Lecture -20
Classification of Induced EMF

Lecture Delivered by

Topics

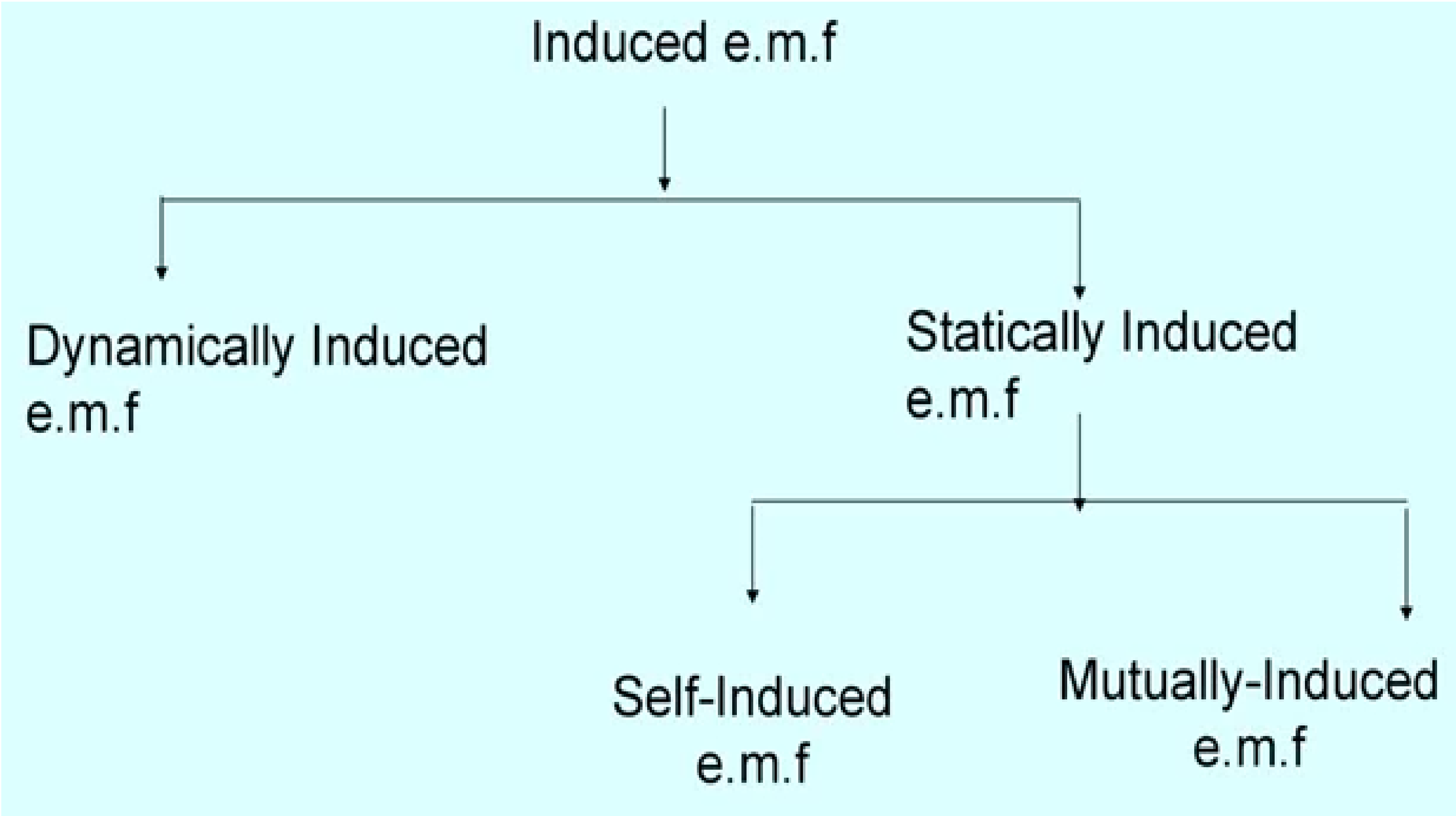
- Dynamically Induced E.M.F
- Self Induced E.M.F
- Self Inductance

Objectives

At the end of this lecture, student will be able to:

- Classify and analyse the effect of induced E.M.F's in electrical circuit
- Derive Self-Inductance for a given circuit

Classification of Induced E.M.F



Dynamically Induced E.M.F

Magnitude of dynamically induced e.m.f

Consider a conductor of length l meters moving in the air gap between the poles of magnet.

