Hall Effect Sensor

Electronic Devices Lab : Experiment 12

Department of Electrical Engineering
Indian Institute of Technology, Bombay

Think it. Make it. Prove it.

Aim

- In this experiment, our aim is to study the Hall Effect.
- Vary the distance between the hall sensor and the magnet, and note the output voltage at every step.
- Determine the strength of the given bar magnet and calculate the doping concentration of the hall element in the given sensor.

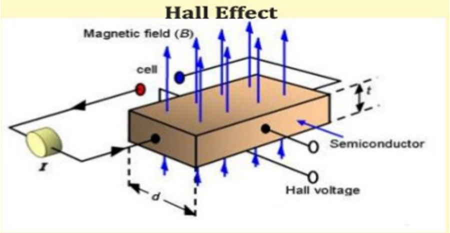
Think it. Make it. Prove it.

Components Required

- 3-terminal hall sensor
- 3 bar magnets
- 2 Multimeters
- 15cm scale
- 2 breadboards
- Connecting wires

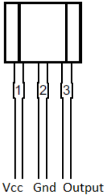
Theory

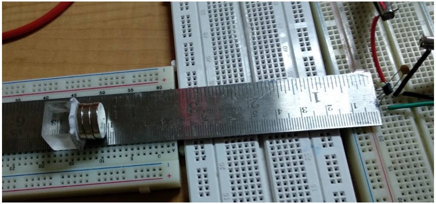
Hall effect suggests that the voltage generated in a conductor is directly proportional to applied magnetic field and also to the current passing through the conductor. Hall effect sensor uses this phenomenon and generates output voltage in response to applied Magnetic flux.



Experiment

1. Provide a DC voltage input of $8V$ between V_{CC} and GND terminals of the hall sensor.
2. Connect a multimeter across output and GND terminals to measure output voltage.
3. Place the two breadboards, the $15cm$ scale and the magnets as shown. This arrangement is just to make sure that the distance between the sensor and the magnets can be noted down precisely. Make sure the curved surface of the hall sensor is facing the magnet.





Experiment

4. After the above setup is made, perform the experiment as follows:
   (i) Place 1 bar magnet $15cm$ away from the hall sensor.
   (ii) Reduce distance between the magnet the sensor in steps of $2mm$ till the distance ≈ 0. Note down the output voltage v/s distance at every step.
   (iii) After the distance ≈ 0, reverse the pole of the magnet facing the sensor, and bring the magnet back to $15cm$ position.
   (iv) Repeat step (ii).
5. Repeat the measurement for 2 bar magnets and 3 bar magnets.
6. Note down the current flowing between the V_{CC} and GND terminals (I_{in}) when no magnetic field is applied.
7. Plot output voltage v/s distance for both the polarities of the magnets and for all the magnets in the same plot. Provide legend appropriately.

Calculating the strength of the bar magnet

- The hall element is a square of side length $a = 0.53mm$, input voltage $V_{in} = 8V$ and mobility $\mu = 0.8m^2/Vs$.
  Longitudinal electric field
  $$E_{long} = \frac{V_{in}}{a}$$
  Lateral electric field due to hall effect
  $$E_{lat} = \frac{|V_{out,0} - V_{out,max}|}{a}$$
  where $V_{out,max}$ is the maximum V_{out} from the plot in the 3 magnets case when magnet is very close to the sensor, and $V_{out,0}$ is the output voltage when no magnetic field is applied.
  At equilibrium and assuming constant magnetic field,
  $$E_{lat} = 3B.\mu.E_{long}$$
  where B is the magnetic field strength of one bar magnet (in T).

Think it. Make it. Prove it.

Determining doping concentration

N=B*I*t/q*Vh

- Given thickness of the hall element $t = 0.053mm$, Hall coefficient (R_H) is given by

$$R_H = \frac{V_{out,max}.t}{I_{in}.B}$$

Doping concentration (N in cm^{-3}) is

$$N = \frac{1}{R_H.e}$$

where $e = 1.6 \times 10^{-19}C$