# Sensitive magnetic sensor

## Magnetoresistive unit can out-Hall Hall Effect devices

CEE Staff Report

The magnetoresistive sensor is a four-pin plastic encapsulated chip that is about the size of a small-signal transistor. It *does* have a silicon substrate, but the mechanics of the device consist of four permalloy strips arranged in a closely knit meander pattern and connected to form the four arms of a Wheatstone bridge.

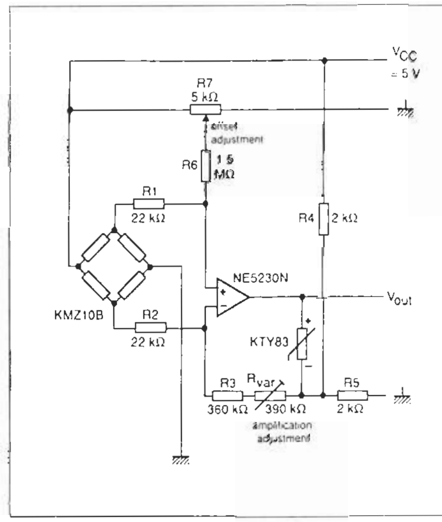
The device is a magnetic field sensor, bringing to mind the well-established Hall Effect semiconductor. There are significant differences. The Hall Effect device, (covered in detail in CEE's November 1987 issue), is a semiconductor, whereas the magnetoresistive device is a passive component, although both require a power source for operation. The magnetoresistive sensor is more rugged, more sensitive and has a higher frequency limit—to several MHz—compared to the Hall Effect device. Unfortunately it's also more expensive at current price levels. The quantity price for the Philips KMZ10 is about Can$3 each.

The magnetoresistive effect is the property of a current carrying magnetic material to change its resistivity in the presence of an external magnetic field. The change occurs by rotation of the magnetization relative to the current direction. In the case of the alloy permalloy, a 90° rotation of the magnetization, caused by the application of a magnetic field normal to the current direction, will produce a 2%-3% change in resistivity.

With the KMZ10 series, the connection of four permalloy channels in a Wheatstone bridge configuration results in a device whose degree of bridge imbalance may be used to indicate magnetic field strength. And, the response can be linear, thanks to a proprietary aluminum stripe pattern deposited on the permalloy channels at right angles. This stripe pattern has the effect of rotating the net current direction through 45°, which results in resistivity decreasing linearly with field strength.

The only Hall device approaching magnetoresistive for sensitivity is the silicon type, with 94 mV at 1 kA/m field strength. The Philips KMZ10A offers 140 mV at the same field, with the advantage also of a much lower offset drift and higher frequency limit. The magnetoresistive product has a high operating temperature, up to 175°C. Flux gate and Weigand effect devices are not only lower temperature limited, their frequency limits are 1,000 times lower.

As a precaution against the sensor flipping, it can be provided with a stabilizing magnetic field parallel to the internal aligning field. This stabilizing field will, however, reduce sensitivity slightly, but since it need not be too strong, the effect is only slight. The stabilizing field may be provided by an auxiliary magnet close to or even glued to the sensor with its axis parallel with the x-axis of the sensor. In some applications, especially where the sensor is used to measure the field of say a moving permanent magnet (as in linear position sensors), the magnet itself may be oriented to provide the auxiliary field.



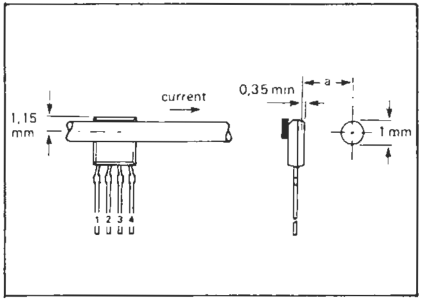

**Simple drive circuitry incorporates temperature compensation**

### APPLICATIONS

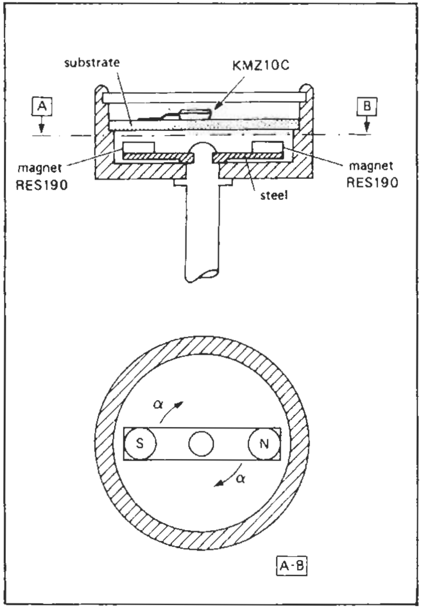
*Movement detection* advantages for the device result from the high sensitivity which means it can detect moving objects at relatively large distances and even through non-ferrous walls.

*Angular and linear measurement* sensing can be done in the far-field region of a magnetic system, and the sensitivity permits cheap ferrite magnets to be used. In low fields, compensation may be required for the earth's magnetic field.

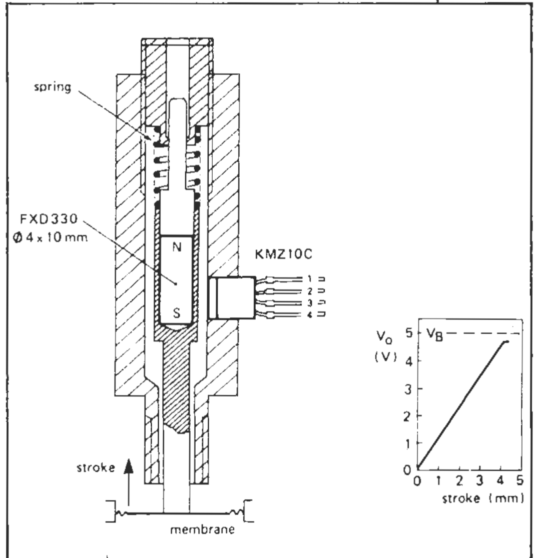
In the case of *current sensing* Hall Effect sensors inevitably disturb the current they are measuring, since they sense the field created by the electromagnet generated by the current. The magnetoresistive type can measure the magnetic field of the current carrying wire directly.




**Measuring current. 1.5 mV/A measured with 2 mm separation from a 1 mm diameter wire, using a biasing magnet. This type of simple circuit lends itself for use as a non-precision ammeter or as an indicator for a burnt-out headlamp**




**A suggestion for a contactless potentiometer**




**Pressure sensor. Membrane movement is transmitted to a permanent magnet. The magnet field is detected by the magnetoresistive sensor. The smaller diagram shows the displacement/voltage characteristic of an amplified, compensated output**

*Automotive applications* include navigation systems, for which a robust compass system is needed with an accuracy of around 1°; traffic control, (detection of vehicles); RPM control; camshaft/flywheel position sensors and force/acceleration/pressure measurement, using a moving magnet. Even a simple ammeter for cars is practical, obviating the long thick cable needed by the moving-iron type meter. A selection of circuits is shown on this page.

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