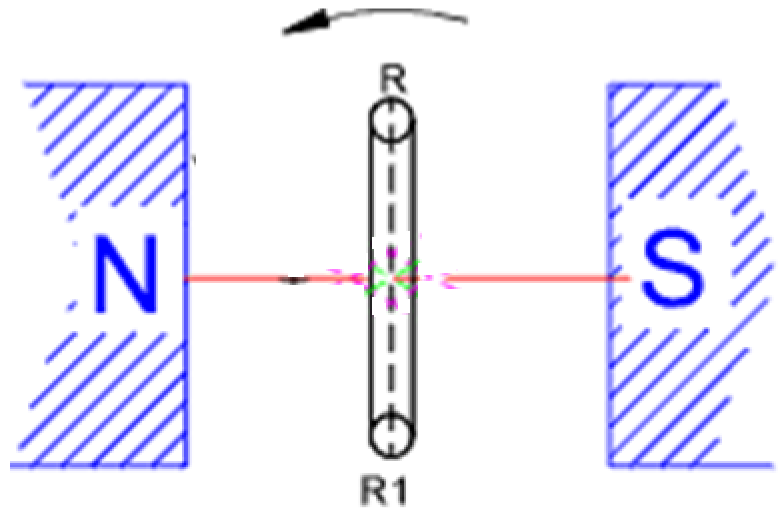
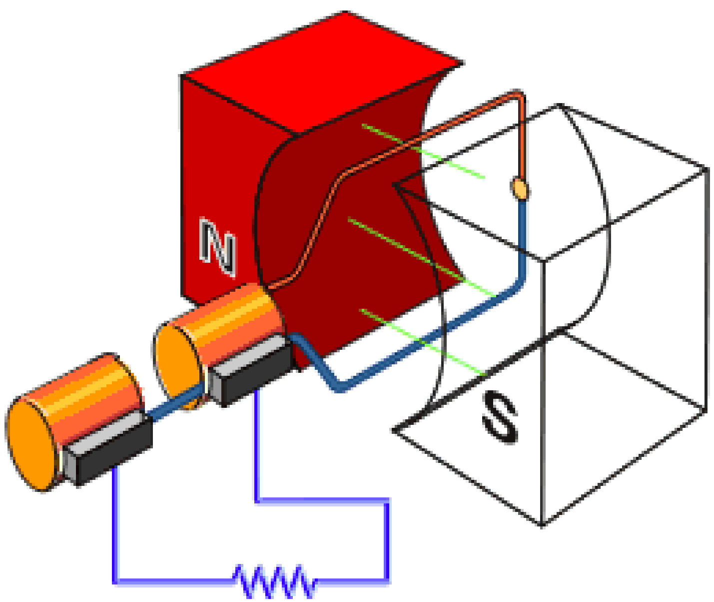
UNIT NO.4

