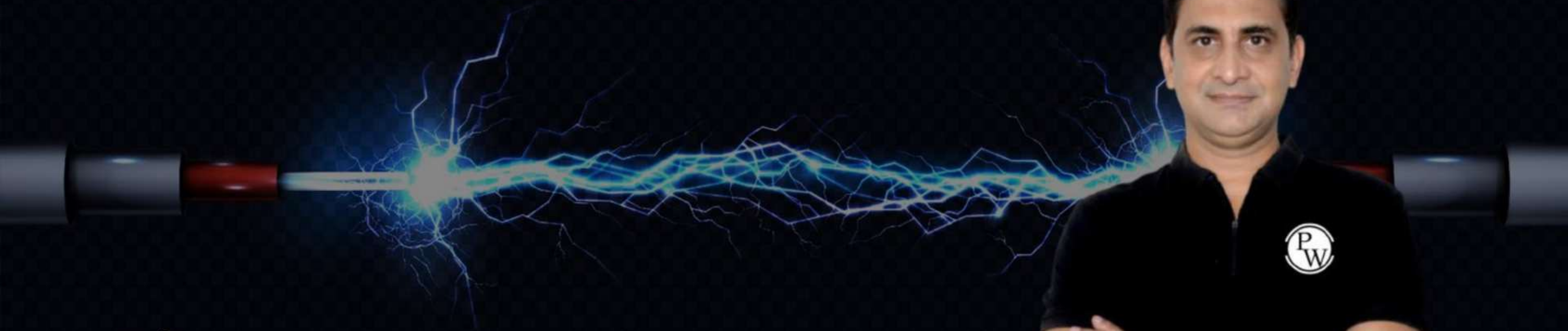


Electrical Engineering

Power System



Lecture No.-01

Introduction

By- Ajay Gupta Sir



Topic to be covered

- ✓ 1. What is power system
- ✓ 2. Generation of Power
- ✓ 3. Indian power scenario
- ✓ 4. Transmission of power
- ✓ 5. Distribution of power
- ✓ 6. Bus - Bar



Books:



Grainger and William D. Stevenson: Power system Analysis.

C L Wadhwa: Electrical Power system

Nagrath Kotari : Modern power system.

V. K. Mehta: Power system

B. R. Gupta: Power system Analysis and design

B.R. Gupta: Generation of electric power ✓

Switchgear and protection: Sunil. S. Rao ✓

Switchgear and protection: Badri Ram ✓

Gate → 10 to 12%

ESE → 20 to 25.



Introduction to power system

System: It is collection of component for an certain objective.

Power: Electrical Power

Objective : To provide quality & reliable power to consumer at minimum cost.

Total study of power system is divided into 3 parts.

- (i) Generation of electrical power
- (ii) Transmission of electrical power
- (iii) Distribution of electrical power



Topic : Generation of electric power of Electric Power

Conventional energy source
(Thermal, Hydro, Nuclear)

Nonconventional energy source.
(Wind, Solar, Bio-gas, Tidal, Geothermal)



Power Plant



Thermal Power Plant:(coal, lignite ,gas , diesel)



Coal Energy → Steam Energy → Mechanical Energy → Electrical Energy

Total installed capacity → 2,49,272 MW (46.79 %)

Hydro Power Plant:

Potential energy → Kinetic energy → Mechanical Energy → Electrical Energy

Installed capacity → 51,415 MW (9.65%)



Power Plant



Nuclear Power Plant:

Nuclear Energy → Steam Energy → Mechanical Energy → Electrical Energy

Installed capacity = 8780 MW (1.65%)

Nonconventional Energy Source:

- ✓♦ Wind
- ✓♦ Solar
- ✓♦ Bio-mass
- ✓♦ Tidal
- ✓♦ Geo-Thermal

Installed capacity – 223273 MW (41.92%)

Total Installed capacity → 4,17,668 MW

Central Government 1,24,108 MW 24.0 %

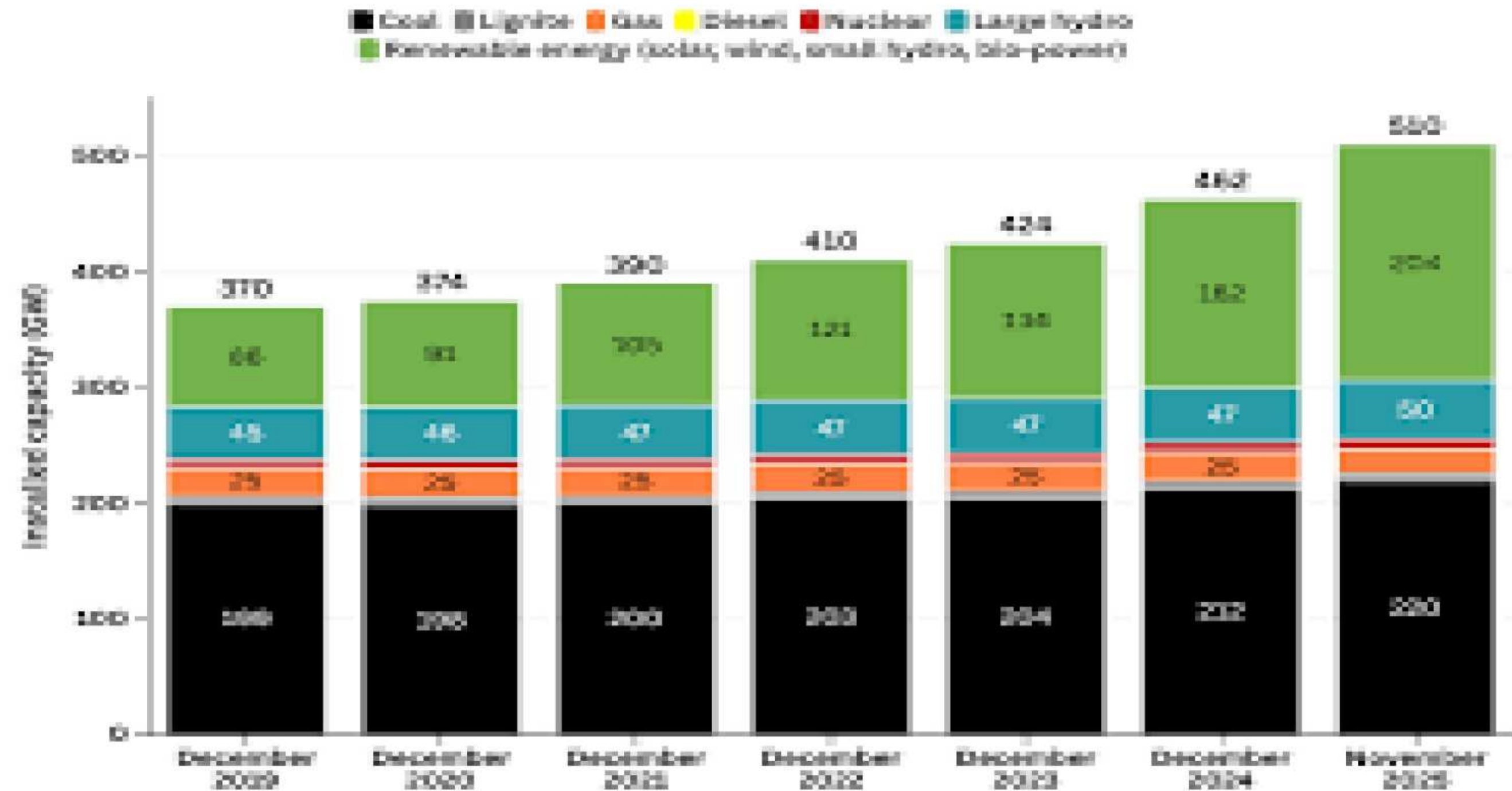
State Government 1,30,000 MW 25.3 %

Private Sector 2,78,632 MW 52-55%

Approximately 1700-1750 BU (Billion Unit)

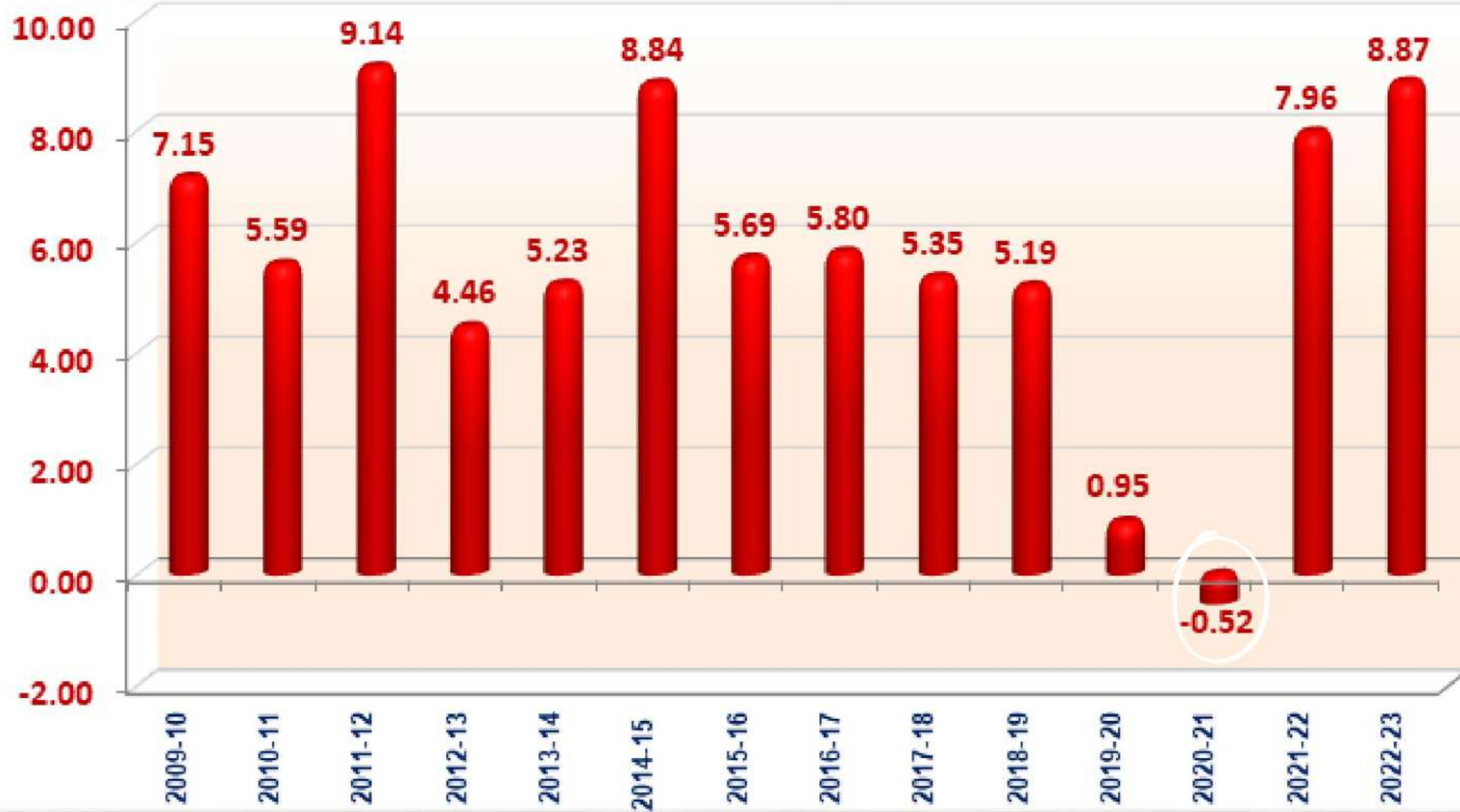
1 unit = 1 kWh

India's total installed power generation capacity (2019-2025)



Source: Central Electricity Authority (CEA), India
 (Data updated till November 2025)

Growth in Total Generation (%)





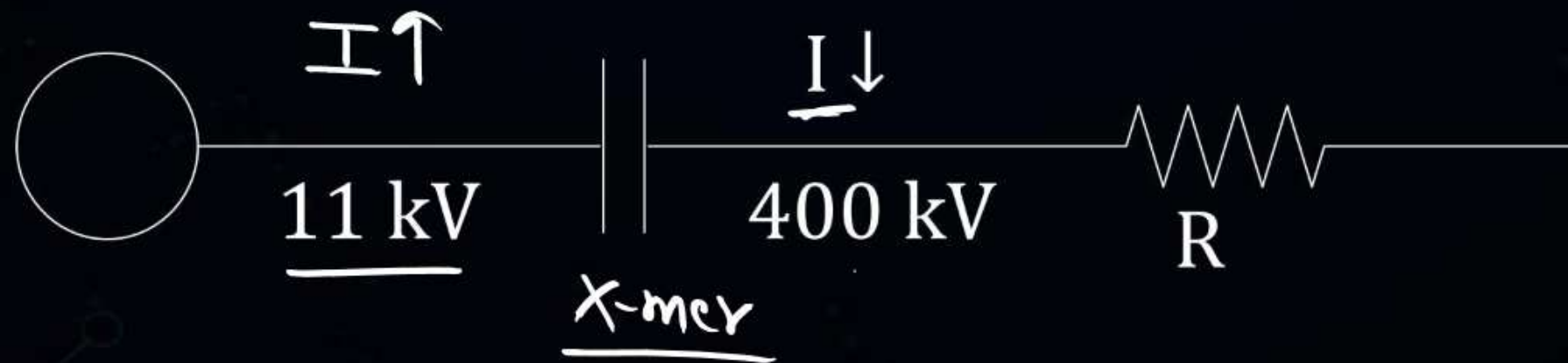
Transmission of electric power





Transmission of Electrical Power

- It is network of conductor, which carries bulk power from generating station to sub-station.
- 3 Phase-3 wire system is used.
- Power is transmitted at high voltage to reduce the loss





Transmission of Electrical Power

$$\checkmark V_1 I_1 = V_2 I_2$$

$$I_2 = \frac{V_1}{V_2} \cdot I_1$$

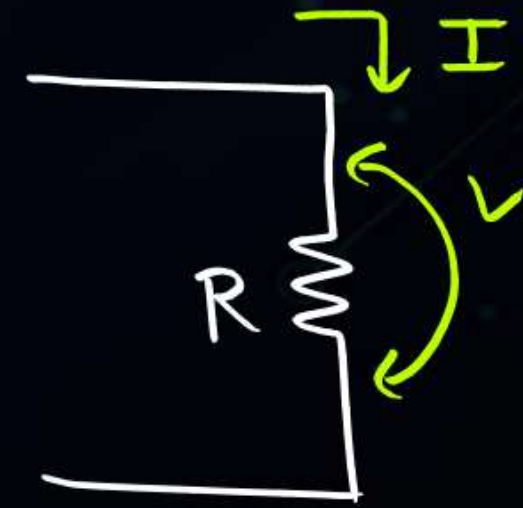
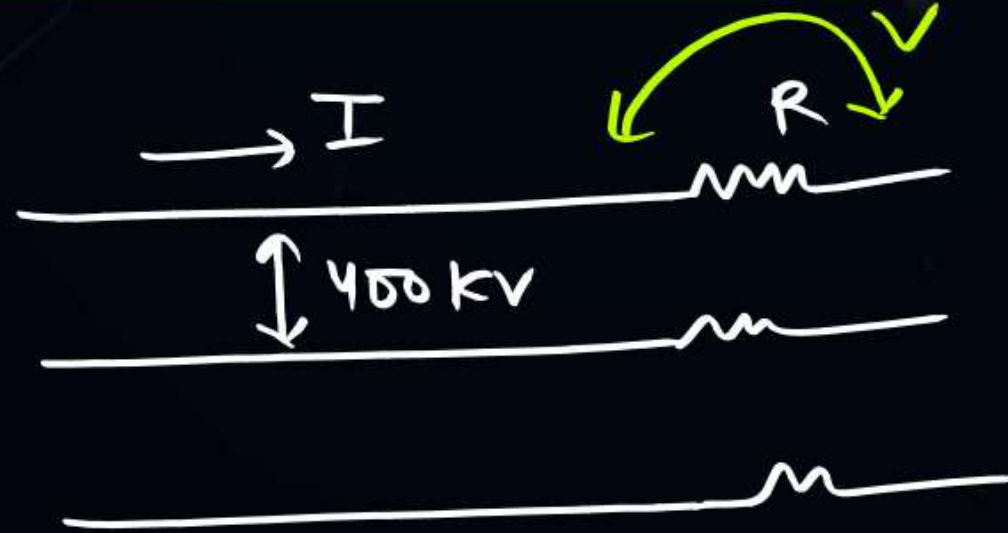
$$\textcircled{I_2} = \frac{11}{400} \cdot I_1$$

$$\underline{I_2 < I_1}$$

$$\checkmark P \downarrow = I^2 \downarrow R$$

11/33/132/220/400/765/1200

✓ ✓ ✓ ✓ ✓ ✓



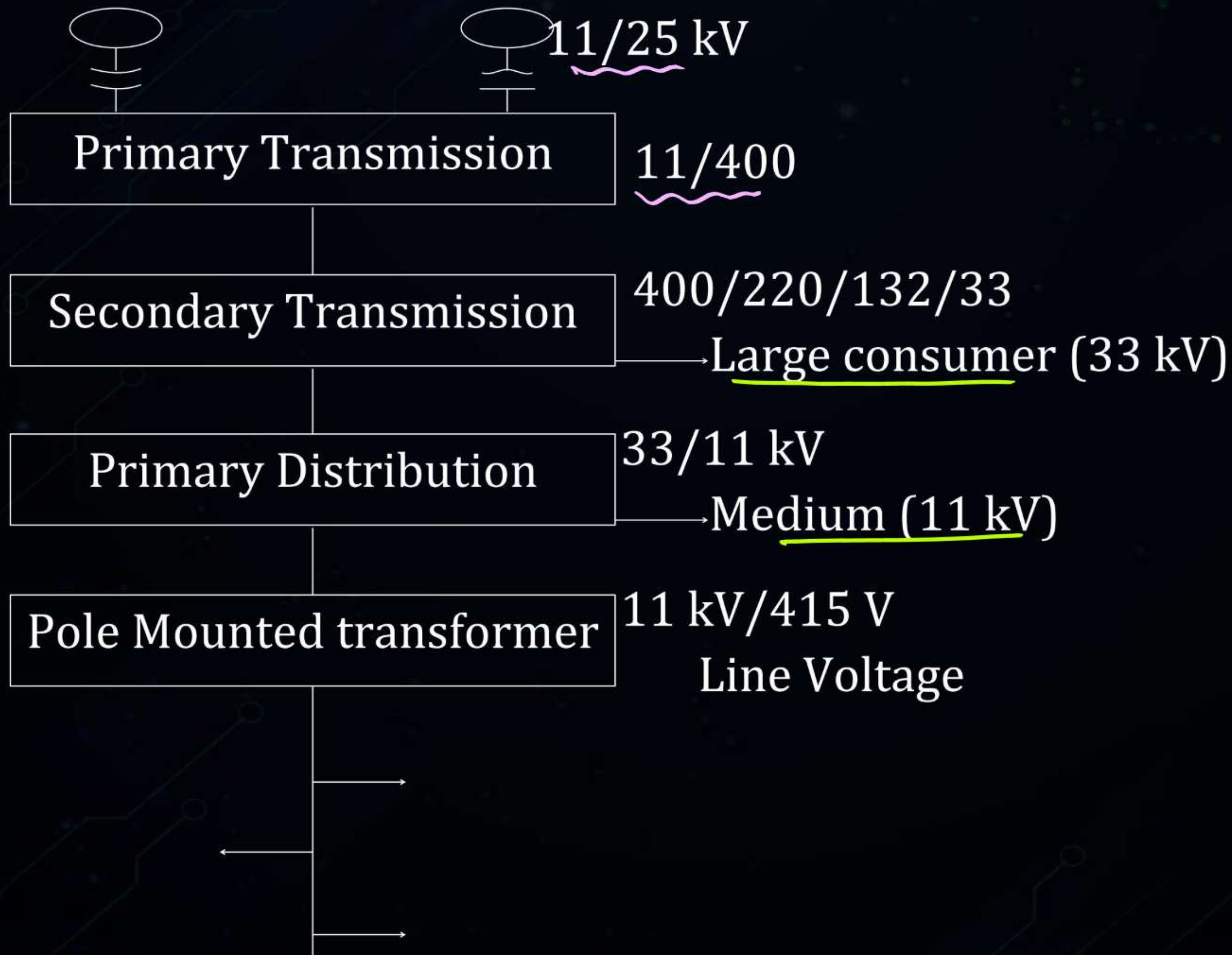
$$P = VI = (IR)I = I^2 R$$
$$= V\left(\frac{V}{R}\right) = \frac{V^2}{R}$$

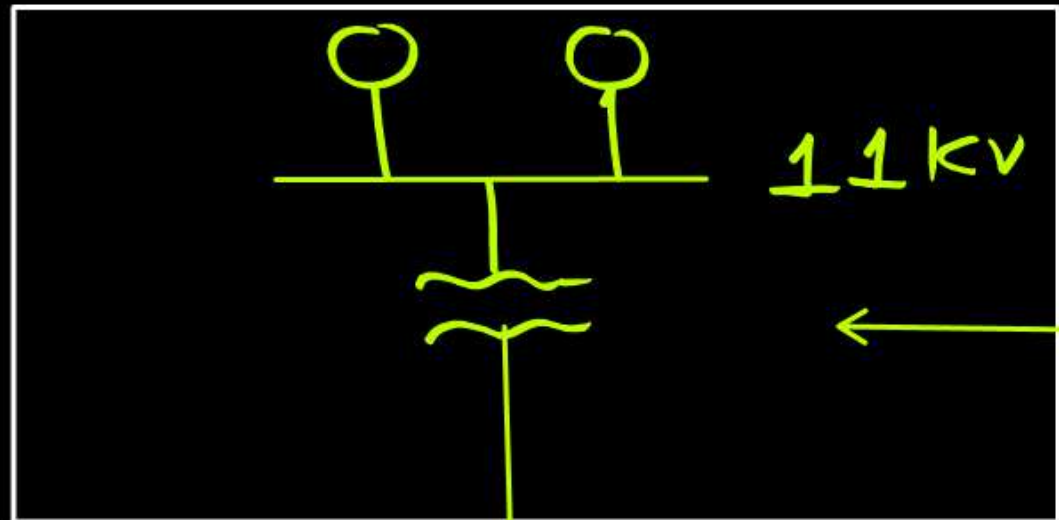


Transmission of Electrical Power

ajay gupta sir pw





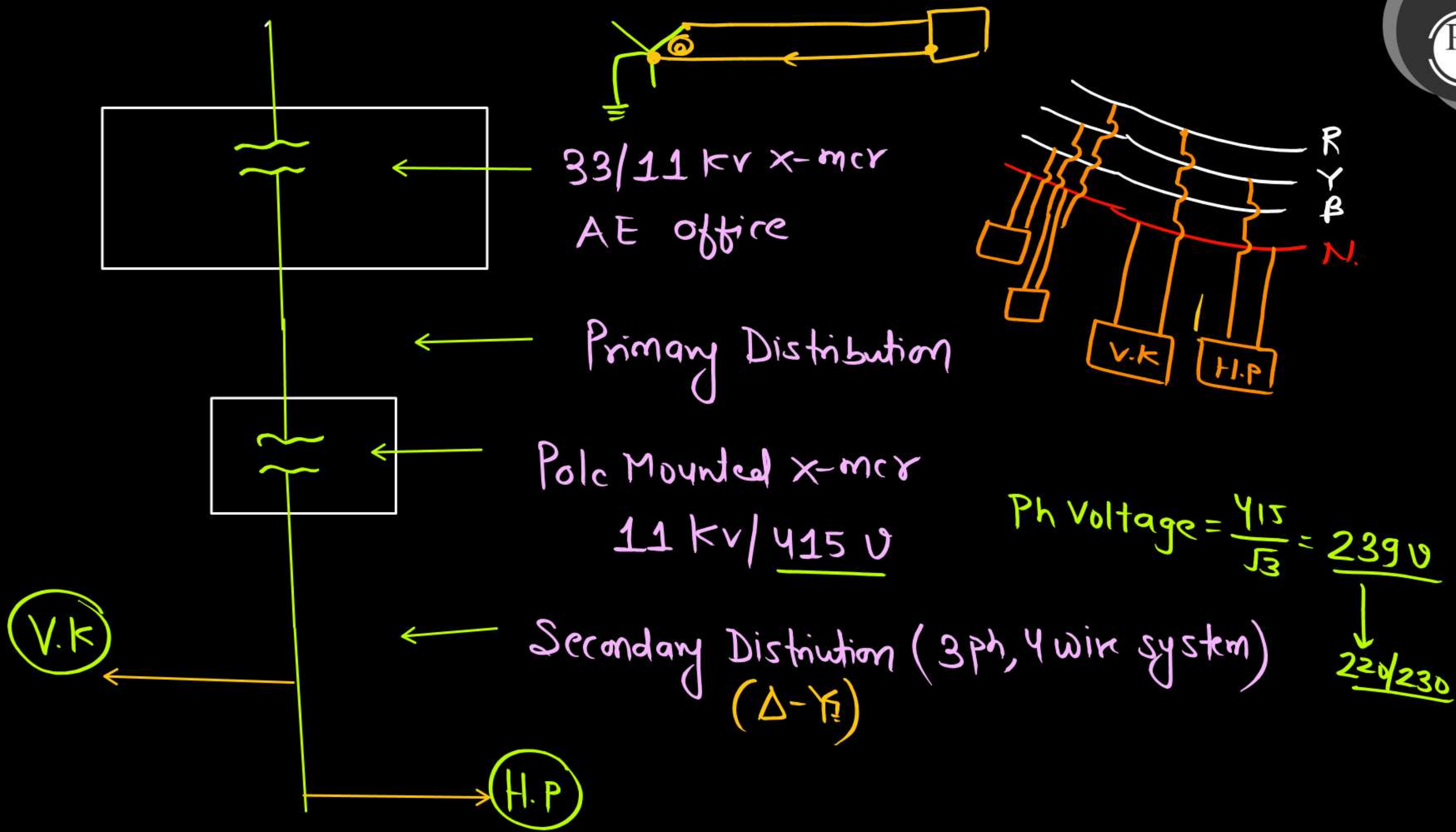


Step up x-mcr
 $11\text{kv} / 765(400)(220) \dots$

Primary Transmission

Step down x-mcr

Secondary transmission



Transmission line classification:

- ◆ Short T.L.
 - ◆ Medium T.L.
 - ◆ Long T.L.
- High length tower is used for power transmission.



