Transformer

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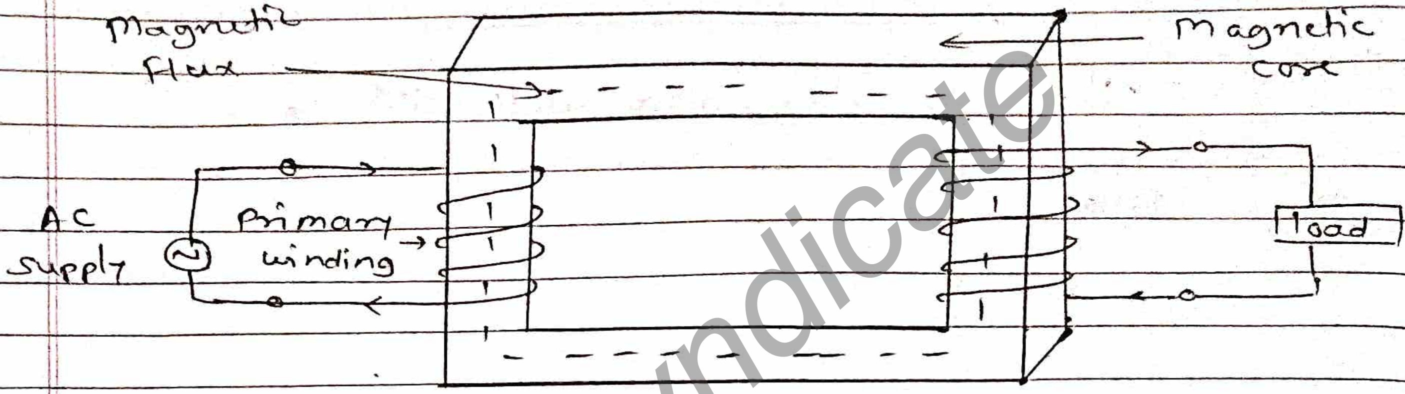
* Transformer - A Transformer is a static device which transferred the electric power from one circuit to another circuit without change in Frequency.



Single phase Transformer.

Core - The core is the backbone of the transformer providing a magnetic path for the flux to flow. It is made up of laminated steel or Ferrite

Working -
Consider a magnetic core having primary and secondary winding having N_1 and N_2 turns respectively. When AC power supply is start, the magnetic flux are change. The flux linkage is

$$\psi_1 = \phi N_1$$
$$\psi_2 = \phi N_2$$

According to the Faradays law of electromagnetic induction. induce emf in primary and secondary coil are.

$$e_1 = -N_1 \frac{d\phi}{dt} \quad — ①$$

$$e_2 = -N_2 \frac{d\phi}{dt} \quad — ②$$

eq^n of flux is

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

emf by turns is

$$e_t = \frac{d}{dt} \phi_m \sin \omega t$$

$$e_t = \phi_m \omega \cos \omega t$$

$$e_t = \phi_m \omega \sin(\omega t - \frac{\pi}{2})$$

$$e_t = 2\pi f \phi_m \sin(\omega t - \frac{\pi}{2})$$

$$e_t = E_m \sin(\omega t - \frac{\pi}{2})$$

where $E_m = 2\pi f \phi_m$

$$E_{trms} = \frac{2\pi f \phi_m}{\sqrt{2}}$$

$$E_{trms} = 4.44 f \phi_m$$

Emf per turn of primary and secondary are same

Induce emf in primary

$$\boxed{E_1 = 4.44 f \phi_m N_1 \text{ Volt}} \quad — ③$$

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Induce emf in secondry coil

$$\boxed{E_2 = 4.44 \, f \, \phi_m \, N_2 \text{ volt}} \quad \text{— (4)}$$

eqn (3) and (4) are called eqn of transformer

divide eqn (4) and (3)

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

This is called Transformation Ratio
Ratio of induce emf of secondary winding to the induce emf of primary winding is called Transformation Ratio (K)

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

- Efficiency of transformer

The ratio of output power to the input power is called efficiency of transformer.

$$\boxed{\eta = \frac{\text{Output power}}{\text{input power}} \times 100}$$

When $k > 1$, $N_2 > N_1$ the transformer is called step up transformer
when $k < 1$, $N_2 < N_1$ the transformer is called step down transformer.

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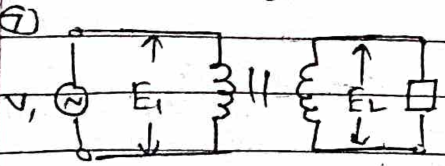
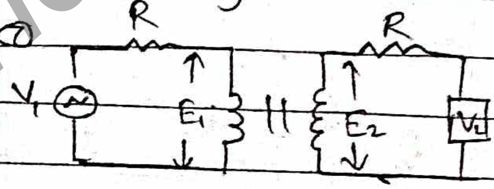
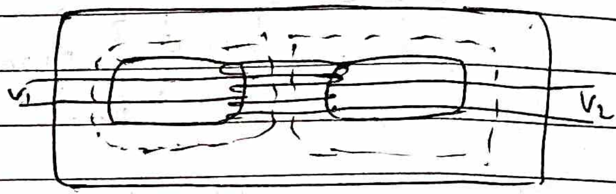
Que Diffⁿ Betⁿ Ideal and practical transformer.

Ideal transformer	Practical transformer
① Core has infinite permiability	① Core has finite permiability.
② There is no leakage of flux	② There is leakage of flux.
③ There is no Hysteresis and eddy current loss	3) There is both Hysteresis and eddy current losses are present.
④ voltage regulation is zero	④ voltage regulation is finite.
⑤ There is no winding resistance Hence No copper loss.	⑤ It has winding resistance Hence copper loss are present.
⑥ Efficiency is 100%.	⑥ Efficiency is less than 100%.
⑦  $E_2 = kE_1$	⑦  $E_1 < V_1$

Que Why transformer does not work on dc

→ Transformers are works on the principle of mutual Induction which requires a changing magnetic field to induce a voltage in the secondary coil.
DC provides a constant current, resulting in a steady magnetic field in the transformer core. This constant field does not induce any change in the secondry coil, so no voltage is generated. Hence transformers need Alternating current because it creates a continuously varing magnetic flux essential for voltage induction in the secondary coil.

Que diffⁿ b/w Core type and Shell type transformer.

Core transformer	Shell transformer
1) The winding enclose the whole core	1) The core enclose the windings.
2) Average length of core is more	2) Average length of core is less.
3) Magnetic Flux has only one continuous path	3) Magnetic Flux is distributed into two parts
4) It is more suitable for high voltage transformer	4) It is more economical for low voltage transformer
5) It is easy to repair	5) It is difficult to repair
6) 	

* Losses in Transformer

1) Copper loss - This is heat energy loss due to the resistance of the copper coil in the transformer windings. This loss can minimize by using wire of very small cross section area.

2) Hysteresis loss - This is energy loss due to continuous magnetization and demagnetization of the transformer. We can minimize this loss by using core of permalloy or silicon iron.

3) Eddy current loss - Eddy current loss is energy loss caused by ~~d~~ Eddy current produced due to relative motion between conductive material and eternal changing magnetic field.
we can minimize this loss by using high resistivity materials like silicon steel.

4) Dielectric loss - It occurs in the insulating material of the transformer that is in the oil of the transformer or in the solid insulation.
we can minimize this loss by using high-quality insulating materials like mica.
This losses affects the efficiency of transformer.