Transformers

&

AC Machines

Lecture-31
Principle of Operation of a Transformer

Lecture delivered by:

Topics

- Transformers Introduction
- Constructional Details
- Transformer Operation
- Classification of Transformers
- Application Examples of Transformer

Objectives

At the end of this lecture, student will be able to:

- State the meaning of "Transformer action”
- Describe physical characteristics of a transformer, including the basic parts, main core types and winding types
- Name the source and load windings of a transformer
- Explain the principle of operation of a transformer
- Classify the transformer based on turns ratio

Transformer

- **Transformer** is a static device that changes ac electric power at one voltage level to ac electric power at another voltage level through the action of a magnetic field.
- Transformer works on the principle of **Faraday's Law Of Electromagnetic Induction**.
- **Faraday's Law,** "Rate of change of flux linkage with respect to time is directly proportional to the induced EMF in a conductor or coil"

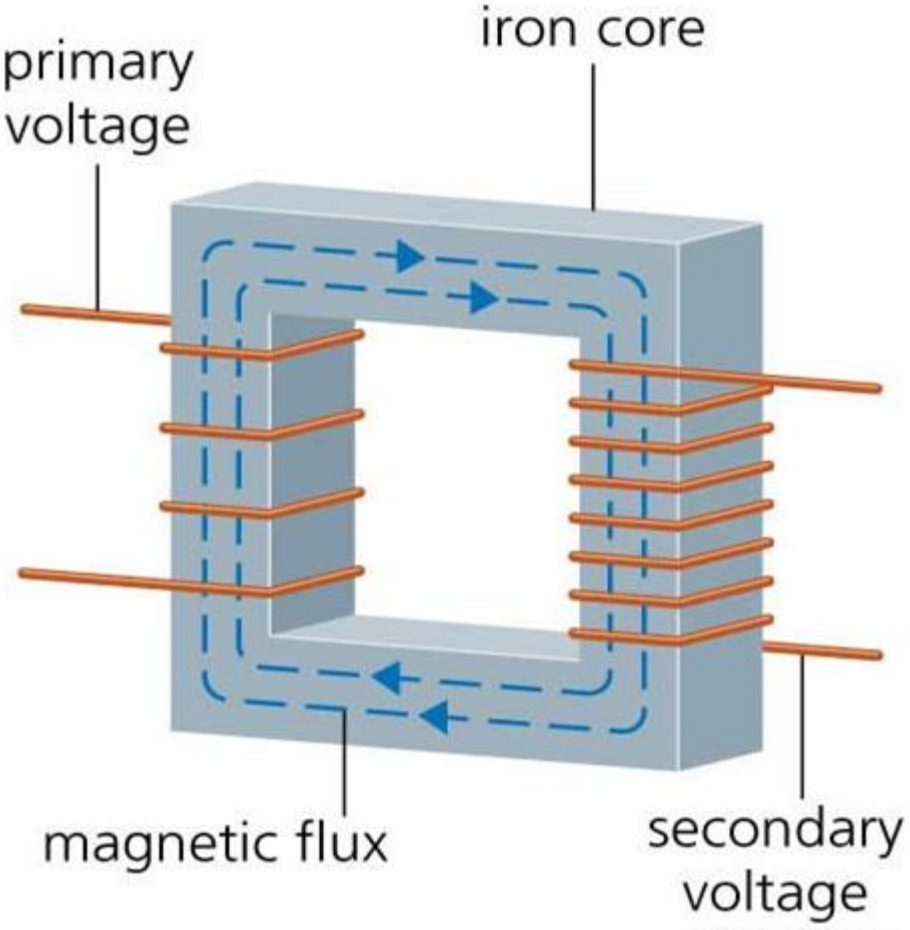
