AC Devices

1 Mark Questions

1. Mention the two characteristic properties of the material suitable for making core of a transformer. [All India 2012]

Ans. (i) Low retentivity or coercivity.

(ii) Low hysterisis loss or high permeability and susceptibility.

2. What is the function of a step-up transformer? [All India 2011C]

Ans. Step-up transformer converts low alternating voltage into high alternating voltage and high alternating current into low alternating current. The secondary coil of step-up transformer has a greater number of turns that the primary ($N_S > N_P$)

3. Write any two factors responsible for energy losses in actual transformers. [Delhi 2009c]

Ans. Two factors for energy losses are

(i) eddy currents

(ii) hysterisis loss

2 Marks Questions

4.State the underlying principle of a transformer. How is the large scale transmission of electric energy over long distances done with the use of transformers? [All India 2012]

Ans. **Principle of transformer** A transformer is based on the principle of mutual induction, i.e. whenever the amount of magnetic flux linked with a coil changes, an emf is induced in the neighbouring coil.

Power transmission Electric power is transmitted over long distances at high voltage.So, step-up transformers are used at power stations to increase the voltage of power whereas a series of step-down transformers are used to decrease the voltage up to 220 V.

5.State the principle of working of a transformer. Can a transformer be used to step-up or step-down a DC voltage? Justify your answer. [All India 2011]

Ans. (i) For principle of transformer A transformer is based on the principle of mutual induction, i.e. whenever the amount of magnetic flux linked with a coil changes, an emf is induced in the neighbouring coil.

(ii) No, transformer cannot be used to change DC voltage. This happens because DC voltage cannot change flux linked with primary or secondary coils.

6. Mention various energy losses in a transformer. [All India 2011]

Ans. Energy losses in transformer:

(i) **Eddy current loss** Eddy current in iron core of transformer facilitates the loss of energy in the form of heat.

(ii) **Flux leakage** Total fluxes linked with primary do not completely pass through the secondary which denotes the loss in the flux.

(iii) **Copper loss** Due to heating, energy loss takes place in copper wires of primary and secondary Coils.

(iv) **Hysterisis loss** The energy loss takes place in magnetizing and demagnetising the iron core over every cycle.

(v) **Humming loss** The magnetostriction effect leads to set core in vibration which in turn produced the sound. This loss is referred as humming loss.

5 Marks Questions

7. (i) Draw a schematic arrangement for winding of primary and secondary coils in a transformer when the two coils are wound on top of each other.

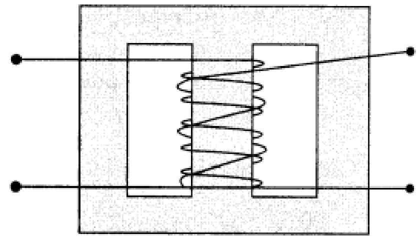
(ii) State the underlying principle of a transformer and obtain the expression for the ratio of secondary to primary voltage in terms of the

- **number of secondary and primary windings and**
- **primary and secondary currents.**

(iii) Write the main assumption involved in deriving the above relations.

(iv) Write any two reasons due to which energy losses may occur in actual transformers. [HOTS]

Ans. (i) The schematic arrangement of a transformer is shown as below:



(*ii*) Principle of transformer

Refer to ans. 4. **(2)**

Working when an alternating current is passed through the primary, the magnetic flux through the iron core changes, which does two things, produces emf in the primary and an induced emf is set up in the secondary. If we assume that the resistance of primary is negligible, then the back emf will be equal to the voltage applied to the primary.

(a) $\therefore V_1 = -N_1 \frac{d\phi}{dt}$

and $V_2 = -N_2 \frac{d\phi}{dt}$

where, N_1 and N_2 are number of turns in the primary and the secondary coils respectively while V_1 and V_2 are their voltages respectively.

(*b*) But for ideal transformers,

$$V_1 I_1 = V_2 I_2$$

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

(iii) Main assumptions

- The primary resistance and current are small.
- The flux linked with primary and secondary coil is some where is no leakage of flux from

the core.

- secondary current is small

(iv) Energy losses in transformer:

(i) **Eddy current loss** Eddy current in iron core of transformer facilitates the loss of energy in the form of heat.

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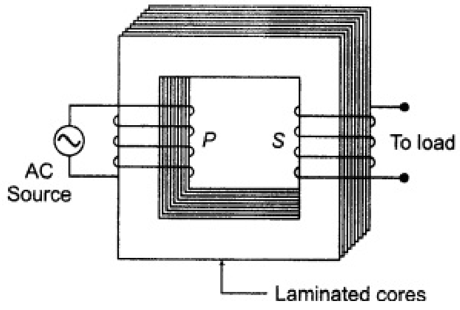
(v) **Humming loss** The magnetostriction effect leads to set core in vibration which in turn produced the sound. This loss is referred as humming loss.

8. (i) State the principle of a step-up transformer. Explain with the help of a labelled diagram, its working.

(ii) Describe briefly and two energy losses giving the reasons for their occurrence in actual transformer. [Foreign 2012]

Ans. **Principle of transformer** A transformer is based on the principle of mutual induction, i.e. whenever the amount of magnetic flux linked with a coil changes, an emf is induced in the neighbouring coil.



