



The sixth sense for automotive applications

Magnetoresistive sensors for rotational, angle and weak-field measurement



Accuracy and reliability are key to NXP sensors

Engine management and ABS, variable valve timing and electronic throttle control, active suspension and electronic steering – just some of automotive applications vital in ensuring today's cars are safer, more comfortable and less fuel hungry. The majority of these systems depend on an accurate and reliable supply of information and NXP Semiconductors provides an extensive portfolio of high-performance sensor solutions to deliver just that. Additionally, as you would expect from a leading supplier of automotive semiconductors, all NXP's sensors have the ruggedness and reliability needed to meet the exacting automotive quality standards.

You can choose from a proven range of magnetoresistive (MR) sensors for angle, rotation and weak-field measurements. They all offer precise measurement, reliable operation and long lifetimes – exactly the qualities needed for automotive use. With numerous options available to match a wide variety of applications, you are sure to find the perfect part for your application.

Magnetoresistive sensors - suited to a host of applications

ABS

Steering angle

E-Gas

Steering torsion

Active transmission

EPAS motor positioning

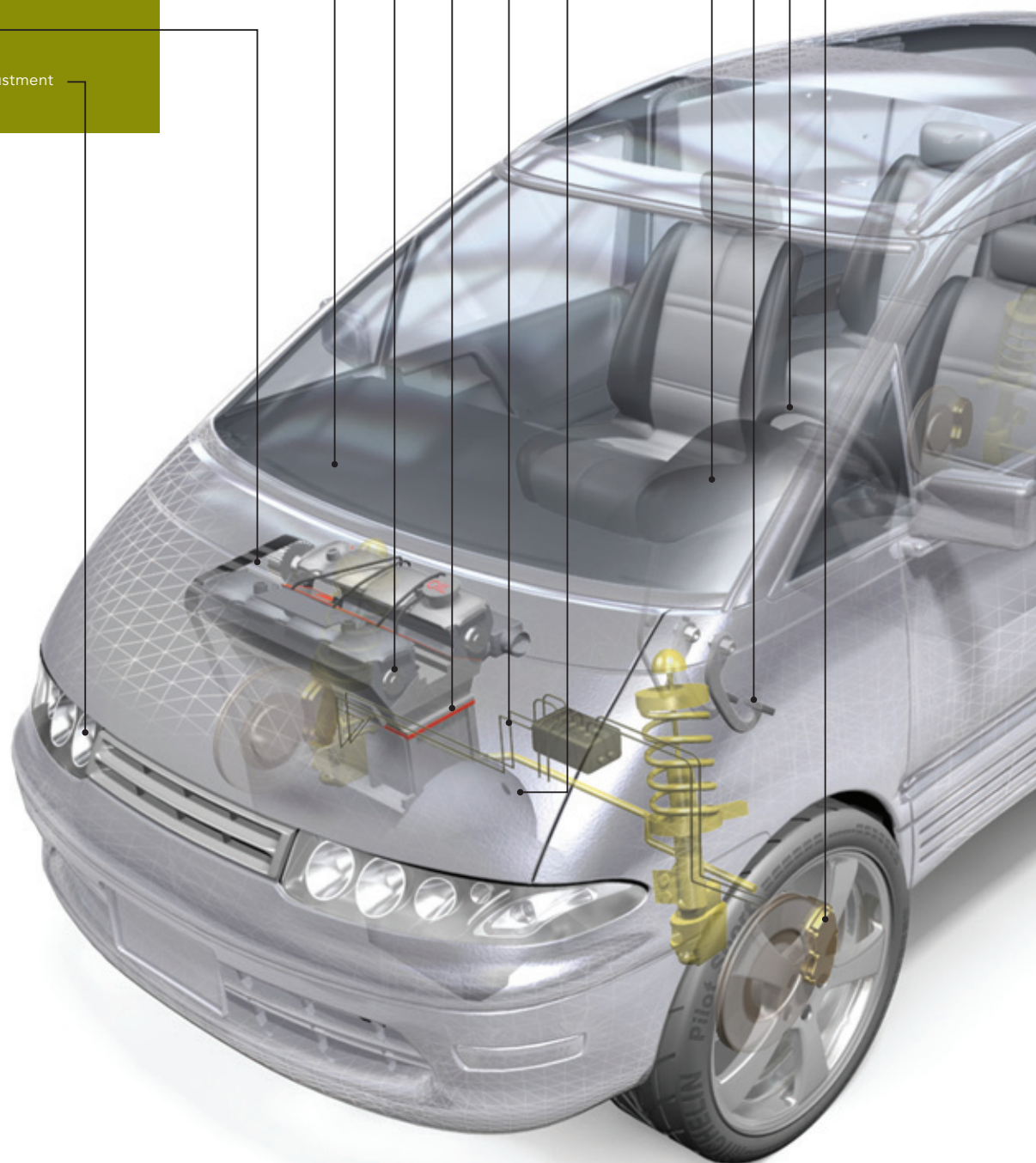
E-throttle

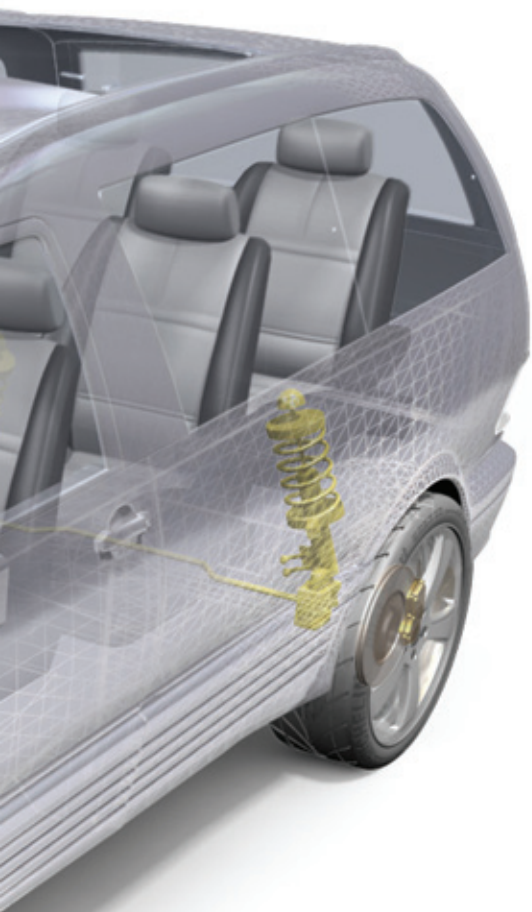
Variable Valve Timing

Window wipers

Crankshaft

Headlight adjustment







NXP's automotive sensors portfolio



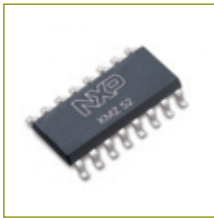
Magnetoresistive rotational speed sensors

Compact and easy to design in, our KMI rotational speed sensors provide a simple and cost-effective rotational sensing solution. They are ready to use and include the sensor, an advanced signal conditioning IC and a choice of three back-biasing magnets, all housed in a special multi-chip package.



Magnetoresistive angle sensors

