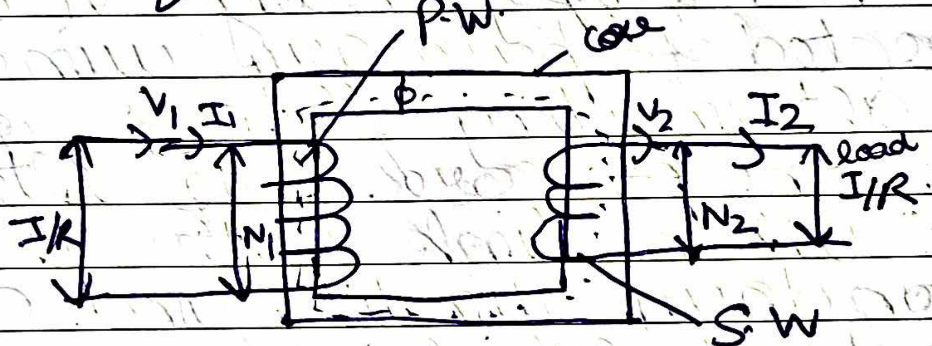
Unit - 2

Magnetic Circuits

Transformer



$$V = V_m \sin \omega t$$

It is a static device which transfers AC electric power from one circuit to the other at the same frequency but with change in voltage level.

If $V_2 > V_1$ the transformer is step up transformer

If $V_2 < V_1$ the transformer is step down transformer.

Working Principle of Transformer:

The basic principle is Electromagnetic induction
Whenever a conductor is placed around a magnetic feild and e.m.f is induced in it.

When AC supply voltage V_1 is connected to primary winding and alternating flux is set up in the ~~po~~ core. This Alternating flux when link with the secondary winding and e.m.f is induced which is known as mutually induced e.m.f. The dirn of this induced e.m.f is opposite to that of applied voltage given V_1.

Although there is no electrical connection b/w primary and secondary winding but still the power is transffered from one side to the other side through mutual flux.

The induced e.m.f in the primary and secondary winding depends on the rate of change of flux.

$$N \frac{d\phi}{dt}$$

The rate of change of flux is same ~~bor~~ for both primary and secondary therefore the induced e.m.f is proportional to no. of turns in primary winding and same for the other winding

$$E_1 \propto N_1$$

Ideal Transformer:

→ In ideal transformer there are no ohmic loses (I^2R).

→ No winding resistance → The primary and secondary winding have zero resistance which means there is no ohmic power loss.

→ No magnetic Leakage → There is no leakage flux and all the flux set up is confined to the core and links both the winding.

→ No iron load (~~Bufste~~ hysteresis & eddy current)

→ zero magnetising Current.

<u>Transformer Looses</u>:

→ <u>Iron losses</u>:

Also known as fixed loses. They are mainly caused by alternating flux in the core and are of two types
→ ~~Hyste~~ Hysteresis
→ Eddy.

Hysteresis → The core of the transformer is subjected to an alternating magnetising force and of each cycle of emf a hysteresis loop is traced down.

$$\boxed{P_H = \eta' (B_{max})^x f \times V}$$

where, f = hysteresis frequency
η' = hysteresis constant
V = Volume of core

x = lies b/w 1.5 to 2.5.
B_{max} = Maximum flux quantity

Eddy Current Loss → The magnetic circuit is made up of iron and the flux setup in the core is variable due to which current will be induced by the induction in the core itself.

$$\boxed{P_e = K_e (B_{max})^2 f^2 t^2 V}$$

where, t = thickness of material.
K_e = eddy current constant

Both these loses are known as iron losses or constant losses and mainly occur during open circuit test of the transformer.

