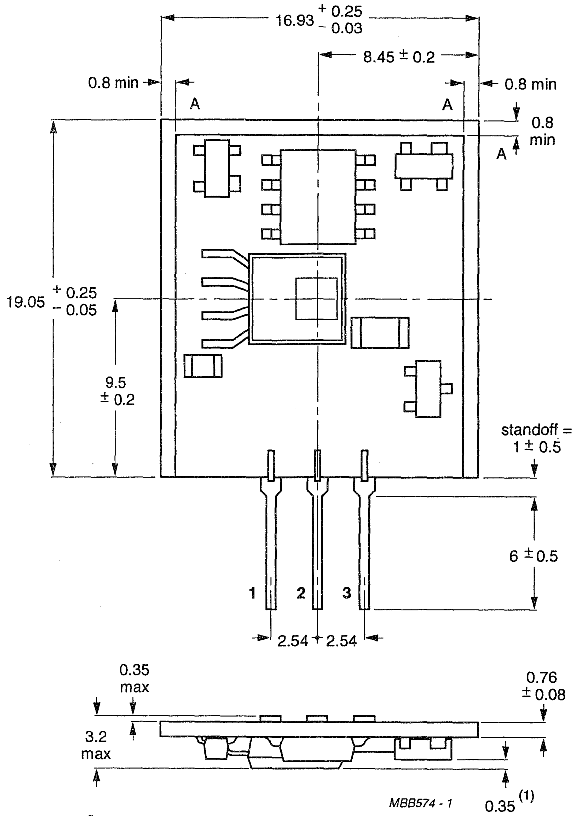
Notes

1. The magnetization is always parallel to the latter dimension given.
2. Between magnet and KMZ sensor front as shown in Fig.3.
3. Special care must be taken to avoid exposure of NdFeB magnets to moisture or vapour.

APPLICATION

In life-support systems, the behaviour of electronic components throughout their working life can be unpredictable. The use of these devices in support systems can only be permitted when there is no danger to life caused by devices failing unexpectedly.

PACKAGE OUTLINE



Dimensions in mm.

Area 'A' free of SMD devices.

(1) Sensitive layer below KMZ front.

Fig.6 KM110BH/2130; KM110BH/2190.

Angle sensor hybrid circuit KM110BH/2270

FEATURES

- Angle measuring range 70°
- Contactless, therefore wear-free and no micro-linearity problems
- Easy to mount, ready for use
- Analog current output signal
- Operating temperatures up to 100 °C
- EMC resistant
- Sample kit with magnet available.

DESCRIPTION

Sensor module for contactless measurement of angular displacements of strong magnetic fields between –35° and +35°. The module is a ready-trimmed (sensitivity and zero point) combination of the magnetoresistive sensor KMZ10B and a signal conditioning circuit in hybrid technology. The KMZ110BH/2270 delivers a sinusoidal current output signal which is a function of the direction of the magnetic field. The module can be used for contactless angle measurement.

PIN OPTIONS

The KMZ110BH/2270 sensor hybrid is available with different electrical contacts.

- Stretched pins with a pitch of 2.54 mm. These pins are recommended for connector and/or cable connections.
- Double 's' bent pins (see Fig. 6) with a pitch of 5.71 mm. Bent pins are recommended for rigid soldered connections to compensate for mechanical stress. This hybrid circuit is available under type number KM110BH/2270G.

PINNING

PIN	DESCRIPTION
1	ground
2	V_{CC}
3	I_o

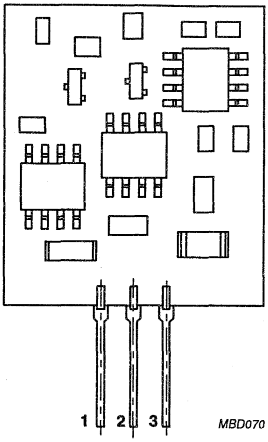


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	8.5	–	V
I_o	output current range	–	4 to 20	–	mA
α	angle range	–	–35 to +35	–	deg
T_{op}	operating temperature	–40	–	+100	°C

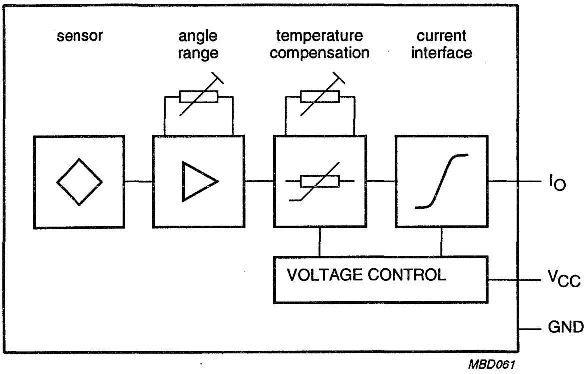


Fig.2 Circuit diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage	8.1	11	V
I_{CC}	supply current	–	40	mA
T_{stg}	storage temperature	–40	+125	°C
T_{op}	operating temperature	–40	+100	°C
	output short-circuit duration	permanent; note 1		

Note

1. If pin 3 is shorted to either pin 1 or pin 2, current may flow permanently, without damage to the device.

CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 8.5 V and a homogeneous magnetic field H_{ext} = 100 kA/m in the sensitive layer of the KMZ10B sensor, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
α	angle range	note 1	–	–35 to +35	–46.5 to +46.5	deg
I_o	output current range	note 2; sinusoidal, see Fig.4	–	4 to 20	3.2 to 20.8	mA
I_{zero}	zero point current	$\alpha = 0°$	–	12	–	mA
I_{offset}	zero point offset current		–	±120	–	μA
S	sensitivity	$\alpha = 0°$; note 3	0.289	0.292	0.295	mA/deg
Rp	reproducibility	$\alpha = 0°$; note 4	–	<0.001	–	deg
Rs	resolution	$\alpha = 0°$; note 5	–	<0.001	–	deg
Rhy	hysteresis	$\alpha = 0°$; note 6	–	<0.05	–	deg
SP_{max}	maximum angular speed		–	20	–	deg/ms
R_L	load resistance		–	200	220	Ω
Temperature coefficients (–40 to +85 °C)						
TCI_{zero}	temperature coefficient of zero point current		–	±1.5	–	μA/K
TCS	temperature coefficient of sensitivity		–	±100	–	ppm/K

Notes

1. Refer to Fig.3. The magnetic field H_{ext} = 100 kA/m can be achieved using the magnets listed in Table 1.
2. Maximum values refer to ±46.5° including offset and sensitivity tolerances.
3. The sensitivity will change slightly with +0.33% per 10% magnetic field increase if H_{ext} deviates from 100 kA/m.
4. Difference in output signal (expressed in degrees) between two zero point ($\alpha = 0$) measurements, in which the zero point is approached from the same side of the measuring range (e.g. cycle: +35° → 0° → +35° → 0°).
5. The smallest detectable change of angle $\Delta\alpha$ for $\alpha = 0°$ (cycle: 0° → $\Delta\alpha$).
6. As note 4, but with the zero point being approached from the upper end and lower end of the measuring range respectively (cycle: +35° → 0° → –35° → 0°).

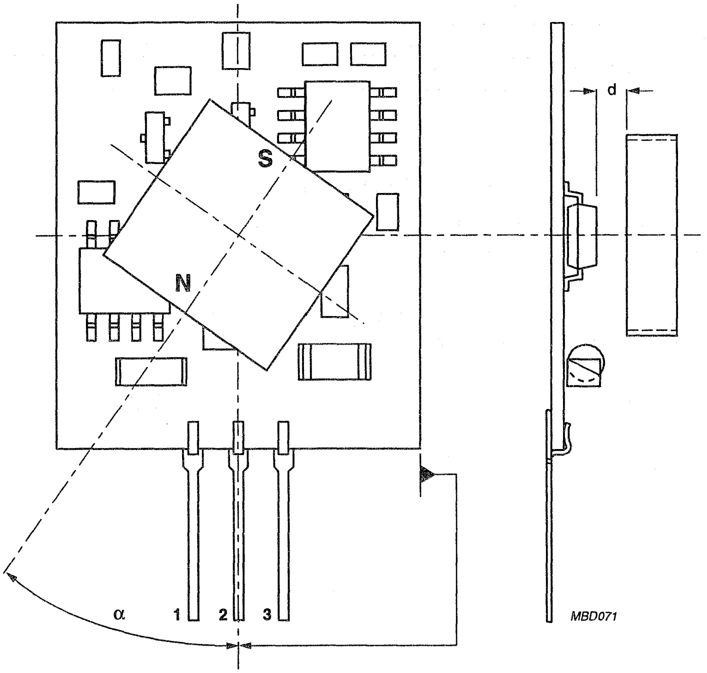


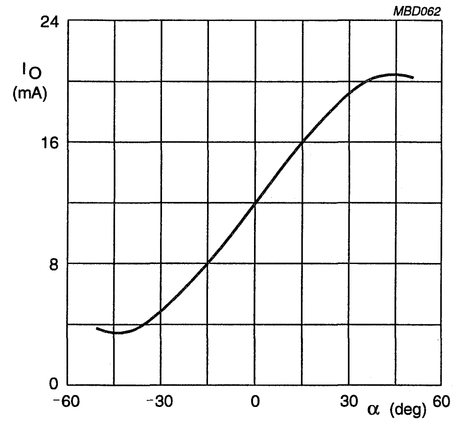
Fig.3 Optimum magnet position relative to the sensor module.

Table 1 Magnets for angle sensor hybrid.

MATERIAL	DIMENSIONS (note 1) (mm)	DISTANCE 'd' (note 2) (mm)	TOLERANCE OF 'd' (note 3) (mm)	EXCENTRICITY (note 4) (mm)	TEMPERATURE RANGE (°C)
Sm_2Co_{17}	11.2 x 5.5 x 8	2.1	±0.30	±0.25	−55 to +125
	6 x 3 x 5	0.7	±0.15	±0.15	
	8 x 3 x 7.5	0.5	±0.30	±0.20	

Notes

1. The magnetization is always parallel to the latter given dimensions.
2. Between magnet and KMZ11B1 sensor front as shown in Fig.3.
3. Maximum deviation of distance 'd' for which the change in sensor output signal is smaller than 0.5% of full scale sensor signal.
4. Maximum deviation of magnet rotational axis to sensor rotational axis for which the change in sensor output signal is smaller than 0.5% of full scale sensor signal.



$I_{o(nom)} = 12 + 8.644 \times \sin(1.935 \times \alpha)$ in the range $-46.5° \leq \alpha \leq +46.5°$.
$T_{amb} = 25$ °C; $V_{CC} = 8.5$ V; $H_{ext} = 100$ kA/m.

Fig.4 Output current as a function of angular displacement.

APPLICATION INFORMATION

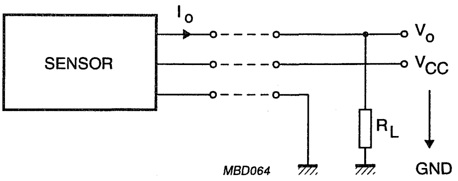
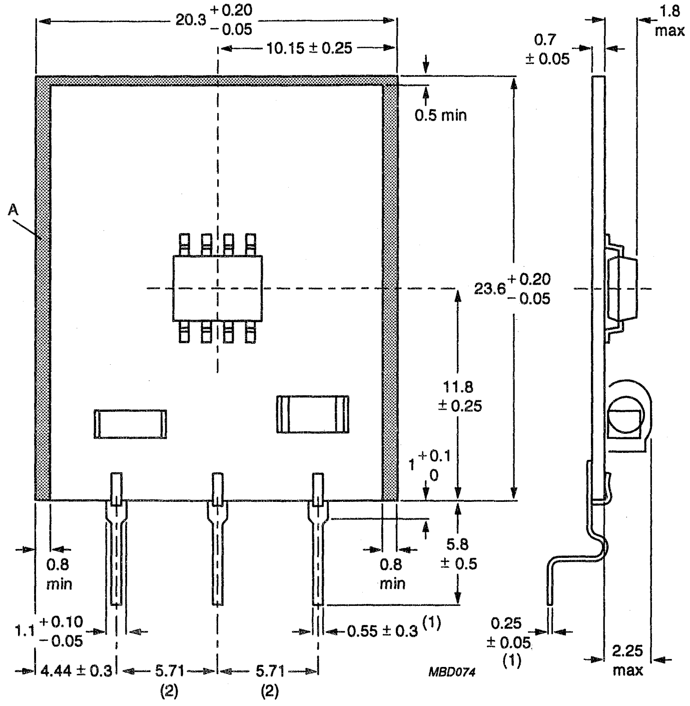


Fig.5 Application example.

PACKAGE OUTLINE - BENT PIN OPTION



Dimensions in mm.

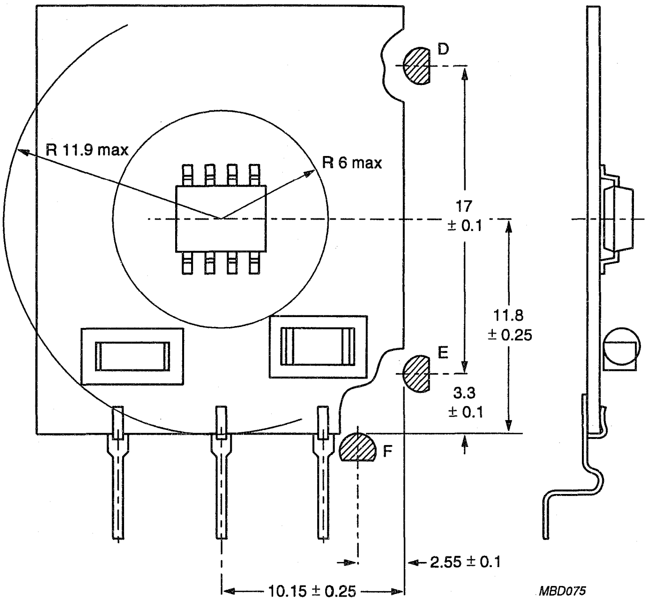
Area 'A' (shaded) free of SMD devices.

(1) Dimension before bath soldering; maximum dimension after bath soldering: 0.7 mm.

(2) Pitch tolerance: 0.2 mm.

Fig.6 KM110BH/2270G.

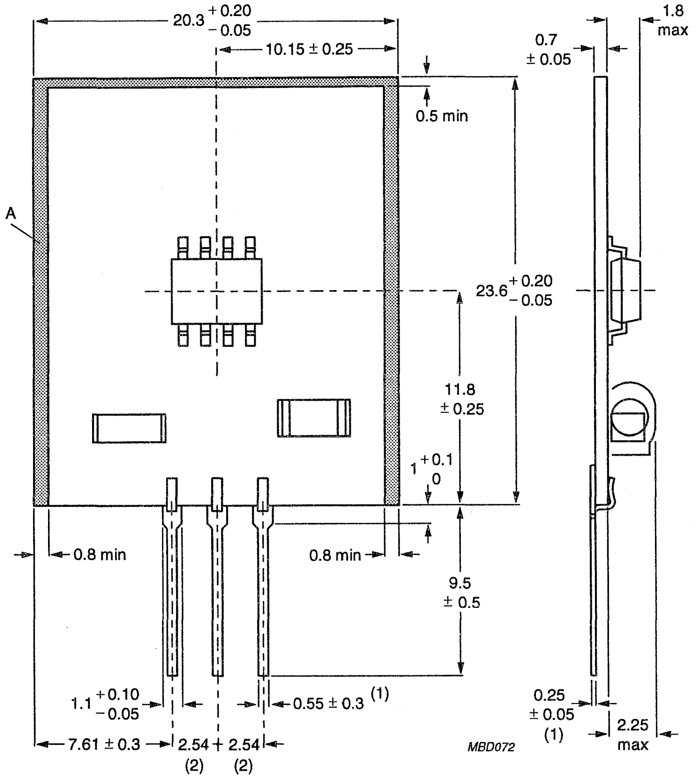
REFERENCE DATA FOR THE ASSEMBLY AND MAGNET POSITIONING - BENT PIN OPTION



Dimensions in mm.
D,E: Definition of reference side for angle α.
D,E,F: Reference points for sensor assembly.
Radii for free rotation of magnets due to height of the components on the hybrid circuit.

Fig.7 KM110BH/2270G.

PACKAGE OUTLINE - STRETCHED PIN OPTION



Dimensions in mm.

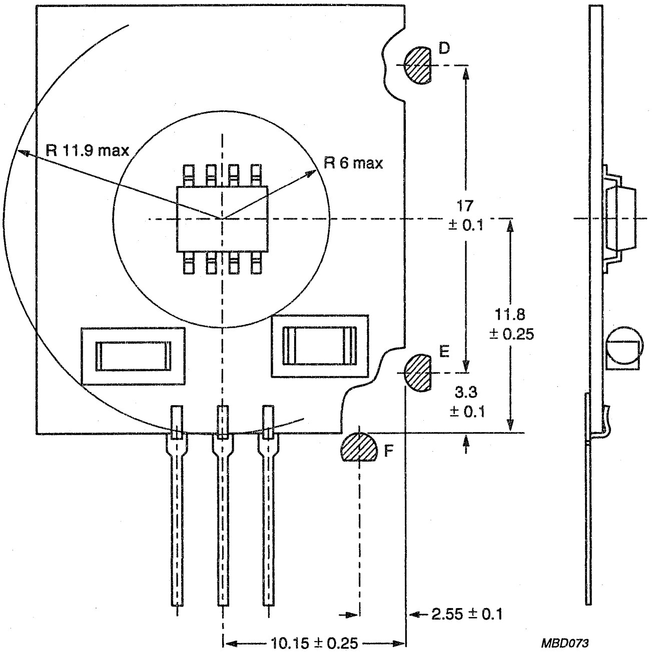
Area 'A' (shaded) free of SMD devices.

(1) Dimension before bath soldering; maximum dimension after bath soldering: 0.7 mm.

(2) Pitch tolerance: 0.2 mm.

Fig.8 KM110BH/2270.

REFERENCE DATA FOR THE ASSEMBLY AND MAGNET POSITIONING - STRETCHED PIN OPTION



Dimensions in mm.
D,E: Definition of reference side for angle α.
D,E,F: Reference points for sensor assembly.
Radii for free rotation of magnets due to height of the components on the hybrid circuit.

Fig.9 KM110BH/2270.

Angle sensor hybrid KM110BH/2390

FEATURES

- Linear angle measuring range >90°
- Contactless, therefore wearfree
- 5 V supply, ratiometric voltage output signal
- Operating temperatures up to 125 °C
- Sample kit with magnet available.

DESCRIPTION

Sensor module for contactless measurement of angular displacements of strong magnetic fields. The module is a ready-trimmed (sensitivity and zero point) combination of a magnetoresistive sensor KMZ and a signal conditioning circuit in hybrid technology. The KM110BH/2390 delivers a voltage output signal which is a linear function of the direction of the magnetic field.

PINNING

PIN	DESCRIPTION
1	GND (ground)
2	V_{CC}
3	V_O

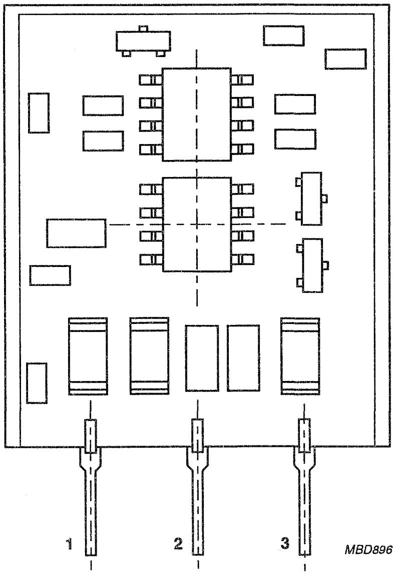


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	4.5	5	16	V
I_{CC}	supply current	–	17	–	mA
T_{oper}	operating temperature	–40	–	+125	°C
α	angle range	–	–45 to +45	–	deg
V_O	output voltage range	–	0.5 to 4.5	–	V

BLOCK DIAGRAM

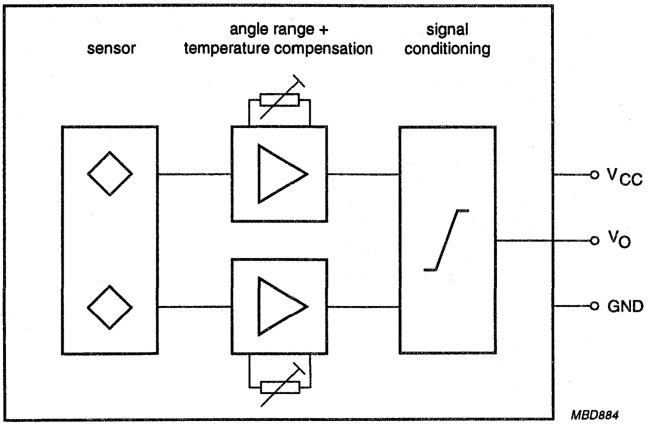


Fig.2 Block diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage	4.5	16	V
I_{CC}	supply current	–	25	mA
T_{stg}	storage temperature	–40	+125	°C
T_{oper}	operating temperature; note 1	–40	+125	°C
	output short-circuit duration	permanent (see note 2)		

Notes

1. For operations above T_{oper} = 100 °C, maximum V_{CC} derates linearly from 16 V to 5 V at T_{oper} = 125 °C.
2. If pin 3 is shorted to pin 1, a current may flow permanently, without damaging the device.

CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 5 V; $R_L \geq 25$ kΩ and a homogeneous magnetic field H_{ext} = 100 kA/m in the sensitive layer of the KMZ sensor, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
α	angle range	note 1	–	–45 to +45	–53 to +53	deg
V_O	output voltage range	linear; see Fig.4	–	0.5 to 4.5	0.15 to 4.85	V
V_{ref}	reference point voltage	$\alpha = 0°$; note 2	–	2.5	–	V
α_{ref}	reference point offset angle	related to hybrid edges; see Fig.5	–	1	3	deg
$\Delta\alpha$	maximum expected angle error	related to V_{ref} = 2.5 V:				
		T_{amb} = –20 to +85 °C	–	–	1	deg
		T_{amb} = –40 to –20 °C	–	–	1.5	deg
		T_{amb} = +85 to +125 °C	–	–	1.5	deg
S	sensitivity	$\alpha = 0°$; note 3	43.5	44.5	45.5	mV/deg
FL	deviation of linearity	note 4	–	±1	±2	%·FS
R_p	reproducibility	$\alpha = 0°$; note 5	–	<0.001	–	deg
FH	hysteresis	$\alpha = 0°$; note 6	–	<0.05	–	deg
SP_{max}	maximum angular speed		–	50	–	deg/ms
R_L	load resistance		10	–	–	kΩ
C_L	load capacitance		–	–	10	nF
Temperature coefficients (–40 to +100°C)						
TCV_O	temperature drift of output voltage	α = constant	–	0.2	0.6	mVK^{-1}
TCS	temperature coefficient of sensitivity		–	$\pm100 \times 10^{-6}$	–	K^{-1}

Notes

1. Refer to Fig.3. The magnetic field H_{ext} = 100 kA/m can be achieved using the magnets listed in Table 1.
2. Any other position of the sensor characteristic can be defined as electrical reference point. Best results in view of temperature stability of reference point will be achieved at V_O = 0.5 V, V_O =2.5 V and V_O = 4.5 V.
3. The sensitivity will change slightly with +0.07% per 10% magnetic field increase if H_{ext} deviates from 100 kA/m.
4. Deviation from best straight line in angle range.
5. Difference in output signal (expressed in degrees) between two zero point ($\alpha = 0°$) measurements, in which the zero point is approached from the same side of the measuring range (e.g. cycle: +45° ⇒ 0° ⇒ +45° ⇒ 0°).
6. As note 5, but with the zero point being approached from the upper end and lower end of the measuring range respectively (cycle: +45° ⇒ 0° ⇒ –45° ⇒ 0°).

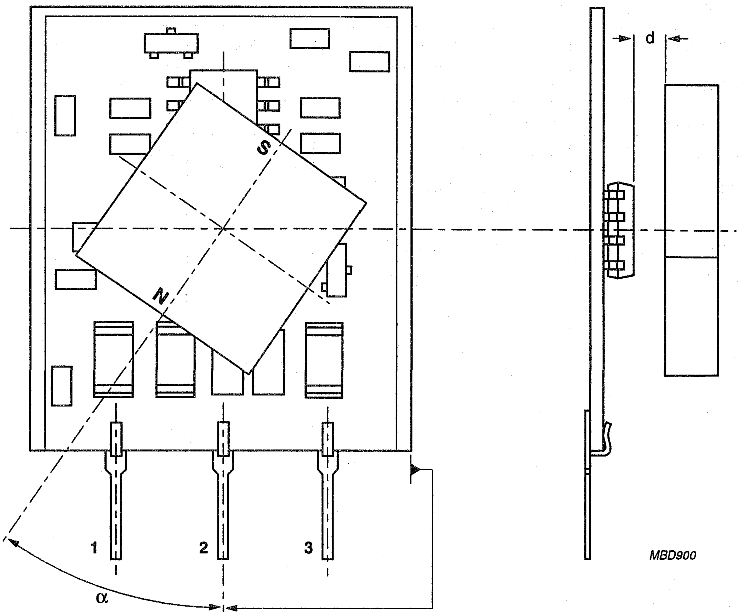


Fig.3 Optimum magnet position relative to the sensor module.

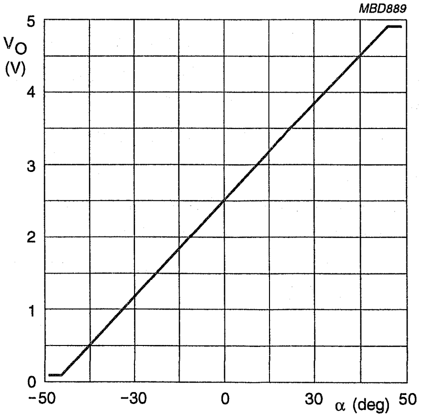
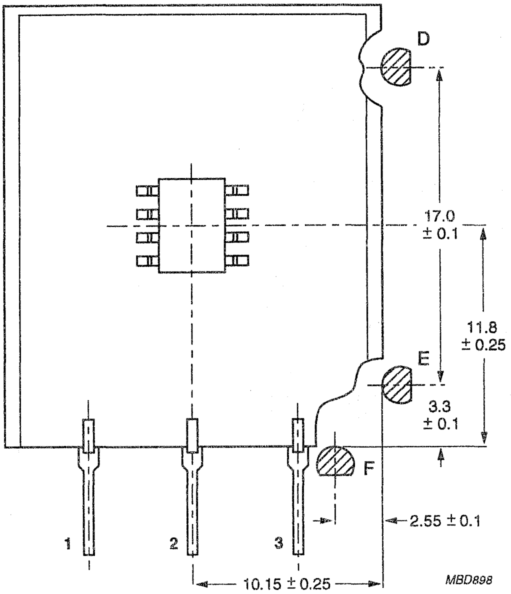


Fig.4 Output signal as a function of angle position.



Dimensions in mm.

D, E and F: reference points for sensor assembly.

D and E: definition points of reference side for angle α.

Fig.5 Reference data for hybrid assembly and magnet positioning.

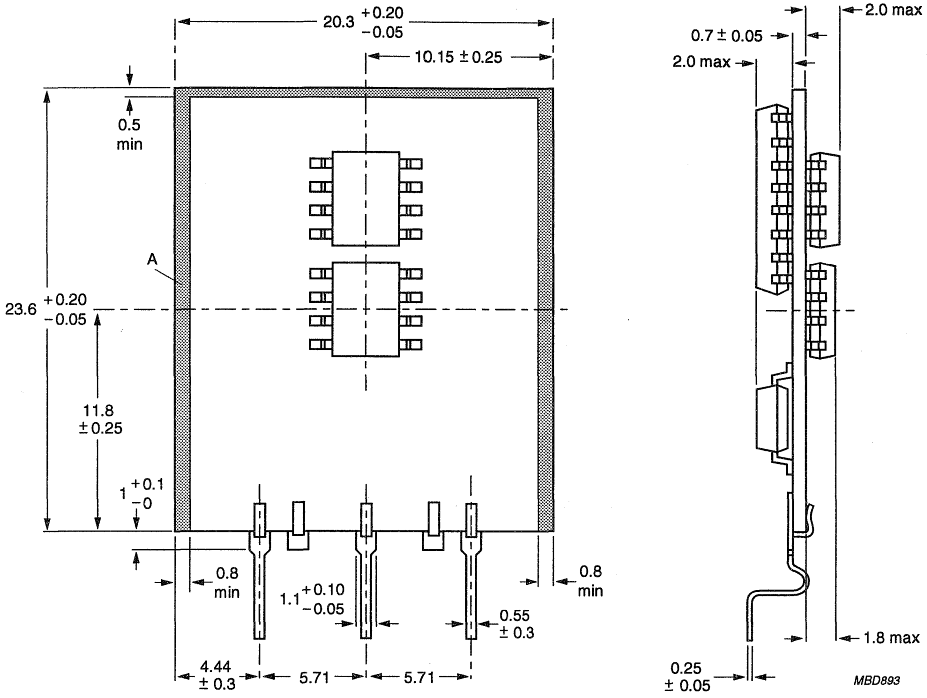
Table 1 Magnets for angle sensor hybrid.

MATERIAL	DIMENSIONS(1) (mm)	d(2) (mm)	TOLERANCE(3) D (MM)	ECCENTRICITY(4) (mm)	T_{amb} (°C)
Sm_2Co_{17}	11.2 × 5.5 × 8	2.1	±0.30	±0.25	−55 to +125
	6 × 3 × 5	0.7	±0.15	±0.15	
	8 × 3 × 7.5	0.5	±0.30	±0.20	

Notes

1. The magnetization is always parallel to the latter dimensions given.
2. Distance (d) between magnet and KMZ sensor front as shown in Fig.3.
3. Maximum deviation of distance (d) for which the change in sensor output signal is smaller than 0.5% of full scale sensor signal.
4. Maximum deviation of magnet rotational axis to sensor rotational axis for which the change in sensor output signal is smaller than 0.5% of full scale sensor signal.

PACKAGE OUTLINE



Dimensions in mm.
Area 'A' free of SMD devices.

Fig.6 Outline of KM110BH/2390.

30° and 70° angle sensor hybrids

KM110BH/2430; KM110BH/2470

FEATURES

- Angle measuring range 30° or 70°
- Contactless, therefore wearfree and no microlinearity problems
- Easy to mount, ready for use
- Analog voltage output signal
- Operating temperatures up to 125 °C
- Precision of ± 0.5° in the temperature range (–15° ≤ α ≤ +15°)
- EMC resistant
- Sample kit with magnet available.

DESCRIPTION

The KM110BH/2430 and the KM110BH/2470 are sensor modules for contactless measurement of angular displacements of strong magnetic fields. The modules are a ready-trimmed (sensitivity and zero point) combination of a magnetoresistive sensor KMZ and a signal conditioning circuit in hybrid technology.

The KM110BH/2430 delivers a voltage output signal which is a linear function of the direction of the magnetic field. The KM110BH/2470 delivers a sinusoidal voltage output signal. The modules can be used for contactless angle measurement.

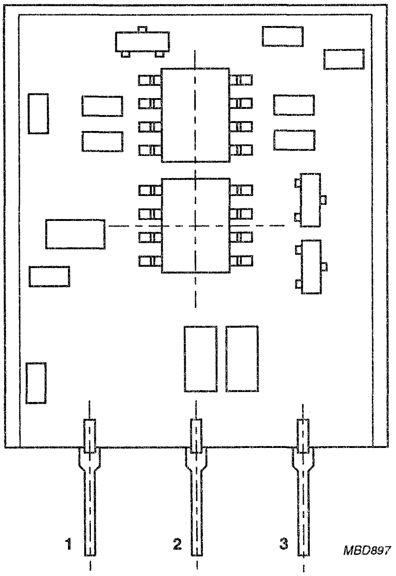


Fig.1 Simplified outline.

PINNING

PIN	SYMBOL	DESCRIPTION
1	GND	ground
2	V_{CC}	DC supply voltage
3	V_O	output voltage

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	4.5	5	16	V
T_{oper}	operating temperature	–40	–	+125	°C
α	angle range:				
	KM110BH/2430	–	–15 to +15	–	deg
	KM110BH/2470	–	–35 to +35	–	deg
V_O	output voltage range	–	0.5 to 4.5	–	V

EMC RESISTIVITY

The EMC compatibility is dependent on the assembly of the sensors. The EMC resistivity has to be tested in the final application.

BLOCK DIAGRAM

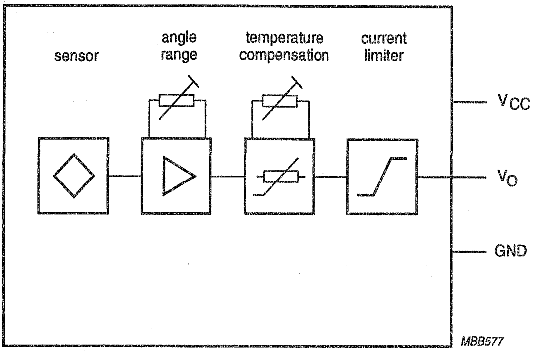


Fig.2 Block diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage	4.5	16	V
I_{CC}	supply current	–	15	mA
T_{stg}	storage temperature	–40	+125	°C
T_{oper}	operating temperature; note 1	–40	+125	°C
	output short-circuit duration	permanent; see note 2		

Notes

1. For operations above T_{oper} = 100 °C, maximum V_{CC} derates linearly from 16 V to 5 V at T_{oper} = 125 °C.
2. If pin 3 is shorted to either pin 1 or pin 2, a current may flow permanently, without damaging the device.

CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 5 V; R_L = 1.7 kΩ and a homogeneous magnetic field H_{ext} = 100 kA/m in the sensitive layer of the KMZ sensor, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
α	angle range:	note 1				
	KM110BH/2430		–	–15 to +15	–	deg
	KM110BH/2470		–	–35 to +35	–	deg
V_O	output voltage range:					
	KM110BH/2430	linear; see Fig.4	–	0.5 to 4.5	–	V
	KM110BH/2470	sinusoidal; see Fig.5	–	0.5 to 4.5	–	V
V_{zero}	zero point voltage	$\alpha = 0°$	–	2.5	–	V
V_{off}	zero point offset voltage:	related to sinusoidal sensor characteristic; see Fig.5				
	KM110BH/2430		–	±25	–	mV
	KM110BH/2470		–	±15	–	mV
α_{off}	zero point offset angle	related to hybrid edges; see Fig.7	–	1	3	deg
S	sensitivity:	$\alpha = 0°$; note 2				
	KM110BH/2430		137	140	143	mV/deg
	KM110BH/2470		73	74.5	76	mV/deg
P	precision:	–20 to +100°C	–			
	KM110BH/2430			0.2	0.5	deg
	KM110BH/2470			0.5	1.2	deg
FL	deviation of linearity:	note 3				
	KM110BH/2430		–	±1	–	%·FS
	KM110BH/2470		–	–	–	%·FS
R_p	reproducibility	$\alpha = 0°$; note 4	–	<0.001	–	deg
R_s	resolution	$\alpha = 0°$; note 5	–	<0.001	–	deg
FH	hysteresis	$\alpha = 0°$; note 6	–	<0.05	–	deg
SP_{max}	maximum angular speed:					
	KM110BH/2430		–	60	–	deg/ms
	KM110BH/2470		–	150	–	deg/ms
R_L	load resistance		1.7	–	–	kΩ
C_L	load capacitance		–	–	10	nF
Temperature coefficients (–40 to +100 °C)						
TCV_{zero}	temperature coefficient of zero point voltage:					
	KM110BH/2430		–	0.2	0.6	mV/K
	KM110BH/2470		–	0.1	0.3	mV/K
TCS	temperature coefficient of sensitivity	–20 to 100°C	–	100×10^{-6}	–	K^{-1}

Notes to the characteristics

1. Refer to Fig.3. The magnetic field H_{ext} = 100 kA/m can be achieved using the magnets listed in Table 1.
2. The sensitivity will change slightly with +0.33% per 10% magnetic field increase if H_{ext} deviates from 100 kA/m.
3. Deviation from best straight line in angle range.
4. Difference in output signal (expressed in degrees) between two zero point ($\alpha = 0°$) measurements, in which the zero point is approached from the same side of the measuring range (e.g. cycle: +15° ⇒ 0° ⇒ +15° ⇒ 0°).
5. The smallest detectable change of angle $\Delta\alpha$ for $\alpha = 0°$ (cycle: 0° ⇒ $\Delta\alpha$).
6. As note 4, but with the zero point being approached from the upper end and lower end of the measuring range respectively (cycle: +15° ⇒ 0° ⇒ −15° ⇒ 0°).

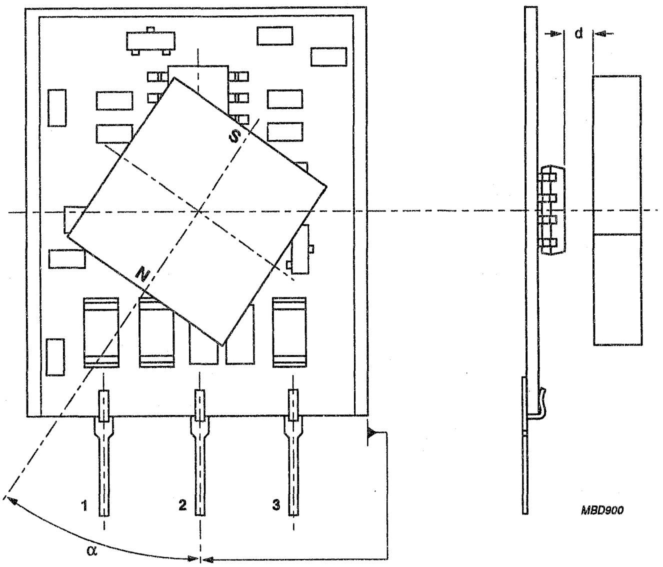


Fig.3 Optimum magnet position relative to the sensor module.