Highly accurate, NXP's angle sensors are ideal for a variety of demanding automotive and industrial applications. These easy-to-use devices provide an output signal virtually independent of magnet tolerances, magnet temperature coefficients, magnet-sensor distance and positioning tolerances, guaranteeing reliability and simplifying your manufacturing process.



Magnetoresistive weak field detection sensors

Capable of detecting weak magnetic fields such as the Earth's, the KMZ5x range are ideal for navigation and traffic detection applications. These devices consist of four magnetically sensitive permalloy resistors arranged in a Wheatstone bridge configuration, maximizing sensitivity while minimizing temperature influences.





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NXP Semiconductors is in the process of being established as a separate legal entity in various countries worldwide. This process will be finalized in the course of 2006.

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Magnetoresistive angle sensor systems

Cover all the angles in your automotive systems

NXP's magnetoresistive sensor technology is the superior choice for automotive measurement systems. Features such as lack of wear, long term stability and direct measurement combine to deliver highly accurate and robust sensors. With stand-alone sensors, companion signal conditioning ICs and complete single-package sensing solutions our range of cost-effective angle sensors covers all your application needs.

Key benefits

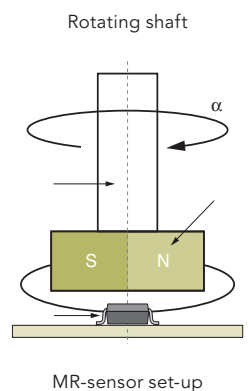
- ▶ Contactless angle measurement up to 180°
- ▶ Measurement independent of magnetic drift caused by life time and temperature changes
- ▶ Operation independent of mechanical tolerances and magnet shifts caused by thermal stress
- ▶ High temperature range
- ▶ Automotive qualification
- ▶ Highly flexible solutions that measure any automotive angle effectively
- ▶ Fully stable operation over long life-cycle

Key applications

- ▶ Electronic throttle control (ETC)
- ▶ Variable valve control (VVC)
- ▶ Pedal and wiper positioning
- ▶ Active suspension
- ▶ Automatic headlight adjustment
- ▶ Electronic steering
- ▶ Seat positioning

