LAB-2 HALL EFFECT

3.1 Introduction

The Hall effect is basic to solid-state physics and an important diagnostic tool for the characterization of materials – particularly semi-conductors. It provides a direct determination of both the sign of the charge carriers, e.g. electron or holes , and their density in a given sample.

3.2 Objective

3.2.1 Educational:

Historically, the Hall effect was used to show that electrons carry current in metals and it also shows that positive charges carry current in some semiconductors. The Hall effect is used today as a research tool to probe the movement of charges, their drift velocities and densities, and so on, in materials.

3.2.2 Experimental:

Determination of charge carrier density in a given semiconductor material.

3.3 Prelab Preparation:

Prior to coming to lab class, read the Hall effect theory and understand the derivation for concentration of charge carriers.

3.4 Equipment needed

1. Hall effect panel
2. Hall probe
3. Electromagnet
4. Constant current power supply
5. Digital gauss meter with hall probe
6. Hall probe stand (wooden).

3.5 Background

Hall Effect basically consists of a thin piece of rectangular p-type semiconductor material such as Gallium Arsenide (GaAs), Indium Antimonide (InSb) or Indium Arsenide (InAs) 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.

As these electrons and holes move side wards a potential difference is produced between the two sides of the semiconductor material by the build-up of these charge carriers. Then the movement of electrons through the semiconductor material is affected by the presence of an external magnetic field which is at right angles to it and this effect is greater in a flat rectangular shaped material.

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, (90o) to the flow of current and be of the correct polarity, generally a south pole.

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.

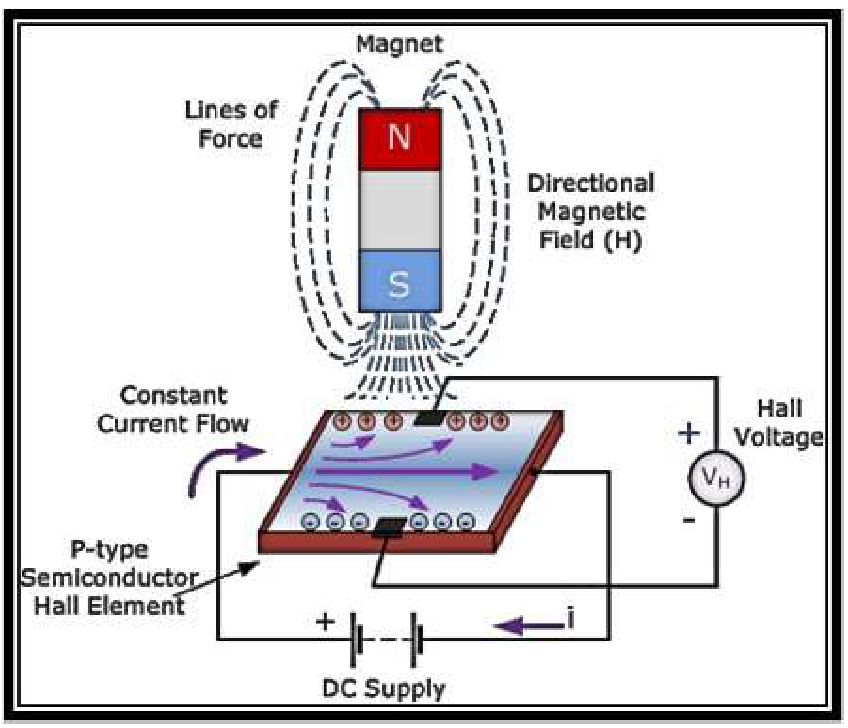

Figure 3.1: Hall Effect

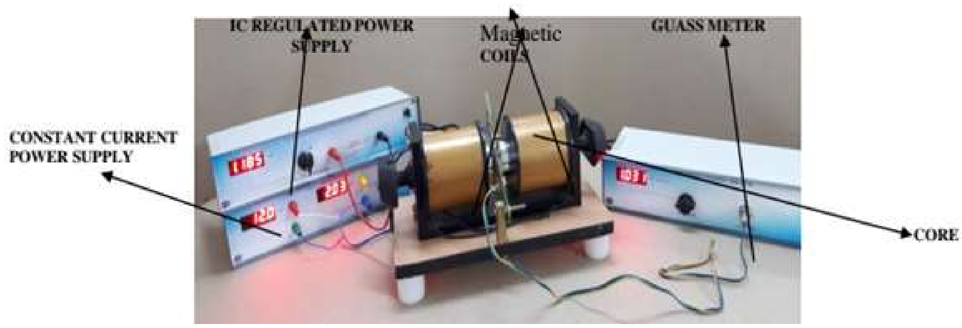

Figure 3.2: Hall effect Setup

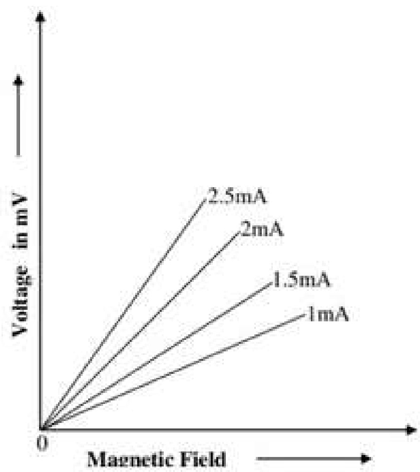

Figure 3.3: Ideal graph

3.6 Procedure

1. To demagnatise the coils, place the sensor mounted PCB exactly at the center of the core. Apply reverse current through the coils till the Gauss meter reads '0.00'.
2. Switch "OFF" all the sources, set the IC regulated power supply (to the magneticcoils) knob to minimum.
3. Increase the gap between magnetic cores to maximum by turning the core knobs.
4. Place crystal & sensor mounted PCB together in the magnetic field exactly at the center of the magnetic cores gap.
5. Connect the crystal mounted PCB to constant current power supply to their respective sockets.
6. Connect Hall probe to Gauss meter. Switch "ON" the Gauss meter, set the Gaussmeter reading to "0.00" by adjusting the knob.
7. Switch "ON" IC regulated power supply to the magnetic coils & constant current power supply.
8. Set the current across the crystal to 1mA, vary magnetic field (starting from 0.00KG) in steps of 0.25KG.This can be achieved by applying current to electromagnetic coils & simultaneously changing the position of electromagnetic cores.

9. Note the corresponding Hall voltage at constant current through semiconductor sample.

10. Plot the graph between magnetic field (B) and hall voltage (VH), which is a straightline & find the slope of the line.

11. Repeat the above steps from 2 to 6 for different values of current applied tosemiconductor crystal say 1mA, 1.5mA, 2mA & 2.5mA.

3.7 Observation

Trail No	Magnetic field B (Tesla)	Thickness (t)	Hall current I (mA)	Hall Volage V_H (mV)	R_H	$n = \frac{1}{eR_H}$
1						
2						
3						
4						
5						

3.8 Calculation

$$R_H = \frac{V_H}{I * B}$$

3.9 Results

Charge carrier concentration n= ————

3.10 Viva Voce

1. Define Hall Effect.
2. What is Hall Coefficient?
3. Write the Hall Coefficient equation.
4.What are the applications of Hall Effect?
5. What is the difference between Electric field and Magnetic field?

3.11 Further Probing Experiments

Determine the mobility of charge carriers.
Repeat the experiment with N type Semiconductor and infer the results.