2):- Statically Induced EMF:-

"The induction of emf in a coil without physical movement of the coil is called Statically induced emf".

→ Hence in this case, conductor is at rest while flux will be variable.

The statically induced emf is further classified as:-

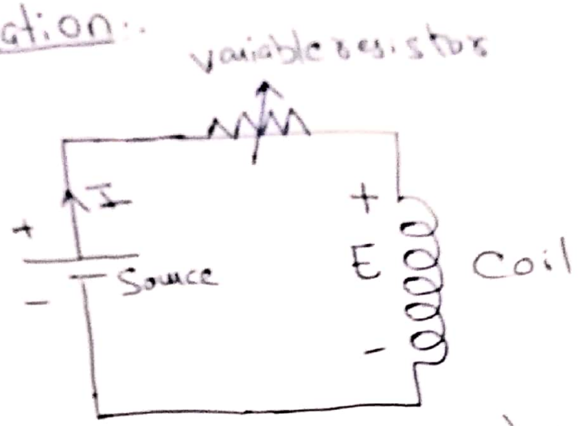
a):- Self Induced emf

b):- Mutually induced emf

Q1. Self Induced emf.

"Self induction is that phenomena in which a change in electric current in a coil produces an induced emf in the coil itself.

Explaination.



→ Consider a coil of N number of turns as shown in the above figure.

→ When the switch S, is closed and current (I) flows through the coil, it produces flux (ϕ) linking with the coil.

→ If the current flowing through the coil is changed by changing the value of variable resistor (R), the flux linking with it also change and hence emf is induced in the coil.

→ This induced emf is called self induced emf

→ The direction of this induced emf is such that it opposes its very own cause which produced it.

→ it means that it opposes the change of current in the coil. This effect is because of Lenz's law.

Since the rate of change of flux linking with the coil depends upon the rate of change of current in the coil.

$$e \propto \frac{dI}{dt}$$

or

$$e = L\frac{dI}{dt}$$

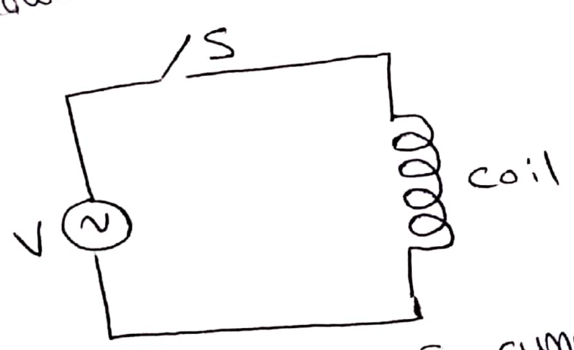
→ or by considering lenz's law

$$\boxed{e = -L\frac{dI}{dt}}$$

→ The magnitude of Self induced emf is directly proportional to the rate of change of current in the coil.

L is constant of proportionality and is called self inductance of the coefficient of self inductance or inductance of the coil.

→ Suppose we have an AC Source. Then the circuit will be drawn as:-



→ As supply is AC. So current will be variable and flux also. Hence in this case, variable resistor is not required.

we know from Faraday's Law:-

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

also $E = -L\frac{dI}{dt}$

Comparing these two. we get:-

$$-N\frac{d\phi}{dt} = -L\frac{dI}{dt}$$

$\Rightarrow$ $N\phi = LI$

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

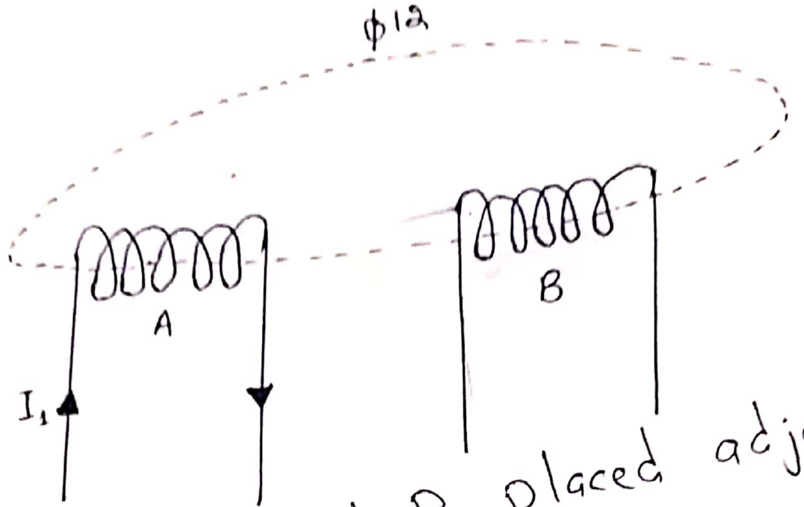
unit of inductance is Henry.