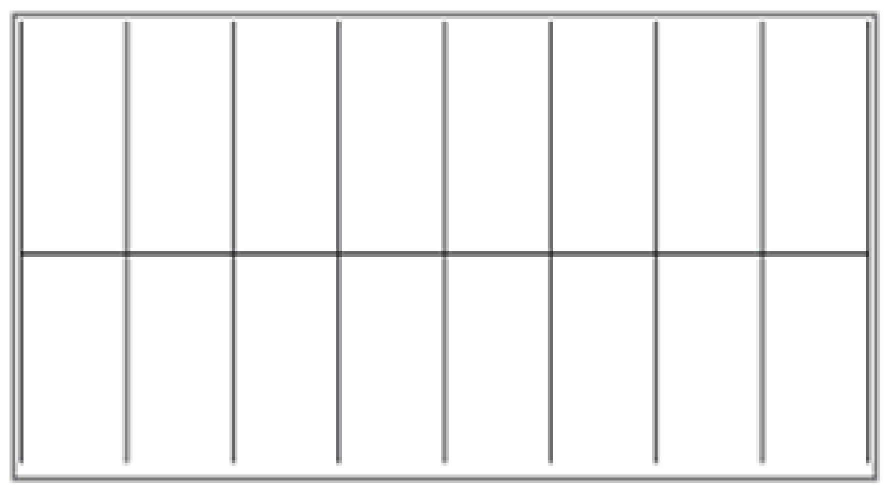
Part 1

POLY PHASE A.C. CIRCUIT

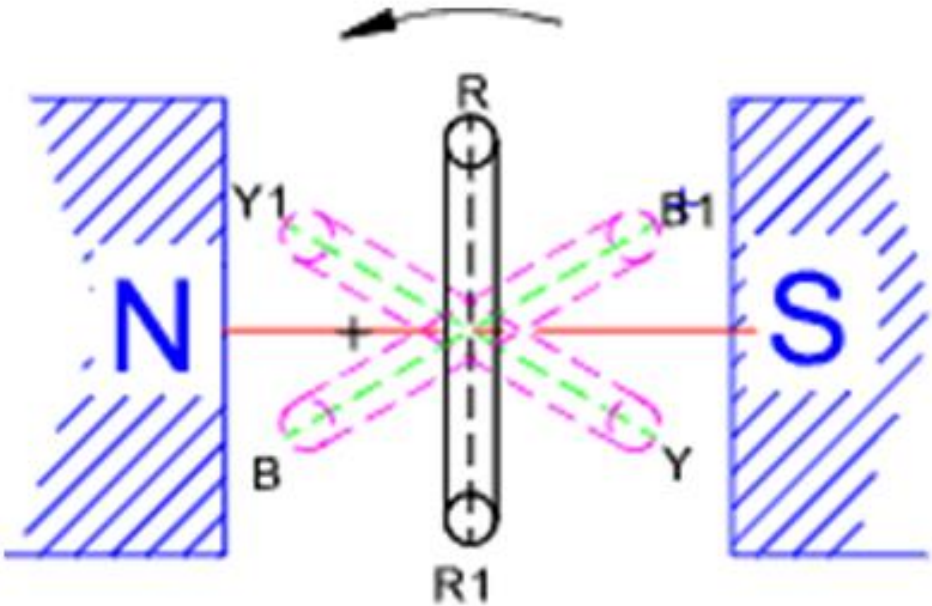
Generation of Single Phase voltage

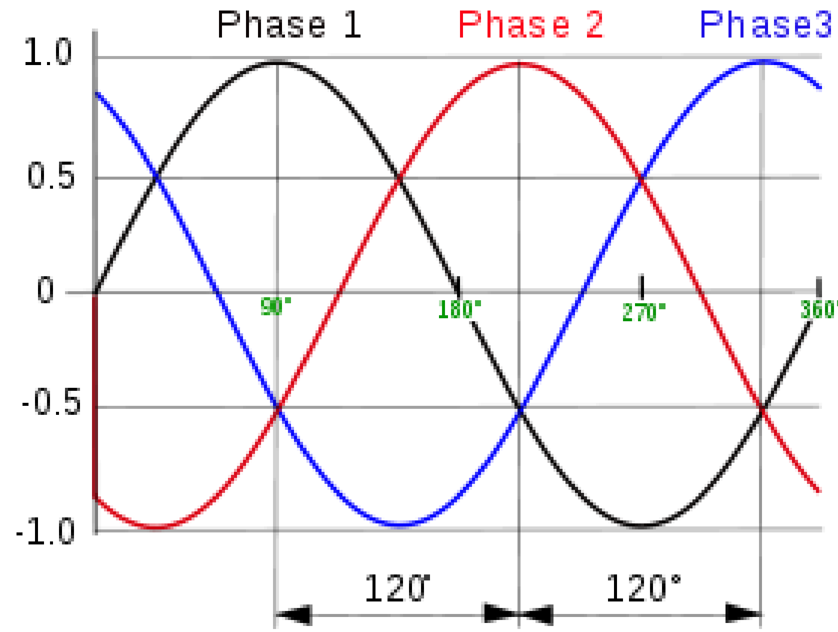


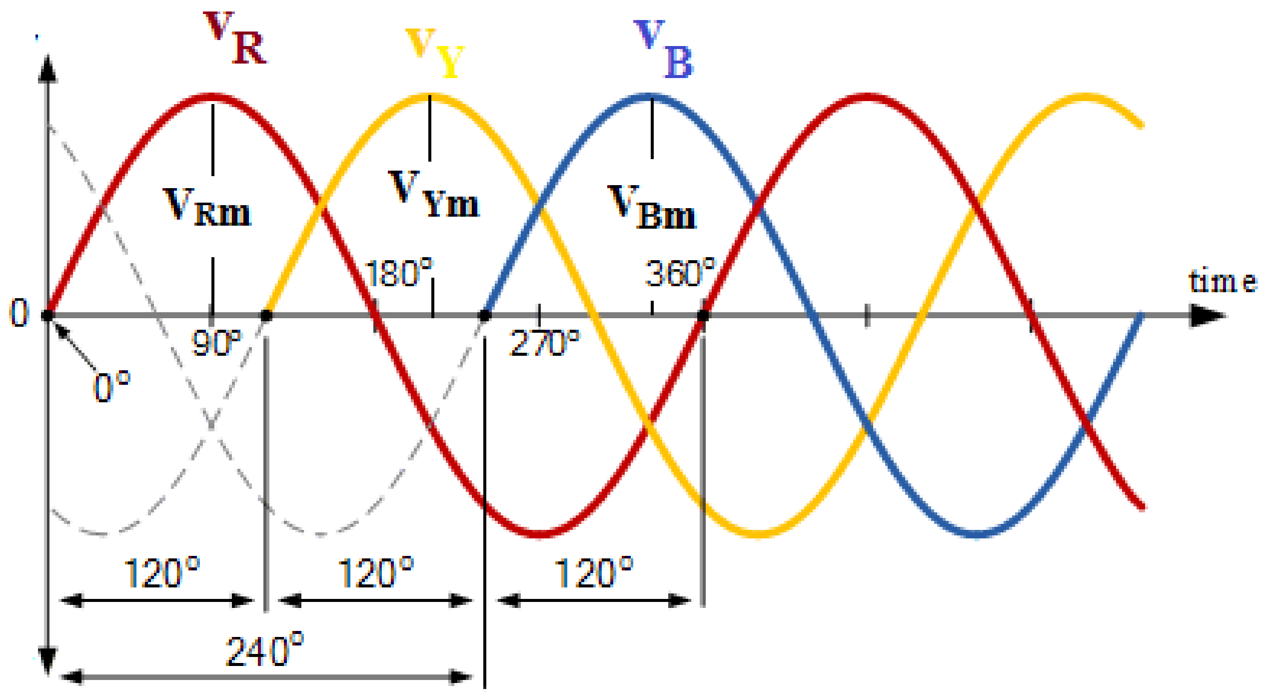




Generation of Three Phase



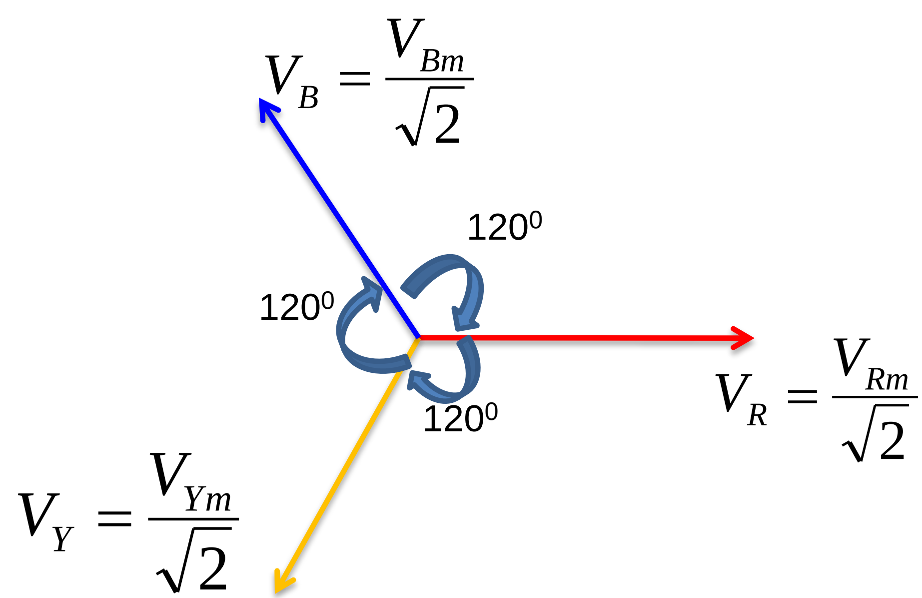




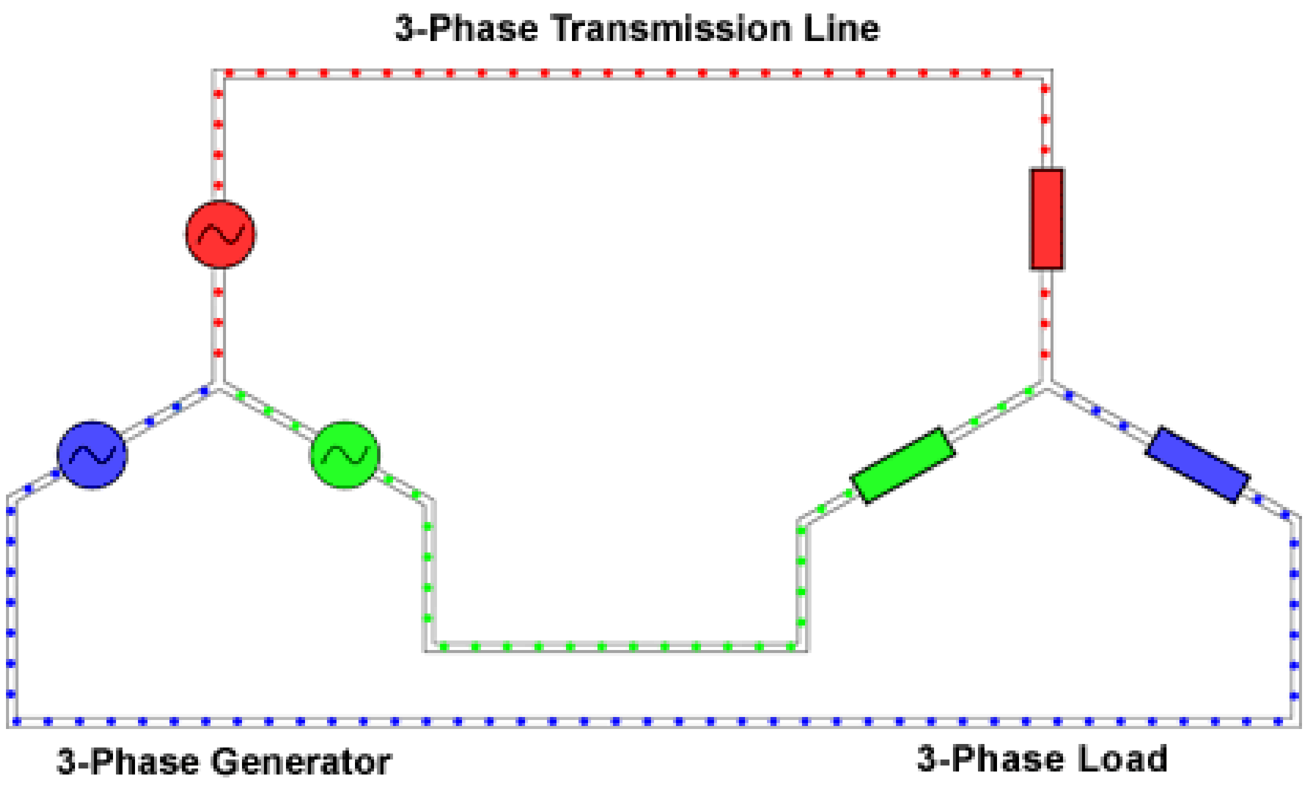
$v_R = V_{Rm} \sin(\theta)$

$v_Y = V_{Ym} \sin(\theta - 120^0)$

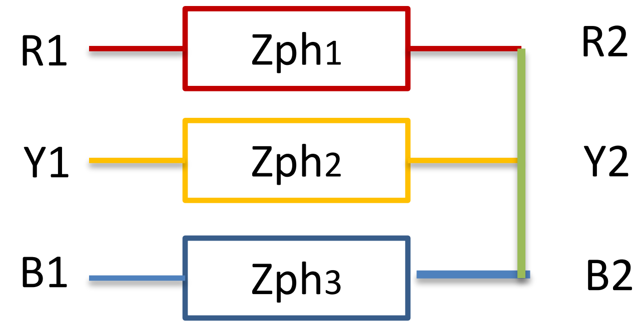
$v_B = V_{Bm} \sin(\theta - 240^0)$

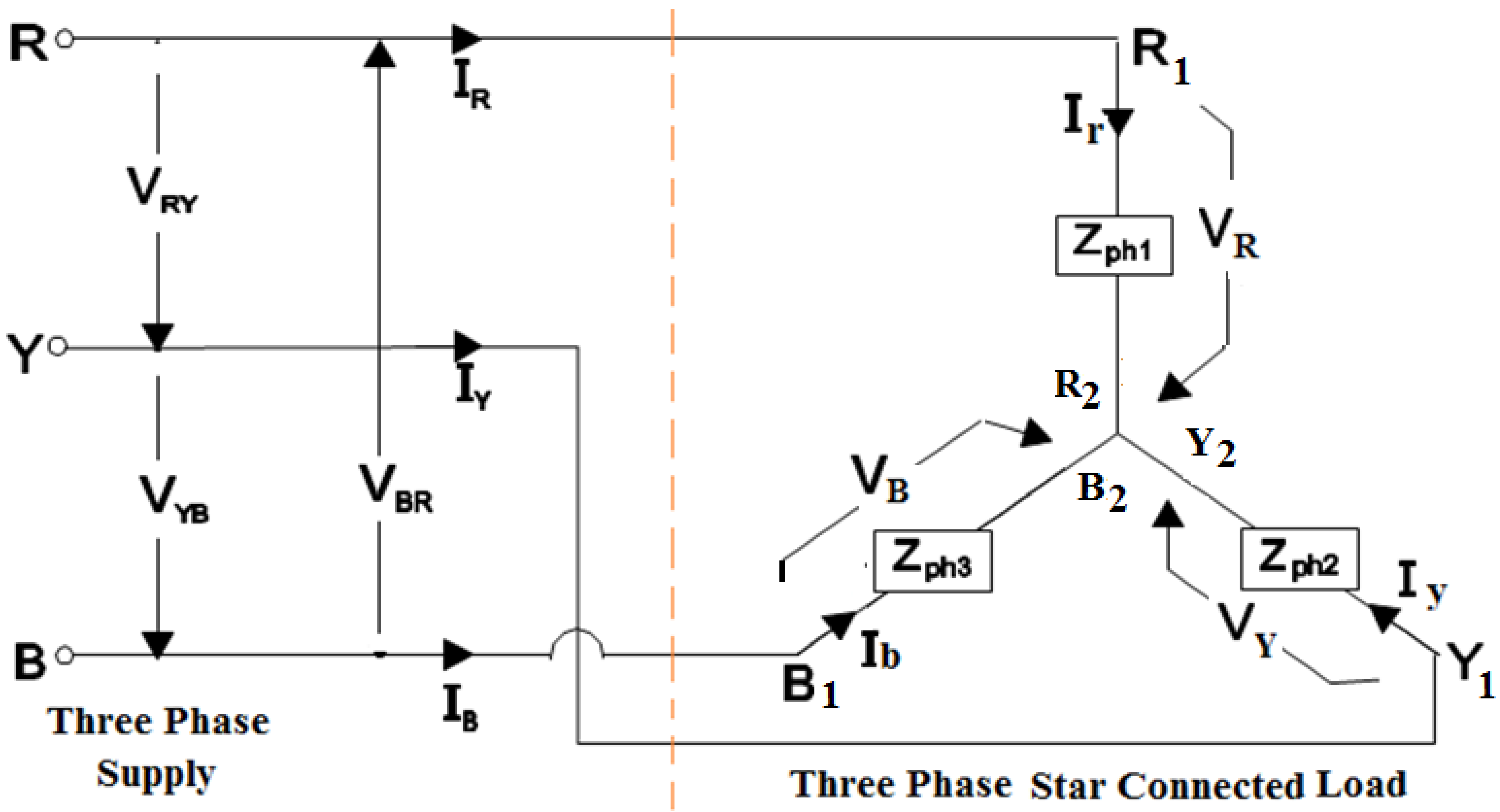


Three Phase Load Connected to three Phase Supply

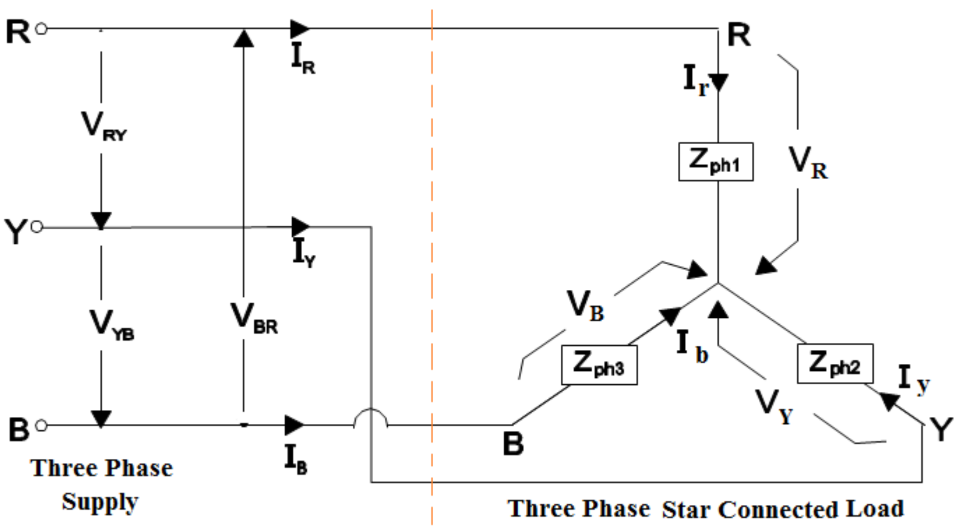


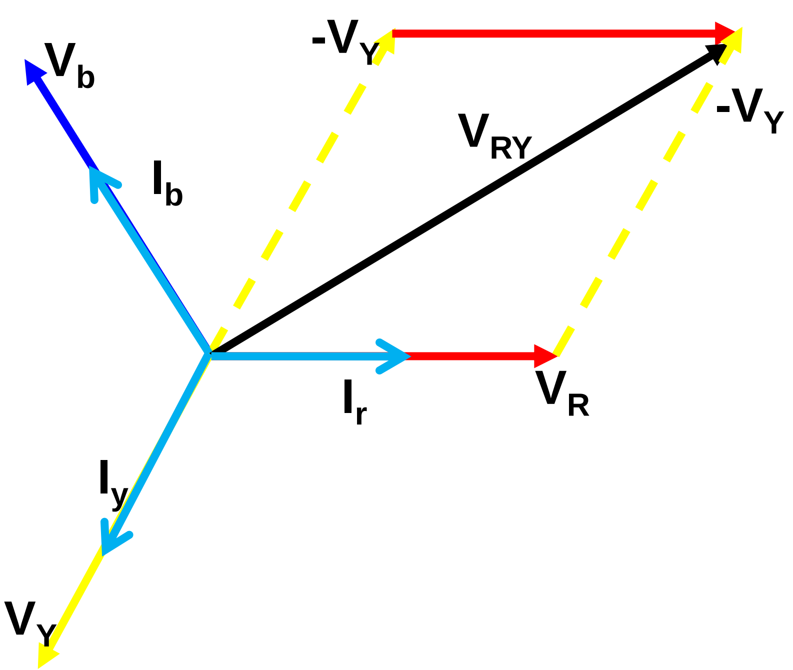
Three Phase Star Connected Load

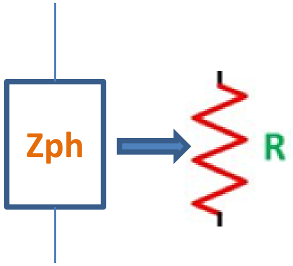




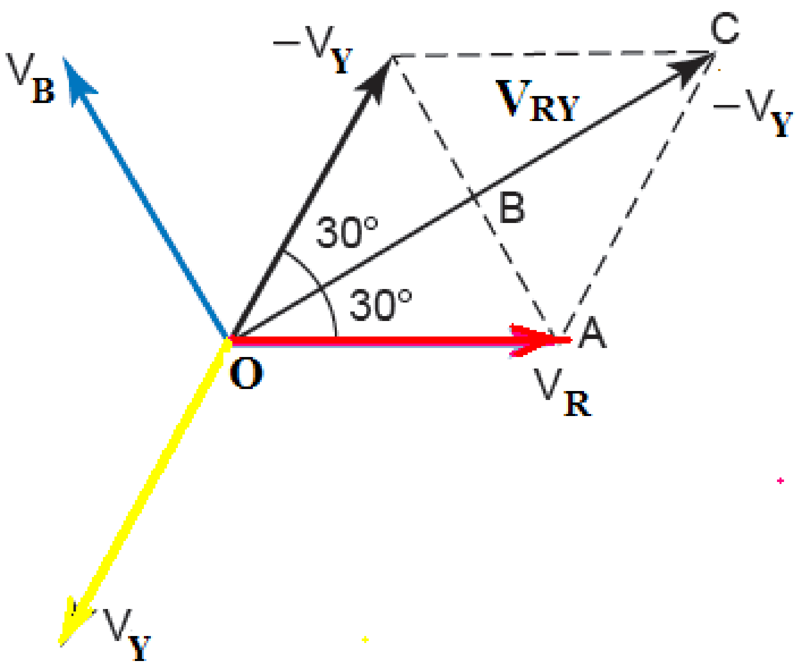
Three phase star connected resistive load

