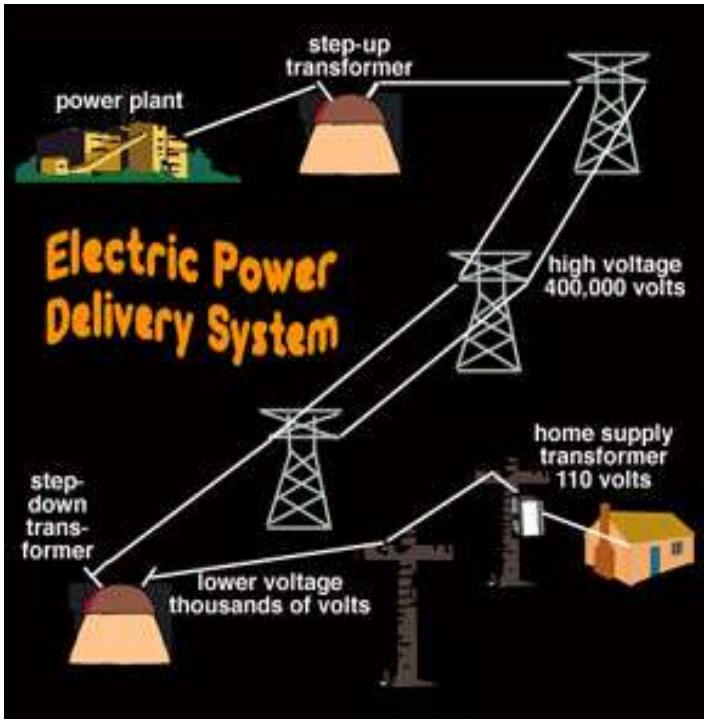
TRANSFORMERS

CONTENTS

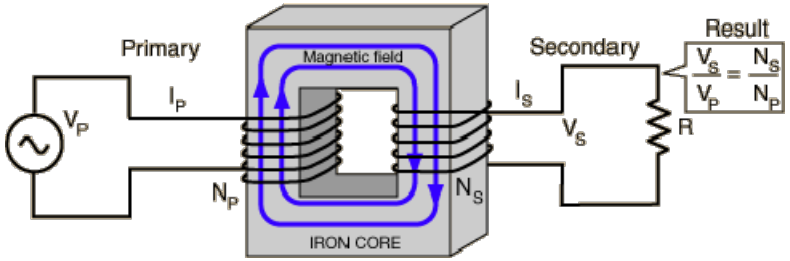
What is Transformer?

- An Electrical device which changes given an Alternating emf into larger or smaller alternating emf.
- It is like a power converter that transfers electrical energy from one circuit to another through inductive coupled conductors. i.e transformer's coils.
- Transformers are used in our homes to keep voltage upto 220 volt.
- Transformer helping to form a safe Electric Power system is shown in Figure:



CONSTRUCTION

- It consists of an iron core on which two separate coils of insulated copper wire are wound.
- The Coil to which A.C power voltage is supplied is Primary Coil.
- The Coil to which this power is delievered to circuit is Secondary Coil.
- The Secondary Coil has a load resistance connected to safe transformer from being heating up.
- These coils have no electrically linked as they have magnetical links.
- Construction of a simple transformer can be seen from figure:

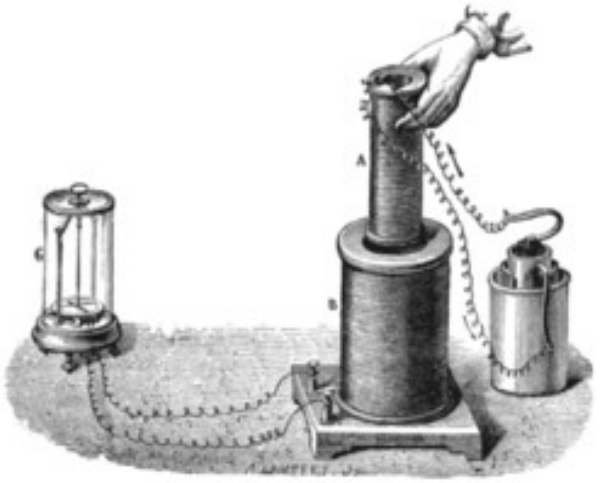


PRINCIPLE

- **The Transformer works on the principle of Mutual Induction that changing Current in Primary coil induces an emf in Secondary Coil**.
- Micheal Faraday laid foundation of this basic principle in 1831.
- Faraday performed the first experiments on induction between coils of wire, including winding a pair of coils around an iron ring, thus creating the first closed-core transformer. However he only applied individual pulses of current to his transformer, and never discovered the relation between the turns ratio and EMF in the coils.
- The turn ratio of transformer can be given as:

$$\frac{V_{\mathrm{s}}}{V_{\mathrm{p}}} = \frac{N_{\mathrm{s}}}{N_{\mathrm{p}}}.$$