Distribution of Electrical Power



- It is a network of conductor, Which carries power from system sub-station to end user.
- 3 Phase, 4 wire is used to supply 1 ϕ power to end user. (Secondary Distribution)
- It carries power at low voltage.
- Current carrying capacity is low.
- Radial distribution system
- Ring distribution system.
- Interconnected distribution system.





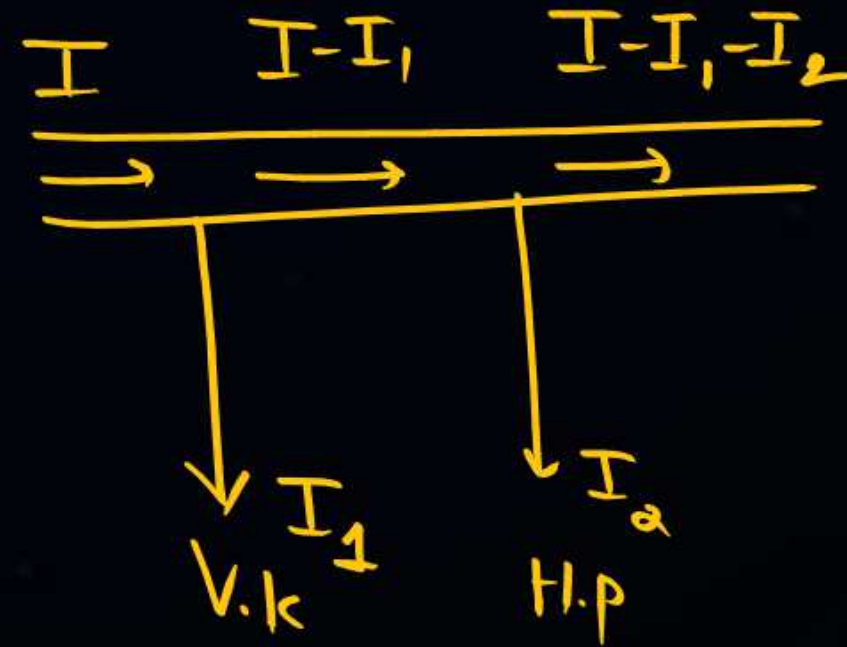
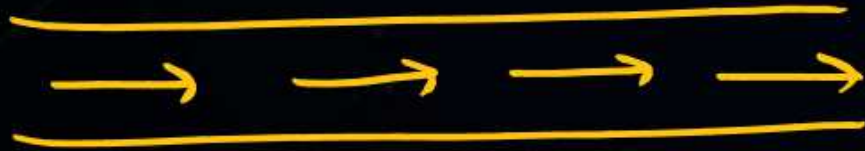
← Distribution x-mcr 11/415V

Feeder :

The current density of feeder is constant everywhere (No tapping is done from feeder)

Distributor :

The current density of distributor are not same everywhere.



GRID: The transmission system of a area is known as grid. The different grid are interconnected to form a regional grid and different regional and is further connected to form the national grid.



1991 → N.E + Eastern.

+

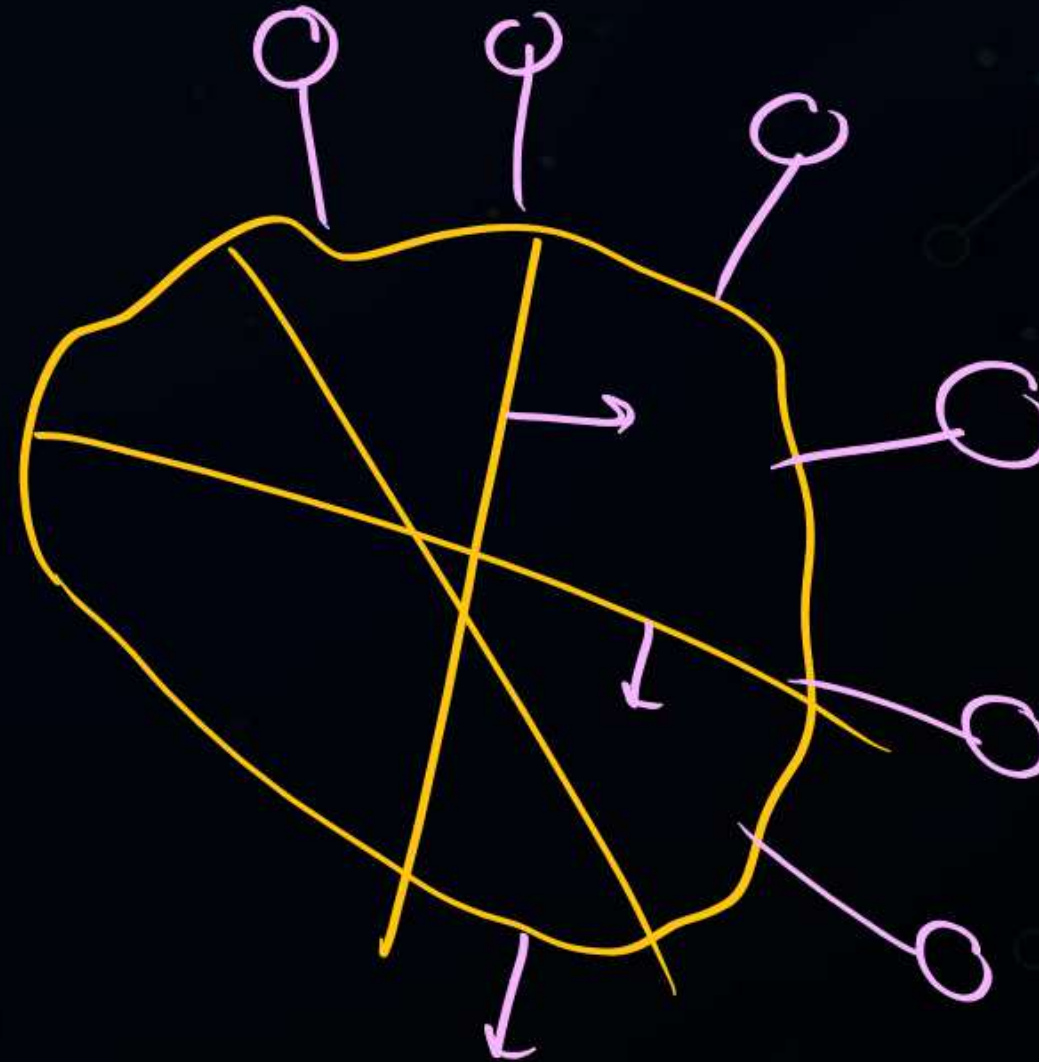
2003 → Western

+

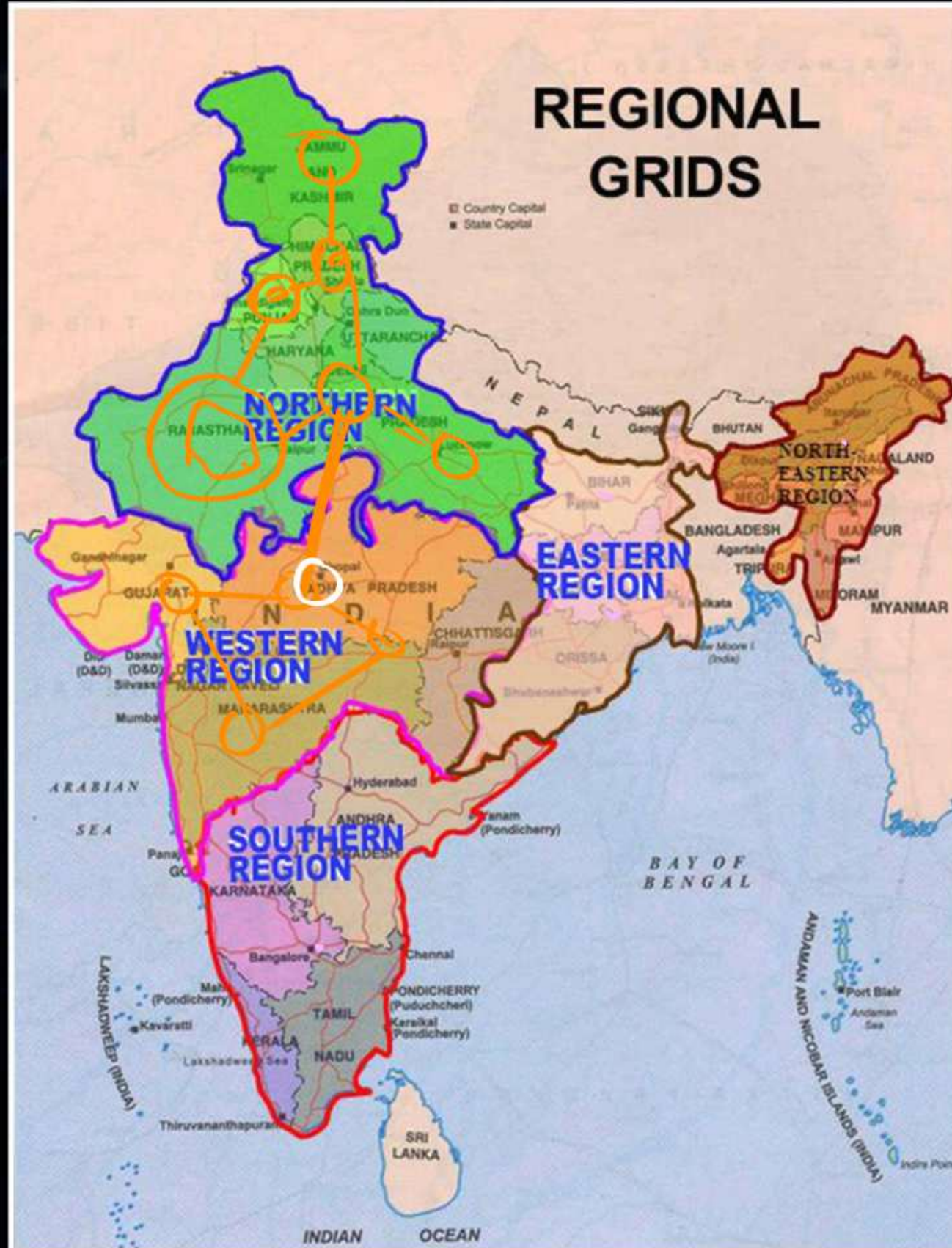
2006 → Northern Grid

+

2013 → Southern Grid.



REGIONAL GRIDS



INSTALLED CAPACITY

✓ Northern	:	1,56,657.MW
✓ Eastern	:	<u>39,607 MW</u>
Sothern	:	1,49,965 MW
✓ Western	:	1,84,692 MW
North-Eastern	:	<u>6,177 MW</u>



2 Minutes Summary

→ What is P.S.

→ Generation

→ Transmission

→ Distribution

→ GRID.

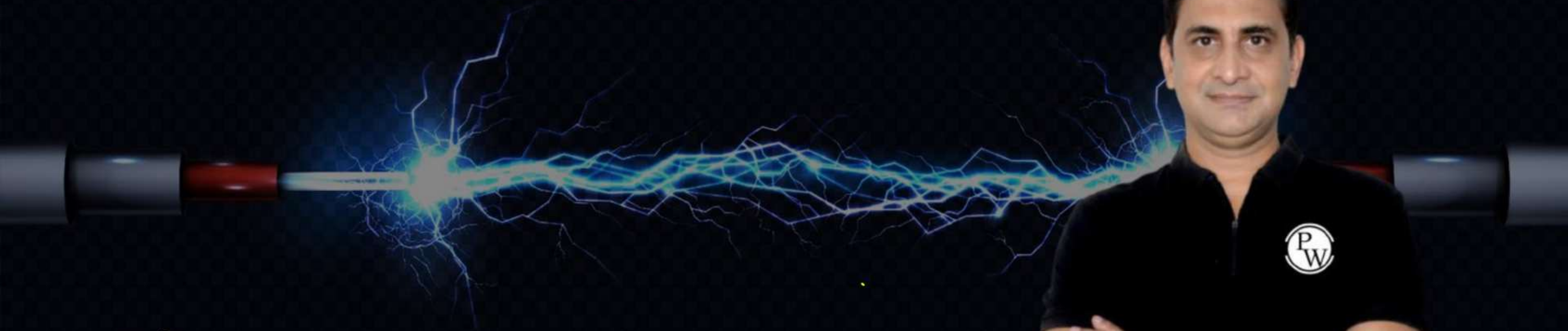
Thank you

GW
Soldiers !



Electrical Engineering

Power System



Lecture No.-02

Introduction



By- Ajay Gupta Sir



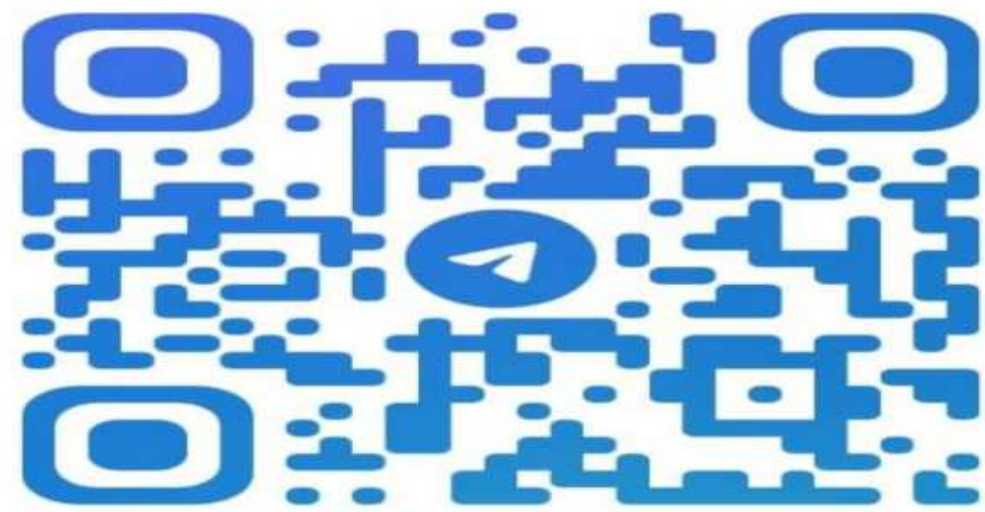
Recap of Previous Lecture

- ✓ 1. What is power system
- ✓ 2. Generation of Power
- ✓ 3. Indian power scenario
- ✓ 4. Transmission of power
- ✓ 5. Distribution of power



Topics to be Covered

- ✓ 1. Basic component of PS
- ✓ 2. Basic component of system
- ✓ 3. Alternator
- ✓ 4. Induction Generator
- ✓ 5. Transformer
- ✓ 6. Bus Bar



@AJAYGUPTASIRPW



Sub Station

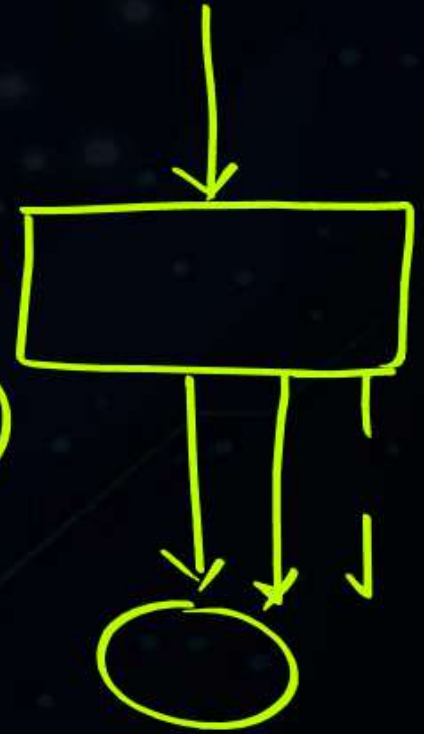




The Main Role of Sub Station

- To step down the voltage.
- Protection of transmission system.
- Maintaining the voltage level (Reactor, Capacitor bank)
- To control the frequency (By load shedding)
- Data transmission for purpose of control and protection.

Voltage $\propto f$ (Reactive power)
frequency $\propto f$ (Active power)







Type of Sub-Station:

1. Primary transmission Sub-Station ✓
2. Secondary Transmission Sub-Station ✓
3. Distribution Sub-Station ✓
4. Converter Sub-Station (HVDC) ✓
5. Switching Station

(Sub-Station without transformer) (It operate at single voltage level).

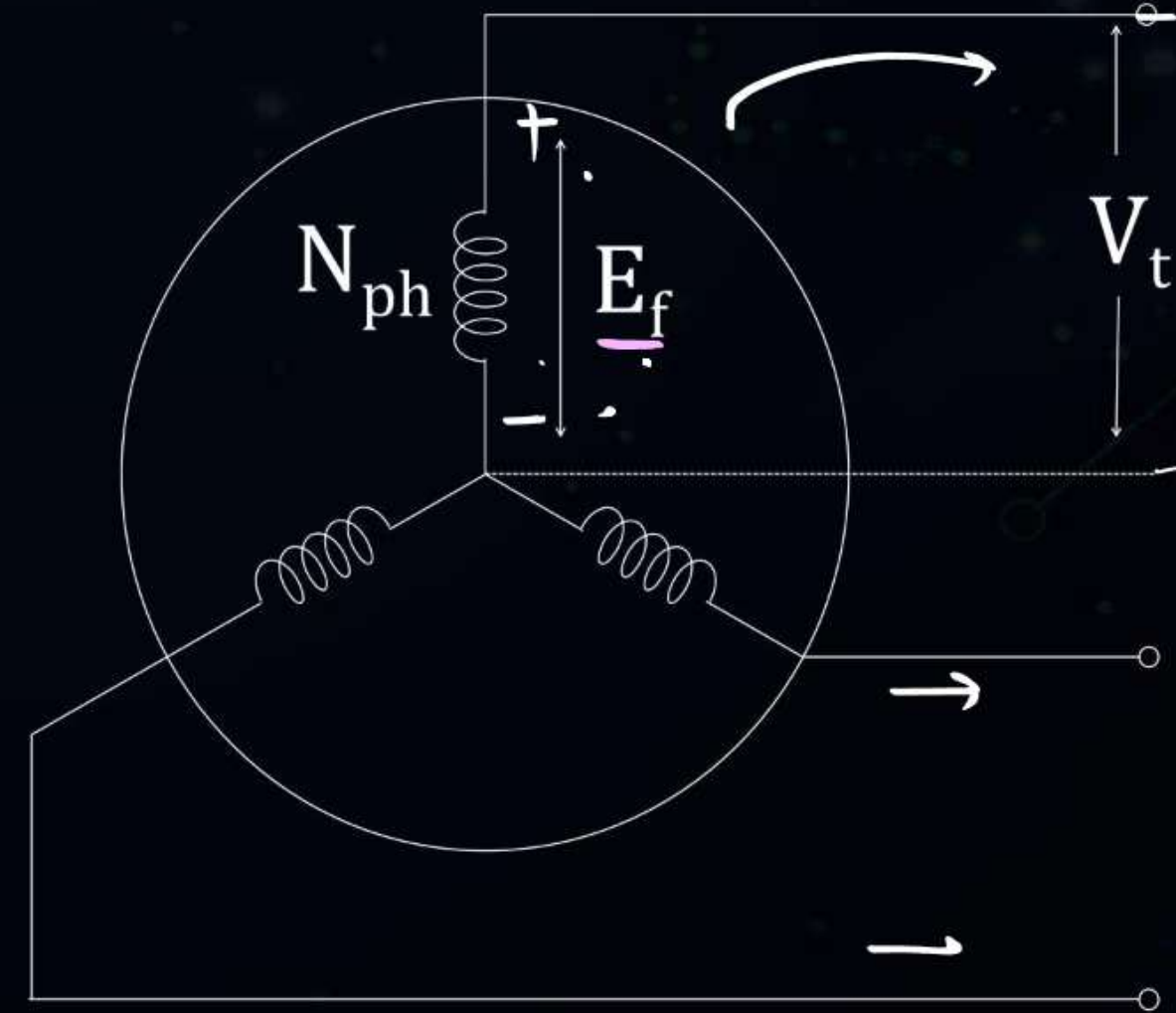
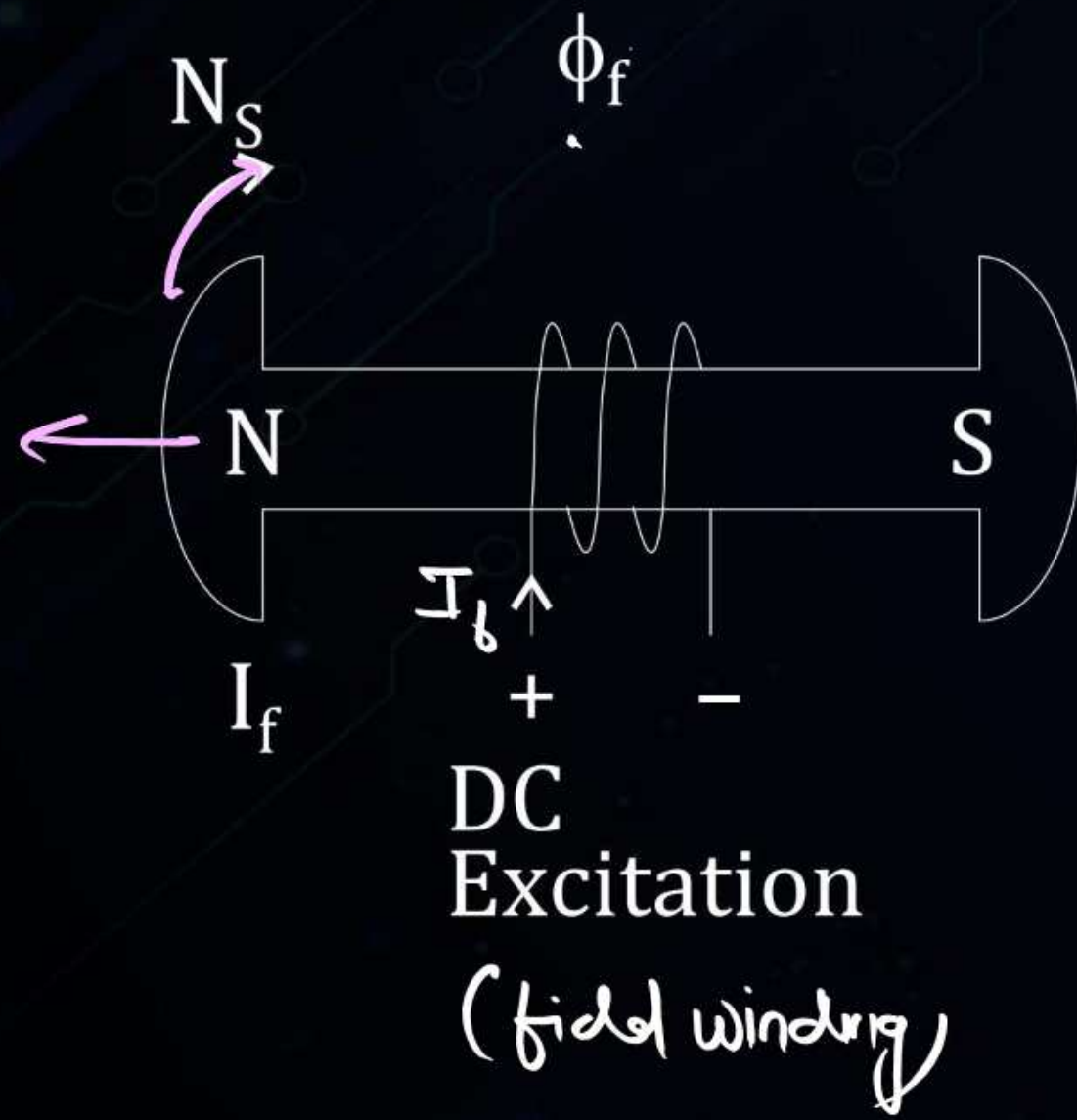
6. Railway Sub-Station (25 kV)
7. Collector Sub-Station [Wind Farm / Solar Farm]

