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AUTONOMOUS INSTITUTION
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VII Semester

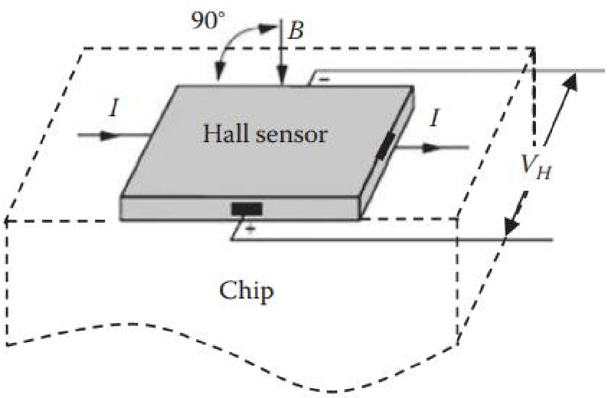
AU3008 Sensors and Actuators

UNIT – 3 - Variable and Other Special Sensors

3.5 Hall Effect Sensor

Principle of Hall Effect Sensors:

The principle of the Hall effect states that when a current-carrying conductor or a semiconductor is introduced to a perpendicular magnetic field, a voltage can be measured at the right angle to the current path.



Hall voltage, is given by,

$$V = \frac{IBL}{nQA}$$

Where,

A: cross-sectional area of the slab

I:The current in the slab

B: Magnetic field strength perpendicular to the current.

n: Charge carrier density (number of charge carriers per unit volume).

q: Charge of the carrier

L: Thickness of the conductor

Construction:

A Hall effect sensor is a device that utilizes the Hall effect to measure magnetic fields. It typically consists of a thin semiconductor material, often silicon or gallium arsenide, with four electrical contacts.

- **Semiconductor Material:** A thin, rectangular piece of semiconductor material, such as silicon or gallium arsenide, forms the core of the sensor. This material is carefully selected for its electrical properties and sensitivity to magnetic fields.
- **Electrical Contacts:** Four electrical contacts are attached to the semiconductor material. These contacts are typically made of metal and are used to apply a current to the material and measure the resulting Hall voltage.
- **Packaging:** The semiconductor material and electrical contacts are often encapsulated in a protective package, which can be a plastic or metal casing. This packaging protects the sensor from environmental factors such as moisture, dust, and mechanical shock.

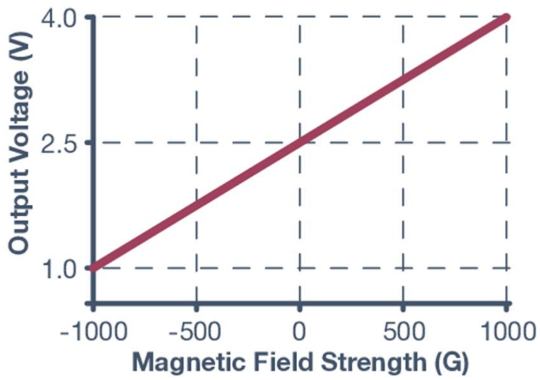
Working Principle of Hall Effect Sensor:

i. The principle of Hall voltage is used as a working principle of the Hall Effect sensor. On a thin strip of a conductor, ***electrons flow*** in a straight line when electricity is applied. When this charged conductor comes in contact with the magnetic field which is in a perpendicular direction to the motion of electrons, the electrons get deflected.

ii. Some electrons get collected on one side while some on another side. Due to this, one of the conductor's plane behaves as negatively charged while the other behaves as positively charged. This creates potential difference and ***voltage is generated***. This voltage is called the Hall voltage.

iii. The electrons continue to move from one side of the plane to other till a balance is achieved between the force applied on charged particles due to an electric field and the force that caused magnetic flux that caused this change. When this separation stops, the hall voltage value at that instant gives the measure of magnetic flux density.

Characteristics of Hall Sensor:



Relationship between the output sensor voltage and the magnetic field strength

- **X-Axis (Magnetic Field Strength, B)**:
  Represents the magnetic field strength applied to the sensor. Units are usually in Tesla (T) or Gauss (G).
- **Y-Axis (Output Voltage, Vout)**:
  Represents the output voltage of the Hall effect sensor in response to the applied magnetic field. Units are typically in volts (V) or millivolts (mV).

The Kay Characteristics obtained from the graph are: Linearity, Sensitivity, offset voltage and operating range.

Linearity: The graph shows a linear relationship between the output voltage and the magnetic field strength within a specific operating range.

Sensitivity: The slope of the graph represents the sensitivity of the sensor

Offset Voltage: Some Hall effect sensors may exhibit a small offset voltage, which is the output voltage when no magnetic field is applied. This offset voltage can be compensated for in the circuit design.

Operating Range: The sensor has a specific operating range of magnetic field strengths within which it can provide accurate measurements. Exceeding this range may lead to non-linearity or saturation.

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Advantages of Hall Sensors:

- Hall Effect sensors boast a multitude of advantages due to their ***non-contact*** nature, leading to ***reduced wear and tear*** and an extended operational lifespan.

- They possess the capability to detect both the presence and direction of a magnetic field, while also demonstrating robust resistance to dust, dirt, and moisture, rendering them ideal for deployment in ***harsh environmental conditions.***
- Moreover, their ***rapid response times*** enable their effective usage in dynamic applications. These combined benefits make Hall Effect sensors a highly versatile and valuable choice across various industries and use cases.

Limitations of Hall effect Sensor:

- **Temperature Sensitivity**
- **Limited Sensing Distance**
- **Magnetic Interference**

Applications of Hall effect sensors:

- Hall effect sensors are used for **position detection** of mechanical components. For example, in **robotics**, they help track the position of joints or moving parts.
- In motors, pumps, and other rotating equipment, Hall effect sensors are used to measure **rotational speed** or **revolutions per minute (RPM)**. By detecting the passing of a magnet attached to a rotating shaft.
- Hall effect sensors act as **proximity detectors** in various industrial machines, where they are used to detect the presence or absence of an object.
- Hall effect sensors are used for **current measurement** in power systems.
- Hall effect sensors are also used in **predictive maintenance** by monitoring the magnetic signature of moving components.

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