- Faraday's experiment with two induction between coils of wire is shown:



POWER

- Power in Ideal Transformer:

- The electrical power in a transformer is transformed form its primary to Secondary coil by changing of flux.

- For an Ideal Transformer, the power input from primary is nearly equal to the power output from Secondary. i.e.

Power input=Power Output

$$P_{\text{incoming}} = I_{\text{p}}V_{\text{p}} = P_{\text{outgoing}} = I_{\text{s}}V_{\text{s}},$$

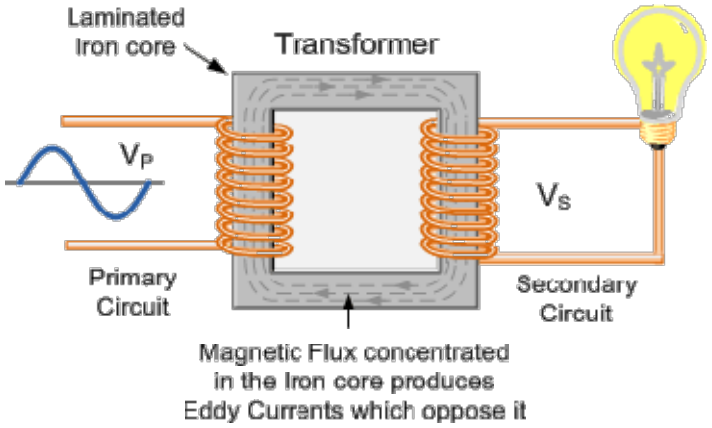
giving the ideal transformer equation

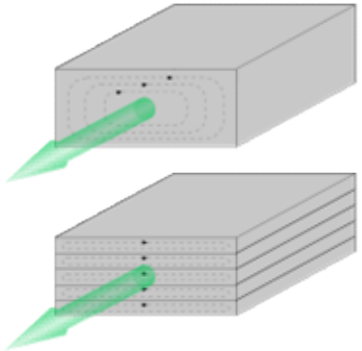
$$\frac{V_{\text{s}}}{V_{\text{p}}} = \frac{N_{\text{s}}}{N_{\text{p}}} = \frac{I_{\text{p}}}{I_{\text{s}}}.$$

POWER LOSES

1. EDDY CURRENTS

- By Changing Flux through a solid conductor, induced currents are set up within the body of a conductor in a direction perpendicular to the flux which are eddy currents.
- Since our iron core is ferromagnetic material, so it allows these currents to pass through the whole body of conductor causing heating of core of conductor.
- This is a power loss in transformer(shown as in figure 1), to reduce this the core should be made of lamination sheets which stop the flow of eddy currents (shown as in figure 2).

