Module 5 Unit 3
Magnetic Sensors

Sensing Magnetic Field

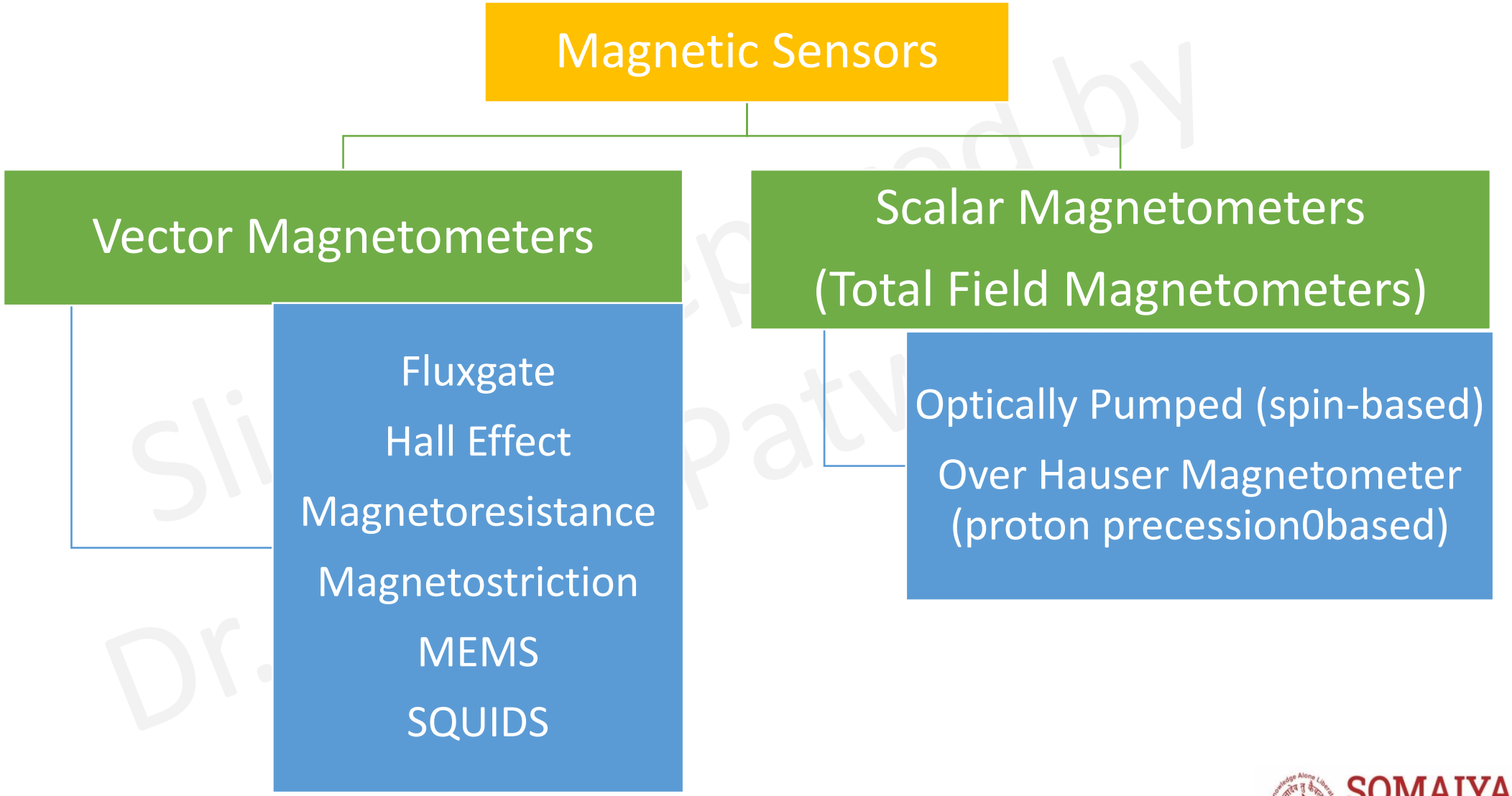
- Magnetic field sensors or magnetic sensors are transducers, which detect the magnitude of magnetic field in a region or each of its components
- Mainly based on link between electric current and magnetic field
- Main noise is the Earth's magnetic field. Typically 30-40 μT

