Philips' Earth field sensors:

the natural choice

Let's make things better.

Philips Semiconductors

PHILIPS

Earth magnetic field sensing:

a Philips strength

Within its extensive range, Philips Semiconductors has a number of magnetoresistive sensors ideal for applications requiring the sensing of the earth's magnetic field and other weak fields, such as electronic compasses, earth magnetic field compensation, traffic detection and so on. They offer all the inherent advantages of magnetoresistive technology, with none of the trade-offs between precision and sensitivity, frequency limitations, temperature restrictions and other drawbacks found with many other sensing techniques.

	KMZ10A	KMZ10A1	KMZ50	KMZ51	Unit
Package	SOT195	SOT195	SO8	SO8	-
Supply voltage	5	5	5	5	V
Sensitivity	16[1]	22	16	16	(mV/V)/(kA/m)
Offset voltage	± 1.5	± 1.5	± 1	± 1	mV/V
Offset voltage temperature drift	± 6	± 6	± 3	± 3	µV/V/K
Applicable field range (y-direction)	± 0.5	± 0.5	± 0.2	± 0.2	kA/m
Set/reset coil on-board	No	No	Yes	Yes	-
Compensation coil on-board	No	No	No	Yes	-

[1] *Hx = 0.5 kA/m*

Philips' latest sensor, the highly sensitive KMZ51, has been designed specifically for these applications, and has the compensation and set/reset coils normally used to compensate for offset and temperature drift integrated onto the silicon (see opposite for more details on compensation). Having these coils on-chip greatly simplifies circuit design and reduces system costs; and as this Philips' solution offers excellent magnetic coupling it is extremely efficient, allowing the sensor to operate from a 5 V supply. And even at this low voltage, the KMZ51 requires no costly and bulky DC-to-DC up-converters.

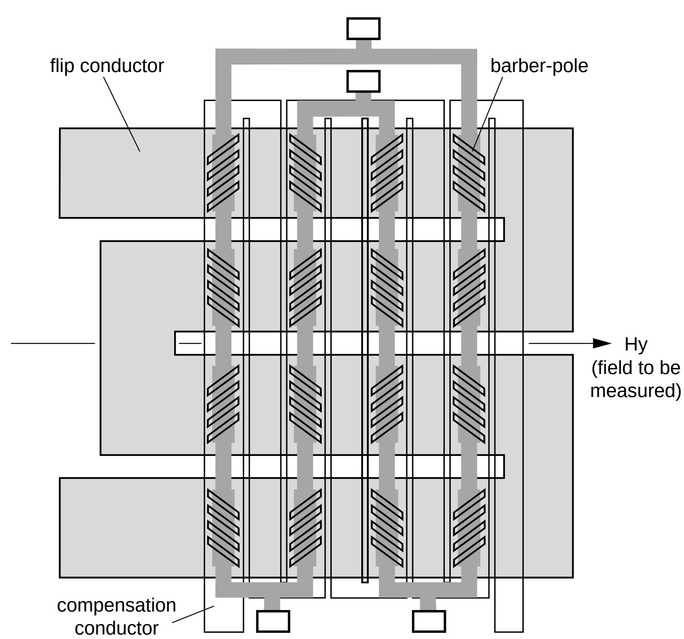


Fig. 1. Layout of KMZ51 sensor

Magnetoresistance: the natural choice for weak field sensing

A magnetoresistive sensor uses a current-carrying magnetic material which changes its resistivity in the presence of an external magnetic field. As an external field is applied, the internal magnetization vector will rotate by an angle α, changing the resistance R of the material according to the relationship R ∞ sin2α. By depositing aluminium strips in a so-called 'Barber pole' arrangement at an angle on the material, the effect can be linearized so the processing electronics can be simpler.