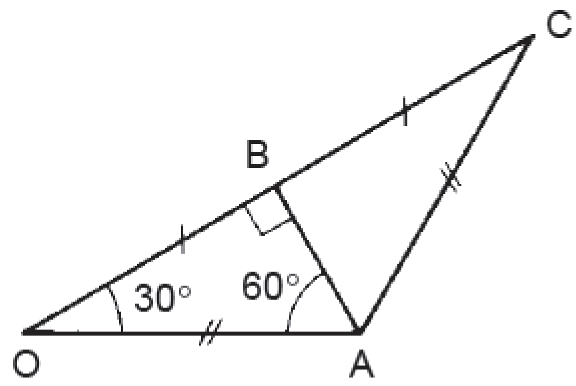






Relation between Line and Phase Voltage





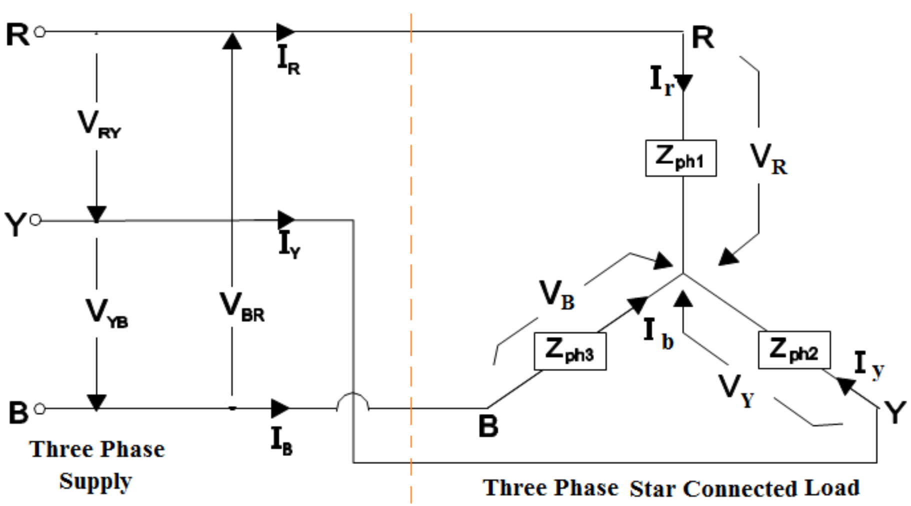
$$V_{RY} = OC = 2OB = 2BC$$

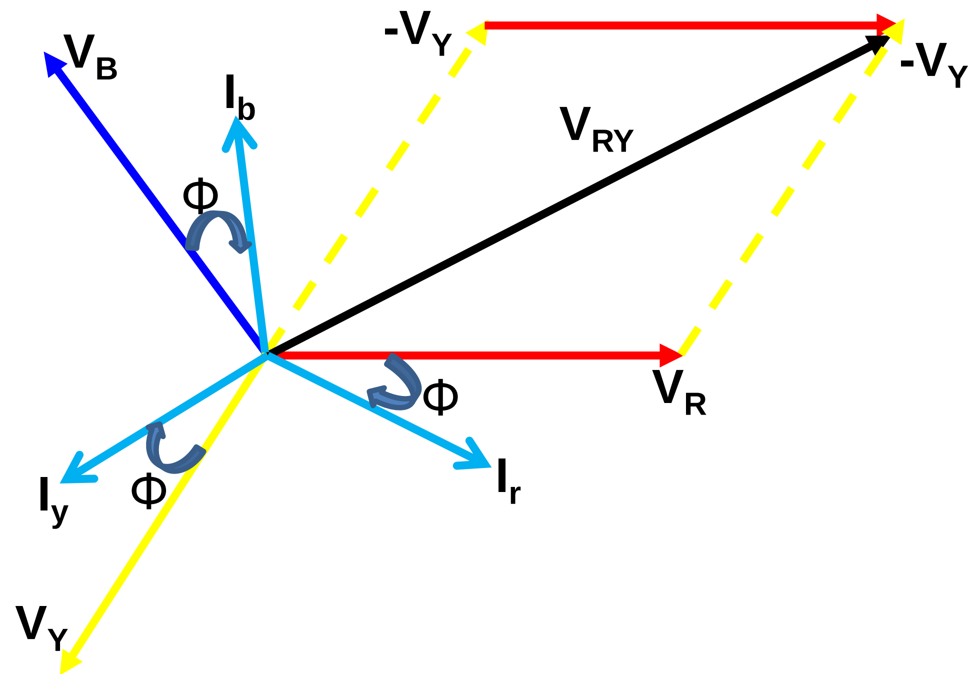
$$Cos\,30 = \frac{OB}{V_R}\ ,OB = V_R\,Cos\,30$$

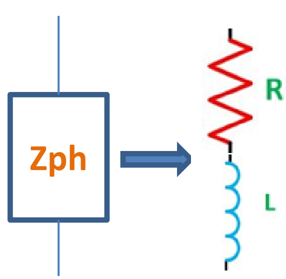
$$V_{RY} = 2OB = 2V_R\,Cos30 = \sqrt{3}\,V_R$$

$$V_L = \sqrt{3}\,V_{ph}$$

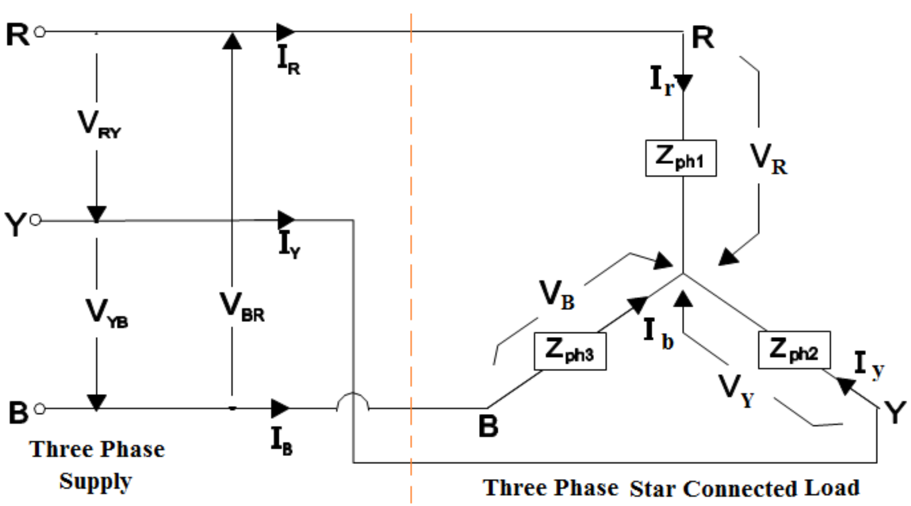
Three phase star connected Inductive load

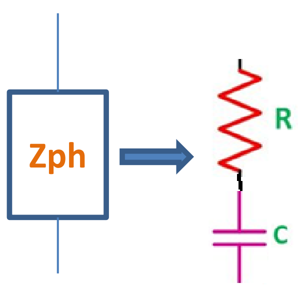


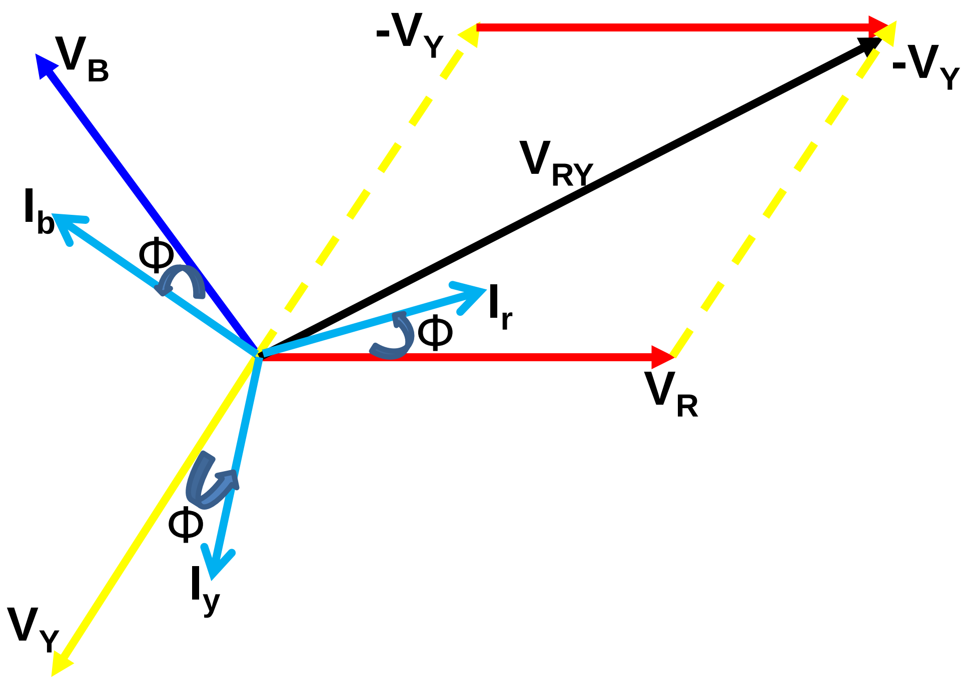




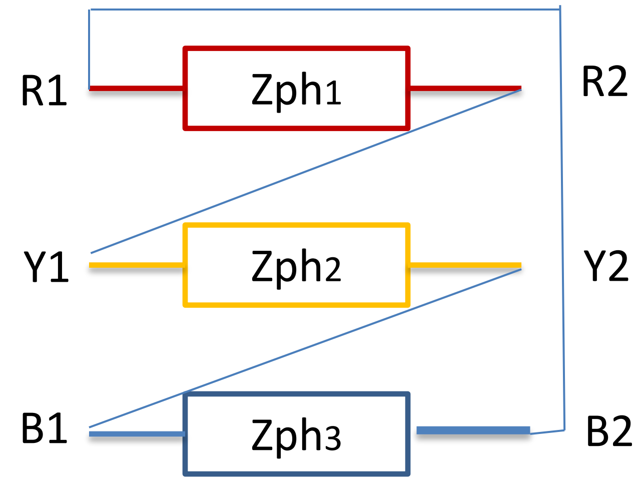
Three phase star connected Capacitive load

