ELECTROMAGNETICS

4. TRANSFORMER

POINTS TO REMEMBER

1. The device based on the principle of mutual induction used to change the value of alternating voltage (or e.m.f.) is defined as transformer.
2. This converts low voltage high currents into high voltage low currents and vice versa.
3. There are two coils in a transformer which are wound on the same iron core.
   A)primary coil B) secondary coil.
   Primary coil: The coil, to which the source of alternating voltage is connected, is defined as the primary coil.
   Secondary coil: The coil in which induced alternating voltage is generated is known as the secondary coil. $\frac{v_p}{v_s} = \frac{n_p}{n_s} = \frac{I_S}{I_P}$. This is known as transformer ratio.
4. Efficiency $\eta = \frac{Power\ output}{Power\ input}$.
5. **Other Salient features :**
   a. In a transformer V_S and V_P are in opposite phase i.e., a phase difference of π exists between them.
   b. In this the frequency of induced e.m.f. (output voltage) is same as that of applied e.m.f. (input voltage) i.e., $n_P=n_S$.
   c. For this the law of conservation of energy is held valid.
   d. It converts magnetic energy into electrical energy.
   e. Direct voltage or current cannot be varied with the help of this instrument.
   f. Alternating current or voltage is obtained with the help of it.
   g. Long distance transmission of electrical energy is effected with the help of it.
   h. It does not amplify power.

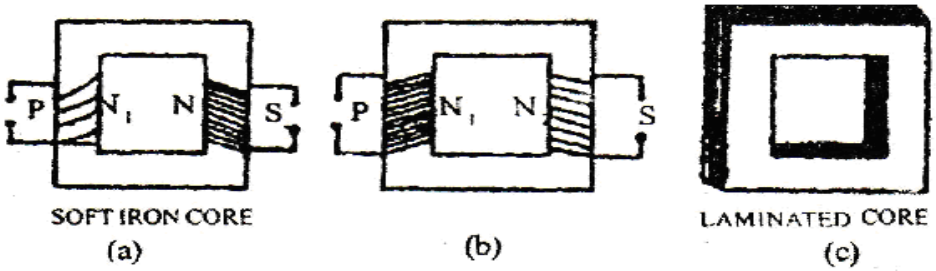
SHORT ANSWER QUESTIONS

1. State the principle on which a transformer works. Describe the working of a transformer with necessary theory.

Ans. A transformer converts high potential low currents into low voltage high currents and vice-versa. Trasformer works only for AC.

A transformer works on the principle of mutual inductance between two coils linked by a common magnetic flux.

A transformer consists of two insulated mutually coupled coils of wire wound on a continuous iron core. One of the coils is called primary coil and the other is called secondary coil. The primary is connected to e.m.f. and secondary to a load. Due to this alternating flux linkage, an e.m.f. is induced in the secondary due to mutual induction.



If N_1 *and* N_2 be number of turns in primary &secondary coils E_1 *and* E_2 be induced e.m.f. in primary and secondary coils, we have

$$\left(\frac{E_2}{E_1}\right)=\left[\frac{output\ E.m.f}{Input\ E.m.f}\right]=\frac{-N_2\left(\frac{d\phi}{dt}\right)}{-N_1\left(\frac{d\phi}{dt}\right)}=\frac{N_2}{N_1}$$

$\left(\frac{N_2}{N_1}\right)$ is called transformer ratio. If $N_2 > N_1$, then it is called a step-up transformer. If $N_2 < N_1$, then it is called a step-down transformer.

VERY SHORT ANSWER QUESTIONS

1. A transformer converts 100V A.C. into 1000V A.C. Calculate the number of turns on the secondary, if the primary has 10 turns.

Ans. $N_1 = 10$; N_2 **= ?**

$E_1 = 100\text{V}$; $E_2 = 1000\text{V}$

$$\frac{E_2}{E_1}=\frac{N_2}{N_1}\Rightarrow N_2=\frac{E_2N_1}{E_1}=\frac{1000\times10}{100}=100\,turns$$

2. What type of transformer is used in a bed lamp? (March2011)

Ans. **S**tep down transformer.

3. What is the phenomenon involved in the working of a transformer? (March2010)

Ans. A transformer works on the principle of mutual induction.

$$\frac{E_2}{E_1}=\frac{\text{Number of turns in secondary}}{\text{Number of turns in primary}}=\frac{N_2}{N_1}$$

SOLVED PROBLEMS

1. The transformation ratio of a transformer is 10 : 1. If the primary voltage is 440 V find its secondary emf. Find also the primary current if the secondary current required is 100 A assuming the transformer to be ideal.

Sol: $i)\ \frac{N_2}{N_1}=\frac{10}{1}; E_1=440V, E_2=?$

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

$$E_2=E_1\left(\frac{N_2}{N_1}\right)=440\left(\frac{10}{1}\right)=4400V.$$

ii) For an ideal transformer,

$E_1I_1 = E_2I_2$

$440\times I_1 = 4400\times100$

$I_1 = 1000A$

UNSOLVED PROBLEMS

1. A step up transformer works on 220V and gives 2A to an external resistor. The turn ratio between the primary and secondary coils is 2 : 25. Assuming 100% efficiency, find the secondary voltage. Primary current and power delivered.

Sol: $\frac{N_p}{N_n}=\frac{2}{25}$; $I_s = 2A$; $V_p = 220V$

$$\frac{V_s}{V_p}=\frac{N_s}{N_p}\Rightarrow V_s=\left(\frac{N_s}{N_p}\right)\times V_p=\frac{25}{2}\times 220=110\times 25=2750V$$

Since efficiency is 100%

$V_p I_p = V_s I_s$

$$\Rightarrow I_p=\frac{V_s I_s}{V_p}=\frac{2750\times 2}{220}=\frac{550}{22}=25A$$

Power delivered = $V_g I_g = 2750\times 2 = 5500W$

2. A step-down transformer has primary voltage 1100V. The transformation ratio is 1:5. If the primary current 10A find the secondary voltage, secondary current assuming the transformer to be an ideal transformer.

Sol: $V_p = 1100V$; $\frac{N_s}{N_p}=\frac{1}{5}$

$I_p = 10A$

$$\frac{V_s}{V_p}=\frac{N_s}{N_p}\Rightarrow V_s=\left(\frac{N_s}{N_p}\right)$$

$$V_p=\frac{1}{5}\times 1100=220V$$

For an ideal transformer $V_s I_s = V_p I_p \Rightarrow I_s=\frac{V_p I_p}{V_s}=\frac{1100\times 10}{220}=50A$

ASSESS YOURSELF

1. Can a transformer be used stepping up or down dc?

Ans. No.

2. Why is the core of a transformer laminated?

Ans. To reduce eddy current losses.