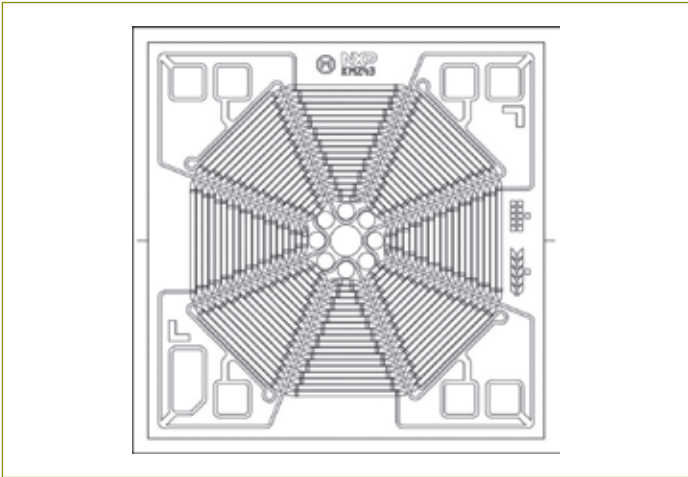
Offering many technical benefits over other technologies, our magnetoresistive (MR) angle sensors provide car manufacturers with a more reliable and accurate solution for automotive angle measurement – reducing the risk of mechanical breakdown and improving overall vehicle safety. This is an increasingly important area within automotive electronics as the industry moves closer to incorporating advanced X-by-wire networks and control systems, such as FlexRay, that rely on accurate measurement data.

MR sensors use magnetic fields to conduct measurement information between physical value and sensor. This contactless principle allows isolation of all rotating components, making the entire sensing system robust with respect to pollution and mechanical degradation. Also, MR sensors evaluate the direction of the magnetic field and not the field strength. As a result, MR sensors can tolerate variations in field strength caused by ageing, mechanical fluctuations or temperature sensitivity of the magnet.



Magnetoresistive angle sensors KMZ41/KMZ43 and UZZ900x

Our KMZ41 and KMZ43 sensor bridges contain eight MR resistors, connected as two individual Wheatstone bridges aligned at 45°. Possessing different sensitivities, our KMZ41 and KMZ43 angle sensors are designed to work with the UZZ900x conditioning ICs. Ensuring maximum flexibility, we offer MR sensor bridges both as standalone devices in SO8 package and as bare die for space-critical solutions.

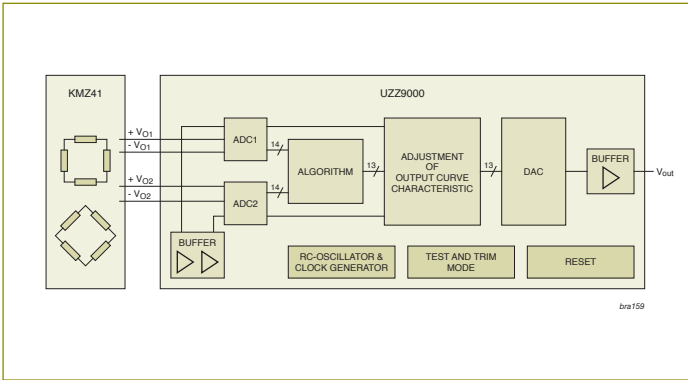


KMZ43T chip layout, showing the two 45° aligned bridges

KMZ41, KMZ43T and X3T-KMZ43 (bare die) key specifications		
Property	KMZ41	KMZ43T X3T-KMZ43
Operating voltage	max. 9 V	max. 9 V
Angle range	180°	180°
Output signal	sin/cos	sin/cos
Saturation field strength	100 kA/m	25 kA/m
Operating temperature range	-40+150 °C	-40+150 °C

Companion signal conditioning ICs for sensor bridges

Designed and developed specifically to complement the KMZ family of angle sensors, the UZZ9000 series provides optimized single-chip signal conditioning solutions with either analog or 13-bit SPI interfacing. Incorporating all conditioning electronics they also offer an adjustable measurement range and zero point to maximize design flexibility.

