TRANSFORMER

Transformer :-

→ A transformer is a static piece of equipment used for either raising or lowering the voltage of an ac supply with a corresponding decrease or increase in current.

→ It consists of two windings, primary winding and secondary winding.

→ These windings are wound on a common laminated magnetic core.

→ The winding connected to A.C. supply is called primary winding. and the one connected to load is called secondary winding.

→ The alternating voltage V_p whose magnitude to be changed is applied to primary and Alternating e.m.f induced in the secondary is V_s (or) E_s. (Ideally both are equal in magnitude).

→ The current in primary is I_p and in secondary is I_s.

→ The No. of turns in primary is N_p and in secondary is N_s.

working of Transformer :-

→ When an alternating voltage V is applied to the primary winding, an alternating flux ϕ is set up in the core.

→ This Alternating flux links both the windings and induces the e.m.fs E_p and E_s in them according to Faraday's law of electromagnetic induction.

→ The E.m.f E_p is termed as primary E.m.f and E_s is termed as secondary e.m.f

$$E_p = -N_p \cdot \frac{d\phi}{dt}$$

$$E_s = -N_s \cdot \frac{d\phi}{dt}.$$

$$\therefore \boxed{\frac{E_s}{E_p} = \frac{N_s}{N_p}} \longrightarrow (1)$$

→ The Magnitudes of E_s and E_p depends on number of turns on secondary and primary.

TYPES of Transformer :-

Step up transformer :-

The transformer in which primary voltage is less than secondary voltage (or) primary turns are less than secondary turns is known as step up transformer.

i.e $\boxed{N_p < N_s}$ or $\boxed{I_p > I_s}$ or $\boxed{E_p < E_s}$

step down transformer :-

The transformer in which primary voltage is greater than secondary voltage (or) primary turns are greater than secondary turns is known as step down transformer.

i.e $\boxed{N_p > N_s}$ or $\boxed{E_p > E_s}$ or $\boxed{I_p < I_s}$

An Isolation transformer :-

An Isolation transformer passes the signal unchanged. (Refer Earl gates)

i.e $\boxed{N_p = N_s}$ or $\boxed{E_p = E_s}$ or $\boxed{I_p = I_s}$

THEORY OF AN IDEAL TRANSFORMER :-

In an Ideal transformer, the following cases will occur

i) No winding Resistance

ii) No leakage flux

iii) NO iron losses.

In transformer (Ideal), the input power = output power.

i.e $E_p I_p = E_s I_s$.

$$\Rightarrow \boxed{\frac{E_p}{E_s} = \frac{I_s}{I_p}} \longrightarrow (2)$$

From Eq (1) and Eq (2).

$$\boxed{\frac{E_s}{E_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}}$$

Note :- A transformer changes the voltage and current of AC only but it can't change their frequency.

TURN'S RATIO :-

The turns Ratio is the number of turns in the secondary winding divided by the number of turns in the primary winding. It can be expressed as following :

$$\boxed{\text{Turn's Ratio} = \frac{N_s}{N_p}}$$

As per Earl gate Text book.

Relation Between Input and output impedances :-

$$Z_i = \frac{E_p}{I_p} \quad ; \quad Z_o = \frac{E_s}{I_s}.$$

where Z_o = load Impedance
Z_i = Source Impedance.

$$\frac{Z_o}{Z_i} = \frac{E_s}{I_s} \cdot \frac{I_p}{E_p}.$$

$$= \frac{E_s}{E_p} \cdot \frac{I_p}{I_s} = \frac{N_s}{N_p} \cdot \frac{N_s}{N_p} = \left(\frac{N_s}{N_p}\right)^2.$$

$$\boxed{\frac{Z_o}{Z_i} = \left(\frac{N_s}{N_p}\right)^2}$$

Applications of Transformer :-

Transformer applications include :

i) Impedance Matching.

ii) phase shifting.

iii) Isolation.

iv) Blocking DC while passing AC, and producing several signals at different voltage levels etc..

NUMERICALS :-

(Q). A transformer has 500 turns in primary and 1000 turns in Secondary. If 120 volt ac is applied to primary

(a) what is the Induced Secondary voltage ?

(b) Is it step up or step down ?

Sol:- (a) $\frac{N_s}{N_p} = \frac{E_s}{E_p} \Rightarrow \frac{1000}{500} = \frac{E_s}{120} \Rightarrow E_s = \frac{1000}{500} \times 120 = 240V$ ac.

$E_s = 240$ volt ac

(b) $E_s > E_p$. So It is step up transformer.

(Q) A transformer has 500 turns in primary and 1000 turns in Secondary. If the primary has a current of 100 milli ampers, How much current flows in the Secondary ?

Sol:- $\frac{N_s}{N_p} = \frac{I_p}{I_s} \Rightarrow \frac{1000}{500} = \frac{100 \times 10^{-3}}{I_s}$.

$\Rightarrow I_s = \frac{500}{1000} \times 100 \times 10^{-3} A = 50 \times 10^{-3} A$

$= 50$ milli Ampere.

(9) What must the turns ratio of a transformer be to match a 4-ohm Speaker to a 100 Ω ~~tea~~ source?

Sol:-

$Z_o = 4\Omega$; $Z_i = 100\Omega$. $\frac{N_s}{N_p} = ?$

$$\frac{Z_o}{Z_i} = \left(\frac{N_s}{N_p}\right)^2 \Rightarrow \frac{N_s}{N_p} = \left(\frac{4}{100}\right)^{1/2} = \left(\frac{1}{25}\right)^{1/2} = \frac{1}{5}$$

NOTE:-

1. Transformers are rated in VA. i.e Volt-Ampere. (or) kVA. (VIMP MCQ)
   i.e kilo Volt-Ampere.
2. If we Apply DC voltage to a transformer, output voltage is Zero (VIMP MCQ)
   (or) Transformer Coil burns.

IMP QUESTIONS (ETE)

1. Explain Construction, working, Types, Applications of transformer and its Numericals.
   Refer: Text book. for diagrams and theory.

In ETE exam, write diagramatic explination and More diagrams of transformer.