

Calibration of Hall Effect Sensor

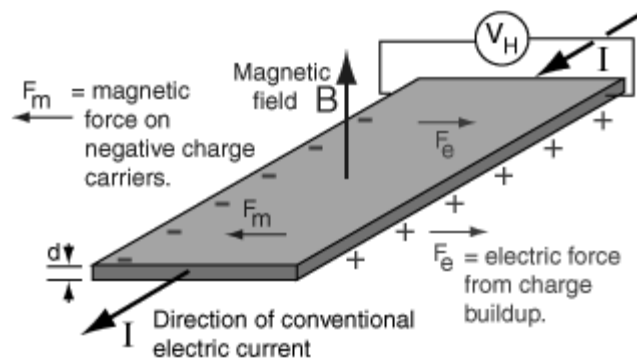
Objective

1. To study the theory and applications of a Hall-effect sensor.
2. To master the experimental skills by practicing the calibration of a Hall-effect sensor.

Introduction

A. Hall Effect and Hall Effect Sensors

If an electric current flows through a conductor in a magnetic field, the magnetic field exerts a transverse force on the moving charge carriers which tends to push them to one side of the conductor. This is most evident in a thin flat conductor as illustrated. A buildup of charge at the sides of the conductors will balance this magnetic influence, producing a measurable voltage between the two sides of the conductor. The presence of this measurable transverse voltage is called the Hall effect after E. H. Hall who discovered it in 1879.



(After <http://hyperphysics.phy-astr.gsu.edu/HBASE/magnetic/hall.html>)

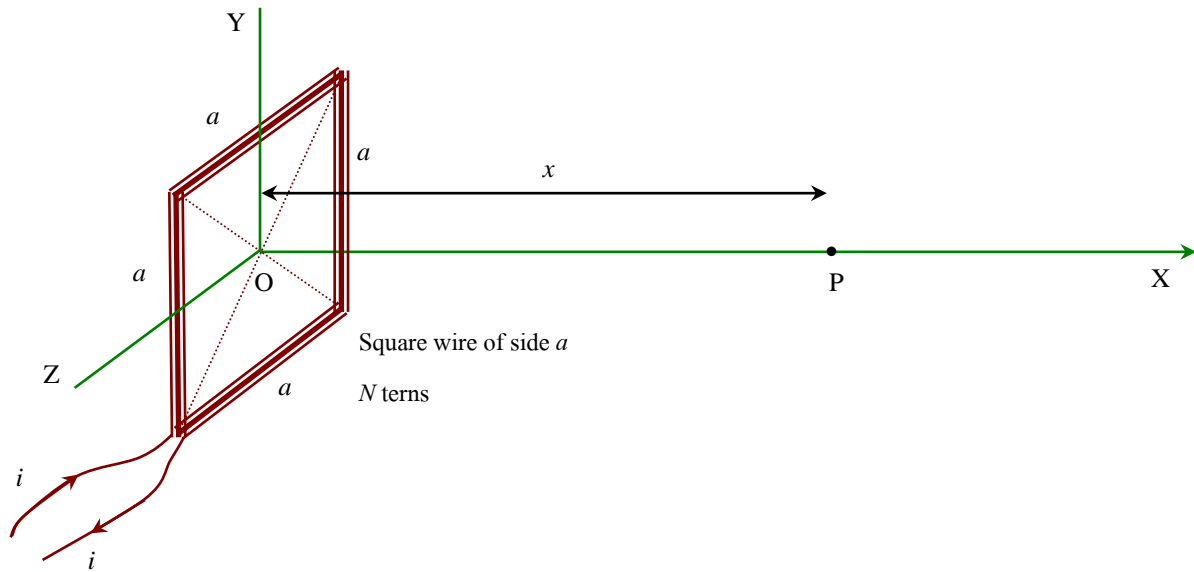
Note that the direction of the current I in the diagram is that of conventional current, so that the motion of electrons is in the opposite direction. That further confuses all the "right-hand rule" manipulations you have to go through to get the direction of the forces.

The Hall voltage is given by

$$V_H = \frac{IB_{\perp}}{ned} \propto B_{\perp}$$

where n is density of mobile charge, e is electron charge, d is thickness of the conductor, and B_{\perp} is the magnetic field component perpendicular to the conductor sheet. Therefore, the Hall Effect can be used to measure the magnetic field. Sensors with this theory behind are called Hall-effect sensors.

B. Magnetic Field Produced by Current-carrying Square Loops



The magnetic field B_{PX} produced at point P on the axis (X -axis in the figure) of current-carrying square loops can be calculated using the Biot-Savart law as

$$B_{PX} = \left(\frac{\mu_0 a^2 i N}{2\pi} \right) \left[\frac{1}{\left(x^2 + \left(\frac{a}{2} \right)^2 \right) \sqrt{x^2 + 2 \left(\frac{a}{2} \right)^2}} \right]$$

where μ_0 is permeability of free space $= 4\pi \times 10^{-7}$ H/m.

C. About This Experiment

In this experiment, students have to conduct an experiment to determine sensitivity of a Hall-effect sensor. In addition, the students have to use this sensor to measure the magnetic field from the given circular magnet.

Experimental List

1. A set of electrical conducting square wires (Total resistance $5.5 \pm 0.1 \Omega$, 130 turns)
2. A multichannel DC power supply
3. A Hall-effect sensor attached on the stand.)
4. A digital multi-meter
5. An analog multi-meter
6. Electric cords
7. A circular magnet
8. A ruler

Experimental Procedure



1. Connect electric cords. The Hall-effect sensor has four electrodes – two banana-plug electrodes for supplying voltage (current) and two crocodile-clip electrodes for reading the Hall-voltage output. The Hall-effect sensor is really FRAGILE. Surging in supplying current may cause its damage. DO GENTLY increase the voltage of power supply for the sensor up to 5 V. Damage of the sensor by your ignorance results in your ZERO grade for this experiment. Note that a healthy sensor gives the intrinsic output about 2.5 V at supply input of 5 V without magnetic field.
2. Use the equipments to:
 - a. Calibrate the sensitivity of the Hall-effect sensor (Change in output/magnetic field)
 - b. Measure the magnetic field at the surface of the circular magnet.
 - c. Determine if the sensor can be used to measure the Earth magnetic field.

Additional Information

- For the circular magnet with the radius of r and the thickness of t , the magnetic field at the point of distance y from the magnet surface along the axis through and perpendicular to the center of the magnet is given by

$$B(y) = B_0 \sqrt{1 + \left(\frac{r}{t}\right)^2} \left\{ \frac{y+t}{\sqrt{(y+t)^2 + r^2}} - \frac{y}{\sqrt{y^2 + r^2}} \right\}$$

where B_0 is the magnetic field at the center of the surface of the magnet.