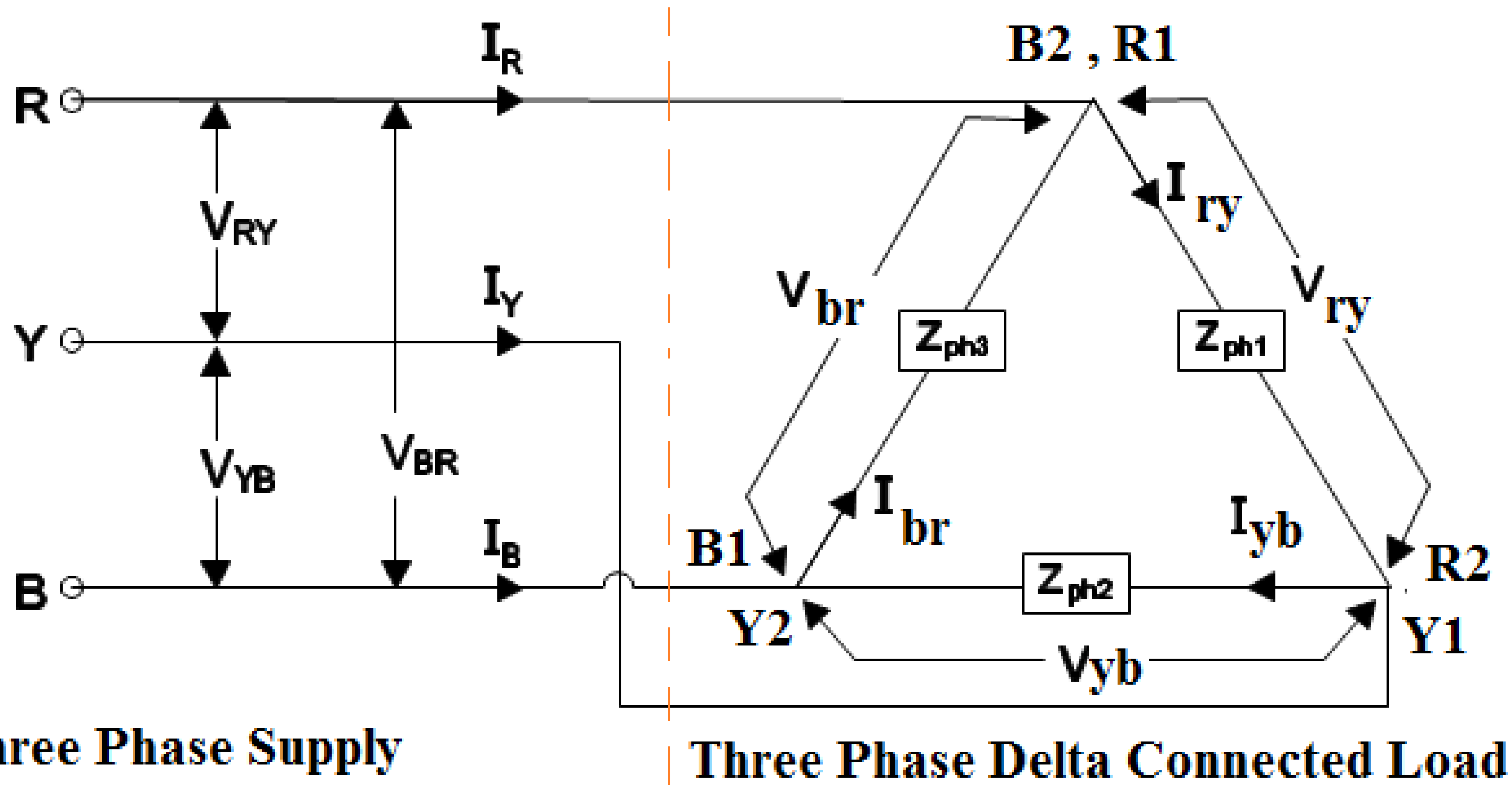




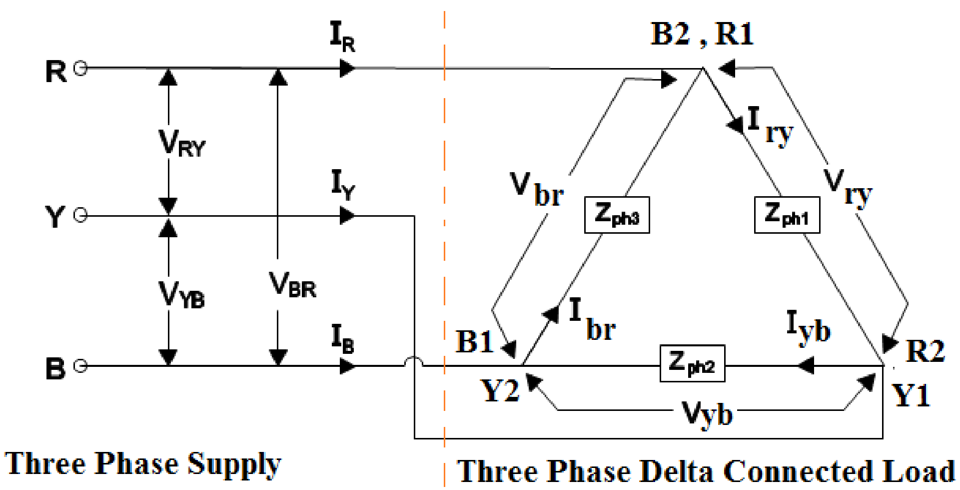


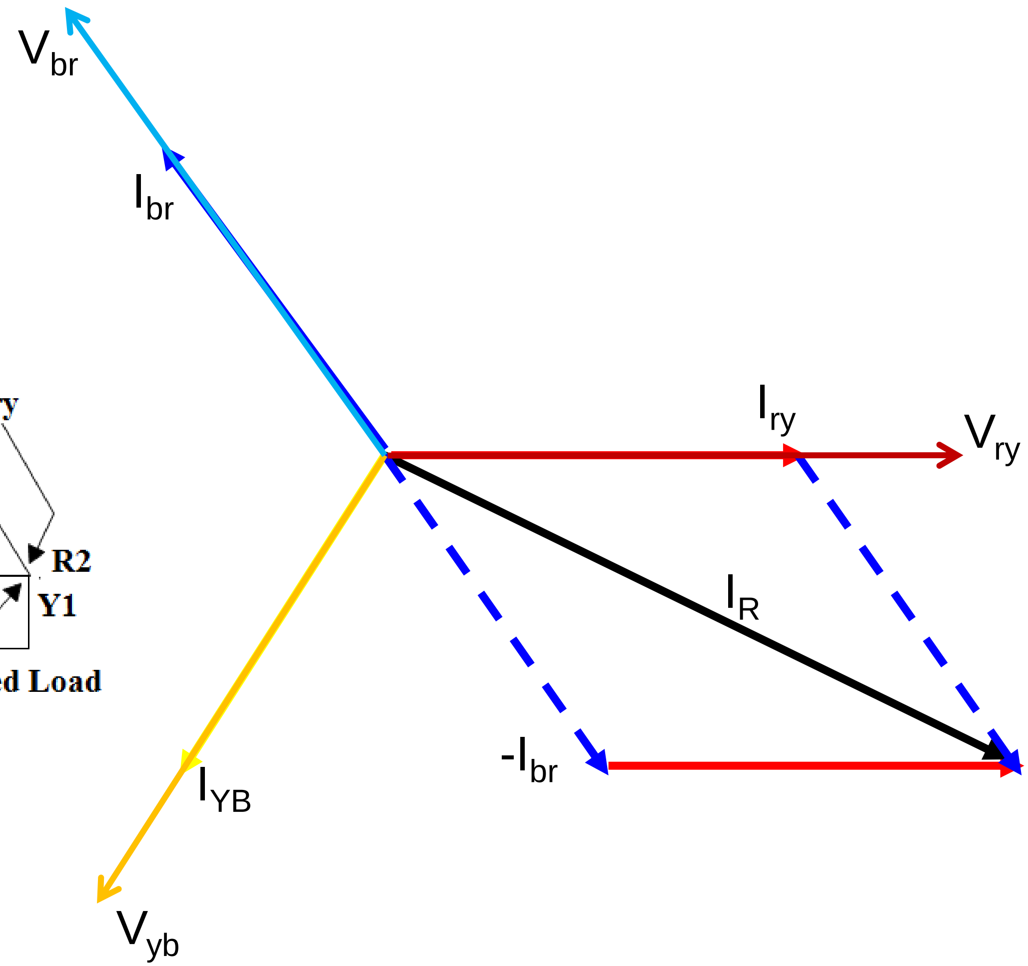
Three Phase Delta Connected Load



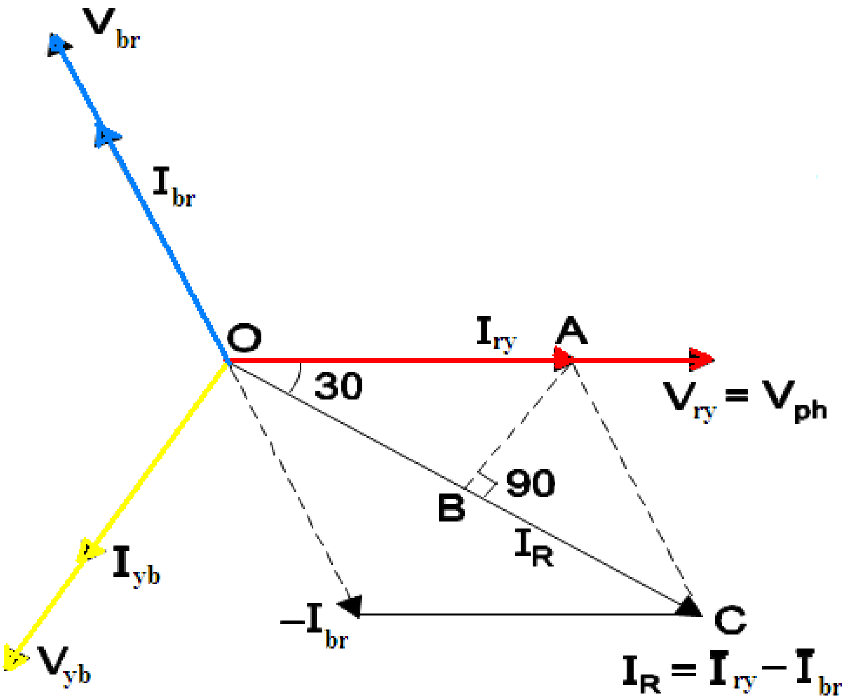


Three Phase Delta connected Resistive Load





Relation between Line and Phase Current



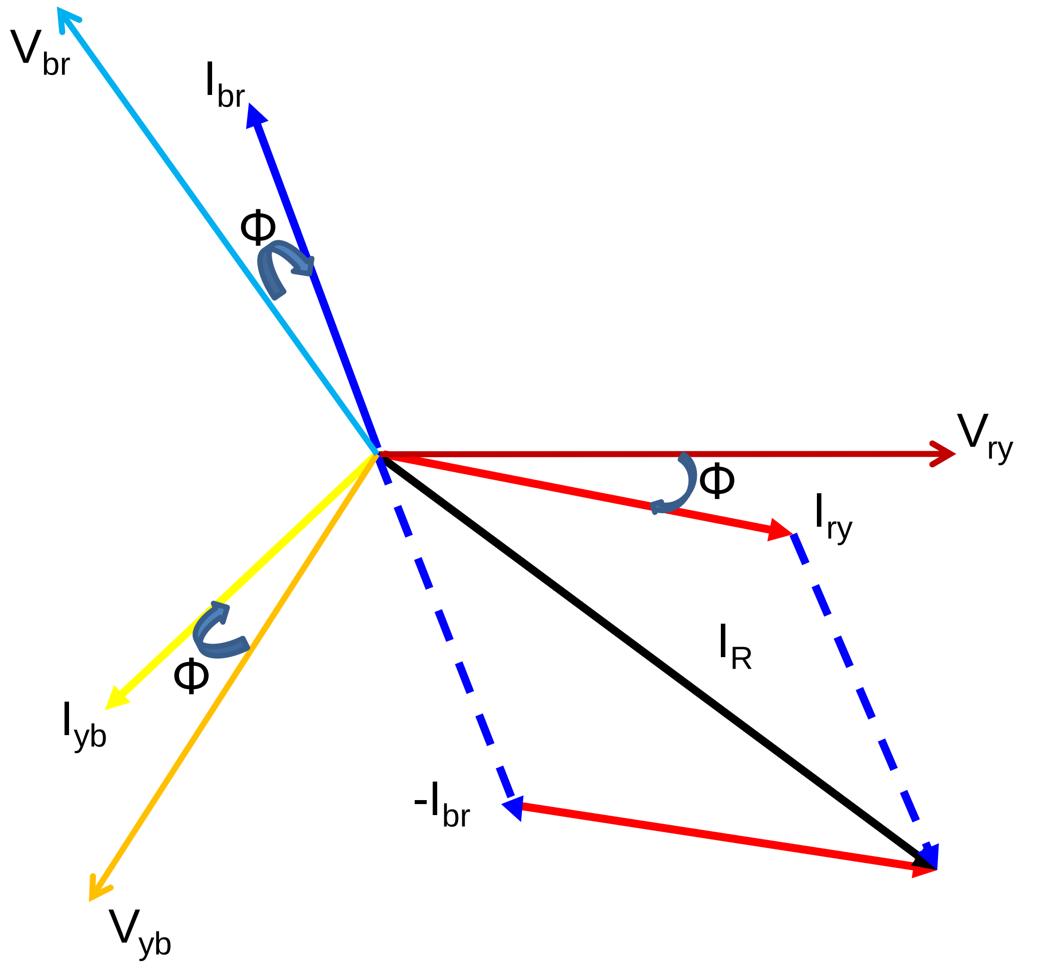
$$I_R = OC = 2OB = 2BC$$

$$Cos\,30 = \frac{OB}{I_{RY}} \;, OB = I_{RY}\,Cos\,30$$

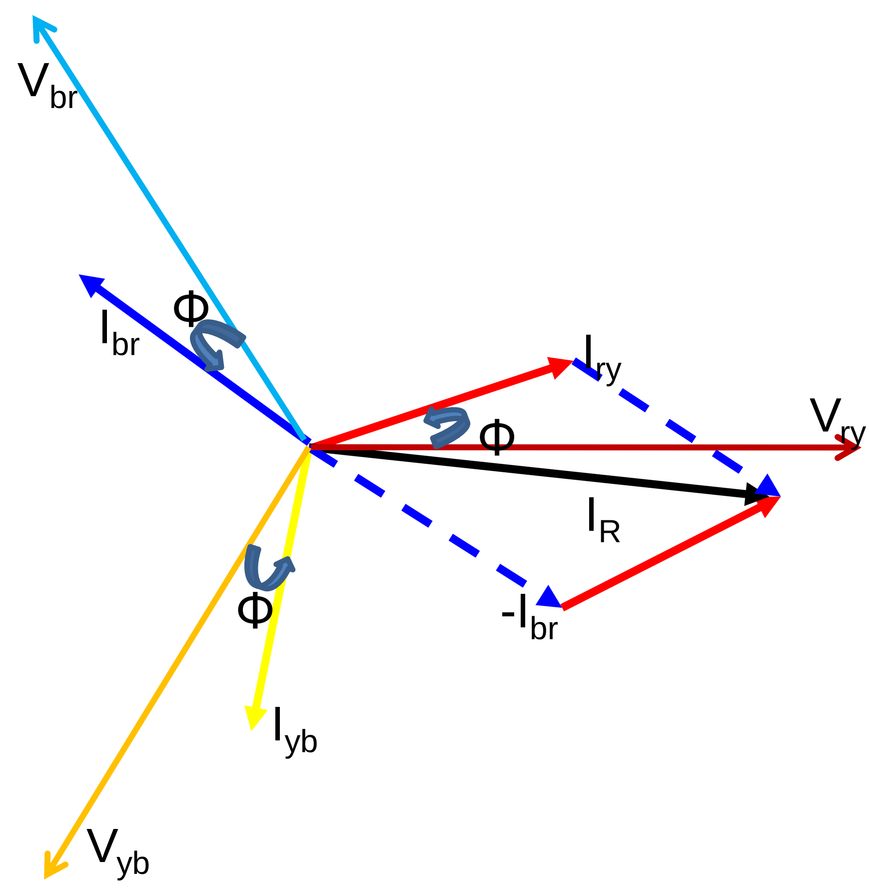
$$I_R = 2OB = 2\,I_{RY}\,Cos30 = \sqrt{3}\,I_{RY}$$

$$I_L = \sqrt{3}\,I_{PH}$$

Three Phase Delta connected Inductive Load

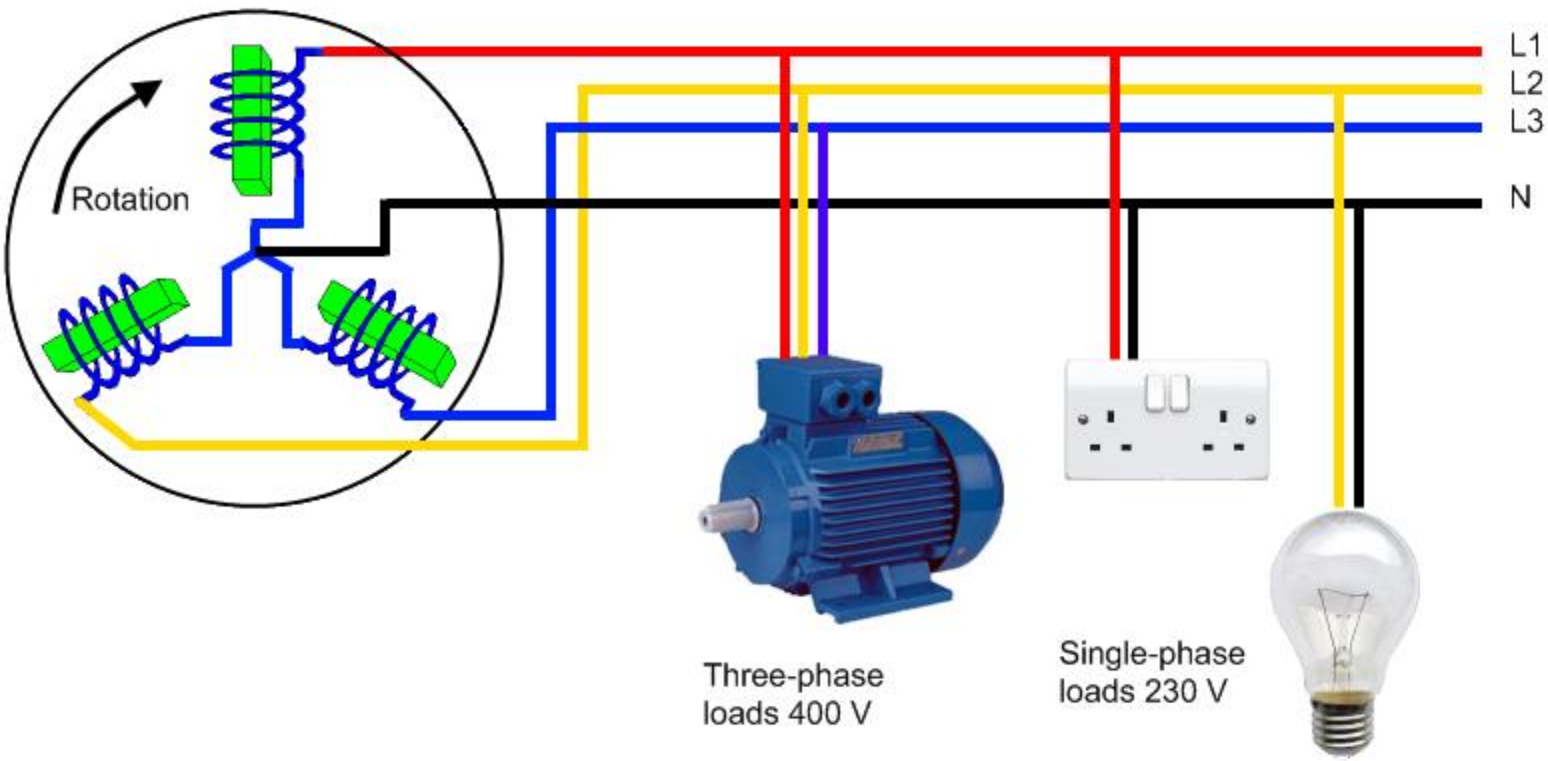


Three Phase Delta connected Capacitive Load



Powers Related with Star and Delta load

Star	Delta
$V_L = \sqrt{3} V_{ph} \quad I_L = Iph$	$V_L = V_{ph} \quad I_L = \sqrt{3} Iph$