Low field/High sensitivity: 0.1 nT or lower

Earth-Field/Medium sensitivity: 0.1 nT-100 μT

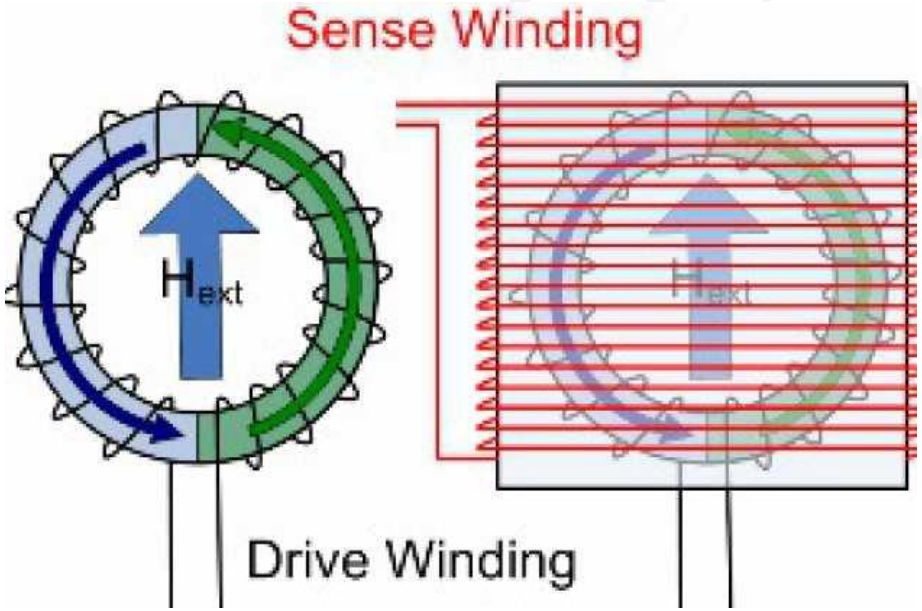
Bias Field/Low sensitivity: above 100 μT