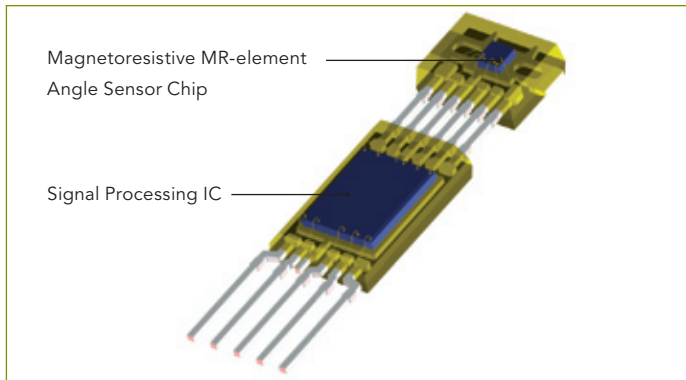


KMZ4x and UZZ900x

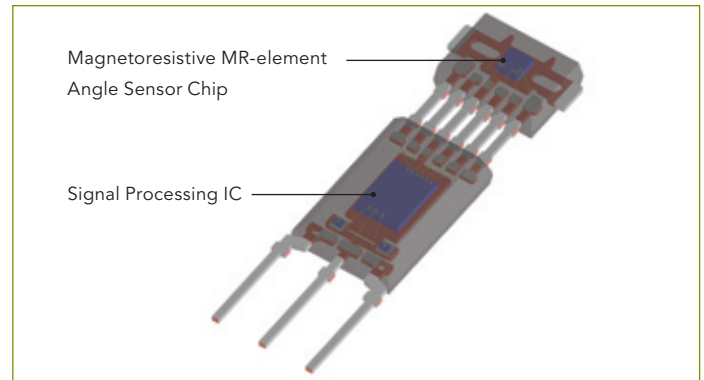
UZZ9000 and UZZ9001 key specifications		
Property	UZZ9000	UZZ9001
Supply voltage	5 V +/- 10 %	5 V +/- 10 %
Maximum angle range	0° to 180°	0° to 180°
Angle range variation	0°- 30 °... 0°- 180° in 10° steps	fixed to 0°- 180°
Zero point offset cancellation	+/- 5° in 0.5° steps	fixed to 0
Output	ratiometric analog voltage	digital (SPI) with 13-Bit
Measurement resolution	< 0.1°	< 0.05°
Accuracy (ideal input)	< +/- 0.4°	< +/- 0.3°
Package	SO24 (SOT137-1)	SO24 (SOT137-1)
Temperature range	-40°C to +150°C	-40°C to +150°C

Single package angle sensor systems with on-chip diagnostics - KMA200 and KMA199

The KMA200 and KMA199 are pre-aligned, ready-to-use sensor systems. They consist of a magnetoresistive element containing two independent MR sensor bridges and a signal conditioning IC in a special multi-chip package that allows 90° bending of the MR-element.



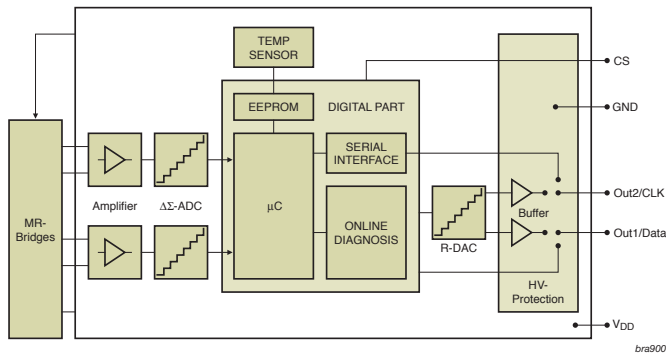
The KMA200 sensor system



The KMA199 sensor system

KMA200 key features

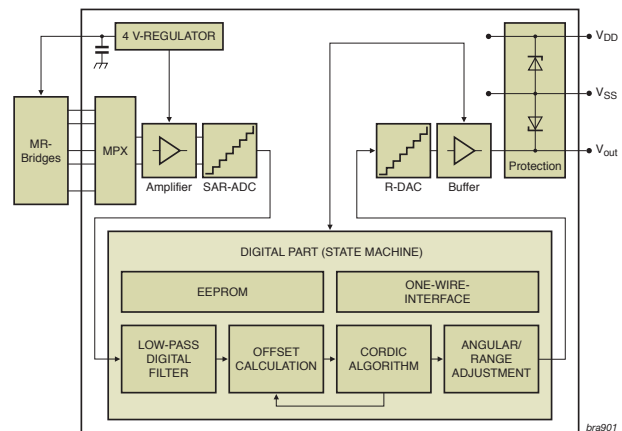
- ▶ Digital SPI for programming (customer settings and calibration)
- ▶ 4 analog and 2 digital output modes, selectable
- ▶ Reverse supply voltage protection up to 16.5 V
- ▶ Over voltage protection up to 26.5 V (32 V for 400 ms)
- ▶ On-line diagnostic of all main functional blocks



KMA200 sensor system

KMA199 key features

- ▶ Single-wire digital interface for programming
- ▶ 3-lead device with analog output
- ▶ Transient protection circuit
- ▶ Active power-loss functionality