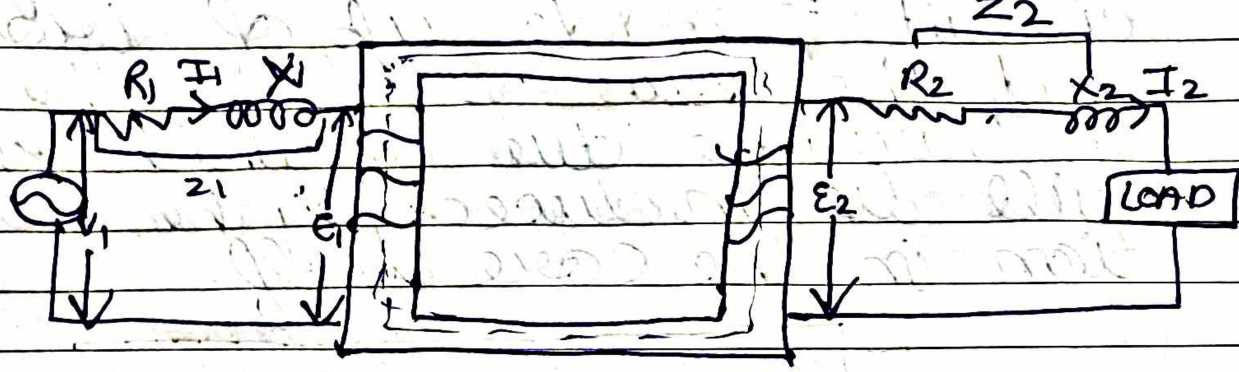
→ Copper of Variable loses:

These losses occur due to the ohmic resistance of the transformer winding.

$$\boxed{C\cdot Loss = I_1^2 R_1 + I_2^2 R_2}$$

Transformer efficiency:

Actual Transformer/ Equivalent Ckt of Transformer:



$$\cancel{Z_1 = R_1 + jX_1}$$
$$\cancel{Z_2 = R_2 + jX_2}$$

An actual Transformer has primary and secondary resistances (R_1 and R_2) and leakage reactances (X_1 and X_2) and Iron and copper losses. Therefore primary impedence is given as

$$\boxed{Z_1 = R_1 + iX_1} \quad -(1)$$

$$\cancel{\boxed{Z_2 = R_2 + iX_2}}$$

The applied voltage is V_1, and the resistance, and the leakage reactance of primary winding is responsible for the voltage drop.

$$\vec{V_1} = \vec{E_1} + \vec{I_1}\vec{Z_1} \quad -(2)$$

Therefore ~~seco~~ secondary impedence is gives as

$$\cancel{X}\, Z_2 = R_2 + iX_2 \quad - (3)$$

The voltage drop for the secondary winding is

$$\bar{V_2} = \bar{E_2} - \bar{I_2}\bar{Z_2} \quad - (4)$$

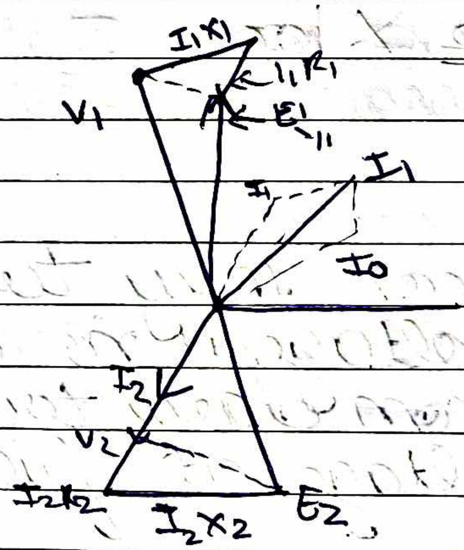
Put (1) in (2).

$$\boxed{V_1 = \bar{E_1} + \bar{I_1}(R_1 + iX_1)}$$

~~$V_2 = E$~~

Put (3) in (4).

$$\boxed{V_2 = \bar{E_2} - I_2(R_2 - iX_2)}$$



Voltage Regulation:

When a transformer is loaded with a const. amt supply voltage the terminal voltage changes depend upon the load and its power factor.

The algebric diffrence b/w the no load and full load terminal voltage is measured in terms of voltage regulation.

At a constant supply voltage the change in secondary terminal voltage from no load to full load with respect to no load voltage is called voltage regulation of the transformer.

$$\frac{E_2 - V_2}{E_2} \times 100$$

where,

E_2 = secondary terminal voltage at no load.

V_2 = Secondary terminal voltage at full load.

Ordinary Transformer

It is a transformer ~~wth~~ with only one wounding ~~bound~~ wound on a laminated core, a part of this winding is common to both primary and secondary side., In an ordinary transformer the primary and secondary winding are ~~insu~~ electrically insulated with each other but connected magnetically ~~on~~ whereas in as ordinary transformer ~~to~~ the primary and secondary connected electrically as well as magnetically.