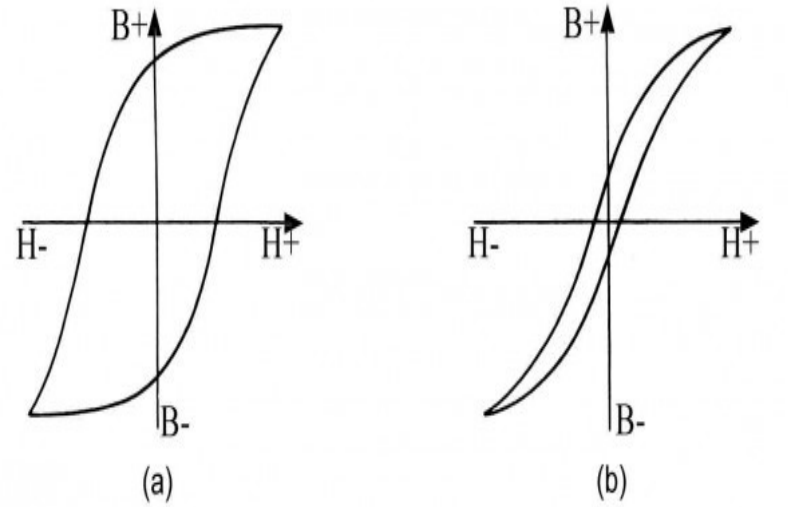




POWER LOSES

1. HYSTERESIS LOSS

- The energy spent in magnetisation and demagnetisation of the core of transformer is called hysteresis loss.
- This loss in energy is expressed by using B-H(magnetic flux density B and flux density H) curve for a specific ferromagnetic material.
- For reducing this loss, we should use such a soft material for core whose hysteresis loop is very small.
- The hysteresis loops of both hard and soft magnetic materials are shown respectively, which shows that soft magnetic materials have small hysteresis loss of energy.



HISTORY

- In 1831, Micheal faraday and Joseph Henry independently gave the principle of transformer in the form of electromagnetic induction showing:

$$|\mathcal{E}| = \left| \frac{d\Phi_B}{dt} \right|$$

where ε is the magnitude of the EMF in volts and ΦB is the magnetic flux through the circuit in webers.

- The first type of transformer to see wide use was the induction coil, invented by Rev. Nicholas Callan of Maynooth College, Ireland in 1836.

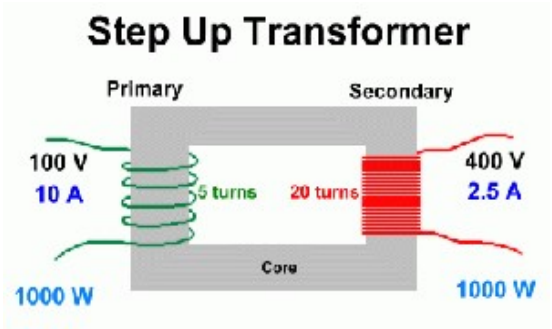
Between the 1830s and the 1870s, efforts to build better induction coils, mostly by trial and error, slowly revealed the basic principles of transformers.

TYPES OF TRANSFORMER

- STEP UP TRANSFORMER

- A transformer in which voltage across secondary is greater than primary voltage is called a step-up transformer (shown in figure)

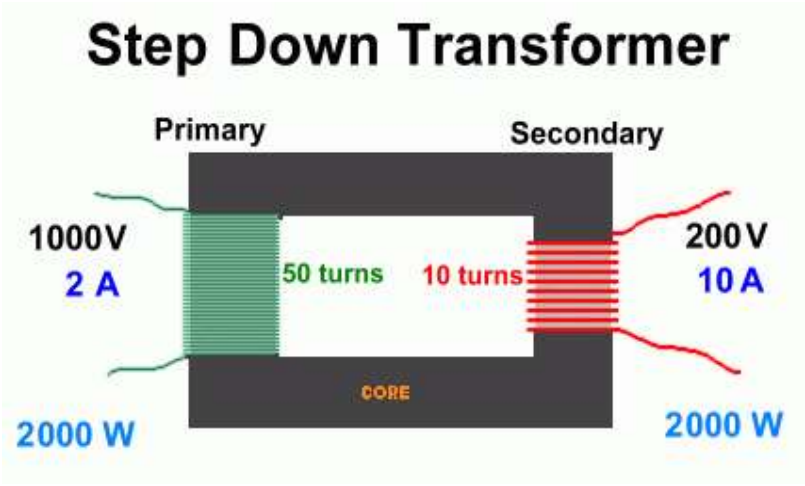
- In this type of transformer, Number of turns in secondary coil is greater than that in Primary coil, so this creates greater voltage across secondary coil to get more output voltage than given through primary coil.



TYPES OF TRANSFORMER

- STEP DOWN TRANSFORMER

- A transformer in which voltage across secondary is lesser than primary voltage is called a step-down transformer (shown in figure)
- In this type of transformer, Number of turns in secondary coil is lesser than that in Primary coil, so this creates lesser voltage across secondary coil, so we get low output voltage than given through primary coil.



APPLICATIONS

- As Described earlier in slide no 3 that transformer help us in making a safe electric power system which is used to transfer electricity over long distances. An electrical substation in Melbourne, Australia showing 3 of 5 220kV/66kV transformers, each with a capacity of 185MVA

  (shown in figure)
- Transformers with several secondaries are used in television and radio receivers where several different voltages are required.