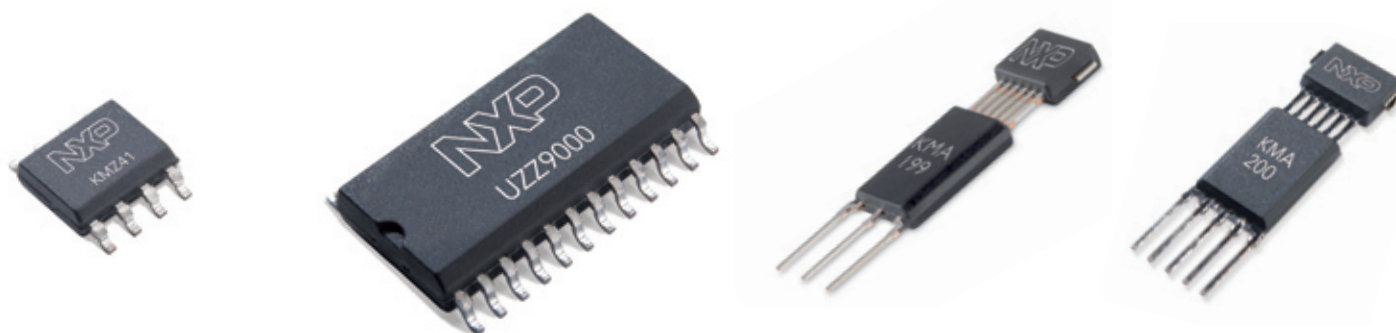


KMA199 sensor system

Key specifications		
Property	KMA200	KMA199
Angular measurement range	180°	180°
Output mode	4 analog/2 digital, selectable	ratiometric analog
Maximum error from reference line	-1.65°...+1.65°	
Linearity error		± 1°
Temperature drift (-25...+125 °C)	-0.64°...+0.64°	
Temperature drift related to room temperature		0.55°
Microlinearity	-0.1°...+0.1°	-0.1°...+0.1°
Temperature range	-40...+160 °C	-40...+140 °C
Supply voltage	5 V + - 10%	5 V + - 10%

Magnetoresistive angle sensors and conditioning ICs

Portfolio overview							
Type	Product	Package	Supply voltage (V)	Angle range	Output value	Output type	Operating temperatures °C
KMZ41	sensor	SO8	5.0 ... 9.0	180°	78 mV peak (5 V)	sin/cos	-40 ...+150
KMZ43	sensor	SO8	5.0 ... 9.0	180°	67 mV peak (5 V)	sin/cos	-40 ...+150
X3T-KMZ43	sensor	die	5.0 ... 9.0	180°	67 mV peak (5 V)	sin/cos	-40 ...+150
UZZ9000	signal conditioning unit	SO24	4.5 ... 5.5	180°	0.5 ... 4.5 V	analog linear	-40 ...+150
UZZ9001	signal conditioning unit	SO24	4.5 ... 5.5	180°	0.5 ... 4.5 V	digital	-40 ...+150
KMA199	sensor system	SOT880	4.5 ... 5.5	180°	0.5 ... 4.5 V	analog linear	-40 ...+140
KMA200	sensor system	SOT637	4.5 ... 5.5	180°	0.5 ... 4.5 V	4 analog linear/2 digital	-40 ...+160



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Rotational speed sensor

Constantly aware of that speed sensation

Compact and easy to design in, our KMI magnetoresistive sensors provide simple and cost-effective solutions for all your rotational speed measurement needs. They meet the high EMC, reliability and temperature range requirements of the automotive sector, and are available in a range of options to maximize design freedom.

Key benefits

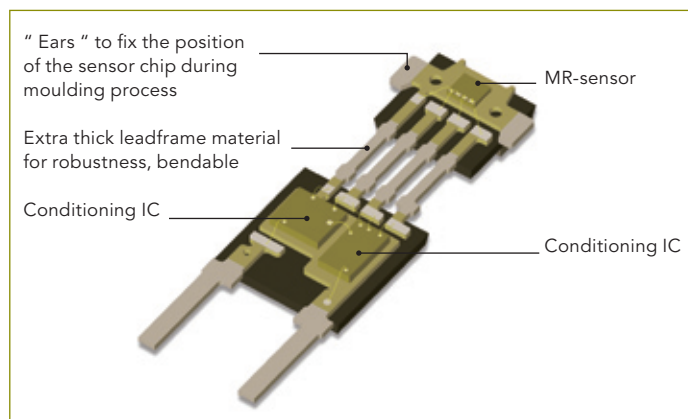
- ▶ Wide air gap between sensor and target
- ▶ Speed detection down to 0 Hz
- ▶ Very low jitter
- ▶ Wide frequency range
- ▶ Insensitive to vibrations
- ▶ Temperature range: -40 to +150 °C
- ▶ Prepared for injection moulding

Key applications

- ▶ ABS
- ▶ Engine management
- ▶ Gearbox
- ▶ Transmission systems
- ▶ Vehicle speed
- ▶ DC motor commutation

Accurate rotational speed measurement is a vital component in maintaining performance, safety and reliability in modern vehicles. It forms the basis of numerous applications from anti-lock braking to engine management systems, and opens the way for embedding intelligence throughout the car with the introduction of advanced X-by-wire networks and control systems.

