UNIT-III

Fundamentals of Electrical Machines

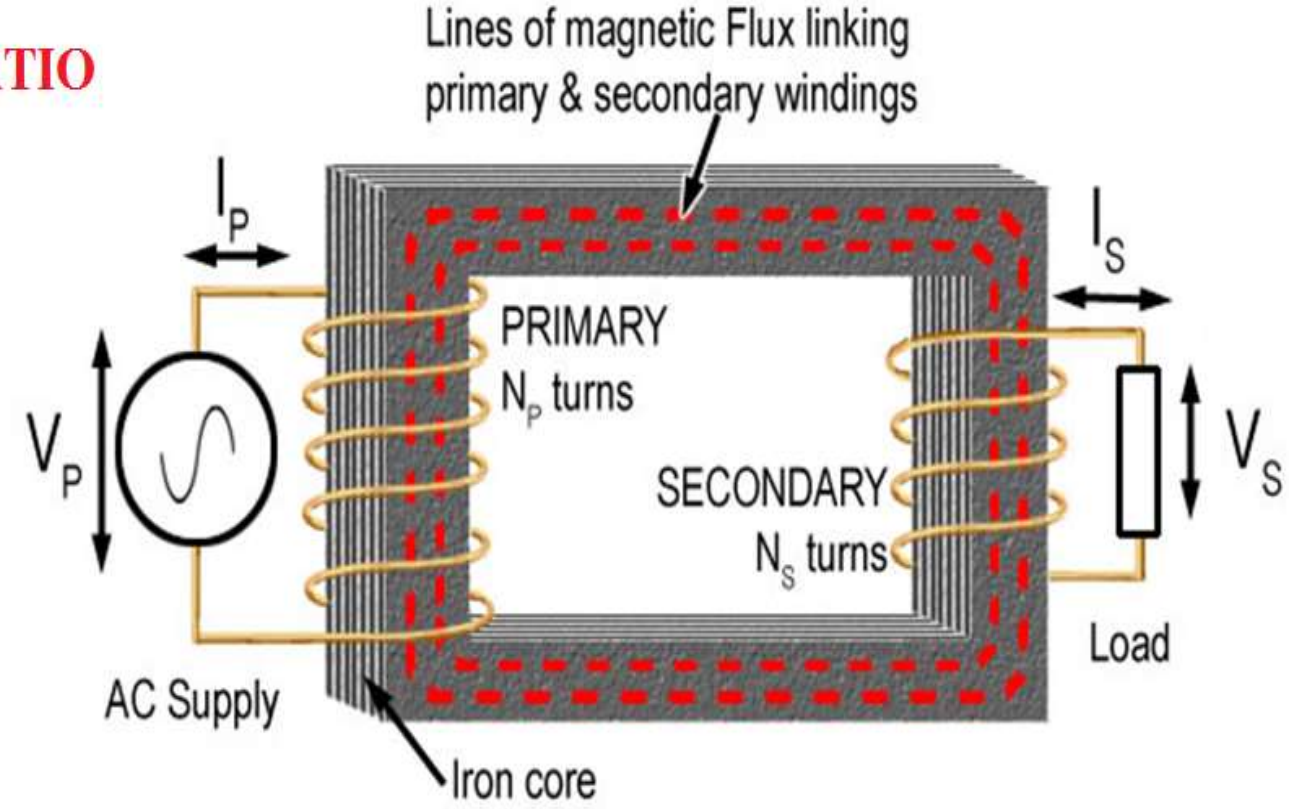
Lecture 16

Prepared By:
Krishan Arora
Assistant Professor and Head

CONCEPT OF TURN RATIO

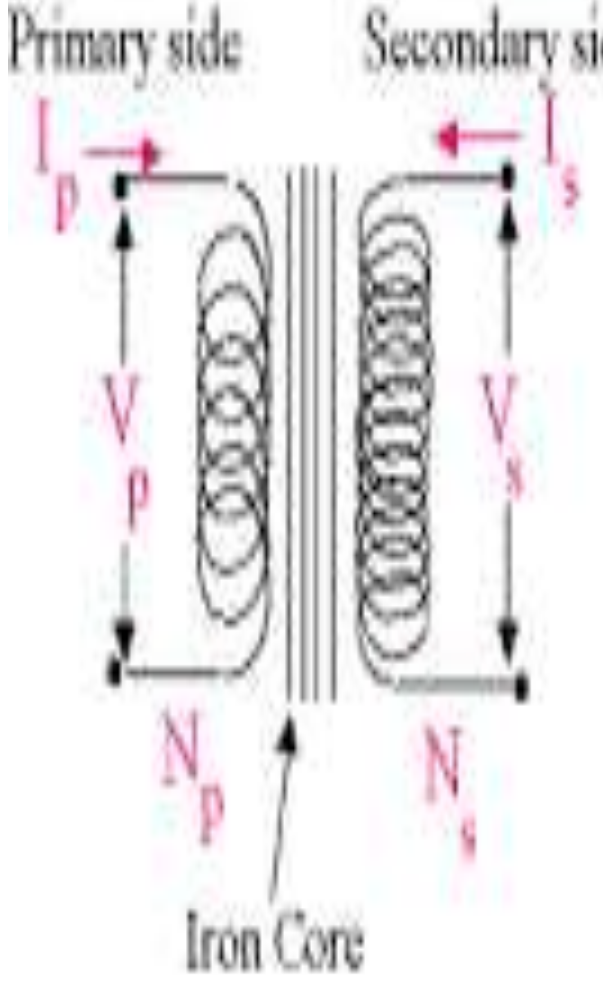
$$a = \frac{n_1}{n_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

where: a = turns ratio of transformer
n_1 = number of turns on primary
n_2 = number of turns on secondary
V_1 = primary voltage
V_2 = secondary voltage
I_1 = primary current
I_2 = secondary current



$$\frac{\text{The number of primary turns } N_P}{\text{The number of secondary turns } N_S} = \frac{\text{The primary voltage } V_P}{\text{The secondary voltage } V_S}$$

$$\frac{\text{The number of secondary turns } N_S}{\text{The number of primary turns } N_P} = \frac{\text{The primary current } I_P}{\text{The secondary current } I_S}$$



$$\frac{V_s}{V_p} = \frac{N_s}{N_p},$$

But,

$$\frac{I_s}{I_p} = \frac{N_p}{N_s}$$

If the purpose is to increase voltage, the secondary coil must have more turns and therefore a thinner wire. Note that at best the output power equals the input power. Ideally, $P_{out} = P_{in}$, or $V_s I_s = V_p I_p$

Writing as proportions: $\frac{V_s}{V_p} = \frac{I_p}{I_s}$

This is true for an ideal transformer only.

EXAMPLE: A transformer has 400 turns on the primary and 1200 turns on the secondary. If 120 volts of AC current are applied across the primary, what voltage is induced into the secondary?

Given

$E_S = ?$

$E_P = 120\,V$

$N_S = 1200\,turns$

$N_P = 400\,turns$

Solution

$$\frac{E_S}{E_P} = \frac{N_S}{N_P}$$

$$\frac{E_S}{120} = \frac{1200}{400}$$

$$E_S = 360\,V$$

Quick Quiz (Poll 1)

- A transformer having 1000 primary turns is connected to a 250 volt ac supply, for a secondary voltage of 400 volt, the no. of secondary turns should be

