Hall Effect Instruments: Their Development and Consequences

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***Abstract*—This paper aims to review the present status and available configurations of technologies based on the Hall effect. The several kinds of Hall-based devices that are currently in use are thoroughly discussed. These include vane sensors, switches, latches, linear and field-programmable sensors, and speed and direction sensors.**

***Index Terms*—Hall effect, sensors, latches, vane sensors, linear sensors, field-programmable sensors, speed sensors**

I. Introduction

The Hall effect is the phenomenon whereby a current-carrying wire strip in a transverse magnetic field produces voltage across it. The output voltage's magnitude is determined by

$$E = \frac{RBI}{h} \tag{1}$$

where h is the thickness of the material and R is the Hall coefficient that depends on the material parameters. The sensitivity of a Hall transducer is determined by two factors: the applied magnetic field strength (B) and the input current (I).

II. Devices Based on the Hall Effect

The three fundamental architectures of linear, digital, and speed sensing constitute the foundation for most integrated circuits (ICs) that use Hall sensors. These architectures can be further utilized for a variety of applications. The following are the main Hall effect-based devices:

- Latches
- Vane sensors
- Linear sensors
- Sensors that are field-programmable
- Unipolar, bipolar, and omnipolar switches
- Pliable Hall detectors
- Sensors that measure direction and speed (gear tooth, single-point, and differential gear tooth sensors)

III. Discussion on Few Applications of the Hall Effect

A. Latches

The Hall effect switch turns "on" when either the north magnetic field on its opposite side face or the south magnetic field on one of its faces is present. It turns "off" when the magnet is removed. A Hall effect latch functions similarly but remains "on" even when the magnet is withdrawn. It turns "off" as soon as the north pole is brought close to the latch or the current is turned "off."

B. Linear Sensors

Linear Hall sensors do not have discrete switching states; instead, their output is directly proportional to the strength of the applied magnetic field.

C. Switches

Digital Hall-effect sensors consist of a basic linear sensor combined with an output controller and a threshold sensor/detector. These digital sensors detect a field as a positive field near the south pole and as a negative field near the north pole. The magnetic field thresholds for turning on and off are denoted by B_{op} and B_{rp}, respectively.

IV. Unwanted Outcomes: Reasons and Remuneration

Similar to many other electrical and electronic devices, the Hall device is not perfect. Furthermore, it is susceptible to unfavorable environmental conditions.

A. Selection of Material

Temperature and material purity significantly impact the Hall effect in materials including titanium, zirconium, and uranium.

B. Low Output Voltage

Most Hall-based devices have modest output drive capacities (10-20 mA), making them unsuitable to power large electrical loads directly.

C. Temperature Dependency

Temperature rise is the environmental condition that most affects how a Hall effect sensor behaves. Because ferromagnetic materials are used in these sensors, there is a strong temperature dependence due to the spin-orbit interaction of polarized conduction electrons.

V. Research Scenario for Hall Devices

Early in the last ten years, there has been a consistent increase in the number of publications in the field of Hall devices. The COVID-19 epidemic has had a negative impact on the sensor, control, and automation industry, as shown in recent market analyses.

VI. Conclusion

An extensive review of Hall-based devices is presented in this study. The Hall effect principle is used by many technologies. The main components include switches, latches, field-programmable sensors, linear sensors, directional sensors, and vane sensors. However, Hall-based devices are not flawless. Temperature rise, noise, and drift are a few undesirable consequences that affect their performance.

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