Hall Effect & Its Applications

Subject: Electricity & Magnetism

Subject Code: BPHY-202

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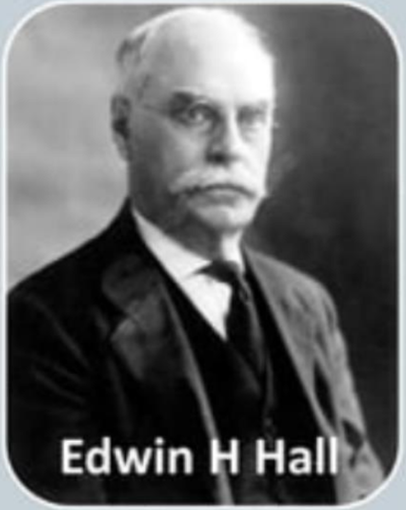
DISCOVERY

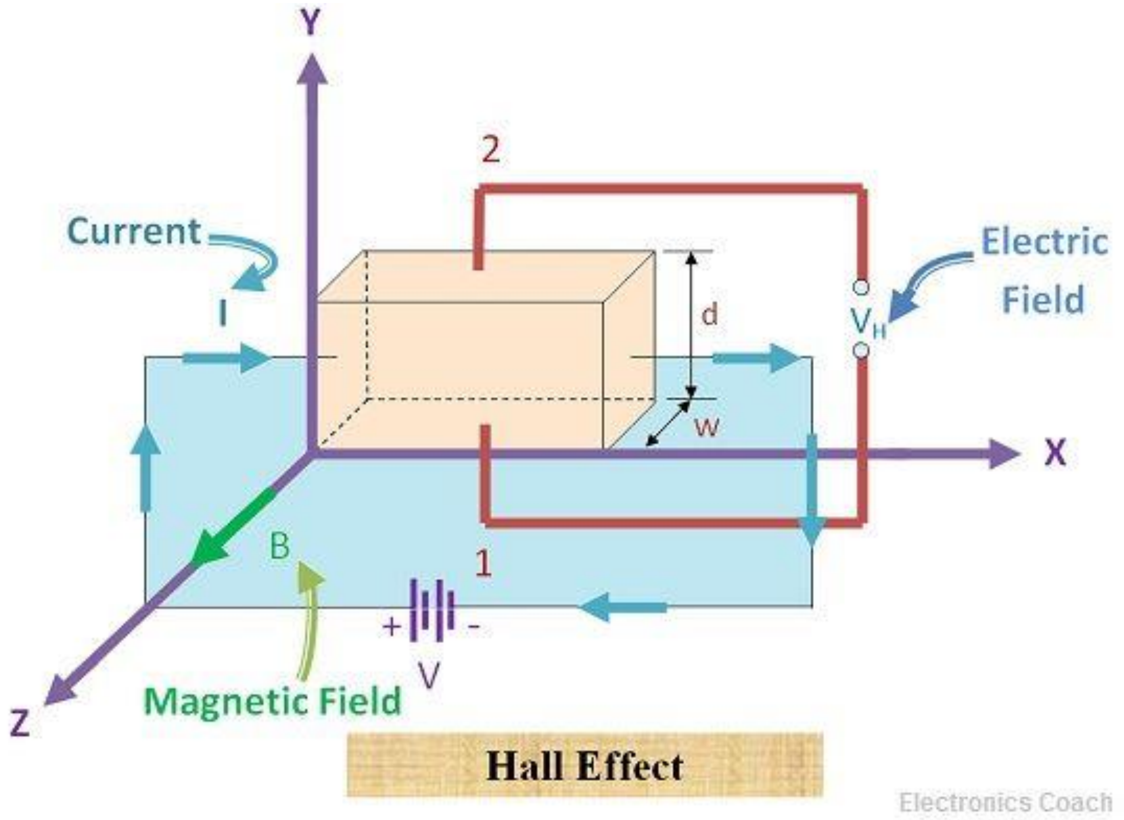
- The Hall effect was discovered in 1879 by **Edwin Herbert Hall** while working on his doctoral degree at the Johns Hopkins University in Baltimore, Maryland, USA
- Discovered 18 years before the electron.



Introduction

The Hall Effect is the production of a voltage difference across an electrical conductor, transverse to the electric current in the conductor and a magnetic field perpendicular to the current.

When a magnetic field is applied, it exerts a force on the moving charge carriers (electrons or holes), causing them to accumulate on one side of the conductor. This accumulation creates a voltage difference across the conductor, known as the Hall voltage.



HALL VOLTAGE AND HALL COEFFICIENT

- Creates internal electric potential, known as Hall voltage.

$$V_h = \frac{B*I}{n*e*d}$$

  where 'd' is the thickness of the metal along the direction of Magnetic field.

- In metals: $$R_H = \frac{E_y}{j_x * B_z}$$

- In semiconductors: $$R_H = \frac{p * \mu_p^2 - n * \mu_n^2}{e * (p * \mu_p + n * \mu_n)^2}$$

- **The Hall Voltage:** When a magnetic field is applied perpendicular to current flow in a conductor and it generates a voltage perpendicular to both the current and magnetic field.
- **Hall Current:** A transverse electric current called Hall current is induced in conductor due to magnetic field resulting in charge separation.
- **Hall Coefficient:** The Hall coefficient is a material-specific constant that quantifies the relationship between the induced Hall voltage and magnetic field and current density.
- **Quantization:** In quantum Hall effect under specific conditions and extremely low temperatures the Hall resistance becomes quantized meaning it only takes on discrete values.

Types of Hall Effect

Classical Hall Effect: Observed in ordinary conductors and semiconductors.

Quantum Hall Effect: Observed in two-dimensional electron systems at very low temperatures and strong magnetic fields, leading to quantized Hall resistance.

Properties and Characteristics

- The Hall coefficient depends on material properties.
- The Hall voltage is directly proportional to magnetic field strength.
- The sign of Hall voltage depends on the type of the charge carriers.
- The Quantum Hall effect exhibits quantized resistance values.

Applications

•**Hall Effect Sensors:** The Hall effect sensors are widely used to measure magnetic fields. They are employed in applications such as magnetic field measurement position sensing and proximity sensing.

•**Magnetic Field Measurement:** The Hall effect sensors can measure the strength and direction of magnetic fields making them useful in compasses and navigation systems.

•**Current Measurement:** The Hall effect sensors can be used to measure electric current indirectly. When a current-carrying conductor is placed near a Hall effect sensor in the presence of a magnetic field.

•**Speed and RPM Sensing:** The Hall effect sensors are used to measure the rotational speed of mechanical systems such as in automotive applications for the vehicle speed sensing.

•**Non-Contact Switches:** The Hall effect sensors are employed in non-contact switches and sensors including those used in the keyboards and industrial automation.

•**Magnetic Imaging:** The Hall effect can be used to map magnetic fields is providing insights into structure and behavior of materials.

Advantages

- The Accurate and precise measurement of magnetic fields.
- The Non-contact current sensing.
- The Suitable for a wide range of the materials.

Disadvantages

- The Requires a Magnetic Field.
- The Limited to specific temperature and magnetic field conditions for quantum Hall effect.

Thanks