Transformer Uses

Changing

- Voltage Levels
- Current Levels
- Impedance values

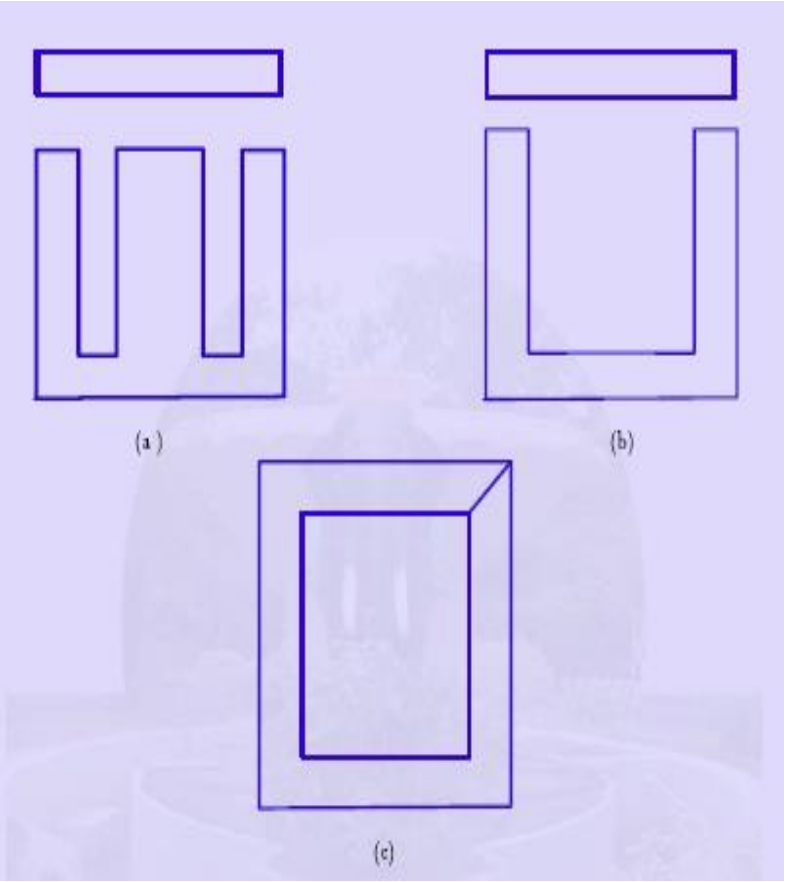
Constructional Details

Basic Structure of Transformer

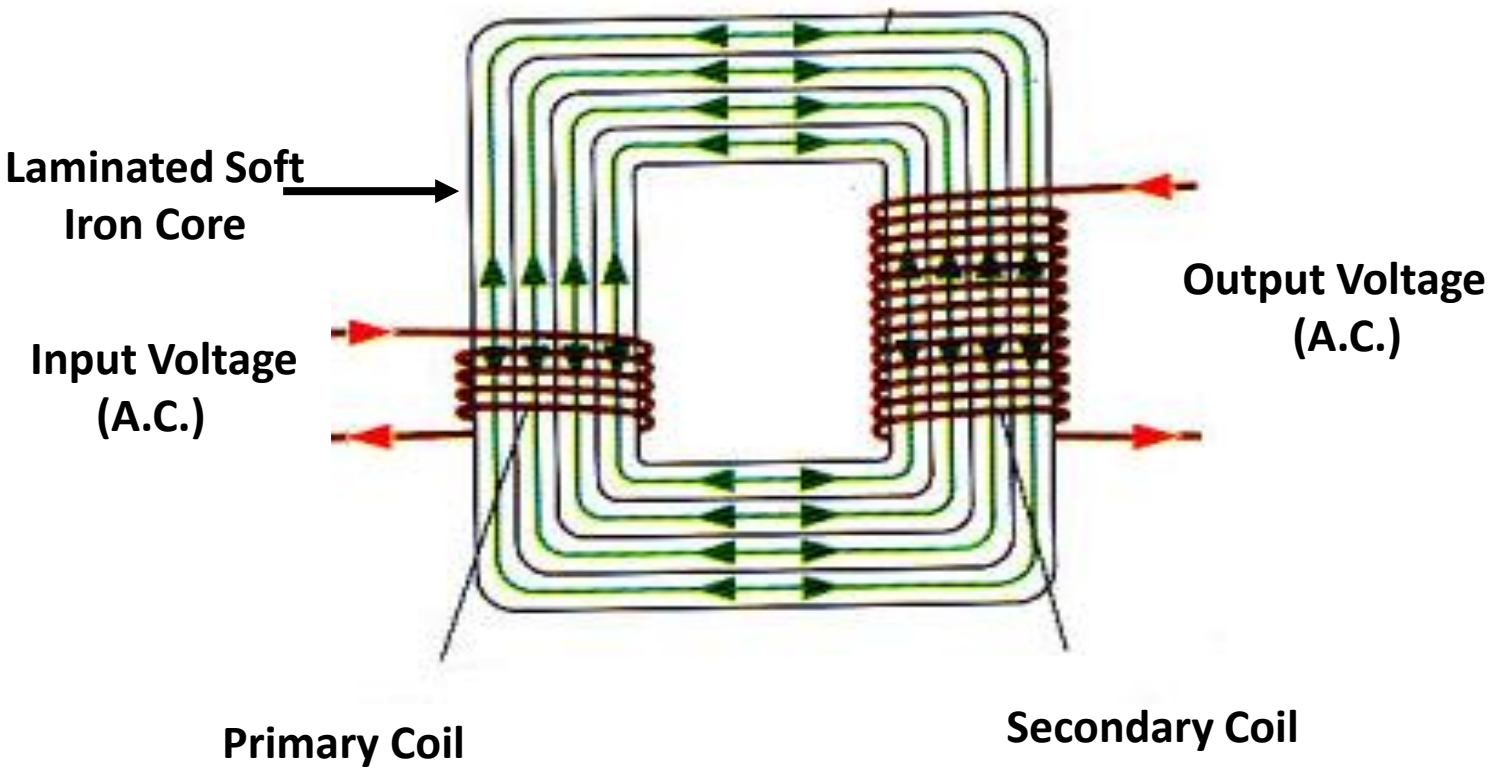


Constructional Details

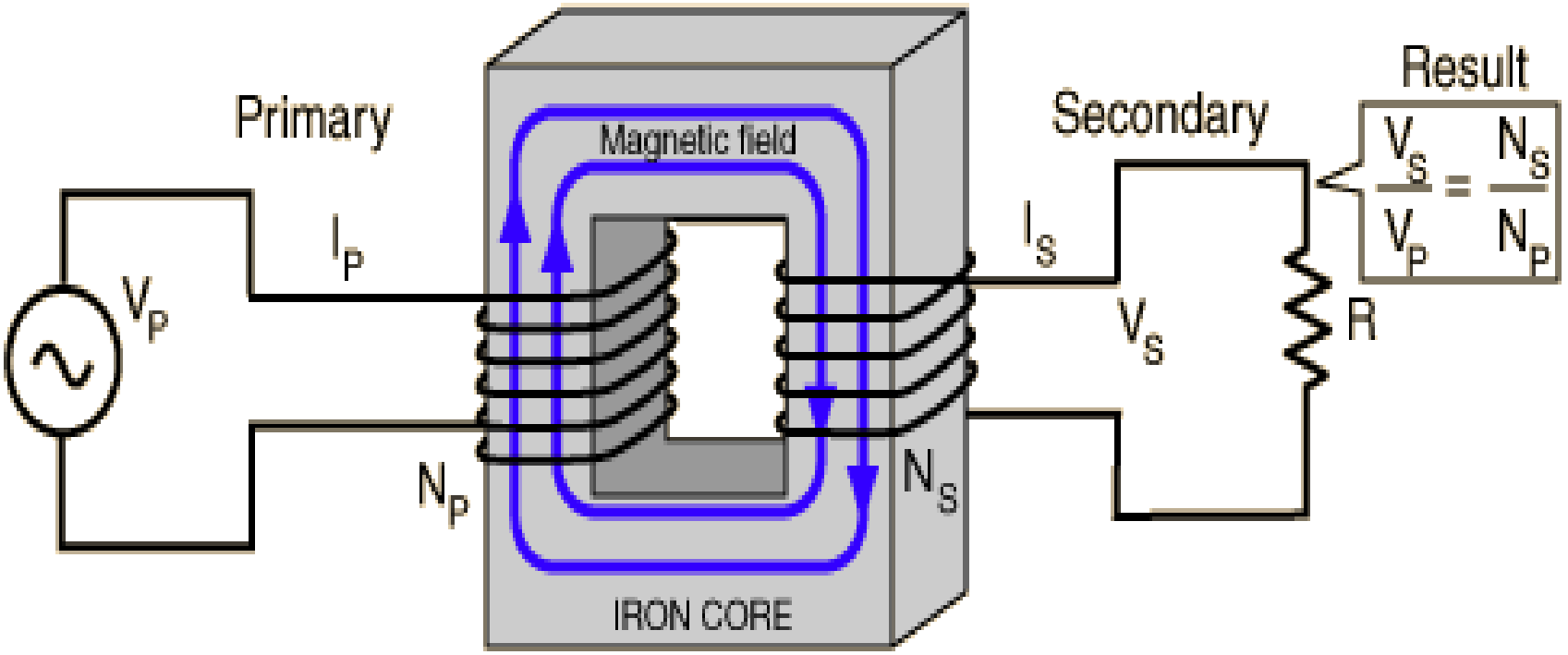
- Requirements of magnetic material are,
  - **High permeability**
  - **Low reluctance**
  - **High saturation flux density**
  - **Smaller area under B-H curve**
- For small transformers, the laminations are in the form of E,I, C and O.