$P = 3 V_{ph} I_{ph} Cos\phi$	$P = 3 V_{ph} I_{ph} Cos\phi$
$P = 3 \frac{V_L}{\sqrt{3}} I_L Cos\phi$	$P = 3 V_L \frac{I_L}{\sqrt{3}} Cos\phi$
$P = \sqrt{3} V_L I_L Cos\phi \; Watt$	$P = \sqrt{3} V_L I_L Cos\phi \; Watt$
$Q = \sqrt{3} V_L I_L Sin\phi \; VAr$	$Q = \sqrt{3} V_L I_L Sin\phi \; VAr$
$S = \sqrt{3} V_L I_L \; VA$	$S = \sqrt{3} V_L I_L \; VA$



Rotation
L1
L2
L3
N
Three-phase
loads 400 V
Single-phase
loads 230 V

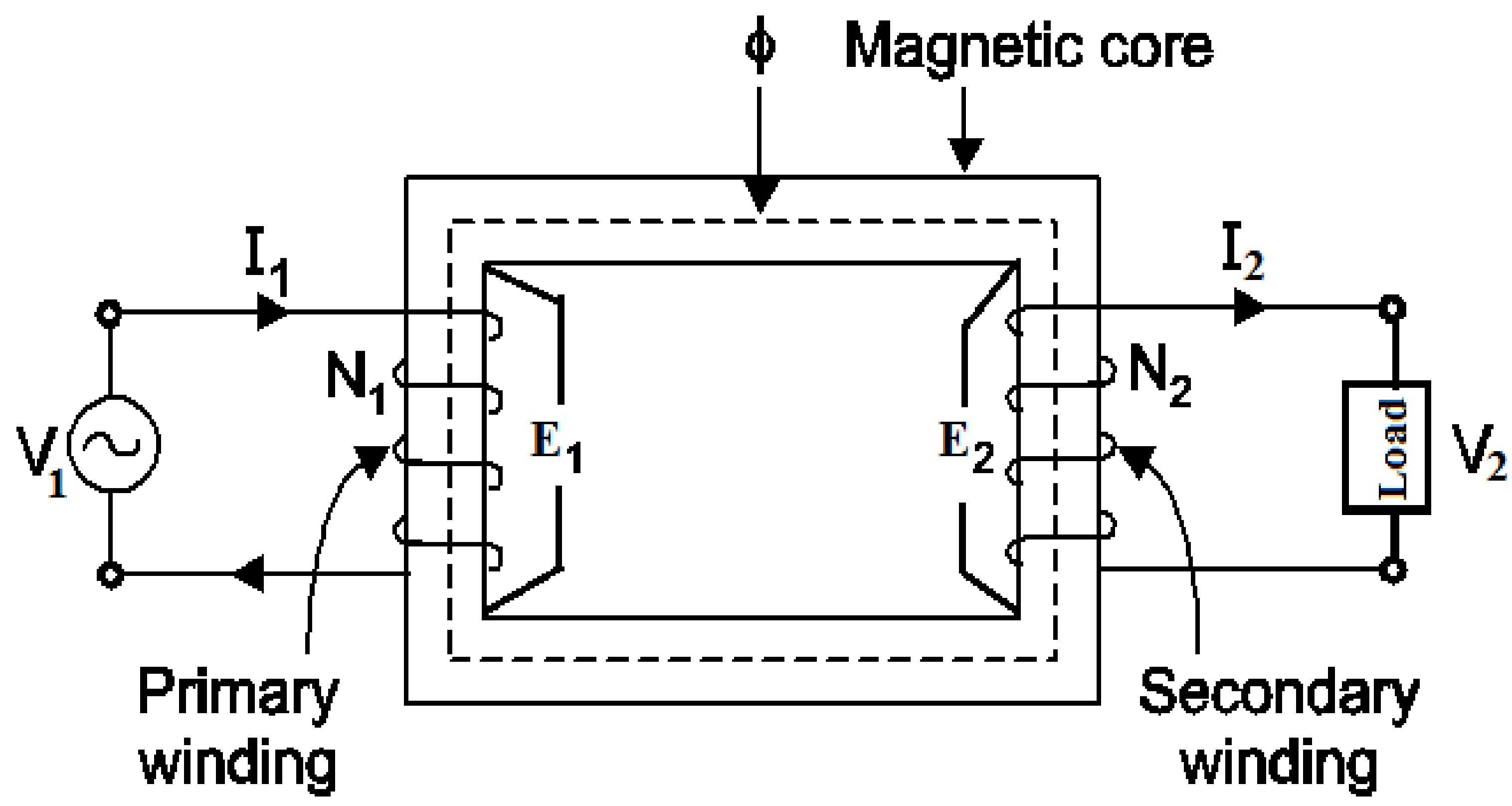
UNIT-4 B
SINGLE PHASE TRANSFORMER

Single phase transformers: principle of working, construction and types, emf equation, voltage and current ratios. Losses, definition of regulation and efficiency, determination of these by direct loading method. Descriptive treatment of autotransformers.