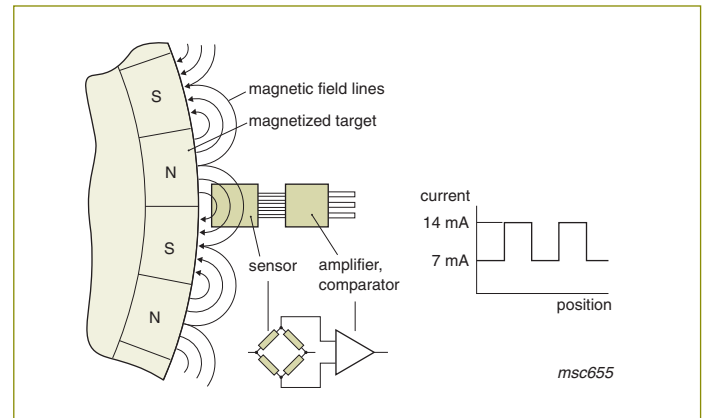
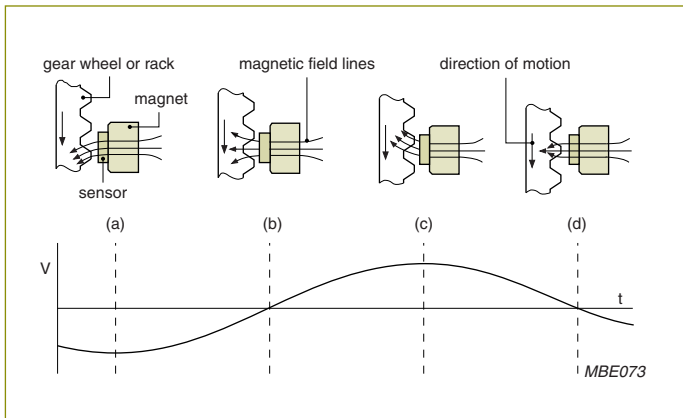
NXP's KMI family of magnetoresistive (MR) rotational speed sensors provides a solution for all applications. Designed specifically to meet the needs of automotive systems, they are complete, ready-to-use modules comprising sensor, back-biasing magnet and advanced signal conditioning IC. Enabling maximum design flexibility, the devices are available with a choice of output signals and individually magnetized back-biasing magnets.



Component detail of the KMI20

How to measure rotation with MR sensors

The KMI sensors are designed to sense the motion of ferrous gear wheels or of magnetized targets. A periodic magnetic field stemming from the effect of flux bending by ferrous gear wheels or directly from magnetized targets will be transformed by a MR sensor into an analog electrical signal. The frequency of this signal is proportional to the rotational speed of the target.



A subsequent integrated circuit transforms the analogue into a digital output signal. The output level is independent of the sensing distance within the measurement range.

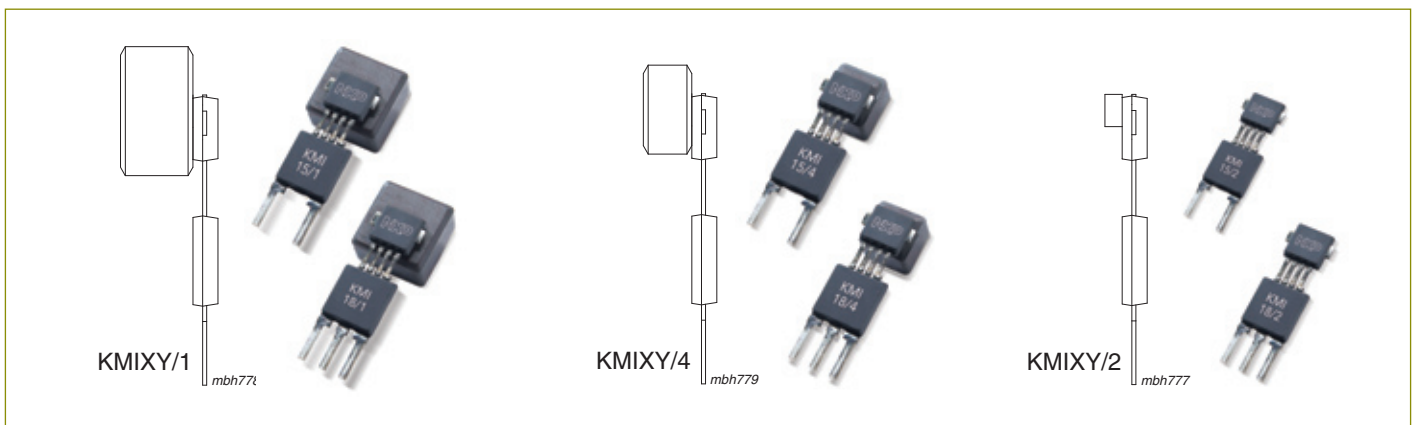
Back-biasing magnets, individually magnetized for each sensor