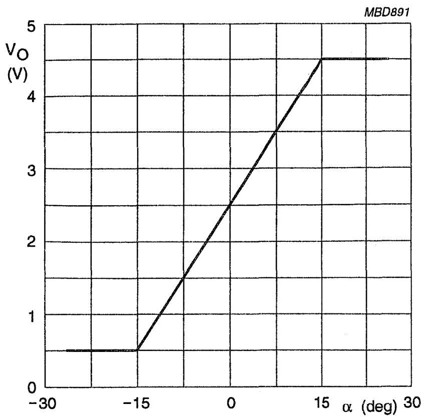


Fig.4 KM110BH/2430 output signal as a function of angle position.

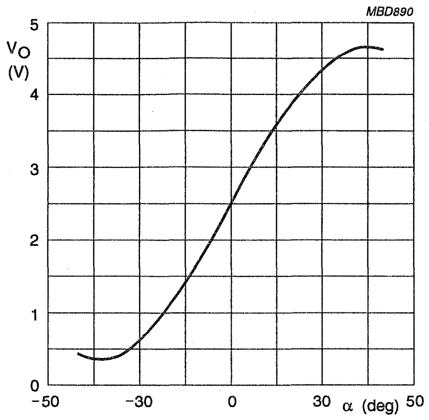
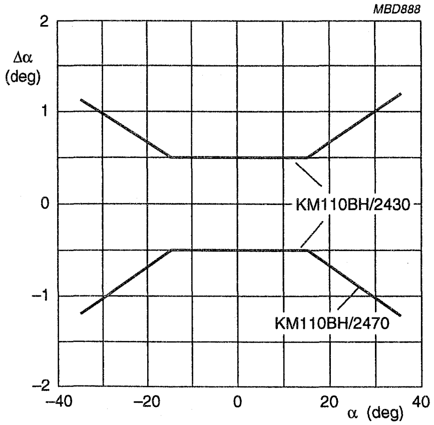


Fig.5 KM110BH/2470 output signal as a function of angle position.



T_{amb} = −25 to +85 °C.

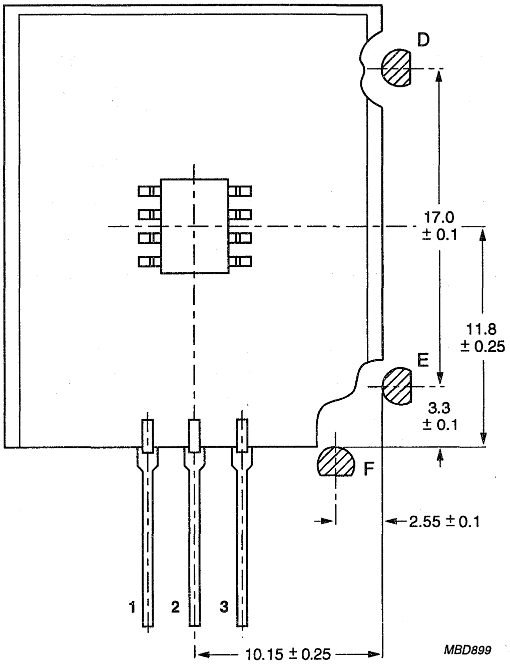
α = 0° for T_{amb} = 25 °C and V_O = 2.5 V.

Δα increases by a factor 2 in the temperature range:

$V_O = 2.5 + 2.128 \times \sin(2\alpha)$ for $-36.5° \leq \alpha \leq +36.5°$.

T_{amb} = 25 °C; V_{CC} = 5 V; H_{ext} = 100 kA/m.

Fig.6 Maximum angle error Δα as a function of the angle position.



Dimensions in mm.
D, E, F : reference points for sensor assembly.
D, E : definition of reference side for angle α.

Fig.7 Reference data for hybrid assembly and magnet positioning.

Table 1 Magnets for angle sensor hybrid

MATERIAL	DIMENSIONS[(1)] (mm)	d[(2)] (mm)	TOLERANCE[(3)] d (mm)	ECCENTRICITY[(4)] (mm)	T_{amb} (°C)
Sm_2Co_{17}	11.2 × 5.5 × 8	2.1	±0.30	±0.25	−55 to +125
	6 × 3 × 5	0.7	±0.15	±0.15	
	8 × 3 × 7.5	0.5	±0.30	±0.20	

Notes

1. The magnetization is always parallel to the latter dimensions given.
2. Distance (d) between magnet and KMZ sensor front as shown in Fig.3.
3. Maximum deviation of distance (d) for which the change in sensor output signal is smaller than 0.5% of full scale sensor signal.
4. Maximum deviation of magnet rotational axis to sensor rotational axis for which the change in sensor output signal is smaller than 0.5% of full scale sensor signal.

APPLICATION INFORMATION

The sensor hybrids KM110BH/2430 and KM110BH/2470 are available with different electrical contacts:

1. Stretched pins with a pitch of 2.54 mm; these pins are recommended for connector and/or cable connections (see Fig.9).
2. Double 's' bent pins (see Fig.10) with a pitch of 5.71 mm; bent pins are recommended for rigid soldered connections to compensate for mechanical stress. Quote type numbers KM110BH/2430G and KM110BH/2470G respectively for these hybrids.

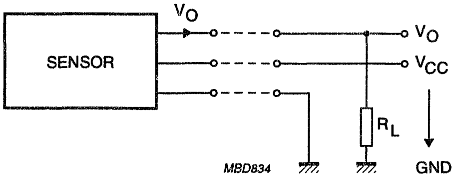
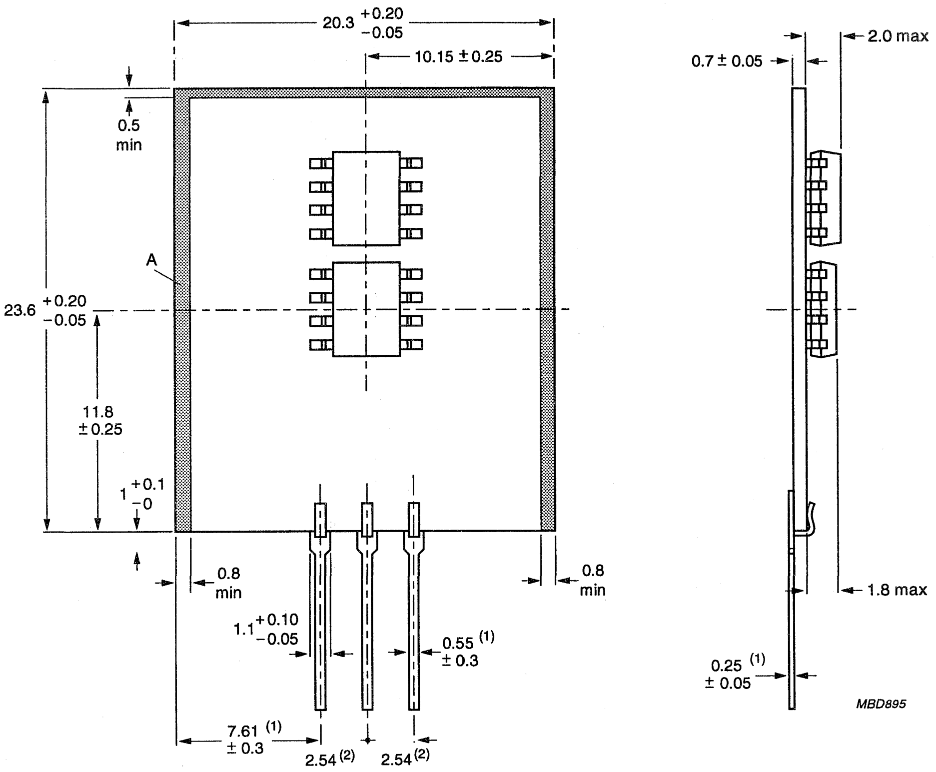


Fig.8 Application circuit.

PACKAGE OUTLINES



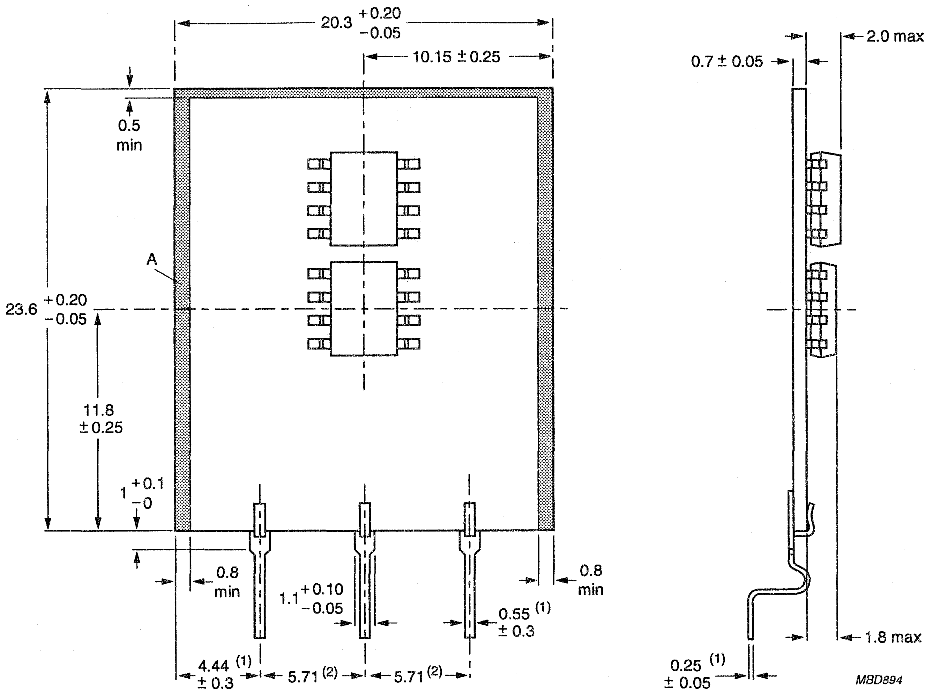
Dimensions in mm.

Area 'A' free of SMD devices.

(1) Dimension before bath soldering, maximum dimension after bath soldering: ∅ 0.7 mm.

(2) Pitch tolerance: ± 0.2 mm.

Fig.9 Outline of KM110BH/2430 and KM110BH/2470.



Dimensions in mm.

Area 'A' free of SMD devices.

(1) Dimension before bath soldering, maximum dimension after bath soldering: Ø 0.7 mm.

(2) Pitch tolerance: ± 0.2 mm.

Fig.10 Outline of KM110BH/2430G and KM110BH/2470G.

Contactless angle sensor KMA10/70

FEATURES

- Angle measuring range 70°
- Contactless, therefore wear-free and no micro-linearity problems
- Easy to mount, ready for use
- Mechanically adjustable
- Analog current output signal
- Operating temperatures up to 100 °C
- Rugged mechanical design
- Resistant against aggressive media, pressurized water, etc.
- EMC resistant
- Sample kit with connector available.

PINNING

PIN	DESCRIPTION
1	ground
2	V_{CC}
3	I_o

DESCRIPTION

Sensor module for contactless measurement of angular displacements of strong magnetic fields between −35° and +35°. The sensor is based on the magnetoresistive sensor KMZ11B1 and contains a signal conditioning circuit in hybrid technology. The KMA10/70 delivers a sinusoidal current output signal which is a function of the angular displacement. The sensor can be used for contactless angle measurement or as a contactless potentiometer and can be directly mounted into equipment.

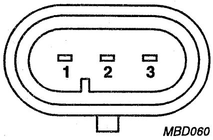


Fig.1 Simplified connector outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	8.5	–	V
I_o	output current range	–	4 to 20	–	mA
α	angle range	–	−35 to +35	–	deg
T_{op}	operating temperature	−40	–	+100	°C

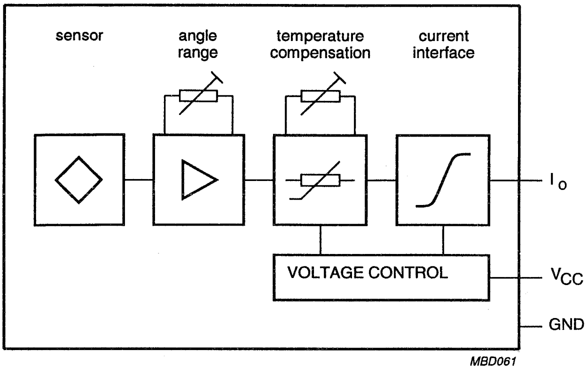


Fig.2 Functional diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage	8.1	11	V
I_{CC}	supply current	–	40	mA
T_{stg}	storage temperature	–40	+125	°C
T_{op}	operating temperature	–40	+100	°C
	output short-circuit duration	permanent; note 1		

Note

1. If pin 3 is shorted to either pin 1 or pin 2, current may flow permanently without damage to the device.

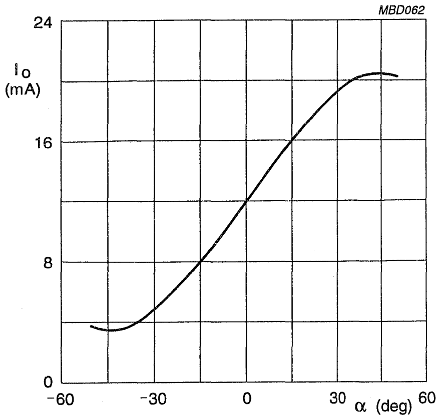
CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 8.5 V, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
α	angle range	see Fig.6	–	–35 to +35	–46.5 to +46.5	deg
I_o	output current range	sinusoidal; note 1 see Fig.3	–	4 to 20	3.2 to 20.8	mA
I_{zero}	zero point current	$\alpha = 0°$	–	12	–	mA
I_{offset}	zero point offset current		–	±120	–	μA
S	sensitivity	$\alpha = 0°$	0.289	0.292	0.295	mA/deg
Rp	reproducibility	$\alpha = 0°$; note 2	–	<0.001	–	deg
Rs	resolution	$\alpha = 0°$; note 3	–	<0.001	–	deg
Rhy	hysteresis	$\alpha = 0°$; note 4	–	<0.05	–	deg
SP_{max}	maximum angular speed		–	20	–	deg/ms
R_L	load resistance		–	200	220	Ω
Temperature coefficients (–40 to +85 °C)						
TCI_{zero}	temperature coefficient of zero point current		–	±1.5	–	μA/K
TCS	temperature coefficient of sensitivity		–	±100	–	ppm/K
Mechanical						
total mechanical travel			–	–75 to +75	–	deg
allowed torque to mechanical stop			–	–	0.2	Nm
maximum torque perpendicular to rotation axis			–	–	30	Nmm
maximum screw torque for fixing with washer (washer diameter ∅10 mm)			2	2.5	3	Nm
number of cycles (70°)			–	1×10^8	–	
number of dither cycles			–	8×10^8	–	
protection class according to DIN 40050			IP65	–	–	

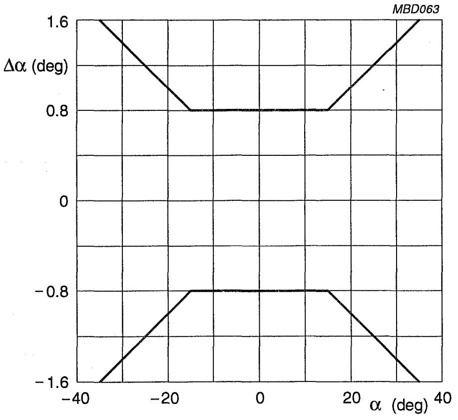
Notes

1. Maximum values refer to ±46.5° including offset and sensitivity tolerances.
2. Difference in output signal (expressed in degrees) between two zero point ($\alpha = 0$) measurements, in which the zero point is approached from the same side of the measuring range (e.g. cycle: +35° → 0° → +35° → 0°).
3. The smallest detectable change of angle $\Delta\alpha$ for $\alpha = 0°$ (cycle: $0° \rightarrow \Delta\alpha$).
4. As note 2, but with the zero point being approached from the upper end and lower end of the measuring range respectively (cycle: +35° → 0° → 35° → 0°).



$I_{o\,(nom)} = 12 + 8.644 \text{ x } \sin (1.935 \text{ x } \alpha)$ in the range $-46.5° \leq \alpha \leq +46.5°$.
T_{amb} = 25 °C; V_{CC} = 8.5 V.

Fig.3 Output current as a function of angular displacement.



The zero point α = 0 is defined for I_o = 12 mA.
T_{amb} = −20 to +85 °C.
Δα increases by a factor of 2 for T_{amb} = −40 to −20 °C and +85 °C to +100 °C.

Fig.4 Maximum absolute angle error Δα.

APPLICATION INFORMATION

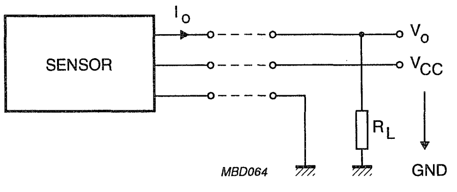


Fig.5 Application example.

MECHANICAL DATA

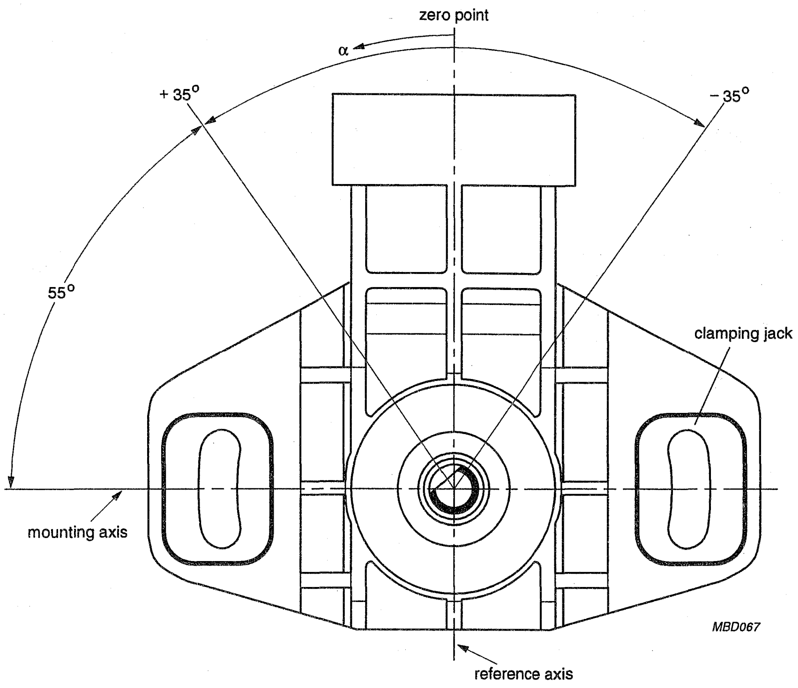


Fig.6 Front view.

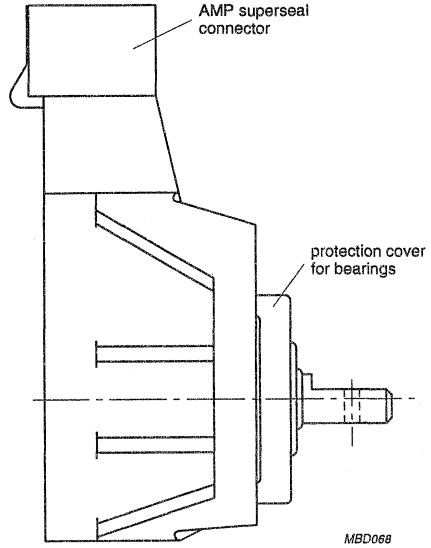
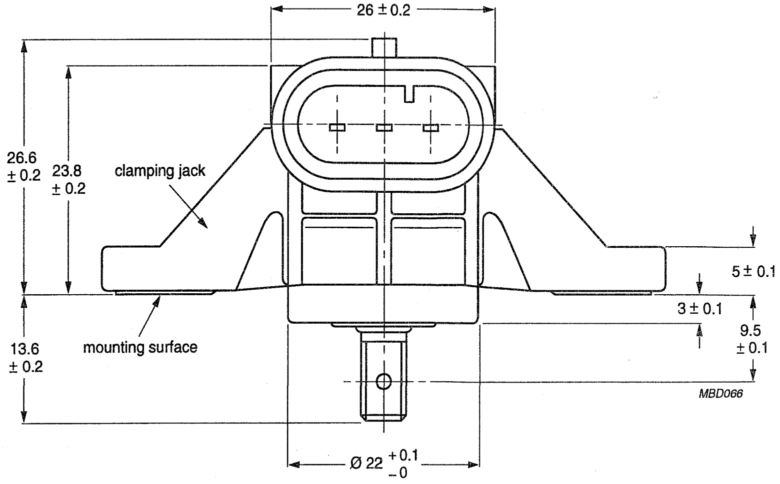
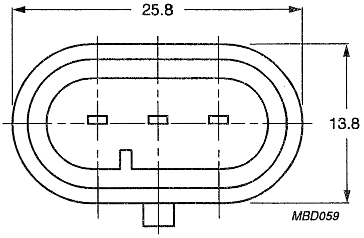


Fig.7 Side view.



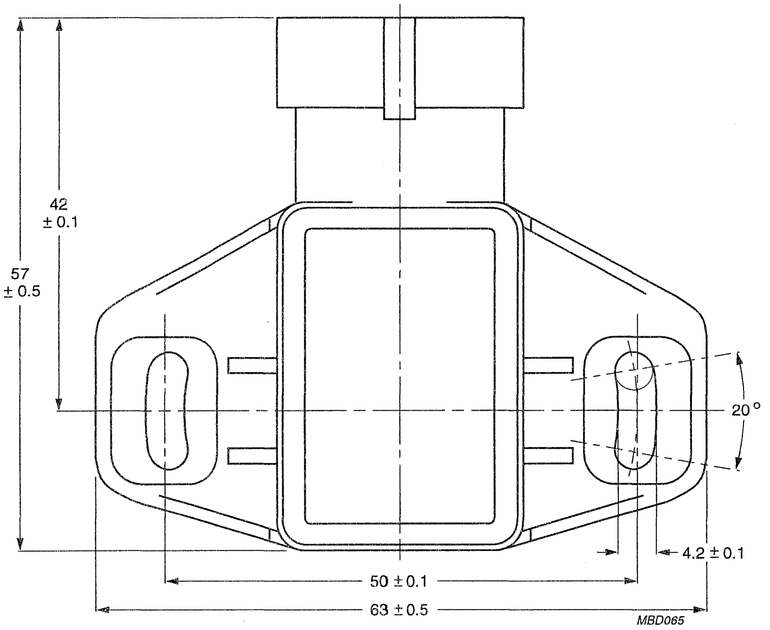
Dimensions in mm.

Fig.8 Top view and dimensions.



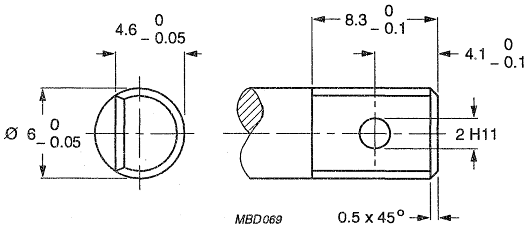
Dimensions in mm.

Fig.9 Connector detail.



Dimensions in mm.

Fig.10 Back view and dimensions.



Dimensions in mm.

Fig.11 Shaft detail.

MOUNTING

When sensor is mounted into equipment, pressure should only be exerted on the clamping jacks. The mounting area should correspond to the washer diameter (maximum mounting pressure 100 N). Pressure should be perpendicular to the clamping surface.

The screw torque for fixing with a washer (washer diameter ∅10 mm) is min. 2, typ. 2.5 and max. 3 Nm.

CONNECTOR

The sensor has a 3 pin AMP SUPERSEAL 1.5 series connector. For the recommended matching plug connector the following AMP part numbers are valid:

- plug connector part number 282087-1
- receptacle contact (strip form, wire size range 1.0 to 1.5 mm^2) part number 282110-1
- single wire seal (yellow, insulation diameter 1.8 to 2.4 mm) part number 281934-2.

Contactless angle sensors

KMA20/30; KMA20/70

FEATURES

- Angle measuring range 30° or 70°
- Contactless, therefore wearfree and no microlinearity problems
- Easy to mount, ready for use
- Mechanically adjustable
- 5 V supply; ratiometric voltage output signal
- Operating temperatures up to 125 °C
- Rugged mechanical design
- Resistant against aggressive media, pressurized water, etc.
- EMC resistant
- Sample kit with connector available.

DESCRIPTION

Encapsulated angle sensors for contactless measurement of angular displacements. The sensor is based on the magnetoresistive Sensor KMZ and contains a signal conditioning circuit in hybrid technology.

The KMA20/30 delivers a linear and the KMA20/70 a sinusoidal voltage output signal which are a function of the angular displacement. These sensors can be used for contactless angle measurement or as contactless potentiometers and can be directly mounted into equipment.

PINNING

PIN	DESCRIPTION
1	GND (ground)
2	V_{CC}
3	V_O

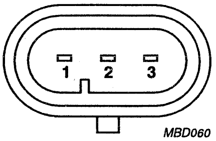


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
T_{oper}	operating temperature	–40	–	+125	°C
α	angle range:				
	KMA20/30	–	–15 to +15	–	deg
	KMA20/70	–	–35 to +35	–	deg
V_O	output voltage range	–	0.5 to 4.5	–	V

EMC RESISTIVITY

The EMC compatibility is dependent on the assembly of the sensors. The EMC resistivity has to be tested in the final application.

BLOCK DIAGRAM

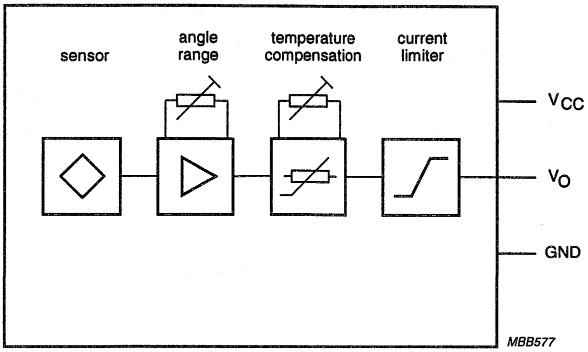


Fig.2 Block diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage	4.5	16	V
I_{CC}	supply current	–	15	mA
T_{stg}	storage temperature	–40	+125	°C
T_{oper}	operating temperature; note 1	–40	+125	°C
	output short-circuit duration to GND	permanent, note 2		

Note

1. For operations above T_{oper} = 100 °C, maximum V_{CC} derates linearly from 16 V to 5 V at T_{oper} = 125 °C.
2. If pin 3 is shorted to either pin 1 or pin 2, current may flow permanently, without damaging the sensors.

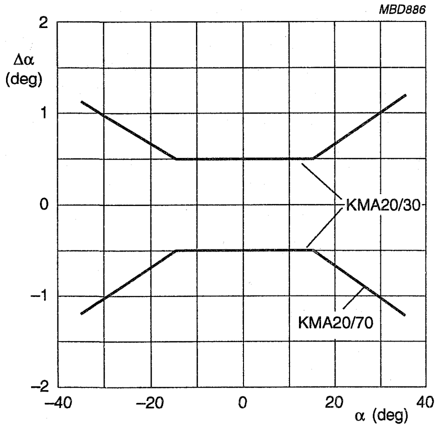
CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 5 V; R_L = 1.7 kΩ, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
α	angle range:	see Fig.12				
	KMA20/30		–	–15 to +15	–	deg
	KMA20/70		–	–35 to +35	–	deg
V_O	output voltage range:					
	KMA20/30	linear; see Fig.5	–	0.5 to 4.5	–	V
	KMA20/70	sinusoidal; see Fig.4	–	0.5 to 4.5	–	V
V_{zero}	zero point voltage	$\alpha = 0°$	–	2.5	–	V
V_{off}	zero point offset voltage:	related to sinusoidal sensor characteristic; see Fig.4				
	KMA20/30		–	±25	–	mV
	KMA20/70		–	±15	–	mV
S	sensitivity:	$\alpha = 0°$				
	KMA20/30		137	140	143	mV/deg
	KMA20/70		73	74.5	76	mV/deg
R_p	reproducibility	$\alpha = 0°$; note 1	–	<0.001	–	deg
R_s	resolution	$\alpha = 0°$; note 2	–	<0.001	–	deg
FH	hysteresis	$\alpha = 0°$; note 3	–	<0.05	–	deg
SP_{max}	maximum angular speed:					
	KMA20/30		–	60	–	deg/ms
	KMA20/70		–	150	–	deg/ms
R_L	load resistance		1.7	–	–	kΩ
C_L	load capacitor		–	–	10	nF
Temperature coefficients (–40 to +100 °C)						
TCV_{zero}	temperature coefficient of zero point voltage:					
	KMA20/30		–	0.25	0.6	mV/K
	KMA20/70		–	0.1	0.3	mV/K
TCS	temperature coefficient of sensitivity		–	100×10^{-6}	–	K^{-1}

Notes

1. Difference in output signal (expressed in degrees) between two zero point ($\alpha = 0°$) measurements, in which the zero point is approached from the same side of the measuring range (e.g. cycle: +15° ⇒ 0° ⇒ +15° ⇒ 0°).
2. The smallest detectable change of angle $\Delta\alpha$ for $\alpha = 0°$ (cycle: 0° ⇒ $\Delta\alpha$).
3. As note 1, but with the zero point being approached from the upper end and lower end of the measuring range respectively (e.g. cycle: +15° ⇒ 0° ⇒ –15° ⇒ 0°).

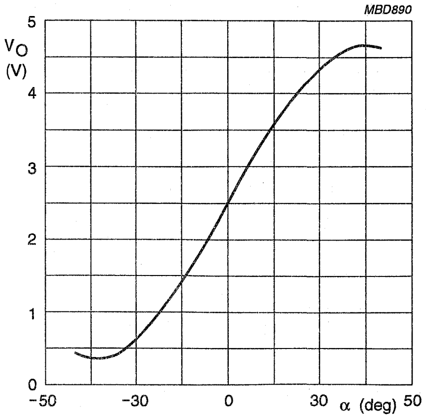


T_{amb} = −25 to +85 °C.

$\alpha = 0°$ for T_{amb} = 25 °C and V_O = 2.5 V.

Δα increases by a factor 2 in the temperature range:
T_{amb} = −40 to −20 °C and +85 to +125 °C.

Fig.3 Maximum angle error Δα as a function of angle position.



$V_O = 2.5 + 2.128 \times \sin(2\alpha)$ for $-36.5° \leq \alpha \leq +36.5°$.

T_{amb} = 25 °C; V_{CC} = 5 V.

Fig.4 KMA20/70 output signal as a function of angle position.

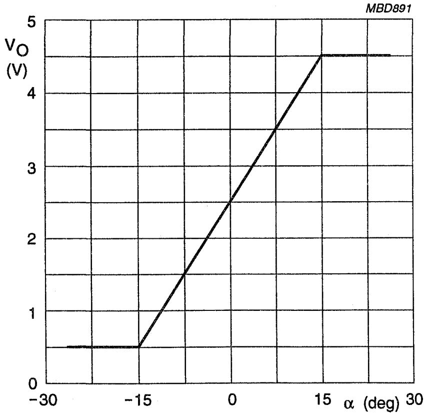


Fig.5 KMA20/30 output signal as a function of angle position.

APPLICATION INFORMATION

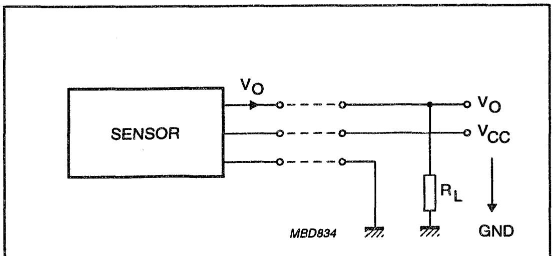


Fig.6 Application circuit.

MOUNTING INSTRUCTIONS

When the sensors are mounted into equipment pressure should be exerted on clamping jacks only. The mounting area should correspond to the washer diameter (maximum mounting pressure is 100 N). Pressure should be perpendicular to clamping surface.

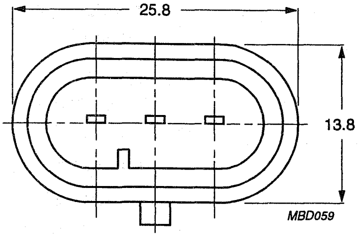
The sensors provides a 3-pin AMP SUPERSEAL 1.5 series connector. For the recommended matching plug connector the following AMP part numbers are valid:

- Plug connector part no. 282087-1
- Receptable contact (strip form, wire size 1.0 to 1.5 mm^2) part no. 282110-1
- Single wire seal (yellow, insulation diameter 1.8 to 2.4 mm) part no. 281934-2.

Mounting data

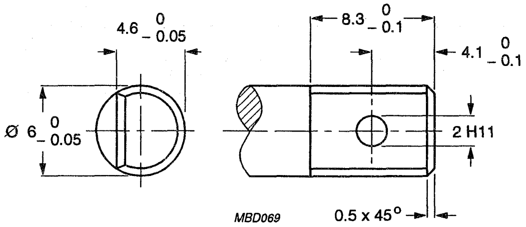
DESCRIPTION	MIN.	TYP.	MAX.	UNIT
Total mechanical travel	–	–75 to +75	–	deg
Allowed torque to mechanical stop	–	–	0.2	Nm
Maximum torque perpendicular to rotation axis	–	–	30	Nmm
Maximum screw torque for fixing with washer (washer diameter ∅ 10 mm)	2	2.5	3	Nm
Number of cycles (70°)	–	1×10^8	–	
Protection class according to DIN	IP65	–	–	

CONNECTOR AND SHAFT DIMENSIONS



Dimensions in mm.

Fig.7 Connector dimensions.



Dimensions in mm.

Fig.8 Shaft dimensions.

PACKAGE OUTLINE

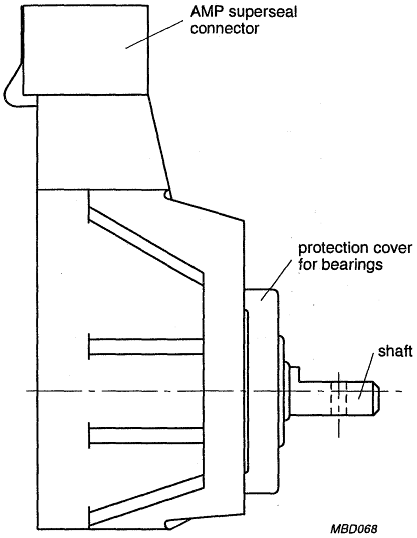
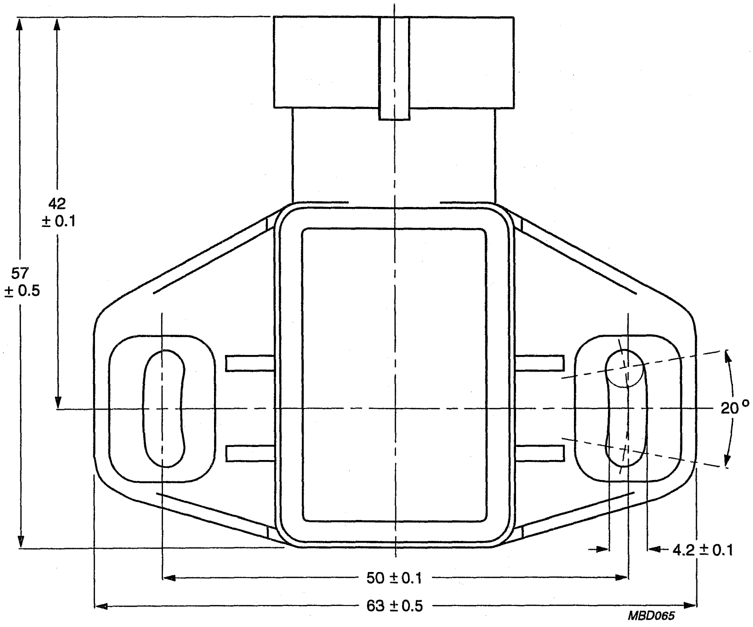
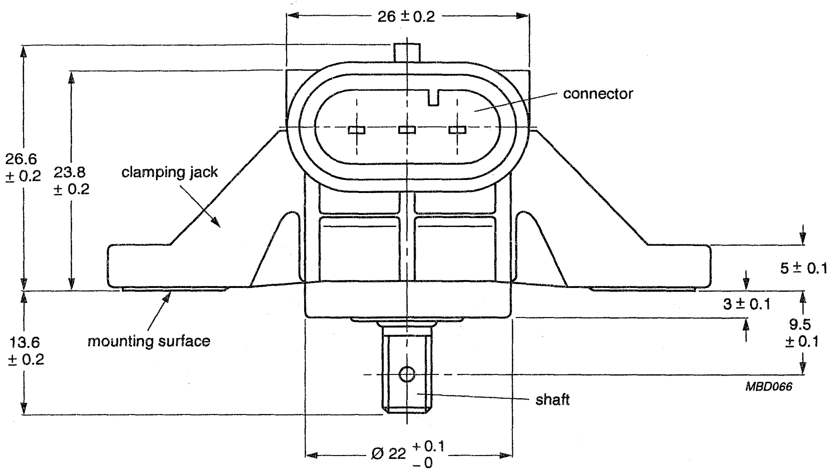


Fig.9 Side view.



Dimensions in mm.

