DISCRETE SEMICONDUCTORS

DATA SHEET

General part 2
Sensor hybrid modules

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Philips Semiconductors

PHILIPS

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.

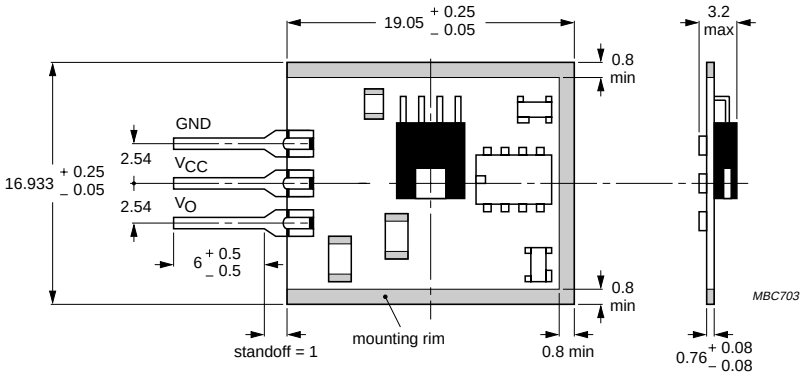
The KM110BH/21 module series

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.

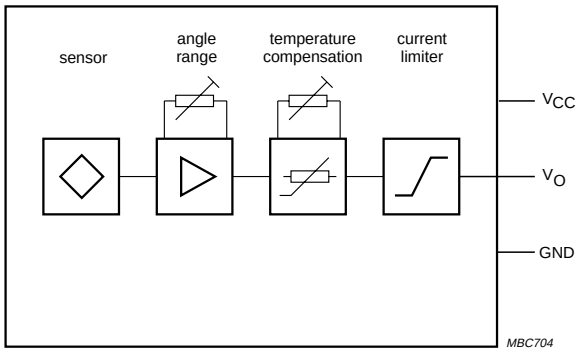
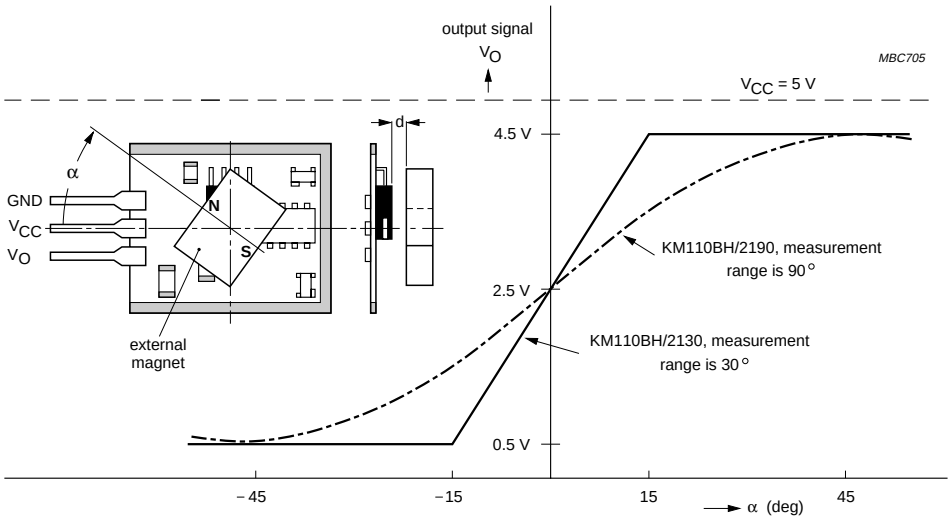


Fig.3 Block diagram of a module circuit.



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 α = 0°). Hysteresis, with a typical value of 0.02° at α = 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.