→ A coil possesses an inductance of 1H when a current through the coil is changing uniformly at a rate of 1A per sec inducing an opposing emf of 1volt in it.

(2):- Mutually Induced emf:-

"The emf induced in a coil due to the changing current in the neighbouring coil is called mutually induced emf."

Explaination:-



→ Consider two coils A and B placed adjacent to each other as shown in the fig. above.

→ If a current (I_1) flows in the coil A, a flux is step up and a part (ϕ_{12}), known as mutual flux, of this flux links the coil (B).

→ If current in the coil (A) is varied, the mutual flux also varies and hence an emf is induced in the coil (B).

→ The emf induced in coil (B) is termed as mutually induced emf.

→ Note that coil (B) is not electrically connected to coil (A). The two coils are magnetically connected.

→ The larger the rate of change of current in coil (A), the greater is the emf induced in coil B. In other words, mutually induced emf in coil B, is directly proportional to the rate of change of current in coil A, i.e.

mutually induced emf in coil B $\propto$ Rate of change of current in coil (A)

or $e_m \propto \frac{dI_1}{dt}$

$$e_m = \frac{M dI_1}{dt}$$

- Where M, is a constant called mutual inductance between the two coils.

→ The unit of mutual inductance is also Henry (H).

→ Hence mutual inductance between two coils is 1H if current changing at the rate of 1A/sec in one coil induces an emf of 1 volt in the other coil.

- By considering Lenz's law:-

→ $$e_m = -M\frac{dI_1}{dt}$$

It means that the mutually induced emf sends current in coil B, in such a direction so as to oppose the change in current in coil A.

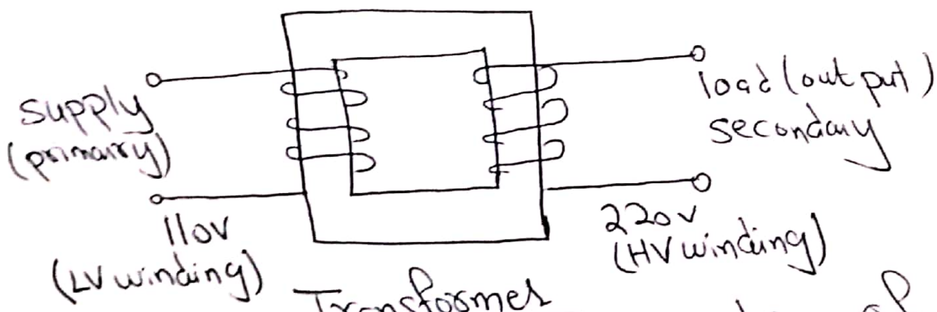
INTRODUCTION TO TRANSFORMER

→ In Power System, if we want to change the values of voltages and currents, we will need a transformer.

Definition:-

"A transformer is a static device which steps up or steps down AC voltages and currents without a change in frequency".

→ A T/R input is electrical and output is also electrical while the medium between them is a magnetic domain.



Transformer

→ A transformer mainly consists of 2 windings.

→ The winding, to which supply is given, is called primary winding.

→ The winding, where load is connected (or output is taken) is known as secondary winding

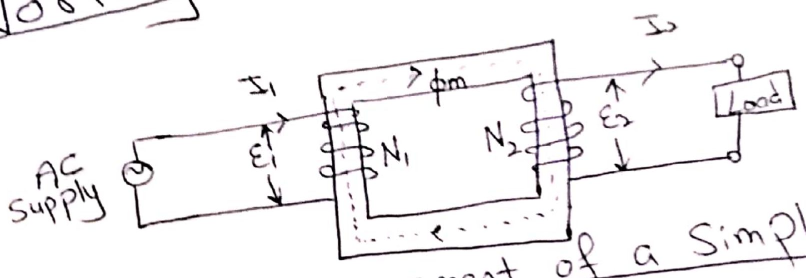
→ It should be noted that it is not necessary that the supply is always connected to left side and load on right side. If supply is connected to right side, then it will be considered primary winding.