a. 1600

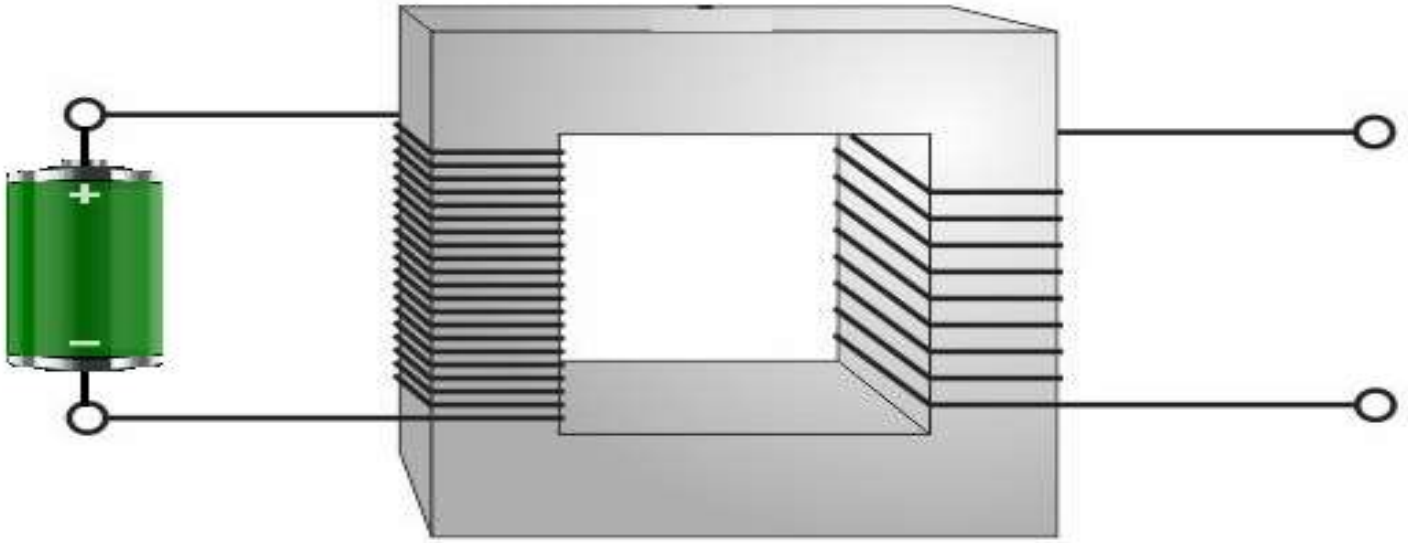
b. 250

c. 400

d. 1250

TRANSFORMER ON DC SUPPLY

What will happen if the Primary of a Transformer is Connected to D.C. Supply????



Transformer doesn't work on a DC supply

According to the principle of Transformer operation
It doesn't work on a DC supply since the rate of change of flux is zero

- A Transformer cannot be operated on the DC source or never connected to DC supply. If a rated dc voltage is applied to the primary of the transformer, the flux produced in the transformer core will not vary but remain constant in magnitude.

- So therefore no emf is induced in the secondary winding except during the moment of switching on the dc supply. As no induced emf is produced current cannot be delivered from the secondary side to the load.

- Therefore heavy current will flow in the transformer primary winding which may result in burning down the transformer primary winding.

LOSSES OF TRANSFORMER

- ***Copper loss in transformer***

Copper loss is I^2R loss, in primary side it is $I_1^2R_1$ and in secondary side it is $I_2^2R_2$ loss, where I_1 & I_2 are primary & secondary current of transformer and R_1 & R_2 are resistances of primary & secondary winding. As the both primary & secondary currents depend upon load of transformer, so ***copper loss in transformer*** *vary with load.*

- ***Core losses in transformer***

Hysteresis loss and eddy current loss, both depend upon magnetic properties of the materials used to construct the core of transformer and its design. So these ***losses in transformer*** *are fixed and do not depend upon the load current. So* ***core losses in transformer*** *which is alternatively known as* ***iron loss in transformer*** *and can be considered as constant for all range of load.*

Applications of Transformers

- Transformers are used in the transmission of electric power over long distances
  - Power dissipation in a electrical wire is $P = V I$
  - DC voltage would waste too much energy in transmission
  - Transformers allow large AC voltage transmission with small current
- Many household appliances use transformers to convert the AC voltage at a wall socket to the smaller DC voltages needed in many devices

Quick Quiz (Poll 2)