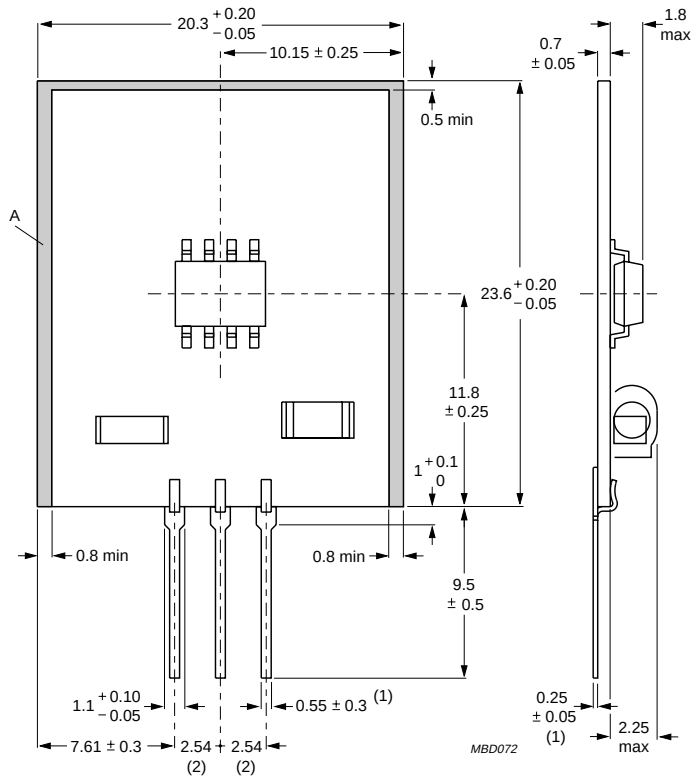
If one of the axis is shifted, the measuring system neglects this tolerance because of the parallel field lines of the magnet. Measurements with magnets 11.2×8 mm^2 faced to the sensor allow for eccentric tolerances of up to 0.5 mm in the event of an accepted V_O tolerance of 1% and up to 0.25 mm for 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)**	$\mathbf{T_{amb}}$ **(°C)**
Sm_2Co_{17}	$11.2 \times 5.5 \times 8$	2.1	±0.30	±0.25	–55 to +125
	$6 \times 3 \times 5$	0.7	±0.15	±0.15	
	$8 \times 3 \times 7.5$	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.

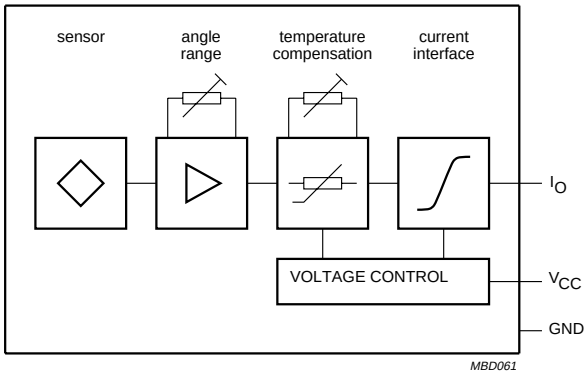


Fig.6 Block diagram of the KM110BH/2270.

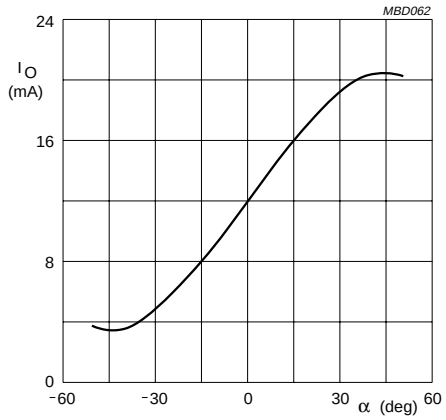
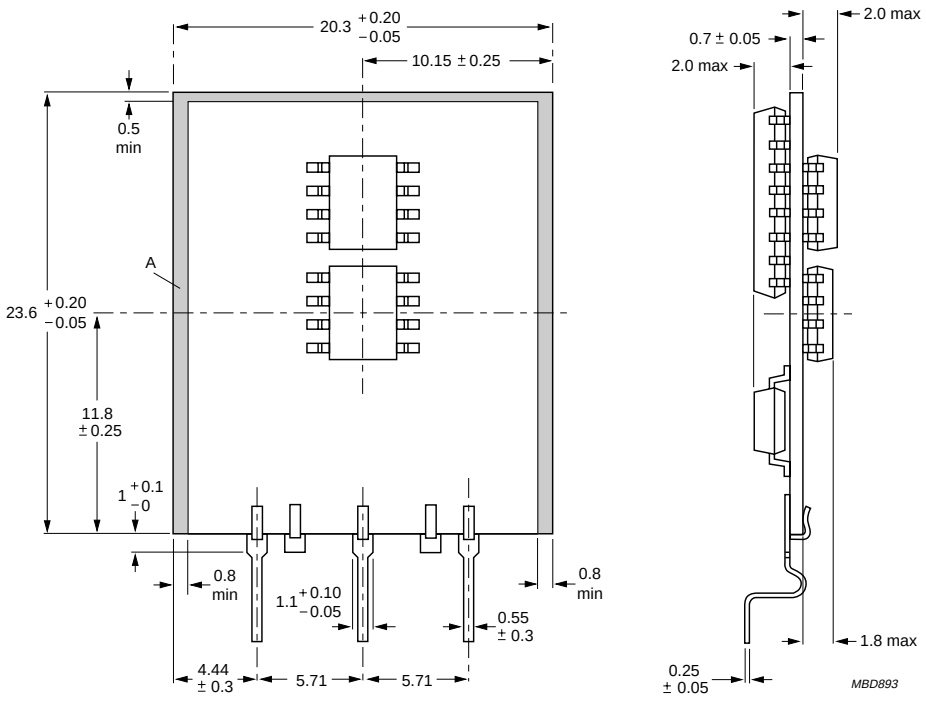