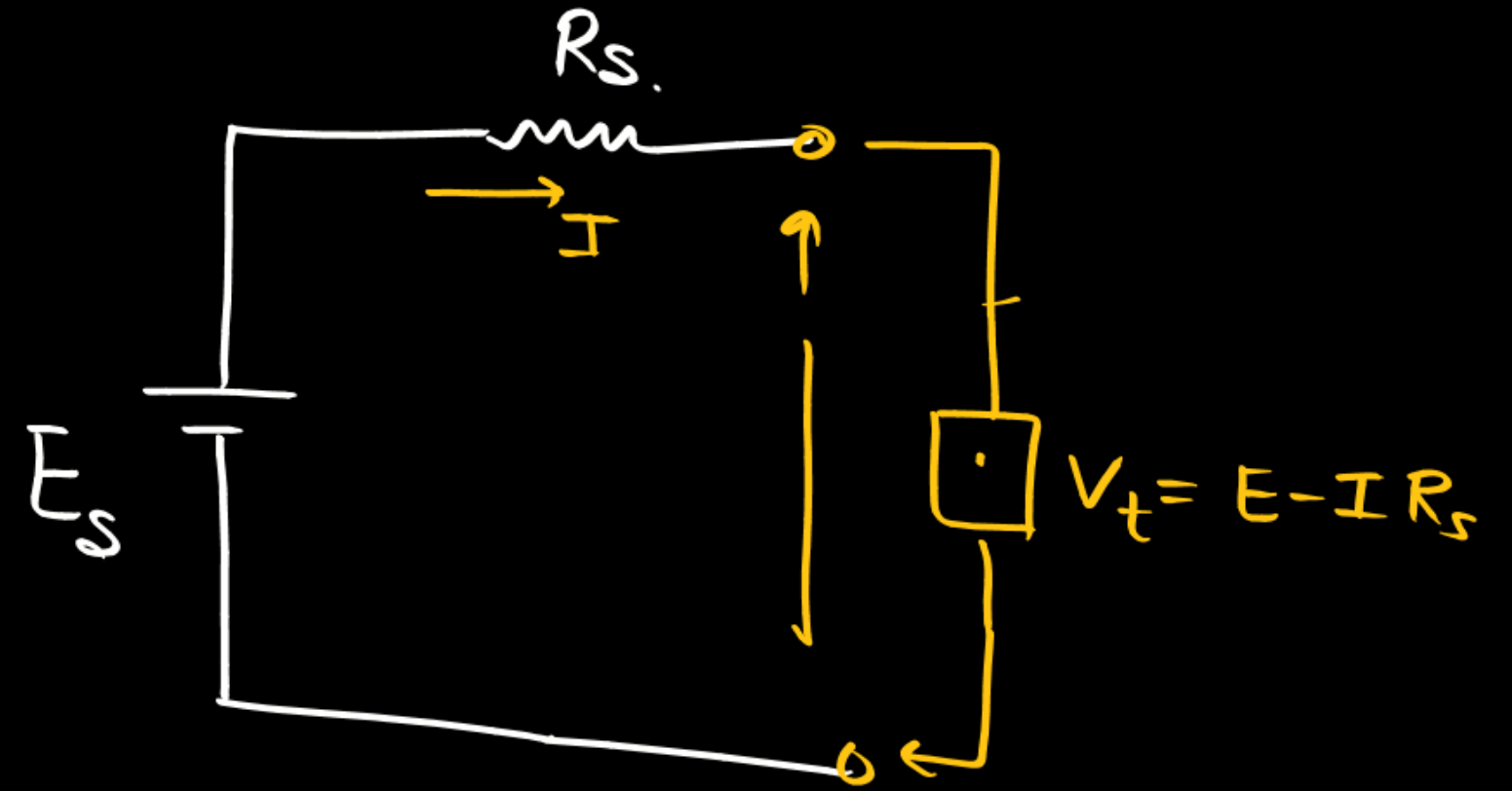
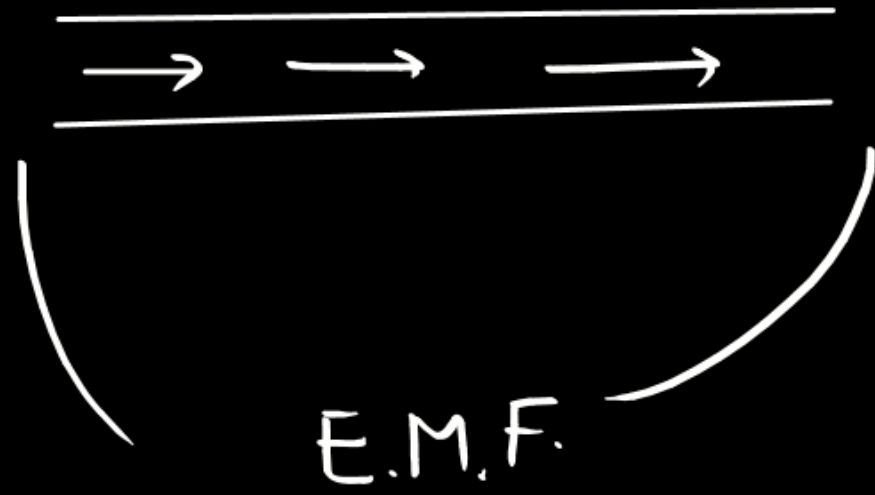
Component of Power system

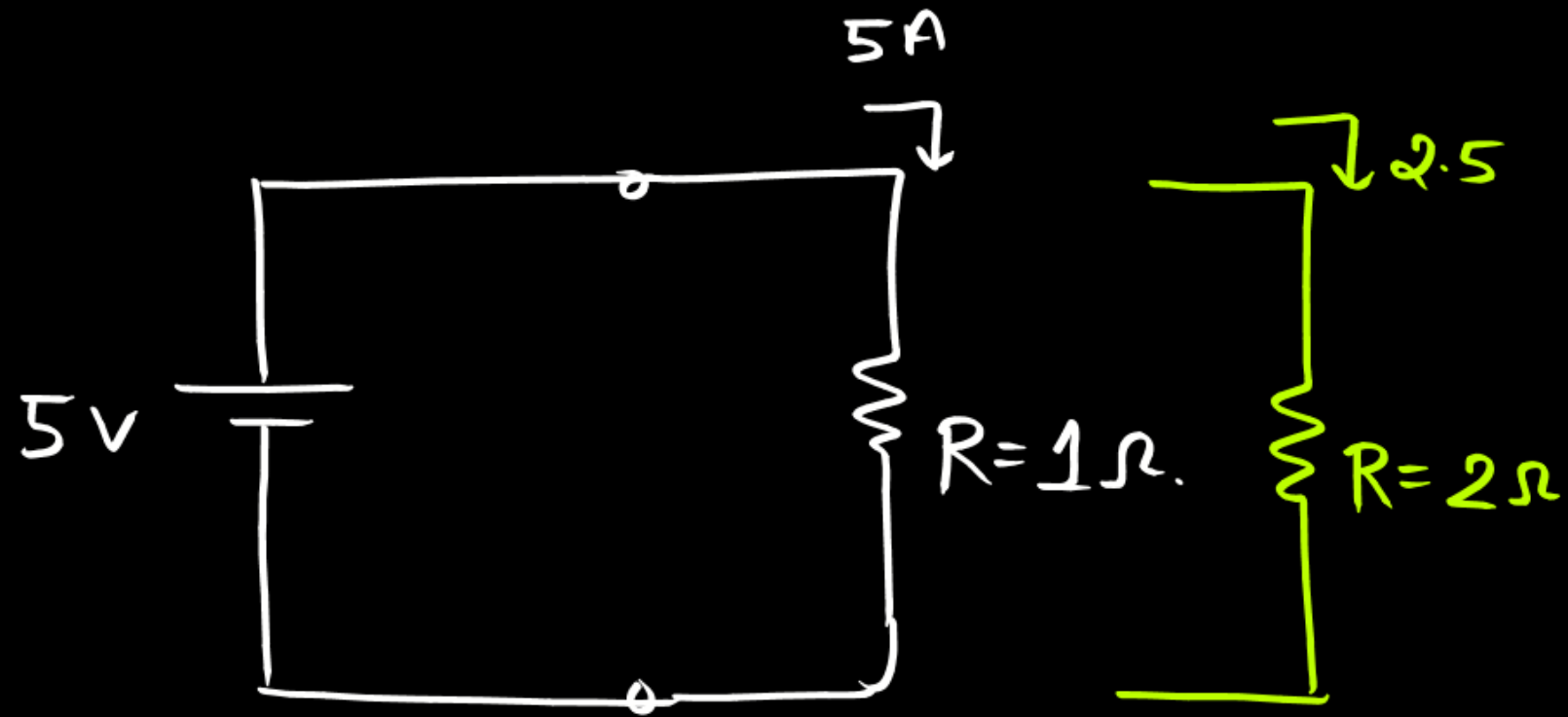


Topic : Alternator → (Synchronous Generator)



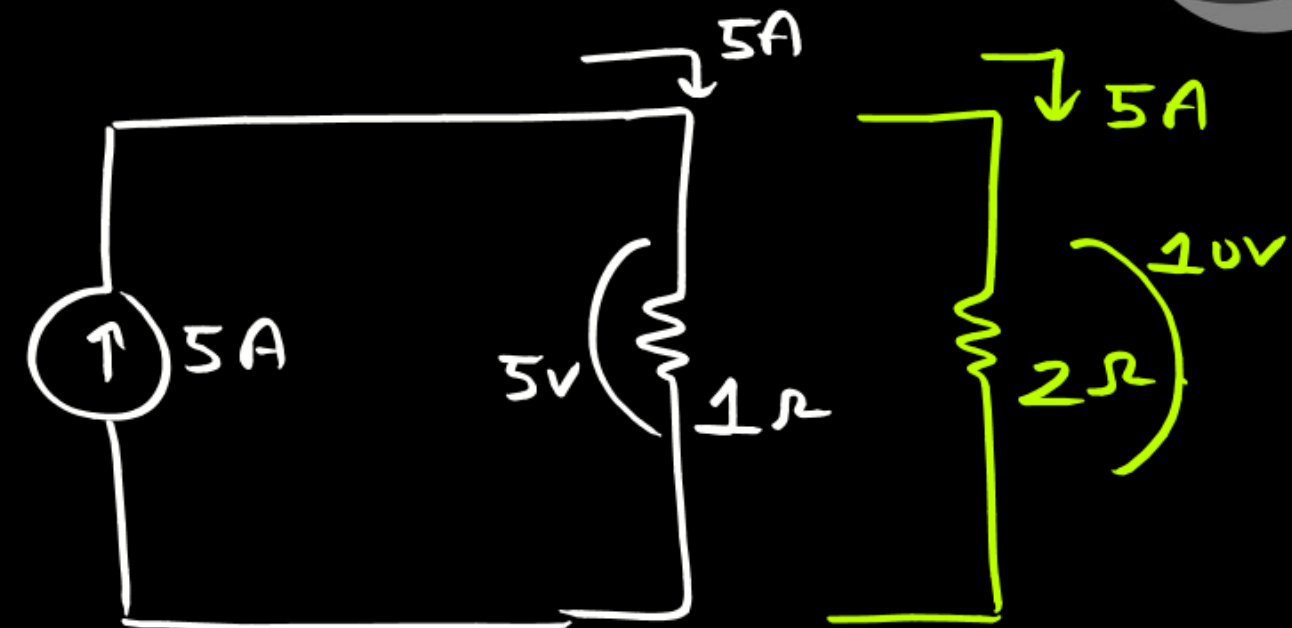






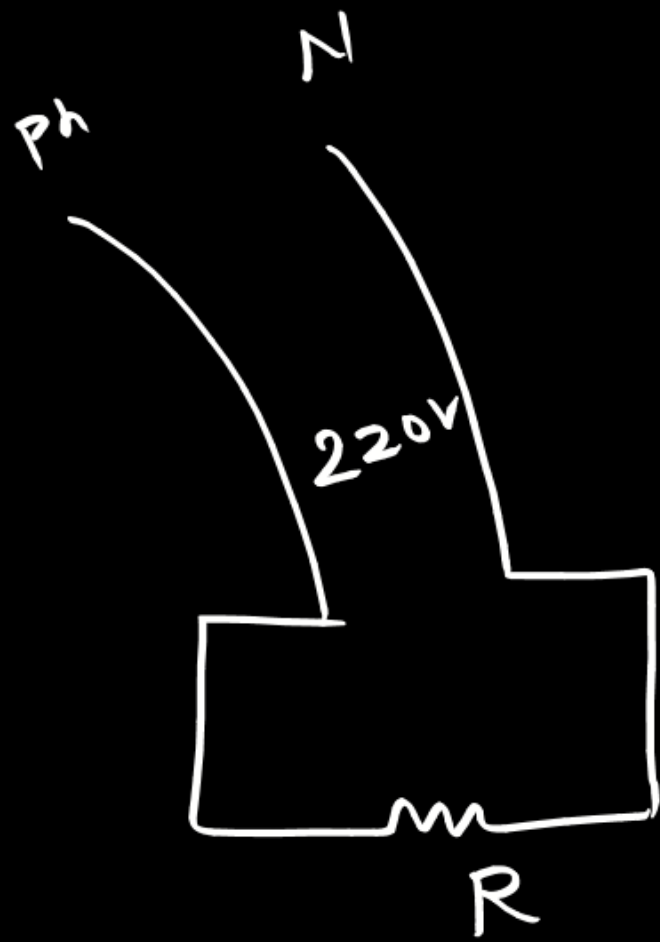
$$P = \underline{V} \underline{I} = 5 \times 5 = 25 \text{ W}$$

$$P = \underline{V} \underline{I} = 5 \times 2.5 = 12.5 \text{ W}$$

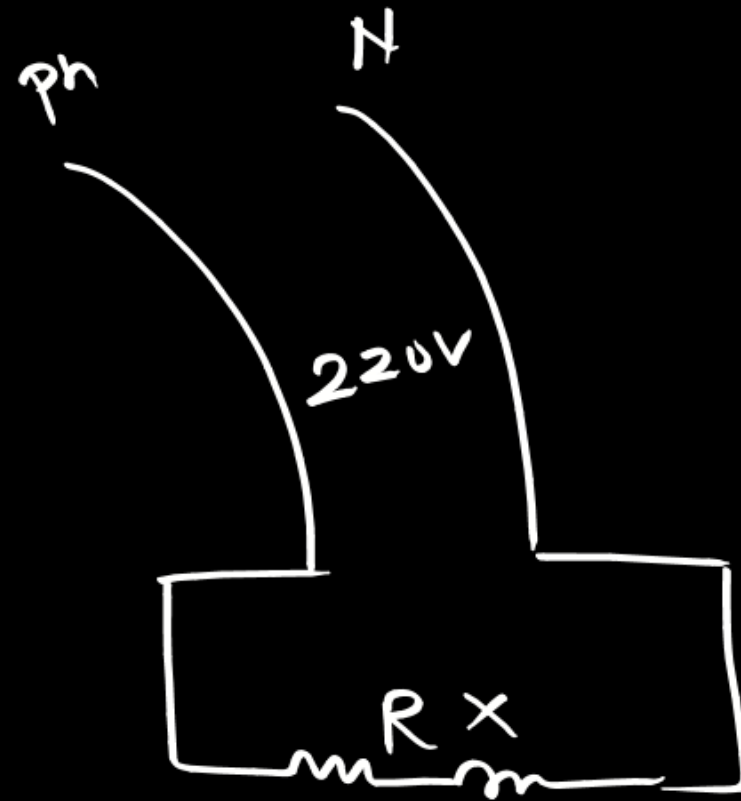


$$P = 5 \times 5 = 25 \text{ W}$$

$$P = 10 \times 5 = 50 \text{ W}$$



$$\cos \theta = 1$$



$$\cos \theta = \frac{R}{Z}$$

$$E_f(\text{ph}) = \sqrt{2} \pi f N_{ph} \phi_f k_w$$

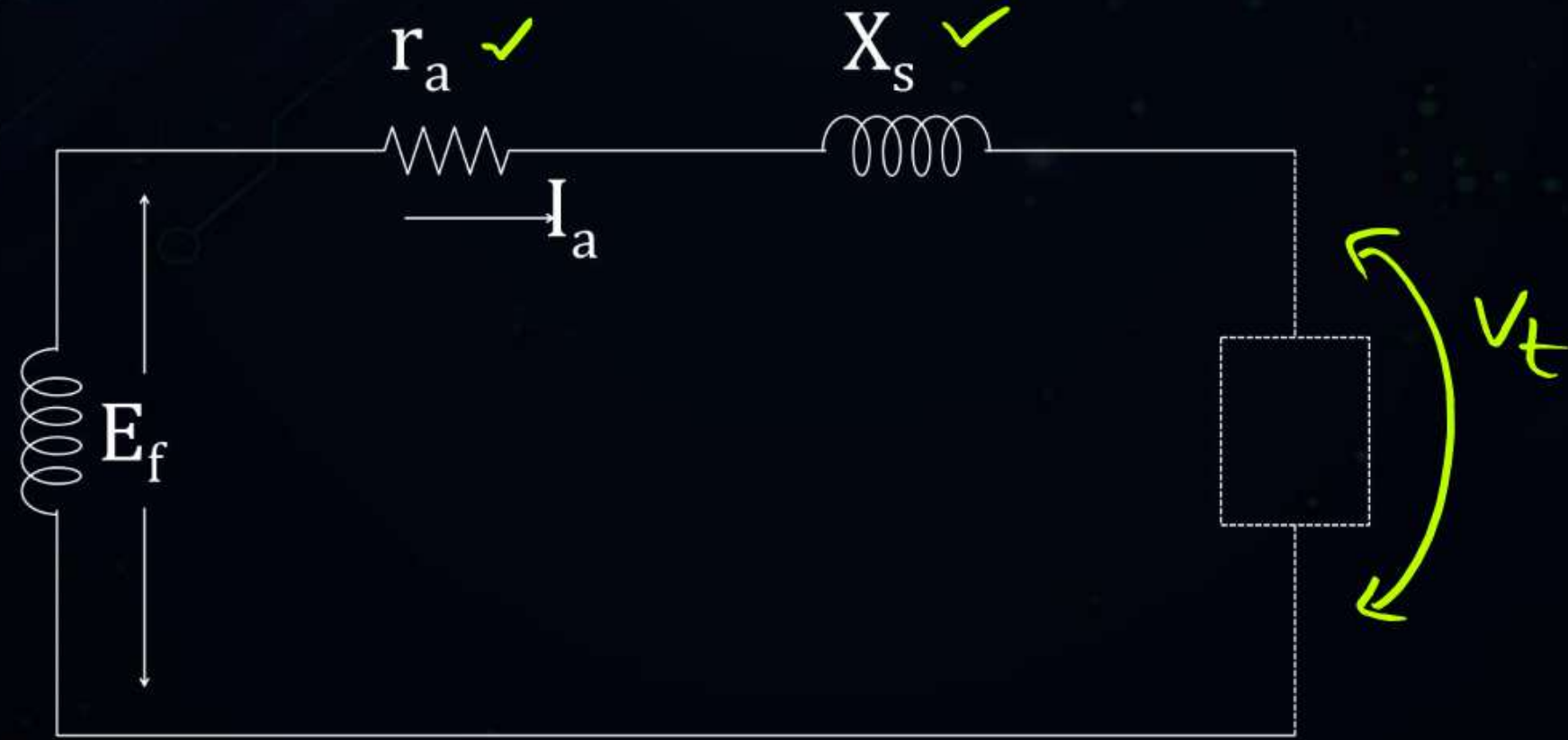
$$\phi_f \propto \underline{I_f}$$

$\underline{k_w}$ = winding factor

➤ By increasing field current (AVR)

$$I_t \uparrow \rightarrow \phi_t \uparrow \rightarrow E_t \uparrow \rightarrow V_t \uparrow$$

$$I_t \downarrow \rightarrow \phi_t \downarrow \rightarrow E_t \downarrow \rightarrow V_t \downarrow$$



$$r_a = 0.01 \text{ pu} \quad X_s = 1 \text{ pu}$$

$$X_s \gg r_a$$

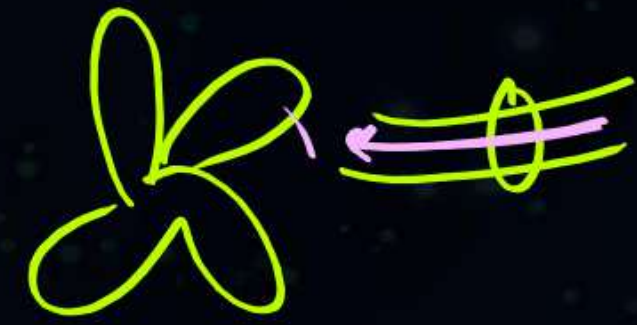
So r_a is neglected

Per phase equivalent
circuit of Alternator



The frequency of induced EMF

$$f \uparrow = \frac{P \cancel{N} \uparrow}{120}$$



By using speed governor, we can change the speed of alternator, so frequency may be changed.

↓
Governor

$$N = \frac{120f}{P}$$

- Over Excited : If $I_f >$ Normal current (it generate Reactive power)
- Under Excited : if $I_f <$ Normal current (it consume Reactive power)
- Normally Excited : if $I_f =$ Normal current

$$\underline{\phi_r} = \phi_f + \phi_a \rightarrow \phi \propto \frac{V}{f} \checkmark$$



Thermal power Plant :

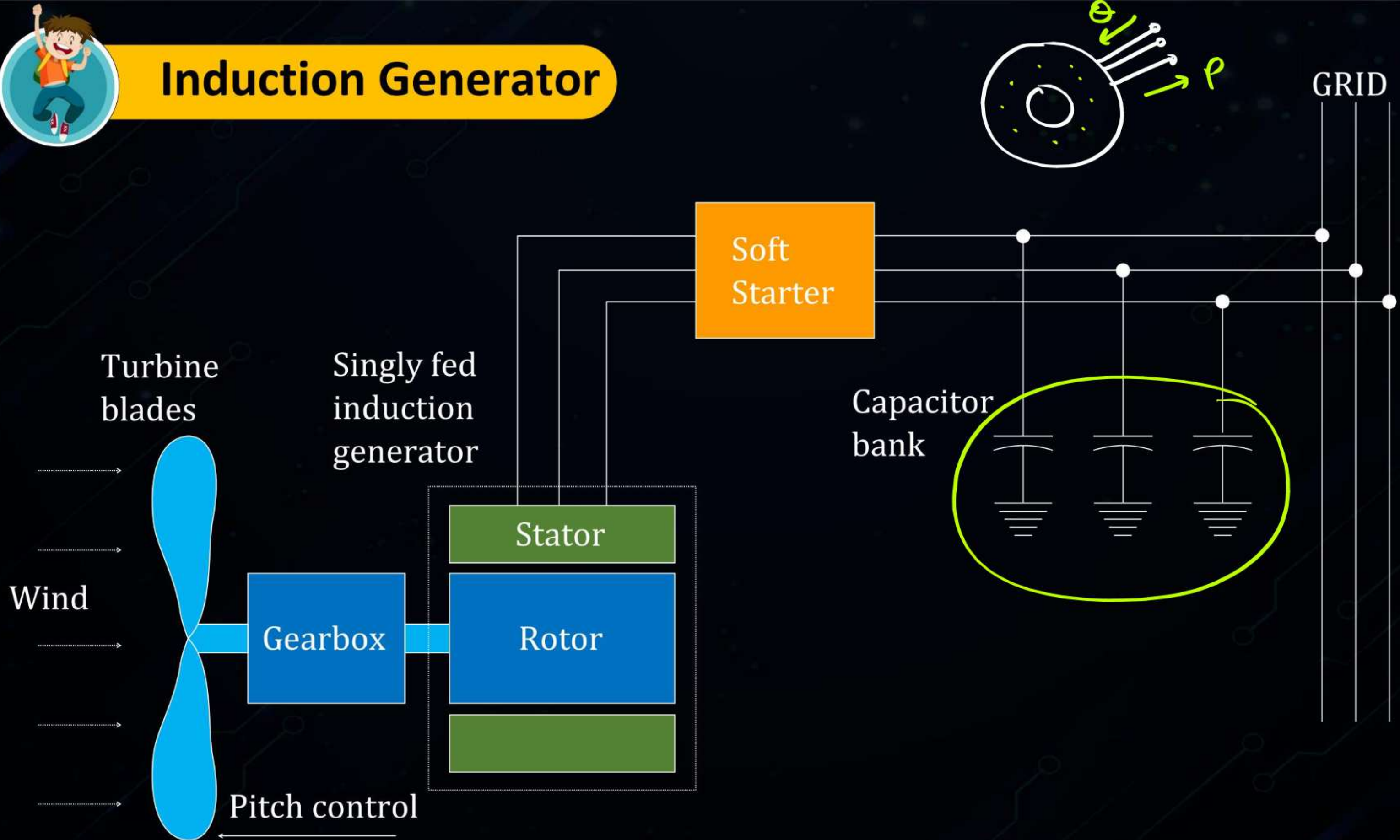
Cylindrical rotor alternator (Turbo alternator)

Hydro Power Plant:

Salient pole alternator (Hydro alternator)



Induction Generator





Induction Generator

- In wind & Tidal power plant, we use induction generator.
★★★★★★★★★★★★
- It takes reactive power from supply and provide active power to same supply.
- It generate power at low voltage.