- Transformer are rated in kVA instead of kW because

a. load power factor is often not known

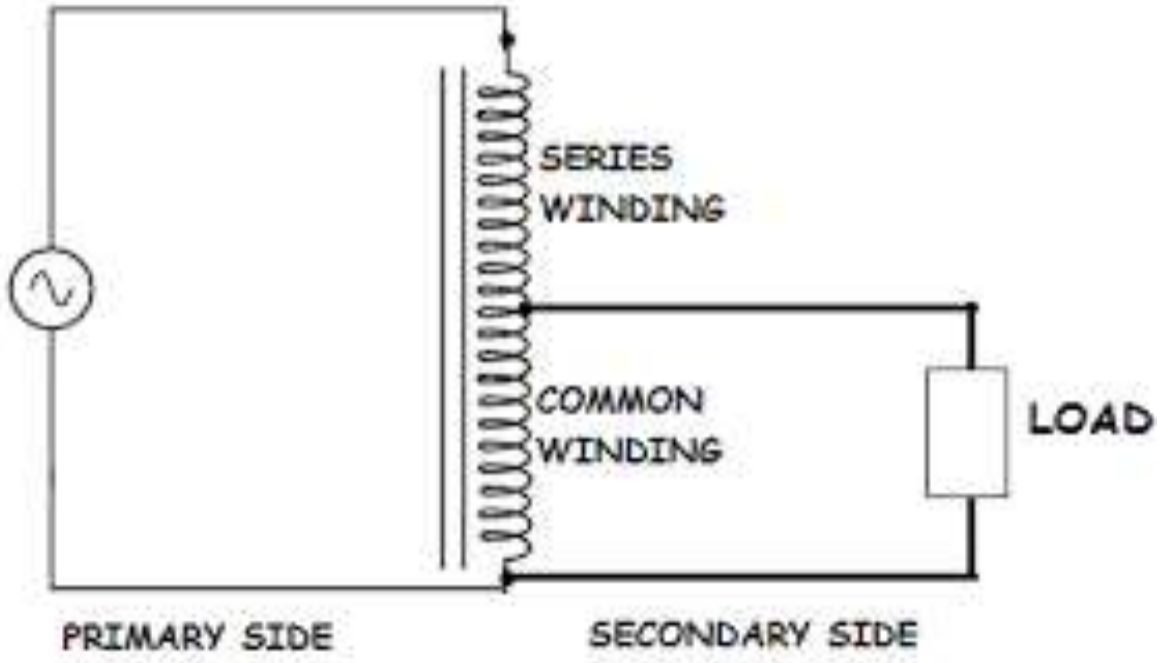
b. kVA is fixed whereas kW depends on load PF

c. total transformer loss depends on the volt ampere

d. it has become customary

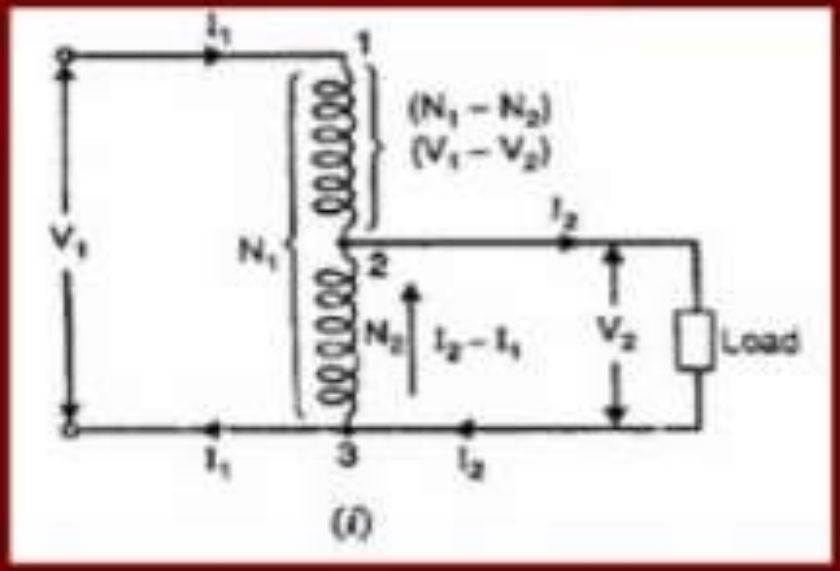
Auto-Transformer

An Auto-transformer is an electrical transformer with only one winding.