Philips' MR sensors consist of four magnetically sensitive permalloy resistors arranged in a Wheatstone bridge configuration. This maximizes sensitivity and minimizes temperature influences so Philips' sensors offer:

- high sensitivity and high reliability
- low offset voltage
- contactless and therefore wear-free measurement/detection
- a wide operating frequency range (0 Hz to 1 MHz)
- high operating temperatures (up to 125 °C peak)
- long operating life, high stability and ruggedness

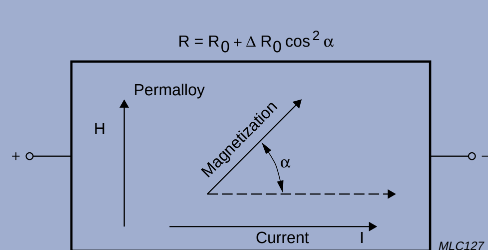


Fig. 2. The magnetoresistive effect in permalloy

Compensation:

the key to weak field sensing

Despite electrical trimming and their inherent high sensitivity, as with any weak field sensor MR devices can have an offset value larger than a typical target weak field, such as the Earth's geomagnetic field. Also, their sensitivity decreases as temperature increases but fortunately, both these effects can easily be compensated, allowing the high sensitivity and reliability of magnetoresistive sensors to be exploited in weak field measurement. Compensation uses two coils wrapped around the sensor which, in Philips' KMZ51 sensor, are already integrated into the housing for easy design-in. The 'flipping' coil both stabilizes the sensor and eliminates offset effects; the other provides electro-magnetic feedback so the sensor is always operating effectively at its zero-point, where offset and sensitivity are unaffected by temperature.

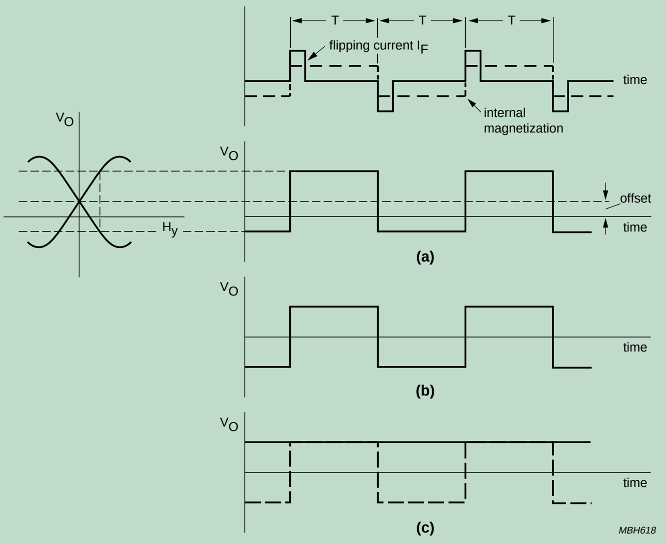


Fig. 3. Timing diagram for flipping circuit

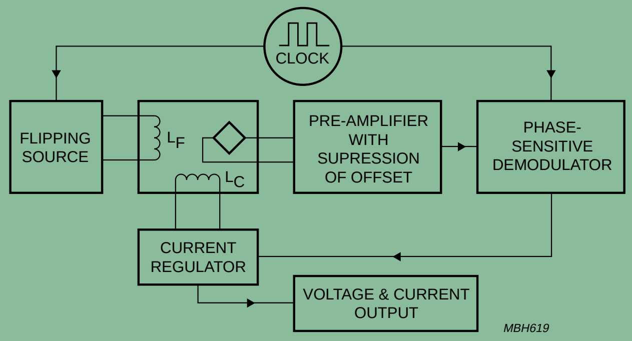


Fig. 4. Compensation circuit

Figure 4 shows a typical compensation circuit. This can be greatly simplified if a microprocessor is available within the system to drive the flipping and compensation coils: for a typical example, see page 6.

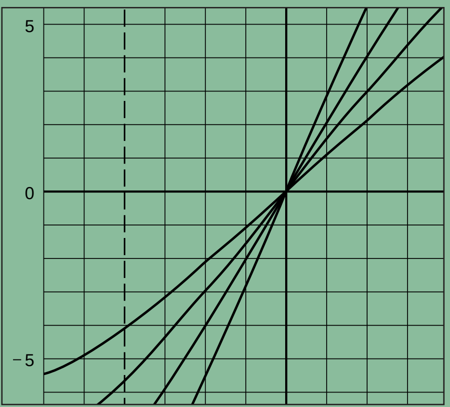


Fig . 5. Different magnetoresistive sensitivities at four different temperatures

Flipping

All magnetoresistive sensors have two stable output characteristics. Using a reversible, pulsed external magnetic field of very short duration, produced using the first current carrying coil wrapped around the sensor, the output is periodically switched or 'flipped' between the two states. Thus the unknown field is measured in one direction in one half of the cycle, while in the second half it is measured in the opposite direction. The two different outputs are symmetrically positioned around the offset value, so simple high pass filtering and rectification produces a single continuous, offset-free output.