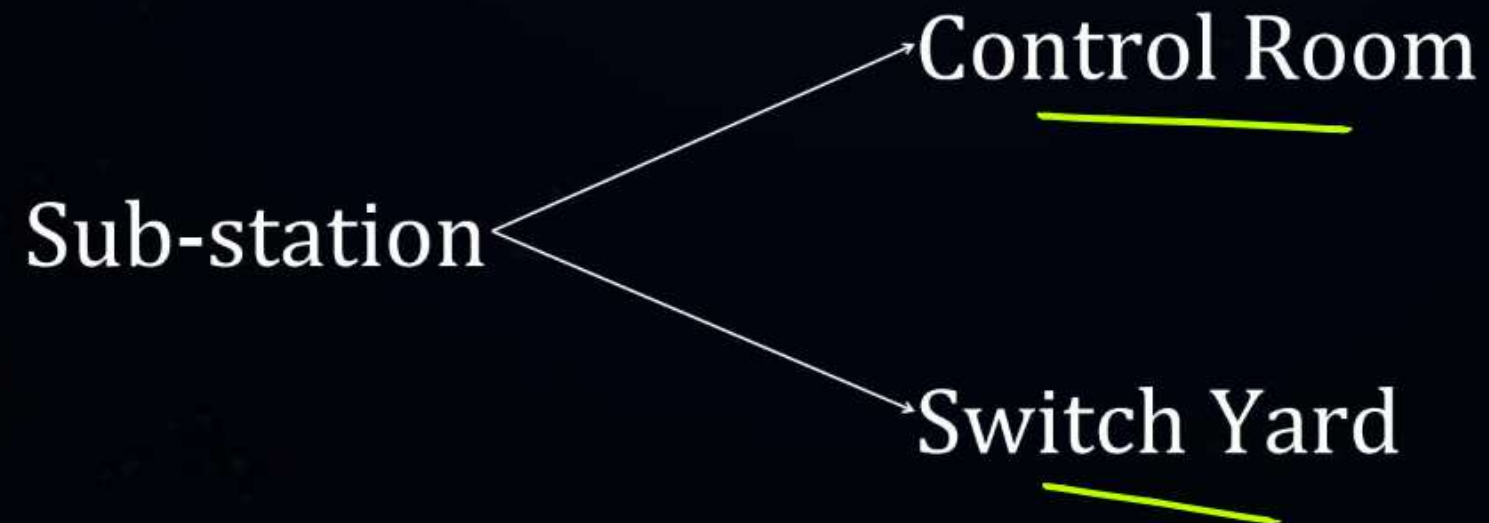




Switch Yard



It is a collection of electrical equipment where high voltage electricity is switched. It is a Important part of sub-station.



In control room, we have relay & control panel.



Control Room





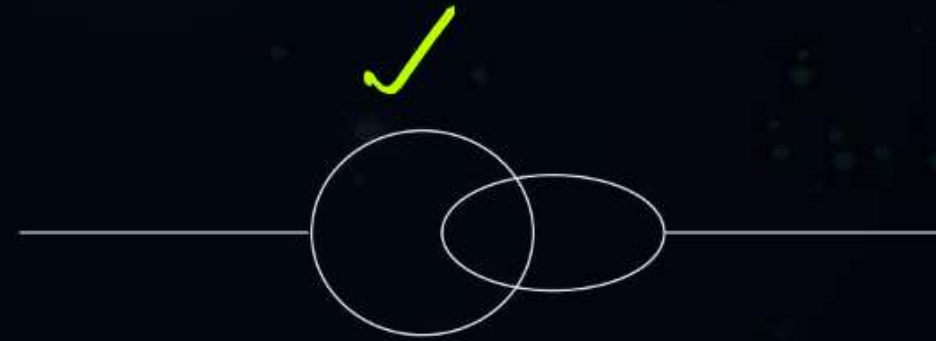
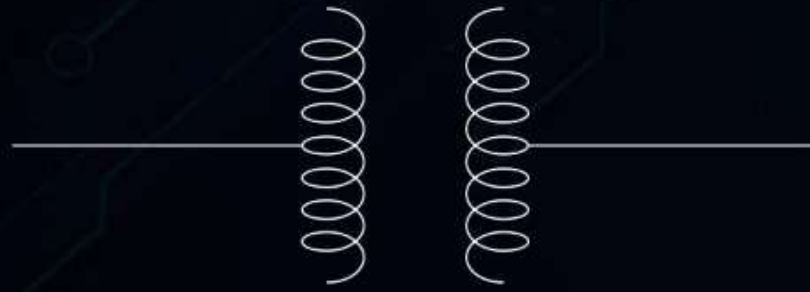
Transformer

- To step up & step down the voltage
- Generating station → step up ($\Delta - Y$)
- Receiving end Sub Station → Step down ($Y - \Delta$)
- In distribution, we use $\Delta - Y$ transformer to supply 1ϕ to end user.
- Nowadays, we mostly use auto transformer.

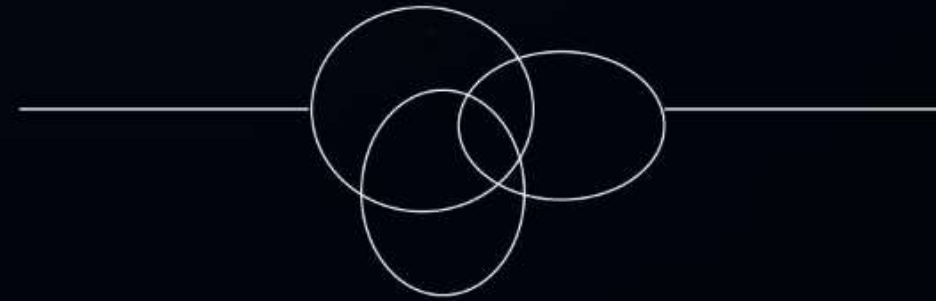
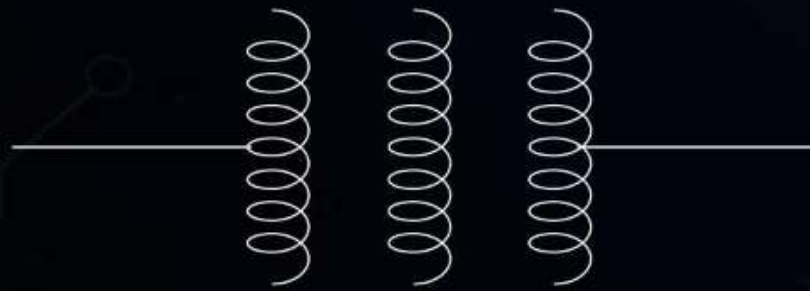
$Y \rightarrow$ High Voltage



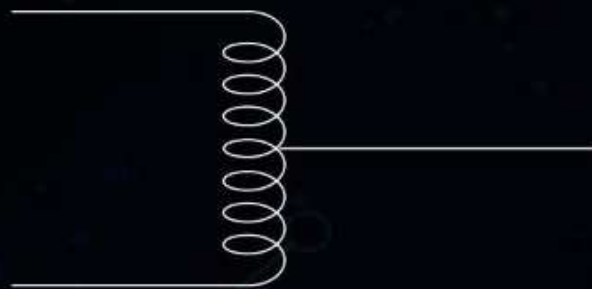




2 Winding transformer



3 Winding transformer



Auto transformer



Topic : Bus-bar





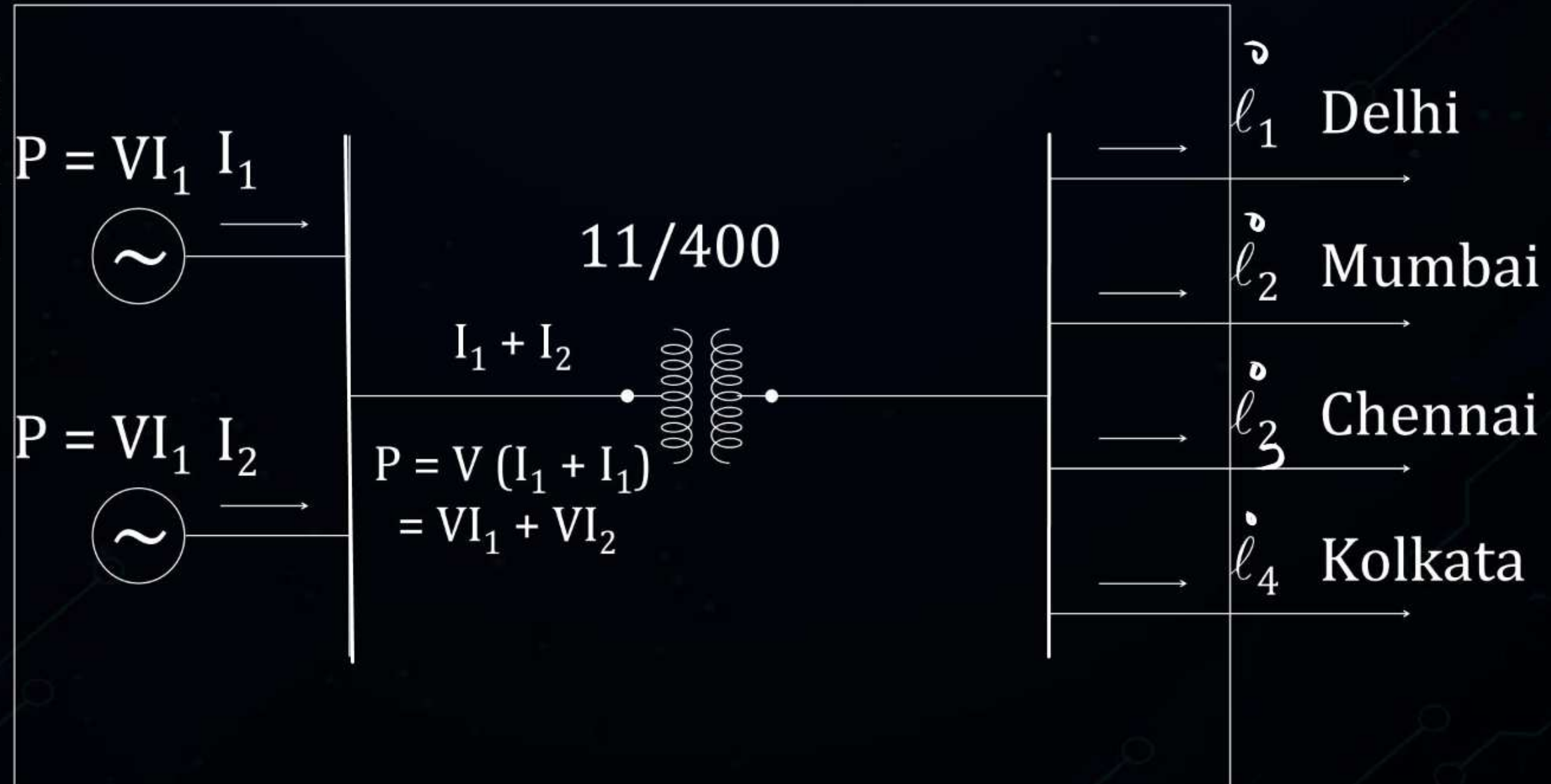
- It is a group of conductor which collect power from input terminal and distribute it to various circuit.
- It is like a node in a power system.
❤❤❤❤❤❤❤❤❤❤❤❤❤❤❤❤
- In single line diagram Bus Bar is represented by vertical line.
- Generally sub-station has two set of bus-bar.
 - (i) HV bus-bar
 - (ii) LV bus-bar
 - ◆ In HV sub-station, it is made of hollow conductor to reduce corona loss.

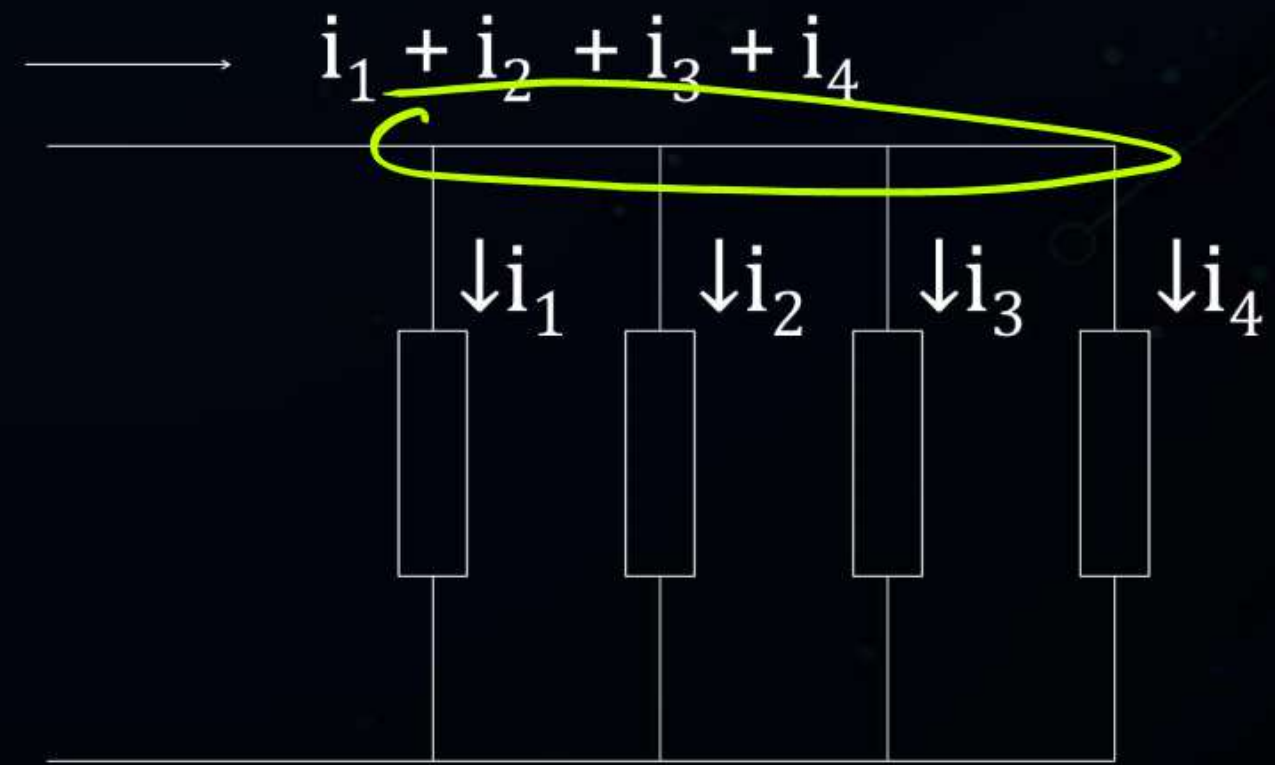
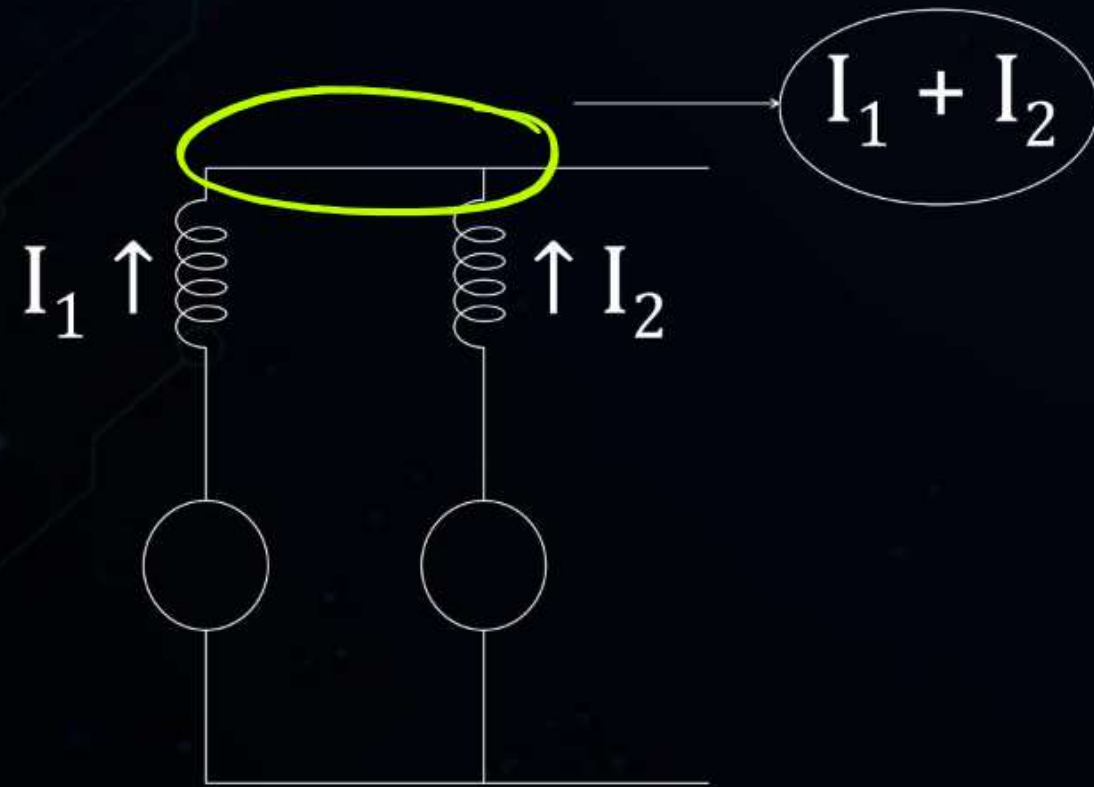


Bus-bar



Generating
Station
Switch yard







Bus-bar

Sub-station

400

220

KTPS

STPS

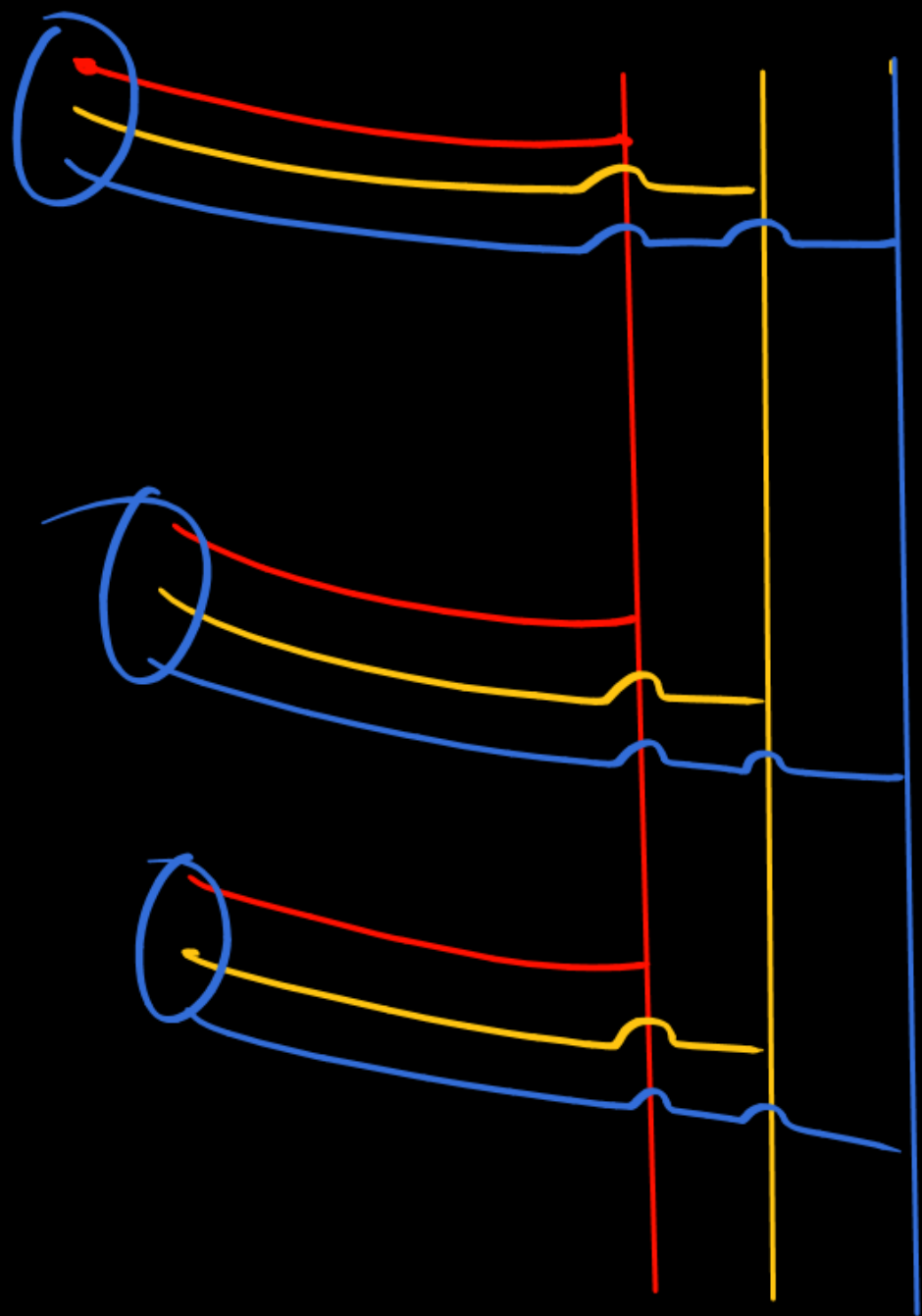
DADRI

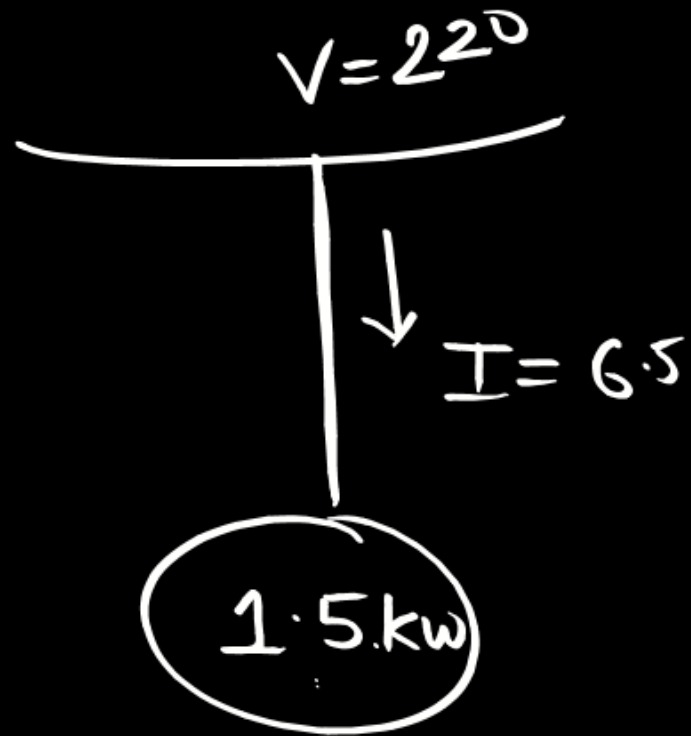
400 kV

400/220



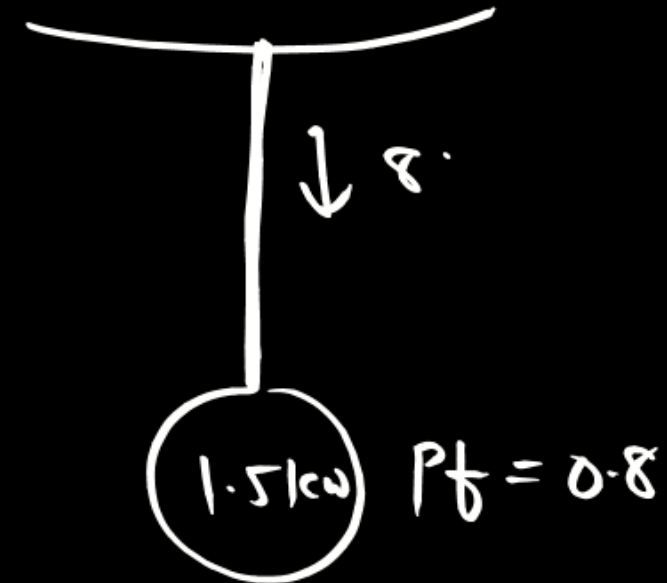
Sub-station at Delhi





$$P = VI \cos \phi$$

$$I = \frac{1500}{220 \times 1} = 6.8$$



$$P = VI \cos \phi$$

$$\frac{1500}{220 \times 0.8} = I$$

$$I = \underline{8.52 \text{ A}}$$



2 Minutes Summary

→ Alternator

→ X-mcr

→ Bus Bar

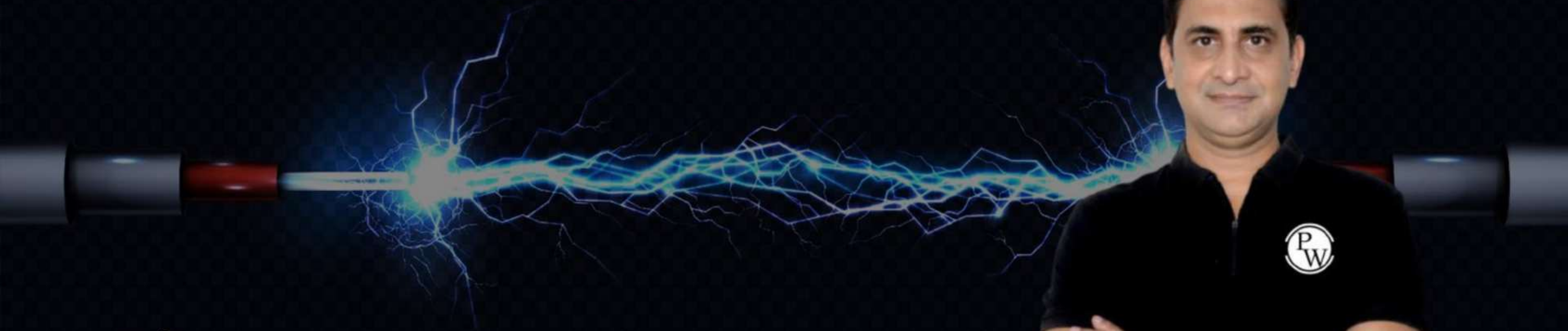
Thank you

GW
Soldiers !