- ▶ Large (8.0 x 8.0 x 4.5 mm) – for maximum air gap between sensor and ferrous targets
- ▶ Medium (5.5 x 5.5 x 3.0 mm) – for use with ferrous targets where space is limited
- ▶ Small (3.8 x 2.0 x 0.8 mm) – for magnetized targets, stabilizing the inherently bi-stable MR sensor

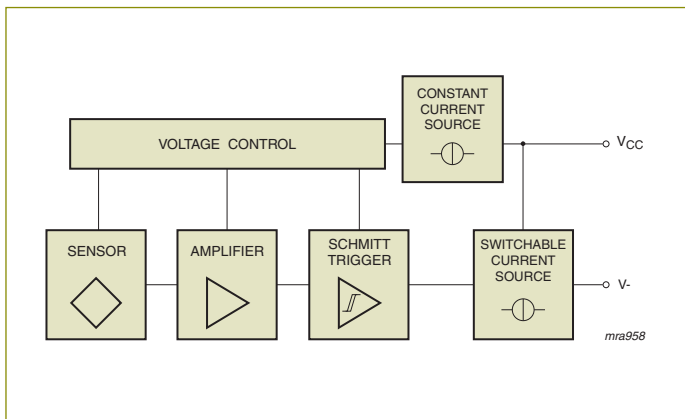
Output signals

For high flexibility in the design of the subsequent signal conditioning electronics, the KMI sensors are available with:

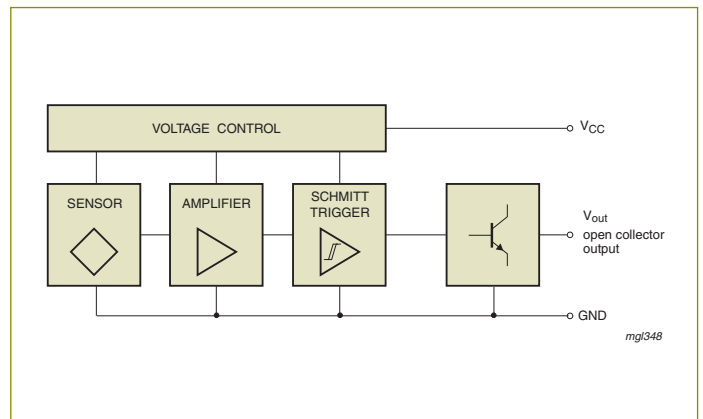
- ▶ a digital current output signal (2-wire)
- ▶ an open collector output signal (3-wire)



KMI15 – 7/14 mA current output (2-wire)

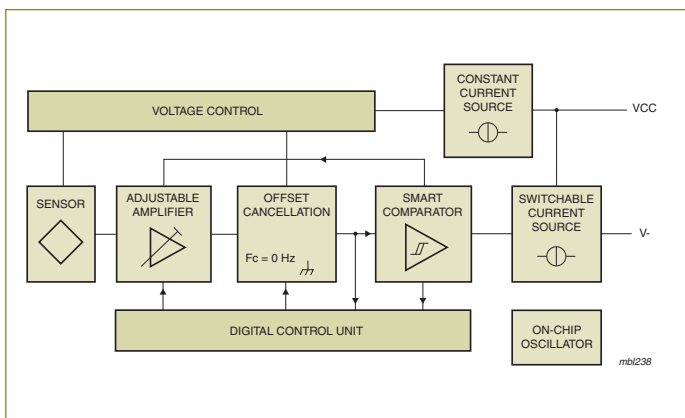


KMI18 – open collector output (3-wire)

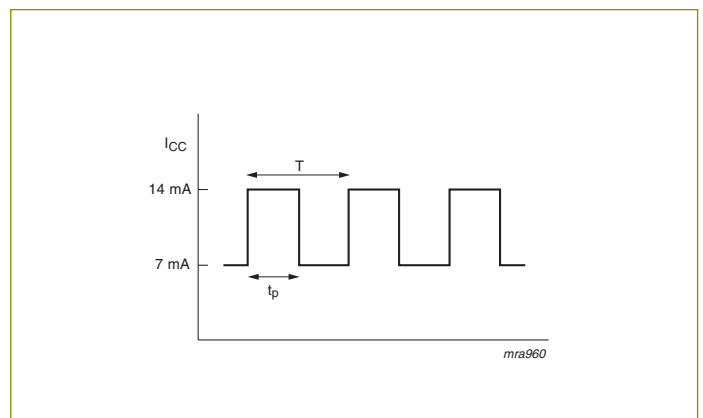


The MR sensor signal is amplified, temperature compensated and passed to a Schmitt trigger.