9. With the help of a labelled diagram, describe briefly the underlying principle and working of a step-up transformer.

(ii) Write any two sources of energy loss in a transformer, (iii) A step-up transformer converts a low input voltage into a high output voltage. Does it violate law of conservation of energy? Explain. [Delhi 2011]

Ans.(i) **Principle of transformer** A transformer is based on the principle of mutual induction, i.e. whenever the amount of magnetic flux linked with a coil changes, an emf is induced in the neighbouring coil.

(ii) Two factors for energy losses are

- eddy currents
- hysterisis loss

(iii) No, it does not violate the law of conservation of energy because voltage increase is accompanied by decrease in it. In alternative, currrent in such a way for an ideal transformer input power equals to the output power.

10. (i) Draw a schematic diagram of a step-up transformer. Explain its working principle. Assuming the transformer to be 100% efficient, obtain the relation for

- **the current in the secondary in terms of the current in the primary and**
- **the number of turns in the primary' and secondary windings.**

(ii) Mention two important energy losses in actual transformers and state how these can be minimized? [All India 2009C; Foreign 2009]

Ans. Principle of transformer A transformer is based on the principle of mutual induction, i.e. whenever the amount of magnetic flux linked with a coil changes, an emf is induced in the neighbouring coil.

(a) Let alternating current, alternating voltage and number of turns in primary and secondary coils are (I_P, I_S), (V_P, V_S) and (N_P, N_S), respectively.
For 100% efficient transformer,
Input power = Output power

$$\Rightarrow \quad V_P I_P = V_S I_S$$

Also, assuming transformation ratio of transformer is r.

$$r = \frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{I_P}{I_S}$$

$$\Rightarrow \quad I_P = \frac{V_S}{V_P} \times I_S$$

(1/2)

(b) $$r = \frac{N_S}{N_P}$$

(1/2)

(ii) Two energy loses in the actual transformers

- **Hysterisis loss** Loss of energy in magnetising and demagnetising the core of transformer in every cycle. It can be minimised by taking core of soft iron having low coercivity, retentivity and hysterisis loop.

- **Eddy current** Energy loss in the form of heat due to eddy current. It can be minimised by taking laminated core consisting of insulated rectangular sheets, piled-up one over another.

11. Draw a schematic diagram of a step-up transformer. Explain its working principle. Deduce the expression for the secondary to primary voltage in terms of the number of turns in the two coils.

In an ideal transformer, how is this relation related to the currents in the two coils.

How is the transformer used in large scale transmission and distribution of electrical energy

over the long distances? [All India 2010]

Ans.

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(a) Let alternating current, alternating voltage and number of turns in primary and secondary coils are (I_P, I_S), (V_P, V_S) and (N_P, N_S), respectively.

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$$r = \frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{I_P}{I_S}$$

$$\Rightarrow \quad I_P = \frac{V_S}{V_P} \times I_S$$ **(1/2)**

(b) $$r = \frac{N_S}{N_P}$$ **(1/2)**

(ii) Two energy loses in the actual transformers

- **Hysterisis loss** Loss of energy in magnetising and demagnetising the core of transformer in every cycle. It can be minimised by taking core of soft iron having low coercivity, retentivity and hysterisis loop.
- **Eddy current** Energy loss in the form of heat due to eddy current. It can be minimised by taking laminated core consisting of insulated rectangular sheets, piled-up one over another.

Step-up transformers are used at generating stations so as to transmit the power at high voltage to minimise the loss in the form of heat, whereas series of step-up transformers are used at receiving ends

12 .A step-up down transformer operated on a 2.5 kV line. It supplies a load with 20 A. The ratio of the primary winding to the secondary is 10 :1. If the transformer is 90% efficient, calculate

- **the power output**
- **the voltage and**
- **the current in the secondary coil. [Foreign 2010]**

Given, input voltages, $V_P = 2.5 \times 10^3$ V **(3)**

Input current, $I_P = 20$ Asss

Also, $\frac{N_P}{N_S} = \frac{10}{1} \Rightarrow \frac{N_S}{N_P} = \frac{1}{10}$ ...(i) **(1/2)**

Percentage efficiency

$$= \frac{\text{Output power}}{\text{Input power}} \times 100$$

$$\Rightarrow \frac{90}{100} = \frac{\text{Output power}}{V_P I_P}$$

(i) Output power $= \frac{90}{100} \times (V_P I_P)$

$$= \frac{90}{100} \times (2.5 \times 10^3) \times (20 \text{ A}) = 4.5 \times 10^4 \text{ W}$$ **(1/2)**

(ii) $\therefore \frac{V_S}{V_P} = \frac{N_S}{N_P} \Rightarrow V_S = \frac{N_S}{N_P} \times V_P$

Voltage $V_S = \frac{1}{10} \times 2.5 \times 10^3 \text{V} = 250$ V **(1/2)**

(iii) $V_S I_S = 4.5 \times 10^4$ W

Current, $I_S = \frac{4.5 \times 10^4}{V_S} = \frac{4.5 \times 10^4}{250}$

$I_S = 180$ A **(1/2)**