Fig.10 Back view.



Dimensions in mm.

Fig.11 Top view.

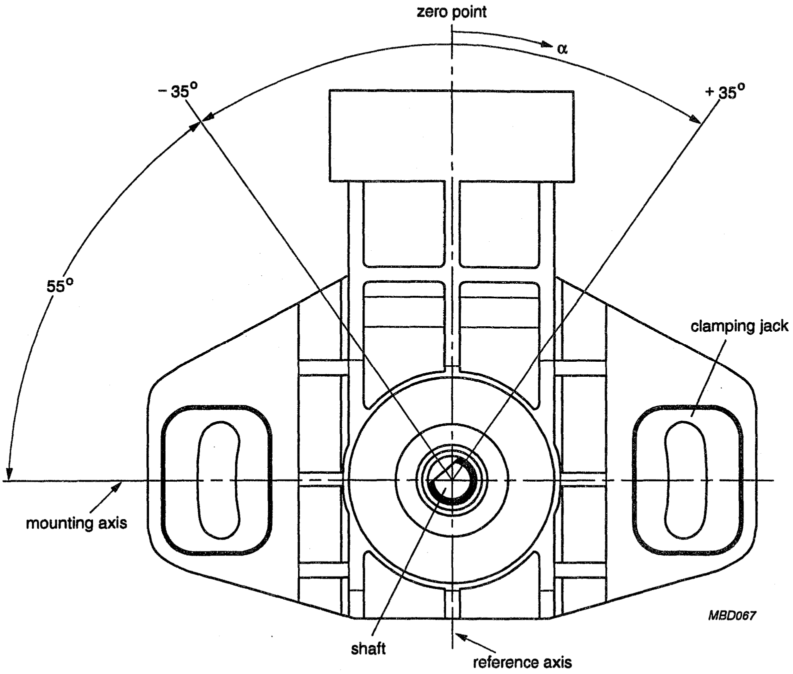


Fig.12 Front view.

Contactless angle sensor KMA20/90

FEATURES

- Linear angle measuring range >90°
- Contactless, therefore wearfree
- Easy to mount, ready for use
- Mechanically adjustable
- 5 V supply; ratiometric voltage output signal
- Operating temperatures up to 125 °C
- Rugged mechanical design
- Resistant against aggressive media, pressurized water, etc.
- EMC resistant
- Sample kit with connector available.

DESCRIPTION

Encapsulated angle sensor for contactless measurement of angular displacements. The sensor is based on the magnetoresistive Sensor KMZ and contains a signal conditioning circuit in hybrid technology.

The KMA20/90 delivers a linear voltage output signal which is a function of the angular displacement. The sensor can be used for contactless angle measurement or as a contactless potentiometer and can be directly mounted into equipment.

PINNING

PIN	DESCRIPTION
1	GND (ground)
2	V_{CC}
3	V_O

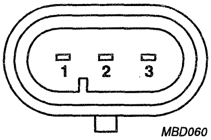


Fig.1 Pin configuration.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MIN.	TYP.	MAX.	UNIT
V_{CC}	DC supply voltage	–	5	–	V
T_{oper}	operating temperature	–40	–	+125	°C
α	angle range	–	–45 to +45	–	deg
V_O	output voltage range	–	0.5 to 4.5	–	V

EMC RESISTIVITY

The EMC compatibility is dependent on the assembly of the sensor. The EMC resistivity has to be tested in the final application.

BLOCK DIAGRAM

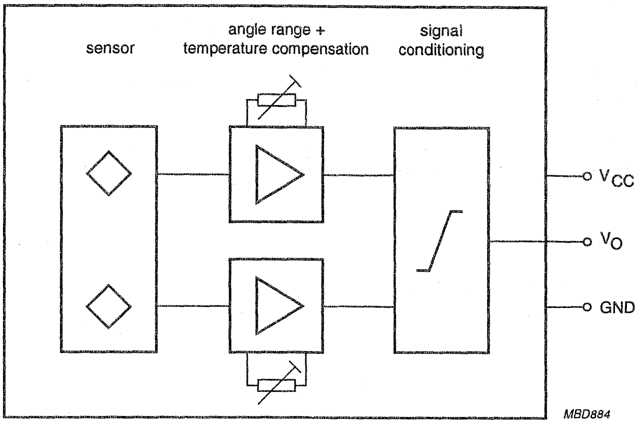


Fig.2 Block diagram.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_{CC}	DC supply voltage	4.5	16	V
I_{CC}	supply current	–	25	mA
T_{stg}	storage temperature	–40	+125	°C
T_{oper}	operating temperature; note 1	–40	+125	°C
	output short-circuit duration to GND	permanent; note 2		

Notes

1. For operations above $T_{oper} = 100$ °C, maximum V_{CC} derates linearly from 16 V to 5 V at $T_{oper} = 125$ °C.
2. If pin 3 is shorted to either pin 1 or pin 2, current may flow permanently, without damaging the sensor.

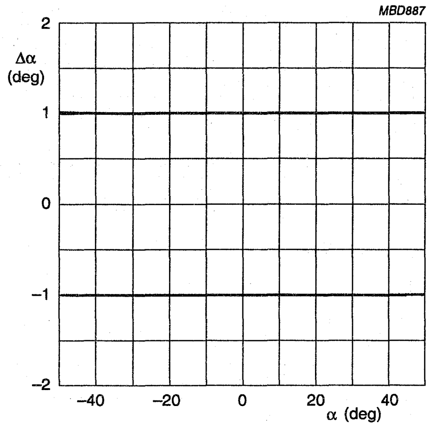
CHARACTERISTICS

T_{amb} = 25 °C; V_{CC} = 5 V; R_L = 25 kΩ, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
α	angle range	see Fig.11	–	–45 to +45	–53 to +53	deg
V_O	output voltage range	linear; see Fig.4	–	0.5 to 4.5	0.15 to 4.85	V
V_{zero}	zero point voltage	$\alpha = 0°$	–	2.5	–	V
S	sensitivity	$\alpha = 0°$	43.5	44.5	45.5	mV/deg
$\Delta\alpha$	maximum expected angle error	related to V_{ref} = 2.5 V:				
		T_{amb} = –20 to +85 °C	–	–	1	deg
		T_{amb} = –40 to –20 °C	–	–	1.5	deg
		T_{amb} = +85 to +125 °C	–	–	1.5	deg
FL	deviation of linearity	note 1	–	1	2	%·FS
R_p	reproducibility	$\alpha = 0°$; note 2	–	<0.001	–	deg
R_s	resolution	$\alpha = 0°$; note 3	–	<0.001	–	deg
FH	hysteresis	$\alpha = 0°$; note 4	–	<0.05	–	deg
SP_{max}	maximum angular speed		–	50	–	deg/ms
R_L	load resistance		10	–	–	kΩ
C_L	load capacitor		–	–	10	nF
Temperature coefficients (–40 to +100 °C)						
TCV_{zero}	temperature coefficient of zero point voltage		–	0.2	0.6	mV/K
TCS	temperature coefficient of sensitivity		–	$\pm 100 \times 10^{-6}$	–	K^{-1}

Notes

1. Deviation of best straight line in angle range.
2. Difference in output signal (expressed in degrees) between two zero point ($\alpha = 0°$) measurements, in which the zero point is approached from the same side of the measuring range (e.g. cycle: +45° ⇒ 0° ⇒ +45° ⇒ 0°).
3. The smallest detectable change of angle $\Delta\alpha$ for $\alpha = 0°$ (cycle: 0° ⇒ $\Delta\alpha$).
4. As note 2, but with the zero point being approached from the upper end and lower end of the measuring range respectively (e.g. cycle: +45° ⇒ 0° ⇒ –45° ⇒0°).



T_{amb} = −25 to +85 °C.
α = 0° for T_{amb} = 25 °C and V_O = 2.5 V.
Δα increases by a factor 2 in the temperature range:
T_{amb} = −40 to −85 °C and +85 to +125 °C.

Fig.3 Maximum angle error Δα as a function of angle position.

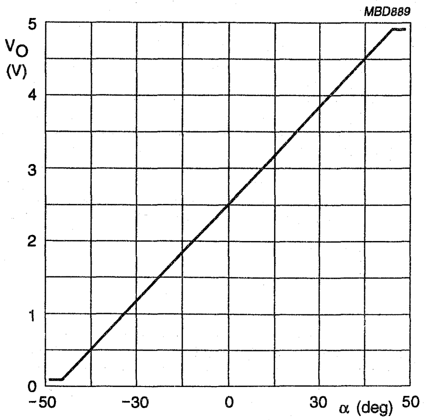


Fig.4 Output signal as a function of angle position.

APPLICATION INFORMATION

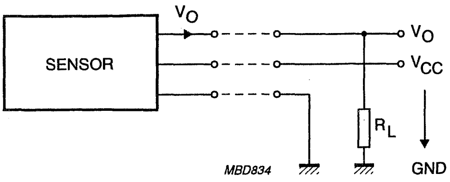


Fig.5 Application circuit.

MOUNTING INSTRUCTIONS

When sensor is mounted into equipment pressure should be exerted on clamping jacks only. The mounting area should correspond to the washer diameter (maximum mounting pressure is 100 N). Pressure should be perpendicular to clamping surface.

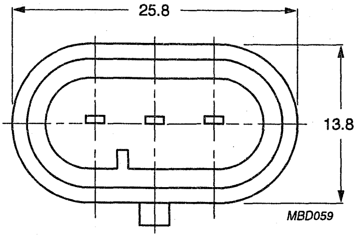
The sensor provides a 3-pin AMP SUPERSEAL 1.5 series connector. For the recommended matching plug connector the following AMP part numbers are valid:

- Plug connector part no. 282087-1
- Receptable contact (strip form, wire size 1.0 to 1.5 mm^2) part no. 282110-1
- Single wire seal (yellow, insulation diameter 1.8 to 2.4 mm) part no. 281934-2.

Mounting data

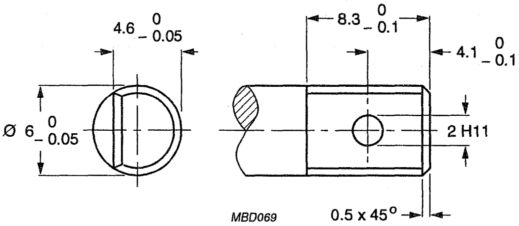
DESCRIPTION	MIN.	TYP.	MAX.	UNIT
Total mechanical travel	–	–75 to +75	–	deg
Allowed torque to mechanical stop	–	–	0.2	Nm
Maximum torque perpendicular to rotation axis	–	–	30	Nmm
Maximum screw torque for fixing with washer (washer diameter ∅ 10 mm)	2	2.5	3	Nm
Number of cycles (90°)	–	1×10^8	–	
Protection class according to DIN	IP65	–	–	

CONNECTOR AND SHAFT DIMENSIONS



Dimensions in mm.

Fig.6 Connector dimensions.



Dimensions in mm.

Fig.7 Shaft dimensions.

PACKAGE OUTLINE

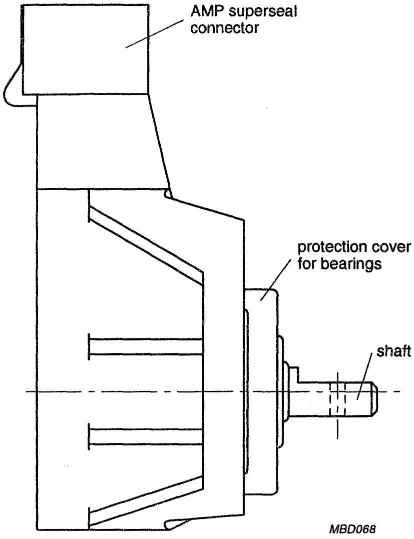
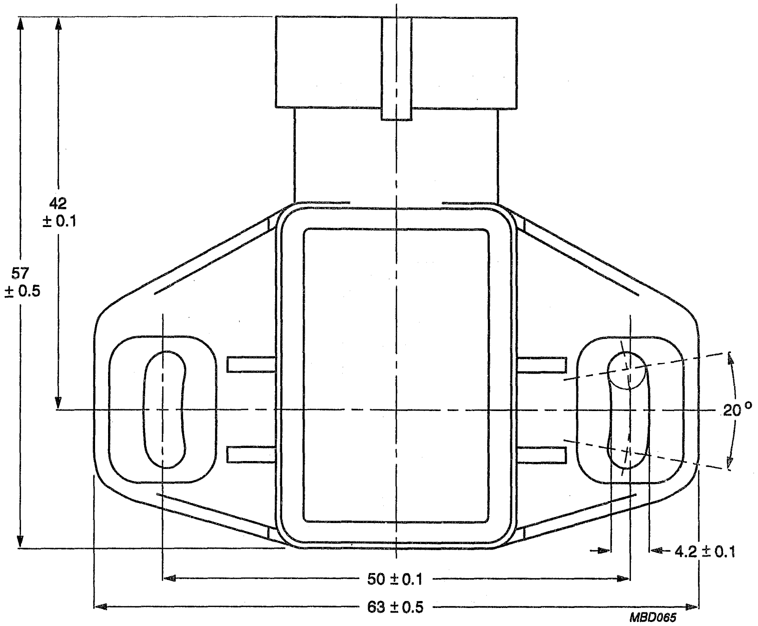
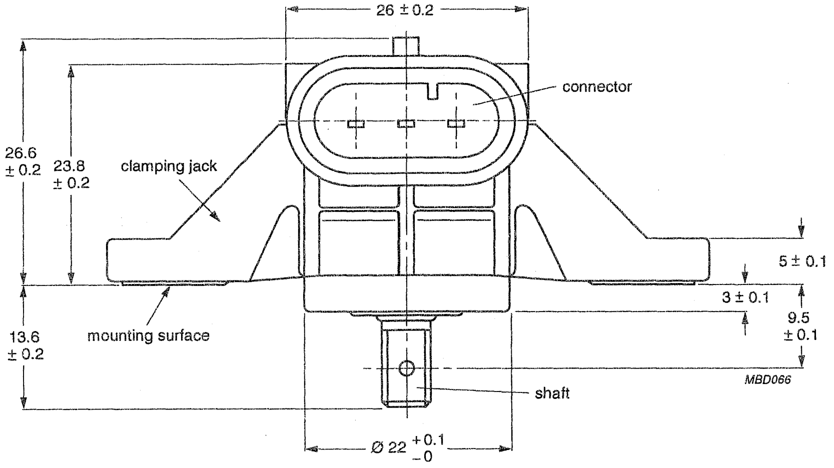


Fig.8 Side view.



Dimensions in mm.

Fig.9 Back view.



Dimensions in mm.

Fig.10 Top view.

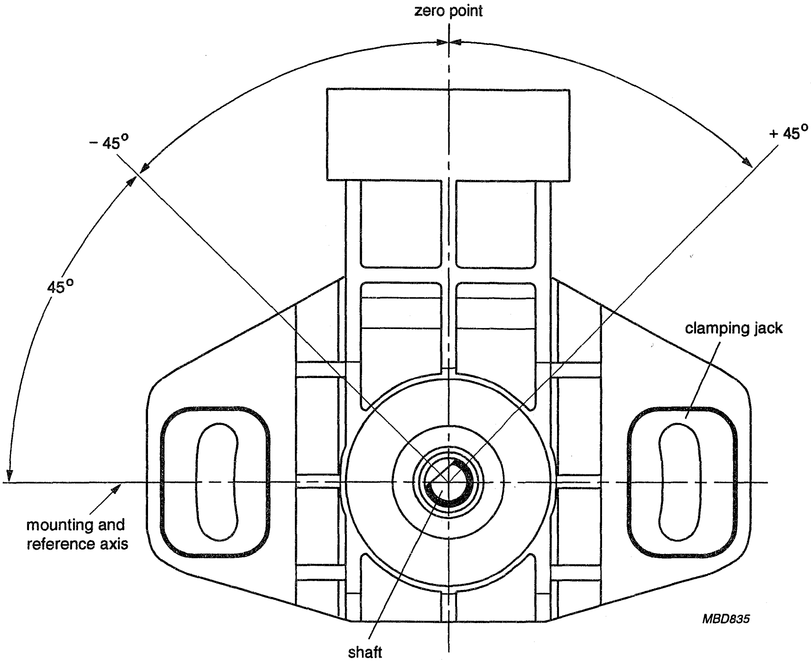


Fig.11 Front view.

TEMPERATURE SENSORS

Page

QUICK REFERENCE DATA

FAMILY TYPE	R_{25} (Ω)	AVAILABLE TOLERANCE (ΔR)	T_{oper} RANGE (°C)	PACKAGE
KTY81-1	1000	±1% up to ±5%	–55 to 150	SOD70
KTY81-2	2000	±1% up to ±5%	–55 to 150	SOD70
KTY82-1	1000	±1% up to ±5%	–55 to 150	SOT23
KTY82-2	2000	±1% up to ±5%	–55 to 150	SOT23
KTY83-1	1000	±1% up to ±5%	–55 to 175	SOD68
KTY84-1	1000 (R_{100})	±3% up to ±5%	–40 to 300	SOD68
KTY85-1	1000	±1% up to ±5%	–40 to 125	SOD80
KTY86-2	2000	±0.5%	–40 to 150	SOD103
KTY87-2	2000(R_{25}) 3344(R_{100})	±0.5%	–40 to 125	SOD103

GENERAL

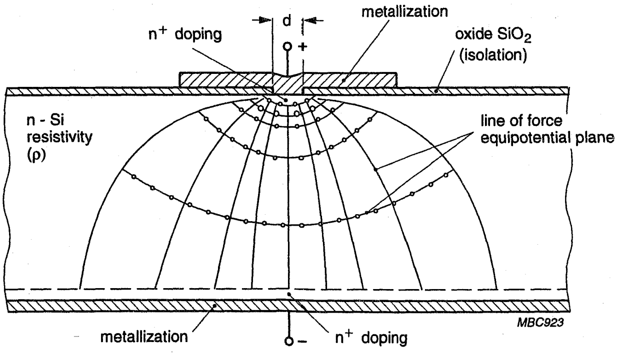
With their high accuracy and reliability, the KTY series of silicon temperature sensors in spreading resistance technology provide an attractive alternative to more conventional sensors using NTC or PTC thermistors. They have a positive temperature coefficient and a virtually linear temperature characteristic.

The sensors use n-type silicon with a doping level between 10^{14} and $10^{15}/cm^3$, providing a nominal resistance at 25 °C of about 1000 Ω (KTY81-1, KTY82-1, KTY83, KTY85) or 2000 Ω (KTY81-2, KTY82-2, KTY86, KTY87).

The nominal resistance of the KTY84 is also 1000 Ω, but specified at 100 °C.

Construction of the sensor: spreading resistance principle

The construction of the basic sensor chip is shown in Fig.1. The chip size is ≈500 × 500 × 240 μm. The upper plane of the chip is covered by an SiO_2 insulation layer, in which a metallized hole with a diameter of ≈20 μm has been cut out. The entire bottom plane is metallized.



The top plane is provided with a circular metal contact; the entire bottom plane is metallized.

$R \approx \frac{\rho}{\pi} \times \frac{1}{d}$.

Fig.1 Section through the crystal showing the spreading resistance principle and the electrode arrangement.

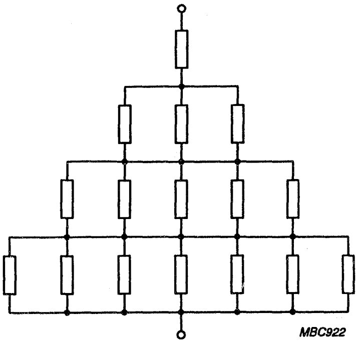


Fig.2 Equivalent circuit symbolically representing the spreading resistance principle shown in Fig.1.

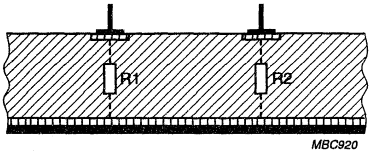


Fig.3 Setup consisting of two single sensors connected in series, but with opposite polarity.

This arrangement provides a conical current distribution through the crystal, hence the name 'spreading resistance' (see Fig.2). A major advantage of this arrangement is that the dependency of the sensor resistance on manufacturing tolerances is significantly reduced. An n^+ region, diffused into the crystal beneath the metallization reduces barrier-layer effects at the metal-semiconductor junctions.

Figure 3 shows a second arrangement, effectively consisting of two single sensors connected in series, but with opposite polarity. This twin-sensor arrangement has the advantage of providing a resistance that is independent of current direction, in contrast to the single-sensor arrangement of Fig.1, which, for larger currents and temperatures above 100 °C, gives a resistance that varies slightly with the current direction.

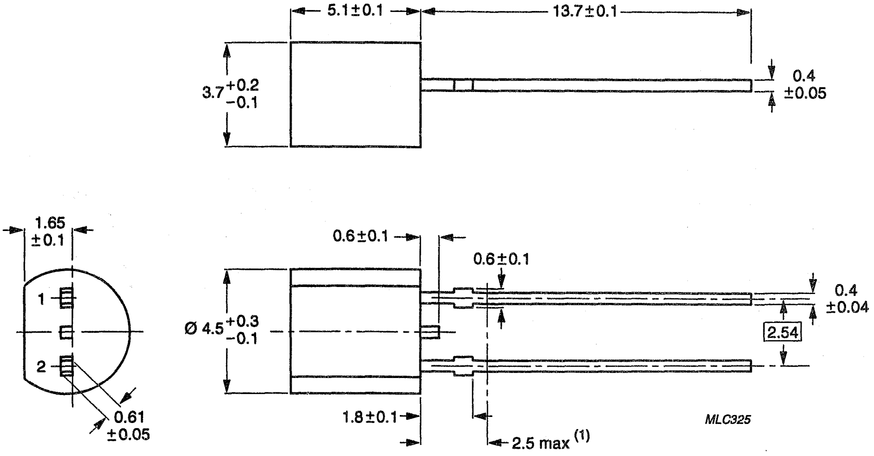
Normally, silicon temperature sensors have a temperature limit of ≈150 °C, imposed by the intrinsic semiconductor properties of silicon. If, however, the single-sensor device is biased with its metal contact positive, the onset of intrinsic semiconductor behaviour is shifted to a higher temperature. This stems from the fact that a positive voltage on the gold contact severely depletes the hole concentration in the upper n^+ diffusion layer, and so effectively insulates holes spontaneously generated within the body of the crystal (due to its intrinsic nature) preventing them from contributing to the total current, and hence from affecting the resistance.

The twin-sensor arrangement shown in Fig.3 has been applied in the KTY81 and KTY82 series. These sensors, in SOD70 (KTY81) and SOT23 (KTY82) packages (Figs 4 and 5), are therefore polarity independent.

The KTY83/84/85 series use the more basic single-sensor arrangement. The simplicity of this arrangement allows the sensors to be produced in the compact SOD68 (KTY83/84) and SOD80 (KTY85) packages (Figs 6 and 7, respectively).

In addition to simplicity, the single-sensor device has another important advantage: the potential for operation at temperatures up to 300 °C. The KTY84 makes use of this property, being specifically designed for operation at temperatures up to 300 °C.

The KTY86/87 temperature sensors consist of two KTY83 sensors in series, the resistance of the latter having been matched, in order to reduce tolerances. For the KTY86, the KTY83 sensors are matched at 25 °C; for the KTY87, at 25 and 100 °C (see Chapter "Quick reference data"). The package outline of the KTY86/87 sensors is given in Fig.8.



(1) Terminal dimensions within this zone are uncontrolled to allow for flow of plastic and terminal irregularities.

Fig.4 Outline of the KTY81 (SOD70).

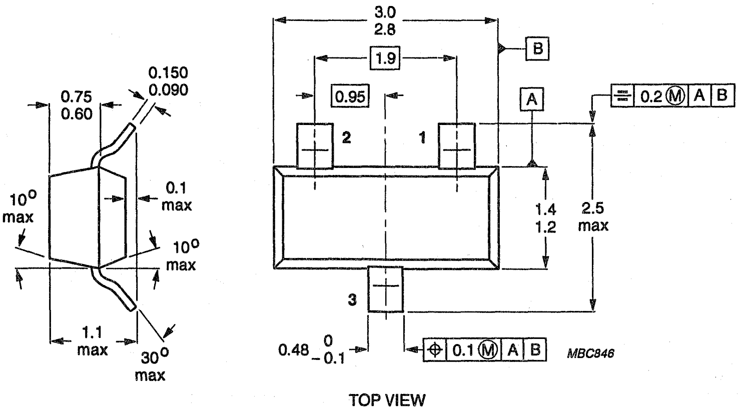


Fig.5 Outline of the KTY82 (SOT23).

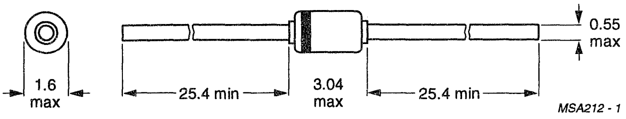
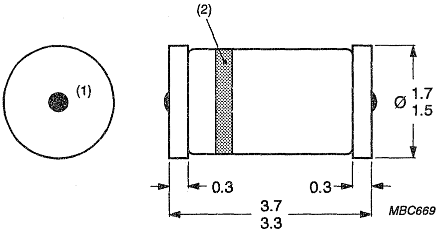


Fig.6 Outline of the KTY83/84 (SOD68).



(1) Area not tinned; small elevations are possible.

(2) Indication of polarity and type tape.

Fig.7 Outline of the KTY85 (SOD80).

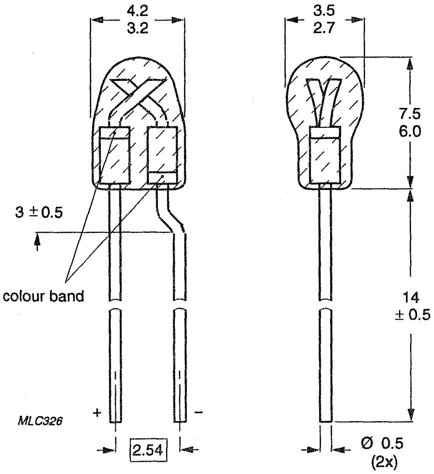


Fig.8 Outline of the KTY86/87 (SOD103).

TEMPERATURE DEPENDENCY

For the KTY83/85/86/87 series of temperature sensors, the mathematical expression for the sensor resistance 'R_T' as a function of temperature is given by:

$$R_T = R_{ref}\left[1 + A(T - T_{ref}) + B(T - T_{ref})^2\right] \quad (1)$$

where:

R_T is resistance at temperature T

R_{ref} is the nominal resistance at the reference temperature (T_{ref})

T_{ref} is reference temperature (100 °C for the KTY84, 25 °C for all other types)

A, B is type-dependent coefficients.

For the KTY81/82/84 series, the slope of the characteristic curve decreases slightly in the upper temperature range above a certain temperature T_I (point of inflection). Therefore, an additional term in equation (1) becomes necessary:

$$R_T = R_{ref}\left[1 + A(T - T_{ref}) + B(T - T_{ref})^2 - C(T - T_I)^D\right]$$

where:

T_I is temperature above which the slope of the characteristic curve starts to decrease (point of inflection).

C, D is type-dependent coefficients.

C is 0 for $T < T_I$.

For the types previously mentioned, the type-dependent constants 'A', 'B', 'C' and 'D', as well as 'T_I', are given in Table 1.

For high-precision applications, e.g. microcontroller-based control systems, the above expressions and the values in Table 1 can be used to generate a calibration table to store in a ROM for look-up and linear interpolation.

If a microcontroller is not used, the slight deviation from linearity can easily be compensated using a parallel resistor (if a constant current source is used), a series resistor (if a constant voltage source is used) or a suitable combination of both. This is discussed in Section "Linearization".

Table 1 Type dependent contstants

SENSOR TYPE	A (K^{-1})	B (K^{-2})	C(1) (K^{-D})	D	T_I (°C)
KTY81-1	7.874×10^{-3}	1.874×10^{-5}	3.42×10^{-8}	3.7	100
KTY81-2	7.874×10^{-3}	1.874×10^{-5}	1.096×10^{-6}	3.0	100
KTY82-1	7.874×10^{-3}	1.874×10^{-5}	3.42×10^{-8}	3.7	100
KTY82-2	7.874×10^{-3}	1.874×10^{-5}	1.096×10^{-6}	3.0	100
KTY83	7.635×10^{-3}	1.731×10^{-5}	–	–	–
KTY84	6.229×10^{-3}	1.159×10^{-5}	3.14×10^{-8}	3.6	250
KTY85	7.635×10^{-3}	1.731×10^{-5}	–	–	–
KTY86/87	7.646×10^{-3}	1.752×10^{-5}	–	–	–

Note

1. For $T < T_I$: C = 0.

RESISTANCE/TEMPERATURE CHARACTERISTICS

Manufacturing tolerances

Silicon temperature sensors are normally produced to quite fine tolerances: 'ΔR' between ±0.5% and ±2% (see Chapter "Quick reference data"). Figure 9 illustrates how these tolerances are specified, except for the KTY87. The tolerance on resistance quoted in our data sheets is given by the resistance spread 'ΔR' measured at 25 °C.

Because of spread in the slope of the resistance characteristics, 'ΔR' will increase each side of the 25 °C point, to produce the butterfly curve shown in Fig.9. To give an indication of this spread in slope, we also quote the ratio of resistance at two other temperatures (−55 °C and 100 °C) to the nominal resistance at 25 °C, i.e. 'R_{-55}/R_{25}' and 'R_{100}/R_{25}'; for the KTY84, we quote 'R_{25}/R_{100}' and 'R_{250}/R_{100}'.

The user, however, is usually more interested in the maximum expected temperature error '±ΔT'. We also provide this in the data sheets, as a graph showing 'ΔT' as a function of 'T'. For the high temperature sensor KTY84, we specify the resistance spread at 100 °C.

The resistance of the KTY87 is specified with a close tolerance at 25 °C and 100 °C. This specification at two temperatures provides an essential improvement of measurement accuracy in this temperature range.

Current dependency of sensor resistance

The resistance of silicon temperature sensors is dependent on the operating current. In applications with an operating current deviating from the nominal current, a deviation of sensor resistance from the nominal values has to be taken into account.

For any application, an operating current ≥0.1 mA is recommended. For lower operating currents, the current dependency is additionally influenced by temperature.

For any application with operating currents above the nominal values, it should be noted, that an additional error caused by self-heating effects will influence the measurement accuracy.

Polarity of current

KTY83, 84, 85, 86 and 87 sensors are marked with a coloured band to indicate polarity. The published characteristics of the sensors will only be obtained if the current polarity is correct. In events where the current polarity is incorrect, the curve $R = f(T_{amb})$ differs in the upper temperature range significantly from the published form. Light, especially infrared, also has an influence.

Linearization

The resistance/temperature characteristics of the silicon temperature sensors are nearly linear, but in some applications further linearization becomes necessary, e.g. control systems requiring high accuracy.

A simple way to do this is to shunt the sensor resistance 'R_T' with a fixed resistor 'R_P' (see Fig.10a). The resistance '$R \times R_T/(R + R_T)$' of the parallel combination then effectively becomes a linear function of temperature, and the output voltage 'V_T' of the linearizing circuit can be used to regulate the control system.

If the circuit is powered by a constant-voltage source (see Fig.10a), a resistor R_S can be connected in series with the sensor. The voltages across the sensor and across the resistor will than again be approximately functions of temperature.

The value of the series or parallel resistor depends on the required operating temperature range of the sensor. A method for finding this resistance is described here, giving zero temperature error at three equidistant points T_a, T_b and T_c.

Consider the parallel arrangement. If the resistance of the sensor at the three points R_a, R_b and R_c, the requirement for linearity at the three points is:

$$R_{pa} - R_{pb} = R_{pb} - R_{pc}$$

i.e.

$$\frac{R \times R_a}{R + R_a} - \frac{R \times R_b}{R + R_b} = \frac{R \times R_b}{R + R_b} - \frac{R \times R_c}{R + R_c}$$

so

$$R = \frac{R_b \times (R_a + R_c) - 2R_a \times R_c}{R_a + R_c - 2R_b}.$$

The same resitor will also be suitable for the series arrangement.

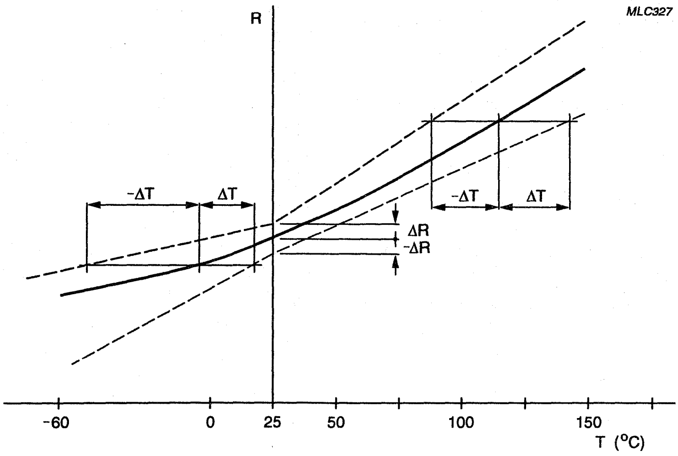
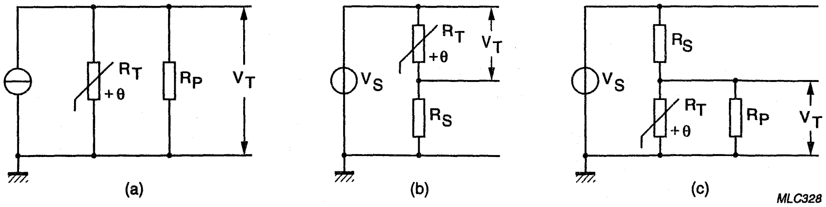


Fig.9 Butterfly curve.



(a) With a resistor 'R_P' shunted across the sensor.

(b) With a resistor 'R_S' in series with the sensor and system powered by a constant-voltage source.

(c) With a series 'R_S' and parallel resistor 'R_P' and system powered by a constant-voltage source.

Fig.10 Linearization of sensor characteristics.

In practice a current source is too expensive and a fixed supply voltage, e.g. 5 or 12 V is used for a specific operating current, e.g. 1 or 0.1mA. In this case, linearization can be achieved by series/parallel resistor combination to the sensor (see Fig.10c). The value of the parallel resistor R_P is equal to the value of R_S. Starting with the value of resistor R and with the desired current I_S through the sensor at a reference temperature T (preferable in the middle of the measured range), the resistor R_S and R_P can be calculated as follows:

$$\text{series resistor: } R_S = \frac{V_S}{I_S \times \left(\frac{R_T}{R} + 1\right)}$$

$$\text{parallel resistor: } R_P = \frac{1}{\frac{1}{R} - \frac{1}{R_S}}.$$

As an example, Fig.11 shows the deviation from linearity to be expected from a nominal KTY81 sensor, linearized over the temperature range 0 to 100 °C with a linearizing resistance of 2870 Ω.

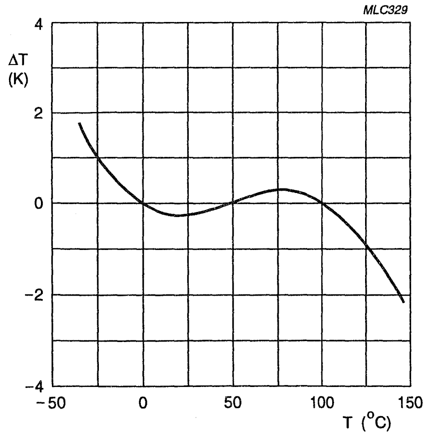
Figure 18 shows an application example using a series/parallel combination for the KTY81 (I_S = 1 mA) and Fig.19 shows an application example for the KTY87 (I_S = 0.1 mA).

EFFECT OF TOLERANCES ON LINEARIZED SENSOR CHARACTERISTICS

In practical applications with an arbitrary sensor, the total uncertainty in the sensor reading will be a combination of spread due to manufacturing tolerances and linearization errors.

As an example, Fig.13 shows the combined effects of manufacturing tolerances and linearization errors for the KTY81 sensor linearized over the temperature range 0 to 100 °C. Calibration of the subsequent circuitry (op-amp, control circuitry, etc.) can reduce this error significantly.

Figure 14 shows the temperature error of the system with (linear) output circuitry calibrated at 50 °C, and Fig.15 shows the error of the same system calibrated at 0 and 100 °C.



Sensor linearized over the temperature range 0 to 100 °C (linearizing resistance 2870 Ω).

Fig.11 Linearization error 'ΔT' to be expected from a nominal KTY81.

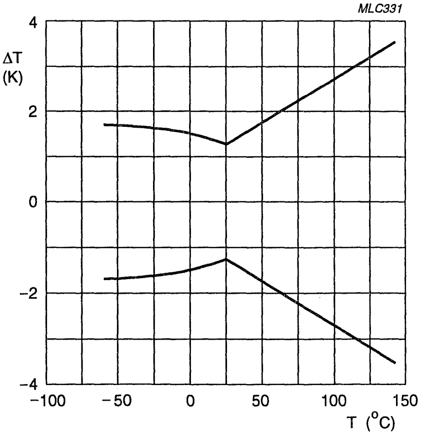


Fig.12 Maximum temperature error 'ΔT' due to manufacturing tolerances expected of a KTY81-1 sensor.

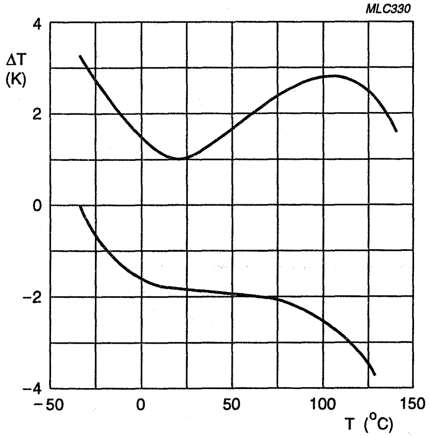


Fig.13 Combined effects of manufacturing tolerances and linearization errors for the KTY81 sensor.