Temperature compensation

By using a principle called current compensation in an electro-magnetic feedback set-up, the MR sensor can always be operated at its null-point, where the output signal is independent of the sensor's actual sensitivity or its drift with temperature (figure 5). This is easily achieved with a second compensation coil wrapped around the sensor, perpendicular to the flipping coil. Variations in the sensor's output are converted to a current and fed back through the compensation coil to produce an equal and opposite field, exactly compensating the change in output signal, regardless of its actual, temperature-dependent value. The value of the target field is then easily derived from the current fed to this coil.

Pointing the way

Probably the most common weak field application for magnetoresistive sensors is in electronic compasses or navigation tools. These use two sensors, aligned in the same plane but at 90° to one another to provide a two dimensional compass, with the sensors measuring the x- and y-components of the measured Earth field (figure 6).

Magnetoresistive-based compasses offer basic set-up simplicity, as well as design flexibility to allow tailoring compass performance to the application. Depending on the level of accuracy required and expected environmental influences, various levels of complexity can be incorporated into the compass drive circuit, to make systems ranging from a simple 8-segment compass to high precision set-ups including a microcontroller. It is also possible to design high-end systems which use a three dimensional compass and gravity sensor, to eliminate their sensitivity to the angle with respect to the Earth's surface, a problem affecting all compasses and particularly noticeable in automotive applications.