Introduction

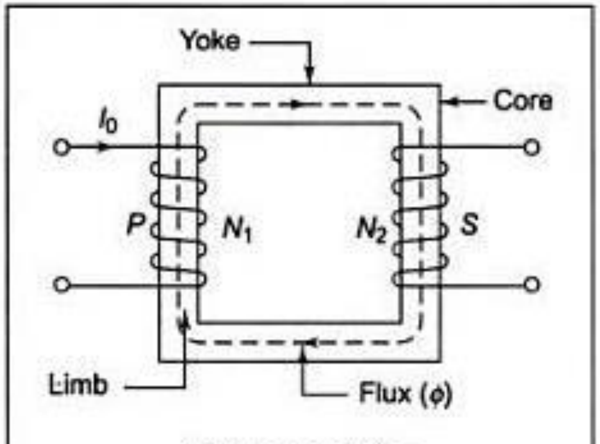
Static device (No Rotating Part)
Transfers Electric Power/Energy
By changing voltage / current level without Changing the Frequency
Works only on AC

Construction and Working principle

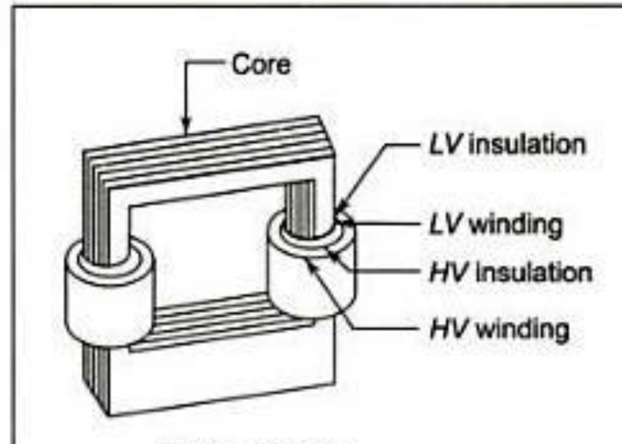


Types of Transformer

Core Type

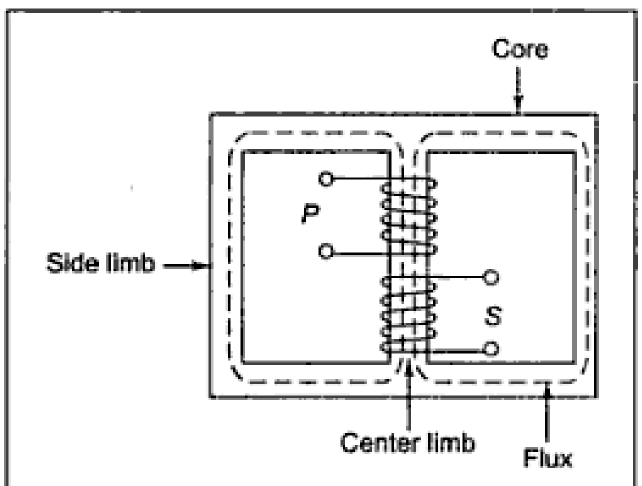


(a) Representation

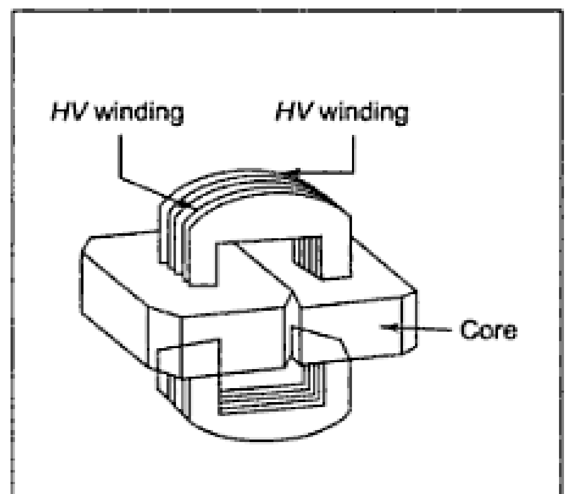


(b) Construction

Shell Type

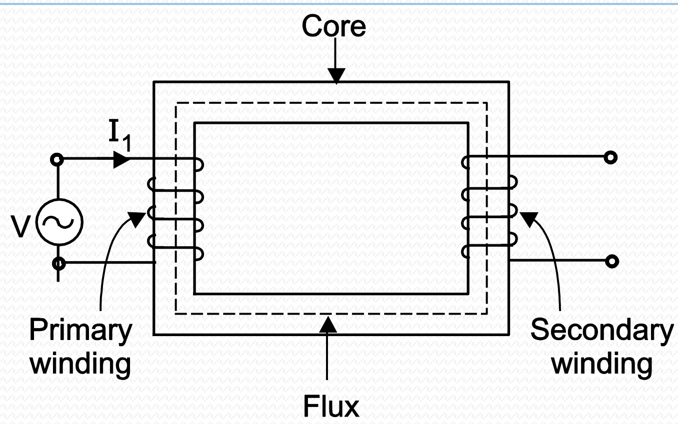
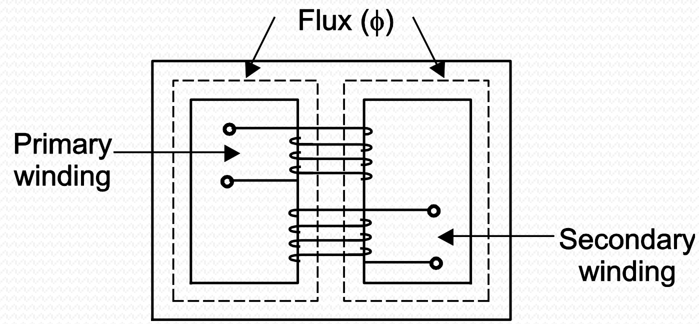


(a) Representation

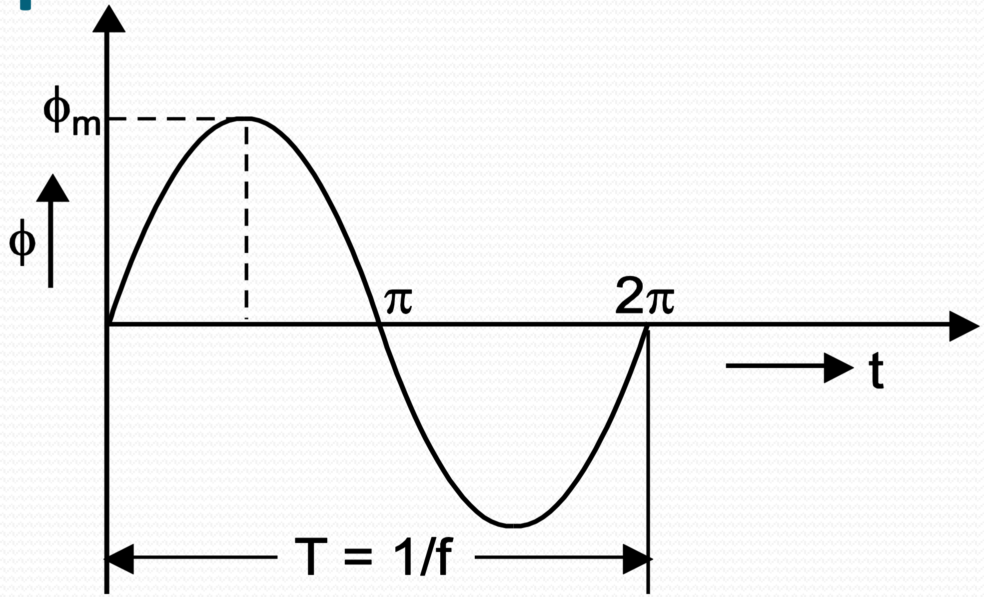


(b) Construction

Core Type and Shell Type (Comparison)

Sr. No.	CoreType Transformer	ShellType Transformer
1.	 It has single magnetic circuit.	 It has double magnetic circuit.
2.	Windings used in core type transformer are cylindrical in form.	Sandwich type windings are used.
3.	Core is surrounded by the winding.	The windings are surrounded by the core.
4.	It is easy for repair and maintenance.	It is difficult for repair and maintenance.
5.	Natural cooling is good.	Natural cooling is poor.

EMF Equation



$E_1 = 4.44\ \O_m f N_1$ volt.

$E_2 = 4.44\ \O_m f N_2$ volt

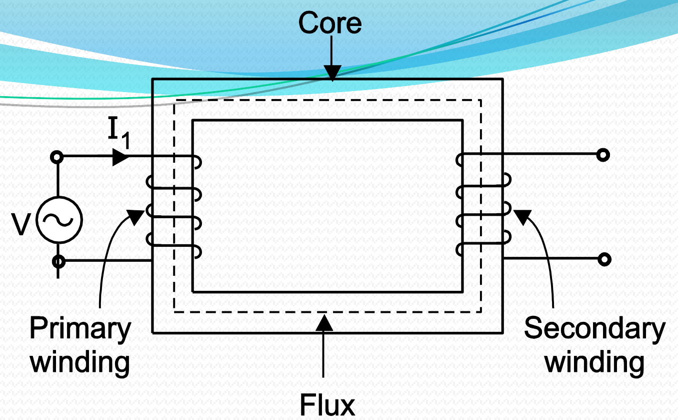
Transformation ratio and KVA rating

$$K = \frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{V_2}{V_1} = \frac{I_1}{I_2}$$

$$KVA\ rating = \frac{V_1 I_1}{1000} = \frac{V_2 I_2}{1000}$$

It is the output given by transformer at rated voltage and rated frequency under usual service conditions without exceeding the standard limits of temperature rise.