How Transformer Works

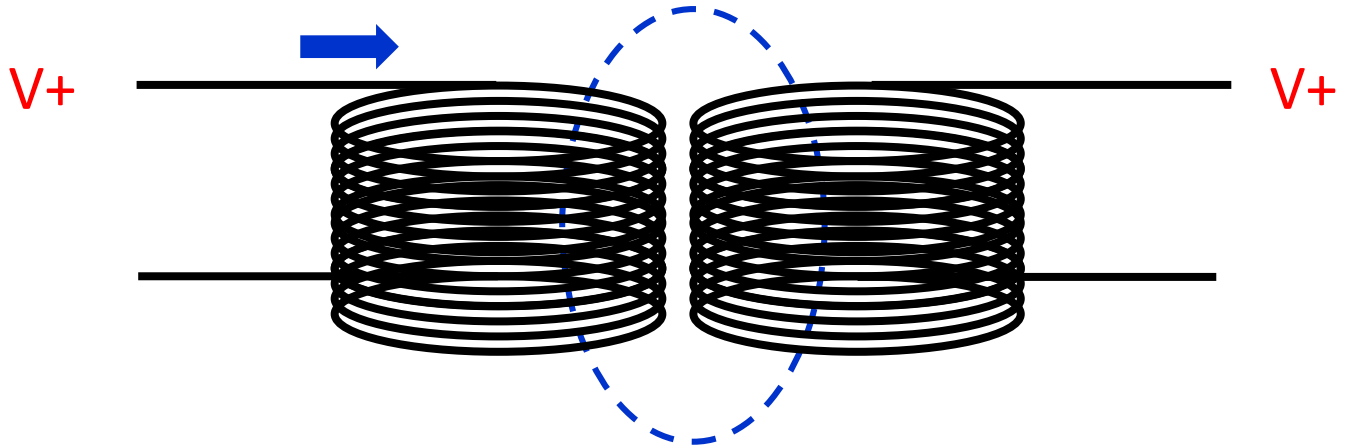


Transformer Operation



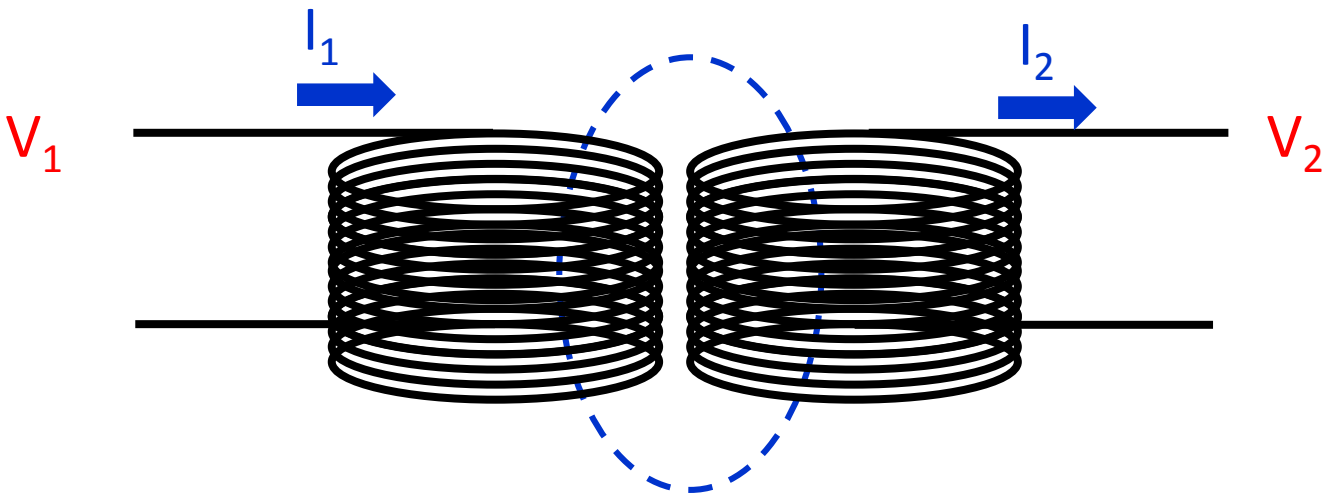
Transformer Operation

- Primary coil is supplied with a AC voltage.
- Current drawn produces a magnetic field
- Magnetic field transported to a secondary coil via a magnetic circuit
- Magnetic field induces a voltage in secondary coil