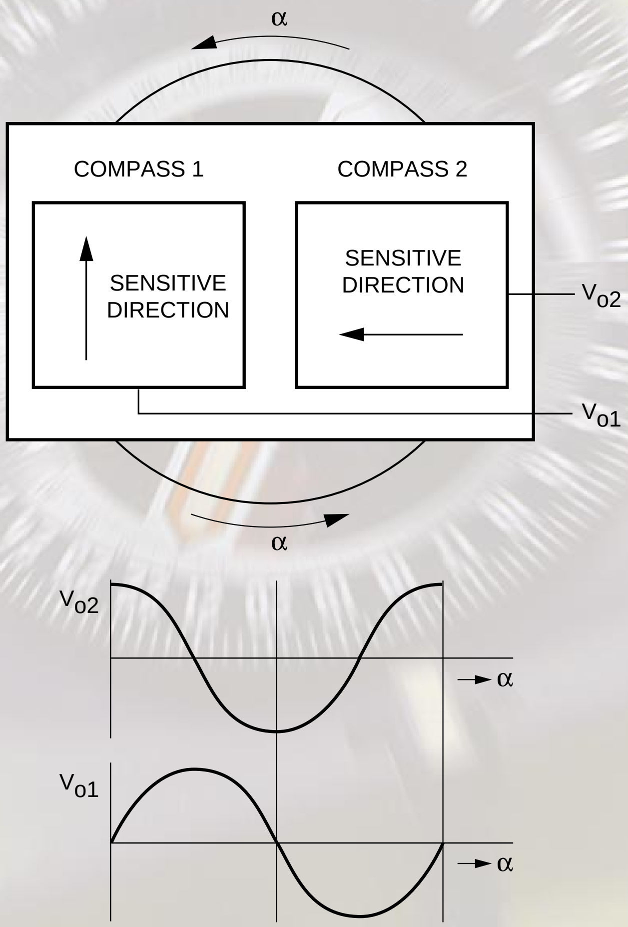


Fig. 6. Simplified block diagram of an electronic compass

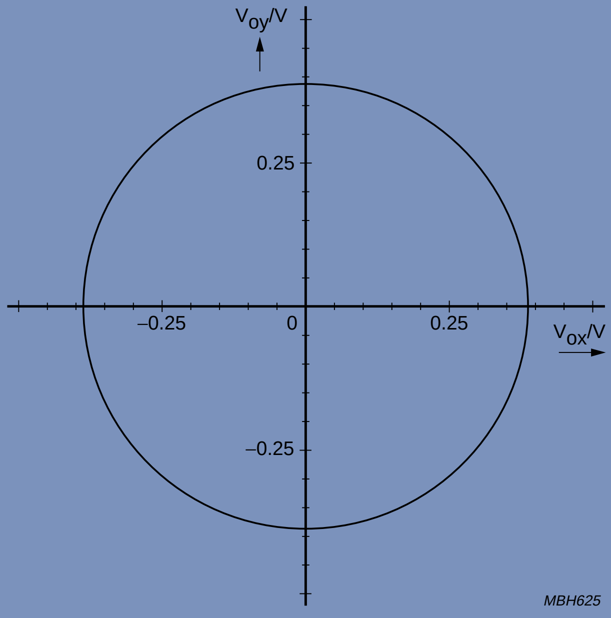


Fig. 7. Output signal from an SMD compass test unit

Simple calibration

A real-world electronic compass must be calibrated to eliminate the effects of extraneous fields, such as from the compass casing. In simple compass applications, the output is simply measured twice with each measurement shifted by 180°. From this so-called "bi-directional calibration" method, the x- and y- components of the extraneous field can be determined and simply compensated for by applying the appropriate current to the compensation coils. With high-end compass applications, a microcontroller can apply this process continuously to provide automatic adjustment in, for example, automotive compasses and thus completely eliminating the need for manual re-adjustment according to vehicle load.

Although simple in essence, to help customers understand more fully the principles and real-world world design factors, Philips has produced an SMD test board for compass system evaluation. The basic high accuracy of MR technology for compass applications is shown in figure 7, with an almost perfectly circular output from the board as it is rotated through 360°.

Simple 8-segment compass

Simple compass applications give an approximate indication of direction, displaying only the eight major compass directions (N, NE, E, etc.). This basic functionality is typically found in simple navigation aids where, for example, car drivers may need to know their rough orientation but do not need an accurate indication of their direction, In such a system, output signals from the two magnetoresistive