- **When plane of the flux is parallel to the plane of the motion of conductors then there is no cutting of flux hence no induced e.m.f**

- **When plane of the flux is perpendicular to the plane of the motion of the conductors then the cutting of flux is maximum and hence induced e.m.f is also maximum.**

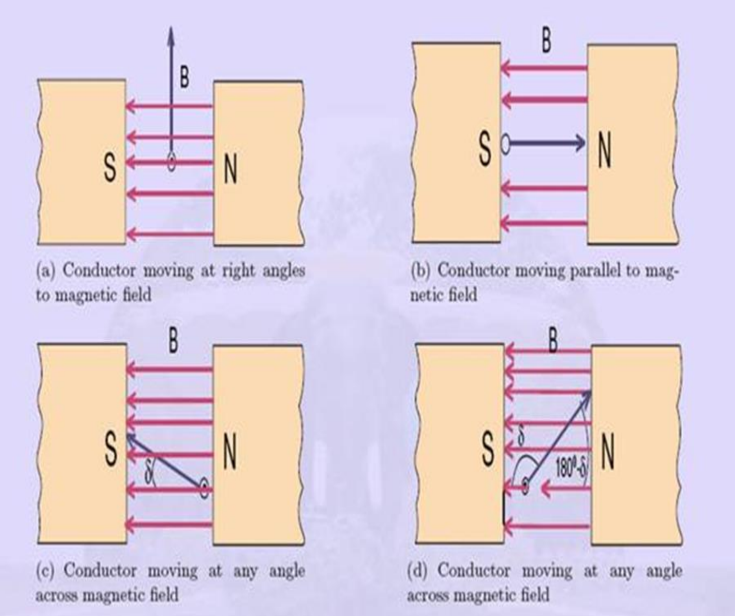


Figure 3: Effect of change of flux linkages on induced EMF in a conductor

Dynamically Induced E.M.F

Where , $\frac{dx}{dt}$ is rate of change of displacement is called velocity of the conductor (v)

$$e = Blv \text{ volts}$$

Note

If conductor is moving with a velocity v at certain angle θ measured with respect to direction of the field (Plane of the flux).

Therefore, $\boldsymbol{e = Blv\ sin\theta\ volts}$

Dynamically Induced E.M.F

- B= flux density in Wb/m^2
- L= Active length of conductor in metres
- V= Velocity in m/sec

Area swept by conductor = $l \times dx$ m^2

Flux cut by conductor = Flux density * Area Swept

$$d\emptyset = B \times l \times dx \text{ Wb}$$

According to Faraday's law, magnitude of induced e.m.f is proportional to the rate of change of flux.

$$e = \frac{d\emptyset}{dt}$$

Here N= 1 as single conductor

$$e = \frac{Bldx}{dt}$$

Flemings Right hand Rule

Fore Finger – Direction of Flux
Thumb – Motion of the conductor
Middle Finger – Direction of E.M.F (current)

- Magnet is moved Keeping the conductor stationary, while application of rule, thumb should point in the direction of relative motion of conductor with respect to flux, assuming the flux stationary.

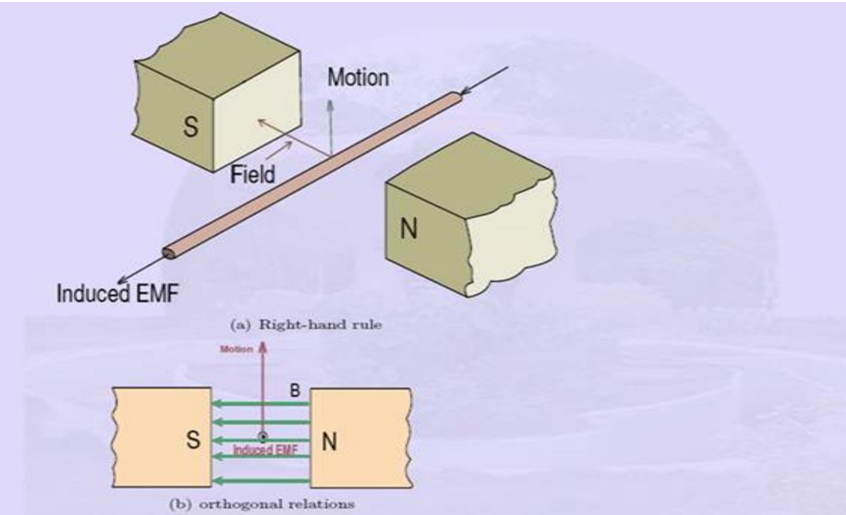


Figure 4: Fleming's right hand rule for direction of induced EMF

Statically Induced E.M.F

- The change in flux lines with respect to coil can be achieved without physically moving the coil or the magnet. Such induced e.m.f is called statically induced e.m.f

Example - Transformer

The statically induced E.M.F is classified as

1) Self Induced e.m.f
2) Mutually induced e.m.f

Video

Self Induced E.M.F

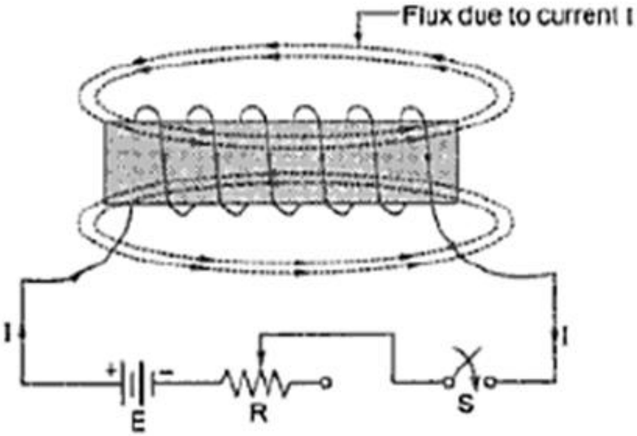
- The e.m.f induced in a coil due to the change of its own flux linked with its is called self induced e.m.f

