# Transformer (Unit 4)

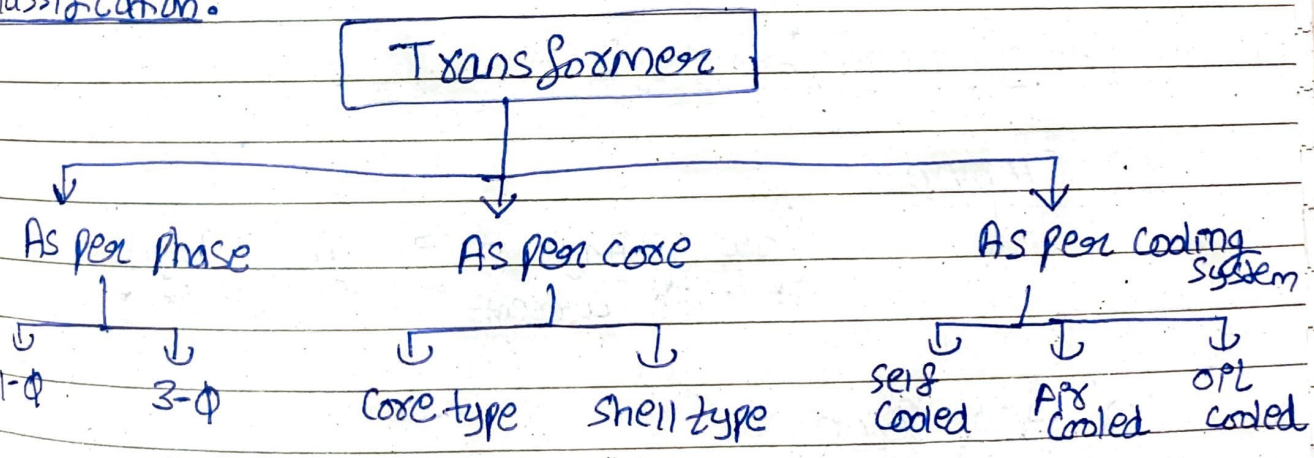
A transformer is used in power transmission of electric energy. It is used to increase or decrease the supply voltage without the change in frequency.

## Principle:

(i) Law of Electromagnetic induction: When a conductor is placed in magnetic field an electromotive force is induced.

(ii) Mutual induction: Property of coils that enables it to oppose changes in current in another coil.

## Classification:




## Terms:

(i) 1-ϕ transformer; Consists of primary and secondary windings put on magnetic core. Magnetic core is used to confine flux to a definite path. It is made up of thin sheets (laminations) and high grade silicon steel. lamination is used to reduce Eddy currents and silicon steel is used to reduce hysteresis losses.

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(ii) 3-ϕ transformer; Consists of three sets of primary and secondary winding and each wound around one leg of an iron core assembly.

(iii) Core type; Core type transformers consists of one magnetic circuit. It has cylindrical windings.

(iv) Shell type; Consists of two magnetic circuits. sandwich winding.

(v) self cooled; A transformer is allowed to cool natural conventional air flow surrounding it through heat radiation.

Two types of transformer:

(1) Step up

Low Voltage → High Voltage
at High current at Low current

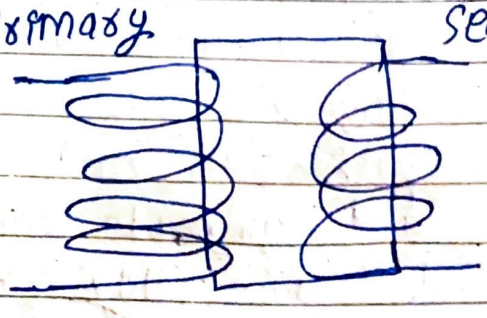
(2) Step Down

High Voltage → Low Voltage
at Low current at High current

Diagram & formulae:

$$\frac{U_s}{U_p} = \frac{N_s}{N_p}$$

$U_s =$
$U_p =$
$N_s =$ , $N_p =$



## Ideal transformer:

An ideal transformer is imaginary transformer in its primary and secondary windings resistance are negligible.

(i) Core has infinite permiability ($\mu$)

(ii) There is no losses due to Copper, Iron, Flux, Hysteresis is efficiency 100%.

(iii) Leakage flux & leakage inductances are zero.

## Losses;

(i) Copper Loss ; due to Resistance winding

(ii) Iron Loss ; due to Eddy Currents

(iii) Flux Loss ; Due to Orientation

(iv) Hysteresis Loss ; Due to Magnetisation & Demagnetisation

## Efficiency;

$$\text{Efficiency} = \frac{\text{Output Power}}{\text{Input Power}}$$

Efficiency of transformer is defined as the ratio of output power to input power.