Fig.7 Output current 'I_O' as a function of angular displacement 'α' for the KM110BH/2270.



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

Fig.8 Outline of the KM110BH/2390.

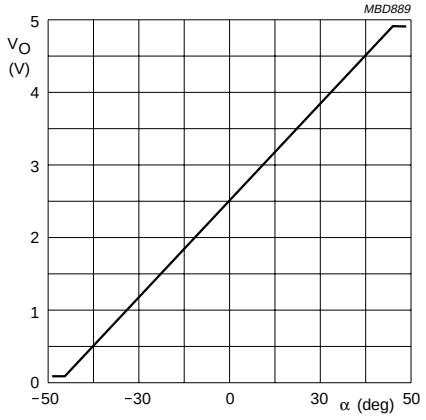
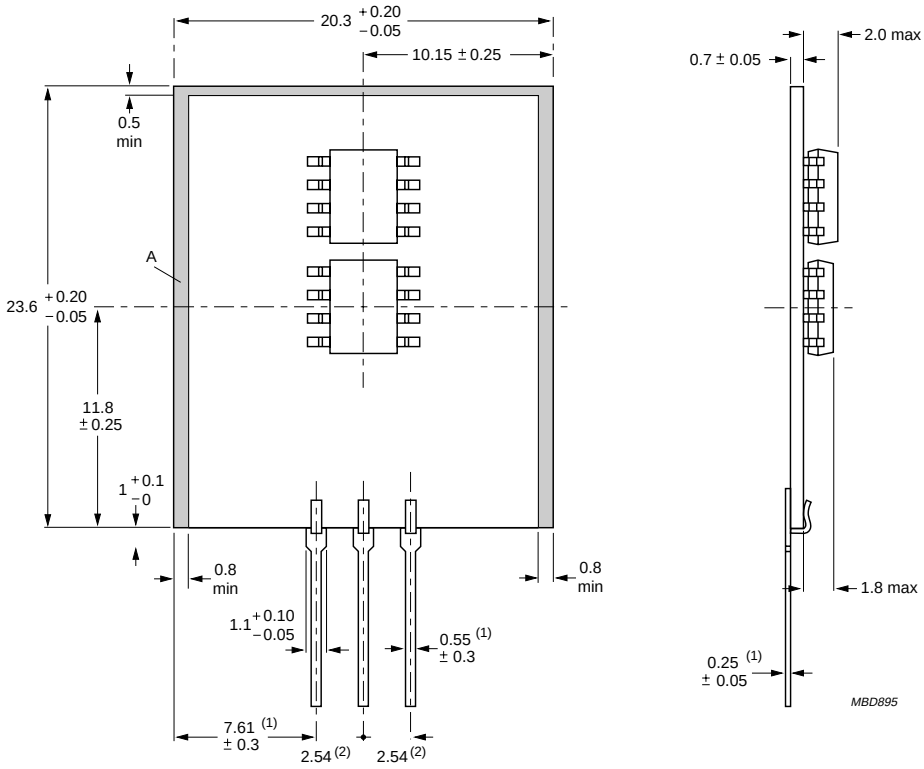


Fig.9 Output voltage 'V_O' as a function of angular displacement 'α' for the KM110BH/2390.