Electrical Engineering

Power System



Lecture No.-03

Introduction

By- Ajay Gupta Sir



Recap of Previous Lecture

- ✓ 1. Basic component of PS
- ✓ 2. Basic component of system
- ✓ 3. Alternator
- ✓ 4. Induction Generator
- ✓ 5. Transformer
- ✓ 6. Bus bar



Topics to be Covered

- ✓ 1. CB
- ✓ 2. Isolator
- ✓ 3. CT PT
- ✓ 4. Surge Arrester
- ✓ 5. Bus coupler



Switch Gear

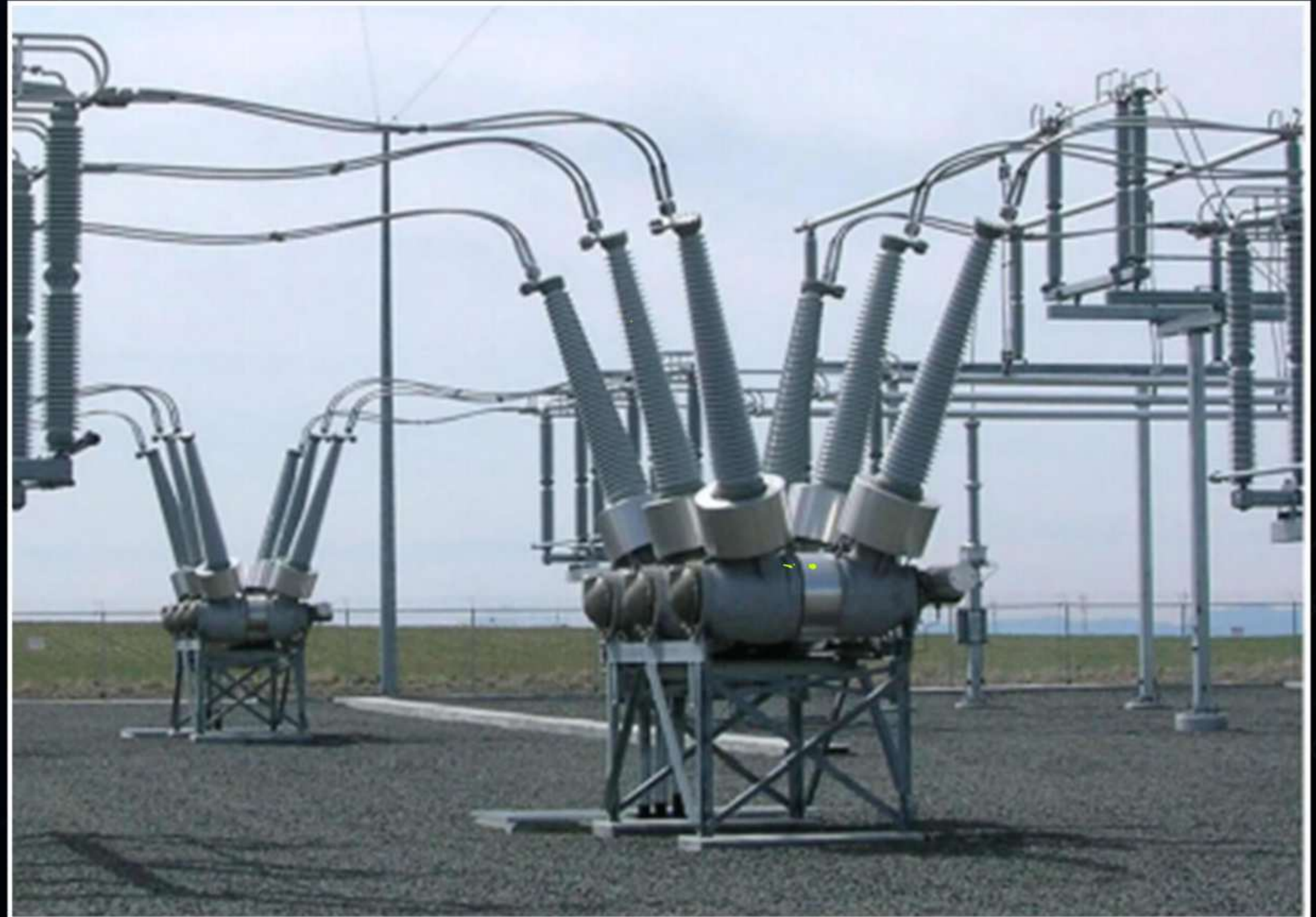


It is general term, which is used for electrical switch & necessary device. Some switchgear equipment are:

- ❖ CB ✓
- ❖ Isolator ✓
- ❖ Earth switch ✓
- ❖ Relay ✓
- ❖ CT ✓
- ❖ PT ✓



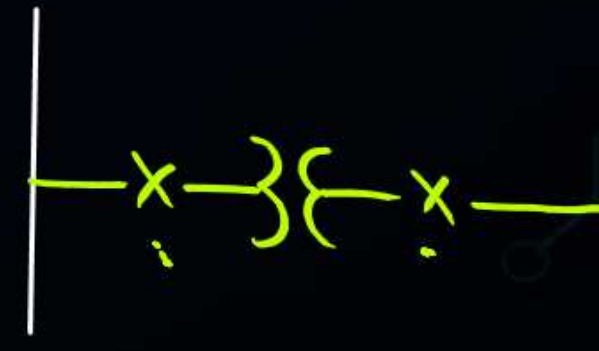
Circuit Breaker





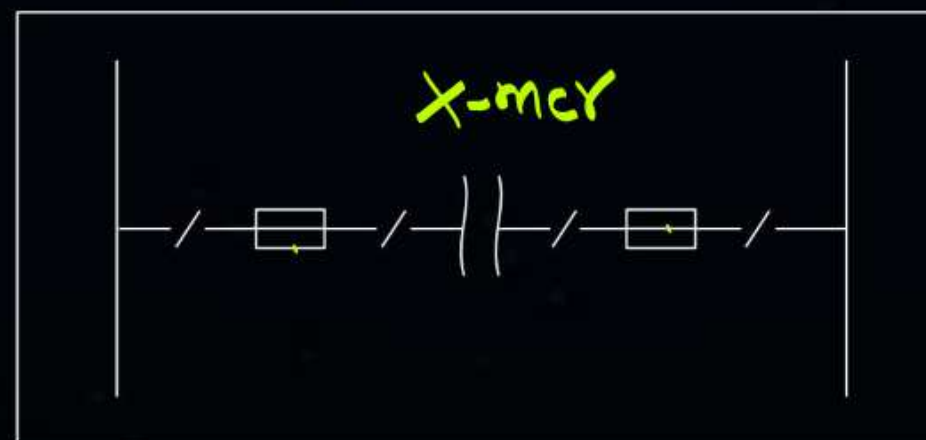
Topic : Circuit Breaker

- It is used to make & break the circuit under normal and abnormal condition.
- CB operate on load condition, so arc quenching medium should be there.



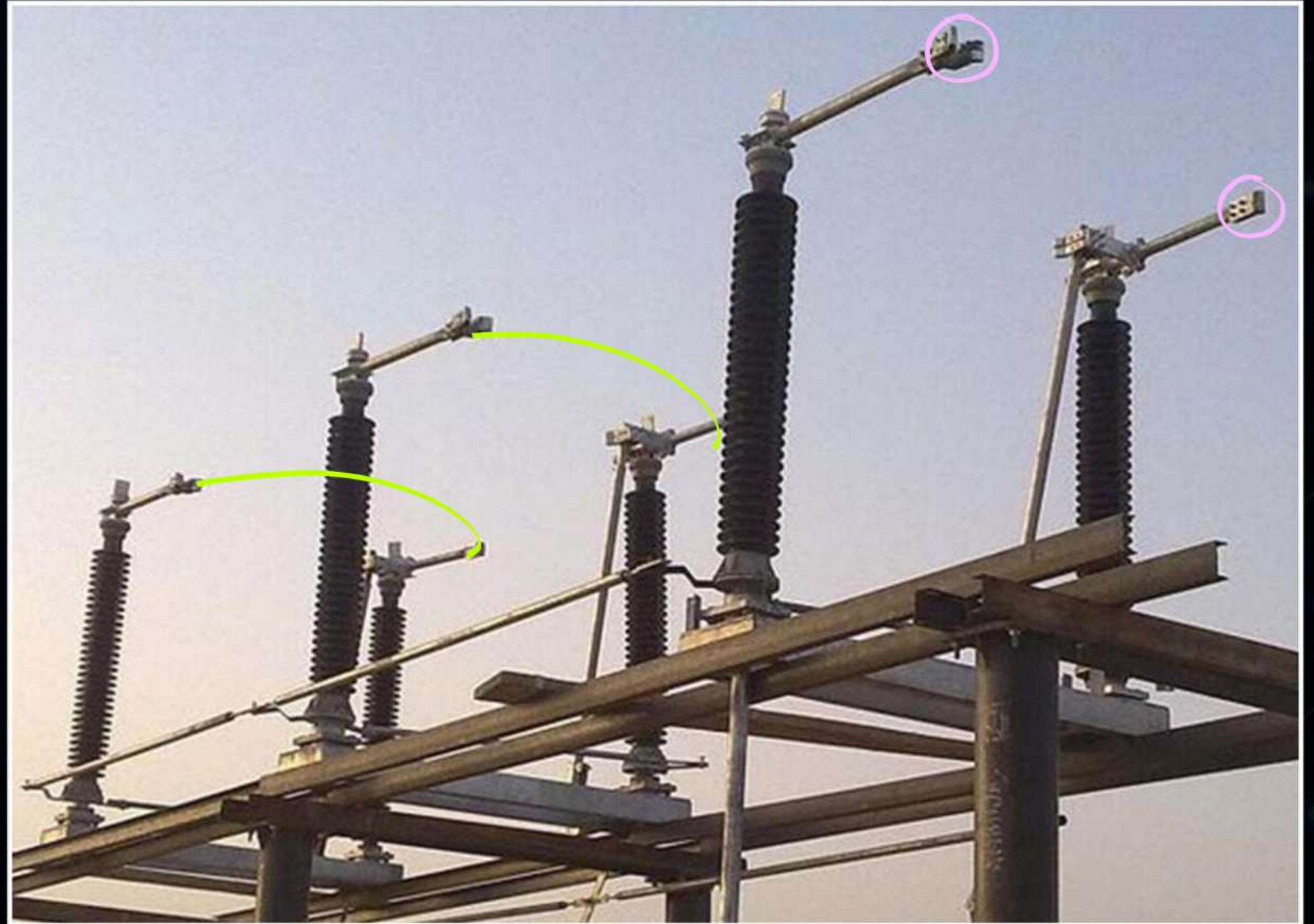


Circuit Breaker





Isolator





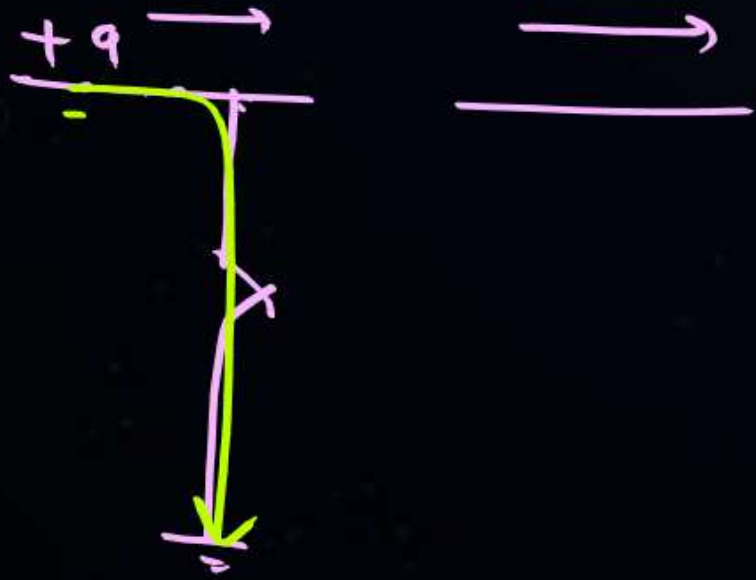
Topic: Isolator



- Isolator operate at no load condition.
★★★★★
- It disconnect a part of system from live part under no load condition
- At both of CB, there should be isolator.



Earth Switch





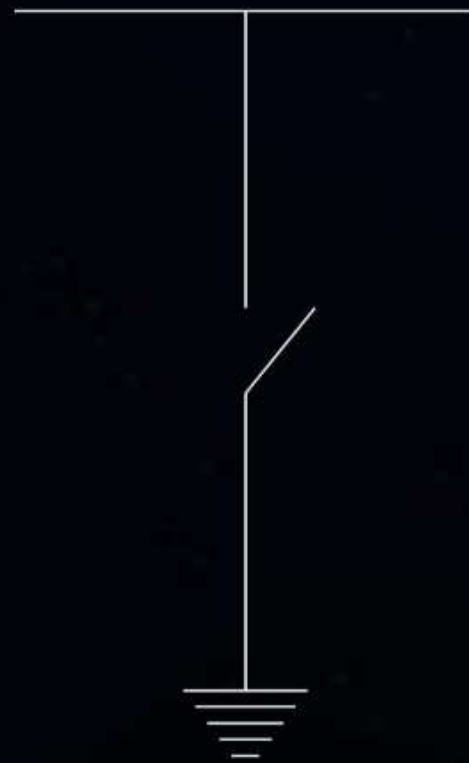
Earth Switch

- It discharge extra static charges at line to earth.
★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★
- It operate after isolator.

CB → open

Isolator – open

E.S. → Close





CT (Current transformer)

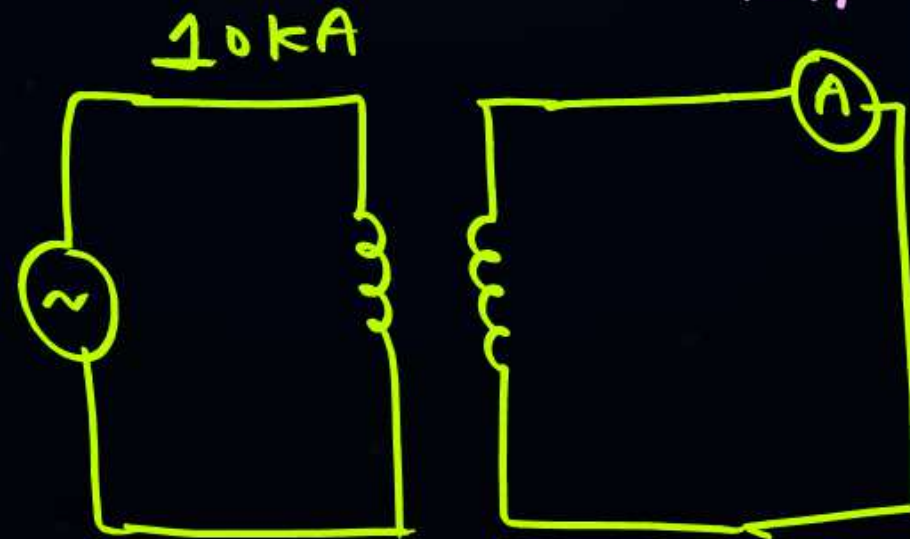
$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

$$\frac{I_1}{I_2} = \frac{N_2}{N_1}$$

$$I_2 = I_1 \times \frac{N_1}{N_2}$$

$$= 10,000 \times \frac{1}{1000}$$

$$I_2 = 10 \text{ A}$$





Topic : CT (Current transformer)

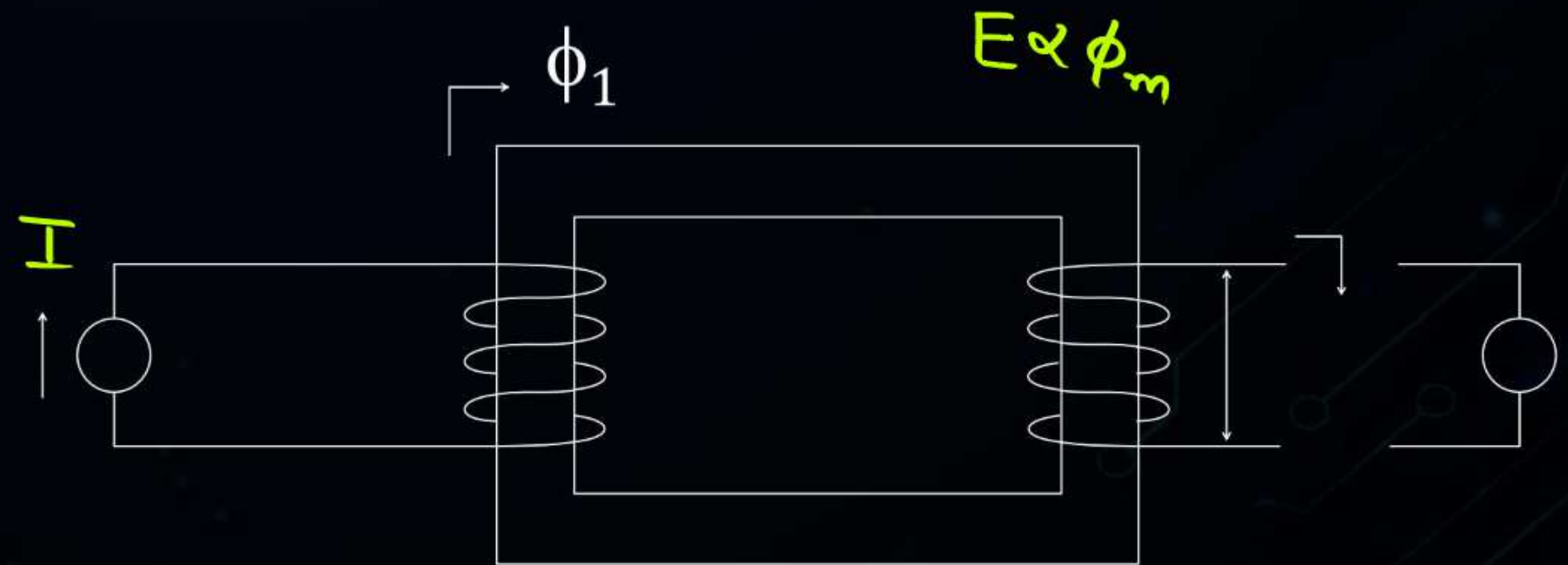
- It step down the current for measurement & protection purpose.
★★★★★★★★★★★★★★★★★★★★



$$\frac{I_1}{I_2} = \frac{N_2}{N_1}$$

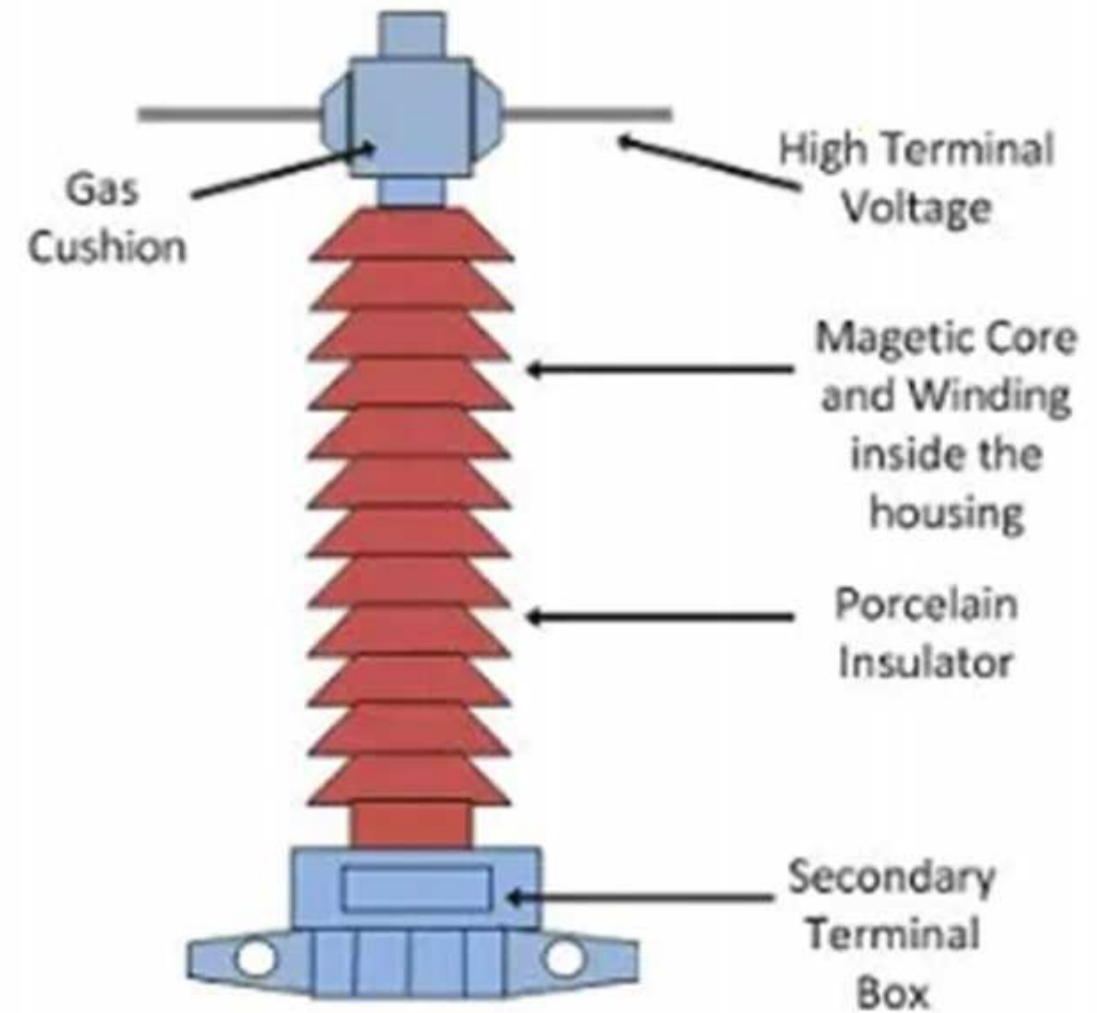
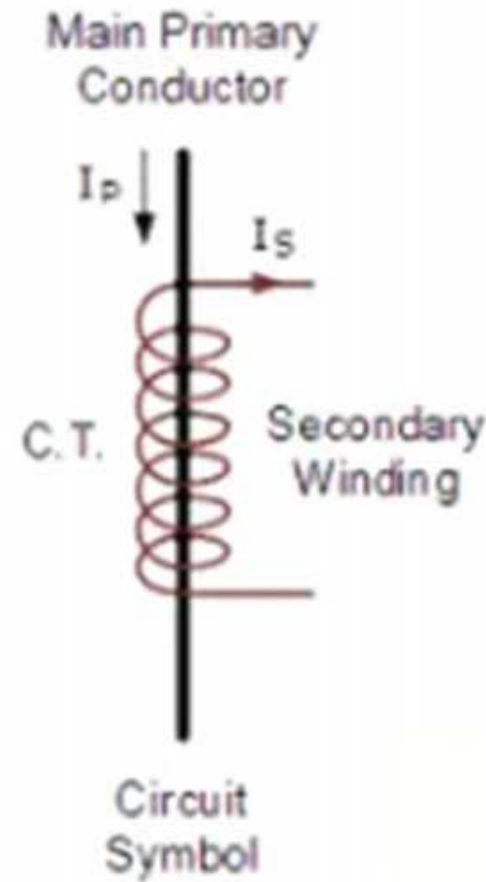
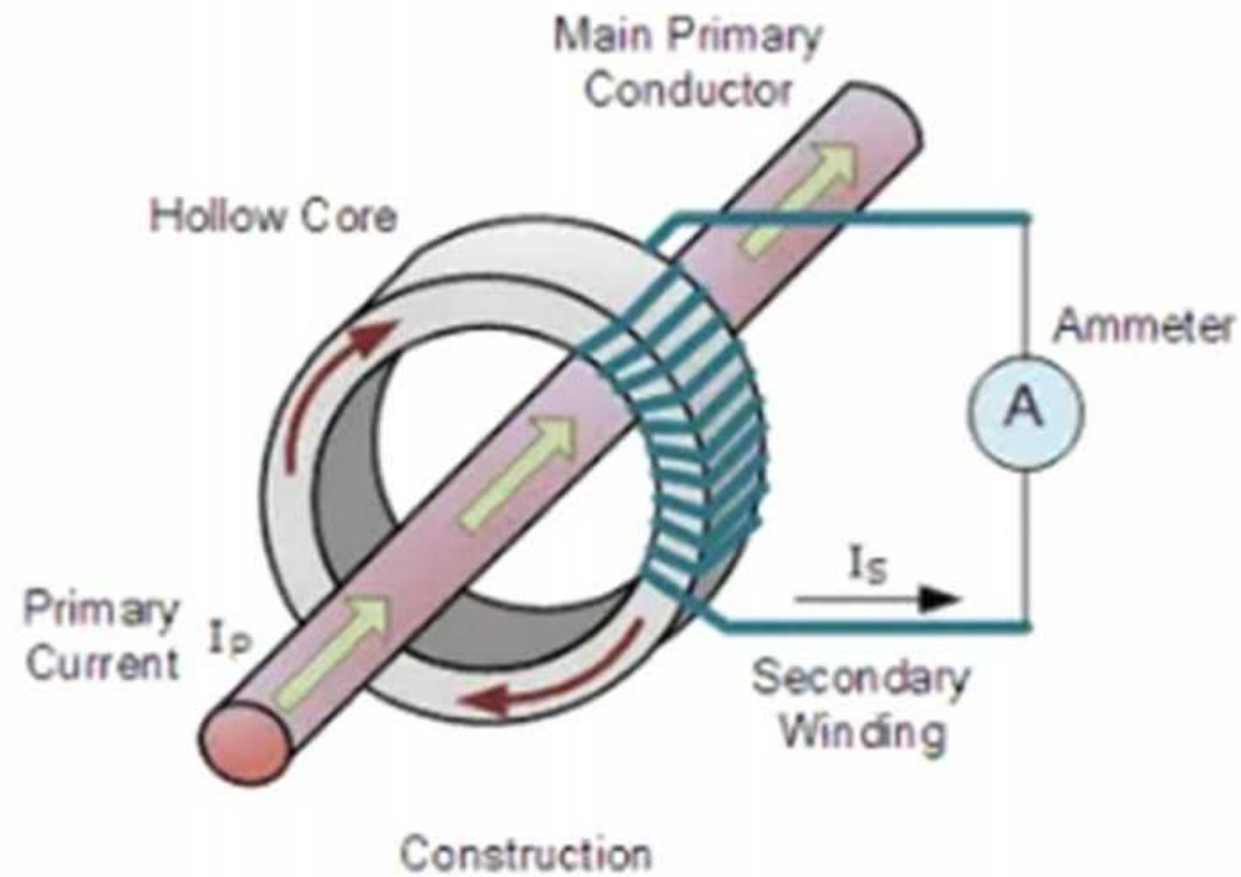
$$I_2 = I_1 \times \frac{N_1}{N_2} = \frac{I_1}{N_2}$$