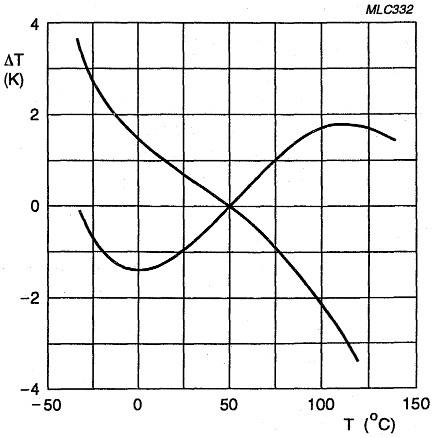


Fig.14 Maximum expected temperature error of a KTY81-1 sensor plus linearization resistor calibrated at 50 °C.

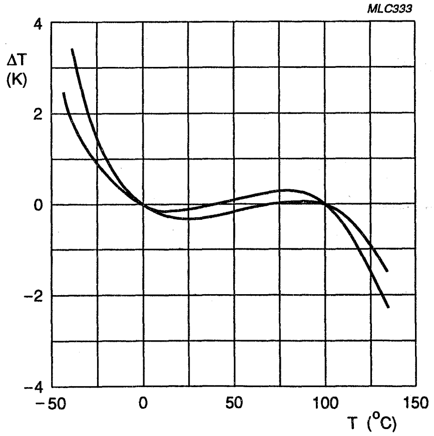


Fig.15 Error of a KTY81-1 sensor (same system as Fig.14) calibrated at 0 and 100 °C.

TEMPERATURE COMPENSATION

In many applications, it is necessary to compensate for the temperature dependency of electronic circuitry. For example, the sensitivity of many magnetic field sensors has a linear drift with temperature. To compensate for this drift, a temperature sensor with linear characteristics is required. The temperature sensors of the KTY series are well suited for this purpose and can be used for compensation of both positive and negative drift.

In many events, as with the magnetoresistive sensor KMZ10B, the temperature drift is negative. For this sensor, two circuits in SMD-technology, which include temperature compensation, are described below. The formulae given can be used to adapt the circuits to other conditions.

Figure 16 shows a simple setup using a single op-amp (NE5230D). The circuit provides the following facilities:

- Compensation of the **average** (sensor-to-sensor) sensitivity drift with temperature via a negative feedback loop incorporating a KTY82-210 silicon temperature sensor
- Offset adjustment by means of potentiometers ‘R1’ and ‘R2’
- Gain adjustment by means of potentiometer ‘R7’.

The temperature sensor is part of the amplifier’s feedback loop and thus increases the amplification with increasing temperature.

With the resistor as shown in Fig.16 the temperature dependent amplification ‘A’ is given by:

$$A = \frac{R7}{R4 + \frac{R_B}{2}}\left(1 + 2\frac{R_T}{R_S}\right) \qquad (2)$$

and the temperature coefficient of the amplification can be calculated to be:

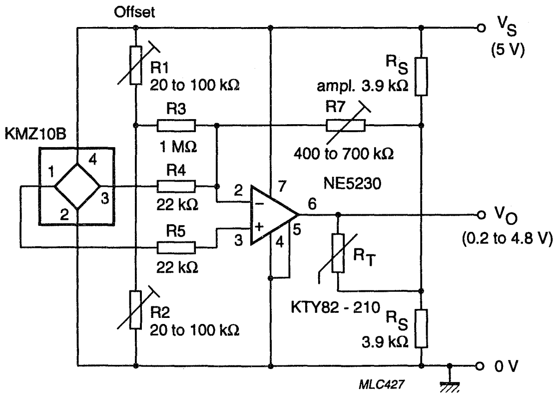
$$TC_A = \frac{R_T \times TC_{KTY}}{R_T + \frac{R_S}{2}}$$

with:

R_T = temperature dependent resistance of the KTY82.

TC_{KTY} = temperature coefficient of the KTY82 at reference temperature (0.79 %/K at 25 °C).

R_B = bridge resistance of the magnetoresistive sensor.



Example: A = 50 (typ.), $TC_A = 0.004\ K^{-1}$.

Fig.16 Temperature compensation circuit.

The temperature coefficient of amplification must be equal and opposite to the magnetic field sensor's 'TC' of sensitivity.

The value of the resistor 'R_S', which determines the positive 'TC' of the amplification is:

$$R_S = 2 \times R_T \left(\frac{TC_{KTY}}{TC_A} - 1 \right).$$

The resistance of the feedback resistor can be derived from equation (2):

$$R7 = R4 \times \left(\frac{A}{1 + 2\frac{R_T}{R_S}} \right).$$

The temperature dependent values 'R_T' and 'A' are taken for a certain reference temperature, usually 25 °C, but in other applications a different reference temperature may be more suitable.

Figure 17 shows an example with a commonly used instrumentation amplifier. The circuit can be divided into two stages: a differential amplifier stage that produces a symmetrical output signal derived from the magnetoresistive sensor, and an output stage that also provides a reference to ground for the amplification stage.

To compensate the negative sensor drift, the amplification is again given an equal but positive temperature coefficient by means of a KTY81-110 silicon temperature sensor in the feedback loop of the differential amplifier.

The amplification of the input stage ('OP1' and 'OP2') is given by:

$$A1 = 1 + \frac{R_T + R_B}{R_A}$$

and the amplification of the complete amplifier by:

$$A = A1 \times \frac{R14}{R10}.$$

The positive temperature coefficient of the amplification is:

$$TC_A = \frac{R_T \times TC_{KTY}}{R_A + R_B + R_T}.$$

For the given negative 'TC' of the magnetoresistive sensor and the required amplification of the input stage 'A1', the resistance 'R_A' and 'R_B' can be calculated by:

$$R_B = R_T \times \left(\frac{TC_{KTY}}{TC_A} \times \left(1 - \frac{1}{A1} \right) - 1 \right)$$

$$R_A = \frac{R_T + R_B}{A1 - 1}.$$

The circuit provides for adjustment of gain and offset voltage of the magnetic-field sensor. The calculated resistance 'R_A' consists of the fixed resistor 'R5' and trimming resistor 'R6' provided for amplification adjustment. Amplification adjustment only negligibly influences the 'TC' of the amplifier. The output stage 'OP3' gives an output voltage of ⅖ of the supply voltage (2 V for $V_S = 5$ V) for zero output voltage of the magnetic field sensor and an output voltage of ±1 V for $V_S = 5$ V. For other supply voltages the circuit has a ratiometric behaviour.

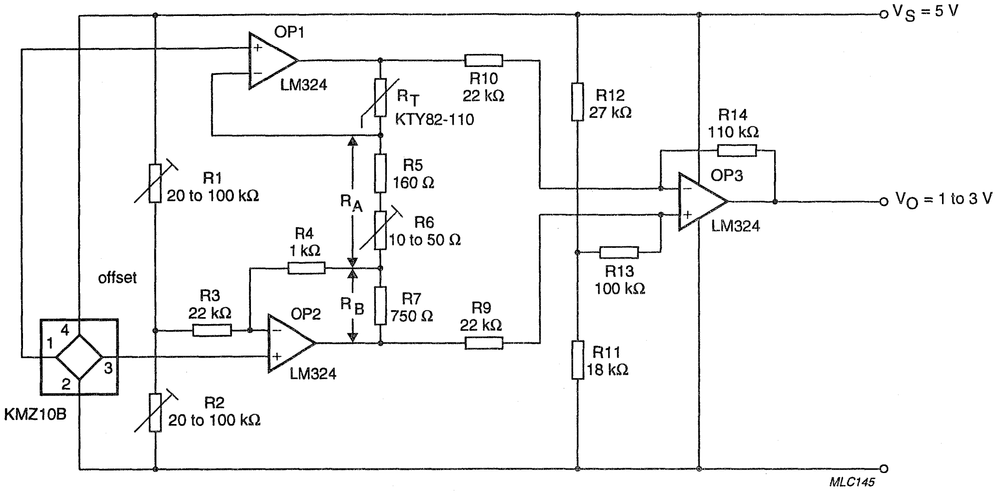
TYPICAL APPLICATION CIRCUIT

Figure 18 shows a typical and versatile temperature measuring circuit using silicon temperature sensors. This example is designed for the KTY81-110 (or the KTY82-110) and a temperature range from 0 to 100 °C.

With resistors 'R1' and 'R2', the sensor forms one arm of a bridge, the other arm being formed by resistor 'R3', potentiometer 'P1' and resistor 'R4'. The values of 'R1' and 'R2' are chosen to supply the sensor with the proper current of ≈1 mA, and to linearize the sensor characteristic over the temperature range of interest: in this event, between 0 and 100 °C. Over this temperature range, the output voltage V_O will vary linearly between $0.2V_S$ and $0.6V_S$, i.e. between 1 V and 3 V for a supply of $V_S = 5$ V.

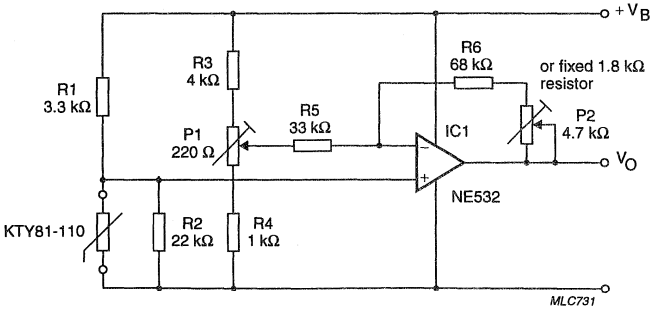
To calibrate the circuit, adjust 'P1' to set 'V_O' to 1 V, with the sensor at 0 °C. Then, at a temperature of 100 °C, adjust 'P2' to set 'V_O' to the corresponding output voltage, in this example 3 V. With this circuit, adjustment of 'P2' has no effect on the zero adjustment.

The measurement accuracy obtained by this two-point calibration is shown in Fig.15. If the application can tolerate a temperature deviation of ±2 K at the temperature extremes (see Fig.14), costs can be reduced by replacing 'P2' with a 1.8 kΩ fixed resistor and adjusting 'V_O' at one temperature (the middle of the range, for example), using 'P1'.



Example: A = 50 (typ.), $TC_A = 0.004\ K^{-1}$.

Fig.17 KMZ10B evaluation circuit with instrumentation amplifier.



A KTY82-110 sensor would be equally suitable.

Temperature range 0 to 100 °C; $V_O = 0.2V_S$ to $0.6V_S$.

For $V_S = 5$ V: $V_O = 1$ to 3 V.

All resistors metal film; tolerance ±1%.

Fig.18 Temperature measuring circuit using a KTY81-110 sensor.

MEASURING CIRCUITS WITH KTY87

The advantages of the KTY87-205 silicon temperature sensor are its improved accuracy and replacement within an evaluation circuit without subsequent re-calibration.

The improved accuracy of the KTY87 is not only effective at one temperature, but over a wide temperature range due to the special series connection of two selected temperature sensors.

Within the temperature range 20 °C to 100 °C the KTY87 provides a less expensive alternative to Pt100 sensors if the somewhat reduced accuracy can be accepted.

Due to component tolerances and offset voltage of common operational amplifiers, the evaluation circuit for the temperature sensor normally has to be adjusted with respect to the sensor. The high accuracy of the KTY87 within the range 25 °C to 100 °C, however, makes it possible to adjust the electronic circuit with respect to nominal resistance sensor values. A sensor within the evaluation circuit can then be subsequently replaced without the need for re-calibration of the circuit. The overall measurement error is less than ±1 °C.

MICROCONTROLLER INTERFACE/GENERAL PURPOSE

The circuit in Fig.19, is effective for the temperature range 0 to 100 °C. It is a suitable preamplifier for AD converters or microcontrollers with ADC inputs of ratiometric behaviour. It may also be used as a general simple signal conditioning circuit for silicon temperature sensors.

Because of the high accuracy of the sensor, a precision operational amplifier with low offset drift and high temperature stable resistors should be used.

The calibration of this circuit as follows:

Replace the sensor by a fixed test resistor of 1 640 Ω (nominal value of KTY87 at 0 °C).

Adjust 'P1' to set 'V_O' to 0.5 V.

Replace the sensor with a test resistor of 3344 Ω (nominal value at 100 °C).

Set $V_O = 4.5$ V by 'P2'.

The circuit is now calibrated for a nominal KTY87 temperature sensor and can be used with any such sensor, giving a measurement accuracy of better than ±1 °C in the range of 20 to 100 °C.

If the circuit is to be matched to a specific sensor the calibration procedure has to be carried out with this sensor subjected to the test temperatures and should be carefully monitored e.g. by use of an accurate liquid thermostat. This method is more costly and gives an increase in measurement accuracy for this specific sensor only.

TWO WIRE TRANSMITTER (4 to 20 mA)

In industrial temperature control, current transmitters with the standardized current output of 4 to 20 mA, are commonly used. Figure 20 shows a two wire current transmitter with the KTY87; temperature measuring range is 0 to 100 °C. It consists of a wheatstone bridge with a preamplifier similar to that in Fig.19, a current transmitter output stage and voltage stabilization circuitry.

The calibration of this current transmitter is as follows:

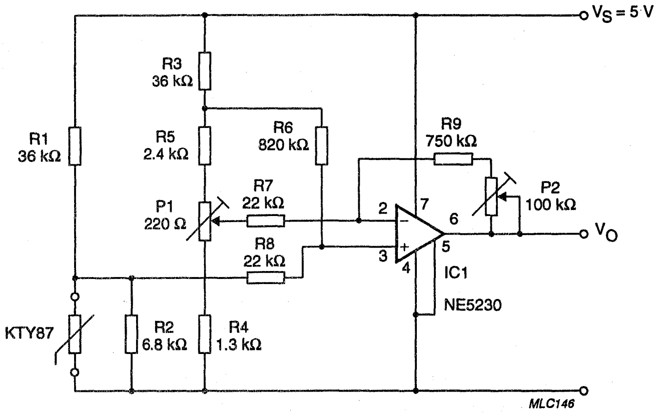
Set the supply voltage to ≈12 V.

Set the internal operating voltage to 5 V by potentiometer 'P3'.

Replace the temperature sensor by a fixed test resistor of 1640 Ω (nominal value of KTY87 at 0 °C) and set the output current to 4 mA by 'P1'.

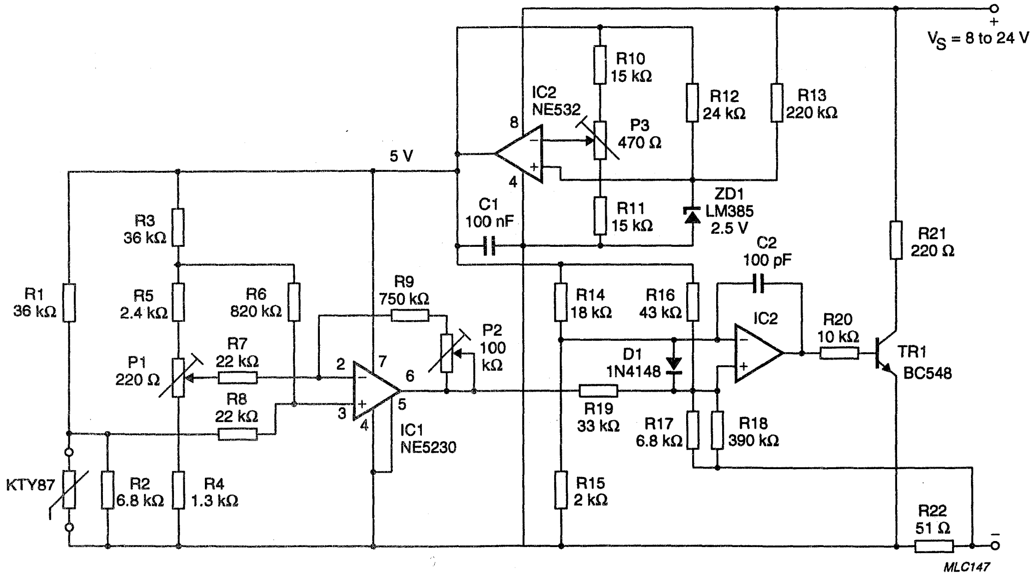
Replace the test resistor with a second test resistor of 3344 Ω inserted (nominal value at 100 °C) and set the output current to 20 mA by potentiometer 'P2'.

The calibration procedure can also be carried out with a specific temperature sensor subjected to the test temperatures 0 °C and 100 °C. The circuit then is calibrated to this specific sensor only.



All resistors: metalfilm, tolerance <±1%, TC < ±50 × 10^{-6} K^{-1}; measuring range: 0 to 100 °C; V_O = 0.5 to 4.5 V for V_S = 5.0 V; $V_O = 0.2V_S \times (0.5 + 0.04 \times TC)$.

Fig.19 Microcontroller interface for KTY87.



All resistors: metalfilm, tolerance <±1%, TC < ±50 × 10^{-6} K^{-1}; measuring range: 0 to 100 °C, I = 4 + T/6.25 with I in mA and T in °C.

Fig.20 Current transmitter (4 to 20 mA) for the KTY87.

HIGH TEMPERATURE MEASUREMENT WITH KTY84

The operating range of silicon temperature sensors normally is limited to about 150 °C (an exception is the KTY83 with an upper temperature limit of 175 °C). This is due to the temperature stability of the package and the increasing intrinsic conductivity of the silicon crystal above 150 °C. The measuring range of the KTY84 silicon temperature sensors is extended up to 300 °C.

The SOD68 diode housing together with special contacts between leads and sensor crystal give the necessary temperature resistivity for the envelope. The influence of the intrinsic conductivity can be suppressed by a sufficiently high operating current flowing in the correct direction.

Figure 21 shows the nominal characteristic for the recommended operating current of 2 mA and the effect of operating the sensor with a lower, and especially, a reverse current. The sensor resistance at the high temperature end makes it impossible to draw the current of 2 mA through the sensor in a common bridge circuit as in the previously suggested circuits. Reasons are the usually limited supply voltage and the fact that the value of the series resistor may not be less than the linearization resistor of ≈5 kΩ. A solution is to supply the sensor by a constant current source.

Figure 22 gives an example with internal voltage stabilization, a supply voltage of 8 to 24 V and for the full measuring range up to 300 °C. Operational amplifier ‘OP1’ and transistor ‘TR1’ form a current source to feed the temperature sensor. ‘OP2’ amplifies the bridge signal to the output voltage range. The circuit provides adjustment for a ‘zero point’, 100 °C equal $V_O = 2$ V (‘P1’), and full range (‘P2’).

A second example for a KTY84 evaluation circuit takes into consideration that in some electronic systems a supply voltage of only 5 V may be used. Under such circumstances it would be impossible to obtain the recommended current of 2 mA. A compromise is suggested by the circuit in Fig.23. A low drop current source supplies the temperature sensor and the linearization resistor. The maximum attainable current at 300 °C is 1.5 mA. This value is below the nominal operating current, but as Fig.21 shows, at up to 250 °C this will not cause any additional measuring error. Between 250 °C and 300 °C, however, a slightly decreasing slope of the sensor characteristic has to be taken into account.

The KTY84 silicon temperature sensor is a reliable and cost effective alternative to more expensive options such as Pt100-resistors or thermocouplers.

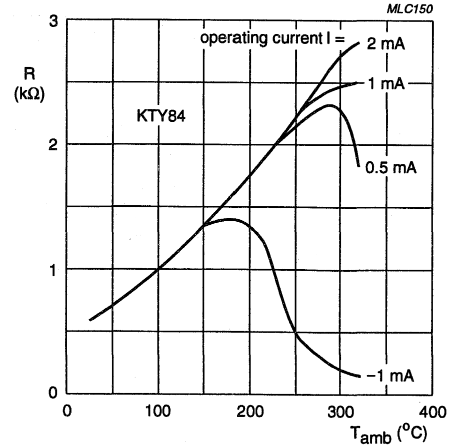


Fig.21 Sensor characteristic of the KTY84.

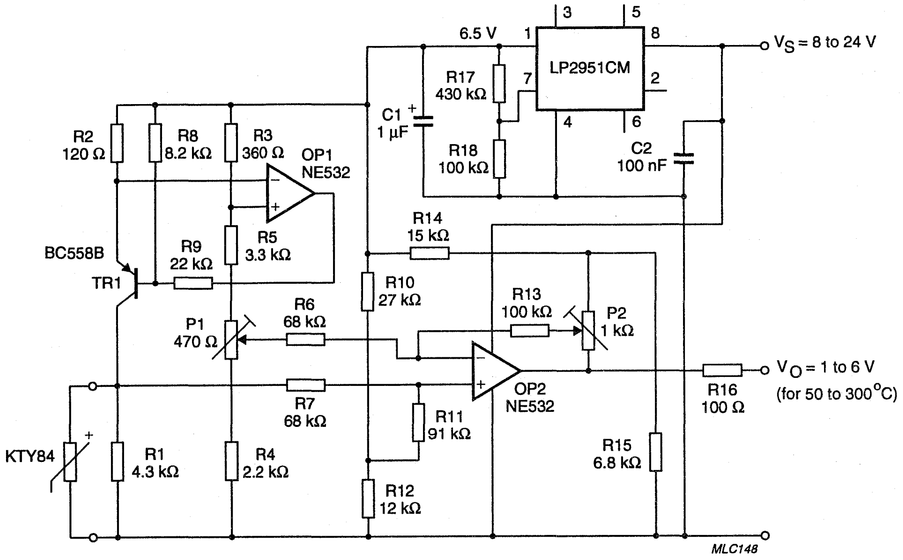


Fig.22 Evaluation circuit for KTY 84 with voltage regulation.

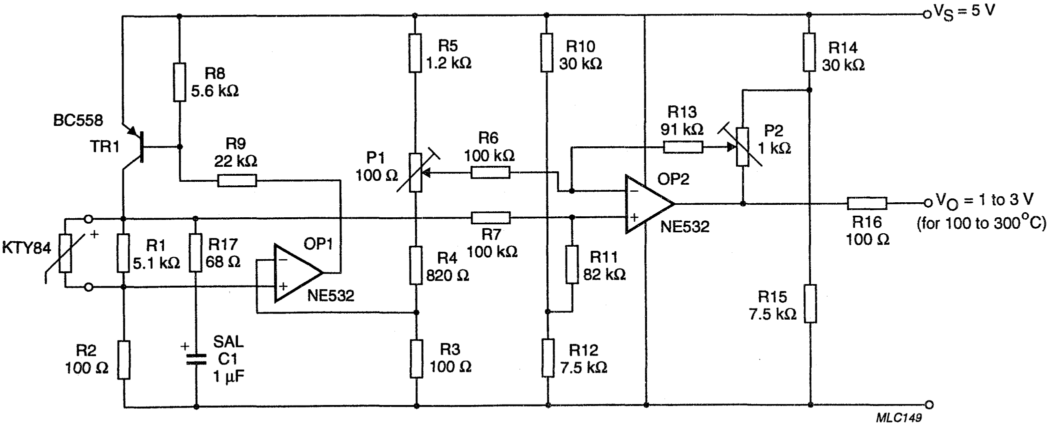


Fig.23 KTY84 evaluation circuit for 5 V power supply.

AD CONVERTER TEMPERATURE COMPENSATION

When an A/D converter is integrated with a microcontroller, temperature compensation is required.

Figure 24 shows a suitable configuration, using a KTY81-210 temperature sensor in series with linearization resistor R_S. This voltage divider provides a linear temperature dependent voltage V_T of between 1.127 V and 1.886 V over the range 0 to 100 °C. This voltage is used as a reference for the A/D converter. The linear slope 'S' of V_T = 7.59 mV/ K.

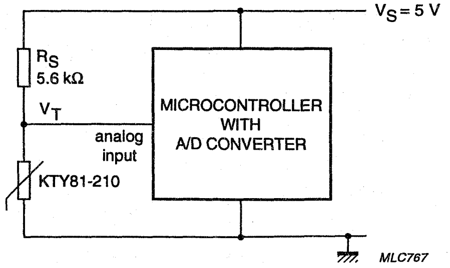


Fig.24 Temperature compensation for A/D converters.

ADDITIONAL TEMPERATURE SENSOR APPLICATIONS

Philips temperature sensors are also suitable for use in a number of other applications, for which information can be supplied on request:

- Electronic circuit protection
- Protection for power supplies
- Domestic appliances
- The white goods industry
- The automotive industry.

MOUNTING AND HANDLING RECOMMENDATIONS

Mounting

KTY81

When potting techniques for KTY81 sensors are used for assembling, care has to be taken to ensure that mechanical stress and temperature development during curing of epoxy resin do not overstress the devices.

KTY83, 84, 86 AND 87

Excessive forces applied to a sensor may cause serious damage. To avoid this, the following recommendations should be adhered to:

- no perpendicular forces must be applied to the body
- during bending, the leads must be supported
- bending close to the body must be done very carefully
- axial forces to the body can influence the accuracy of the sensor and should be avoided.

Handling

ELECTROSTATIC DISCHARGE (ESD) SENSITIVITY

Electrostatic discharges above a certain energy can lead to irreversible changes of the sensor characteristic. In extreme events, sensors can even be destroyed. In accordance with the test methods described in IEC 47 (CO)955, temperature sensors are classified as sensitive components with respect to ESD. During handling (testing, transporting, fitting), the common rules for handling of ESD sensitive components should be observed.

If necessary, the ESD sensitivity in the practical application can be further reduced by connecting a 10 nF capacitor in parallel to the sensor.

Soldering

KTY81

The common rules for soldering components in TO-92 packages should be observed.

KTY 82

The common rules for soldering SMD components in SOT23 packages should be observed (see Chapter *"Mounting and soldering in Handbook SC10a"*).

KTY83, 86 AND 87

Avoid any force on the body or leads during, or just after, soldering. Do not correct the position of an already soldered sensor by pushing, pulling or twisting the body. Prevent fast cooling after soldering. For hand soldering, where mounting is not on a printed-circuit board, the soldering temperature should be <300 °C, the soldering time <3 s and the distance between body and soldering point >1.5 mm. For hand soldering, dip, wave or other bath soldering, mounted on a printed-circuit board, the soldering temperature should be <300 °C, the soldering time <5 s and the distance between body and soldering point >1.5 mm.

KTY85

The common rules for surface mounted devices in SOD80 packages should be observed. Hand soldering is not recommended, because there is a great risk of damaging the glass body or the inner construction by uncontrolled temperature and time.

Welding

The KTY84 sensors are manufactured with nickel plated leads suitable for welding. The distance between the body and the welding point should be >0.5 mm. Care should be taken to ensure that welding current never passes through the sensor.

TAPE AND REEL PACKAGING

Tape and reel packaging meets the feed requirements of automatic pick and place equipment. It is also an ideal shipping container.

Table 2 Packaging quantities

TYPE	PACKAGE OUTLINE	PACKAGING METHOD	SPQ	PQ	12NC NUMBER XXXX XXX XX...
KTY81	SOD70	bulk pack	500	4000	112
		single pack	100	1000	114
		reel pack, radial	2000	10000	116
KTY82	SOT23	bulk pack	500	25000	212
		reel pack, SMD low profile 7"	3000	3000	215
		reel pack, SMD low profile 11¼"	10000	10000	235
KTY83, 84	SOD68	reel pack axial 52 mm	10000	10000	113
		ammopack axial small size	1000	1000	153
KTY85	SOD80	bulk pack	1000	10000	112
		reel pack, SMD, 7"	2500	2500	115
KTY86, 87	SOD103	bulk pack	500	2000	112
		single pack	10	100	114
		reel pack	2000	2000	116

SILICON TEMPERATURE SENSORS

These sensors have a positive temperature coefficient of resistance and are for use in measurement and control.

QUICK REFERENCE DATA

Resistance at T_{amb} = 25 °C I_C = 1 mA	KTY81-110	R_{25}	990 - 1010 Ω
	KTY81-120	R_{25}	980 - 1020 Ω
	KTY81-121	R_{25}	980 - 1000 Ω
	KTY81-122	R_{25}	1000 - 1020 Ω
	KTY81-150	R_{25}	950 - 1050 Ω
	KTY81-151	R_{25}	950 - 1000 Ω
	KTY81-152	R_{25}	1000 - 1050 Ω

Operating ambient temperature range T_{amb}	−55 to +150 °C

MECHANICAL DATA

Dimensions in mm

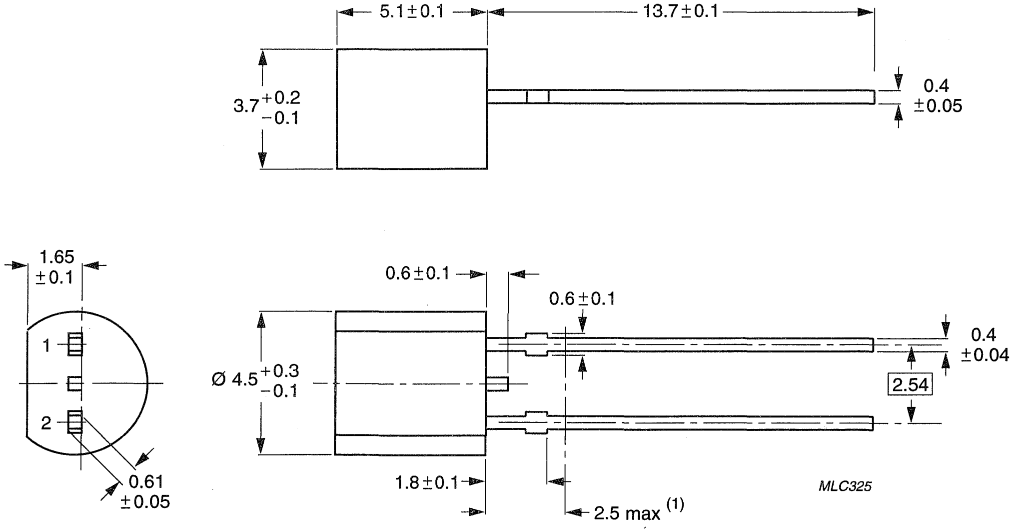


Fig. 1 SOD-70.

Note

1. Terminal dimensions within this zone are uncontrolled to allow for flow of plastic and terminal irregularities.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air			
T_{amb} = 25 °C	I_C	max.	10 mA
T_{amb} = 150 °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C unless otherwise specified).

Resistance			
I_C = 1 mA	KTY81-110	R_{25}	990 - 1010 Ω
	KTY81-120	R_{25}	980 - 1020 Ω
	KTY81-121	R_{25}	980 - 1000 Ω
	KTY81-122	R_{25}	1000 - 1020 Ω
	KTY81-150	R_{25}	950 - 1050 Ω
	KTY81-151	R_{25}	950 - 1000 Ω
	KTY81-152	R_{25}	1000 - 1050 Ω

Temperature coefficient		typ.	0.79 %/K
Resistance ratio	R100/R25		1.696 ± 0.020
	R–55/R25		0.490 ± 0.010
Thermal time constant*			
in still air		typ.	30 s
in still liquid**		typ.	5.0 s
in flowing liquid**		typ.	3.0 s
Measuring temperature range			–55 to +150 °C

T_{amb} °C	Resistance Ω
–55	490
–50	515
–40	567
–30	624
–20	684
– 10	747
0	815
10	886
20	961
25	1000
30	1040
40	1122

T_{amb} °C	Resistance Ω
50	1209
60	1299
70	1392
80	1490
90	1591
100	1696
110	1805
120	1915
130	2023
140	2124
150	2211

Ambient temperature and corresponding average resistance values of sensor (I_C = 1 mA).

---

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

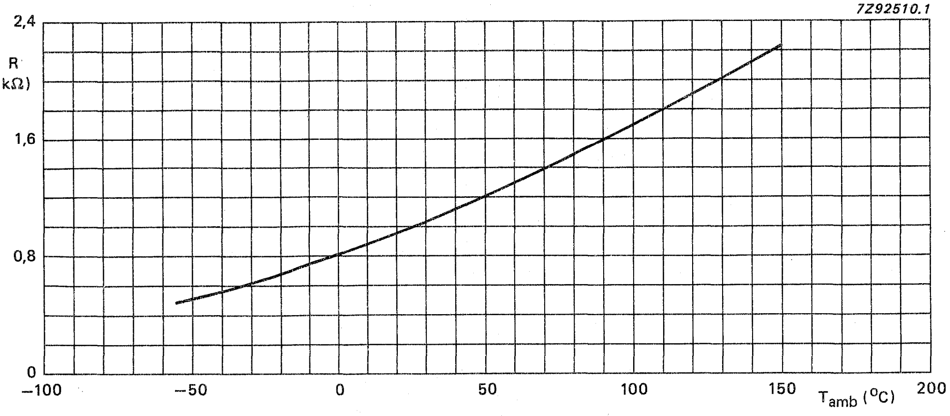


Fig. 2 Average resistance value of sensor at I_C = 1 mA as a function of temperature.

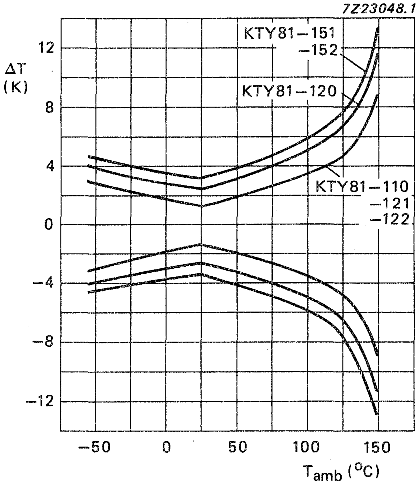


Fig. 3 Maximum expected temperature error ΔT.

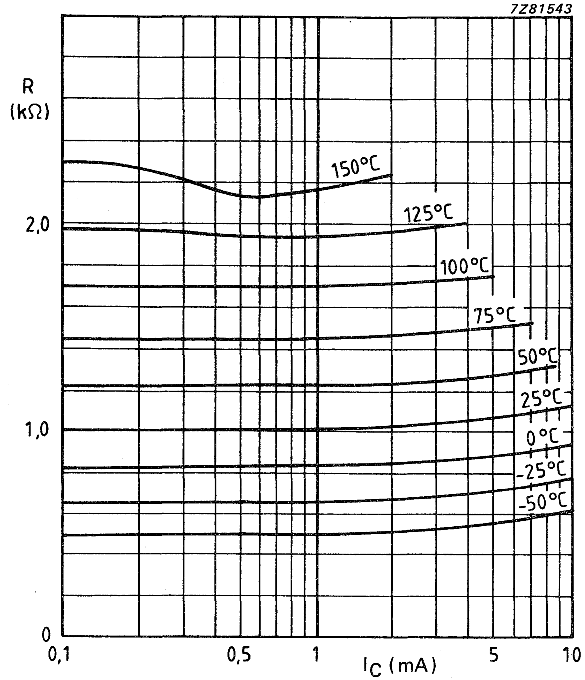


Fig. 4 Sensor resistance as a function of operating current (see Note).

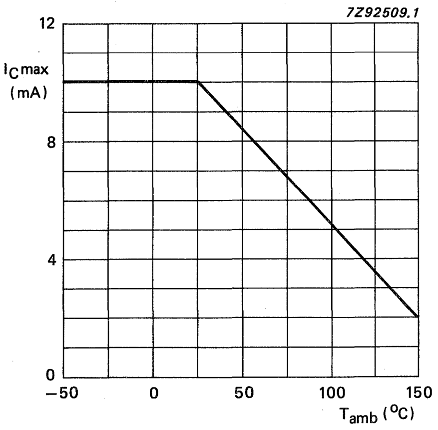


Fig. 5 Maximum operating current for safe operation.

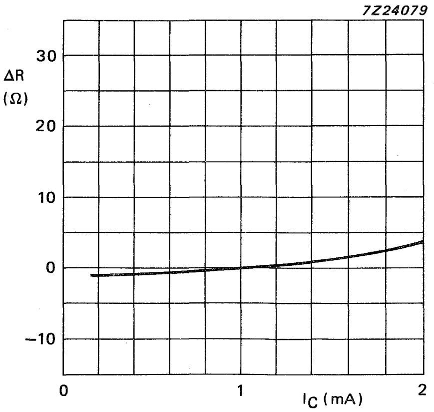


Fig. 6 Resistance deviation as a function of measuring current in still liquid; T_{amb} = 25 °C.

Note

To minimize temperature error, an operating current of I_C = 1 mA is recommended for temperatures above 100 °C.

SILICON TEMPERATURE SENSORS

These sensors have a positive temperature coefficient of resistance and are for use in measurement and control systems.