sensors can be compared with each other to provide the basic N, S, E, W information and can also show whether the sensor signal is changing positively or negatively. Simple comparators can then be used to obtain three digital signals, which can drive a display unit via a multiplexer.

High-end compass

Compass resolution can be increased from the basic eight by adapting the evaluation circuit and using a microcontroller to calculate the angle from the two signals. Compass resolution then depends on the microcontroller and the A/D converters used. Using a microcontroller also enables additional functionality to be included, such as storing a reference direction or eliminating magnetic influences from encapsulation or other magnetic components.

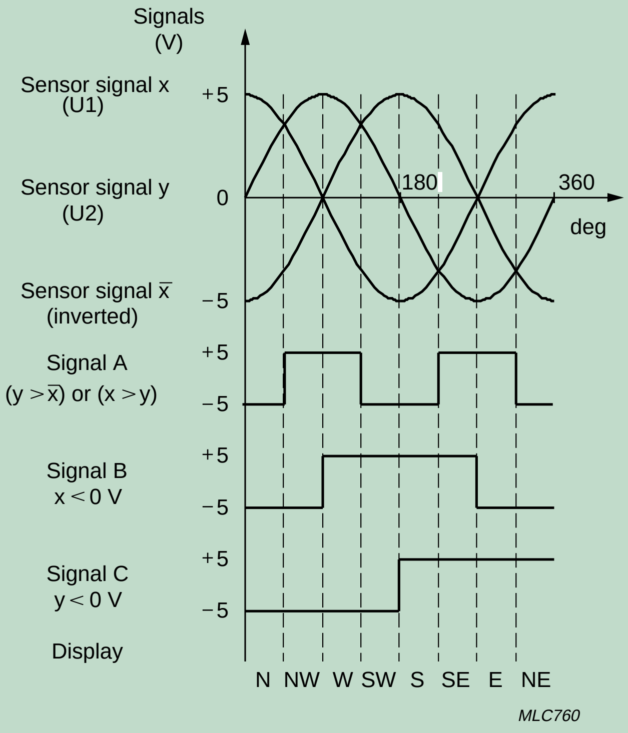


Fig. 8. Output signals from two sensors can be compared to give a simple 8-segment compass

Support material

Technical support is crucial to reduce time to market for new designs. For its range of magnetoresistive sensors, Philips Semiconductors provides comprehensive support including samples, demonstration boards and application reports, to help you evaluate the KMZ range and speed up the design-in process.

Squaring the picture

The Earth's geomagnetic field is strong enough to cause problems for TV and monitor manufacturers. It influences the trajectory of electrons in a CRT tube, producing a horizontal tilt in the geometry and convergence error shifts, creating unacceptable picture distortion which is especially noticeable with increasingly popular 16:9 aspect ratios. The solution is straightforward and, if a magnetoresistive weak field sensor is incorporated into the system, can be made fully automatic.