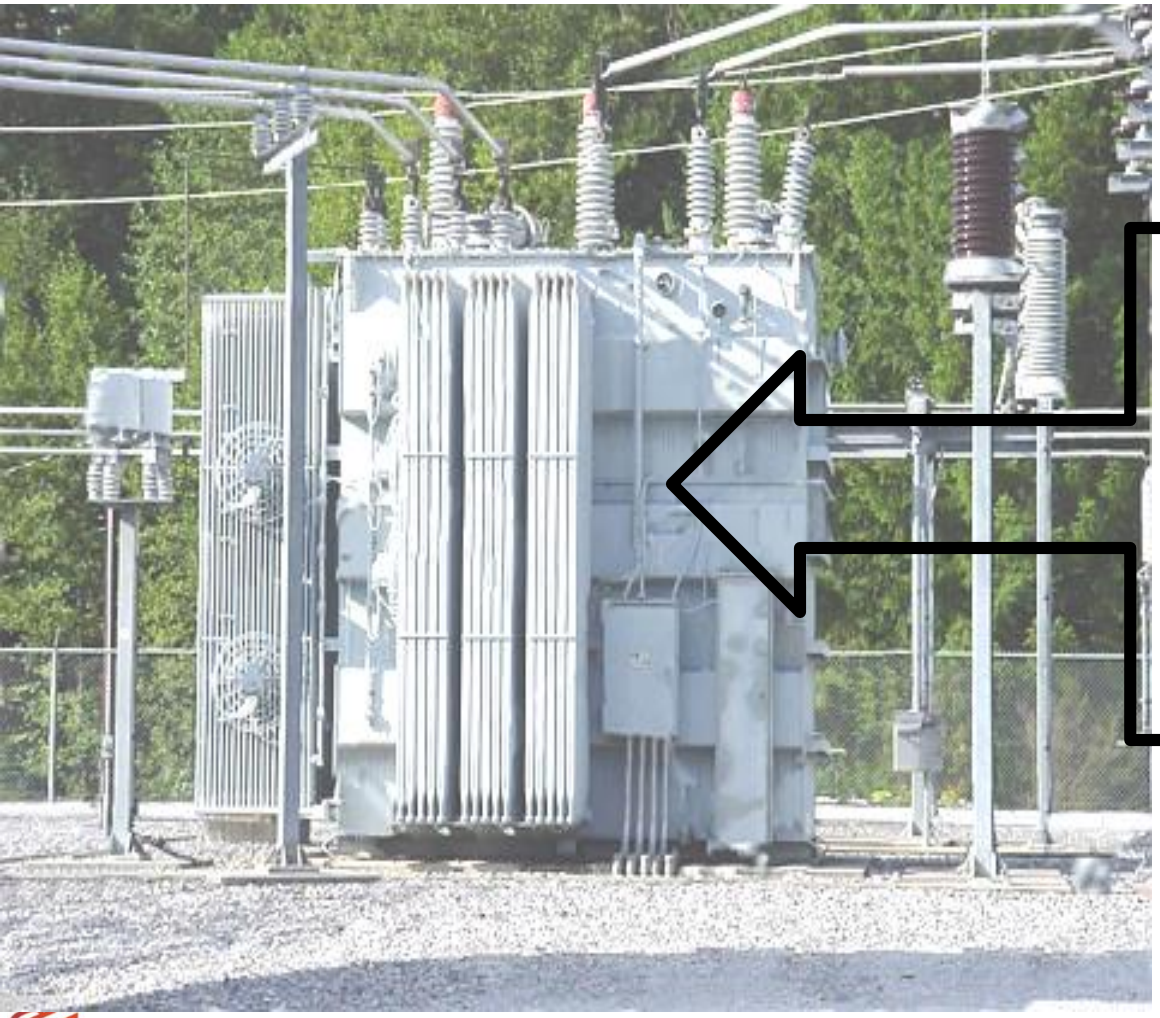


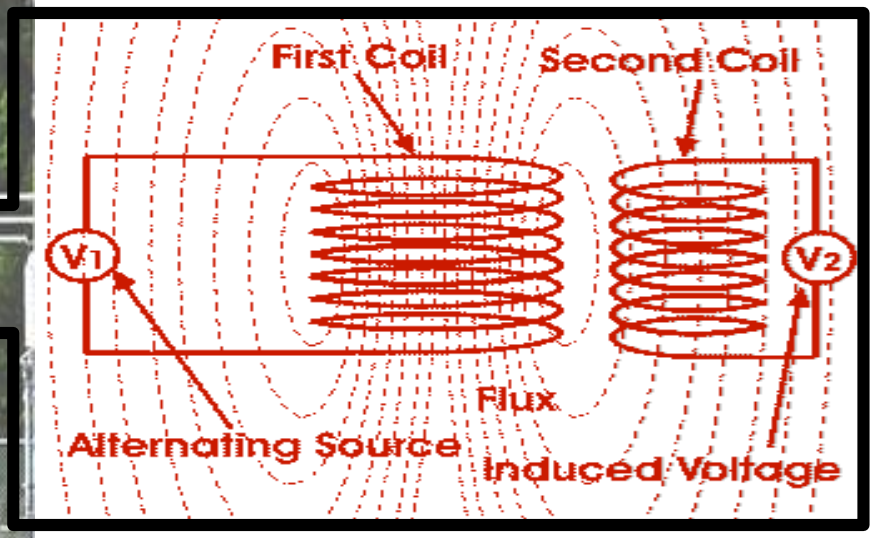
Transformer Operation

- Primary coil normally has a subscript of 1
- Secondary coil has a subscript of 2



