MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO

Sensors & Actuator for Automatic Systems

LAB # 03

MAGNETIC FIELD MEASUREMENT THROUGH HALL EFFECT SENSOR

Roll No:	**Date:**
Checked by:	**Grade:**

Object: Understand basic concepts of Hall Effect and measuring the strength of magnetic field using Hall effect sensor through MCM 14/EV Transducers Module

Theory:

1. Introduction to Hall effect

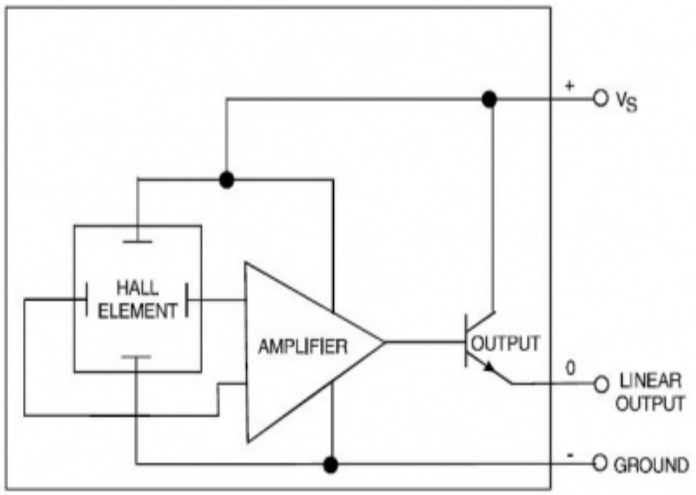
The effect of generating a measurable voltage by using a magnetic field is called the **Hall Effect** after Edwin Hall who discovered it back in the 1870's with the basic physical principle underlying the Hall effect being Lorentz force. To generate a potential difference across the device the magnetic flux lines must be perpendicular, (90^o) to the flow of current and be of the correct polarity, generally a south pole. The bigger the magnetic field, the more the electrons are deflected; the bigger the current, the more electrons there are to deflect. Either way, the bigger the potential difference (known as the Hall voltage) will be. In other words, the Hall voltage is proportional in size to both the electric current and the magnetic field.

The Hall effect provides information regarding the type of magnetic pole and magnitude of the magnetic field. For example, a south pole would cause the device to produce a voltage output while a north pole would have no effect. Generally, Hall Effect sensors and switches are designed to be in the "OFF", (open circuit condition) when there is no magnetic field present. They only turn "ON", (closed circuit condition) when subjected to a magnetic field of sufficient strength and polarity.

2. Hall effect sensor

Hall Effect Sensors consist basically of a thin piece of rectangular p-type semiconductor material passing a continuous current through itself. When the device is placed within a magnetic field, the magnetic flux lines exert a force on the semiconductor material which deflects the charge carriers, electrons and holes, to either side of the semiconductor slab. This movement of charge carriers is a result of the magnetic force they experience passing through the semiconductor material.

The Hall Effect sensor typically consists of a semiconductor material plate, an amplifier inside it (normally operational amplifier) and a load driving transistor shown in fig: below. Current is supplied to the plate which is then exposed to South Pole of permanent magnet that then deflects the charges to form Hall Voltage.