QUICK REFERENCE DATA

Resistance at T_{amb} = 25 °C I_C = 1 mA	KTY81-210	R_{25}	1980 - 2020 Ω
	KTY81-220	R_{25}	1960 - 2040 Ω
	KTY81-221	R_{25}	1960 - 2000 Ω
	KTY81-222	R_{25}	2000 - 2040 Ω
	KTY81-250	R_{25}	1900 - 2100 Ω
	KTY81-251	R_{25}	1900 - 2000 Ω
	KTY81-252	R_{25}	2000 - 2100 Ω

Operating ambient temperature range T_{amb}	−55 to +150 °C

MECHANICAL DATA

Dimensions in mm

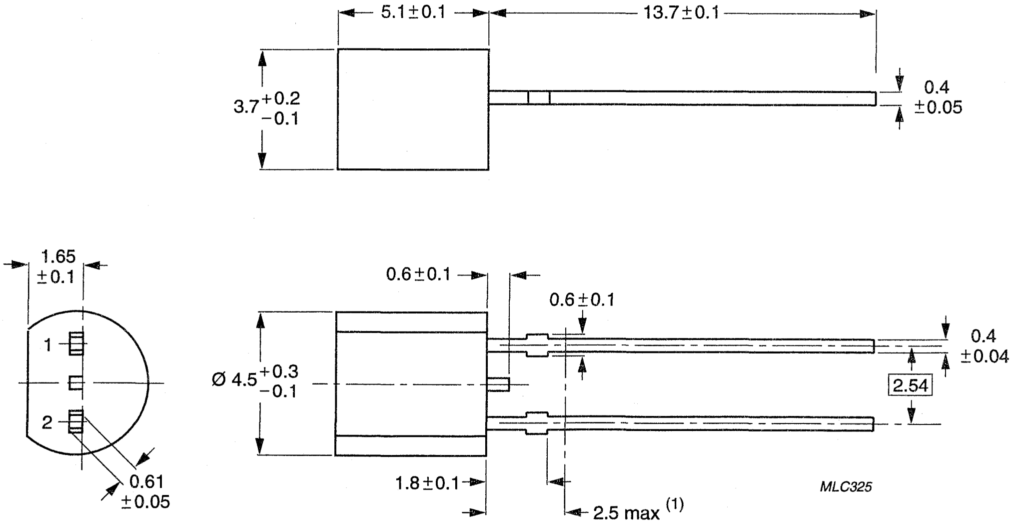


Fig. 1 SOD-70.

Note

1. Terminal dimensions within this zone are uncontrolled to allow for flow of plastic and terminal irregularities.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air

T_{amb} = 25 °C	I_C	max.	10 mA
T_{amb} = 150 °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C unless otherwise specified).

Resistance				
I_C = 1 mA	KTY81-210	R_{25}	1980 - 2020 Ω	
	KTY81-220	R_{25}	1960 - 2040 Ω	
	KTY81-221	R_{25}	1960 - 2000 Ω	
	KTY81-222	R_{25}	2000 - 2040 Ω	
	KTY81-250	R_{25}	1900 - 2100 Ω	
	KTY81-251	R_{25}	1900 - 2000 Ω	
	KTY81-252	R_{25}	2000 - 2100 Ω	
Temperature coefficient			typ.	0.79 %/K
Resistance ratio		R100/R25	1.696 ± 0.020	
		R−55/R25	0.490 ± 0.010	
Thermal time constant*				
in still air			typ.	30 s
in still liquid**			typ.	5 s
in flowing liquid			typ.	3 s
Measuring temperature range ***				−55 to +150 °C

T_{amb} °C	Resistance Ω
−55	980
−50	1030
−40	1135
−30	1247
−20	1367
−10	1495
0	1630
10	1772
20	1922
25	2000
30	2080
40	2245
50	2417
60	2597
70	2785
80	2980
90	3182
100	3392
110	3607
120	3817
125	3915
130	4008
140	4166
150	4280

Ambient temperatures and corresponding resistance values of sensor (IC = 1 mA).

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

*** Restricted accuracy in the temperature range 125 °C to 150 °C.

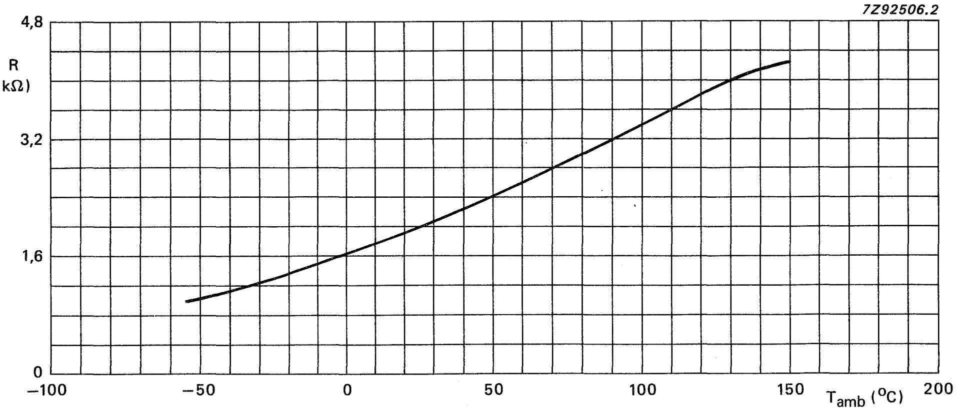


Fig. 2 Average resistance value of sensor at I_C = 1 mA as a function of temperature.

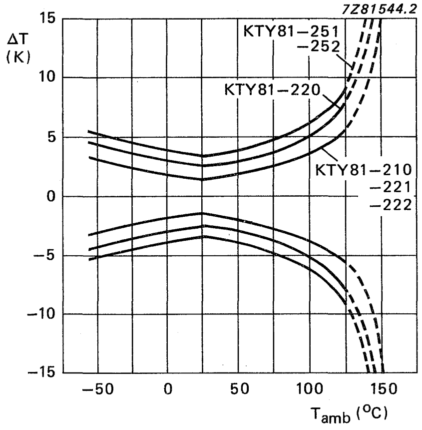


Fig. 3 Maximum expected temperature error ΔT.

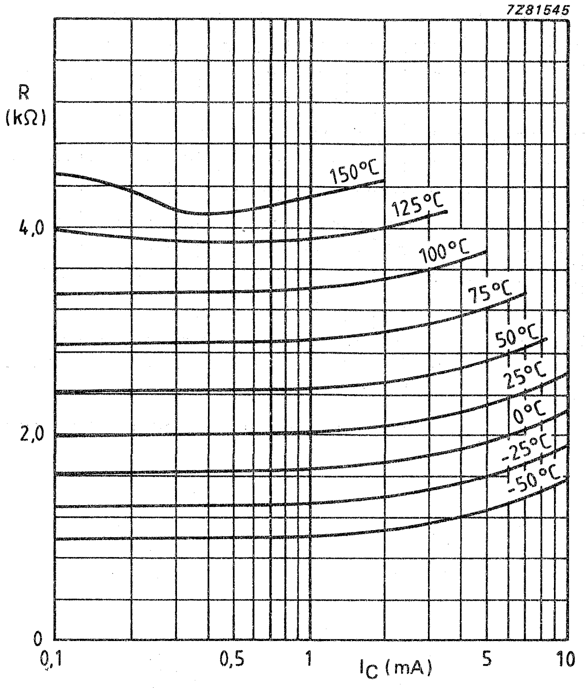


Fig. 4 Sensor resistance as a function of operating current (see Note).

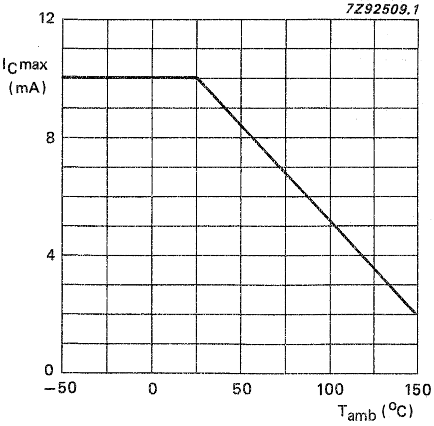


Fig. 5 Maximum operating current for safe operation.

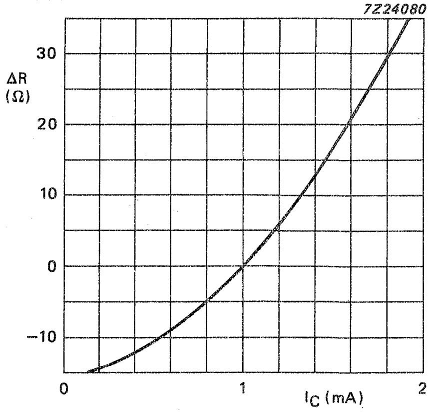


Fig. 6 Resistance deviation as a function of measuring current in still liquid; T_{amb} = 25 °C.

Note

To keep the temperature error low, an operating current of I_C = 1 mA is recommended for temperatures above 100 °C.

Silicon temperature sensors KTY82-1 series

DESCRIPTION

These temperature sensors have a positive temperature coefficient of resistance and are for use in measurement and control systems.

PINNING

PIN	DESCRIPTION
1	electrical contact
2	electrical contact
3	substrate (must remain potential free)

Marking codes:

KTY82-110: 110.
KTY82-120: 120.
KTY82-121: 121.
KTY82-122: 122.
KTY82-150: 150.
KTY82-151: 151.
KTY82-152: 152.

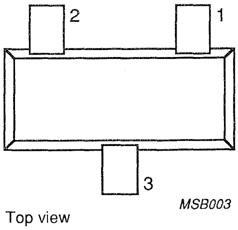


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
R_{25}	sensor resistance	T_{amb} = 25 °C; I_{cont} = 1 mA			
	KTY82-110		990	1010	Ω
	KTY82-120		980	1020	Ω
	KTY82-121		980	1000	Ω
	KTY82-122		1000	1020	Ω
	KTY82-150		950	1050	Ω
	KTY82-151		950	1000	Ω
	KTY82-152		1000	1050	Ω
T_{amb}	ambient operating temperature range		−55	150	°C

Note

Tolerances of 0.5% or other special selections available on request.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
I_{cont}	continuous sensor current	in free air; T_{amb} = 25 °C	–	10	mA
		in free air; T_{amb} = 150 °C	–	2	mA
T_{amb}	ambient operating temperature range		–55	150	°C

CHARACTERISTICS

T_{amb} = 25 °C, in liquid, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
R_{25}	sensor resistance	T_{amb} = 25 °C; I_{cont} = 1 mA				
	KTY82-110		990	–	1010	Ω
	KTY82-120		980	–	1020	Ω
	KTY82-121		980	–	1000	Ω
	KTY82-122		1000	–	1020	Ω
	KTY82-150		950	–	1050	Ω
	KTY82-151		950	–	1000	Ω
	KTY82-152		1000	–	1050	Ω
TC	temperature coefficient		–	0.79	–	%/K
R_{100}/R_{25}	resistance ratio	at T_{amb} = 100 °C and 25 °C	1.676	1.696	1.716	
R_{-55}/R_{25}	resistance ratio	at T_{amb} = –55 °C and 25 °C	0.480	0.490	0.500	
τ	thermal time constant (note 1)	in still air	–	7	–	s
		in still liquid (note 2)	–	1	–	s
		in flowing liquid	–	0.5	–	s
	rated temperature range		–55	–	150	°C

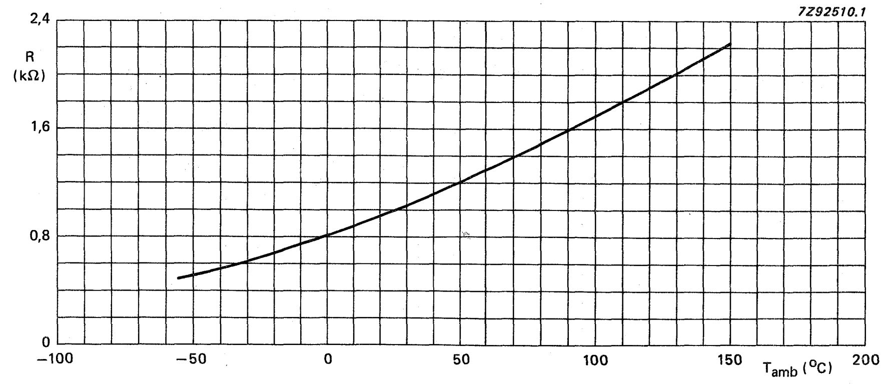
Notes

1. The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For example, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.
2. Inert liquid FC43 by 3M.

AMBIENT TEMPERATURES AND CORRESPONDING RESISTANCE OF SENSOR

I_{cont} = 1 mA.

AMBIENT TEMPERATURE (°C)	RESISTANCE (Ω)
−55	490
−50	515
−40	567
−30	624
−20	684
−10	747
0	815
10	886
20	961
25	1000
30	1040
40	1122
50	1209
60	1299
70	1392
80	1490
90	1591
100	1696
110	1805
120	1915
125	1969
130	2023
140	2124
150	2211



I_{cont} = 1 mA.

Fig.2 Average resistance value of sensor as a function of ambient temperature.

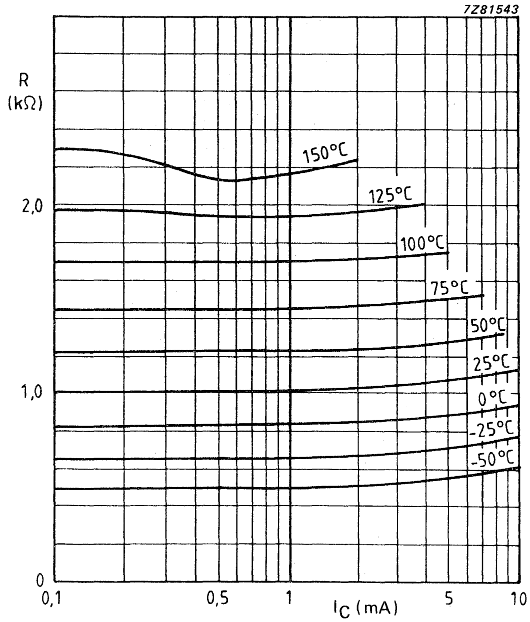


Fig.3 Sensor resistance as a function of operating current.

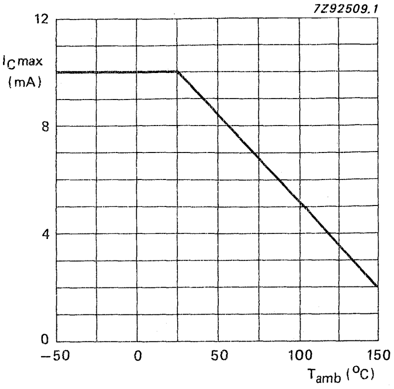
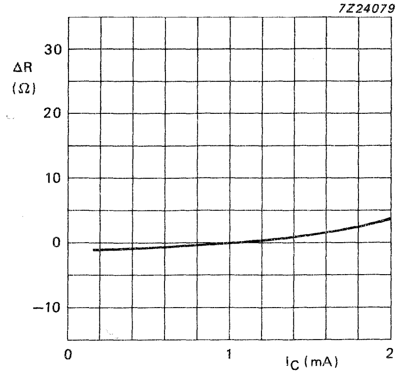


Fig.4 Maximum operating current for safe operation.



T_{amb} = 25 °C.

Fig.5 Deviation of sensor resistance as a function of operating current in still liquid.

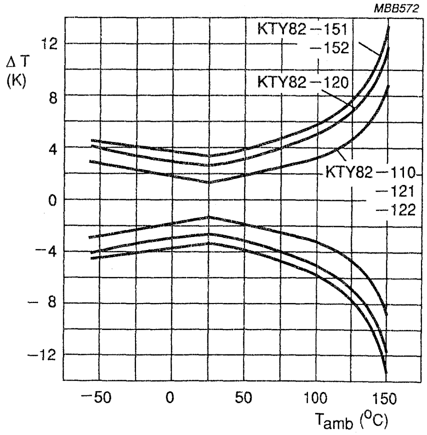


Fig.6 Maximum expected temperature error (ΔT).

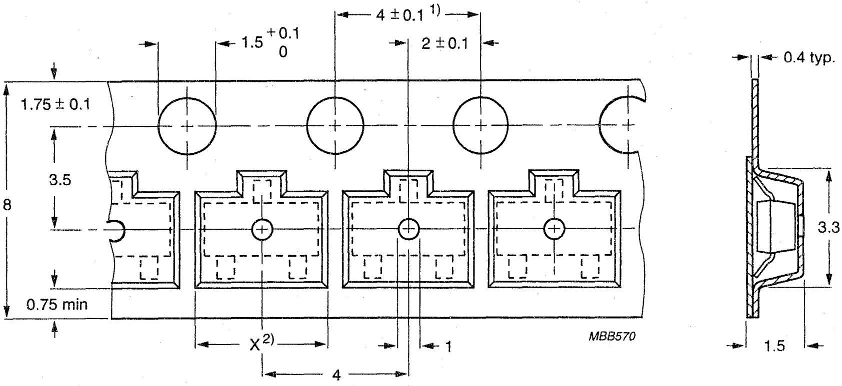
Note

To keep the temperature error low, an operating current of I_{cont} = 1 mA is recommended for temperatures above 100 °C.

PACKING DIMENSIONS

Tape specification

Sensors in SOT23 encapsulation are delivered in reel packing for automatic placement on hybrid circuits and printed circuit boards. The devices are placed with the mounting side downwards in compartments.



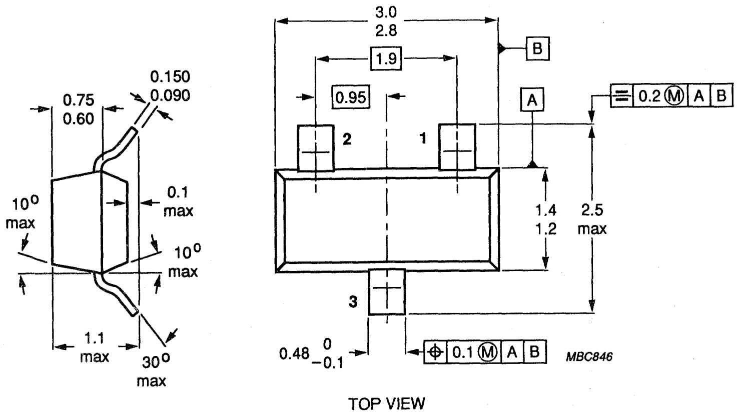
Dimensions in mm.

1) Tolerance over any 10 pitches: ±0.2 mm.

X = component length + 0.2 mm.

Fig.7 Configuration of bandolier.

PACKAGE OUTLINE



Dimensions in mm.

Weight: 0.01 g.

Fig.8 SOT23.

Silicon temperature sensors KTY82-2 series

DESCRIPTION

These temperature sensors have a positive temperature coefficient of resistance and are for use in measurement and control systems.

PINNING

PIN	DESCRIPTION
1	electrical contact
2	electrical contact
3	substrate (must remain potential free)

Marking codes:
KTY82-210: 210.
KTY82-220: 220.
KTY82-221: 221.
KTY82-222: 222.
KTY82-250: 250.
KTY82-251: 251.
KTY82-252: 252.

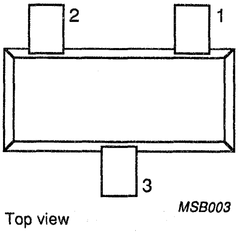


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
R_{25}	sensor resistance	T_{amb} = 25 °C; I_{cont} = 1 mA			
	KTY82-210		1980	2020	Ω
	KTY82-220		1960	2040	Ω
	KTY82-221		1960	2000	Ω
	KTY82-222		2000	2040	Ω
	KTY82-250		1900	2100	Ω
	KTY82-251		1900	2000	Ω
	KTY82-252		2000	2100	Ω
T_{amb}	ambient operating temperature range		–55	150	°C

Note

Tolerances of 0.5% or other special selections available on request.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
I_{cont}	continuous sensor current	in free air; T_{amb} = 25 °C	–	10	mA
		in free air; T_{amb} = 150 °C	–	2	mA
T_{amb}	ambient operating temperature range		–55	150	°C

CHARACTERISTICS

T_{amb} = 25 °C, in liquid, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
R_{25}	sensor resistance	T_{amb} = 25 °C; I_{cont} = 1 mA				
	KTY82-210		1980	–	2020	Ω
	KTY82-220		1960	–	2040	Ω
	KTY82-221		1960	–	2000	Ω
	KTY82-222		2000	–	2040	Ω
	KTY82-250		1900	–	2100	Ω
	KTY82-251		1900	–	2000	Ω
	KTY82-252		2000	–	2100	Ω
TC	temperature coefficient		–	0.79	–	%/K
R_{100}/R_{25}	resistance ratio	at T_{amb} = 100 °C and 25 °C	1.676	1.696	1.716	
R_{-55}/R_{25}	resistance ratio	at T_{amb} = –55 °C and 25 °C	0.480	0.490	0.500	
τ	thermal time constant (note 1)	in still air	–	7	–	s
		in still liquid (note 2)	–	1	–	s
		in flowing liquid	–	0.5	–	s
	rated temperature range (note 3)		–55	–	150	°C

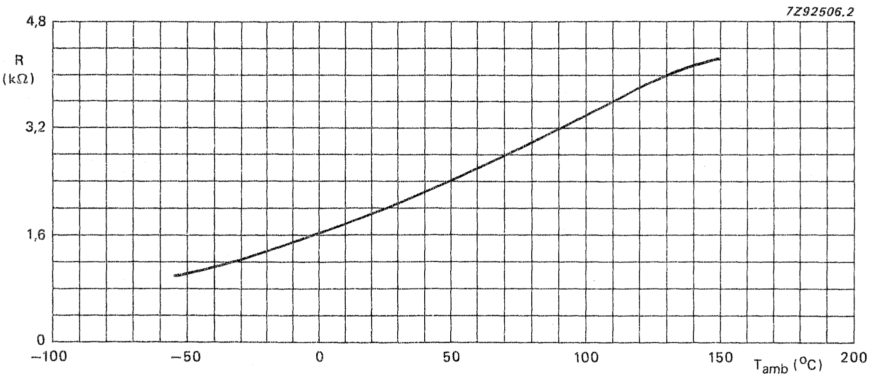
Notes

1. The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For example, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.
2. Inert liquid FC43 by 3M.
3. Restricted accuracy in the temperature range 125 to 150 °C.

AMBIENT TEMPERATURES AND CORRESPONDING RESISTANCE OF SENSOR

I_{cont} = 1 mA.

AMBIENT TEMPERATURE (°C)	RESISTANCE (Ω)
−55	980
−50	1030
−40	1135
−30	1247
−20	1367
−10	1495
0	1630
10	1772
20	1922
25	2000
30	2080
40	2245
50	2417
60	2597
70	2785
80	2980
90	3182
100	3392
110	3607
120	3817
125	3915
130	4008
140	4166
150	4280



I_{cont} = 1 mA.

Fig.2 Average resistance value of sensor as a function of ambient temperature.

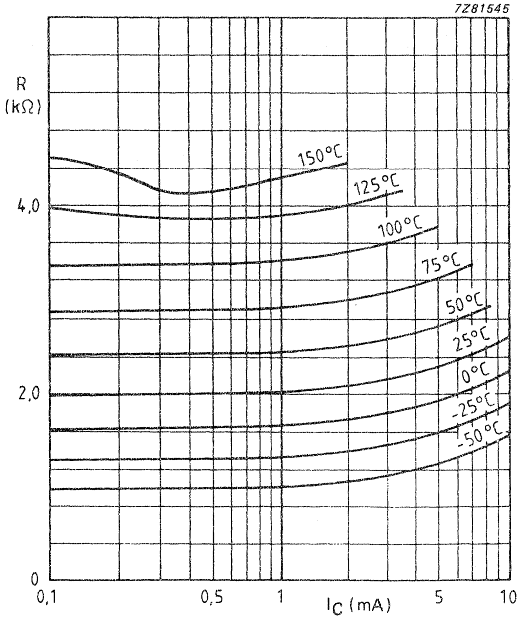


Fig.3 Sensor resistance as a function of operating current (ΔT).

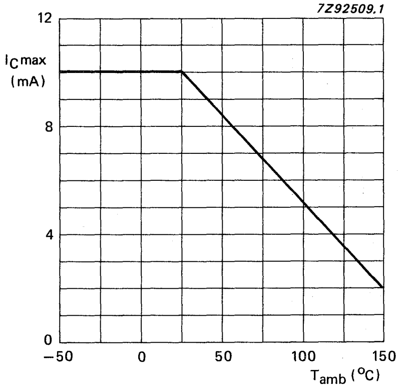
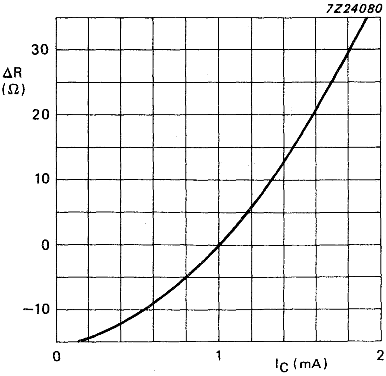


Fig.4 Maximum operating current for safe operation.



T_{amb} = 25 °C.

Fig.5 Deviation of sensor resistance as a function of operating current in still liquid.

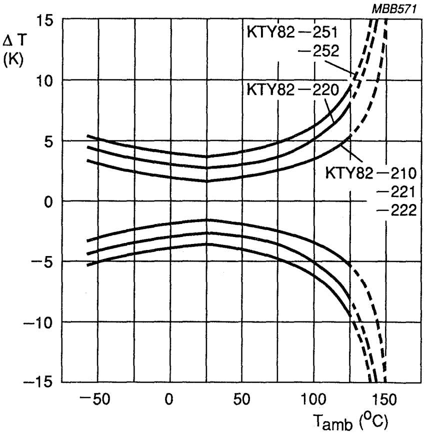


Fig.6 Maximum expected temperature error (ΔT).

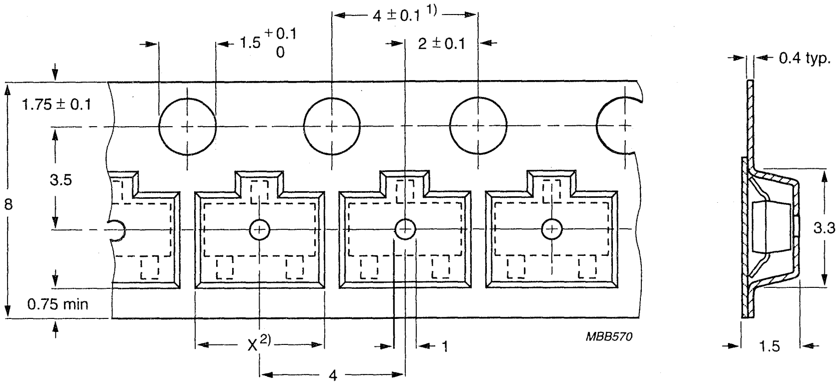
Note

To keep the temperature error low, an operating current of I_{cont} = 1 mA is recommended for temperatures above 100 °C.

PACKING DIMENSIONS

Tape specification

Sensors in SOT23 encapsulation are delivered in reel packing for automatic placement on hybrid circuits and printed circuit boards. The devices are placed with the mounting side downwards in compartments.



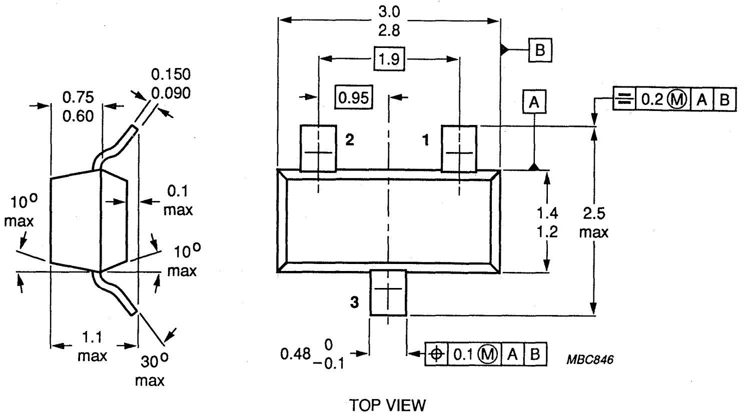
Dimensions in mm.

1) Tolerance over any 10 pitches: ±0.2 mm.

X = component length + 0.2 mm.

Fig.7 Configuration of bandolier.

PACKAGE OUTLINE



Dimensions in mm.
Weight: 0.01 g.

Fig.8 SOT23.

SILICON TEMPERATURE SENSORS

These sensors have a positive temperature coefficient of resistance and are for use in measurement and control.

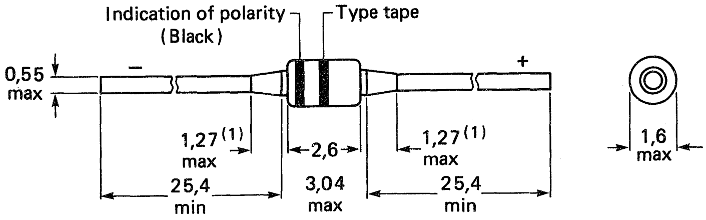
QUICK REFERENCE DATA

			Type tape (identification colour)
Resistance at T_{amb} = 25 °C I_C = 1 mA	KTY83-110	R_{25} = 990 - 1010 Ω;	yellow
	KTY83-120	R_{25} = 980 - 1020 Ω;	red
	KTY83-121	R_{25} = 980 - 1000 Ω;	white
	KTY83-122	R_{25} = 1000 - 1020 Ω;	green
	KTY83-150	R_{25} = 950 - 1050 Ω;	grey
	KTY83-151	R_{25} = 950 - 1000 Ω;	black
	KTY83-152	R_{25} = 1000 - 1050 Ω;	blue

Operating ambient temperature range T_{amb} –55 to +175 °C

MECHANICAL DATA

Dimensions in mm



(1) Lead diameter in this zone uncontrolled

Fig.1 SOD68 (DO-34)

Note

The sensor has to be operated with the lower potential at the marked connection (black type).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air

$T_{amb} = 25$ °C	I_C	max.	10 mA
$T_{amb} = 175$ °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at $T_{amb} = 25$ °C unless otherwise specified)

Resistance

$I_C = 1$ mA	KTY83-110	$R_{25} =$ 990 - 1010 Ω
	KTY83-120	$R_{25} =$ 980 - 1020 Ω
	KTY83-121	$R_{25} =$ 980 - 1000 Ω
	KTY83-122	$R_{25} =$ 1000 - 1020 Ω
	KTY83-150	$R_{25} =$ 950 - 1050 Ω
	KTY83-151	$R_{25} =$ 950 - 1000 Ω
	KTY83-152	$R_{25} =$ 1000 - 1050 Ω

Temperature coefficient	typ.	0.76 %/K
Resistance ratio	R100/R25	1.67 ± 0.02
	R−55/R25	0.50 ± 0.01
Thermal time constant*		
in still air	typ.	20 s
in still liquid**	typ.	1.0 s
in flowing liquid**	typ.	0.5 s
Measuring temperature range		−55 to +175 °C

T_{amb} °C	Resistance Ω
−55	500
−50	525
−40	577
−30	632
−20	691
−10	754
0	820
10	889
20	962
25	1000
30	1039
40	1118
50	1202
60	1288

T_{amb} °C	Resistance Ω
70	1379
80	1472
90	1569
100	1670
110	1774
120	1882
125	1937
130	1993
140	2107
150	2225
160	2346
170	2471
175	2535

Ambient temperatures and corresponding resistance values of sensor ($I_C = 1$ mA).

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

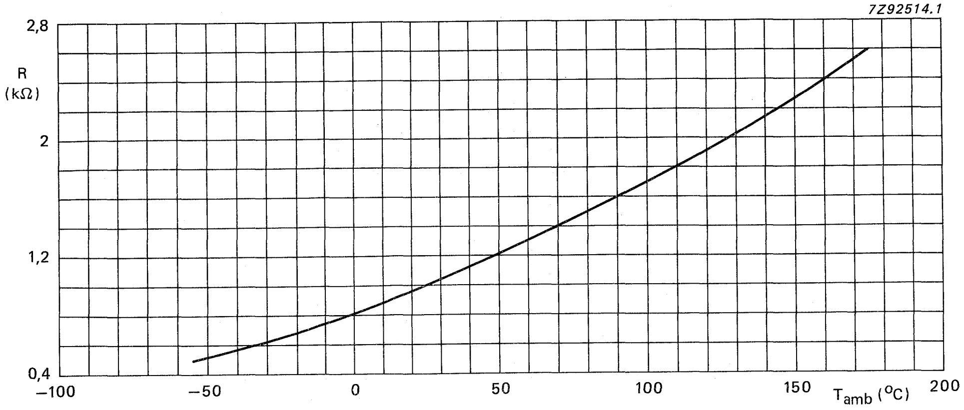


Fig. 2 Average resistance value of sensor at I_C = 1 mA as a function of temperature.

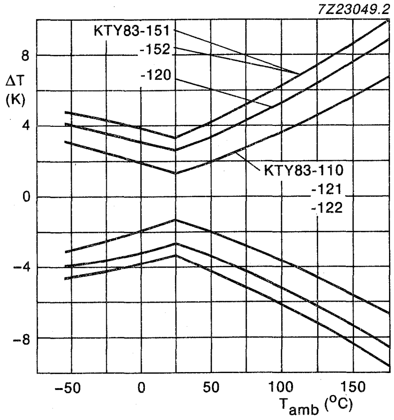


Fig. 3 Maximum expected temperature error ΔT.

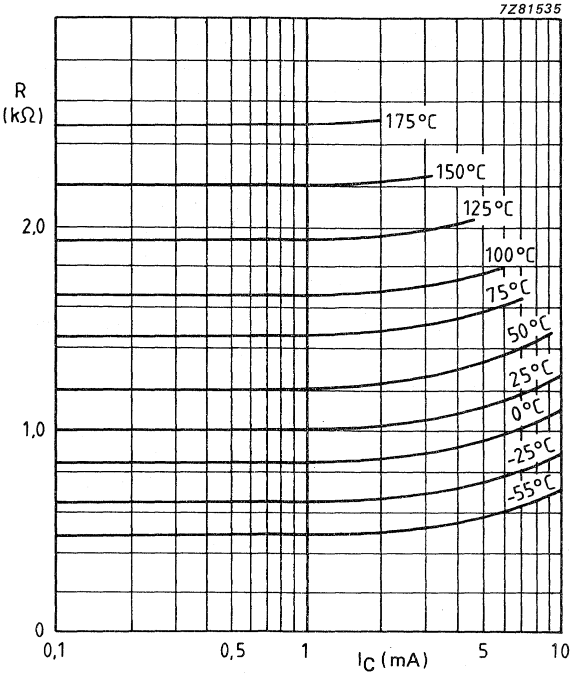


Fig. 4 Sensor resistance as a function of operating current.

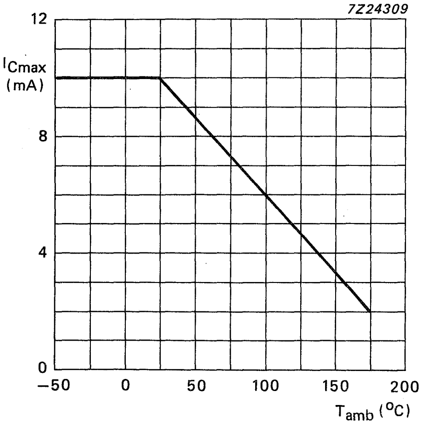


Fig. 5 Maximum operating current for safe operation.

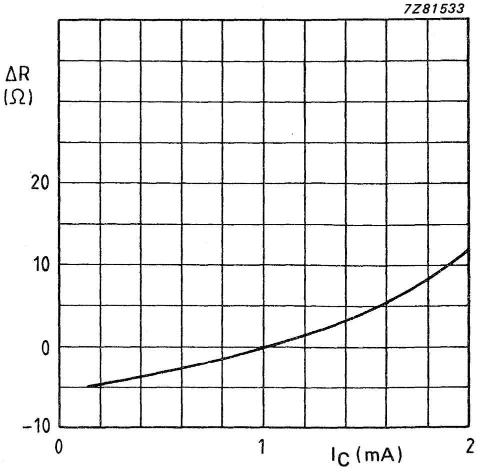


Fig. 6 Resistance deviation as a function of measuring current in still liquid; T_{amb} = 25 °C.

Silicon temperature sensors KTY84-130/150/151/152

DESCRIPTION

These temperature sensors have a positive temperature coefficient of resistance and are for use in measurement and control over a temperature range of −40 to +300 °C.

PACKAGE OUTLINE

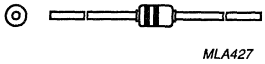


Fig.1 Simplified outline.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT	TYPE TAPE (IDENTIFICATION COLOUR)
R_{100}	resistance	T_{amb} = 100 °C; I_{cont} = 2 mA				
	KTY84-130		970	1030	Ω	yellow
	KTY84-150		950	1050	Ω	grey
	KTY84-151		950	1000	Ω	black
	KTY84-152		1000	1050	Ω	blue

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
I_{cont}	continuous sensor current	in free air; T_{amb} = 25 °C; (note 1)	–	10	mA
		in free air; T_{amb} = 300 °C	–	2	mA
T_{amb}	operating temperature range		–40	300	°C
T_{stg}	storage temperature range		–55	300	°C

Note

1. For temperatures greater than 200 °C, a sensor current of I_{cont} = 2 mA must be used.

CHARACTERISTICS

T_{amb} = 100 °C, in liquid, unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
R_{100}	resistance	I_{cont} = 2 mA				
	KTY84-130		970	–	1030	Ω
	KTY84-150		950	–	1050	Ω
	KTY84-151		950	–	1000	Ω
	KTY84-152		1000	–	1050	Ω
TC	temperature coefficient		–	0.62	–	%/K
R_{250}/R_{100}	resistance ratio		2.140	2.195	2.250	
R_{25}/R_{100}	resistance ratio		0.590	0.598	0.606	
τ	thermal time constant (note 1)					
		in still air	–	20	–	s
		in still liquid (note 2)	–	1	–	s
		in flowing liquid (note 2)	–	0.5	–	s

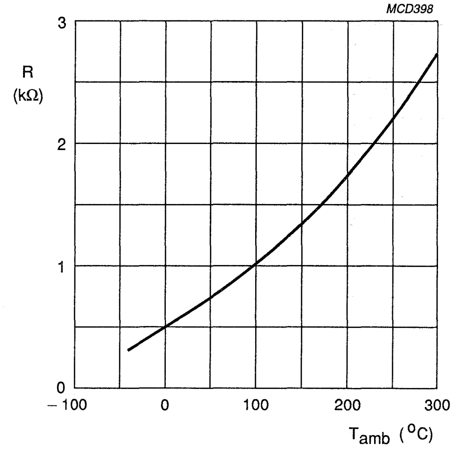
Notes

1. The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For example, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.
2. Inert liquid FC43 by 3M.

