2/11/2024

(Unit -3)

* Transformer *

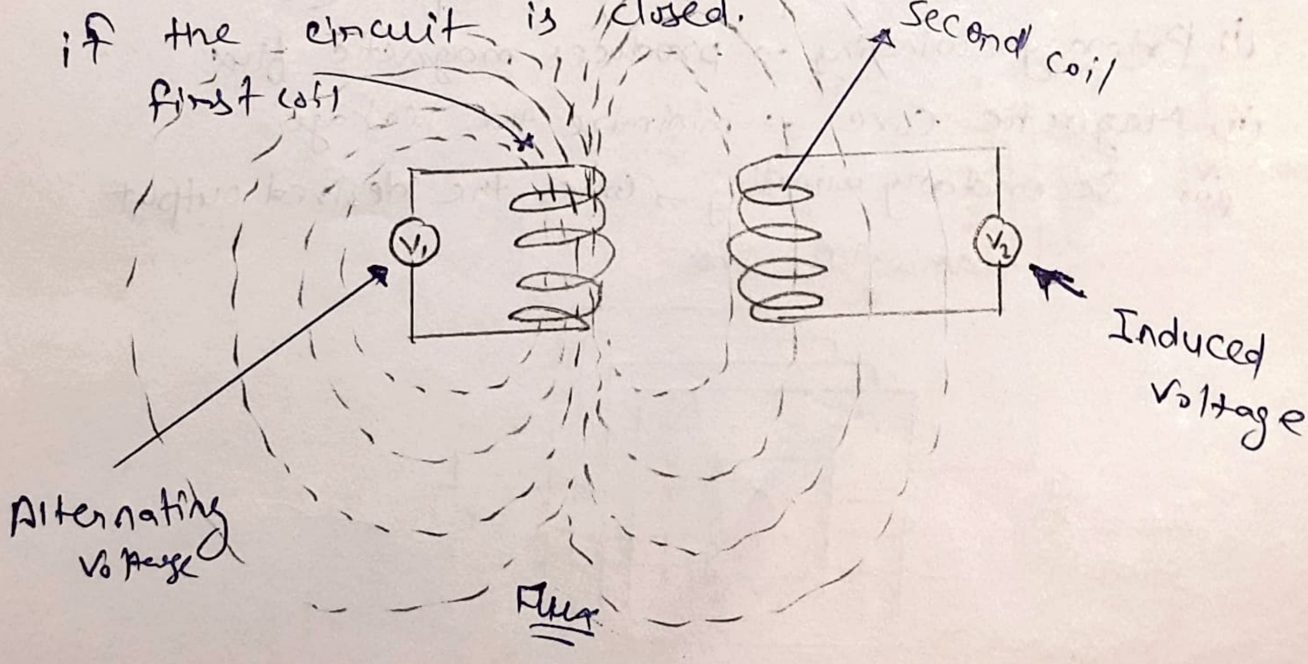
Definition :- Transformer is a static device which works on the principle of electromagnetic induction.

-> It is used for transforring electical power from one cirauit to another circuit without changing in it's frequency.

- **Working Principle** :- Mutual induction.

Transformer one winding is supplied by an alternating electrical source. A changing current causes of alternating flux in that winding. Another 2nd winding is placed very close to it, so some portion of this alternating flux will link with second winding.

According to faraday's law, EMF will be induced in secondary winding and current will flow if the circuit is closed.



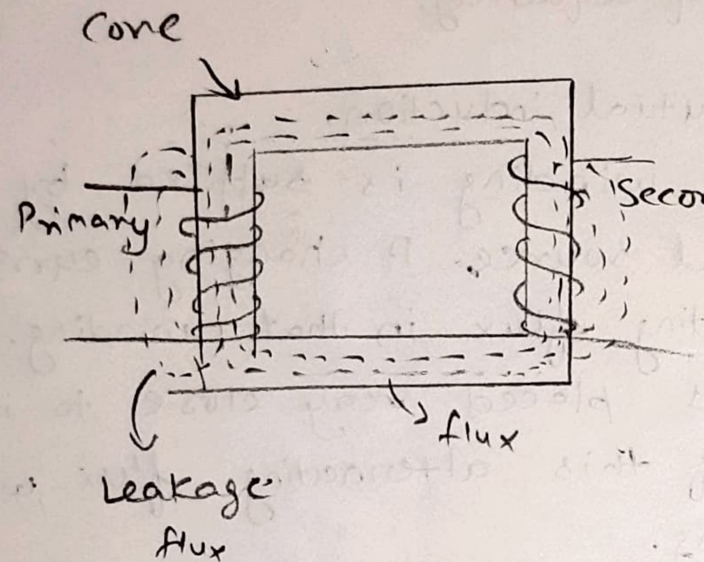
Note A transformer that increase voltage between the primary to secondary winding is known as a Step-up transformer and a transformer that decrease voltage between primary to secondary winding is known as step down transformer.