$$N_1 < N_2$$



400 : 5 (CT Ratio)

What is a Current Transformer?



ical



Topic : What is Current Transformer?

Measuring CT (Normal) (Normal current = 10 kA)

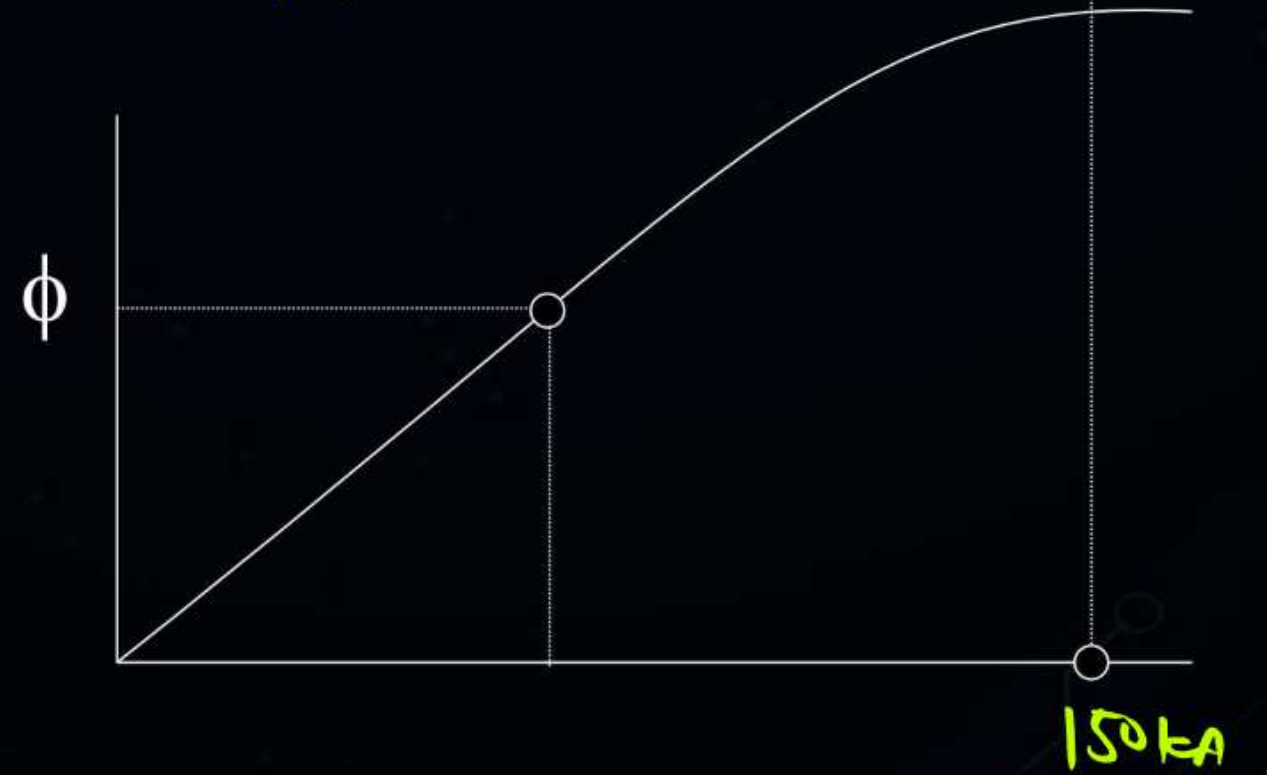
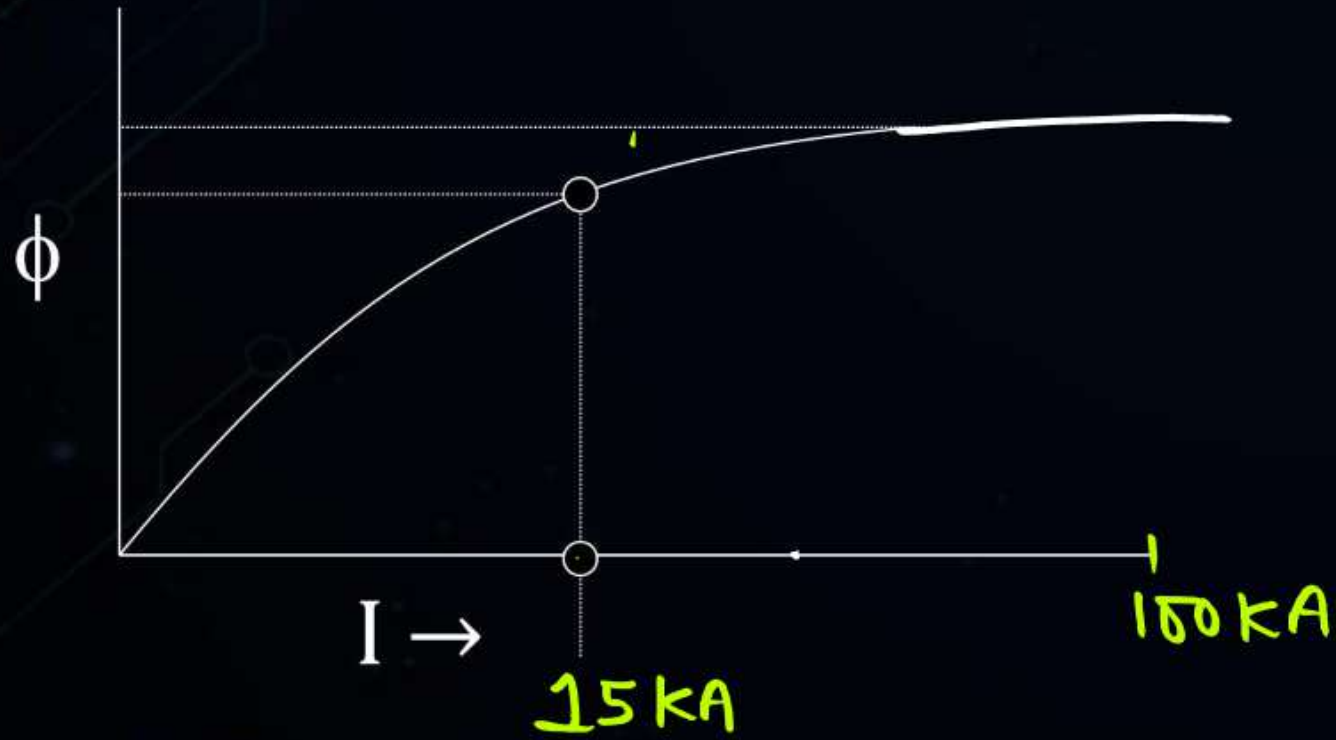
Protection CT (Abnormal) (fault current = 100 kA)

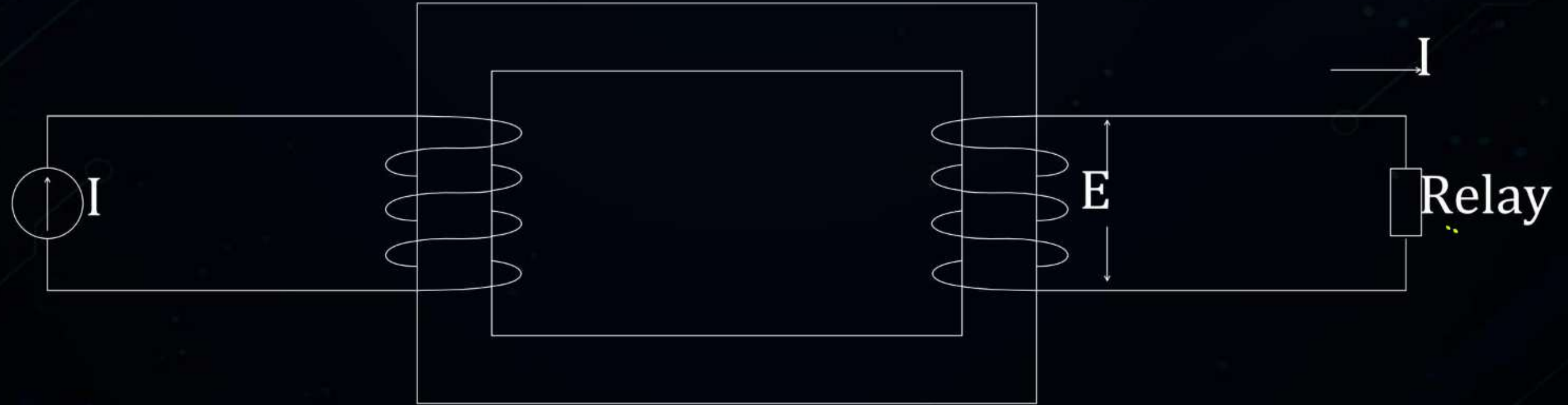
- Measuring CT is not able to push short circuit high current through secondary circuit. Because it will be high than its saturated value.
- Protective CT is able to push high short circuit current to secondary side because relay need to measure during fault condition.
- Protective CT provide Input to relay.



Topic : What is Current Transformer?

Lalu $\rightarrow$ 2 hr
Kalu $\rightarrow$ 6 hr







Potential transformer



- It step down the voltage for measurement & protection purpose.
- Protective PT provide Input to relay.

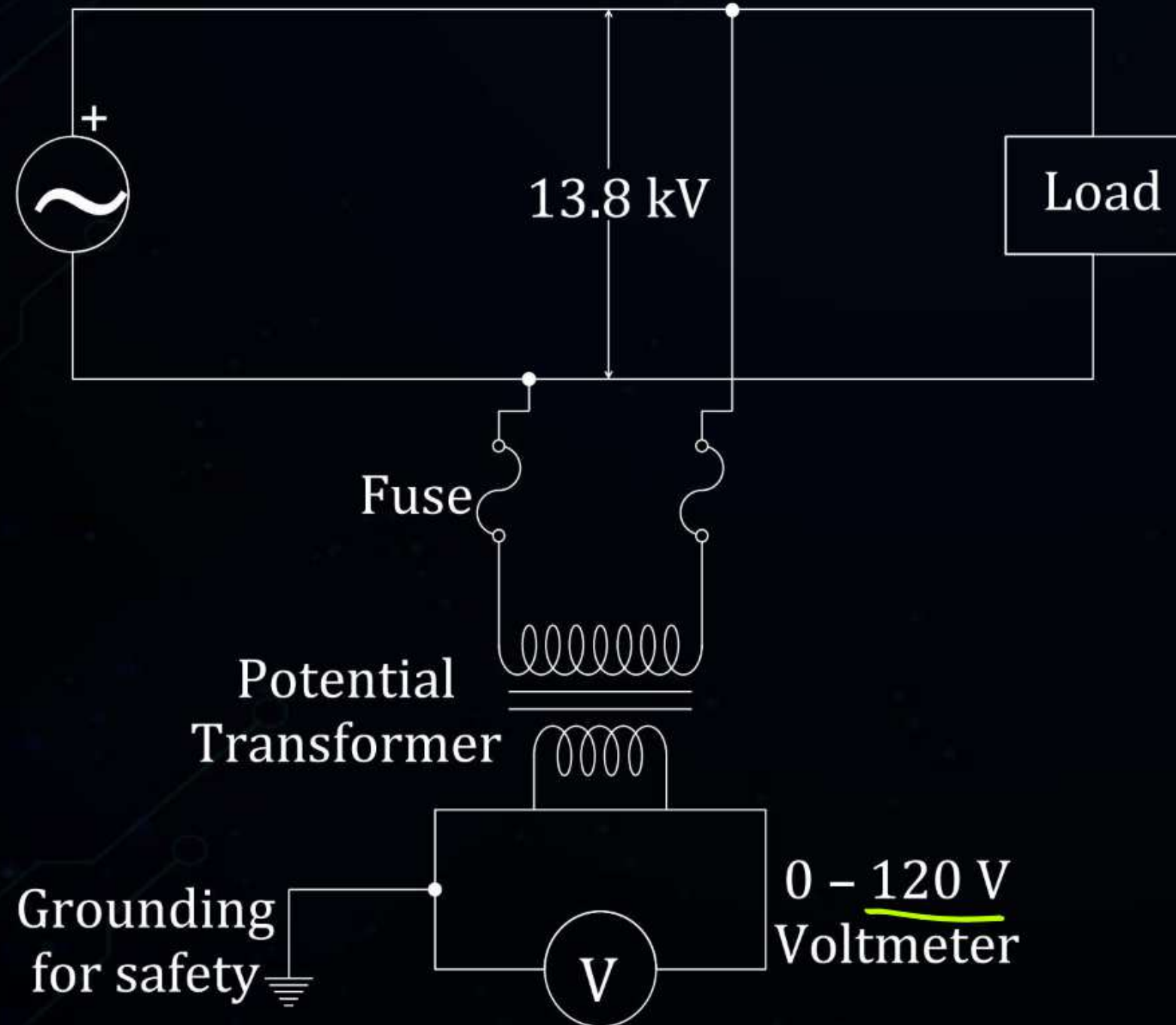


Electromagnetic type

Capacitive type



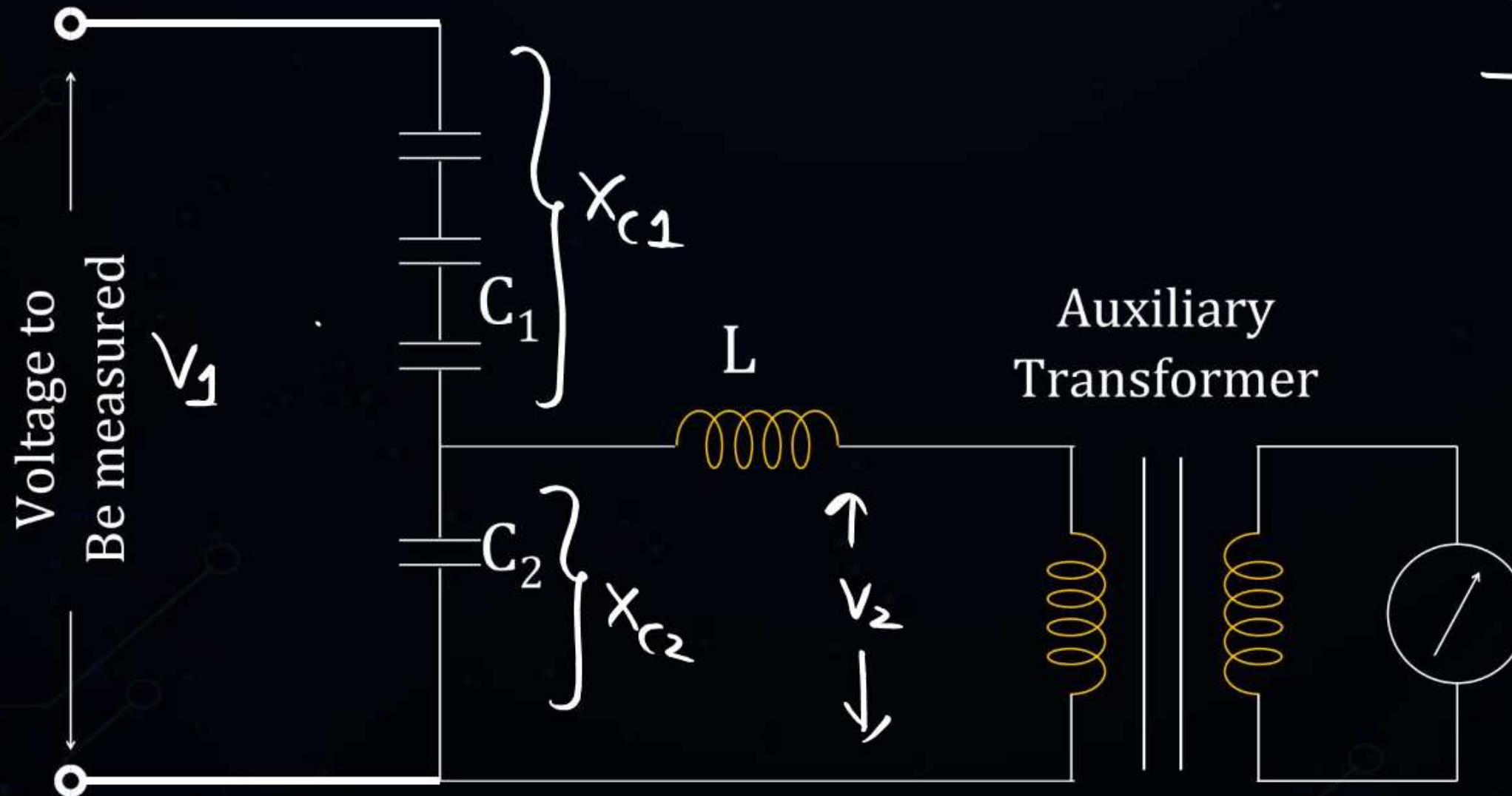
Electromagnetic. P. transformer





Capacitive voltage transformer

Capacitor voltage transformer or capacitor completed voltage transformer.



$$\frac{V_2}{V_1} = \frac{X_{C2}}{X_{C1} + X_{C2}}$$



Capacitive voltage transformer

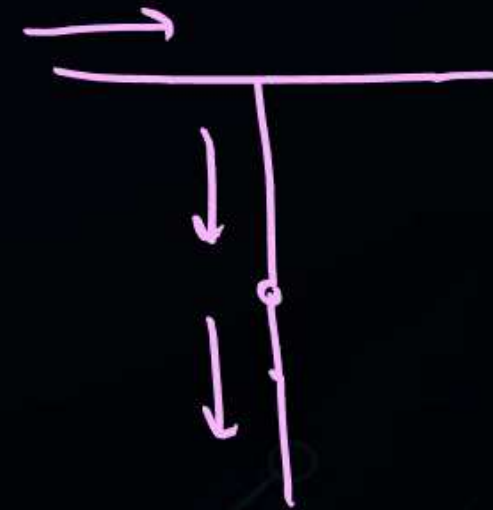
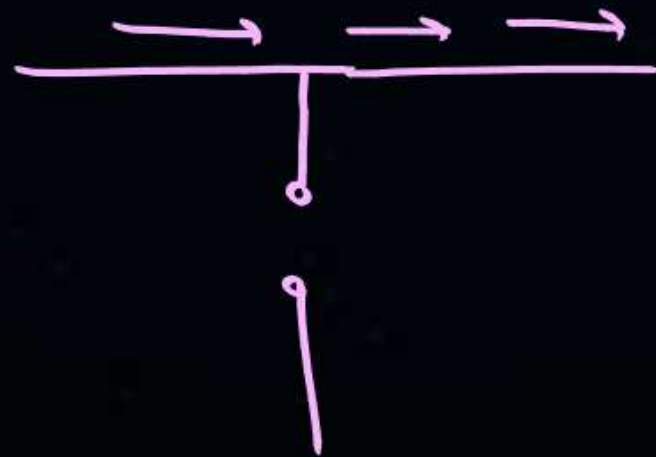
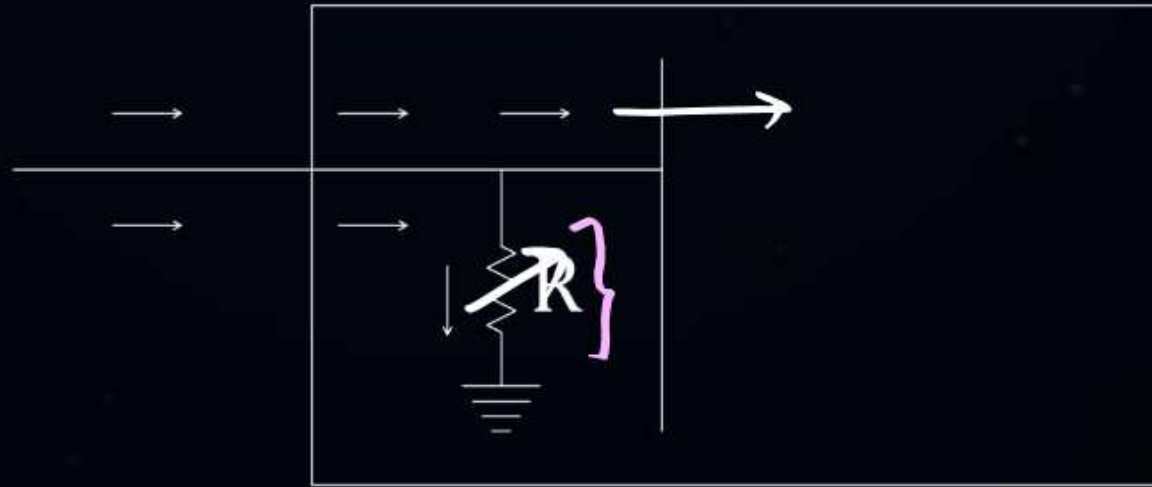
- It is a potential transformer, which step down the voltage.
- Here we are using capacitor voltage divider circuit.
★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★
- It can be turned with PLCC so it can be operated as a coupling capacitor.
- About 100 kV, we used CVT instead of normal PT.
★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★



Surge arrester/Lightning arrester

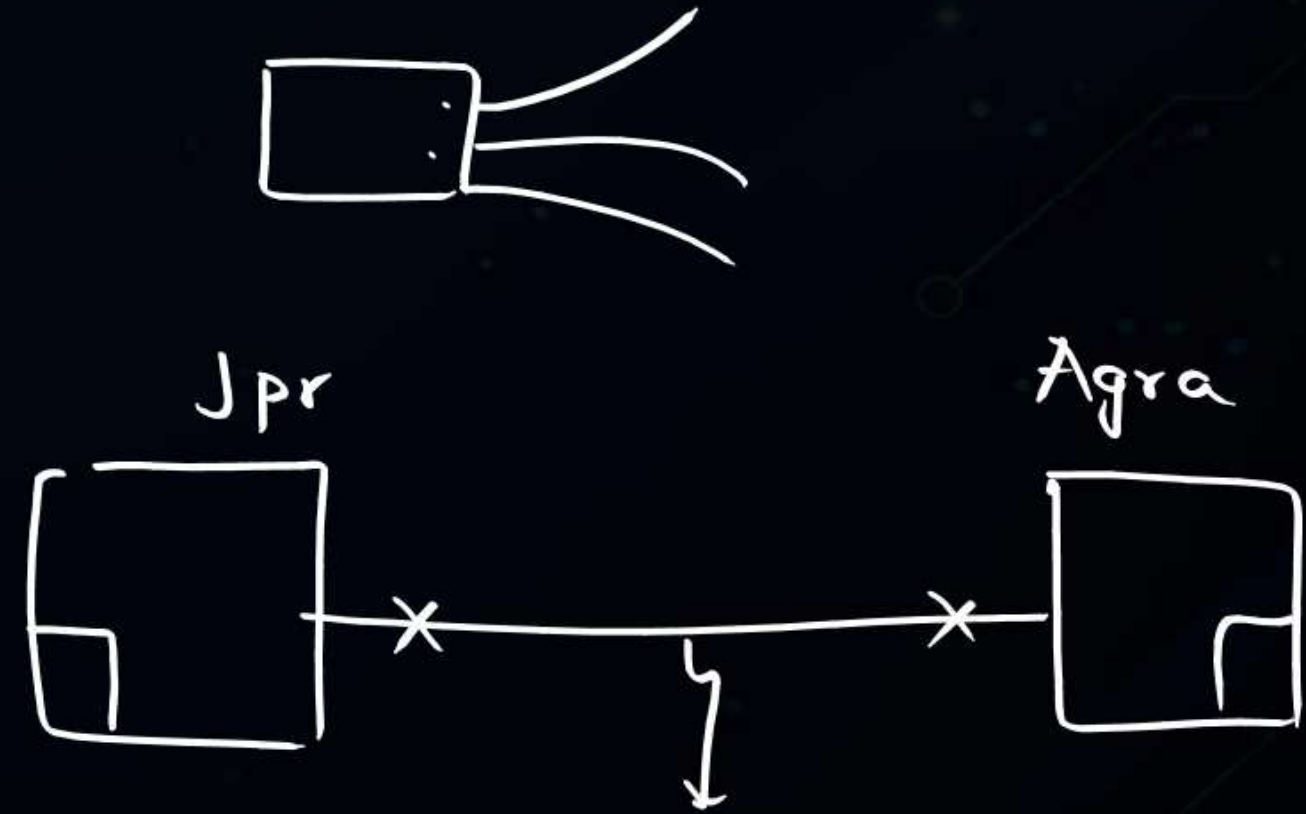


- It divert high voltage lighting surge to earth. But maintain continuity during normal operation.



