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Name of the course— B.Sc. (H) Physics

Semester- IV

Name of the paper—Electrical circuits and Network Skills

Paper code-32223903

Lecture timings: 10:40 to 12:40 AM

Topics to be Covered:

- **Classification of transformer**
- **Few problems based on transformers**

Transformers can also be classified according to the type of cooling employed. The different types according to these classifications are:

Types of Transformers based on cooling method

1. Oil Filled Self-Cooled Type

Oil filled self-cooled type uses small and medium-sized distribution transformers. The assembled windings and core of such transformers are mounted in a welded, oil-tight steel tanks provided with a steel cover. The tank is filled with purified, high quality insulating oil as soon as the core is put back at its proper place. The oil helps in transferring the heat from the core and the windings to the case from where it is radiated out to the surroundings.

For smaller sized transformers the tanks are usually smooth surfaced, but for large size transformers a greater heat radiation area is needed, and that too without disturbing the cubical capacity of the tank. This is achieved by frequently corrugating the cases. Still larger sizes are provided with radiation or pipes.

2. Oil Filled Water Cooled Type

This type is used for much more economic construction of large transformers, as the above-told self-cooled method is very expensive. The same method is used here as well- the windings and the core are immersed in the oil. The only difference is that a cooling coil is mounted near the surface of the oil, through which cold water keeps circulating. This water carries the heat from the device. This design is usually implemented on transformers that are used in high voltage transmission lines. The biggest advantage of such a design is that such transformers do not require housing other than their own. This reduces the costs by a huge amount. Another advantage is that the maintenance and inspection of this type is only needed once or twice in a year.

3. Air Blast Type

This type is used for transformers that use voltages below 25,000 volts. The transformer is housed in a thin sheet metal box open at both ends through which air is blown from the bottom to the top.

Other Types of Transformers

The types of transformers differ in the manner in which the primary and secondary coils are provided around the laminated steel core of the transformer:

- Based on **winding**, the transformer can be of three types

  1. Two winding transformer (ordinary type) 2. Single winding (auto type)

  3. Three winding (power transformer)

- Based on the **arrangement of the coils,** the transformers are classified as:

  1. Cylindrical type 2. Disc type

- According to **use**

  1. Power transformer 2. Distribution transformer 3. Instrument transformer

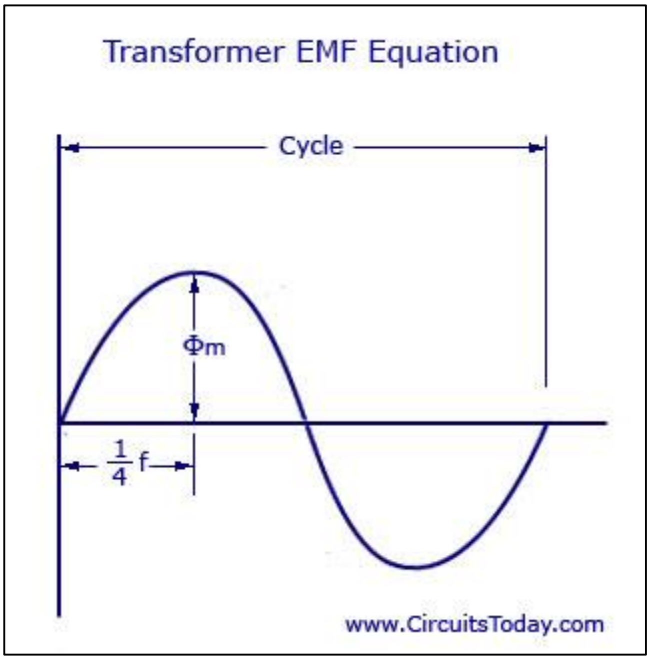
❖ **Instrument transformer** can subdivided into two types:

a) Current transformer b) Potential transformer

❖ According to the **type of cooling** (mentioned above), the transformer can be of two types

1. Natural cooling 2. Oil immersed natural cooled 3. Oil immersed natural Cooled with forced oil circulation

E.M.F Equation of a Transformer



Let,

N_A = Number of turns in primary

N_B = Number of turns in secondary

$Ø_{max}$ = Maximum flux in the core in webers = B_{max} X A

f = Frequency of alternating current input in hertz (H_Z)

As shown in figure above, the core flux increases from its zero value to maximum value $Ø_{max}$ in one quarter of the cycle , that is in ¼ frequency second.

Therefore,

Average rate of change of flux = $Ø_{max}$/ ¼ f = 4f $Ø_{max}$Wb/s

Now, rate of change of flux per turn means induced electro motive force in volts.

Therefore,

Average electro-motive force induced/turn = 4f $Ø_{max}$volt

If flux Ø varies sinusoidally, then r.m.s value of induced e.m.f is obtained by multiplying the average value with **form factor**.

Form Factor = r.m.s. value/average value = 1.11

Therefore,

r.m.s value of e.m.f/turn = 1.11 X 4f $Ø_{max}$ = 4.44f $Ø_{max}$

Now, r.m.s value of **induced e.m.f** in the whole of primary winding

= (induced e.m.f./turn) X Number of primary turns

Therefore,

$E_A = 4.44f\ N_A Ø_{max} = 4.44f N_A B_m A$

Similarly,

r.m.s value of induced e.m.f in secondary is

$E_B = 4.44f\ N_B Ø_{max} = 4.44f N_B B_m A$

In an ideal transformer on no load,

$V_A = E_A$ and $V_B = E_B$, where V_B is the terminal voltage

Voltage Transformation Ratio (K)

From the above equations we get

$E_B/ E_A = V_B/ V_A = N_B/N_A = K$

This constant K is known as voltage transformation ratio.

(1) If $N_B > N_A$, that is K>1 , then transformer is called **step-up transformer.**

(2) If $N_B < 1$, that is K<1 , then transformer is known as **step-down transformer**.

Again for an ideal transformer,

Input V_A = output V_A

$V_A I_A = V_B I_B$

Or, $I_B/I_A = V_A/V_B = 1/K$

Hence, currents are in the inverse ratio of the (voltage) transformation ratio.

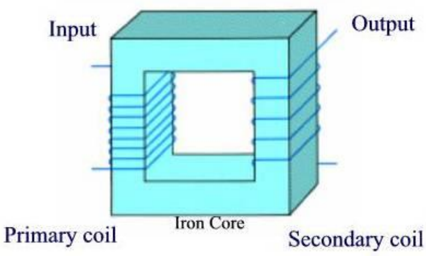
Applications of a transformer

Transformers are used in most electronic circuits. A transformer has only 3 applications;

1. To step up voltage and current.
2. To Step down voltage and current
3. To prevent DC – transformers can pass only Alternating Currents so they totally prevent DC from passing to the next circuit.

Problems:

Question 1. A transformer has 8 windings in its primary core and 5 in its secondary coil. If the primary voltage is 240 V, find the secondary voltage.



Answer: Because electric power must be the same in both coils, the following relationship must be true.

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

For this problem we only need the number of turns (N) and voltage (V).

$$\frac{N_1}{N_2} = \frac{V_1}{V_2}$$

Rearranging the equation we get $$V_2 = \frac{V_1 N_2}{N_1}$$

V_1= 240V, N_1=8 turns, N_2=5 turns

$$V_2 = \frac{V_1 N_2}{N_1} = \frac{(240\ \text{V})(5\ \text{turns})}{(8\ \text{turns})} = 150\ \text{V}$$.

Further, the problems can be solved on the following website:

http://physicstasks.eu/1548/transformer