Self - Inductance

When current flows in a ckt the magnetic flux produced by the current depends on geometry of the ckt.

For non-ferromagnetic material it is proportional to current

$$\Phi = LI \quad \cdots (1)$$

$\Phi \rightarrow$ Magnetic flux.

$L \rightarrow$ Self Inductance

$I \rightarrow$ Current flowing in ckt

Defn of Self Inductance

Total flux linked with ckt for unit current flowing in the ckt.

For rigid stationary ckt, change in flux caused by change in current

$$\therefore \left(\frac{d\Phi}{dt}\right) = \left(\frac{d\Phi}{dI}\right)\left(\frac{dI}{dt}\right) \quad \cdots (2)$$

If 'Φ' is not linearly related to 'I', i.e. for ferromagnetic materials, whose permeability depends on current.

$$\therefore \text{Induced emf} = \mathcal{E} = -\left(\frac{d\phi}{dt}\right) = -L\left(\frac{dI}{dt}\right) \quad \cdots (3)$$

where, $$L = \left(\frac{d\Phi}{dI}\right) \quad \cdots (4)$$

Defn of 'L'

Emf induced in ckt for unit rate of change of current in ckt.

Self inductance measures ability of circuit to "oppose" variation of current in it.

S.I. unit.

From $\phi = L.I \Rightarrow 1 \text{ henry} = \frac{1 \text{ weber}}{1 \text{ Amp}} = \frac{1.\text{volt} \times \text{sec}}{\text{amp}} = \text{volt amp}^{-1}.\text{sec}.$

Mutual Inductance

Suppose there are 'N' number of ckts described by 1, 2, ... N. When ckt carry currents, flux produced by current in one ckt may link with other ckt.

'Φ_i' linked with 'i' determined by adding up contributions from each ckt

$$\Phi_i = (\Phi_{i1} + \Phi_{i2} + \cdots \Phi_{iN}) \cdots (1)$$

$$= \sum_{j=1}^{N} \Phi_{ij} \cdots (1)$$

Flux through ith ckt due to jth ckt.

For non-ferromagnetic materials,

$$\Phi_{ij} = M_{ij} I_j \cdots (2) \quad (i \neq j)$$

M_{ij} is mutual inductance betn ckt 'i' and 'j'.

∴ **Mutual Inductance defn**

Mutual inductance betn two ckt is defined as flux linked with one ckt due to unit current in other.

$$\therefore \mathcal{E}_i = -\left(\frac{d\Phi_i}{dt}\right) = -\sum_{j=1}^{N} \left(\frac{d\Phi_{ij}}{dt}\right) \cdots (3)$$

For rigid fixed ckt, change in 'Φ_{ij}' ~~due to~~ caused by change in current

$$\left(\frac{d\Phi_{ij}}{dt}\right) = \left(\frac{d\Phi_{ij}}{dI_j}\right) \frac{(dI_j)}{(dt)}$$

$$= M_{ij} \left(\frac{dI_j}{dt}\right) \cdots (4)$$

where, $M_{ij} = \left(\frac{d\Phi_{ij}}{dI_j}\right) \cdots (5)$

Emf induced in 'i'th ckt due to change in current in jth ckt is.

$$\mathcal{E}_{ij} = -M_{ij} \left(\frac{dI_j}{dt}\right) \cdots (6)$$

Mutual Inductance betn two ckt defined as, "Emf induced in one ckt due to unit rate of change of current in other."