KMI20 – 7/14 mA current output (2-wire), extended air gap



The MR sensor signal is fed into the conditioning IC. The offset, gain and hysteresis are digitally adapted to ensure an exceptional air gap capability.

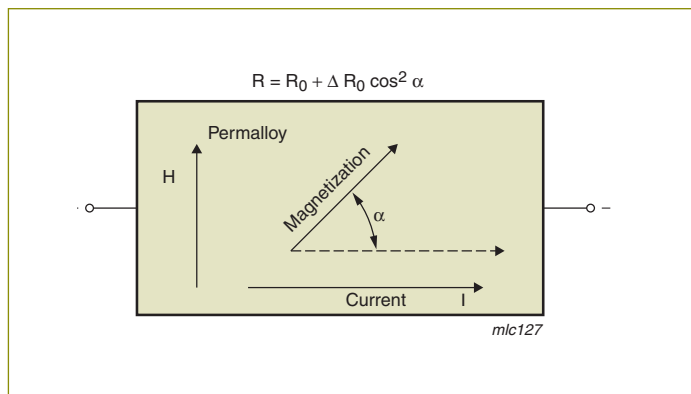


7/14 mA output signal as a function of time

Product overview					
Sensor type	typ. sensing distance (mm)	Tooth frequency (Hz)	Target	Interface	Magnet size (mm)
KMI15/1	0.9 - 2.9	0 - 25.000	note 1	Current	8 x 8 x 4.5
KMI15/2	0.5 - 2.7	0 - 25.000	note 2	Current	3.8 x 2 x 0.8
KMI15/4	0.5 - 2.3	0 - 25.000	note 1	Current	5.5 x 5.5 x 3
KMI18/1	0.9 - 2.9	0 - 25.000	note 1	Open collector	8 x 8 x 4.5
KMI18/2	0.5 - 2.7	0 - 25.000	note 2	Open collector	3.8 x 2 x 0.8
KMI18/4	0.5 - 2.3	0 - 25.000	note 1	Open collector	5.5 x 5.5 x 3
KMI20/1	0.9 - 3.5*	0 - 2.500	note 1	Current	8 x 8 x 4.5
KMI20/2	0.5 - 3.2*	0 - 2.500	note 2	Current	3.8 x 2 x 0.8
KMI20/4	0.5 - 2.8*	0 - 2.500	note 1	Current	5.5 x 5.5 x 3

* + 1 mm dynamic reserve | note 1 - ferrous target | note 2 - magnetized target

Advantages by design



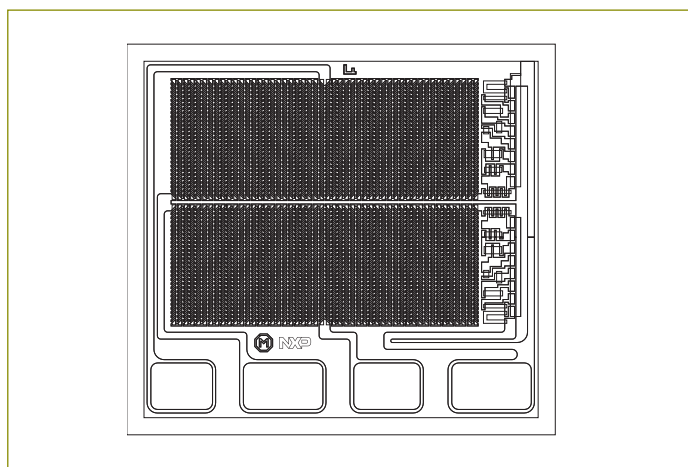
The magnetoresistive effect in permalloy

The MR sensor consists of four sensitive resistors in a Wheatstone bridge configuration, with each resistor arranged to maximize sensitivity and minimize temperature influences. Such a Wheatstone bridge design along with the inherent benefits of MR technology provides several advantages:

- ▶ reduction of temperature drift
- ▶ independent of mechanical assembly tolerances / shifts
- ▶ maximum signal output
- ▶ reduction of non-linearity

MR sensors offer a uniquely versatile combination of features and important cost benefits. Based on the MR effect, specifically designed sensors for angle and linear displacement measurements are also available from NXP, as are solutions for weak field detection.

NXP sensors are based on the MR effect, where the resistance of a current-carrying magnetic material, for example a permalloy (19% Fe, 81% Ni) changes under the influence of an external magnetic field. If an external field is applied, in the plane of the current flow, the internal magnetization vector will rotate by the angle of this field, changing the resistance of the material.



Typical sensor bridge structure