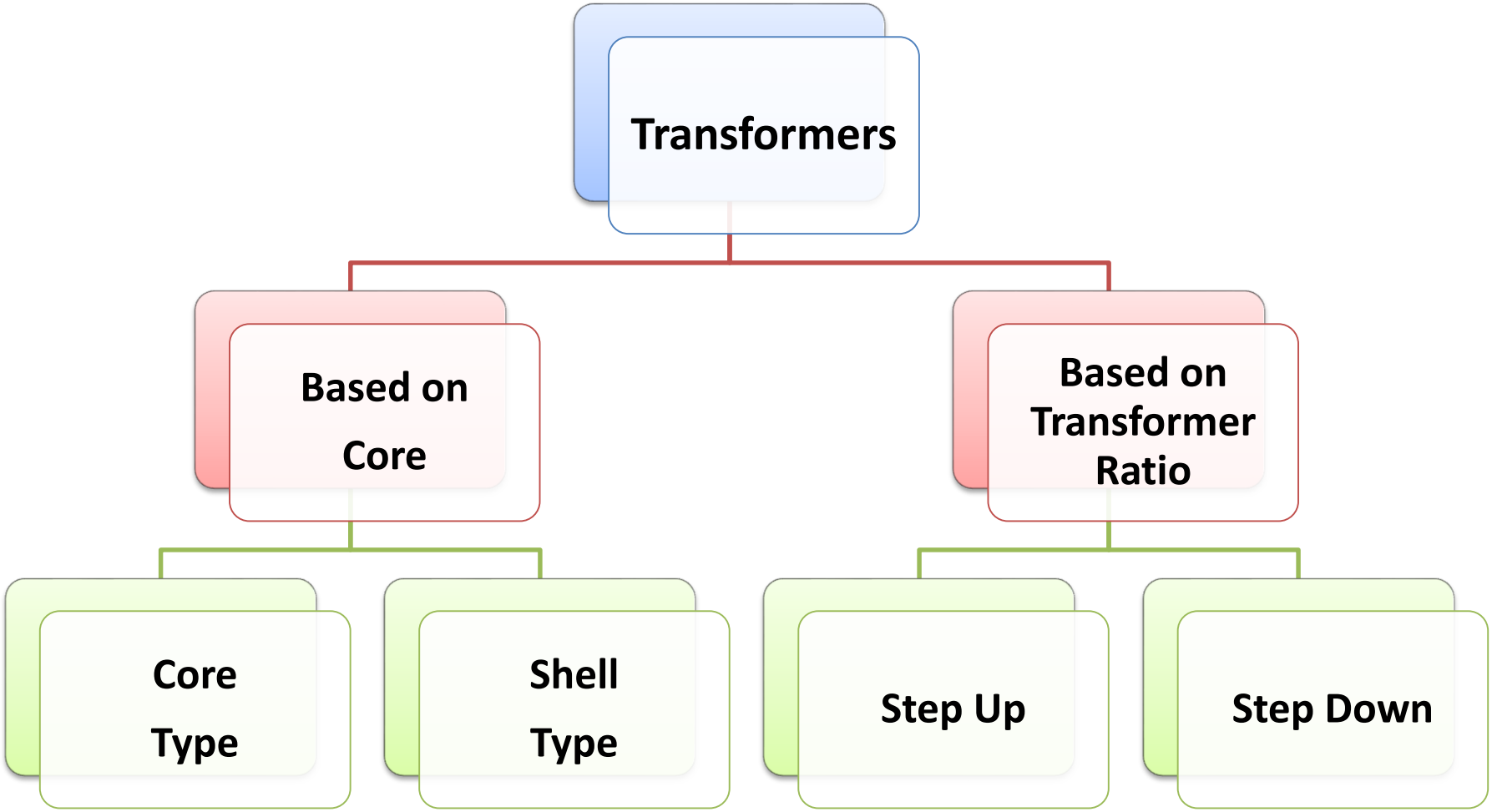
Working Transformer





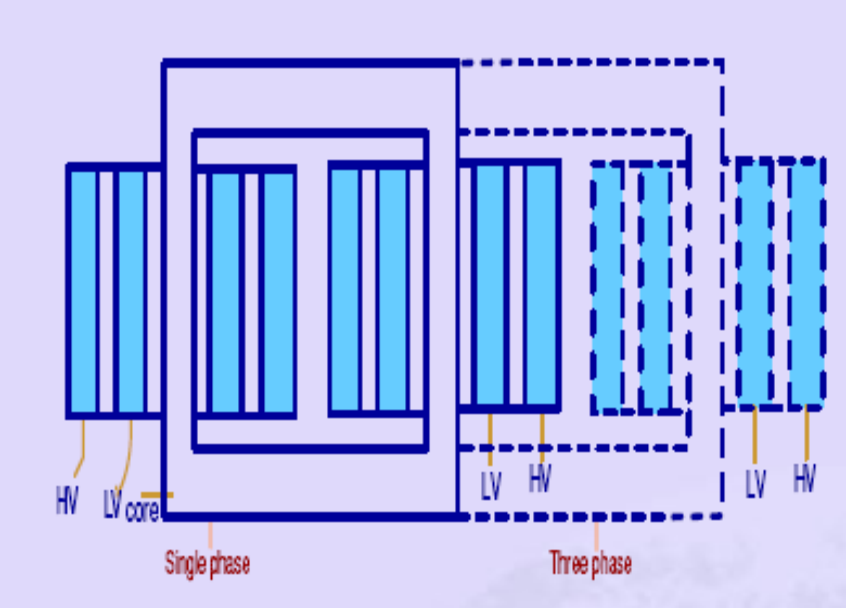
Ultra high Voltage Transformer

Classification of Transformers

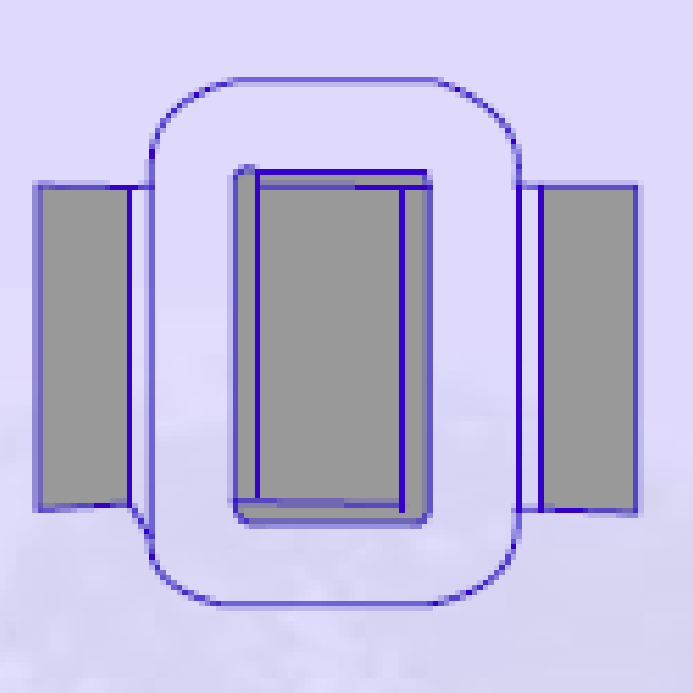


Transformer Core

Core type Construction



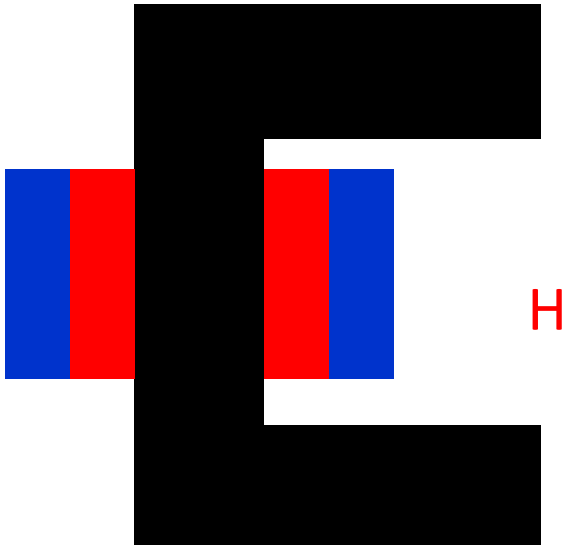
Shell Type Construction



Winding Types

- Three types

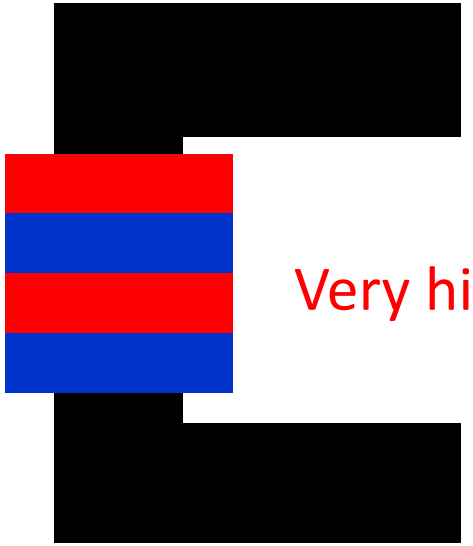
Concentric



Higher voltage closest to Iron

Winding Types

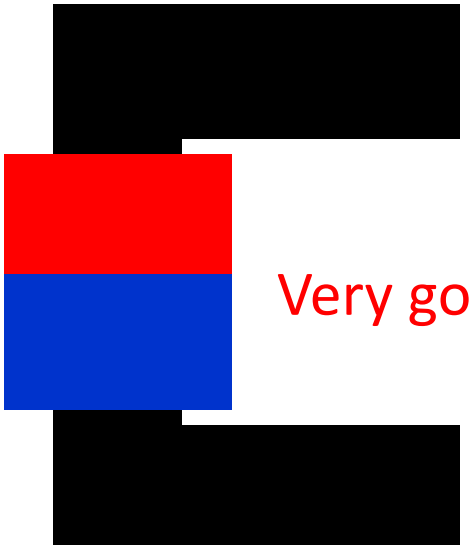
Sandwich or Pancake



Very high voltages on both windings

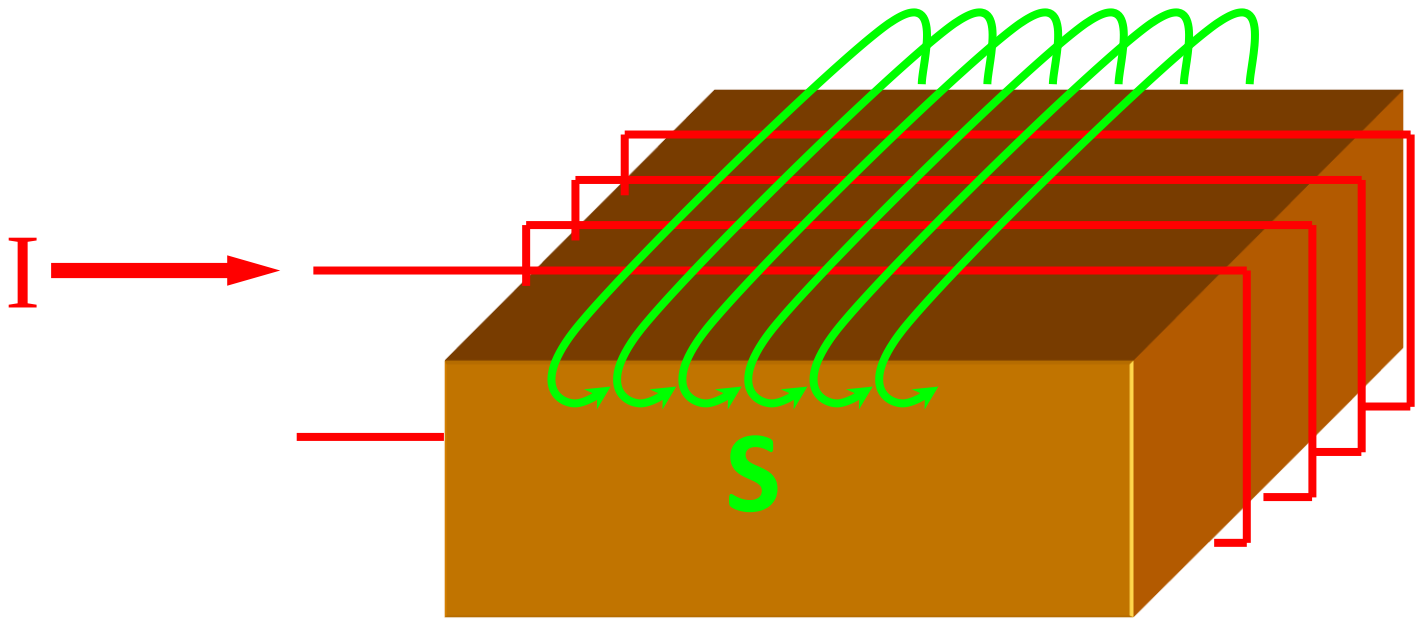
Winding Types