A DC-current carrying coil is wrapped around the neck of the CRT and generates a magnetic field that opposes the Earth's field, cancelling the twist in the electrons path and reducing the number of convergence errors. This coil also compensates for any other extraneous electromagnetic field sources emanating from the TV such as the loudspeakers. Residual picture twist and North/South trapezoid errors can be eliminated with a simple shift in the compensation current.

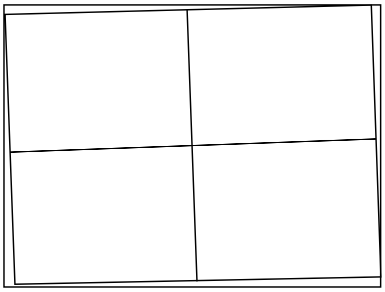


Fig. 8. Geometry error - horizontal picture tilt

Automatic adjustment

Although highly effective, this method still requires manual adjustment of the coil drive currents to meet the varying geomagnetic fields around the world. Here, magnetoresistive sensors come into their own - they detect the magnitude of the Earth's field and sensor output can be used to drive the compensation field accordingly. This makes adjustment fully automatic and the same compensation circuitry will deliver the same high quality picture geometries anywhere in the world.

For all but low-end monitors and TVs, there is always a microcontroller or microprocessor in the system, which can then be used to drive the flipping and compensation coils. This greatly simplifies the design of the sensor circuitry (see figure 9) and in principle, this is true for any application which uses a microcontroller/microprocessor.

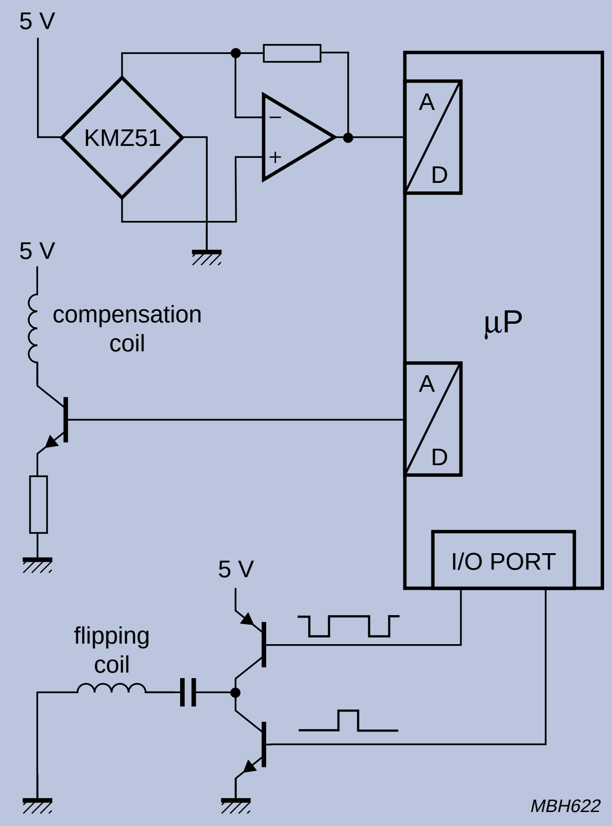
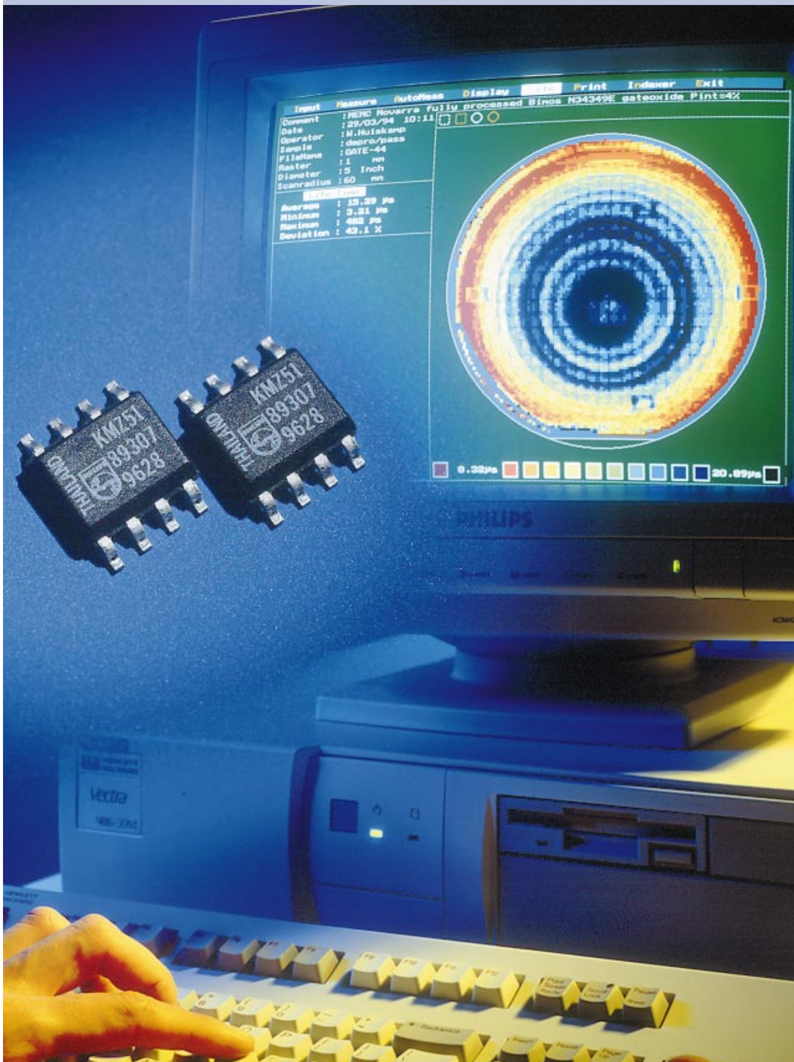
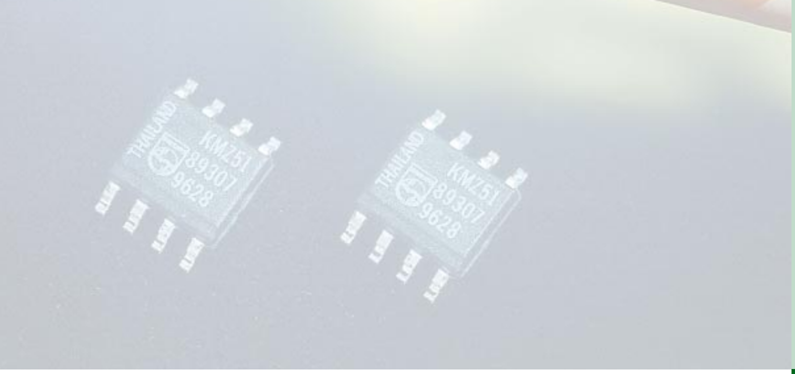