Types of Magnetometers

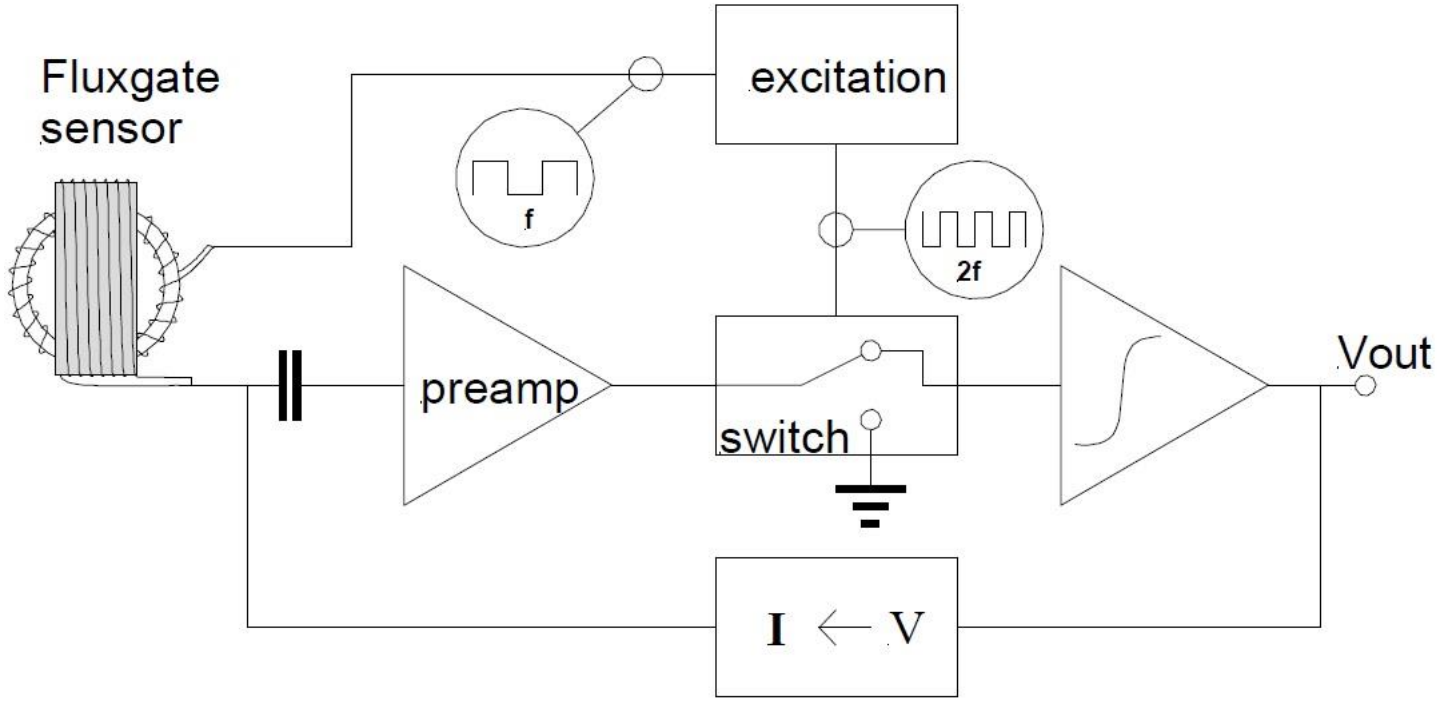


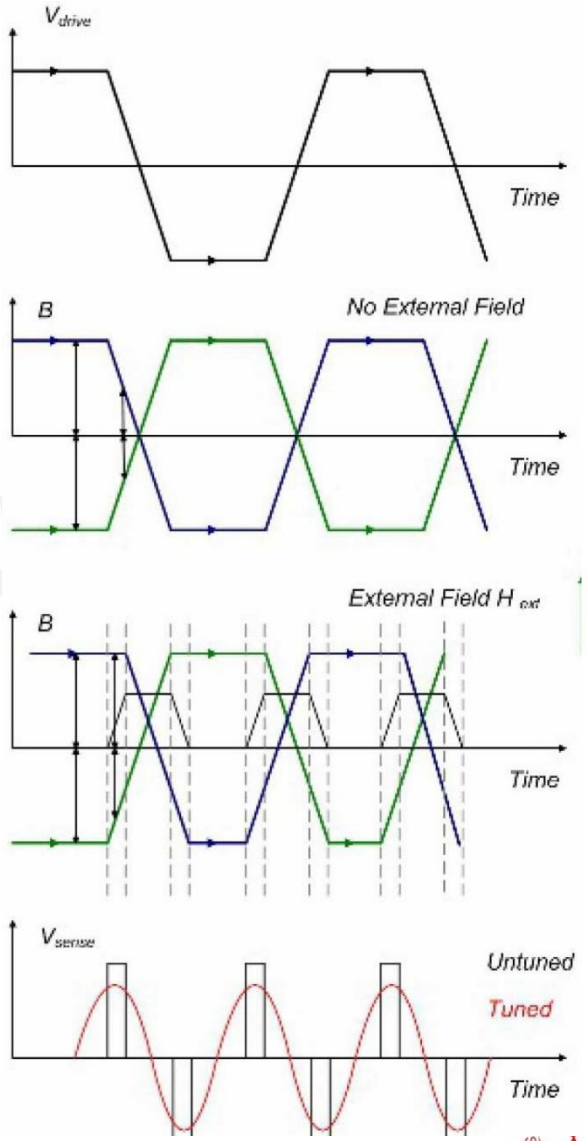
Fluxgate Magnetometer

- Based on electromagnetic induction (EMI)
- Driver coil operates the ferromagnetic core in to saturation
- Sensor coil is used to detect the change in current due to external field
- Sensitivity can be as low as 10^{-2} nT