⇒ In Step-up transformer $N_1 > N_2$

In step-down transformer $N_2 > N_1$

N_1 = number of turns in first winding

N_2 = number of turns in second winging



→ in Core type transformer: Leakage of flux is less than a shell type transformer

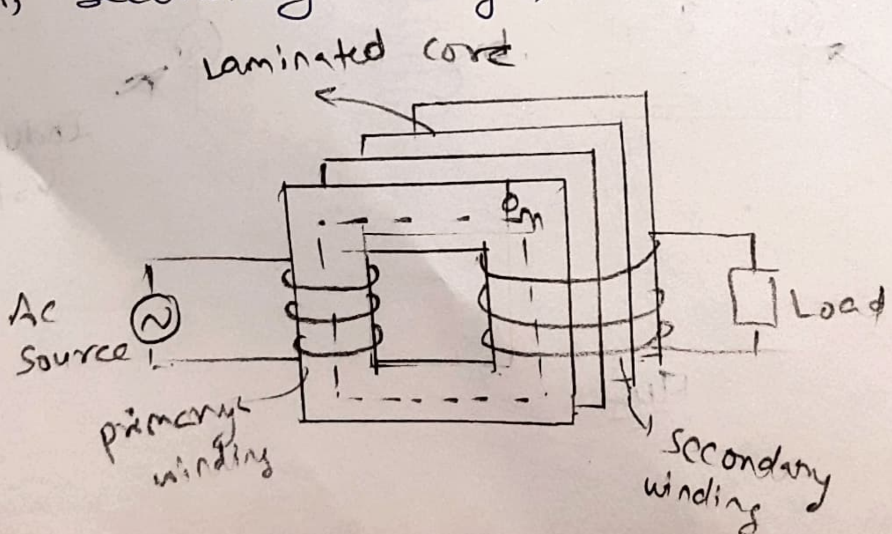
★ Construction of transformer:-

The three main parts of transformer-

(i) Primary winding → produces magnetic flux

(ii) Magnetic core → minimize the leakage

(iii) Secondary winding → Gives the desired output



Ideal transformer

(i) No copper losses

(ii) No iron losses in the core

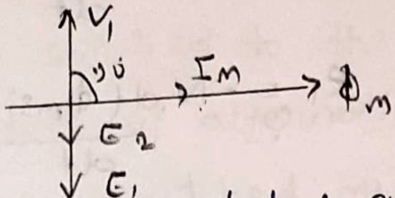
(iii) no leakage flux.

~~intp~~

input power = output power

- Characteristics of Ideal transformer:-

(1) zero winding Resistence - Both coils are purely inductive in nature.



(2) 100% effeciency.

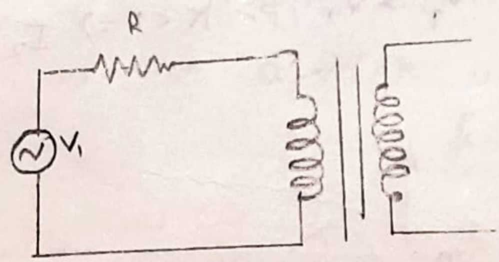
(3) No leakage flux.

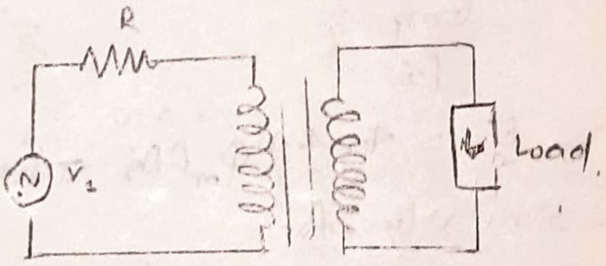
(4) No iron loss - As the iron core is subjected to alternating flux there occurs eddy current & hysteresis loss → Iron loss ⇒ zero in ideal transformer.

Practical transformer :-

There are two cases for practical transformer

(i) On load (ii) No load.