fig. 9. Weak-field measurement compensation circuit using a microprocessor



Handling traffic flows

As the number of vehicles using already congested roads steadily increases, traffic control systems are a powerful tool in avoiding time consuming traffic jams. By monitoring traffic flow, average speed and traffic density they allow optimal control of electronic road signs, regulating traffic flow and speed at known trouble spots. They can also indicate possible incidents points, where traffic speeds fall significantly below average and, with simple modifications, they are effective in improving safety and monitoring ground traffic at airports.



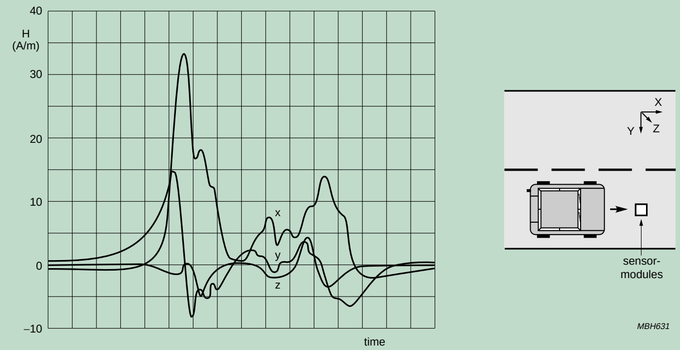


Fig. 10. Spectra for an Opel Kadett from ground sensor

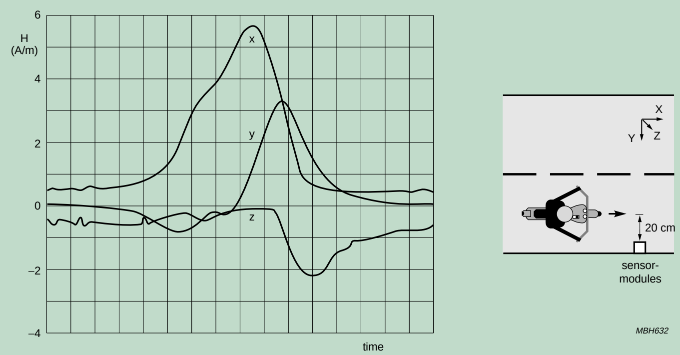
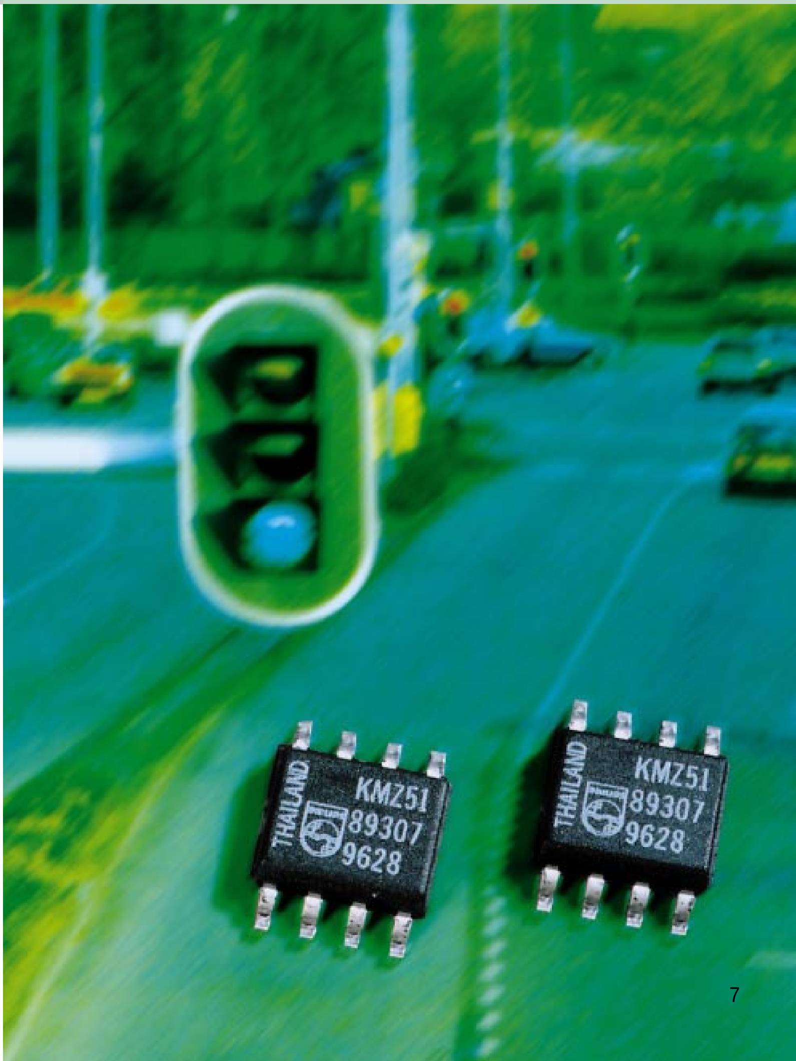


Fig. 11. Spectra for a motorbike

A traffic system is only as accurate and reliable as its inputs and systems based on magnetoresistive technology have none of the drawbacks of existing inductive systems. They can be easily and quickly installed in any stretch of road, or even by the side of the road, if necessary, due to their small size and simple placement. Combined with almost negligible power consumption, this makes magnetoresistive control systems inexpensive and highly efficient. They meet all functional requirements and environmental conditions, such as large temperature ranges, insensitivity to climatic changes, low power consumption and, most of all, low cost, high reliability and ruggedness.

More than just detection

Every vehicle manufactured contains some ferromagnetic components, which in turn produce a measurable magnetic field specific to an individual model. Even with the greater use of aluminium in manufacture and if the vehicle has been demagnetized, Philips' high sensitivity weak field MR sensors can still detect a measurable change in geomagnetic field strength and flux density created by the vehicle (figure 10). Moreover, unlike other methods, magnetoresistive measuring provides information on vehicle type and can even detect and distinguish motorbikes (even with engine, frame and wheels being made of aluminium) (figure 11).



Addresses .eps

Let's make things better.