AMBIENT TEMPERATURES AND CORRESPONDING RESISTANCE OF SENSOR

I_{cont} = 2 mA.

AMBIENT TEMPERATURE (°C)	RESISTANCE (Ω)
−40	355
−30	386
−20	419
−10	455
0	493
10	533
20	576
25	598
30	621
40	668
50	718
60	769
70	824
80	880
90	939
100	1000
110	1063
120	1129
130	1197
140	1268
150	1340
160	1415
170	1493
180	1572
190	1654
200	1739
210	1825
220	1914
230	2006
240	2099
250	2195
260	2293
270	2392
280	2490
290	2584
300	2668



I_{cont} = 2 mA.

Fig.2 Resistance value of sensor as a function of ambient temperature.

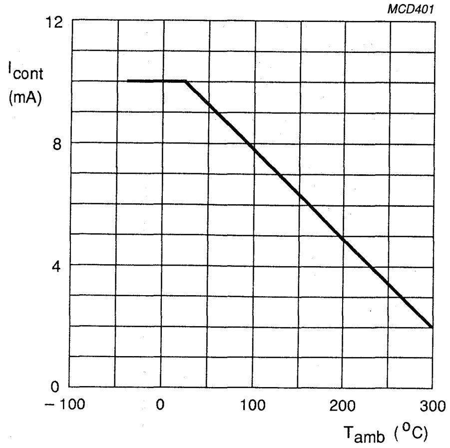
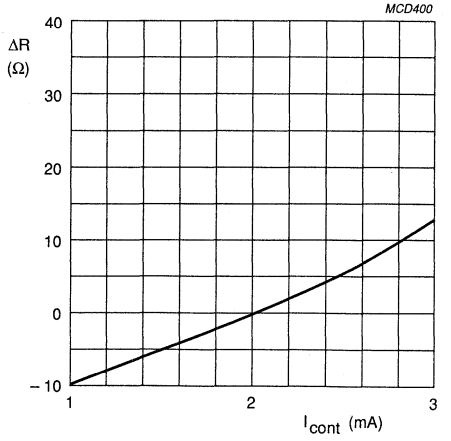


Fig.3 Maximum operating current for safe operation.



T_{amb} = 100 °C.

Fig.4 Deviation of sensor resistance as a function of operating current in still liquid.

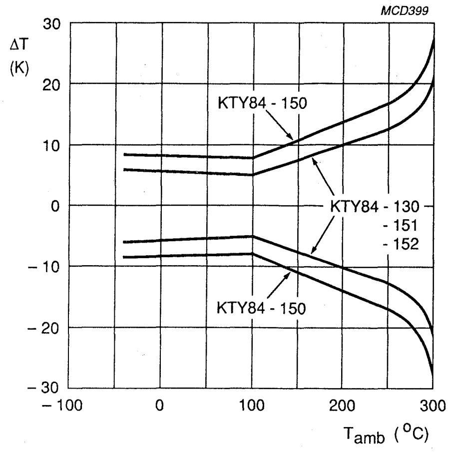
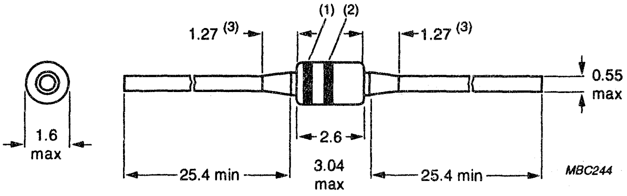


Fig.5 Maximum expected temperature error.



Dimensions in mm.

(1) Indication of polarity (green).

(2) Type tape.

(3) Lead diameter within this zone is not controlled.

Fig.6 SOD68 (DO-34).

SILICON TEMPERATURE SENSORS

These sensors have a positive temperature coefficient of resistance and are for use in measurement and control.

QUICK REFERENCE DATA

Resistance at T_{amb} = 25 °C

I_C = 1 mA

Type tape (identification colour)

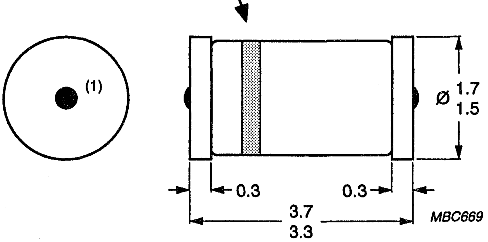
KTY85-110 R_{25} = 990 - 1010 Ω; yellow
KTY85-120 R_{25} = 980 - 1020 Ω; red
KTY85-121 R_{25} = 980 - 1000 Ω; white
KTY85-122 R_{25} = 1000 - 1020 Ω; green
KTY85-150 R_{25} = 950 - 1050 Ω; grey
KTY85-151 R_{25} = 950 - 1000 Ω; black
KTY85-152 R_{25} = 1000 - 1050 Ω; blue

Operating ambient temperature range T_{amb} −40 to +125 °C

MECHANICAL DATA

Dimensions in mm

Indication of polarity and type tape



(1) Area not tinned; small elevations are possible.

Fig. 1 SOD-80.

Note

The sensor has to be operated with the lower potential at the marked connection.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air

T_{amb} = 25 °C	I_C	max.	10 mA
T_{amb} = 125 °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C unless otherwise specified)

Resistance I_C = 1 mA	KTY85-110	R_{25} = 990 - 1010 Ω		
	KTY85-120	R_{25} = 980 - 1020 Ω		
	KTY85-121	R_{25} = 980 - 1000 Ω		
	KTY85-122	R_{25} = 1000 - 1020 Ω		
	KTY85-150	R_{25} = 950 - 1050 Ω		
	KTY85-151	R_{25} = 950 - 1000 Ω		
	KTY85-152	R_{25} = 1000 - 1050 Ω		
Temperature coefficient		typ.	0.76	%/K
Resistance ratio		R100/R25	1.670 ± 0.020	
		R−40/R25	0.577 ± 0.008	
Thermal time constant*				
in still air		typ.	20	s
in still liquid**		typ.	1.0	s
in flowing liquid**		typ.	0.5	s
Measuring temperature range			−40 to +125	°C

---

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

T_{amb} °C	Resistance Ω
−40	577
−30	632
−20	691
−10	754
0	820
10	889
20	962
25	1000
30	1039
40	1118
50	1202
60	1288
70	1379
80	1472
90	1569
100	1670
110	1774
120	1882
125	1937

Ambient temperatures and corresponding resistance values of sensor (I_C = 1mA).

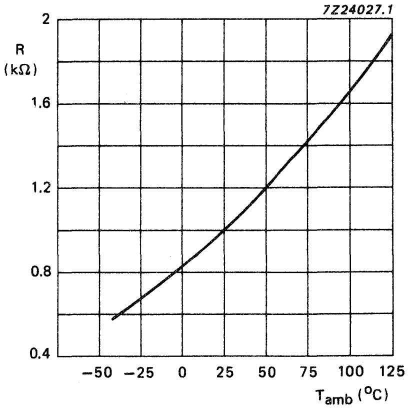


Fig. 2 Average resistance value of sensor at I_C = 1 mA as a function of ambient temperature.

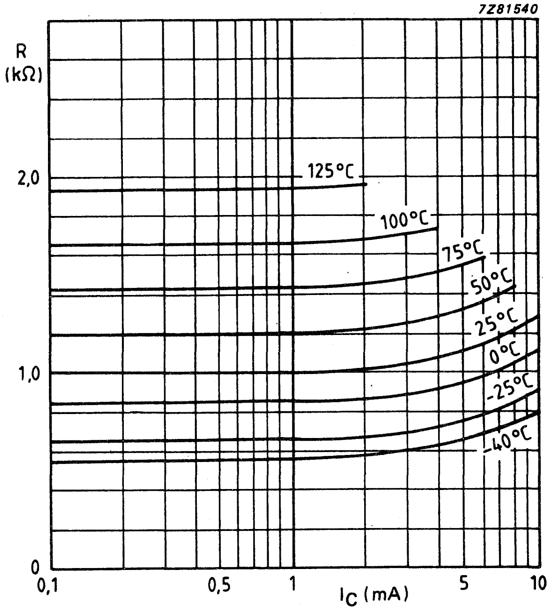


Fig. 3 Sensor resistance as a function of operating current.

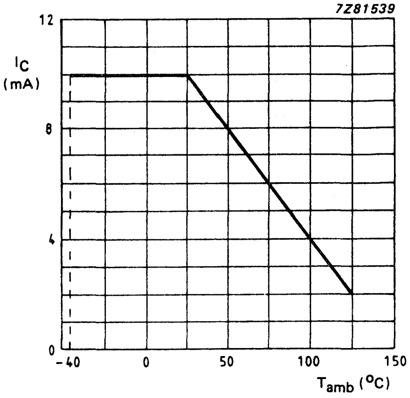


Fig. 4 Maximum operating current for safe operation.

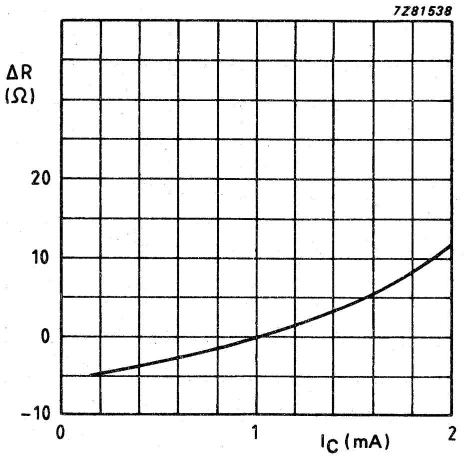


Fig. 5 Deviation of sensor resistance R as a function of operating current I_C in still liquid; T_{amb} = 25 °C.

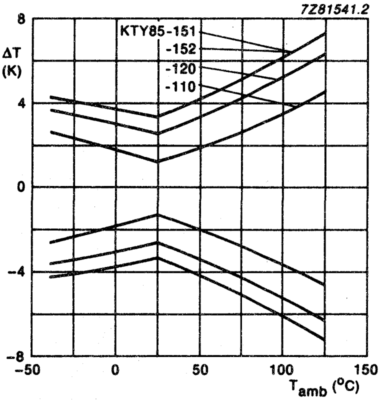


Fig. 6 Maximum expected temperature error ΔT.

SILICON TEMPERATURE SENSORS

These sensors are high accuracy temperature sensors with a positive temperature coefficient of resistance. Each sensor consists of a pair of 1000 Ω sensors in series and its main application fields are the measurement and control of temperature.

QUICK REFERENCE DATA

Resistance at T_{amb} = 25 °C I_C = 0.1 mA	KTY86-205	R_{25}	2000 ± 10 Ω
Operating ambient temperature range		T_{amb}	−40 to + 150 °C

MECHANICAL DATA

Dimensions in mm

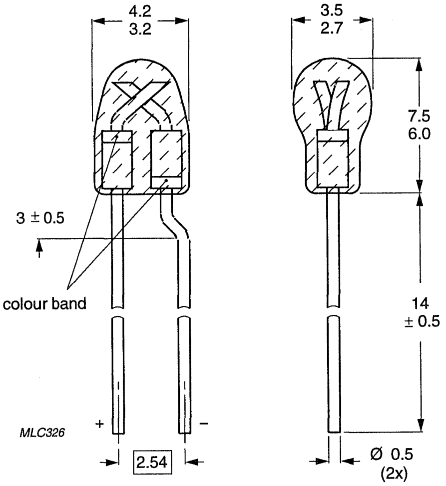


Fig.1 SOD103; colour band is white.

Note

The sensor has to be operated with the lower potential at the bent lead.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air			
T_{amb} = 25 °C	I_C	max.	10 mA
T_{amb} = 150 °C	I_C	max.	2.0 mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C; I_C = 0.1 mA unless otherwise specified).

Resistance	KTY86-205	R_{25} =		2000 ± 10 Ω
Resistance ratio				
$R_{100\,°C}/R_{25\,°C}$				1.672 ± 0.020
$R_{-40\,°C}/R_{25\,°C}$				0.577 ± 0.008
Temperature coefficient			α_{-40}	0.93 %/K
			α_{25}	0.76 %/K
			α_{100}	0.61 %/K
Thermal time constant*				
in still air			typ.	30 s
in still liquid**			typ.	2.2 s
in flowing liquid**			typ.	1.7 s
Measuring temperature range				−40 to +150 °C

---

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference, for instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

T_{amb} °C	Resistance Ω
−40	1154
−30	1265
−20	1383
−10	1508
0	1640
10	1779
20	1924
25	2000
30	2077
40	2237
50	2404
60	2578
70	2759
80	2947
90	3142
100	3344
110	3553
120	3769
130	3992
140	4222
150	4459

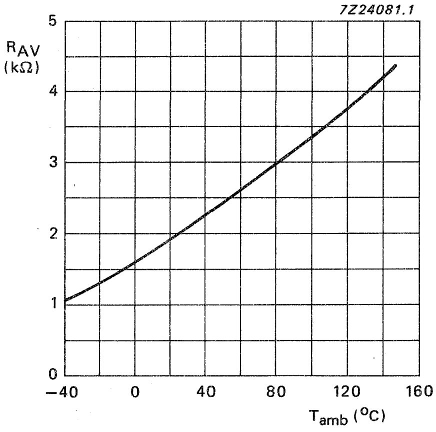


Fig. 2 Average resistance value of sensor at I_C = 0.1 mA as a function of ambient temperature.

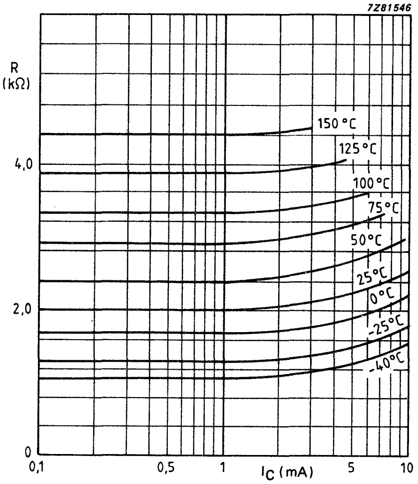


Fig. 3 Sensor resistance as a function of operating current.

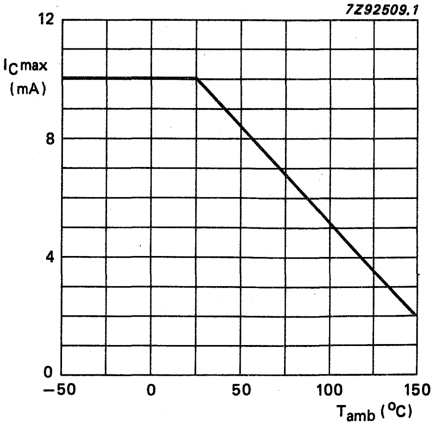


Fig. 4 Maximum operating current for safe operation.

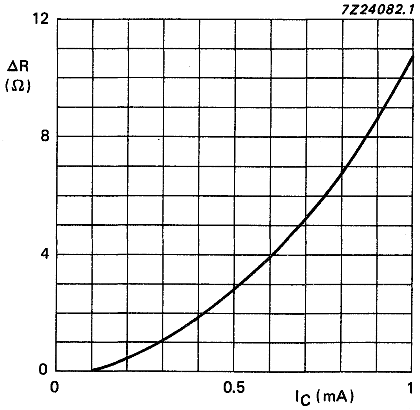


Fig. 5 Deviation of sensor resistance R as a function of operating current I_C in still liquid; T_{amb} = 25 °C.

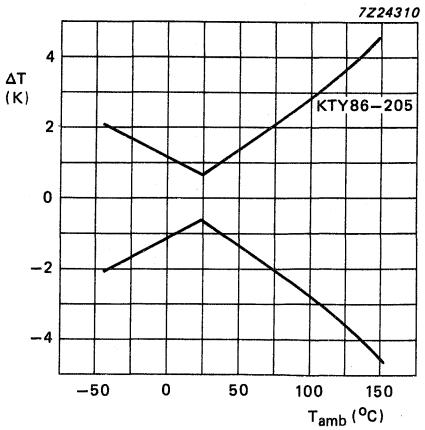


Fig. 6 Maximum expected temperature error ΔT.

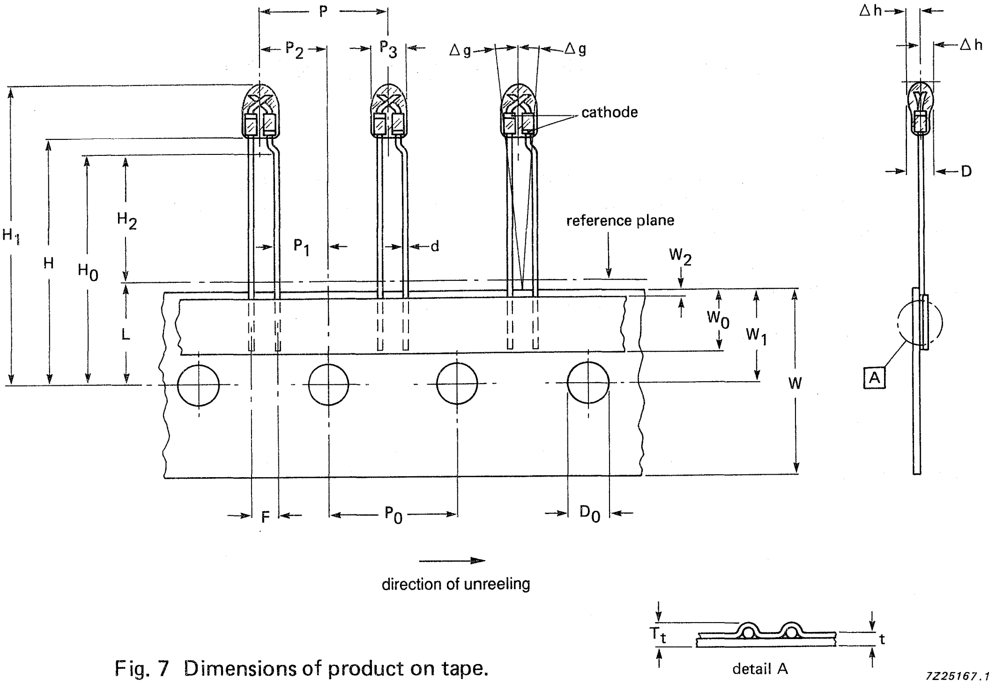


Fig. 7 Dimensions of product on tape.

Table 1 Dimensions of product on tape

symbol	dimensions
D	2.7 - 3.5
D_0	4.0 ± 0.2
d	0.48 - 0.55
F	2.54 + 0.4/−0.1
Δg	$0 + 5^{o}$
H	24.5 max.
H_0	22.0 max.
H_1	32.0 max.
H_2	12.0 max.
Δh	± 2.0
L	10.0 max.

symbol	dimensions
P	12.7 ± 1.0
P_0	12.7 ± 0.3
P_1	5.09 ± 0.7
P_2	5.95 ± 1.0
P_3	3.2 - 4.2
Tt	1.5 max.
t	0.7 ± 0.2
W	18.0 ± 1.0/−0.5
W_0	6.0 min.
W_1	9.0 ± 0.5
W_2	0 - 1.5

SILICON TEMPERATURE SENSORS

The KTY87 are high precision temperature sensors with a positive temperature coefficient of resistance for temperature measuring and temperature control. In the temperature range 10 °C to 110 °C the measuring accuracy is better than ± 1 °C.

QUICK REFERENCE DATA

Resistance at $I_C = 0.1$ mA	
$T_{amb} = 25$ °C	$R_{25} = 2000 \pm 10\ \Omega$
$T_{amb} = 100$ °C	$R100 = 3344 \pm 17\ \Omega$
Operating temperature range	−40 to + 125 °C

MECHANICAL DATA

Dimensions in mm

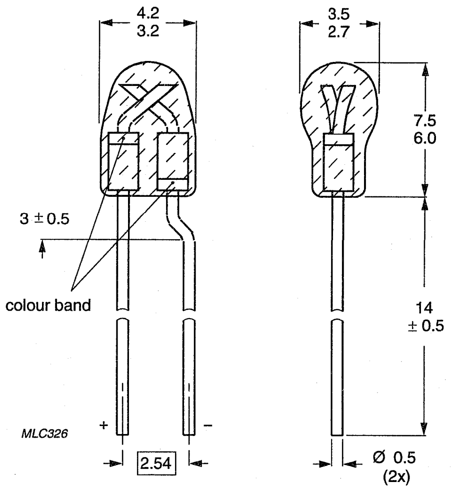


Fig.1 SOD103; colour band is green.

Notes

1. The sensor has to be operated with the lower potential at the bent lead.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Continuous sensor current in free air				
T_{amb} = 25 °C	I_C	max.	10	mA
T_{amb} = 125 °C	I_C	max.	2.0	mA

CHARACTERISTICS

(Based on the measurements in liquid at T_{amb} = 25 °C; I_C = 0.1 mA unless otherwise specified)

Resistance	R25	=	2000 ± 10	Ω
T_{amb} = 100 °C	R100	=	3344 ± 17	Ω
Temperature coefficient	at −40 °C	=	0.93	%/K
	at 25 °C	=	0.75	%/K
	at 100 °C	=	0.61	%/K
Resistance ratio	R−40/R25	=	0.577 ± 0.008	
Thermal time constant*				
in still air		typ.	30	s
in still liquid**		typ.	2.2	s
in flowing liquid**		typ.	1.7	s
Operating temperature range			−40 to + 125	°C

---

* The thermal time constant is the time the sensor needs to reach 63.2% of the total temperature difference. For instance, the time needed to reach a temperature of 72.4 °C, when a sensor with an initial temperature of 25 °C is put into an ambient with a temperature of 100 °C.

** Inert liquid FC43 of 3M company.

T_{amb} °C	Resistance Ω
−40	1154
−30	1265
−20	1383
−10	1508
0	1640
10	1779
20	1924
25	2000
30	2077
40	2237
50	2404
60	2578
70	2759
80	2947
90	3142
100	3344
110	3553
120	3769
125	3880

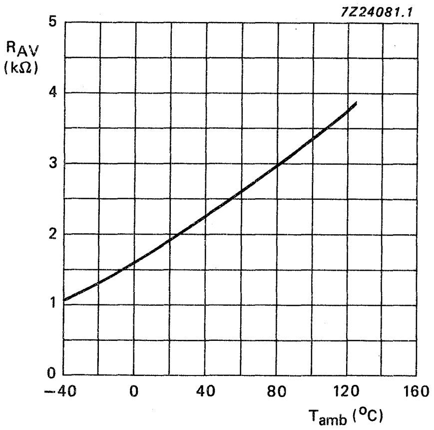


Fig. 2 Average resistance value of sensor at I_C = 0.1 mA as a function of ambient temperature.

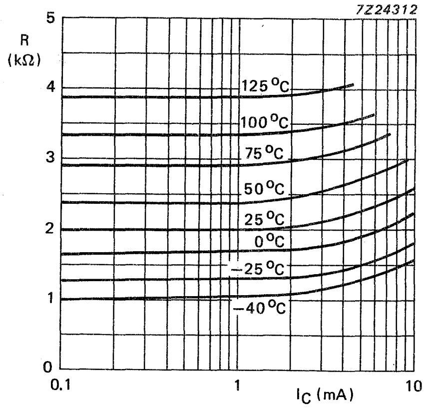


Fig. 3 Sensor resistance as a function of operating current.

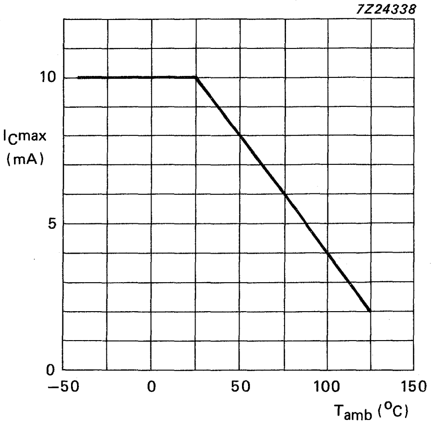


Fig. 4 Maximum operating current for safe operation.

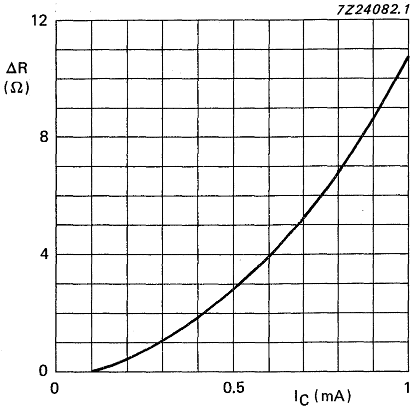


Fig. 5 Deviation of sensor resistance R versus operating current I_C in still liquid.

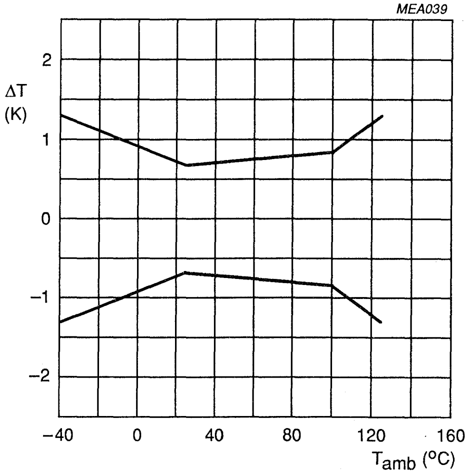


Fig. 6 Maximum temperature error ΔT.

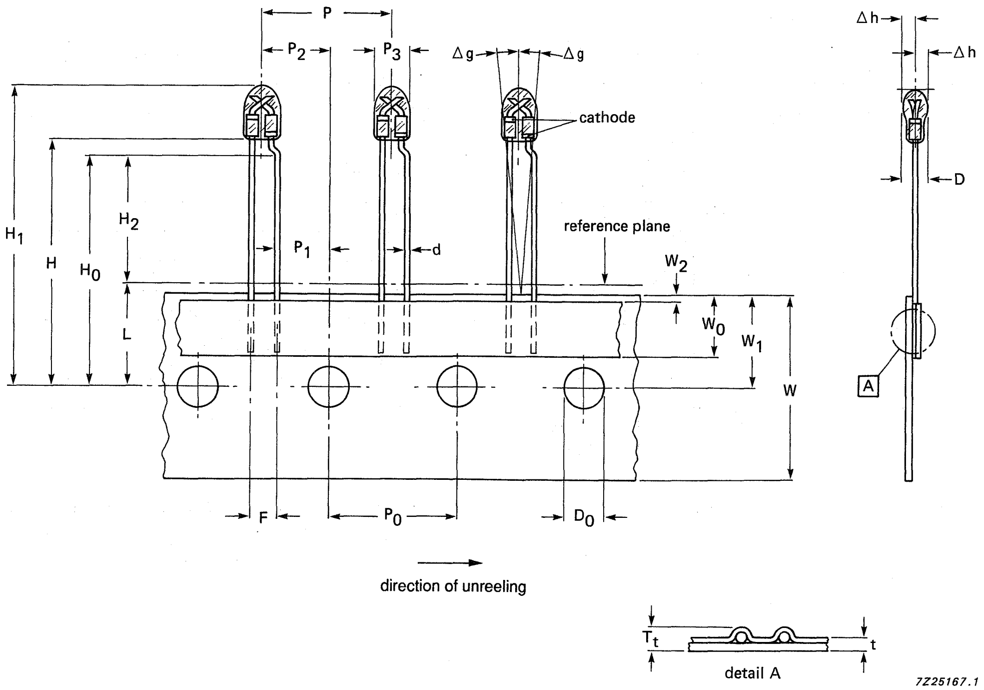


Table 1 Dimensions of product on tape

symbol	dimensions
D	2.7 – 3.5
D_0	4.0 ±0.2
d	0.48 – 0.55
F	2.54 +0.4/–0.1
Δg	0 +5°
H	24.5 max.
H_0	22.0 max.
H_1	32.0 max.
H_2	12.0 max.
Δh	±2.0
L	10.0 max
P	12.7 ±1.0
P_0	12.7 ±0.3
P_1	5.09 ±0.7
P_2	5.95 ±1.0
P_3	3.2 – 4.2
Tt	1.5 max
t	0.7 ±0.2
W	18.0 + 1.0/–0.5
W_0	6.0 min
W_1	9.0 ±0.5
W_2	0 – 1.5

Fig. 7 Dimensions of product on tape.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Stud type	OM type	L × W (mm) (max.)	V_B V	I_o (mA) (max.)	false polarity protection	short circuit/ overload protection	R_x		LED connection
							discrete	integrated	
M5	2860 2870	21.5 × 3	4.7 to 30	250	supply with spikes protection	transient protection	yes	no	no
	3105N	20 × 3	6 to 35	250	supply with spikes protection	yes/ transient protection	no	yes	note 3
	3105P	20 × 3	6 to 35	250	supply with spikes protection	yes/ transient protection	no	yes	note 3
M8	386B(1) 387B(1)	43.6 × 5	10 to 30	250	supply/load	yes	yes	yes	yes
	386M(1) 387M(1)	22.5 × 5(2)	10 to 30	250	supply/load	yes	yes	yes	yes
M12	388B(1) 389B(1)	26.5 × 5	10 to 30	250	supply/load	yes	yes	yes	yes
M18	390(1)	14.2 × 14.2	10 to 30	250	supply/load	yes	yes	yes	yes

Notes

1. The 300-series provides the possibility of directly connecting a LED function control, without additional power dissipation.
2. After assembly.
3. LED mounted on substrate, but version available with output pad for external LED connection.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M8 hollow stud. The OM386B is for positive supply voltage and the OM387B is for negative supply voltage. The circuit consists of a voltage regulator, an oscillator, a rectifier stage, a Schmitt trigger, an output stage and a protection circuit.

The circuit performs a make function: when actuated the current flows through the load, which can be e.g. the coil of an electromagnetic relay, a LED or a photocoupler.

Features:

- protection against short-circuit and overload
- protection of output transistor against transients by a voltage regulator diode
- protection against false polarity of the three connection leads
- choice between two methods to adjust the operating (switching) distance i.e. trimming a resistor integrated on the substrate or mounting a resistor
- possibility of connecting a LED for function control

The devices are thin-film circuits deposited on ceramic substrates. They may be potted, together with the oscillator coil, in a non-magnetic tube.

QUICK REFERENCE DATA

D.C. supply voltage range	V_B		10 to 30	V
Output current at V_B = 10 to 30 V	I_o	max.	250	mA
Operating (switching) distance (depends on R_x value and oscillator coil)	S		1 to 5	mm
Differential travel (hysteresis in switching distance)	H		3 to 10	%
Operating (switching) frequency	f	<	5	kHz
Operating substrate temperature range*	T_s		−40 to +85	°C
Substrate length	L		43,4 ±0,2	mm
Substrate width	W		4,8 ±0,2	mm
Height of circuit including substrate	h	max.	1,7	mm

MECHANICAL DATA

Dimensions in mm

Fig. 1 (see next page).

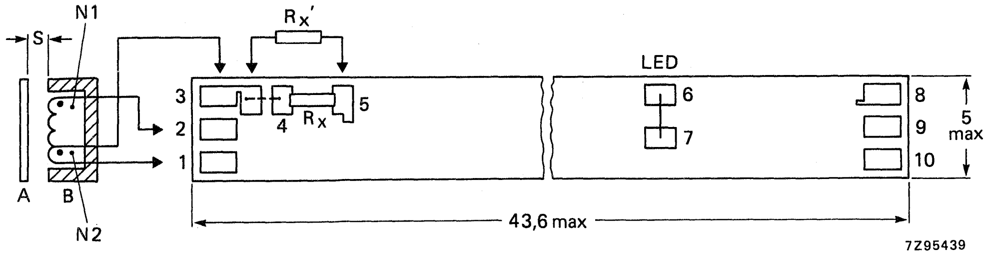
---

* The tube, potting and connection materials are the main limiting factors for the operating temperature range of a completely assembled proximity detector.

MECHANICAL DATA (outline and connections)

Dimensions in mm

Fig. 1.



A = metal actuator; B = open potcore or potcore half with coil.

Mechanical outline and connections: note that the supply polarities to points 8 and 10 are given for the OM386B; for the OM387B the polarities are point 8: $-V_B$, and point 10: $+V_B$.

S is the operating distance.

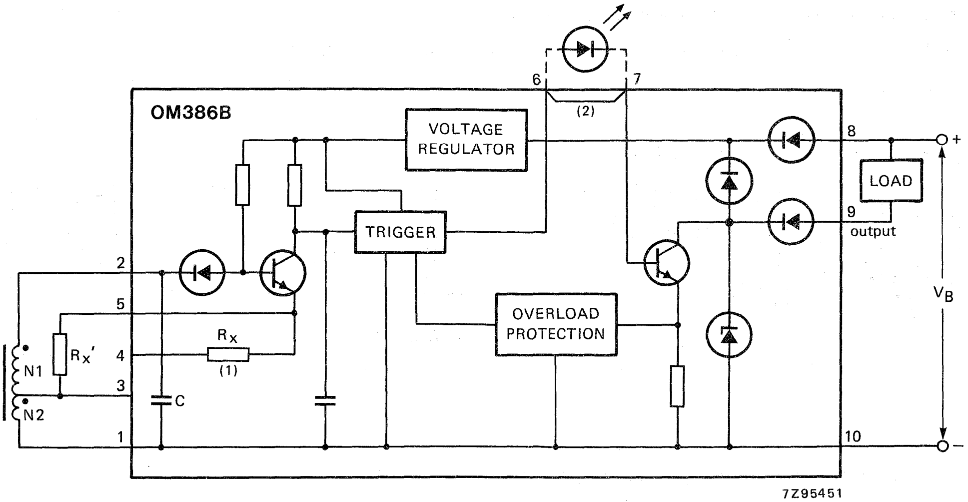


Fig. 2 Circuit diagram of OM386B.

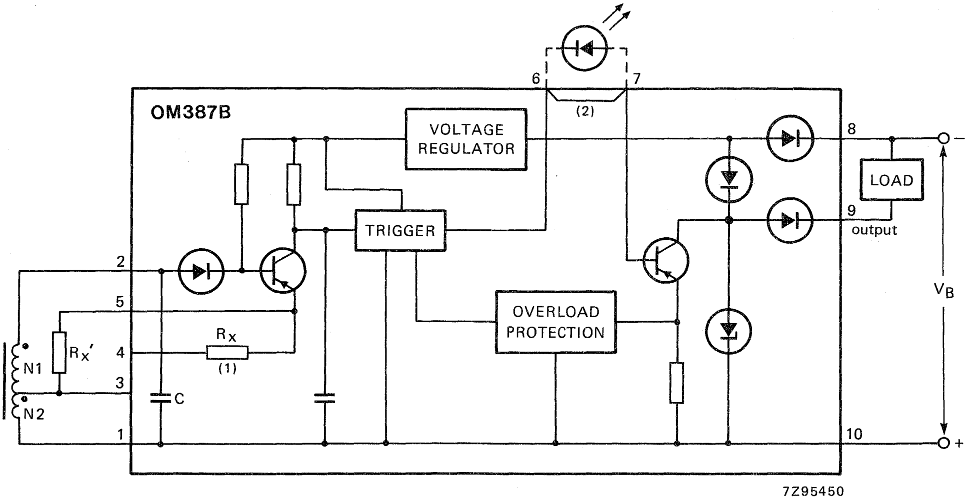


Fig. 3 Circuit diagram of OM387B.

(1) R_X is integrated on the substrate and suitable for trimming (laser or sandblasting). To use integrated resistance R_X it is necessary to connect point 3 to 4.

(2) If a LED is to be connected, the jumper between points 6 and 7 should be removed.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

D.C. supply voltage	V_B	max.	30 V
Output current	I_o	max.	250 mA
Storage temperature	T_{stg}		−40 to +125 °C
Operating substrate temperature	T_s		−40 to +85 °C

CHARACTERISTICS

Conditions (unless otherwise specified)

D.C. supply voltage	V_B	24 V
External resistor (R_X) and oscillator coil Device embedded in brass tube	see operating distance table below	
Substrate temperature	T_s	25 °C

Performances

Supply current			
output stage "ON"	I_B	typ.	8,4 mA
output stage "OFF"		typ.	4,8 mA
Voltage drop			
I_o = 250 mA	V_d	max.	1,9 V
I_o = 10 mA		max.	1,0 V

Operating (switching) distance*

type	oscillator coil number of turns		average operating distance S in mm at R_X (Ω)			recommended potcore	oscillator frequency kHz
	N1	N2	200	250	300		
M8	32	16	1	1,5	–	ϕ 5,8 mm (Neosid)	800
M12	40	10	2	3	–	P9 Philips**	600
M18	46	4	3	4	5	P14 Philips**	600

Differential travel (in % of S)	H		3 to 10 %
Operating frequency (according to EN 50010)	f	<	5 kHz

---

* The operating distance S depends on the oscillator coil, the material of the metal actuator and R_X. For measuring purposes a square steel sheet (St 37) with dimensions such that a circle with the diameter of the core can be inscribed, and 1 mm thickness can be used. R_X must not be chosen outside the range of 200 to 300 Ω.

** Grade 3B7/3H1.

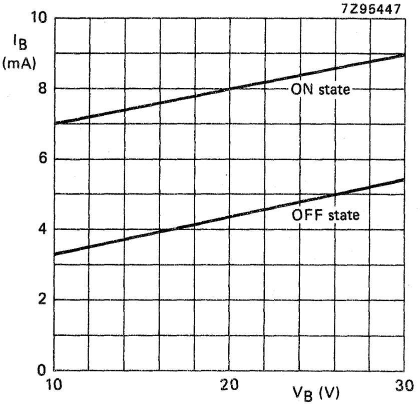


Fig. 4 Supply current as a function of supply voltage; $T_s = 25$ °C.