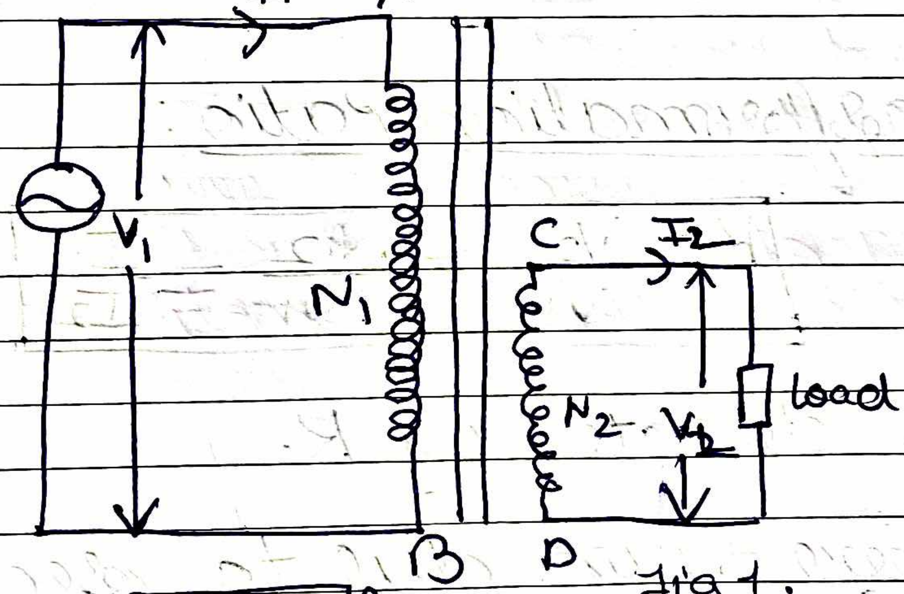


Fig 1.

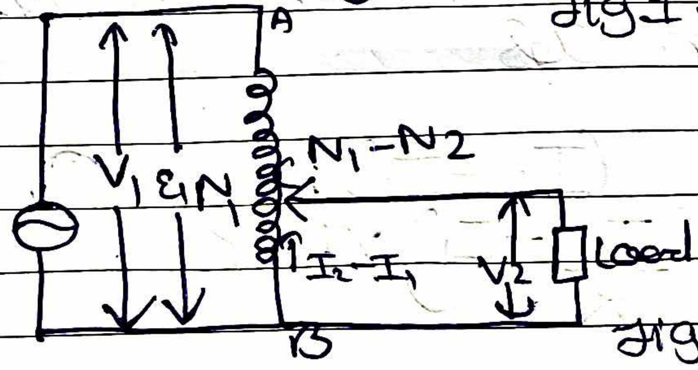


Fig 2.

Fig 2. shows the primary winding AB from which a tapping at point C is taken such that CB act as secondary winding the supply voltage is applied across AB and the load is connected across CB.

When AC voltage V_1 is applied across AB and alternating flux is set up in the core which induce an emf ~~e1~~ E1 in the winding AB the part of this e.m.f is taken in the secondary side.

<u>Transformation Ratio</u>:

$$\boxed{K = \frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2}}$$

It is denoted by K.

Amphere turn due to section BC is given as

$$(I_2 - I_1) N_2 \quad \text{---} (1)$$
$$= \left(\frac{I_1}{K} - I_1\right) \times N_1 K$$

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$$= I_1 N_1 (1-K) \quad -(2)$$

Amphere Turn due to section ~~AB~~ AC is given as

$$= I_1 (N_1 - N_2) \quad -(3).$$
$$= I_1 \cdot (N_1 - N_1 K)$$
$$= I_1 N_1 (1-K) \quad -(4).$$

Eqn (2) & (4) show that the amphere turn due to section BC and AC balance each other and define the characterstics of transformer action.

__Use of ordinary Transformer:__

→ It is used to give a small boost to a distribution cable to correct the Voltage drop.

→ It is used as a regulating transformer.

→ It mainly gives 50 to 60 percent of ~~rising~~ Vo' rise in voltage to the induction motor while starting

__limitations:__

* It is advisable not to use an auto transformer for inter connecting high voltage and low voltage system therefore it is only limited to the places where slight variation of output voltage from the input voltage is required.

*

BH Curve (Magnetic Hystersis Curve):

When a magnetic material is magnetise. ~~For~~ 1st in one direction and than in the other direction than the flux density (B) ~~o~~ in the material lacks behind the applied magnetising force (H).
The phenomenon of flux density (B) lacking behind the magnetising force (H) in the magnetic material is called Magnetic Hystersis.