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A REVIEW ON DIFFERENT TYPES OF MAGNETIC SENSORS

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Abstract

It is possible to distinguish magnetic sensors according to whether they calculate the overall magnetic field or the magnetic field vector components. Current research investigates the kinds of magnetic sensors that are currently available. For several decades, magnetic sensors have aided mankind in analysing and monitoring thousands of functions. The methods used to manufacture all types of magnetic sensors include many facets of physics and electronics, most of them focused on the intimate relation between magnetic and electrical phenomena. Here, we identify and compare most of the different magnetic field sensing technologies utilized. These include search coil, fluxgate, optically pumped, nuclear precession, SQUID, Hall Effect, anisotropic magnetoresistance, giant magnetoresistance, magnetic tunnel junctions, giant magnetoimpedance, hybrid magnetostrictive/piezoelectric, magnetodiode, magnetotransistor, magnetic sensors based on fibre optic, magnetooptic, and microelectromechanical devices. It also presents the use of these sensors in relation to interacting in or around the magnetic field of the Earth.

KEYWORDS: *Magnetic, MEMS, Sensors, Super Conductor.*

I. INTRODUCTION

This paper addresses magnetic sensors and examines them. For several decades, magnetic sensors have aided mankind in analysing and monitoring millions of processes. By using magnetic sensors in magnetic storage discs and tape drives, computers have virtually limitless memory. Due to the high efficiency of non-contact switching of magnetic sensors, aeroplanes operate with higher safety criteria. In some positions, such as the engine crank shaft and wheel brakes, cars use magnetic sensors to determine their position. Because of the stability and low price of magnetic sensors, industries have greater efficiency[1].

Magnetic forces are sensed in many ways, most of them based on the close relation between magnetic and electrical phenomena. The more common sensor technology will be represented with examples of products in the first half of this article. The key applications of magnetic sensors are discussed in the second half in four categories: measuring fields greater than the field of the Earth, measuring disturbances in the field of the Earth, measuring slight differences or gradients in magnetic fields produced or caused, and medical/biological applications. A common theme among all applications is that a very robust, stable and maintenance-free technology is supported by magnetic sensors[2].

A vast variety of theories and phenomena from the fields of physics and material science are exploited by magnetic sensing techniques. Responsive sensors must either have a wide dynamic range because of the large magnitude of the Earth's magnetic field, or have a coil to minimise the field at the sensor's place. Over distances of the order of kilometres, geomagnetic noise is spatially associated since it occurs from sources that are spatially high, such as ionospheric currents powered by tidal forces and winds. It is thus possible to calculate magnetic field variations smaller than geomagnetic noise by taking the difference between the readings of two or more spatially spaced sensors. At low frequencies, the geomagnetic noise is around 0.1 nT and has a -like frequency distribution. It is worth remembering that the readout electronics affect the sensitivity range for each type of sensor. There are several other factors that influence that sensor is suitable for an operation, particularly frequency response, scale, and strength. If the magnetometer calculates only the magnitude of the field or measures each of its vector components is another important factor. Since vector magnetometers have additional detail, one would assume that vector magnetometers are often superior than magnetometers that only test the field's magnitude. The above are also called magnetometers of the scalar or absolute field[1], [3].

Scalar magnetometers are much stronger than vector magnetometers for some uses. Consider using a magnetometer on a driving car and seeking to track subtle changes due to objects that are ferromagnetic. Rotational movements attributable to the rotation of the vehicle can produce changes that are hard to distinguish from the signal in the vector components of the Earth's field detected by a vector magnetometer. This changes are also much greater in the materials than the changes attributable to ferromagnetic artefacts. It is impossible to calculate the total field correctly from the vector components since the sensitivities of the three vector magnetometers must be equal and their axes must be precisely perpendicular. Thus, a full field magnetometer is even easier than a vector field magnetometer in this application[4].

II. DISCUSSION

A. **Magnetic Sensors: -**

The various types of magnetic sensors are explained in this paper.

1. Search-Coil Magnetometer: Faraday's law of induction is the theory behind the search-coil magnetometer. A voltage proportional to the magnitude of change of the flux is produced between its leads if the magnetic flux changes through a coiled conductor. If

the coils is in a magnetic field which changes over time, if the coil is rotated in a uniform field, or if the coil is passed through a non-uniform field, the flux thru the coil will shift. In order to "gather" the surrounding magnetic field and raise the flux density, a rod of a ferromagnetic material with a high magnetic permeability is usually placed inside the coil[5].

2. Fluxgate Magnetometer**:** The magnetometer for the fluxgate consists of a wound of ferromagnetic material with two coils, a push and a feel coil. It utilises magnetic induction along with the fact that at high fields, all ferromagnetic material is saturated. The centre achieves its saturation magnetization once every half-cycle, when a significantly strong sinusoidal current is applied to the drive coil[6].