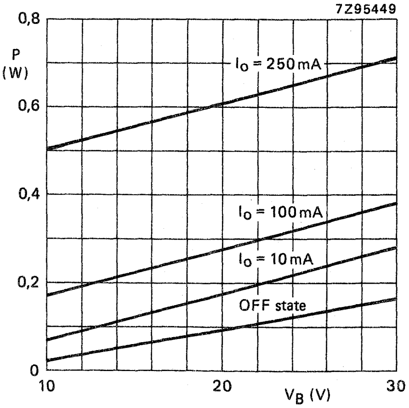


Fig. 5 Power dissipation as a function of supply voltage.

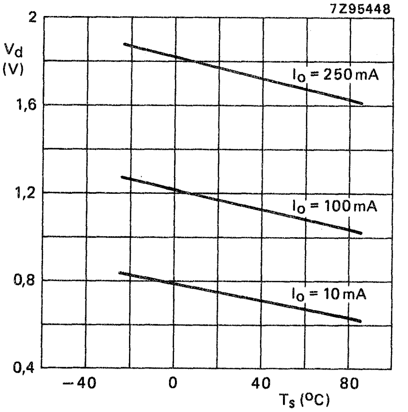


Fig. 6 Voltage drop as a function of substrate temperature.

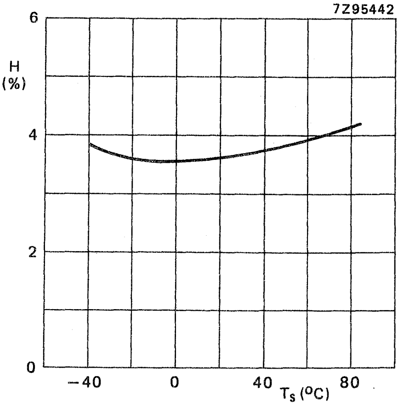
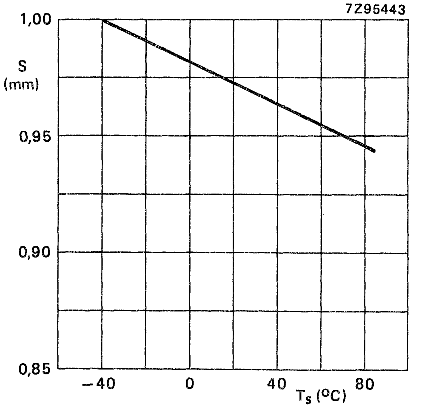


Fig. 7 Hysteresis as a function of substrate temperature.



Conditions relating to Figs 7 and 8:
potcore ϕ 5,8 mm Neosid
osc. coil N1 = 32, N2 = 16 turns
$R_x = 200\ \Omega$.

Fig. 8 Operating distance as a function of substrate temperature.

MOUNTING RECOMMENDATIONS

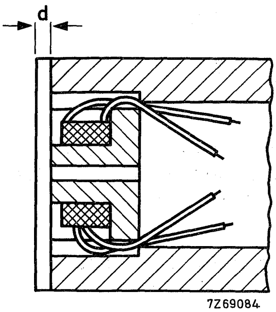


Fig. 9 Insertion of potcore in brass tube.

If a protective cap is incorporated, it should be as thin as possible, because its thickness d forms part of the operating distance S.
A brass stud wall should not extend beyond the potcore.
The exact value of S with its spread is determined by a number of variables, e.g.

- value of the adjustment resistor R_X
- the oscillator coil
- the metal of the actuator
- the material and shape of the housing.

Soldering recommendations

Use normal 60/40 solder; use a soldering iron with a fine point; soldering time as short as possible and it should not exceed 2,5 s per soldering point (T_{sld} = max. 250 °C).
The substrate is preferably preheated to a temperature of 100 °C with a minimum of 80 °C and a maximum of 125 °C.

Potting recommendations

First cover the hybrid IC with about 0,5 mm of silicone rubber, let it harden and with the parts inserted in the tube, fill up the tube with an epoxy.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M8 hollow stud. The OM386M is for positive supply voltage and the OM387M is for negative supply voltage. The circuit consists of a voltage regulator, an oscillator, a rectifier stage, a Schmitt trigger, an output stage and a protection circuit.

The circuit performs a make function: when actuated the current flows through the load, which can be e.g. the coil of an electromagnetic relay, a LED or a photocoupler.

Compared to the types OM386B/OM387B the substrate length is drastically reduced.

Features:

- extra-small dimensions
- protection against short-circuit and overload
- protection of output transistor against transients by a voltage regulator diode
- protection against false polarity of the three connection leads
- choice between two methods to adjust the operating (switching) distance i.e. trimming a resistor integrated on the substrate or mounting a resistor
- possibility of connecting a LED for function control

The devices are thin-film circuits deposited on ceramic substrates. They may be potted, together with the oscillator coil, in a non-magnetic tube.

QUICK REFERENCE DATA

D.C. supply voltage range	V_B		10 to 30	V
Output current at V_B = 10 to 30 V	I_o	max.	200	mA
Operating (switching) distance (depends on R_x value and oscillator coil)	S		1 to 5	mm
Differential travel (hysteresis in switching distance)	H		3 to 10	%
Operating (switching) frequency	f	$<$	5	kHz
Operating substrate temperature range*	T_s		−40 to +85	°C
Substrate length after assembly	L		22,3 ±0,2	mm
Substrate width	W		4,8 ±0,2	mm
Thickness of assembled hybrid (two parts glued together back to back)	h	max.	3,8	mm

MECHANICAL DATA

Dimensions in mm

Fig. 1 (see next page).

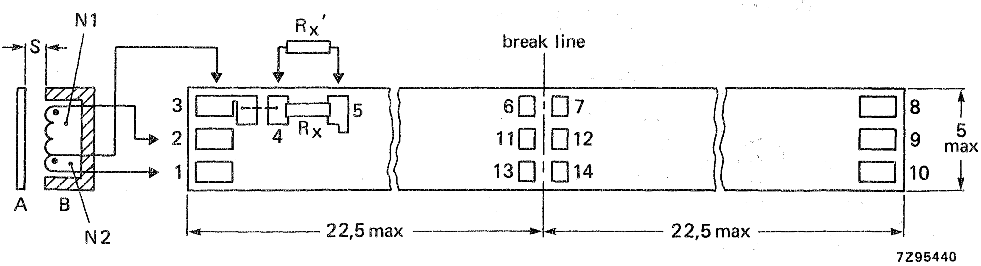
---

* The tube, potting and connection materials are the main limiting factors for the operating temperature range of a completely assembled proximity detector.

MECHANICAL DATA (outline and connections)

Dimensions in mm

Fig. 1.



A = metal actuator; B = open potcore or potcore half with coil.

Mechanical outline and connections: note that the supply polarities to points 8 and 10 are given for the OM386M; for the OM387M the polarities are point 8: $-V_B$, and point 10: $+V_B$.

S is the operating distance.

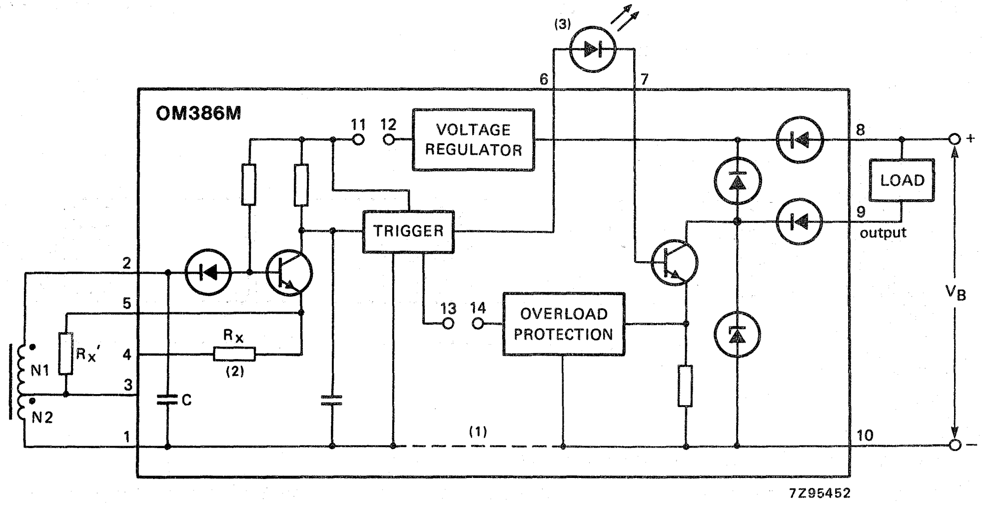


Fig. 2 Circuit diagram of OM386M.

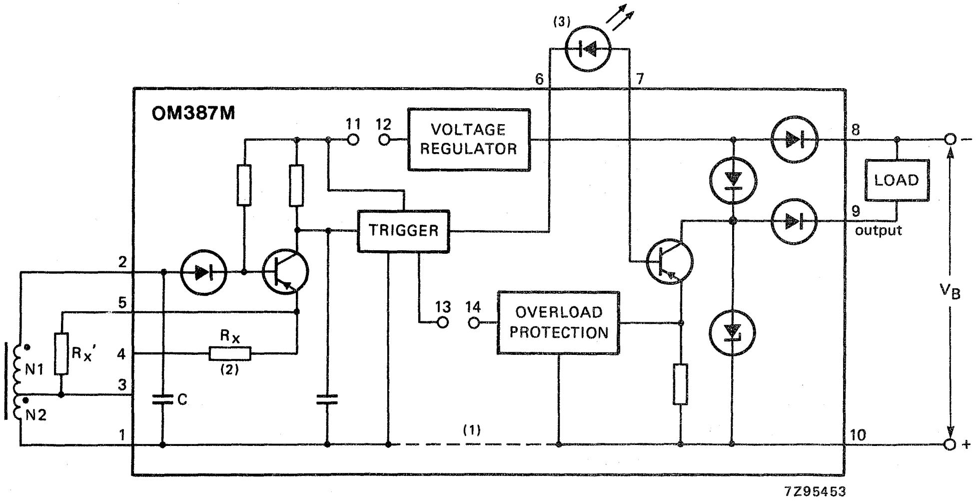


Fig. 3 Circuit diagram of OM387M.

(1) Connect point 1 to point 10 after assembling.

(2) R_X is integrated on the substrate and suitable for trimming (laser or sandblasting). To use integrated resistance R_X it is necessary to connect point 3 to 4.

(3) If no LED is used, connect point 6 to point 7.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

D.C. supply voltage	V_B	max.	30 V
Output current	I_o	max.	200 mA
Storage temperature	T_{stg}		−40 to +125 °C
Operating substrate temperature	T_s		−40 to +85 °C

CHARACTERISTICS

Conditions (unless otherwise specified)

D.C. supply voltage	V_B	24 V
External resistor (R_X) and oscillator coil Device embedded in brass tube	see operating distance table below	
Substrate temperature	T_s	25 °C

Performances

Supply current			
output stage "ON"	I_B	typ.	7,4 mA
output stage "OFF"		typ.	4,8 mA
Voltage drop			
I_o = 200 mA	V_d	max.	1,9 V
I_o = 10 mA		max.	1,0 V

Operating (switching) distance*

type	oscillator coil number of turns		average operating distance S in mm at R_X (Ω)			recommended potcore	oscillator frequency kHz
	N1	N2	200	250	300		
M8	32	16	1	1,5	–	ϕ 5,8 mm (Neosid)	800
M12	40	10	2	3	–	P9 Philips**	600
M18	46	4	3	4	5	P14 Philips**	600

Differential travel (in % of S)	H		3 to 10 %
Operating frequency (according to EN 50010)	f	<	5 kHz

---

* The operating distance S depends on the oscillator coil, the material of the metal actuator and R_X. For measuring purposes a square steel sheet (St. 37) with dimensions such that a circle with the diameter of the core can be inscribed, and 1 mm thickness can be used. R_X must not be chosen outside the range of 200 to 300 Ω.

** Grade 3B7/3H1.

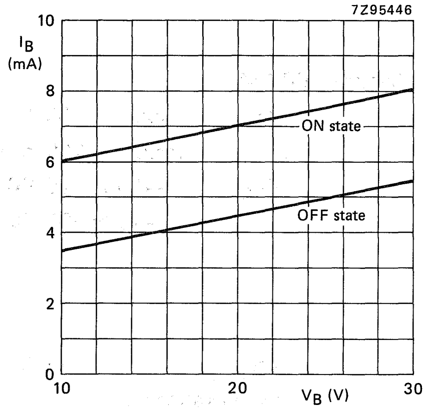


Fig. 4 Supply current as a function of supply voltage; $T_s = 25\ ^{\circ}C$.

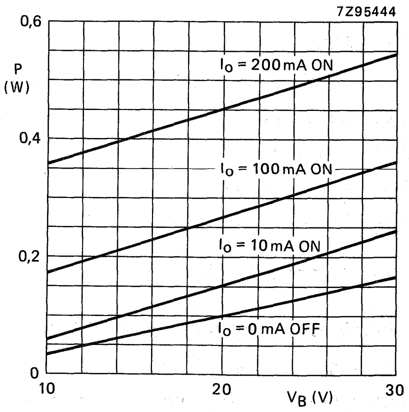


Fig. 5 Power dissipation as a function of supply voltage.

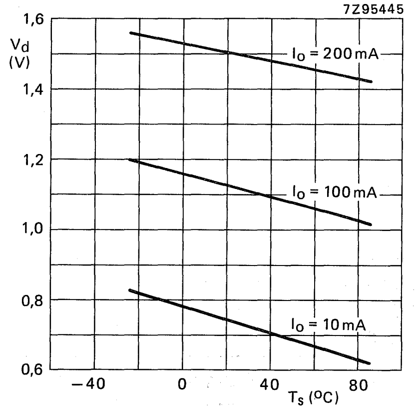


Fig. 6 Voltage drop as a function of substrate temperature.

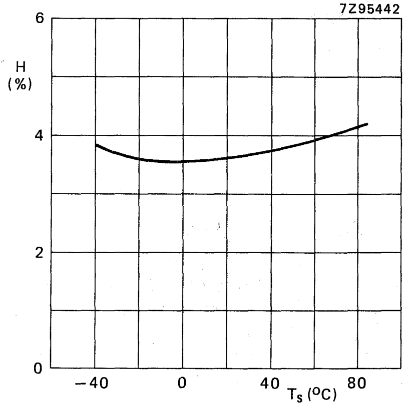
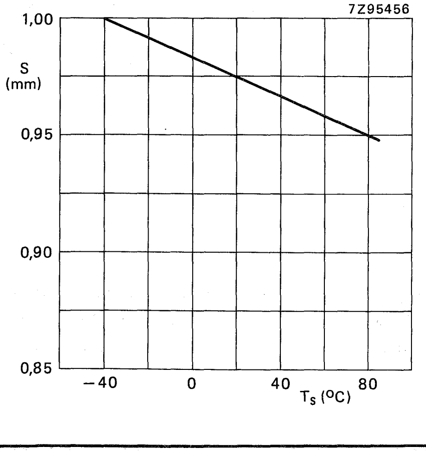


Fig. 7 Hysteresis as a function of substrate temperature.



Conditions relating to Figs 7 and 8:
potcore ϕ 5,8 mm Neosid
osc. coil N1 = 32, N2 = 16 turns
$R_X = 200\ \Omega$.

Fig. 8 Operating distance as a function of substrate temperature.

MOUNTING RECOMMENDATIONS

A. Assembling and connecting the two half substrates:

- Use the breakline to break the substrate in two pieces.
- Apply glue (e.g. epoxy Ablebond 293-1) to the blank sides of the two parts.
- After hardening of the glue connect the pads according to Fig. 9.

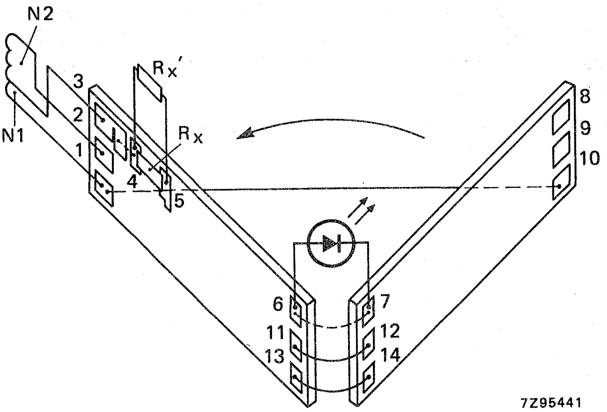


Fig. 9 If no LED is used, connect point 6 to point 7;
connect points 11 and 12, point 13 to 14 and point 1 to point 10.

B. If a protective cap is incorporated, it should be as thin as possible, because its thickness d forms part of the operating distance S.
A brass stud wall should not extend beyond the potcore.
The exact value of S with its spread is determined by a number of variables, e.g.
- value of the adjustment resistor R_X
- the oscillator coil
- the metal of the actuator
- the material and shape of the housing.

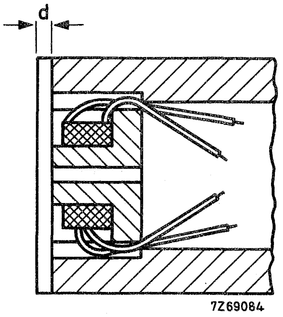


Fig. 10 Insertion of potcore in brass tube.

Soldering recommendations

Use normal 60/40 solder; use a soldering iron with a fine point; soldering time as short as possible and it should not exceed 2,5 s per soldering point (T_{sld} = max. 250 °C).

Potting recommendations

First cover the hybrid IC with about 0,5 mm of silicone rubber, let it harden and with the parts inserted in the tube, fill up the tube with an epoxy.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M12 hollow stud. The OM388B is for positive supply voltage and the OM389B is for negative supply voltage. The circuit consists of a voltage regulator, an oscillator, a rectifier stage, a Schmitt trigger, an output stage and a protection circuit.

The circuit performs a make function: when actuated the current flows through the load, which can be e.g. the coil of an electromagnetic relay, a LED or a photocoupler.

Features:

- protection against short-circuit and overload
- protection of output transistor against transients by a voltage regulator diode
- protection against false polarity of the three connection leads
- choice between two methods to adjust the operating (switching) distance i.e. trimming a resistor integrated on the substrate or mounting a resistor
- possibility of connecting a LED for function control

The devices are thin-film circuits deposited on ceramic substrates. They may be potted, together with the oscillator coil, in a non-magnetic tube.

QUICK REFERENCE DATA

D.C. supply voltage range	V_B		10 to 30	V
Output current at V_B = 10 to 30 V	I_o	max.	250	mA
Operating (switching) distance (depends on R_X value and oscillator coil)	S		2 to 5	mm
Differential travel (hysteresis in switching distance)	H		3 to 10	%
Operating (switching) frequency	f	$<$	5	kHz
Operating substrate temperature range*	T_s		−40 to +85	°C
Substrate length	L		25,4 ±0,2	mm
Substrate width	W		8,0 ±0,2	mm
Height of circuit including substrate	h	max.	1,7	mm

MECHANICAL DATA

Dimensions in mm

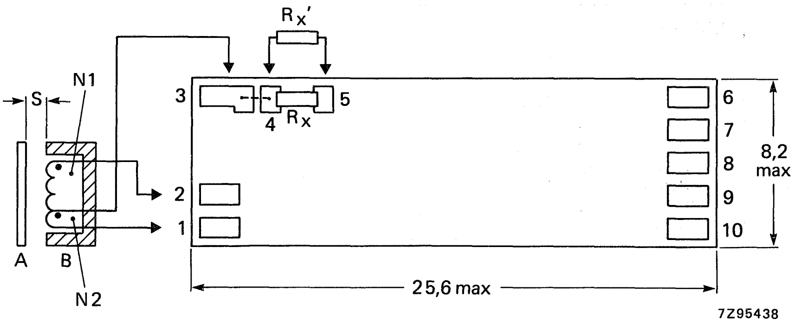
Fig. 1 (see next page).

---

* The tube, potting and connection materials are the main limiting factors for the operating temperature range of a completely assembled proximity detector.

MECHANICAL DATA (outline and connections). Dimensions in mm

Fig. 1.



A = metal actuator; B = open potcore or potcore half with coil.

Mechanical outline and connections: note that the supply polarities to points 8 and 10 are given for the OM388B; for the OM389B the polarities are point 8: $-V_B$ and point 10: $+V_B$.

S is the operating distance.

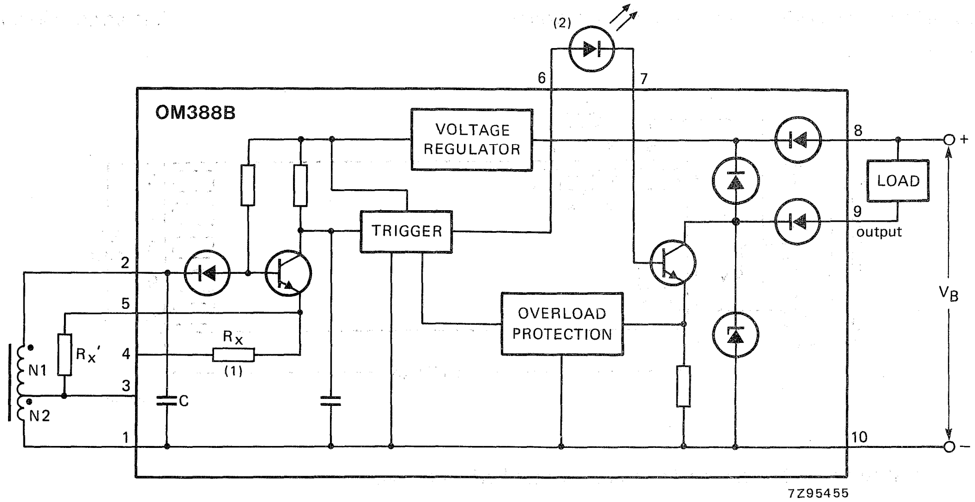


Fig. 2 Circuit diagram of OM388B.

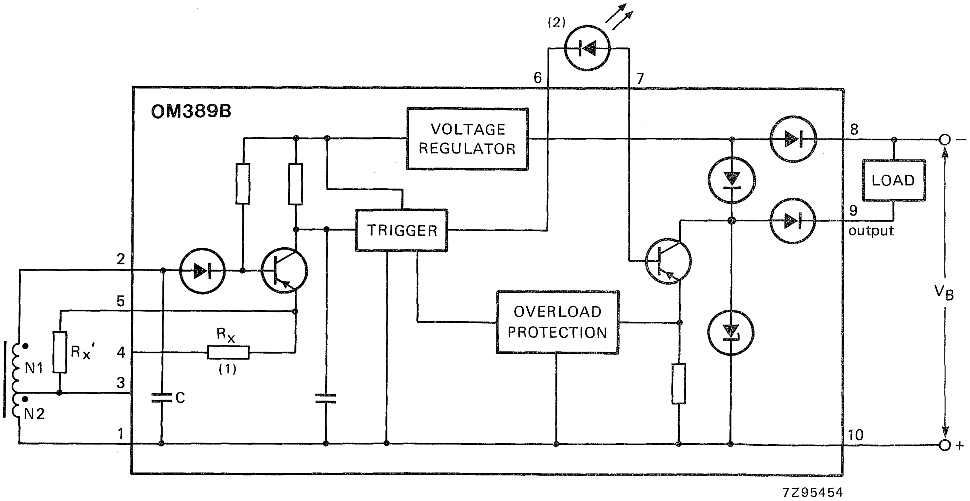


Fig. 3 Circuit diagram of OM389B.

(1) R_X is integrated on the substrate and suitable for trimming (laser or sandblasting). To use integrated resistance R_X it is necessary to connect point 3 to 4.

(2) If no LED is used, point 6 is to be connected to point 7.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

D.C. supply voltage	V_B	max.	30 V
Output current	I_o	max.	250 mA
Storage temperature	T_{stg}		−40 to +125 °C
Operating substrate temperature	T_s		−40 to +85 °C

CHARACTERISTICS

Conditions (unless otherwise specified)

D.C. supply voltage	V_B	24 V
External resistor (R_X) and oscillator coil Device embedded in brass tube	see operating distance table below	
Substrate temperature	T_s	25 °C

Performances

Supply current			
output stage "ON"	I_B	typ.	8,4 mA
output stage "OFF"		typ.	4,8 mA
Voltage drop			
I_o = 250 mA	V_d	max.	1,9 V
I_o = 10 mA		max.	1,0 V

Operating (switching) distance*

type	oscillator coil number of turns N1	N2	average operating distance S in mm at R_X (Ω) 200	250	300	recommended potcore	oscillator frequency kHz
M12	40	10	2	3	–	P9 Philips**	600
M18	46	4	3	4	5	P14 Philips**	600

Differential travel (in % of S)	H		3 to 10 %
Operating frequency (according to EN 50010)	f	<	5 kHz

---

* The operating distance S depends on the oscillator coil, the material of the metal actuator and R_X. For measuring purposes a square steel sheet (St 37) with dimensions such that a circle with the diameter of the core can be inscribed, and 1 mm thickness can be used. R_X must not be chosen outside the range of 200 to 300 Ω.

** Grade 3B7/3H1.

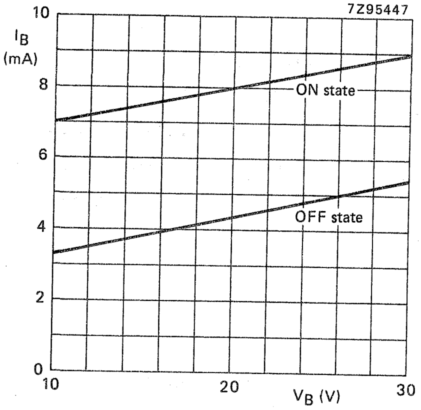


Fig. 4 Supply current as a function of supply voltage; $T_s = 25\ ^oC$.

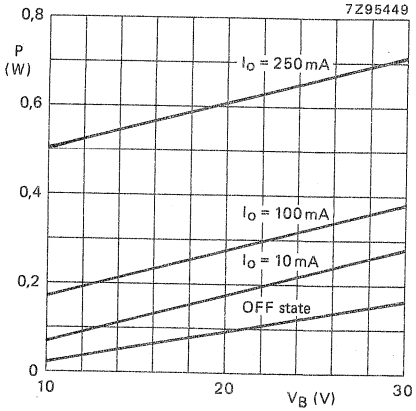


Fig. 5 Power dissipation as a function of supply voltage.

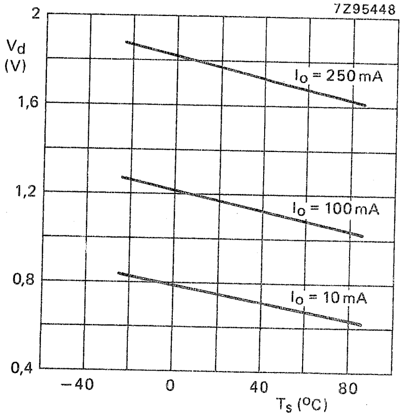


Fig. 6 Voltage drop as a function of substrate temperature.

MOUNTING RECOMMENDATIONS

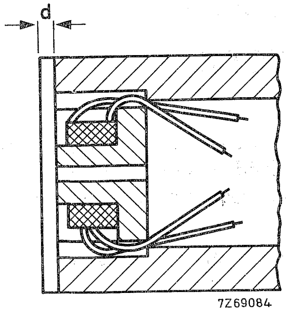


Fig. 7 Insertion of potcore in brass tube.

If a protective cap is incorporated, it should be as thin as possible, because its thickness d forms part of the operating distance S.
A brass stud wall should not extend beyond the potcore.
The exact value of S with its spread is determined by a number of variables, e.g.

- value of the adjustment resistor R_x
- the oscillator coil
- the metal of the actuator
- the material and shape of the housing.

Soldering recommendations

Use normal 60/40 solder; use a soldering iron with a fine point; soldering time as short as possible and it should not exceed 2,5 s per soldering point (T_{sld} = max. 250 °C).
The substrate is preferably preheated to a temperature of 100 °C with a minimum of 80 °C and a maximum of 125 °C.

Potting recommendations

First cover the hybrid IC with about 0,5 mm of silicone rubber, let it harden and with the parts inserted in the tube, fill up the tube with an epoxy.

HYBRID INTEGRATED CIRCUITS FOR INDUCTIVE PROXIMITY DETECTORS

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M18 hollow stud. The OM390 is for positive supply voltage and the OM391 is for negative supply voltage. The circuit consists of a voltage regulator, an oscillator, a rectifier stage, a Schmitt trigger, an output stage and a protection circuit.

The circuit performs a make function: when actuated the current flows through the load, which can be e.g. the coil of an electromagnetic relay, a LED or a photocoupler.

Features:

- Protection against short-circuit and overload
- Protection of output transistor against transients by a voltage regulator diode
- Protection against false polarity of the three connection leads
- Choice between two methods to adjust the operating (switching) distance i.e. trimming a resistor integrated on the substrate or mounting a resistor
- Possibility of connecting a LED for function control

The devices are thin-film circuits deposited on ceramic substrates. They may be potted, together with the oscillator coil, in a non-magnetic tube.

QUICK REFERENCE DATA

D.C. supply voltage range	V_B		10 to 30	V
Output current at V_B = 10 to 30 V	I_o	max.	250	mA
Operating (switching) distance (depends on R_x value and oscillator coil)	S		2 to 5	mm
Differential travel (hysteresis in switching distance)	H		3 to 10	%
Operating (switching) frequency	f	$<$	5	kHz
Operating substrate temperature range*	T_s		−40 to +85	°C
Substrate length	L		14,0 ±0,2	mm
Substrate width	W		14,0 ±0,2	mm
Height of circuit including substrate	h	max.	1,7	mm

MECHANICAL DATA

Dimensions in mm

Fig. 1 (see next page).

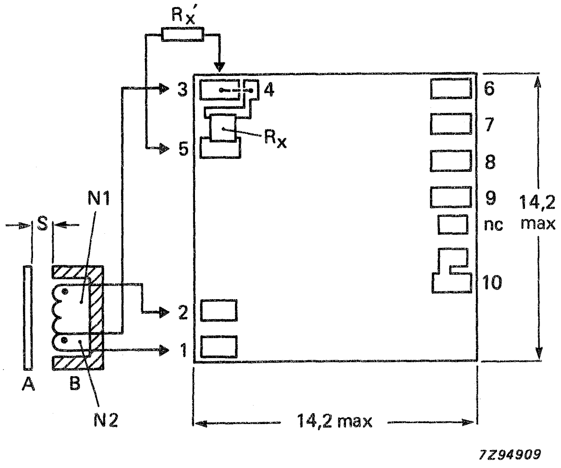
---

* The tube, potting and connection materials are the main limiting factors for the operating temperature range of a completely assembled proximity detector.

MECHANICAL DATA (outline and connections).

Dimensions in mm

Fig. 1.



A = metal actuator; B = open potcore or potcore half with coil. S is the operating distance.

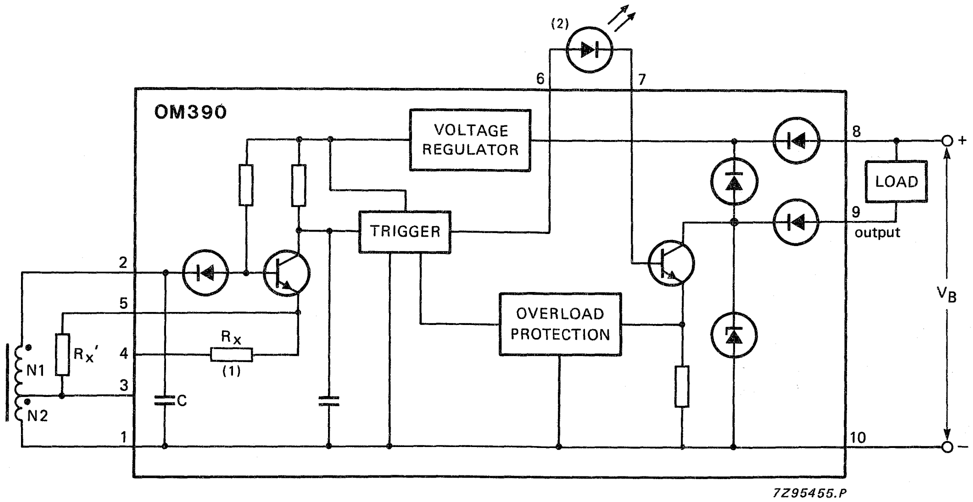


Fig. 2 Circuit diagram of OM390.

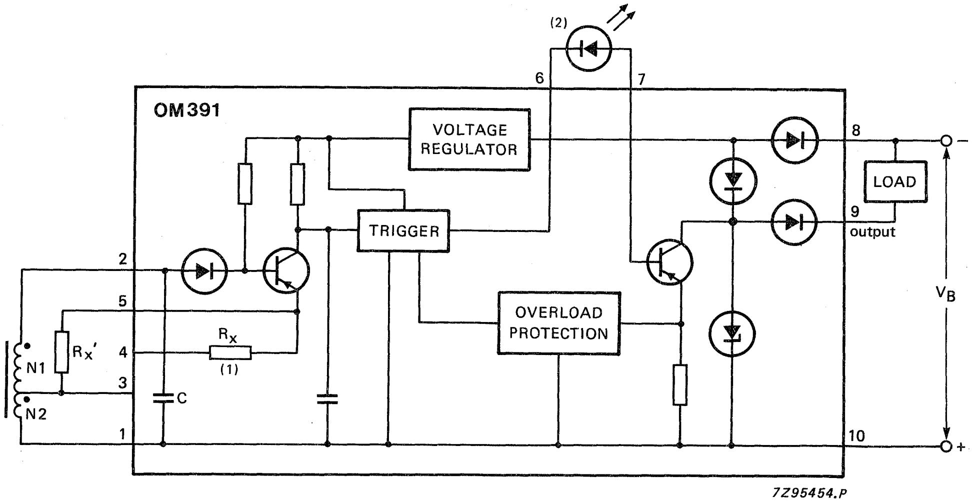


Fig. 3 Circuit diagram of OM391.

(1) R_X is integrated on the substrate and suitable for trimming (laser or sandblasting). To use integrated resistance R_X it is necessary to connect point 3 to 4.

(2) If no LED is used, point 6 is to be connected to point 7.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

D.C. supply voltage	V_B	max.	30	V
Output current	I_o	max.	250	mA
Storage temperature	T_{stg}		−40 to +125	°C
Operating substrate temperature	T_s		−40 to +85	°C

CHARACTERISTICS

Conditions (unless otherwise specified)

D.C. supply voltage	V_B	24	V
External resistor (R_X) and oscillator coil Device embedded in brass tube	see operating distance table below		
Substrate temperature	T_s	25	°C

Performances

Supply current				
output stage "ON"	I_B	typ.	8,4	mA
output stage "OFF"		typ.	4,8	mA
Voltage drop				
$I_o = 250$ mA	V_d	max.	1,9	V
$I_o = 10$ mA		max.	1,0	V

Operating (switching) distance*

type	oscillator coil number of turns		average operating distance S in mm at R_X (Ω)			recommended potcore	oscillator frequency kHz
	N1	N2	200	250	300		
M18	46	4	3	4	5	P14 Philips**	600

Differential travel (in % of S)	H		3 to 10	%
Operating frequency (according to EN 50010)	f	<	5	kHz

---

* The operating distance S depends on the oscillator coil, the material of the metal actuator and R_X. For measuring purposes a square steel sheet (St 37) with dimensions such that a circle with the diameter of the core can be inscribed, and 1 mm thickness can be used. R_X must not be chosen outside the range of 200 to 300 Ω.

** Grade 3B7/3H1.

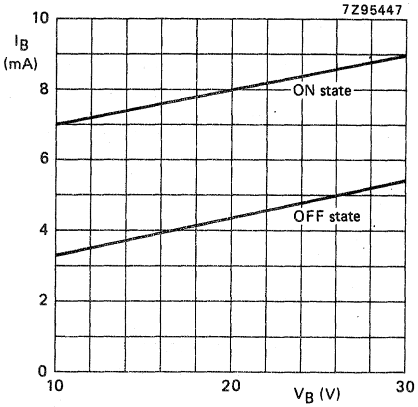


Fig. 4 Supply current as a function of supply voltage; $T_s = 25\ ^\circ C$.

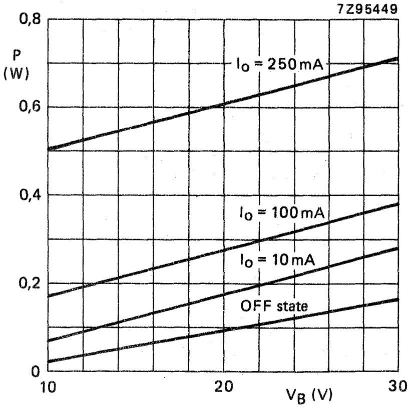


Fig. 5 Power dissipation as a function of supply voltage.

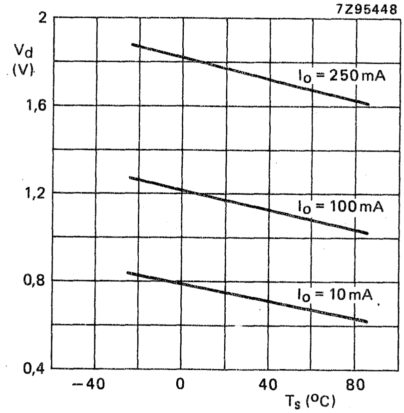


Fig. 6 Voltage drop as a function of substrate temperature.