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.

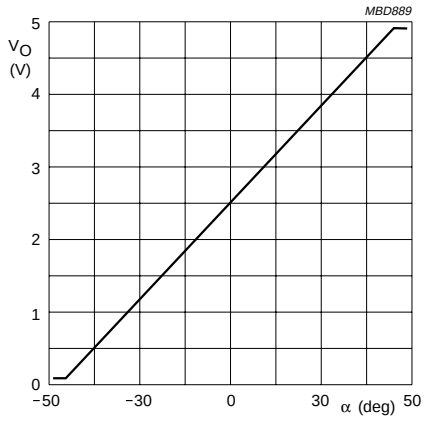


Fig.11 Output voltage 'V_O' as a function of angular displacement 'α' for the KM110BH/2430.

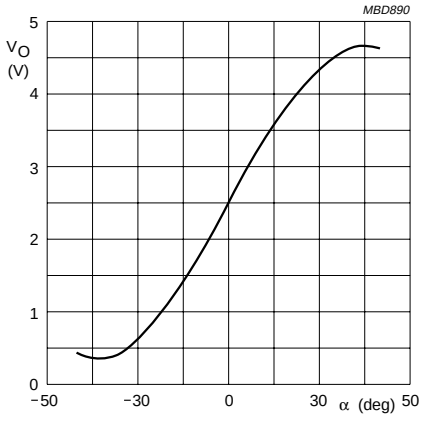


Fig.12 Output voltage 'V_O' as a function of angular displacement 'α' for the KM110BH/2470.

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.

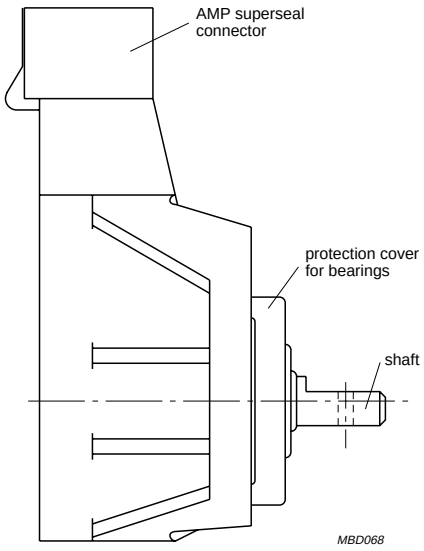


Fig.14 Encapsulation of the KMA sensors.

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°.

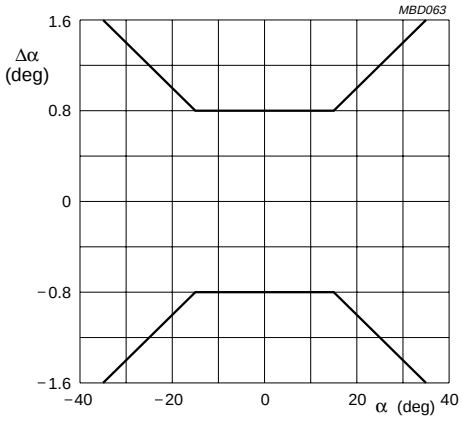
A summary of data of the KMA10 and KMA20 sensors is given in Table 3.

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	

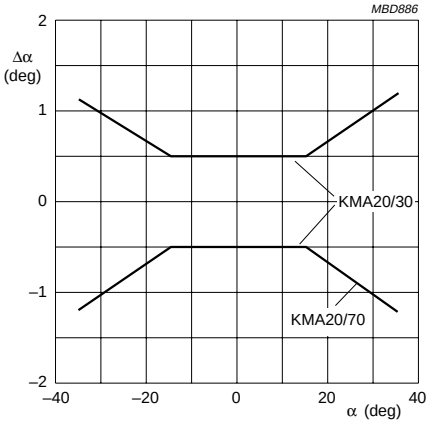
Note

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.

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