## Regulation Voltage of a transformer;

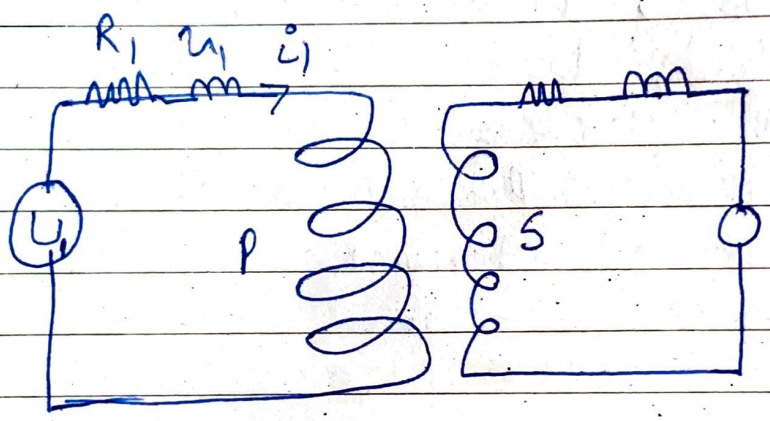
The change in voltage from no load to full load w.r.to No load.

$$VR = \frac{V_{NL} - V_{FL}}{V_{NL}}$$

Auto transformer ; is a electrical transformer with only one winding . Portions of same winding acts as both primary and secondary sides of transformer.

## Equivalent Circuit of Transformer

During working of Transformer some parameters exists that is represented by a circuit that is known as equivalent circuit of transformer.




Primary secondary

$x_1$ = Leakage inductance

$V_1$ = Primary voltage
$I_1$ = Primary current
$R_1$ = Primary winding Resistance

When current is flowing through primary winding then flux produces around primary winding that flux completely don't link with secondary winding i.e. Leakage flux.

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• Conditions of Voltage Regulation is to be figured;

(i) Rated voltage, current and frequency.
(ii) Power factor of load should be mentioned if not specified then assumed unity.
(iii) Waveform should be assumed sinusodial unless stated.

## Measuring instruments (unit 4)

• Moving iron instruments

Construction:

(i) Instrument consists of stationary coil in which current to be measured is passed.
(ii) A piece of unmagnetized soft iron which is oval in shape is mounted rigidly on spindle. The iron is free to move about the spindle and along with spindle.

Working:

(i) The current to be measured is flowing in coil, produces magnetic field. Iron gets attracted to centre of MF and pointer deflects on scale.
(ii) Control torque is provided either by control spring or by gravity control.
(iii) Damping is provided by air friction damping.
(iv) Scale is non linear. mirror is provided to avoid parallax error.

- Attraction type Moving iron instruments

(i) This instrument consists of stationary coil in which current is measured is passed.
(ii) A piece of unmagnadized soft iron which is oval in shape mounted rigidly on spindle. The iron is free to move around spindle and with along spindle.
(iii) A pointer is fixed on the spindle.

- Repulsion type moving iron instruments

Construction;

(i) This instrument consists of ~~two~~ two iron vanes, one is attached to stationary coil and other one is attached to movable spindle.
(ii) Both vanes are surrounded by stationary coil, current to be measured is passing through this coil.

Working;

(i) Current to be measured is passing through stationary coil produces MF. Both vanes magnetises with similar polarities.
(ii) As a result force of repulsion is set up b/w 2 vanes.
(iii) This force produces a deflecting torque on movable vanes gives deflection on scale.

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## • Permanent Moving Coil instruments

- It consists of Permanent magnet which is stationary
- Moving system consists of spindle attached to rectangular Aluminium frame. A coil made up of thin copper wire is wound over frame. The current to be measured is passing through coil.
- A soft iron core is placed in space within aluminium frame
- Two spiral springs are mounted on spindle to produce Control Torque

### Construction:

(i) ''
(ii) ''
(iii) ''. This core is stationary and is provided to reduce the reluctance of magnetic path b/w 2 poles of Permanent magnet.

### Working:

(i) The current to be measured is passing through Moving coil.
(ii) A current carrying moving coil in a MF. Acc to Flemings Left hand Rule torque is produced.

### Merits:

(i) Power Consumption is very Low
(ii) Uniform Scale

### Demerits:

(i) High Cost than MI
(ii) ~~Only~~ used only for DC Supply

## Electrodynamic Instruments

- ~~Instruments consists of stationary~~
- Stationary part consists of two fixed coils i.e. connected in series so they carry same current.
- Moving system consists of coil mounted on spindle which is free to rotate. Made up of thin copper wires and air cored to avoid hysteresis.
- Control torque provided by Spiral Springs.
- Current to be measured is passed through stationary coil forms MF.
- As do Flemings Left hand rule when current carrying conductor placed in MF it experiences torque.

**Merits:**

(1) Used as Ammeter, voltmeter and Wattmeter
(2) also known as dynamometer instruments

**Demerits:**

(1) Scale is non uniform
(2) More expensive
(3) Weak MF