Side by Side



Very good insulation between windings

Why do we laminate the core?



Basic Types of Transformer

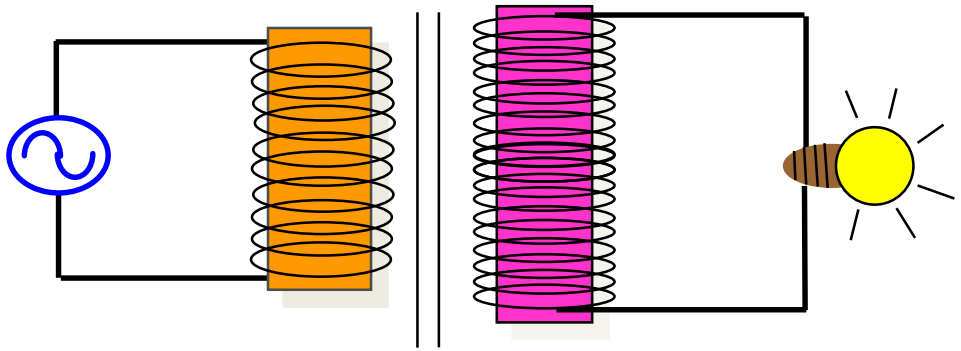
- Based on TURNS RATIO

1. **Step-up**

   turns ratio > 1

   $V_S > V_P$

   $I_S < I_P$

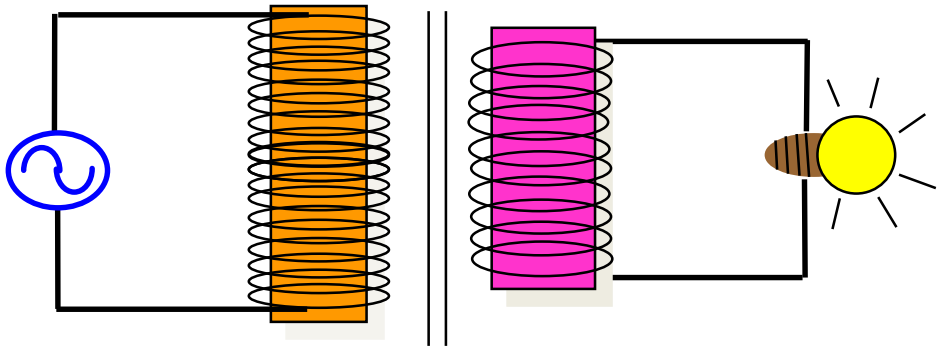


2. **Step-down**

   turns ratio < 1

   $V_S < V_P$

   $I_S > I_P$



Transformer Symbols

N_P = number of turns in the primary

N_S = number of turns in the secondary

V_P or E_P or V_1 = voltage of the primary

V_S or E_S or V_2 = voltage of the secondary

I_P or I_1 = current in the primary

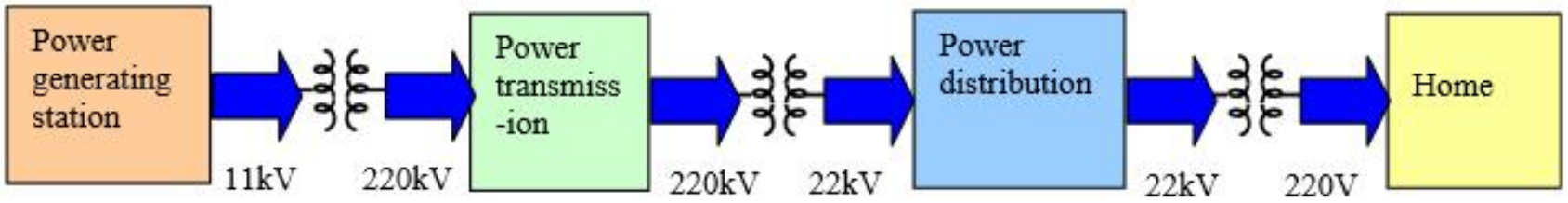
I_S or I_2 = current in the secondary

Application Example of Transformer

- Transformers are a necessary part of all power supplies.

Application Example of Transformer

- Power distribution systems



Summary

- Transformer is a very common magnetic structure found in many everyday applications.
- Transformer couples two circuits magnetically rather than through any direct connection.
- Transformers are used to raise or lower voltage and current between one circuit and the other, and plays a major role in almost all AC circuits.
- Transformer works on the principle of mutual induction