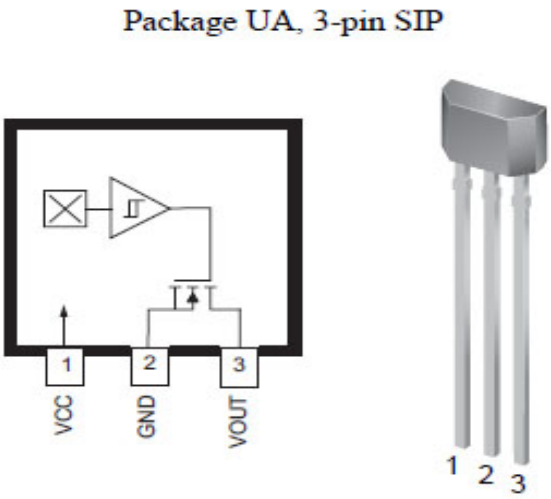


Fig:01 Inside view of Hall Effect sensor

Fig:02 The sensor physical shape

2.1 Operation of Hall Effect sensor

1. When an electric current flows through a material, move through it in pretty much a straight line.

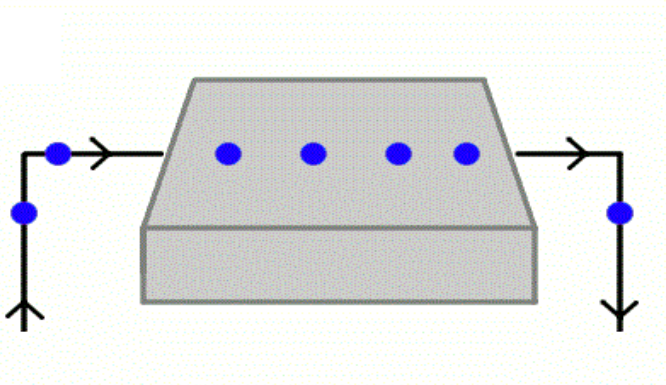


Fig:03 Current flowing through the sensor plate

2. Put the material in a magnetic field and the electrons inside it are in the field too. A force acts on them (the Lorentz force) and makes them deviate from their straight-line path.

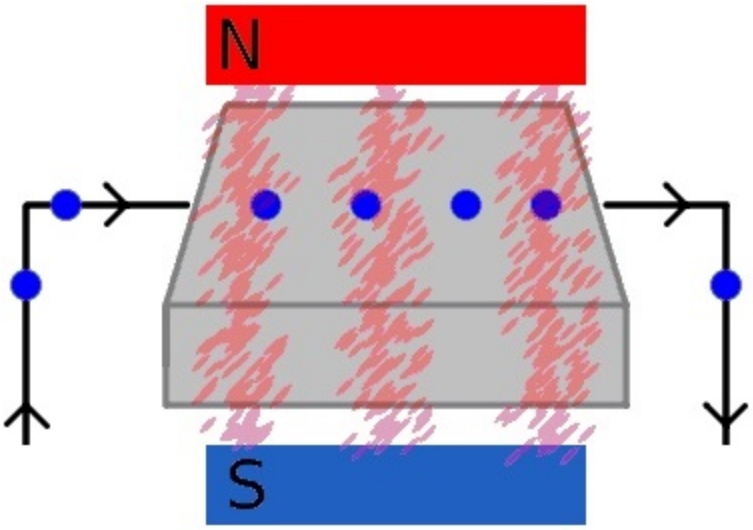


Fig:04 Permanent magnet exposed to the sensor plate

3. Now looking from above, the electrons in this example would bend as shown. With more electrons on the lower side of the material than on the upper side, there would be a difference in potential (a voltage) between the two sides .The size of this voltage is directly proportional to the size of the electric current and the strength of the magnetic field.

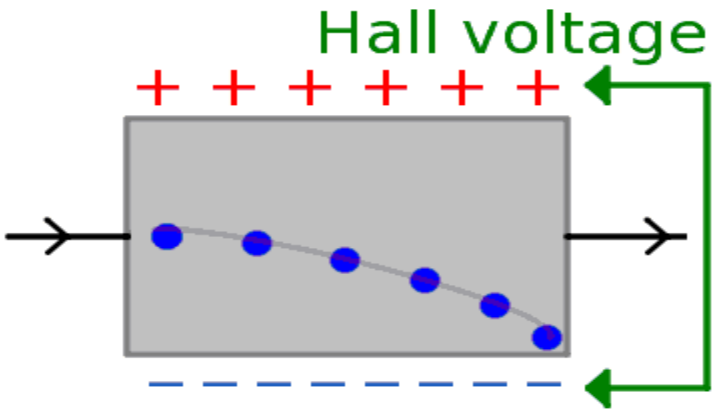


Fig:05 Deflection of charges & generation of *Hall Voltage*

2.2 Hall Effect sensor Materials

The key factor determining sensitivity of Hall Effect sensors is high electron mobility. As a result following materials are especially suitable for Hall Effect sensors:

- Gallium arsenide (GaAs)
- Indium arsenide (InAs)
- Indium phosphide (InP)
- Indium antimonide (InSb)
- Graphene

2.4 Hall Effect sensor applications

- Position sensing
- DC current transformers
- Automotive fuel level indicator
- Keyboard Switch

Lab Exercises

1. Calculate the output voltage of the Hall Effect sensor when
    - The south pole is exposed to the sensor plate
    - The north pole is exposed to sensor plate
2. Explain the reason of why you get that voltage in both the cases as calculated in above activity.

Short answer questions

1. Discuss any application of Hall Effect sensor.