Theory of Autotransformer

- N1=primary turn(1-3)
- N2=secondary turn(2-3)
- I1=primary current
- I2=secondary current
- V1=primary voltage
- V2=secondary votage



(i)

From the above fig. We get

$$\frac{V_2}{V_1 - V_2} = \frac{N_2}{N_1 - N_2}$$

$$V_2(N_1 - N_2) = N_2(V_1 - V_2)$$

$$V_2N_1 - V_2N_2 = N_2V_1 - N_2V_2$$

$$V_2N_1 = N_2V_1$$

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = K$$

Advantages

Some of the **advantages of auto-transformer** are that,

- they are smaller in size,
- cheap in cost,
- low leakage reactance,
- increased kVA rating,
- low exciting current etc.

Disadvantages

- Any undesirable condition at primary will affect the equipment at secondary (as windings are not electrically isolated),
- due to low impedance of auto transformer, secondary short circuit currents are very high,
- harmonics generated in the connected equipment will be passed to the supply.

Instrument Transformers

- The original magnitude can be determined by just multiplying the result with the transformation ratio. Such specially constructed transformers with accurate turns ratio are called as **Instrument transformers**.
- These instruments transformers are of two types –

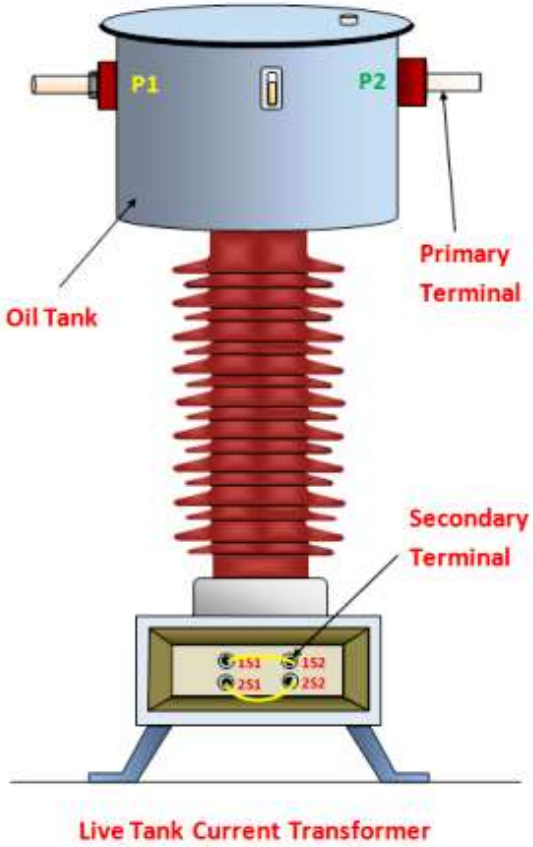
  (i) **Current Transformers (CT)** and

  (ii) **Potential Transformers (PT)**.