→ Suppose if rating of primary winding of a T/R is 110v and secondary winding is 220v, then it will be written as 110v/220v.

→ In this case, the primary winding will be considered as Low voltage (LV) winding and 220v will be considered as High voltage (HV) winding. Also, this transformer will be considered as step up T/R as it is increasing the magnitude of voltage.

→ If a T/R is rated as 220v/110v, then it will be considered as step down transformer as it is decreasing the magnitude of voltage.

Working Principle of Transformer:-



Arrangement of a Simple Transformer

→ Consider two coils 1 and 2 wound on a simple magnetic circuit as shown in the above figure.

→ These two coils are insulated from each other and there is no electrical connection between them.

→ Let N_1 and N_2 be the number of turns in coil 1 and 2 respectively.

→ When a source of alternating voltage V_1 is applied to coil 1, an alternating current I_1 flows in it.

→ This alternating current produces an alternating flux ϕ_m in the magnetic circuit. The path of this flux is shown in the figure by the dotted line.

→ This alternating flux links the turns N_1 of coil 1 and induces an alternating voltage E_1 in them by self induction.

→ Also, all the flux produced by coil 1 also linkes N_2 turns of coil 2 and induces a voltage E_2 in them by mutual induction.

→ If coil 2 is connected to a load, then an alternating current will flow through it and energy will be delivered to the load.

→ Thus electrical energy is transferred from coil 1 to coil 2 by a common magnetic circuit.

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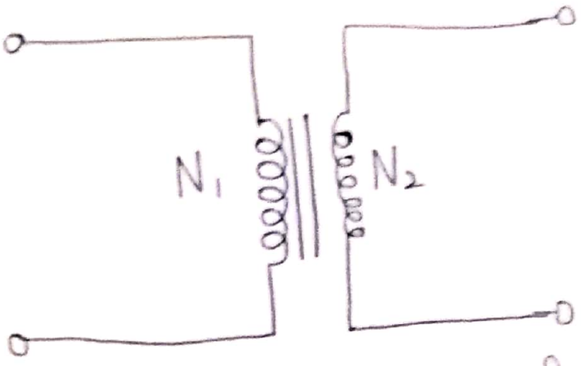


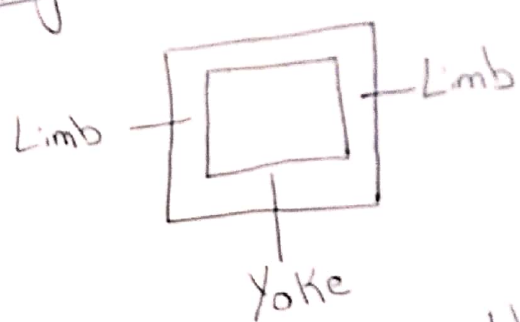
→ The circuit symbol for a two winding T/R is shown above. The two vertical bars are used to signify tight magnetic coupling between the windings.

Construction of Transformer:-

The two basic parts of a transformer are:-

i). magnetic Core (2). Windings or coils

i). Magnetic Core:-



→ Core provides path for magnetic flux (ϕ).

→ Two types of losses occur in the core namely Hysterisis loss and eddy current loss

→ These two losses are togetherly called magnetic losses or iron losses.

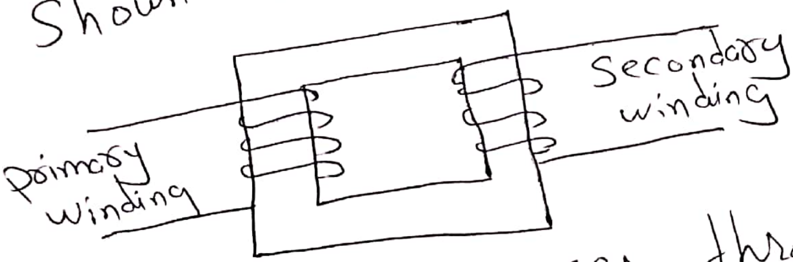
→ Generally core is made up of high grade Silicon Steel as it has high permeability and to reduce hysteresis loss

→ In the earlier days, core was made up of iron.

→ Core is made up of thin laminations in order to minimize eddy current loss.

(2):- Windings or Coils:-

→ Windings are wound over the limb of core as shown below:.



→ Electric current passes through these windings.

→ These windings are made up of copper and are insulated from each other.

→ current passing through these windings also result in I^2R losses also known as copperlosses.