PLCC (Power line carrier communication)

- PLCC is used for telecommunication, tele-monitoring, tele protection between electrical system.
- Number of component is used is PLCC
 - (a) Wave trap
 - (b) Coupling Capacitor





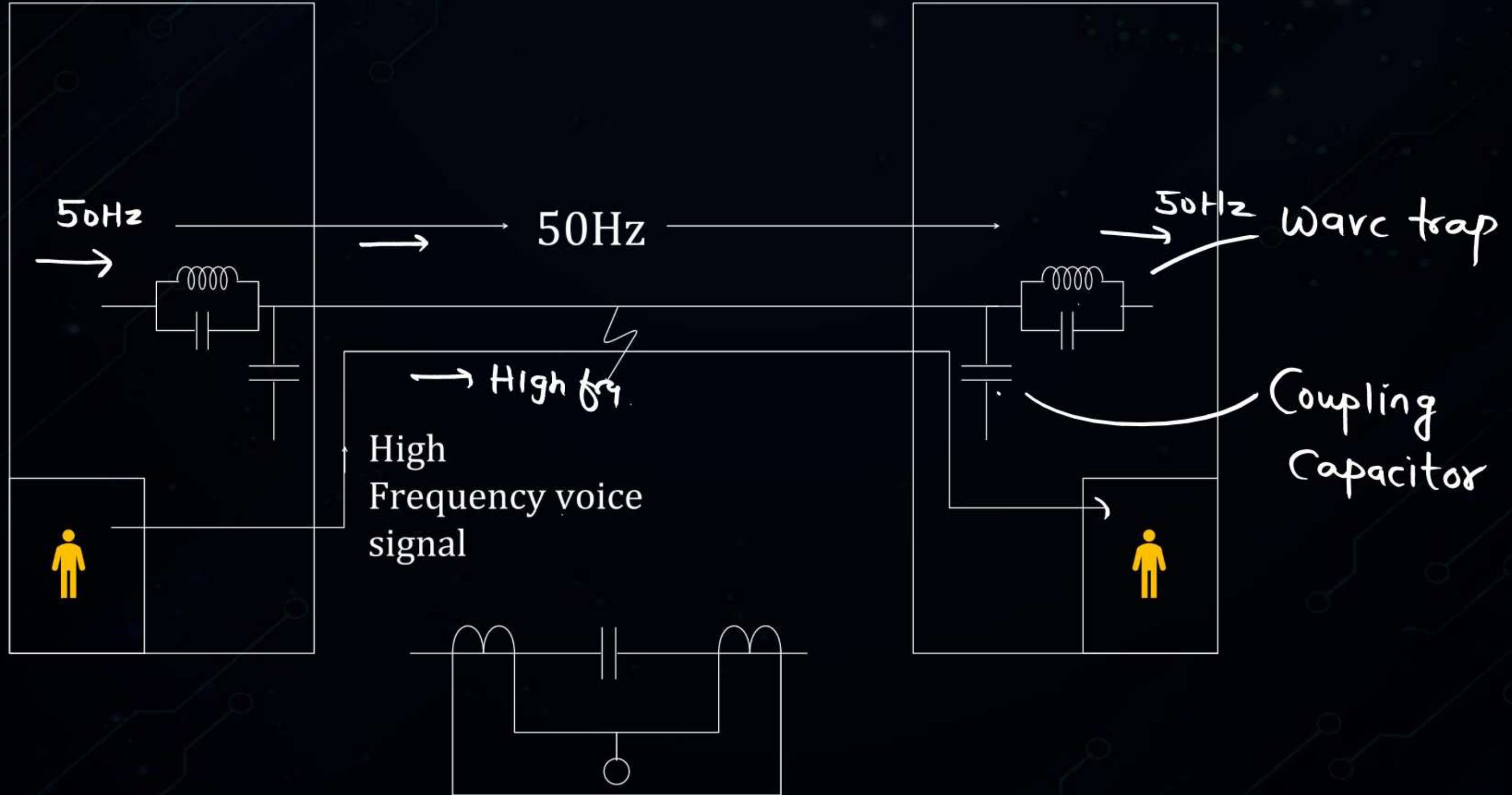
Wave trap/ line trap



- It is high frequency stopper. It prevent the transmission of high frequency signal to unwanted destination.
- Wave trap is first equipment connected in system.

Agra

Kanpur



Surge Arresters

Selection, Application and Testing Overview

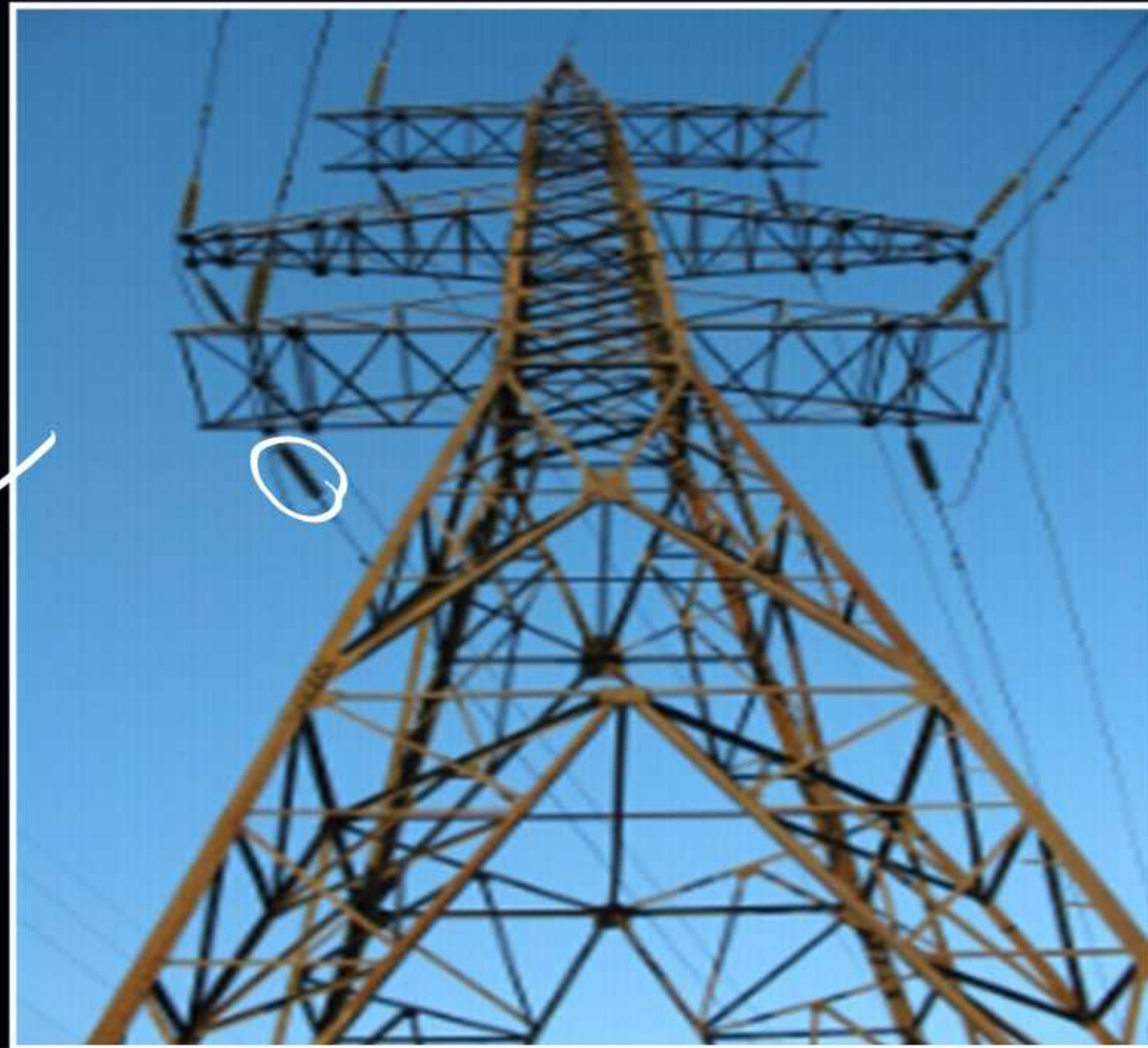
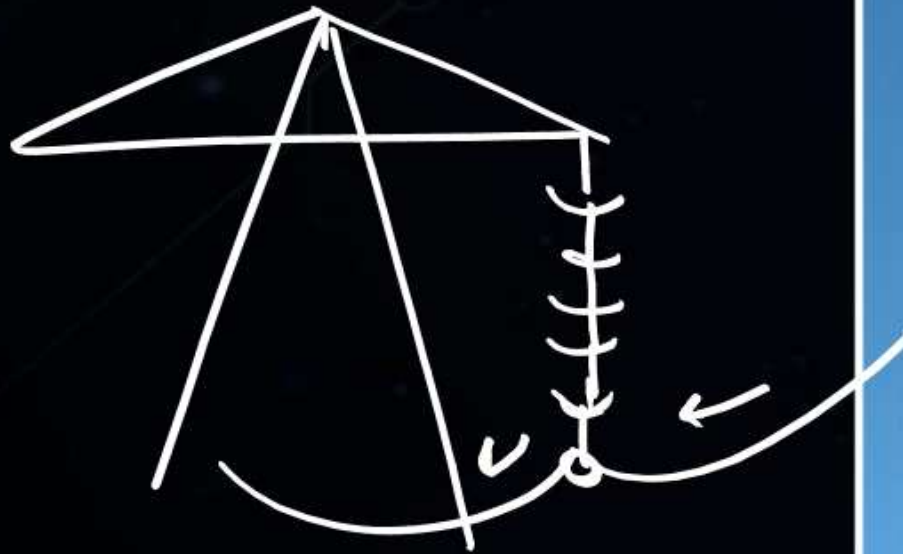


Relay : Relay is fault sensing device & give command to CB.



Tower: It support the overhead line conductor, it provide necessary clearance from ground. It is at ground potential.

- Tower cross arm has insulator on which power conductor is connected.

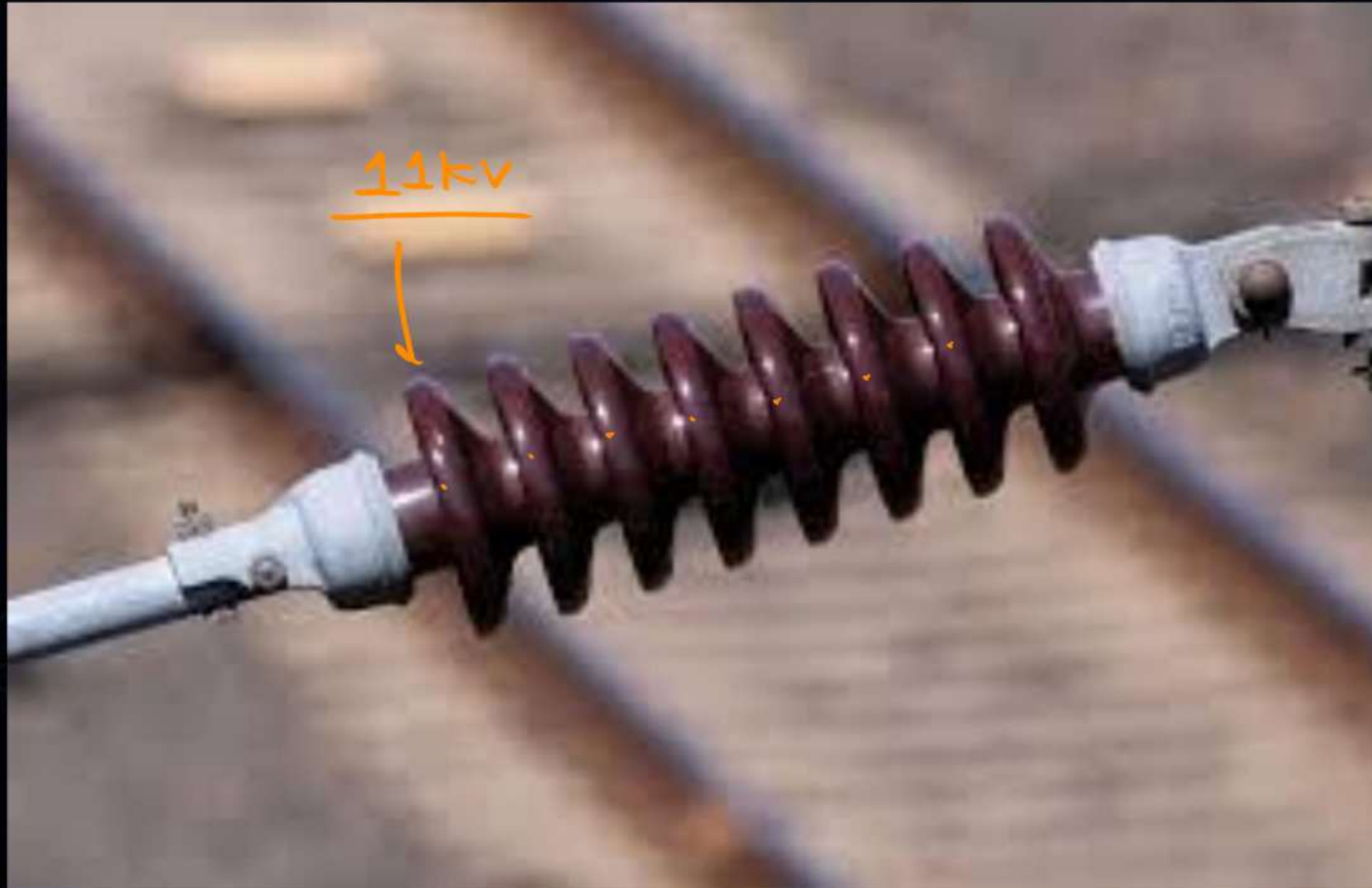


Power line Maker: It is used to make TL visible to pilot & drone operator.
It is a ball of orange color.



Insulator :

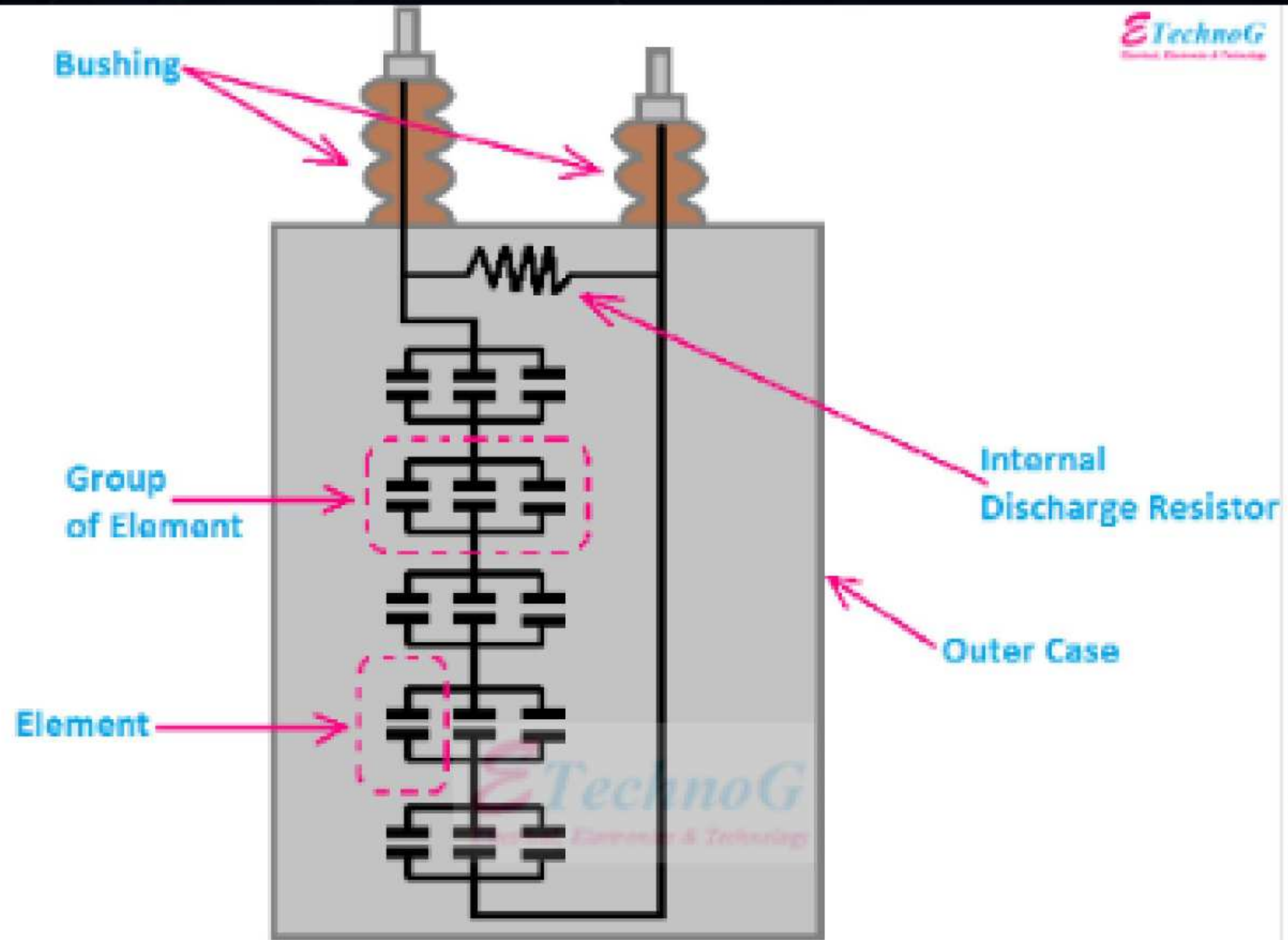
Insulator provide necessary insulation between conductor & tower.



Shunt Capacitor

- It provide reactive power, when voltage reduce.
- Shunt capacitor in substation in connected between tertiary winding of transformer & earth.
- It also improve p.f. so it is also connected near to load center where reactive power required.

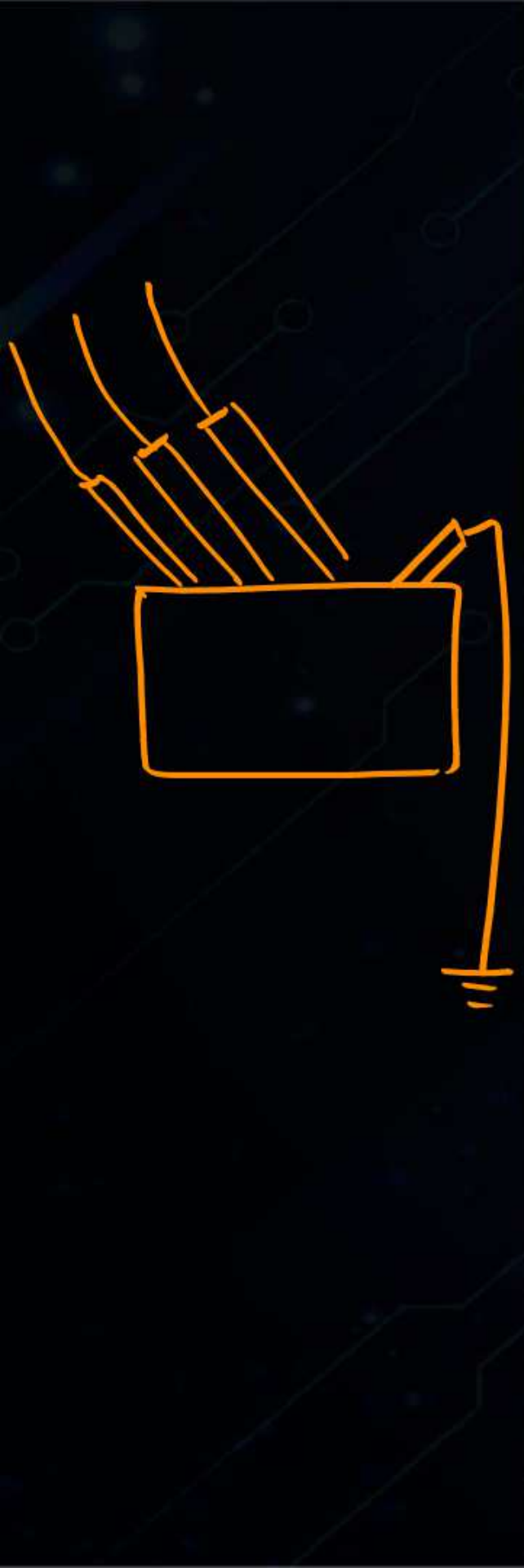




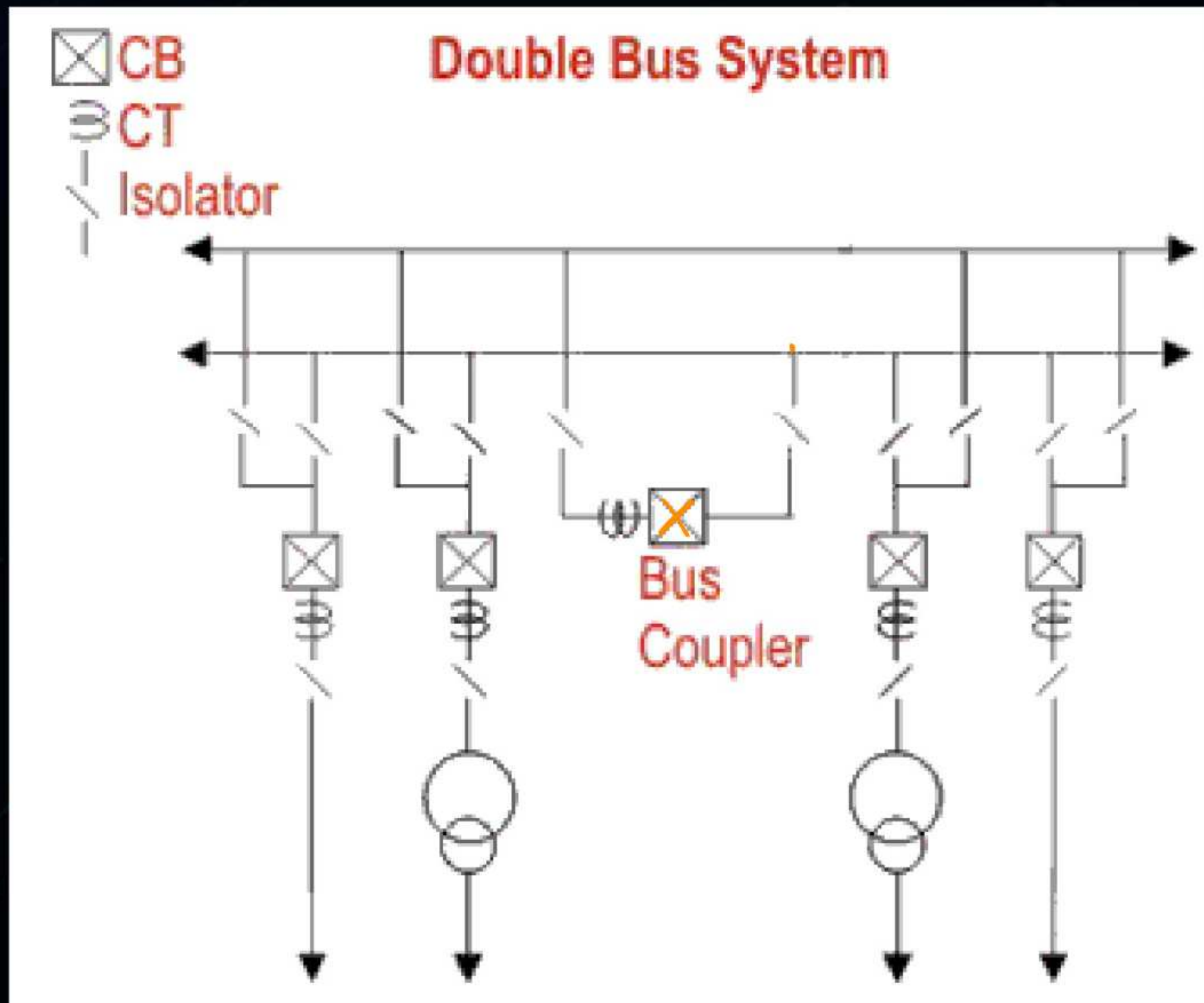
Shunt Capacitor Internal Diagram

Shunt Reactor

- It consume reactive power so it is used as a reactive power compensator.
- It is used to reduce the voltage (if voltage is increased due to Ferranti effect).