MOUNTING RECOMMENDATIONS

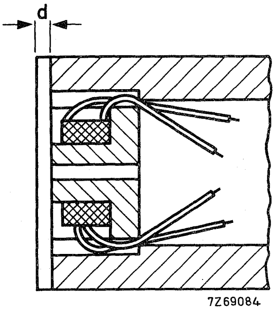


Fig. 7 Insertion of potcore in brass tube.

If a protective cap is incorporated, it should be as thin as possible, because its thickness d forms part of the operating distance S.

A brass stud wall should not extend beyond the potcore.

The exact value of S with its spread is determined by a number of variables, e.g.

- value of the adjustment resistor R_X
- the oscillator coil
- the metal of the actuator
- the material and shape of the housing.

Soldering recommendations

Use normal 60/40 solder; use a soldering iron with a fine point; soldering time as short as possible and it should not exceed 2,5 s per soldering point (T_{sld} = max. 250 °C).

The substrate is preferably preheated to a temperature of 100 °C with a minimum of 80 °C and a maximum of 125 °C.

Potting recommendations

First cover the hybrid IC with about 0,5 mm of silicone rubber, let it harden and with the parts inserted in the tube, fill up the tube with an epoxy.

Philips Semiconductors

Data sheet	
status	Product Specification
date of issue	August 1990

OM2860/OM2870

Hybrid integrated circuits for inductive proximity detectors

FEATURES

- Extra small dimensions.
- Wide range of supply voltage.
- High output current.
- Well proven oscillator stage using discrete transistors.
- RC filter on the supply lines.
- Output transistor protected against transients from the inductive load by a voltage regulator diode.
- Circuit protected against false polarity connection of the supply voltage.

DESCRIPTION

Hybrid integrated circuits intended for inductive proximity detectors in tubular construction, especially the M5 hollow stud.

The OM2860 is for positive supply voltage and the OM2870 is for negative supply voltage. The circuit consists of an oscillator, a rectifier stage, a Schmitt trigger, an output stage and a supply filter.

The circuit performs a make function: when actuated, the current flows through the load, which can be for example, the coil of an electromagnetic relay, a LED or an optocoupler.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_B	DC supply voltage		4.7	30	V
I_o	output current	$V_B = 24$ V	-	250	mA
$f_{switch-max.}$	operating frequency		-	5	kHz
T_s	substrate operating temperature range		−40	+85	°C

MECHANICAL DATA

Dimensions in mm

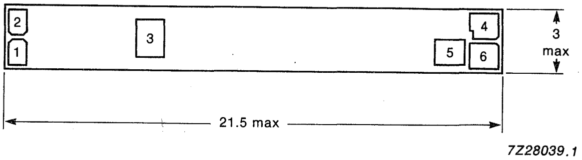


Fig.1 Outline and connections.

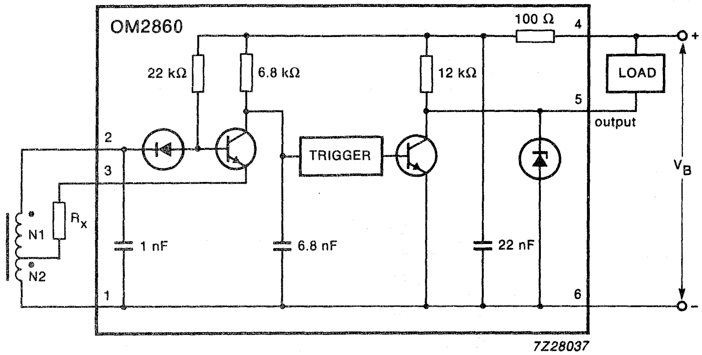


Fig.2 Circuit diagram of OM2860.

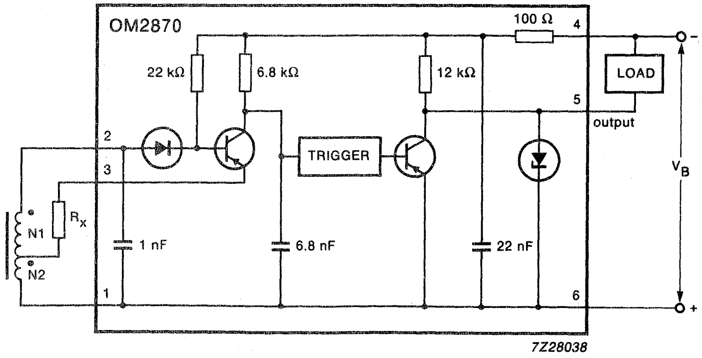


Fig.3 Circuit diagram of OM2870.

LIMITING VALUES

Limiting values in accordance with the Absolute Maximum System (IEC 134)

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_B	DC supply voltage	-	30	V
I_o	output current	-	250	mA
T_{stg}	storage temperature range	−40	+125	°C
T_s	substrate operating temperature range	−40	+85	°C

CHARACTERISTICS

$V_B = 24$ V(DC); $T_s = 25°C$; unless otherwise specified.

SYMBOL	PARAMETERS	CONDITIONS	TYP.	MAX.	UNIT
I_B	supply current	output stage "ON" output stage "OFF"	9.0 7.7	- -	mA mA
V_d	voltage drop	$I_o = 250$ mA $I_o = 10$ mA	- -	1 0.25	V V

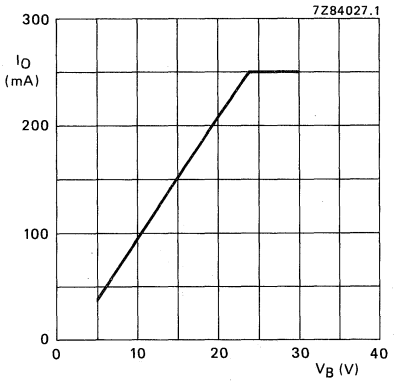


Fig.4 Maximum allowable output current as a function of supply voltage; $T_s = 25°C$.

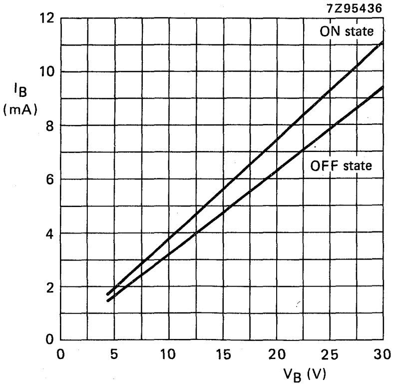


Fig.5 Supply current as a function of supply voltage; $T_s = 25°C$; typical values.

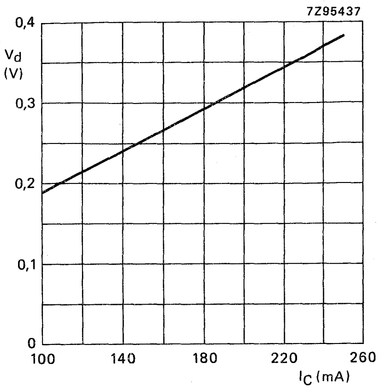


Fig.6 Voltage drop as a function of collector current; $V_B = 24$ V; $T_s = 25$°C; typical values.

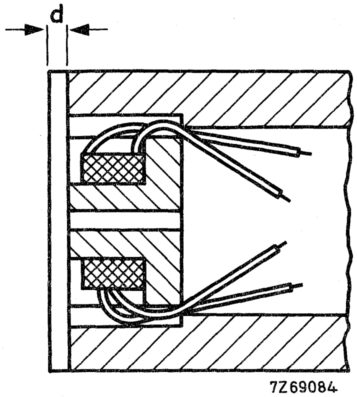


Fig.7 Insertion of potcore in brass tube.

MOUNTING RECOMMENDATIONS

If a protective cap is incorporated, it should be as thin as possible, because its thickness "d" forms part of the operating distance "S".
A brass stud wall should not extend beyond the potcore.
The exact value of "S" with its spread is determined by a number of variables, e.g.

- value of the adjustment resistor R_X
- the oscillator coil
- the metal of the actuator
- the material and shape of the housing.

SOLDERING RECOMMENDATIONS

- use normal 60/40 solder
- use a soldering iron with a fine point
- soldering time should be kept to a minimum, not exceeding 2.5 s per soldering point (T_{sld} = max. 250°C).
- the substrate should preferably be preheated to a temperature of 100°C with a minimum of 80°C and a maximum of 125°C.

Hybrid integrated circuits for inductive proximity detectors

OM3105N

FEATURES

- Extra small dimensions (3 x 20 mm max.)
- Wide supply voltage range (6 to 35 V)
- Supply current typical 1.5 mA (output stage switched off)
- High output current
- RC filter on the supply lines
- NPN output transistor protected against transients from the inductive load
- Circuit protected against wrong polarity connection of the supply voltage
- Electronic short-circuit protection; a capacitor of 0.2 μF can be connected in parallel with the load
- Detection distance adjustable by a chip resistor (R_d), type 1206
- Only a simple coil in one part is required; e.g. the OM2860 requires a coil in two parts
- Hysteresis adjustable by a chip resistor (R_h), type 0603, for using the OM3105N with other then M5 coils
- Status of the output is shown by a red LED mounted on the substrate surface
- The OM3105N is also available without a LED, but with an output pad for external LED connection
- A version with a PNP output transistor is available (OM3105P).

DESCRIPTION

The OM3105N is a hybrid integrated circuit intended for inductive proximity detectors in a tubular construction, especially the M5 hollow stud. The circuit performs a make function; when actuated, the current flows through the load, which can be for example a LED or an optocoupler. It is also possible to perform a break function when using version OM3115N.

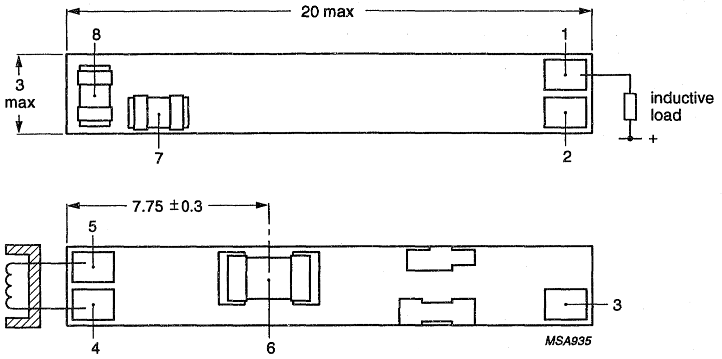
Available versions:

OM3105N: npn output; make function
OM3115N: npn output; break function
OM3105P: pnp output; make function
OM3115P: pnp output; break function
OM31.5./0: for external LED connection.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	TYP.	MAX.	UNIT
V_B	DC supply voltage		6	35	V
I_O	output current	V_B = 24 V; T_s = 25 °C	–	250	mA
f_{sw}	operating switching frequency	M5 coil	–	5	kHz
T_s	operating substrate temperature		–20	+70	°C

MECHANICAL DATA



Dimensions in mm.
Coil: Ø 0.063 mm Cu wire, 80 turns.
Potcore: 3.3 x 1.3 mm.

Fig.1 Outline and connections.

PAD INFORMATION

PAD NUMBER	DESCRIPTION
1	output
2	negative supply (–)
3	positive supply (+)
4	coil connection
5	coil connection
6	R_d resistor (type 1206) for adjusting the detection distance
7	R_t resistor (type 0603) for adjusting the stability with temperature variations
8	R_h resistor (type 0603) for adjusting the hysteresis

LIMITING VALUES

Limiting values in accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_B	DC supply voltage	6	35	V
I_O	output current; T_s = 25 °C	–	250	mA
T_{stg}	storage temperature	–40	+125	°C
T_s	operating substrate temperature	–20	+70	°C

CHARACTERISTICS

V_B = 24 V (DC); T_s = 25 °C; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	TYP.	MAX.	UNIT
I_B	supply current	output stage ON	11	–	mA
		output stage OFF	1.5	–	mA
V_d	voltage drop	I_O = 250 mA	1	1.5	V
d	detection distance	coil M5	0.8	–	mm

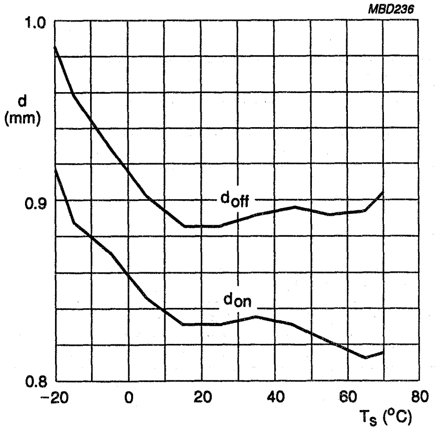


Fig.2 Switching distance as a function of the substrate temperature.

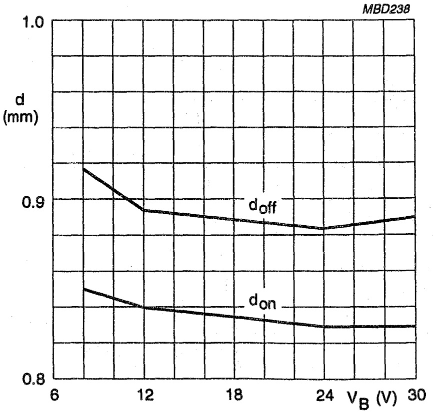


Fig.3 Switching distance as function of the DC supply voltage.

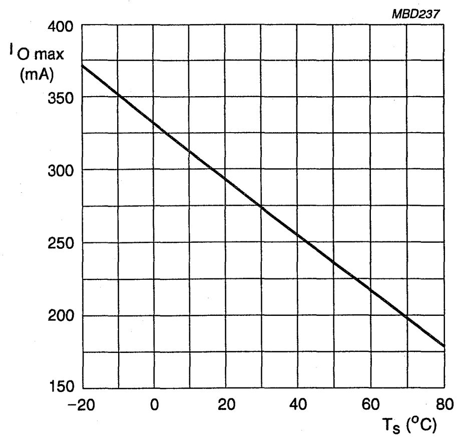


Fig.4 Overload protection as a function of the substrate temperature.

MOUNTING RECOMMENDATIONS

General

If a protective cap is incorporated, it should be as thin as possible, because its thickness “d” forms part of the operating distance “S”.
A brass stud wall should not extend beyond the potcore.
The exact value of “S” with its spread is determined by a number of variables, e.g.:

value of the adjustment resistor R_x,

the oscillator coil,

the metal of the actuator,

the material and shape of the housing.

Soldering recommendations

- Use normal 60/40 solder.
- Use a soldering iron with a fine point.
- Soldering time should be kept to a minimum, not exceeding 2.5 s per soldering point (T_{sld} = 250 °C maximum).
- The substrate should preferably be pre-heated to a temperature of 100 °C with a minimum of 80 °C and a maximum of 125 °C.

Potting recommendations

First cover the hybrid IC with about 0.5 mm of silicone rubber, let it harden and with the parts inserted in the tube, fill up the tube with epoxy.

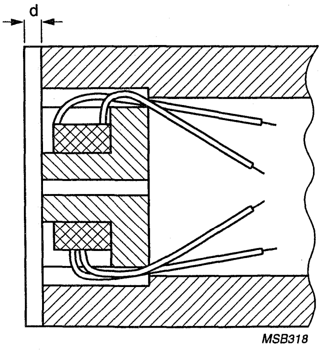


Fig.5 Insertion of potcore in brass tube.

Hybrid integrated circuits for inductive proximity detectors

OM3105P

FEATURES

- Extra small dimensions (3 x 20 mm max.)
- Wide supply voltage range (6 to 35 V)
- Supply current typical 1.5 mA (output stage switched off)
- High output current (250 mA max.)
- RC filter on the supply lines
- PNP output transistor protected against transients from the inductive load
- Circuit protected against wrong polarity connection of the supply voltage
- Electronic short-circuit protection
- Detection distance adjustable by a chip resistor (R_d), type 1206
- Only a simple coil in one part is required; e.g. the OM2860 requires a coil in two parts
- Hysteresis adjustable by a chip resistor (R_h), type 0603, for using the OM3105P with other then M5 coils
- Status of the output is shown by a yellow or red LED mounted on the substrate surface
- The OM3105P is also available without a LED, but with an output pad for external LED connection
- A version with a NPN output transistor is available (OM3105P).

DESCRIPTION

The OM3105P is a hybrid integrated circuit intended for inductive proximity detectors in a tubular construction, especially the M5 hollow stud. The circuit performs a make function (version 1): when actuated, the current flows through the load, which can be for example a LED or an optocoupler. It is also possible to perform a break function when using version OM3115P.

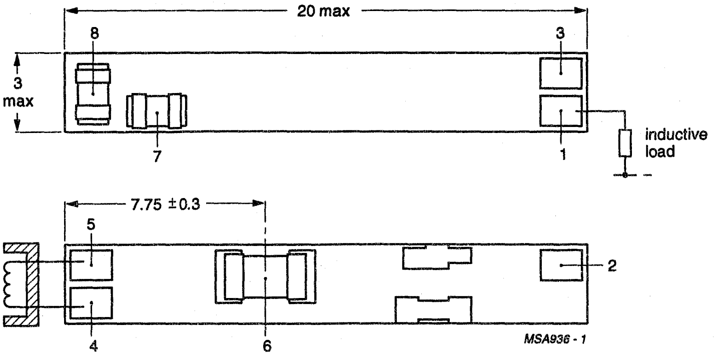
Available versions:

OM3105P: pnp output; make function
OM3115P: pnp output; break function
OM3105N: npn output; make function
OM3115N: npn output; break function
OM31.5./0: for external LED connection.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	TYP.	MAX.	UNIT
V_B	DC supply voltage		6	35	V
I_O	output current	V_B = 24 V; T_s = 25 °C	–	250	mA
f_{sw}	operating switching frequency	M5 coil	–	5	kHz
T_s	operating substrate temperature		–20	+70	°C

MECHANICAL DATA



Dimensions in mm.
Coil: Ø 0.063 mm Cu wire, 80 turns.
Potcore: 3.3 x 1.3 mm.

Fig.1 Outline and connections.

PAD INFORMATION

PAD NUMBER	DESCRIPTION
1	output
2	negative supply (–)
3	positive supply (+)
4	coil connection
5	coil connection
6	R_d resistor (type 1206) for adjusting the detection distance
7	R_t resistor (type 0603) for adjusting the stability with temperature variations
8	R_h resistor (type 0603) for adjusting the hysteresis

LIMITING VALUES

Limiting values in accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	MIN.	MAX.	UNIT
V_B	DC supply voltage	6	35	V
I_O	output current; $T_s = 25$ °C	–	250	mA
T_{stg}	storage temperature	–40	+125	°C
T_s	operating substrate temperature	–20	+70	°C

CHARACTERISTICS

$V_B = 24$ V (DC); $T_s = 25$ °C; unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	TYP.	MAX.	UNIT
I_B	supply current	output stage ON	11	–	mA
		output stage OFF	1.5	–	mA
V_d	voltage drop	$I_O = 250$ mA	1	1.5	V
d	detection distance	coil M5	0.8	–	mm

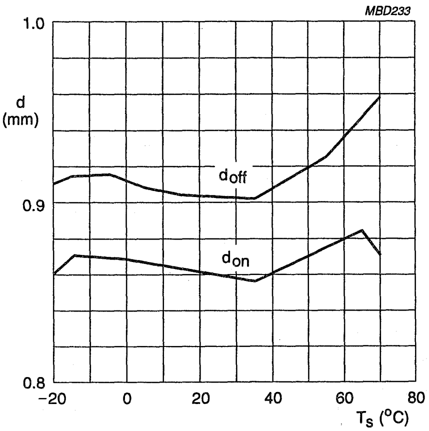


Fig.2 Switching distance as a function of the substrate temperature.

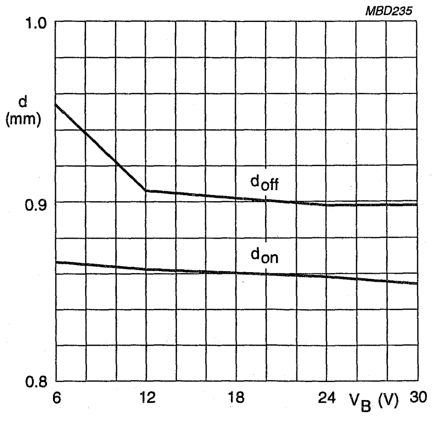


Fig.3 Switching distance as a function of the DC supply voltage.

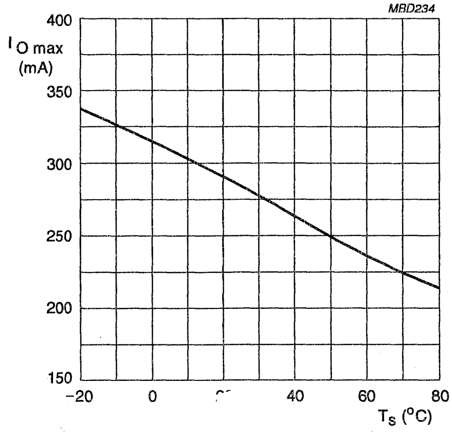


Fig.4 Overload protection as a function of the substrate temperature.

MOUNTING RECOMMENDATIONS

General

If a protective cap is incorporated, it should be as thin as possible, because its thickness “d” forms part of the operating distance “S”.
A brass stud wall should not extend beyond the potcore.
The exact value of “S” with its spread is determined by a number of variables, e.g.:

value of the adjustment resistor R_x,

the oscillator coil,

the metal of the actuator,

the material and shape of the housing.

Soldering recommendations

- Use normal 60/40 solder.
- Use a soldering iron with a fine point.
- Soldering time should be kept to a minimum, not exceeding 2.5 s per soldering point (T_{sld} = 250 °C maximum).
- The substrate should preferably be pre-heated to a temperature of 100 °C with a minimum of 80 °C and a maximum of 125 °C.

Potting recommendations

First cover the hybrid IC with about 0.5 mm of silicone rubber, let it harden and with the parts inserted in the tube, fill up the tube with epoxy.

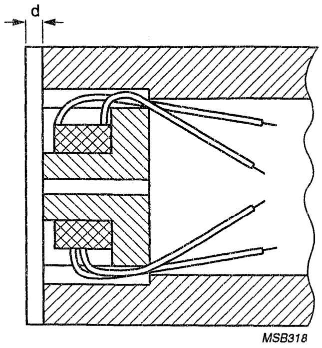


Fig.5 Insertion of potcore in brass tube.

DATA HANDBOOK SYSTEM

Data handbook system

DATA HANDBOOK SYSTEM

Philips Semiconductors data handbooks contain all pertinent data available at the time of publication and each is revised and reissued regularly.

Loose data sheets are sent to subscribers to keep them up-to-date on additions or alterations made during the lifetime of a data handbook.

Catalogues are available for selected product ranges (some catalogues are also on floppy discs).

Our data handbook titles are listed here.

Integrated circuits

Book	*Title*
IC01	Semiconductors for Radio and Audio Systems
IC02	Semiconductors for Television and Video Systems
IC03	Semiconductors for Telecom Systems
IC04	CMOS HE4000B Logic Family
IC05	Advanced Low-power Schottky (ALS) Logic Series
IC06	High-speed CMOS Logic Family
IC08	100K ECL Logic Family
IC10	Memories
IC11	General-purpose/Linear ICs
IC12	Display Drivers and Microcontroller Peripherals (planned)
IC13	Programmable Logic Devices (PLD)
IC14	8048-based 8-bit Microcontrollers
IC15	FAST TTL Logic Series
IC16	ICs for Clocks and Watches
IC17	RF/Wireless Communications
IC18	Semiconductors for In-car Electronics and General Industrial Applications (planned)
IC19	Semiconductors for Datacom: LANs, UARTs, Multi-protocol Controllers and Fibre Optics
IC20	8051-based 8-bit Microcontrollers
IC21	68000-based 16-bit Microcontrollers (planned)
IC22	ICs for Multi-media Systems (planned)
IC23	QUBIC Advanced BiCMOS Interface Logic ABT, MULTIBYTE™
IC24	Low Voltage CMOS Logic

Discrete semiconductors

Book	*Title*
SC01	Diodes
SC02	Power Diodes
SC03	Thyristors and Triacs
SC04	Small-signal Transistors
SC05	Low-frequency Power Transistors and Hybrid IC Power Modules
SC06	High-voltage and Switching NPN Power Transistors
SC07	Small-signal Field-effect Transistors
SC08a	RF Power Bipolar Transistors
SC08b	RF Power MOS Transistors
SC09	RF Power Modules
SC10	Surface Mounted Semiconductors
SC13	PowerMOS Transistors including TOPFETs and IGBTs
SC14	RF Wideband Transistors, Video Transistors and Modules
SC15	Microwave Transistors
SC16	Wideband Hybrid IC Modules
SC17	Semiconductor Sensors

Professional components

PC01	High-power Klystrons and Accessories
PC06	Circulators and Isolators

MORE INFORMATION FROM PHILIPS SEMICONDUCTORS?

For more information about Philips Semiconductors data handbooks, catalogues and subscriptions contact your nearest Philips Semiconductors national organization, select from the **address list on the back cover of this handbook**. Product specialists are at your service and enquiries are answered promptly.

OVERVIEW OF PHILIPS COMPONENTS DATA HANDBOOKS

Our sister product division, Philips Components, also has a comprehensive data handbook system to support their products. Their data handbook titles are listed here.

Display components

Book	*Title*
DC01	Colour TV Picture Tubes and Assemblies Colour Monitor Tubes
DC02	Monochrome Monitor Tubes and Deflection Units
DC03	Television Tuners, Coaxial Aerial Input Assemblies
DC05	Flyback Transformers, Mains Transformers and General-purpose FXC Assemblies

Magnetic products

MA01	Soft Ferrites
MA03	Piezoelectric Ceramics Specialty Ferrites
MA04	Dry-reed Switches

Passive components

PA01	Electrolytic Capacitors
PA02	Varistors, Thermistors and Sensors
PA03	Potentiometers
PA04	Variable Capacitors
PA05	Film Capacitors
PA06	Ceramic Capacitors
PA07	Quartz Crystals for Special and Industrial Applications
PA08	Fixed Resistors
PA10	Quartz Crystals for Automotive and Standard Applications
PA11	Quartz Oscillators

Professional components

PC04	Photo Multipliers
PC05	Plumbicon Camera Tubes and Accessories
PC07	Vidicon and Newvicon Camera Tubes and Deflection Units
PC08	Image Intensifiers
PC12	Electron Multipliers

MORE INFORMATION FROM PHILIPS COMPONENTS?

For more information contact your nearest Philips Components national organization shown in the following list.

Argentina: Buenos Aires, Tel. (541)786 7635, Fax. (541)786 9367.
Australia: NORTH RYDE, Tel. (02)805 4455, Fax. (02)805 4466.
Austria: WIEN, Tel. (01)60101 1820, Fax. (01)60101 1210.
Belgium: EINDHOVEN, Tel. (31)40 783749, Fax. (31)40 788399.
BRAZIL: SÃO PAULO, TEL. (011)821 2333, FAX. (011)829 1849.
Canada: SCARBOROUGH, Tel. (0416)292 5161, Fax. (0416)754 6248.
Chile: SANTIAGO, Tel. (02)77 38 16, Fax. (02)735 3594.
China (Peoples Republic of): Shanghai, Tel. (021)326 4140, Fax. (021)320 2160.
Colombia: BOGOTA, Tel. (571)249 7624/(571)217 4609, Fax. (571)217 4549.
Denmark: COPENHAGEN, Tel. (032)883 333, Fax. (031)571 949.
Finland: ESPOO, Tel. (9)0-50261, Fax. (9)0-520971.
France: SURESNES, Tel. (01)4099 6161, Fax. (01)4099 6431.
Germany: HAMBURG, Tel. (040)3296-0, Fax. (040)3296 213.
Greece: TAVROS, Tel. (01)489 4339/(01)489 4911, Fax. (01)481 5180.
Hong Kong: KWAI CHUNG, Tel. (852)424 5121, Fax. (852)428 6729.
India: BOMBAY, Tel. (022)4938 541, Fax. (022)4938 722.
Indonesia: JAKARTA, Tel. (021)5201122, Fax. (021)5205189.
Ireland: DUBLIN, Tel. (01)640 203, Fax. (01)640 210.
Israel: Tel Aviv Tel. (9723)6450333, Fax. (9723)493272.
Italy: MILANO, Tel. (02)6752.3302, Fax. (02)6752 3300.
Japan: TOKIO, Tel. (03)3740 5143, Fax. (03)3740 5035.
Korea (Republic of): SEOUL, Tel. (02)709-1412, Fax. (02)709-1415.
Malaysia: Kuala Lumpur, Tel. (03)757 5511, Fax. (03)757 4880.
Mexico: CHI HUA HUA, Tel. (016)18-67-01/(016)18-67-02, Fax. (016)778 0551.
Netherlands: EINDHOVEN, Tel. (040)783749, Fax, (040)788399.
New Zealand: AUCKLAND, Tel. (09)849-4160, Fax. (09)849-7811.
Norway: OSLO, Tel. (22)74 8000, Fax. (22)74 8341.
Pakistan: KARACHI, Tel. (021)587 4641-49, Fax. (021)577035/5874546.
Philippines: MANILA, Tel. (02)810-0161, Fax. (02)817-3474.
Portugal: Linda-A-Velha, Tel. (01)14163160/4163333, Fax. (01)14163174/4163366.
Singapore: SINGAPORE, Tel. (65)350 2000, Fax. (65)355 1758.
South Africa: JOHANNESBURG, Tel. (011)470-5911, Fax. (011)470-5494.
Spain: BARCELONA, Tel. (03)301 6312, Fax. (03)301 4243.
Sweden: STOCKHOLM, Tel. (08)632 2000, Fax. (08)632 2745.
Switzerland: ZÜRICH, Tel. (01)488 2211, Fax. (01)481 77 30.
Taiwan: TAIPEI , Tel. (02)388 7666, Fax. (02)382 4382.
Thailand: BANGKOK, Tel. (662)398-0141, Fax. (662)398-3319.
Turkey: ISTANBUL, Tel. (0212)279 2770, Fax. (0212)269 3094.
United Kingdom: LONDON, Tel. (071)580 6633, Fax. (071)636 0394.
United States: RIVIERA BEACH, Tel.(407)881-3200, Fax. (407)881 3300.
Uruguay: MONTEVIDEO, Tel. (02)704 044, Fax. (02)920 601.

For all other countries apply to:
Philips Components,
Marketing Communications,
P.O. Box 218,
5600 MD, EINDHOVEN, The Netherlands
Telex 35000 phtcnl, Fax. +31-40-724547.

NOTES

Philips Semiconductors – a worldwide company

Argentina: IEROD, Av. Juramento 1992 - 14.b, (1428)
BUENOS AIRES, Tel. (541)786 7633, Fax. (541)786 9367
Australia: 34 Waterloo Road, NORTH RYDE, NSW 2113,
Tel. (02)805 4455, Fax. (02)805 4466
Austria: Triester Str. 64, A-1101 WIEN, P.O. Box 213,
Tel. (01)60 101-1236, Fax. (01)60 101-1211
Belgium: Postbus 90050, 5600 PB EINDHOVEN, The Netherlands,
Tel. (31)40 783 749, Fax. (31)40 788 399
Brazil: Rua do Rocio 220 - 5th floor, Suite 51,
CEP: 04552-903-SÃO PAULO-SP, Brazil.
P.O. Box 7383 (01064-970).
Tel. (011)821-2333, Fax. (011)829-1849
Canada: PHILIPS SEMICONDUCTORS/COMPONENTS:
Tel. (800) 234-7381, Fax. (708) 296-8556
Chile: Av. Santa Maria 0760, SANTIAGO,
Tel. (02)773 816, Fax. (02)777 6730
Colombia: IPRELENSO LTDA, Carrera 21 No. 56-17,
77621 BOGOTA, Tel. (571)249 7624/(571)217 4609,
Fax. (571)217 4549
Denmark: Prags Boulevard 80, PB 1919, DK-2300 COPENHAGEN S,
Tel. (032)88 2636, Fax. (031)57 1949
Finland: Sinikalliontie 3, FIN-02630 ESPOO,
Tel. (9)0-50261, Fax. (9)0-520971
France: 4 Rue du Port-aux-Vins, BP317,
92156 SURESNES Cedex,
Tel. (01)4099 6161, Fax. (01)4099 6427
Germany: P.O. Box 10 63 23, 20043 HAMBURG,
Tel. (040)3296-0, Fax. (040)3296 213.
Greece: No. 15, 25th March Street, GR 17778 TAVROS,
Tel. (01)4894 339/4894 911, Fax. (01)4814 240
Hong Kong: PHILIPS HONG KONG Ltd., 6/F Philips Ind. Bldg.,
24-28 Kung Yip St., KWAI CHUNG, N.T.,
Tel. (852)424 5121, Fax. (852)428 6729
India: Philips INDIA Ltd, Shivsagar Estate, A Block ,
Dr. Annie Besant Rd. Worli, Bombay 400 018
Tel. (022)4938 541, Fax. (022)4938 722
Indonesia: Philips House, Jalan H.R. Rasuna Said Kav. 3-4,
P.O. Box 4252, JAKARTA 12950,
Tel. (021)5201 122, Fax. (021)5205 189
Ireland: Newstead, Clonskeagh, DUBLIN 14,
Tel. (01)640 000, Fax. (01)640 200
Italy: PHILIPS SEMICONDUCTORS S.r.l.,
Piazza IV Novembre 3, 20124 MILANO,
Tel. (0039)2 6752 2531, Fax. (0039)2 6752 2557
Japan: Philips Bldg 13-37, Kohnan 2-chome, Minato-ku, TOKYO 108,
Tel. (03)3740 5028, Fax. (03)3740 0580
Korea: (Republic of) Philips House, 260-199 Itaewon-dong,
Yongsan-ku, SEOUL, Tel. (02)794-5011, Fax. (02)798-8022
Malaysia: No. 76 Jalan Universiti, 46200 PETALING JAYA,
SELANGOR, Tel. (03)750 5214, Fax. (03)757 4880
Mexico: 5900 Gateway East, Suite 200, EL PASO, TX 79905,
Tel. 9-5(800)234-7381, Fax. (708)296-8556
Netherlands: Postbus 90050, 5600 PB EINDHOVEN, Bldg. VB
Tel. (040)783749, Fax. (040)788399
New Zealand: 2 Wagener Place, C.P.O. Box 1041, AUCKLAND,
Tel. (09)849-4160, Fax. (09)849-7811
Norway: Box 1, Manglerud 0612, OSLO,
Tel. (022)74 8000, Fax. (022)74 8341
Pakistan: Philips Electrical Industries of Pakistan Ltd.,
Exchange Bldg. ST-2/A, Block 9, KDA Scheme 5, Clifton,
KARACHI 75600, Tel. (021)587 4641-49,
Fax. (021)577035/5874546.
Philippines: PHILIPS SEMICONDUCTORS PHILIPPINES Inc,
106 Valero St. Salcedo Village, P.O. Box 2108 MCC, MAKATI,
Metro MANILA, Tel. (02)810 0161, Fax. (02)817 3474
Portugal: PHILIPS PORTUGUESA, S.A.,
Rua dr. António Loureiro Borges 5, Arquiparque - Miraflores,
Apartado 300, 2795 LINDA-A-VELHA,
Tel. (01)4163160/4163333, Fax. (01)4163174/4163366.
Singapore: Lorong 1, Toa Payoh, SINGAPORE 1231,
Tel. (65)350 2000, Fax. (65)251 6500
South Africa: S.A. PHILIPS Pty Ltd.,
195-215 Main Road Martindale, 2092 JOHANNESBURG,
P.O. Box 7430 Johannesburg 2000,
Tel. (011)470-5911, Fax. (011)470-5494.
Spain: Balmes 22, 08007 BARCELONA,
Tel. (03)301 6312, Fax. (03)301 42 43
Sweden: Kottbygatan 7, Akalla. S-164 85 STOCKHOLM,
Tel. (0)8-632 2000, Fax. (0)8-632 2745
Switzerland: Allmendstrasse 140, CH-8027 ZÜRICH,
Tel. (01)488 2211, Fax. (01)481 77 30
Taiwan: PHILIPS TAIWAN Ltd., 23-30F, 66, Chung Hsiao West
Road, Sec. 1. Taipeh, Taiwan ROC, P.O. Box 22978,
TAIPEI 100, Tel. (02)388 7666, Fax. (02)382 4382.
Thailand: PHILIPS ELECTRONICS (THAILAND) Ltd.,
209/2 Sanpavuth-Bangna Road Prakanong,
Bangkok 10260, THAILAND,
Tel. (662)398-0141, Fax. (662)398-3319.
Turkey: Talatpasa Cad. No. 5, 80640 GÜLTEPE/ISTANBUL,
Tel. (0212)279 2770, Fax. (0212)269 3094
United Kingdom: Philips Semiconductors LTD.,
276 Bath Road, Hayes, MIDDLESEX UB3 5BX,
Tel. (081)73050000, Fax. (081)7548421
United States: 811 East Arques Avenue, SUNNYVALE,
CA 94088-3409, Tel. (800)234-7381, Fax. (708)296-8556
Uruguay: Coronel Mora 433, MONTEVIDEO,
Tel. (02)70-4044, Fax. (02)92 0601

For all other countries apply to: Philips Semiconductors,
International Marketing and Sales, Building BE-p,
P.O. Box 218, 5600 MD, EINDHOVEN, The Netherlands,
Telex 35000 phtcnl, Fax. +31-40-724825

SCD35

Printed in The Netherlands

143051/21000/02/pp323 Date of release: December 1994
Document order number: 9398 652 81011

Philips Semiconductors

PHILIPS