Magnitude of self Induced E.M.F

From Faraday's Law$e = -N\frac{d\emptyset}{dt}$ $\quad \emptyset = \left(\frac{Flux}{Ampere}\right) \times Ampere = \frac{\phi}{I} \times I$

- Rate of change of flux = $\frac{\emptyset}{I} \times$ Rate of change of current

$$\frac{d\emptyset}{dt} = \frac{\emptyset}{I} \times \frac{dI}{dt}$$



Self Induced E.M.F

$$e = -N \times \frac{\emptyset}{I} \times \frac{dI}{dt}$$

- $\frac{N\emptyset}{I}$ is the quantitative measure of the property due to which coil opposes any change in current. So this constant is called coefficient of self inductance and denoted by 'L'

$$\boldsymbol{L = \frac{N\phi}{I}}$$

Its unit is Henry (H)

Therefore, $\boldsymbol{e = -L\frac{dI}{dt}}$ **volts**

- Coefficient of self inductance is also defined as the e.m.f induced in volts when the current in the circuit changes uniformly at the rate of one ampere per second.

Self Inductance

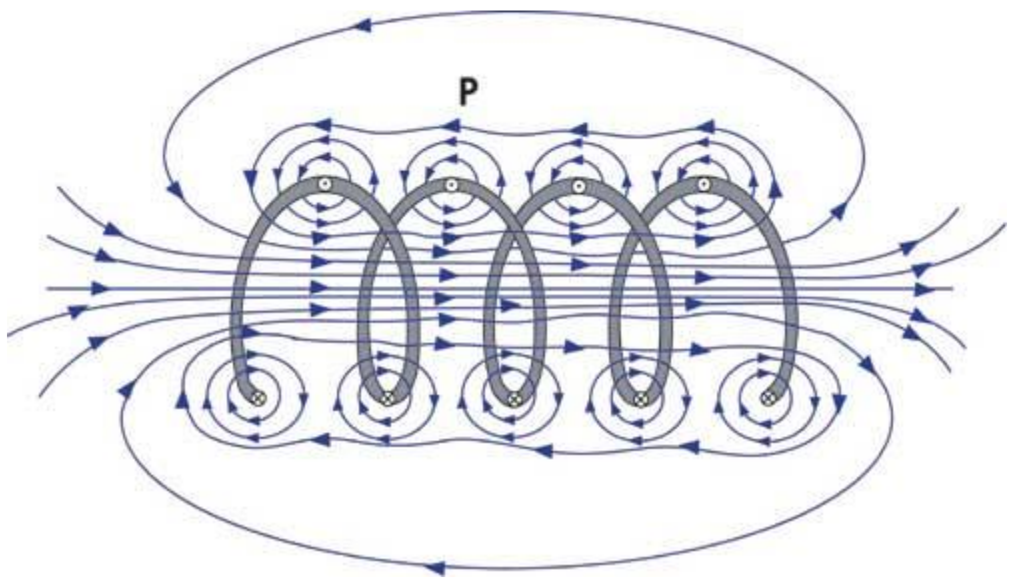
- It is the property of the coil through which it opposes the change in current
- When current flows through the coil it establishes a flux which links with itself
- Any change in current will cause a change in flux which induces an e.m.f as per Faraday's and Lenz's law

$$e = L\frac{di}{dt} \Rightarrow L = \frac{e}{{di}/{dt}}$$

Self Inductance

- It is also defined as the flux linkages produced per unit current

$$L = \frac{N\phi}{I}$$



Magnetic flux lines in a coil carrying current

Self Inductance

Q. If a coil has 500 turns is linked with a flux of 50 mWb, when carrying a current of 125A. Calculate the inductance of the coil. If this current is reduced to zero uniformly in o.1 sec, Calculate the self induced e.m.f in the coil.

Ans. The inductance is given by, $L = \frac{N\emptyset}{I}$

Where N= 500, ϕ= 50mWb and I = 25A

So L is 0.2H

$e = -L\frac{dI}{dt} = -L\frac{Final\ value\ of\ I - Initial\ Value of\ I}{Time}$ = 250volts

Summary

- It is produced due to physical movement of coil or conductor wit respect to flux or movement of magnet with respect to stationary coil or conductor.
- The change in flux lines with respect to coil can be achieved without physically moving the coil or the magnet. Such induced e.m.f is called statically induced e.m.f
- The e.m.f induced in a coil due to the change of its own flux linked with its is called self induced e.m.f
- Self Inductance is the property of the coil through which it opposes the change in current