B. **Superconductor Magnetometers:**

1. SQUID sensors: The superconducting quantum interference system is the most sensitive of all devices for detecting a magnetic field at low frequencies (1 Hz) (SQUID). When such substances are chilled under a superconducting transition temperature, it is focused on the extraordinary correlations of electric currents and magnetic fields found. The substances become superconductors at this temperature and they lack all resistance to electricity flow.
2. Using the Meissner effect: Magnetic fields below a threshold field are excluded by induced currents in superconductors. The Meissner effect is called this effect. To build a magnetometer, the Meissner effect was used in a superconducting flux-to-field converter. With a diameter that is 0.7 times the radius and that has a micron scale constriction, they use a superconducting loop perpendicular to the field path. In the constriction, the shielding current, which is significantly improved, produces a field determined by a GMR sensor located near the constriction. A low-noise giant magnetoresistance sensor senses the ground. The small-size protype is capable of weighing 32 fT or nT at 4 K and can be used at 77 K.
3. Hall Effect Sensor: A commonly available, low-cost sensor is the Hall Effect sensor. The sensor utilises a physical mechanism which was discovered more than 100 years ago by Edwin H. Hall. He discovered that when an electric current is transmitted down its length, a voltage differential occurs across a thin rectangle of gold put in a heavy magnetic field perpendicular to the plane of the rectangle. An electron travelling through a magnetic field encounters a force that is perpendicular to both its direction of motion and the direction of the field, defined as the Lorentz force. It is the reaction that generates the Hall voltage to this power.
4. Spin-Valve Transistors: Spin-valve transistors are spin-valves, one of which is the emitter and the other the collector, sandwiched between a pair of semiconductors. As a result of the magnetic field, the current through the apparatus varies. Recent improvements have been observed with growing magnetic fields as high as 200%, but output currents are usually of order microamps and are too weak for most sensor applications.

5. Giant Magnetoimpedance (GMI) Magnetic Sensors: In fields below 50 Oe, the impedance of amorphous wires and ribbons decreases dramatically. The giant magnetoimpedance (GMI) phenomenon has been called the effect. A good function of both the magnetic field and the frequency of the drive current is the impedance. For standardised, single-phase materials, the impedance dependency of the skin depth, which is a transverse permeability property, is the origin of the effect. The extent of the impedance transition peaks at a frequency of many MHz for NiFe/Cu composite wires, which depends on the wire's annealing treatment. It involves using GHz drive currents to use the effect[7].
6. Magnetodiode: A magnetodiode is basically a diode, or junction, of a semiconductor. In a magnetodiode, however, an area of undoped silicon divides the region from the region. By depositing silicon and then silicon dioxide on a sapphire layer, the unit is manufactured. If a positive potential is given to a metal contact on the -doped region and a negative potential is given to a metal contact on the -doped region, holes in the p-type material and electrons in the -type material can be inserted into the undoped silicone. The sum of the hole current and the electron current is the current[8].
7. Magnetotransistor: This sensor is an integrated silicon unit, as is the magnetodiode. If the magnetodiode is the junction version, the magnetotransistor version is the transistor version. Like the transistor, it is made of a -doped Emitter isolated by a -doped base from a -doped collector. The distinction is that, instead of one, there are two collectors. Equal numbers of charge carriers arrive at all collectors in the absence of a magnetic field. Depending on the orientation of the field, whether there is a magnetic field perpendicular to the direction of movement of the charge carriers, they are deflected toward one collector or the other. A differential amplifier, whose output is proportional to the magnitude magnetic field, is fed to the two-collector voltages[1].
8. MEMS Based Magnetometers: Many of the first magnetic sensor projects made use of basic magnetic resistance to ferrous artefacts. The resulting motion was then measured to log metal structures or to track them. The first magnetic field triggered fuze for mines was a structure similar to a compass needle. The principle of using motion to detect magnetic fields is being reevaluated with the advancement of microelectromechanical systems (MEMS)[9].

III. CONCLUSION

Most of the traditional methods of magnetic sensing have been illustrated in this paper and the underlying physical concepts governing their use have been highlighted. It also defined a varied range of applications that leverage unique characteristics of these sensors.

From the same two viewpoints, mechanics and applications, the future developments in magnetic sensors should be addressed. Discoveries with new mechanics have contributed to new sensor technology in the past. In the 1800s and early 1900s, many of the phenomena exploited by sensors were discovered. There have, however, been some more recent discoveries that have influenced magnetic sensor technology, as discussed here. Josephson tunnelling, for instance, was found in the 1960s in superconducting systems. More recently, information retrieval and sensor technology have been greatly influenced by giant magnetoresistance and magnetic tunnel junctions. Future discoveries are expected to open up new possibilities for better magnetic sensors. From the perspective of apps, the need for improved sensors is omnipresent. Magnetic sensors are used when other sensors provide unwanted signals from the changing environment.

For comparable or better efficiency, the trend is constantly towards smaller sizes, lower power usage and lower prices. Regardless of scale, strength, and cost, there is not much need to boost sensitivity. Instead, one has to make a trade off between sensitivity, scale, capacity, and cost for each use. 1) novel phenomena, 2) new uses of current phenomena, 3) better components, and 4) improved processing and development are the potential routes for improving the performance of magnetic sensors. A big need is to reduce the expense of electronic signal processing because, in many circumstances, electronic signal processing is far more costly than the sensor portion.

There are, perhaps, more methods than any other sensed parameter of magnetic field calculation. Many of these methods have gone to the point that they are testing the boundaries of physics by comprehensive engineering. One of the main methods for making improvements in the scale, strength, and cost of magnetic sensors would therefore be to obtain improved material properties. The thousands of scientific studies conducted each year are the effect of changes in material properties. It is impossible to determine which materials will see the most important change, and, most certainly, in certain situations, these changes will come in small stages.

However, there's many cases where major changes are feasible. For starters, half-metal research has been performed. There are metals at the Fermi stage that do not have minority spin states. If MTJ sensors could be produced using half-metal components, the magnetoresistance would be infinite. Creation of materials that are half metal at room temperature turned out to be hard or difficult. The new spintronic field is expected to lead to better magnetic sensors. The spin-valve transistor mentioned above is a recent example of a modern class of system.

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