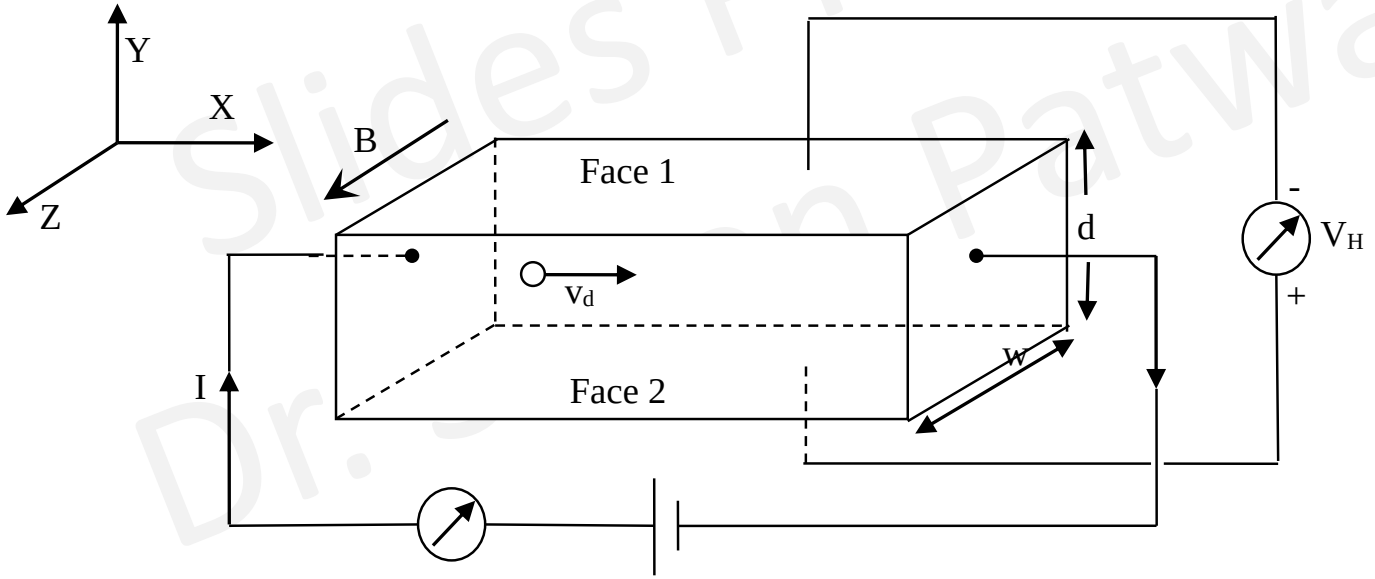
Fluxgate – Circuit and Waveforms





Hall Effect Sensor

- Based on Lorentz force
- DC current is setup in a semiconductor thin film
- Magnetic filed acting at right angles generates voltage called Hall Voltage



$$V_H = R_H \frac{I.B.d}{A};$$

$$R_H = \frac{1}{qp} \text{ or } \frac{1}{qn}$$

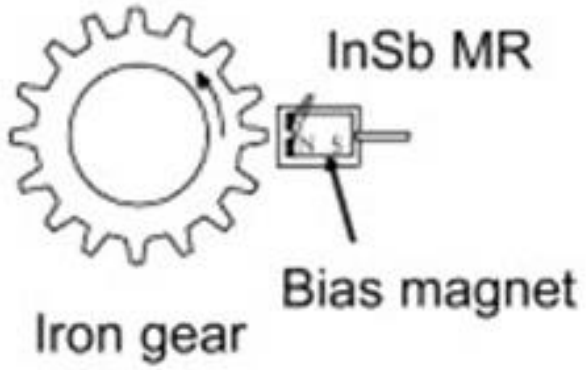
(Hall coefficient)