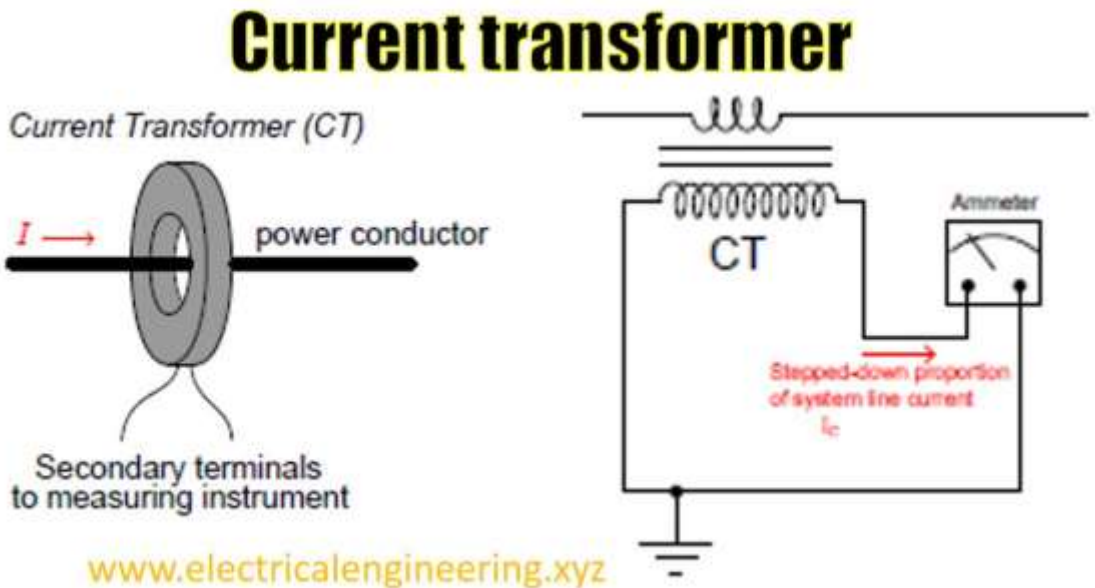
Current Transformers

Construction of C.T.:

- C.T. has a primary coil of one or more turns made of thick wire connected in series with the line whose current is to be measured.
- The secondary consists of a large number of turns made of fine wire and is connected across an ammeter



Live Tank Current Transformer



Potential Transformers

Construction and working of P.T.:

Construction

- A potential transformer has many primary winding turns but few number of secondary winding turns that makes it a step-down transformer.
- A Voltmeter is connected to the secondary winding is usually a voltmeter of 150 V.

Working (Measurement):

- Primary terminals are connected in parallel across the line to which the voltage is to be measured.
- The voltmeter reading gives the transformed value of the voltage across the secondary terminals.

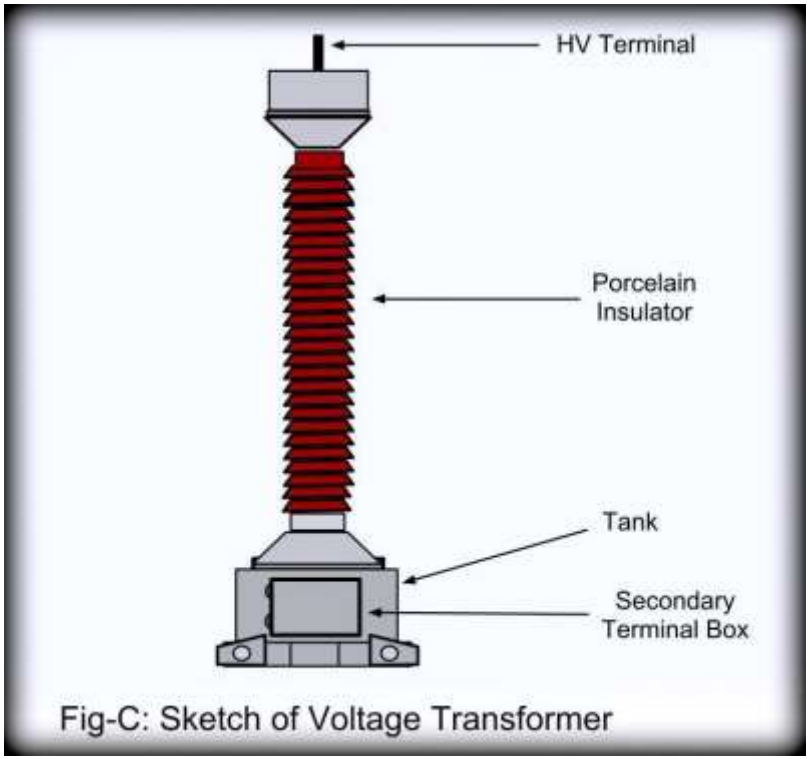
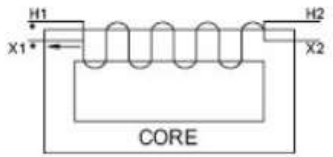


Fig-C: Sketch of Voltage Transformer

Potential Transformer

Voltage Transformer



Voltage Example
Primary 7200 Volts
Ratio 60:1 or 7200:120 Volts

Quick Quiz (Poll 3)

- What are the types of Instrument Transformer?

A. Auto Transformer
B. Current transformer
C. Potential Transformer
D. Both B and C