AMR SENSORS FOR MAGNETIC FIELD

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Abstract

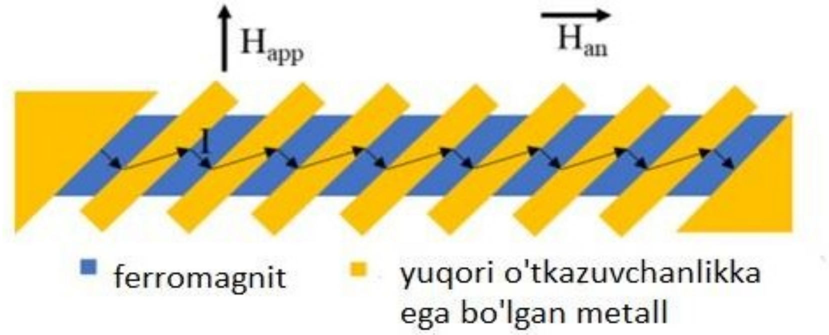
The development of electronic devices is increasing the need for magnetic sensors, which in turn is driving the development of magnetic sensors. In this work, the theory, principle of operation, efficiency and economic importance of AMR magnetic sensors were considered.

Keywords: AMR anisotropic magnetoresistance, Ferromagnet, Wheatstone bridge.

In 1856, William Thomson, also known as Lord Kelvin, discovered the magnetoresistance (MR) property of a material, expressed by the change in its electrical resistance when placed in a magnetic field, and gave the following expression $MR\left(\frac{\Delta\rho}{\rho}\right), \left(\frac{\Delta\rho}{\rho}\right) = \frac{R(H)-R(0)}{R(0)}$

He demonstrated the change in the electrical resistance of ferromagnetic materials, such as a sample of iron, by applying an external magnetic field. It showed that the resistance increases by 0.2% when the direction of magnetization of the object and the external magnetic field are in the same direction, and decreases by 0.4% when they are perpendicular to each other. In this case, MR occurs because the displacement speed (v) of all charge carriers is not the same [1].

The resistance of some materials depends on the angle between the direction of the external magnetic flux and the direction of magnetization of the material, and this is called anisotropic magnetoresistance (AMR). Lord Lelwin observed that the magnetic resistance of nickel is three times stronger than that of iron. Although a normal strain of any ferromagnetic material exhibits AMR, the effect is not linear with respect to field strength. $Rmax$ is $Rmax$ when the direction of external magnetic flux and magnetization of ferromagnetic material is parallel, and $Rmin$ is orthogonal. The change in resistance is $\Delta R = Rmax - Rmin$.



Ferromagnet A metal with high conductivity

If this structure has a total magnetic anisotropy field, Han, and an applied external field, Happ, the resistance is given by [2]

$$R = R_{max} - R_{min}\left(\frac{H_{app}}{H_{an}}\right)^2 \quad (2)$$

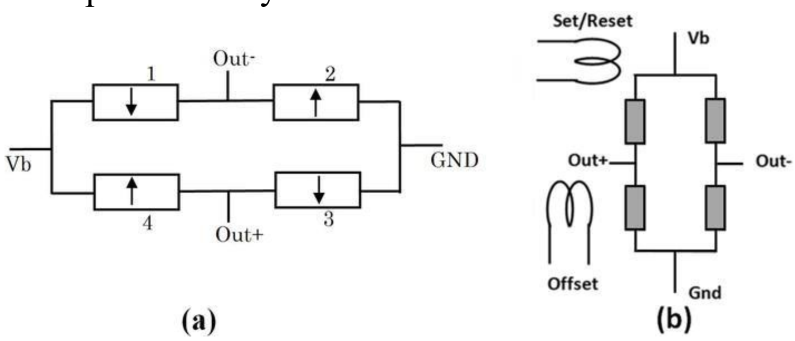
The resistance of a typical ferromagnetic structure varies non-linearly with the applied field. Also, if the applied area is small (Happ<<Han), the sensitivity of the sensor will be very small. A V-shaped panel of ferromagnetic material can be used to linearize the effect, and another method is to lay high-conductivity conductor lines over the ferromagnetic material and use a 45o barber pole construction. In the latter method, the current moves in the conductor than in the ferromagnet, the direction of the current in the ferromagnetic material is rotated by 45o to the plane of the applied field. The field-dependent resistance equation for such a structure is given as follows.

$$R = R_0 - \Delta R \frac{H_{app}}{H_{an}} \sqrt{1 - \left(\frac{H_{app}}{H_{an}}\right)^2} \quad (3)$$

For low values of the applied magnetic field, i.e., Happ<Han/2, the resistance expression of the barber pole structure shows a nonlinearity of less than 5%. AMR sensors

The most common material for Permalloy, an alloy of iron and nickel. In particular, the content of Ni0.81Fe0.19 is important, AMR sensors are less sensitive than GMR and TMR sensors, but they are much easier to manufacture, flexible in device shape and resistance [3].

Below we will consider some parameters of HMC1001 type AMR sensor. Wheatstone bridge resistors are commonly used in the manufacture of AMR sensors. For example in Honeywell's HMC1001.



a) Magnetic resistance of AMR sensor together with Wheatstone bridge b) Construction of AMR sensor together with offset and set/reset panels

The offset is a metallized spiral panel connected to the sensitivity axis of the sensor elements. By using an offset panel, it is possible to compensate for unwanted signal such as bridge voltage and DC magnetic field. Typically Most low-field magnetic sensors output signal distortion is caused by large magnetic fields (>4 - 20 gauss). To reduce this effect and maximize signal output, a set/reset (S/R) panel can be applied to the MR bridge to eliminate the effect of previous magnetic memory. The purpose of the (S/R) panel is to reset the MR sensor to a high sensitivity state for measuring magnetic fields. Due to the simplicity of the production process of AMR sensors, it is being used and new generations are being created. Its miniaturization (a trend toward smaller and smaller mechanical, optical, and electronic products and devices), simple and robust structure allows it to be fabricated on a variety of flexible and stretchable substrates. For example, a 7-µm-thick polymer foil [4] was coated on a polymer silicon wafer, and a sputtered permalloy ($Ni_{0.81}Fe_{0.19}$) film served as an AMR sensor in the form of a meander. The use of an AMR sensor with a microstructured gas channel and a bending magnet for oxygen detection is presented in [5]. Oxygen is paramagnetic and has a higher sensitivity than other gases in the environment, making the sensor highly selective. The AMR sensor can be used to detect oxygen levels from 0% to 100%.

References

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