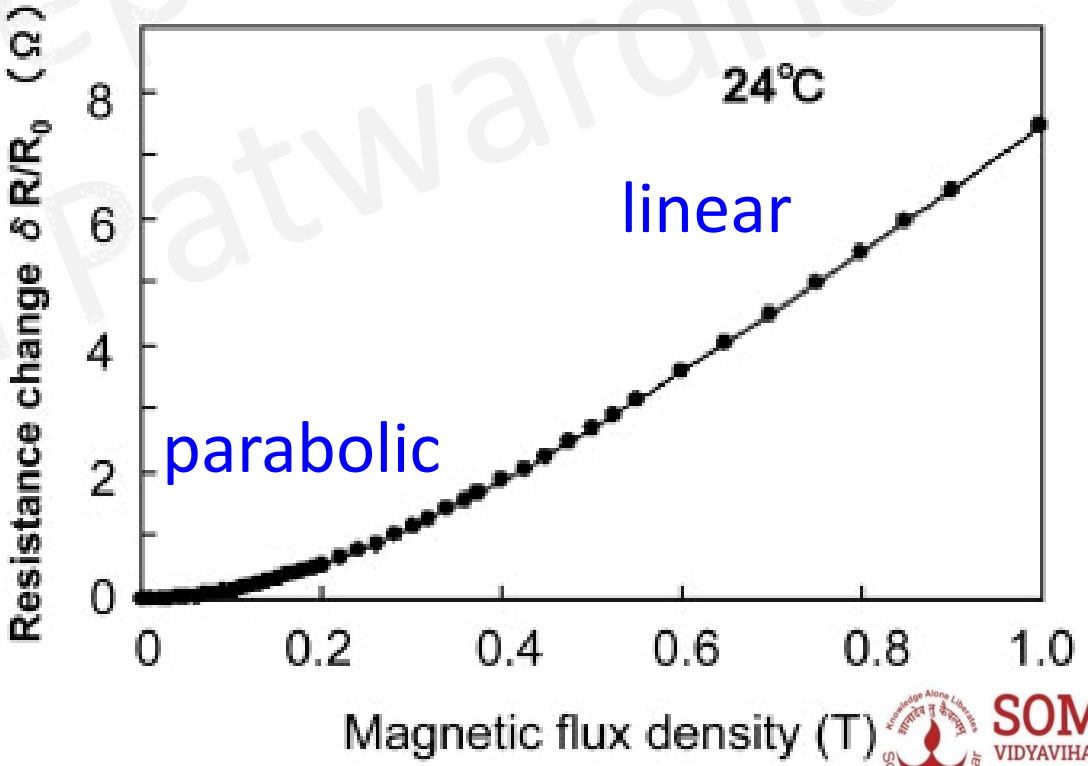
Action of Hall Effect Sensor

Magnetoresistance

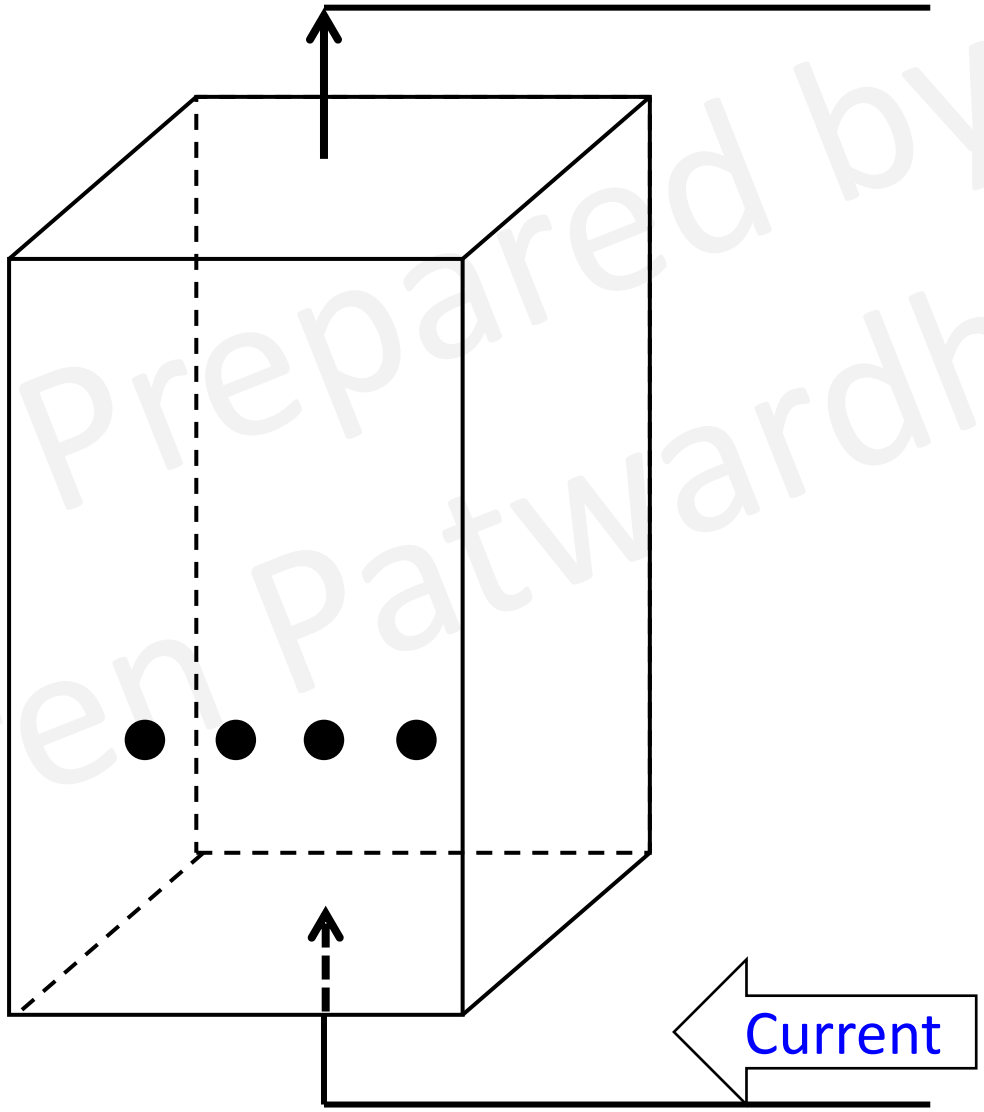
- Resistance of some materials change on application of magnetic field
- The material is called magnetoresistor
- Property can be used for several applications e.g. tachometer, HDD