• EMF equation

Flux $\Rightarrow \phi = \phi_m \sin\omega t$

By Faraday's law

$$e = -N\frac{d\phi}{dt}$$

For primary side

$$e_1 = -N_1\frac{d\phi}{dt}$$

$$e_1 = -N_1\frac{d(\phi_m \sin\omega t)}{dt}$$

$$e_1 = -N_1\omega\phi_m \sin\omega t$$

$$\omega = 2\pi f$$

$$e_i = -2\pi f N_1 \phi \sin\omega t$$

$$\omega t \rightarrow 90^\circ$$

$$\boxed{E_{m_1} = 2\pi f \phi_m N_1}$$

Rms value

$$= \frac{E_{m_1}}{\sqrt{2}}$$

$$E_1 = 4.44\,\phi_m f N_1 \quad \text{(i)}$$

Similarly for secondary side

$$E_2 = 4.44\,\phi_m f N_2 \quad \text{(ii)}$$

by (i) & (ii)

$$\boxed{\frac{E_1}{E_2} = \frac{N_1}{N_2}}$$

$E_1 \approx V_1$ & $E_2 \approx V_2$

So

$$\frac{E_1}{E_2} = \frac{V_1}{V_2} = \frac{N_1}{N_2} = K \text{ (turn ratio)}$$

* power concept

P(primary side) = P(secondary side)

$$V_1 I_1 = V_2 I_2$$

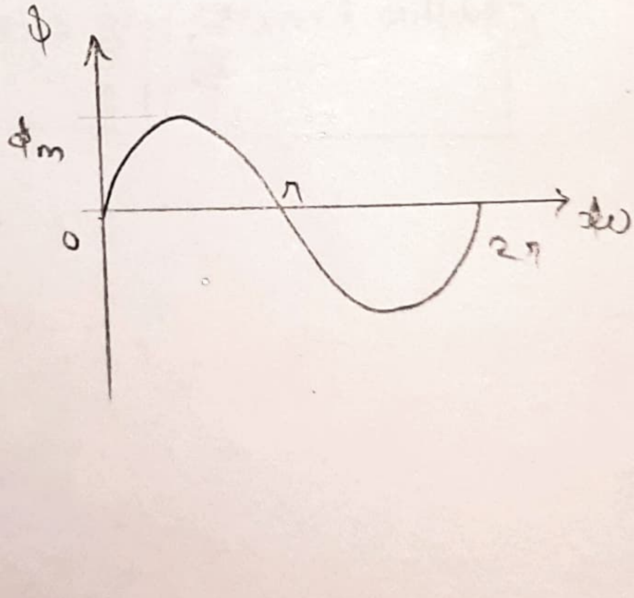
$$\frac{V_1}{V_2} = \frac{I_2}{I_1} \quad \text{(for Ideal transformer)}$$

For step up ($N_2 > N_1$)

$V_2 > V_1 \Rightarrow K > 1 \Rightarrow I_1 > I_2$

For step down ($N_2 < N_1$)

$V_1 > V_2 \Rightarrow K < 1 \Rightarrow I_2 > I_1$



★ Losses in Transformer :-

Loss in terms of power.

(i) Core Losses / (Iron losses) :- losses occuring in the core.

(a) Hysteresis loss when the core repeatedly magnetized & demagnetized.

→ Use of soft iron or silicon iron.

(b) Eddy current loss AC current is supplied to the primary winding which sets up alternating flux. but due to leakage of flux, it linked other parts of its conducting body & produce circulating current (Eddy current) which are opposite in direction to the main current. which cause of energy loss.

→ Use thinner plates instead of a solid block of Iron. (paneled form)

(ii) Copper losses :- Occurs due to resistance in windings.

Copper loss $\propto I^2R$ $\qquad R = \frac{\rho l}{A}$

→ Use a thick wire in winding. (Crossed sectional Area (A) should be high)

• Efficiency of Transformer :-

$$\eta_{Load.} = \frac{P_{(Input)} - P_{(Losses)}}{P_{(Input)}}$$

(efficiency ⇒ 95 to 98.5 %)

[Connected with load]

$$\eta = \frac{P_{output}}{P_{input}}$$

[~~Conn~~ No load]

Note Efficiency of transformer will be maximum when copper loss is equal to iron loss.

- Voltage Regulation

Change in the magnitude of receiving & sending voltage of the transformer.

For load is connected

Voltage Regulation $= \frac{E_2 - V_2}{E_2}$

$E_2 \Rightarrow$ voltage for No load (Secondary)

E

$V_2 \Rightarrow$ Voltage for load.

For No load

Voltage regulation

$= \frac{E_1 - V_1}{V_1}$

$E_1 =$

$V_1 =$