Ideal Transformer



Zero leakage flux:

- Fluxes produced by the primary and secondary currents are confined within the core

The windings have no resistance:

- Induced voltages equal applied voltages

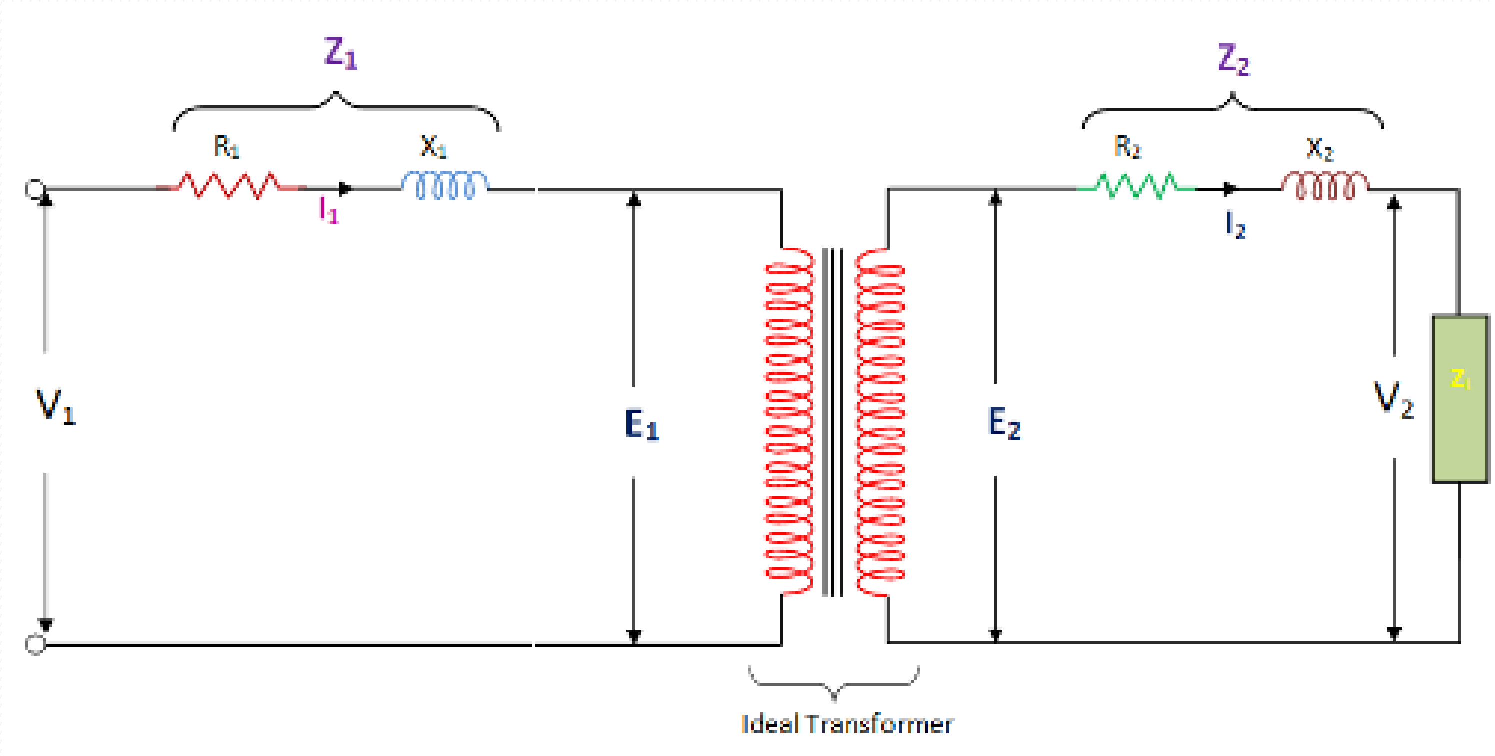
The core has infinite permeability

- Reluctance of the core is zero
- Negligible current is required to establish magnetic flux

Loss-less magnetic core

- No hysteresis or eddy currents

Practical Transformer

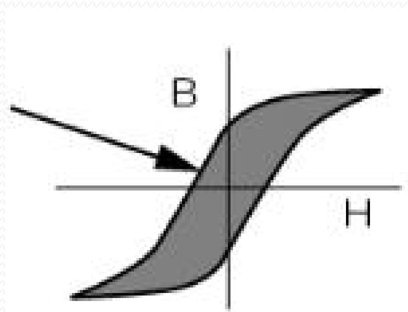


Losses

- Iron Loss
- Copper Loss

Iron Loss

- Hysteresis Loss

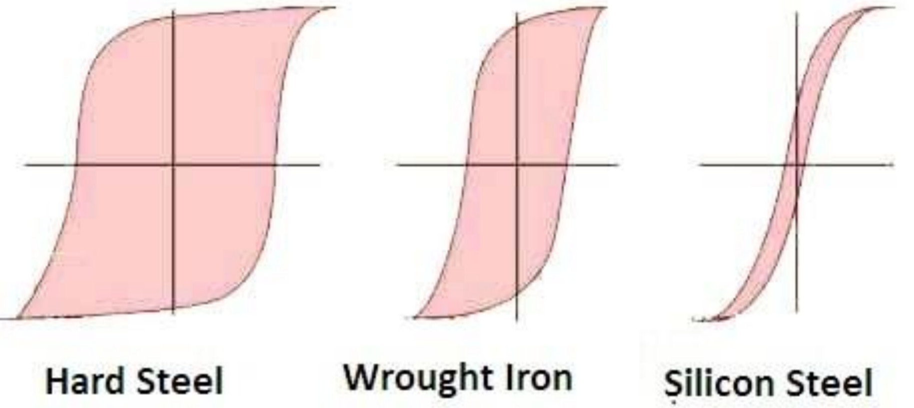


$$P_h = K_h B_m^{1.6} f v \; Watts$$

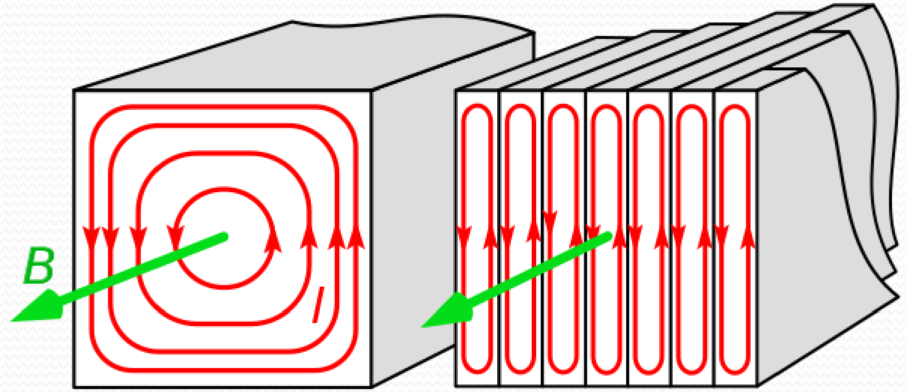
- Eddy Current Loss

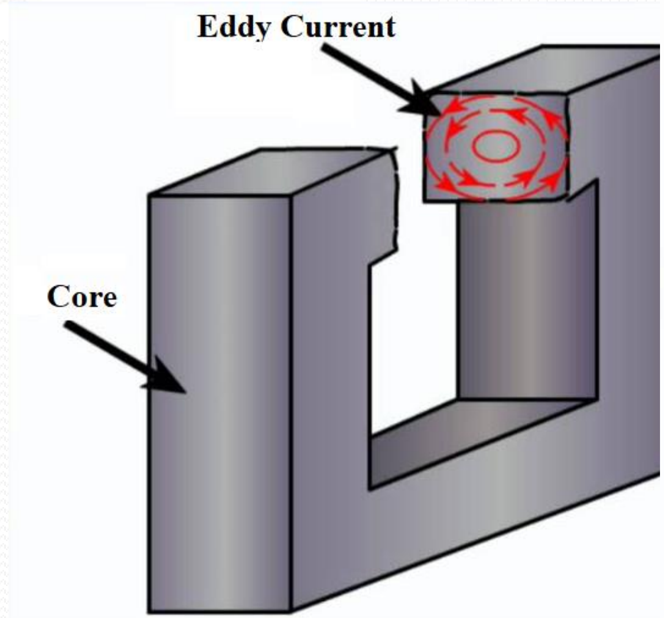
$$P_e = K_e B_m^{2} f^{2} t^{2} v \; Watts$$

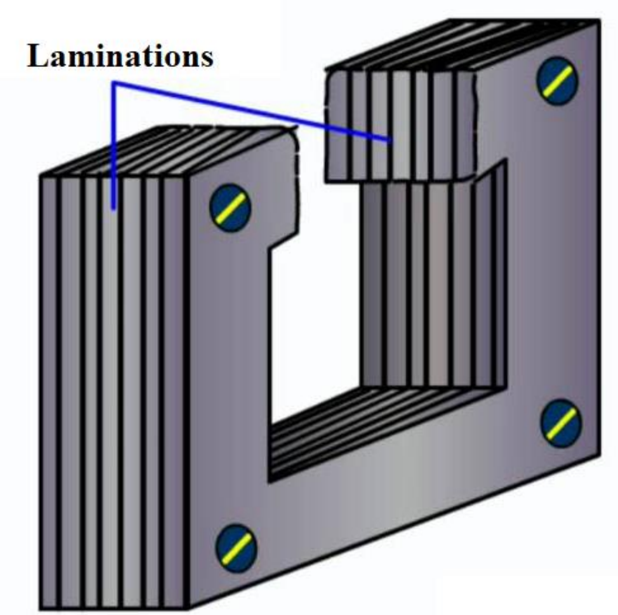
Reduction of Iron Losses



Hysteresis Loops







Copper Loss

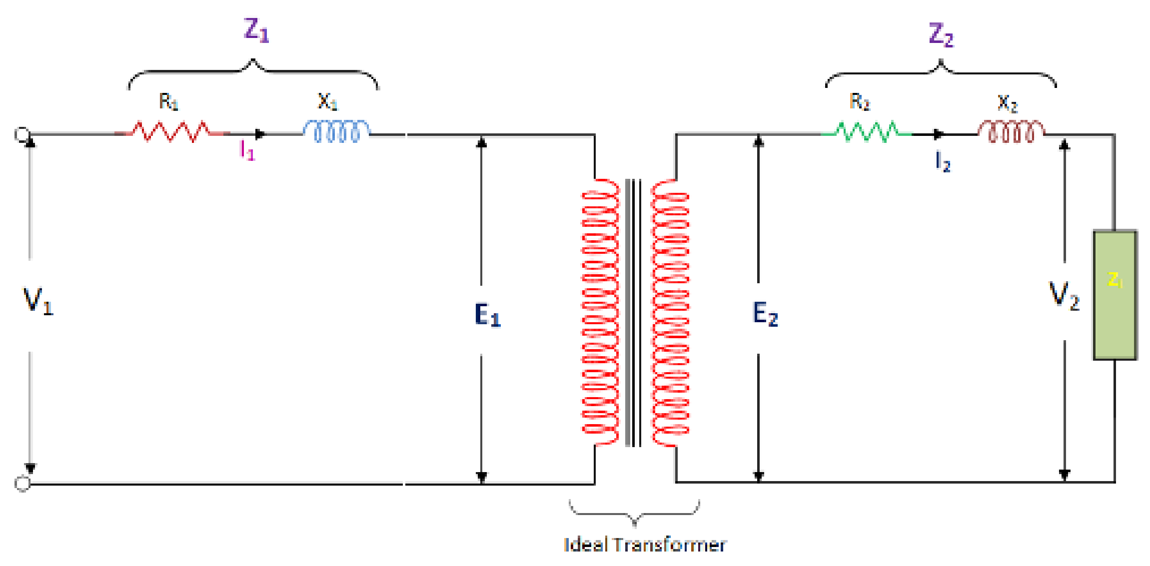
These losses occurs in the primary and secondary windings due to resistance of primary and secondary winding.

Let I_1 and I_2 : the primary and secondary current.

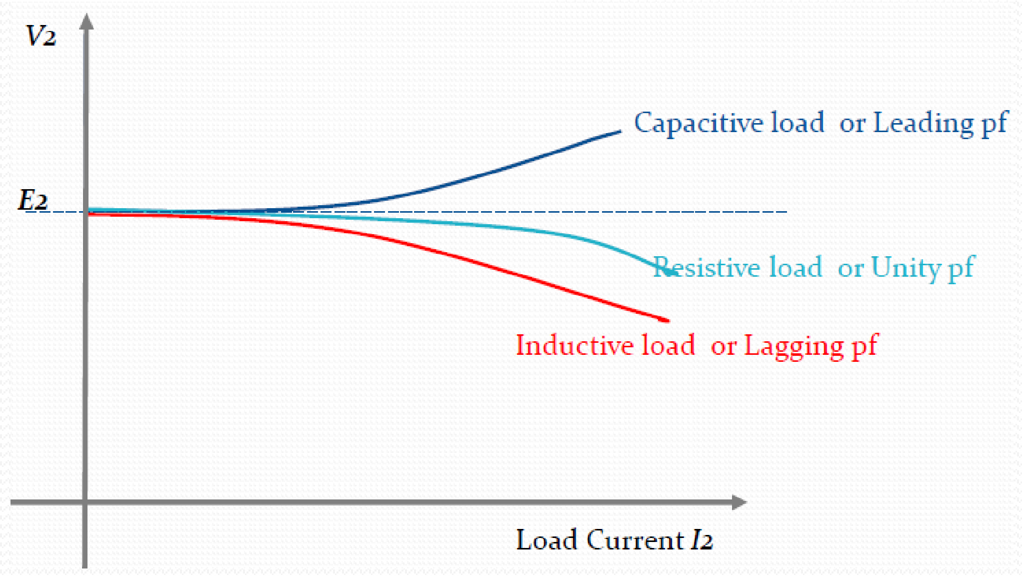
R_1 and R_2 : the primary and secondary winding resistance.