$$R = R_0\left(1 + \frac{\Delta R}{R}\cos^2\alpha\right)$$

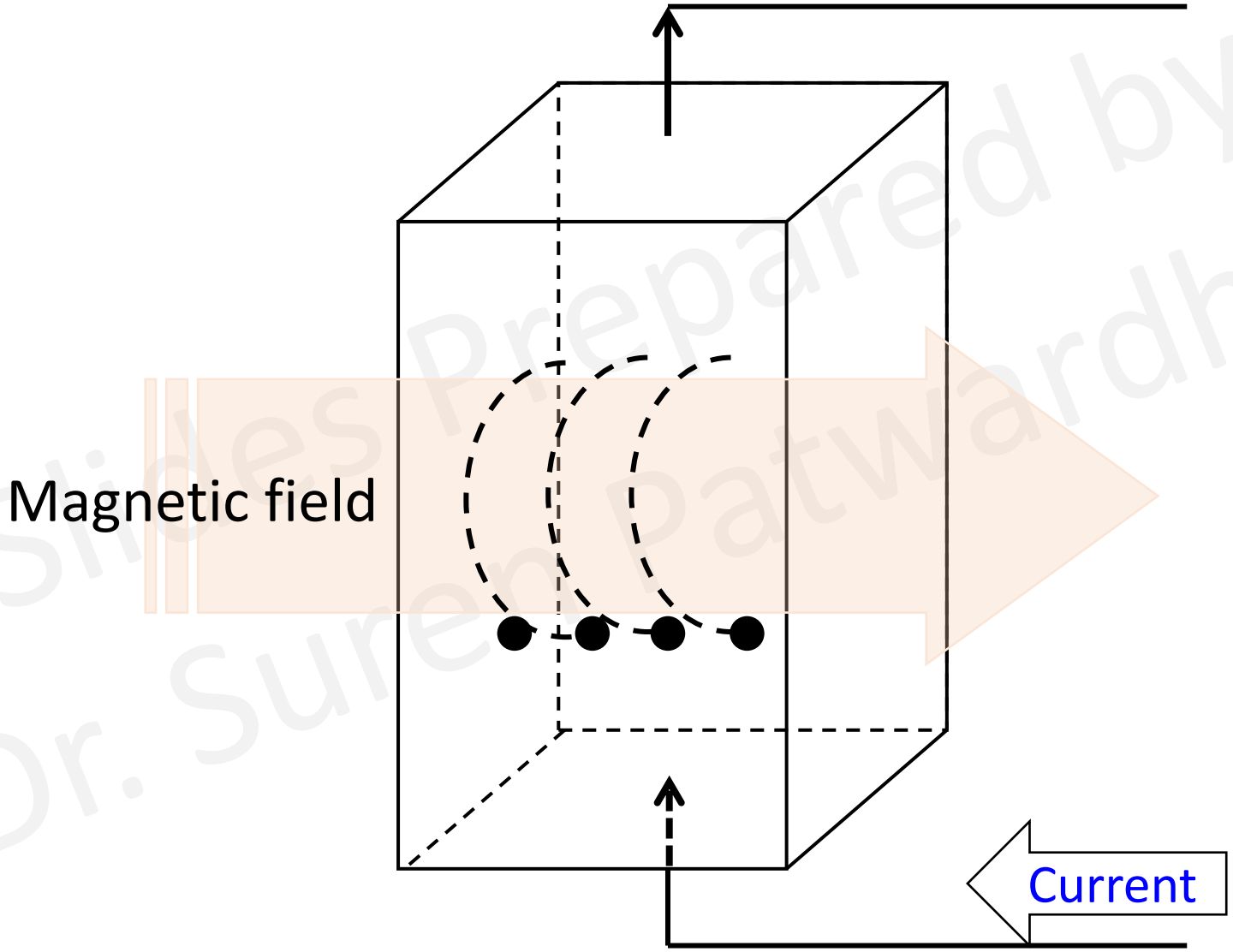




Scattering-Related Resistance Change



Scattering-Related Resistance Change



Difference between Hall Resistance and Magnetoresistance

Hall Resistance	Magnetoresistance
Resistance along direction perpendicular to the flow of current is measured	Resistance along the direction of current is measured
Change in resistance is negligible	Change in resistance is significant
Charge accumulation takes place along direction perpendicular to magnetic field	Charge accumulation does not take place
Material is not magnetised	Material is magnetised
e.g. Si	e.g. Ni-Fe alloy

Types of Magnetoresistance

- Ordinary Magnetoresistance (known from a long time)
- Anomalous/Anisotropic Magnetoresistance
  - Resistance is related to the orientation between the current and the magnetic field
- Tunnel Magnetoresistance
  - Change in resistance of two ferromagnetic materials are separated by a thin insulator (few nm)
- Giant Magnetoresistance
  - Large change in resistance between two ferromagnetic layers that are separated by a non-magnetic conductor