Hence, **Total copper loss $= I_1^2 R_1 + I_2^2 R_2$ Watt**

Voltage Regulation



$$\%\text{Regulation} = \frac{E_2 - V_2}{E_2} \times 100$$



Efficiency

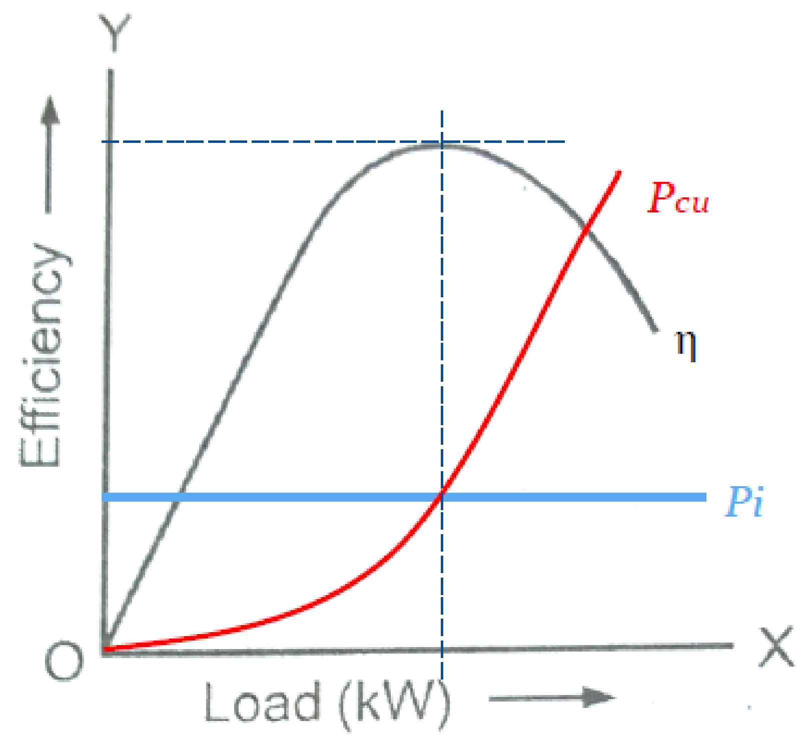
$$\eta = \frac{Output\ power}{Input\ Power} x100$$

$$\eta = \frac{Output\ power}{(Output\ Power + Losses)} x100$$

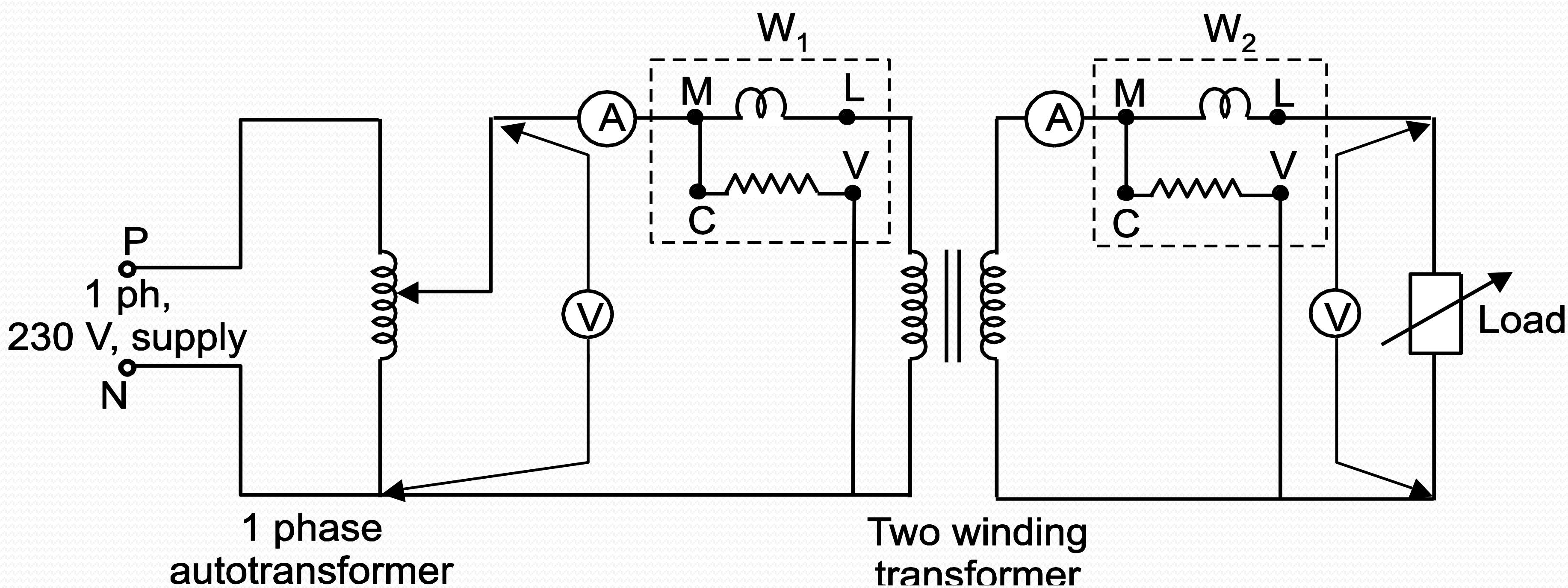
$$\eta = \frac{V_2 I_2 cos\varphi_2}{(V_2 I_2 cos\varphi_2 + P_i + P_{cu})} x100$$

$$\eta = \frac{x\ (VA\ Rating)\ pf}{x\ (VA\ Rating)\ pf + P_i + x^2\ P_{cu\ fl}}$$

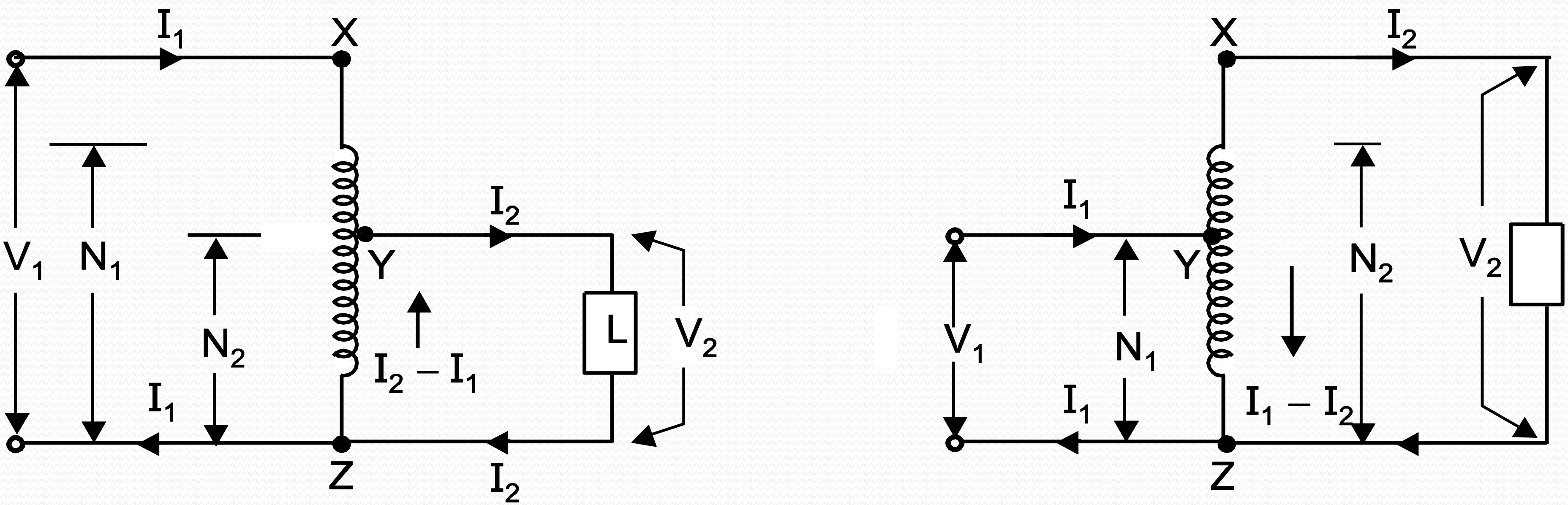
x – Fraction of full load.



Direct loading Test



Auto Transformer



Advantages

- Copper required in case of auto transformer is always less than the two winding transformer, it is always cheaper.
- For same rating, weight of auto transformer is less than two winding transformer.
- The copper losses taking place in a transformer are less.
- Due to less copper loss, efficiency of the transformer is higher than that of two winding transformer.
- Auto transformer has better voltage regulation than that of two winding transformer.

Disadvantages

There is always risk of electric shock, as the primary and secondary are not electrically separated.

In case of step down auto transformer, if the common part gets opened due to any fault, the high voltage on primary side will damage the measuring instrument (typically voltmeter) connected on secondary side.

Applications

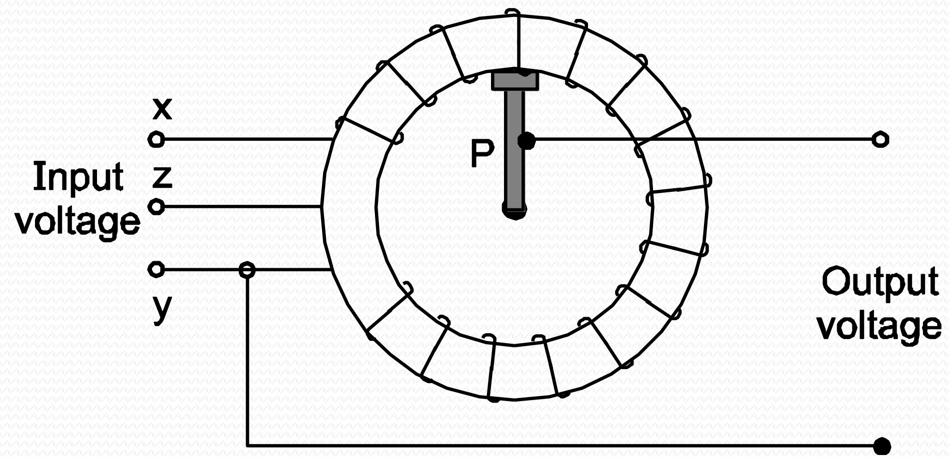
It can be used as starter for squirrel cage induction motor.

It can be used as booster to raise the voltage in A.C. feeders.

It can be used in industry as furnace transformers for getting required voltage.

It can be used as dimmer for dimming the light.

Dimmerstat



Example 1. **An 80KVA, 3200/400v, 50Hz, single phase transformer has 111 turns On the secondary calculate 1) No of turns on primary 2) secondary full load current 3) c/s area of the core if the maximum flux density is 1.2 tesla.**

Solution:

$$KVA = 80$$
$$E_1 = 3200\,V$$
$$E_2 = 400V$$
$$f = 50Hz$$
$$N_2 = 111$$
$$K = \frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{E_2}{E_1} = \frac{I_1}{I_2}$$

$$\frac{N_2}{N_1} = \frac{E_2}{E_1}$$
$$\frac{111}{N_1} = \frac{400}{3200}$$
$$N_1 = \frac{3200 \times 111}{400}$$
$$N_1 = 888$$