Bus coupler



Bus coupler

- It is used to couple two bus without any interruption & with average arc.
- It is a CB, which coupled two Bus.





2 Minutes Summary



Different Component of P.S.

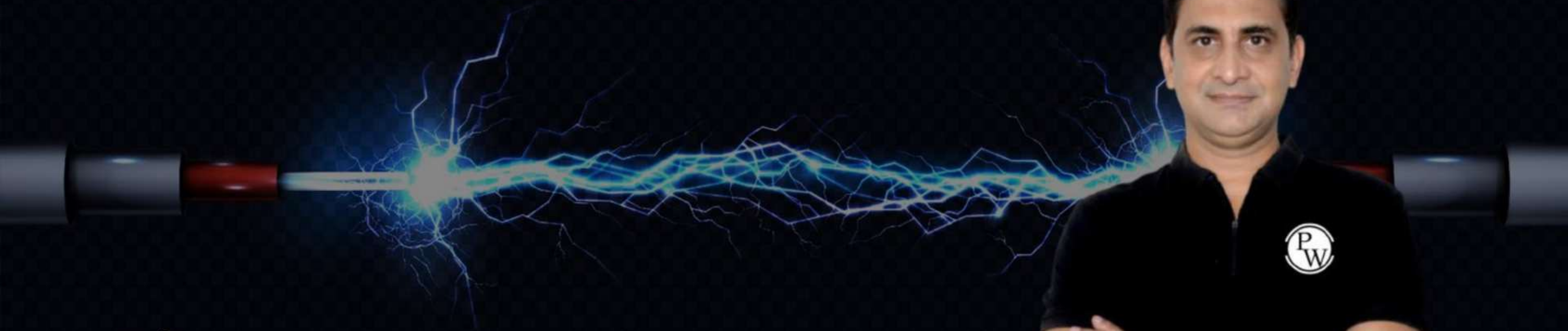
Thank you

GW
Soldiers !



Electrical Engineering

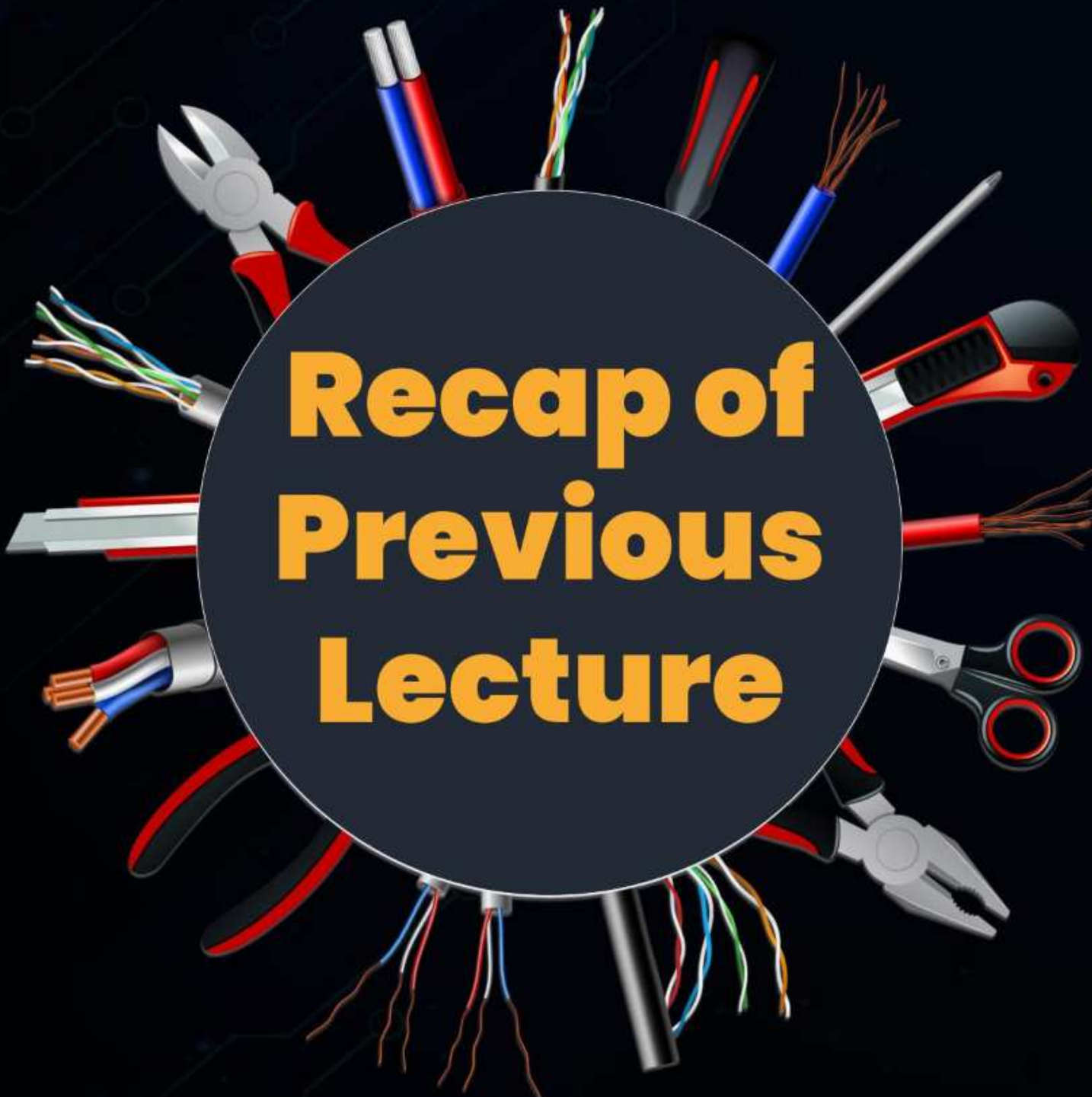
Power System



Lecture No.-04

Introduction

By- Ajay Gupta Sir



Recap of Previous Lecture

- ✓ 1. CB
- ✓ 2. Isolator
- ✓ 3. CT PT
- ✓ 4. Surge Arrester
- ✓ 5. Shunt Capacitor
- ✓ 6. Shunt Reactor
- 7. PLCC



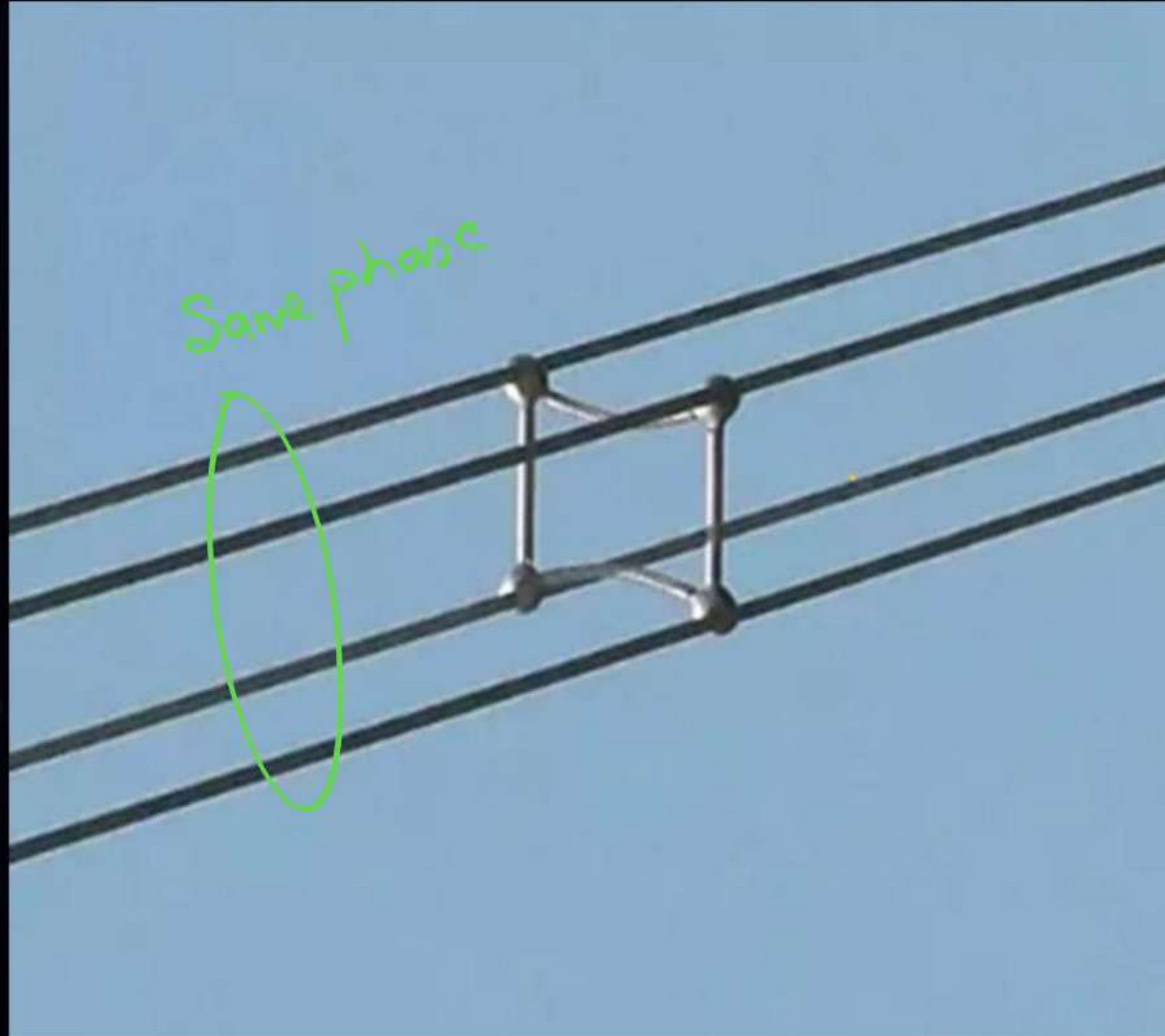
Topics to be Covered

1. Active and reactive power

2. Leading and lagging reactive power

Spacer

- It is used to provide necessary space between same phase conductor.

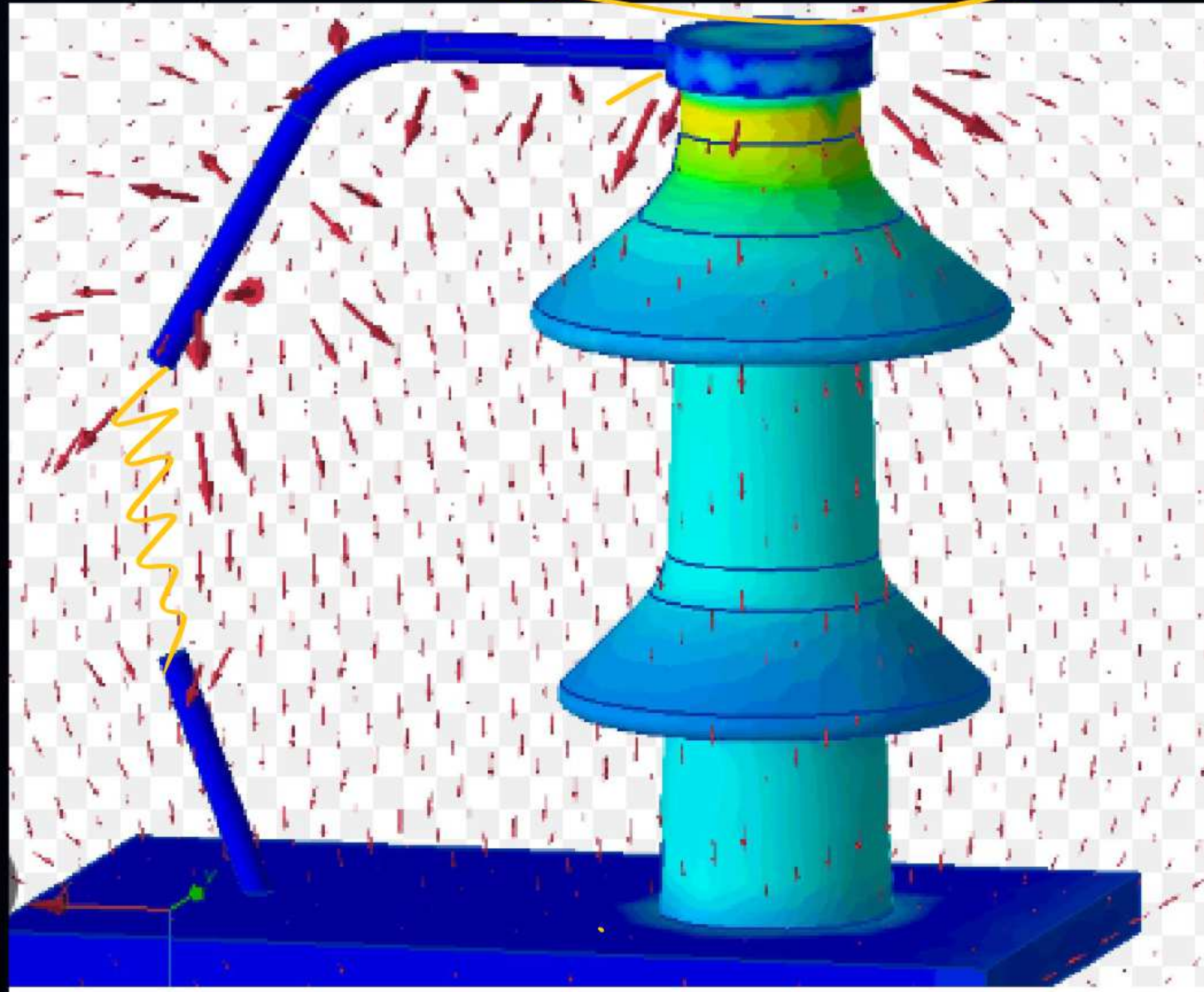
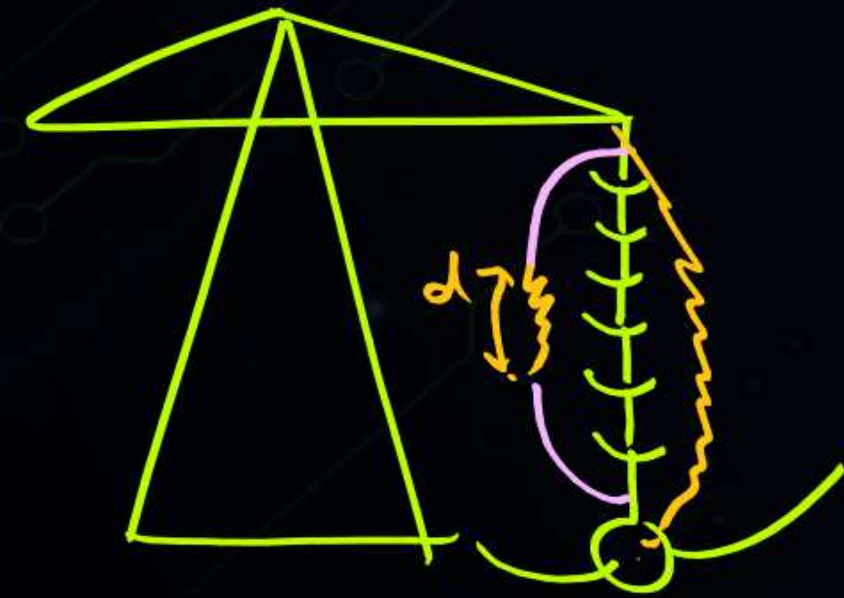


Stock bridge damper



- Stock bridge damper is used to reduce mechanical vibration (Galloping) of T.L.
★★★★★★★★★★★★★★★★★★★★
- It increase the Inertia of conductor so vibration is reduce.

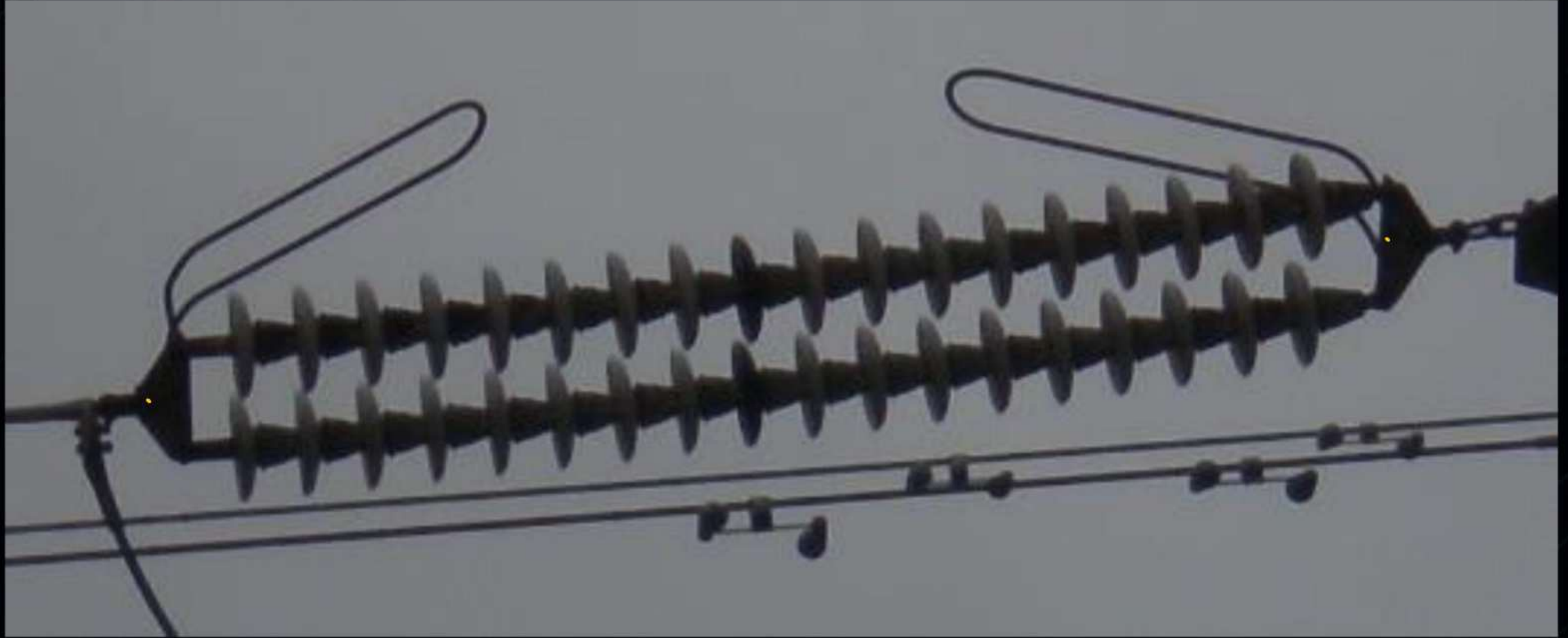
Arching horn



$$\frac{E}{F} \frac{V}{d} \downarrow$$

$$\frac{400}{\sqrt{3}} = 234$$

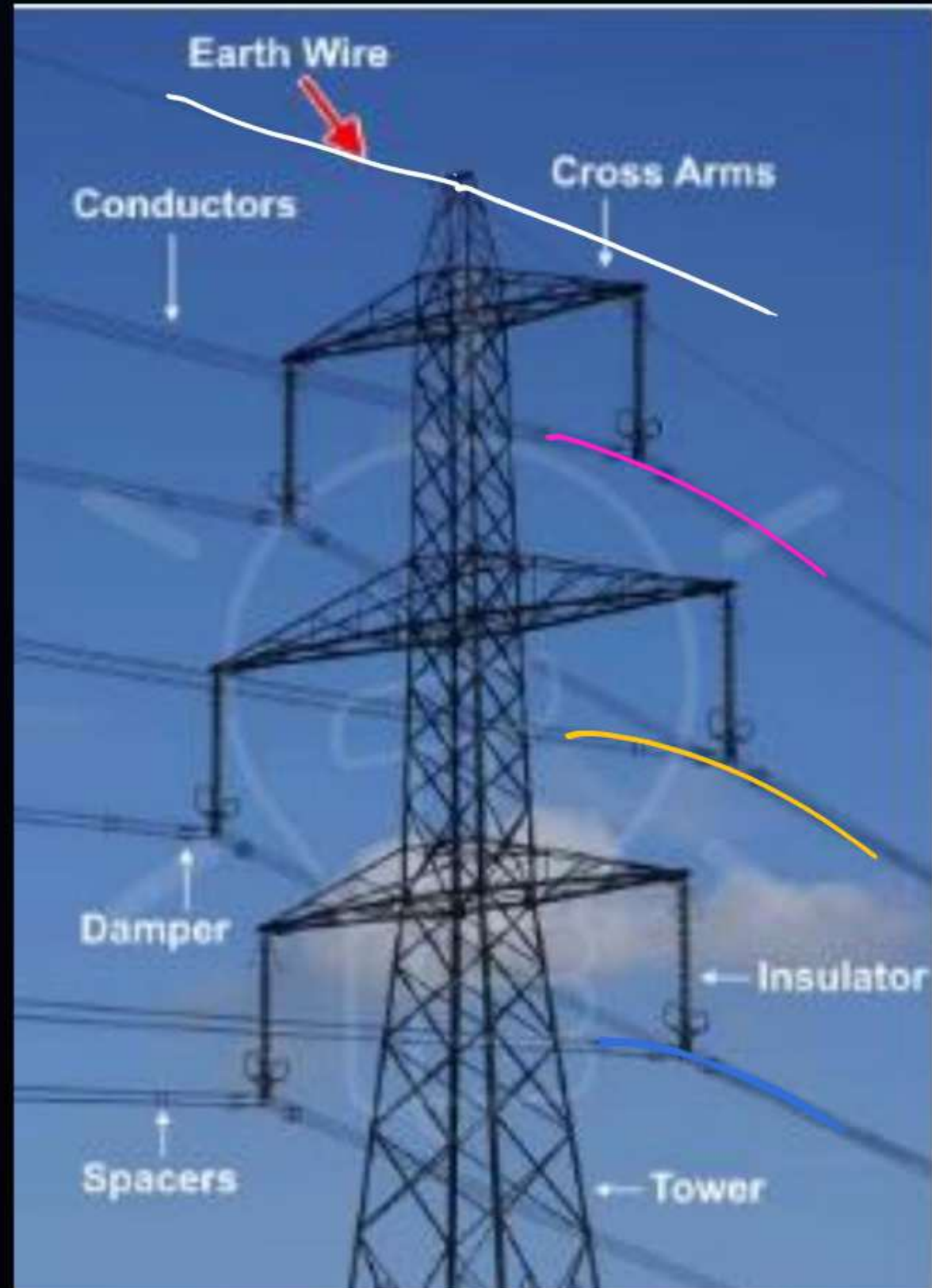
280

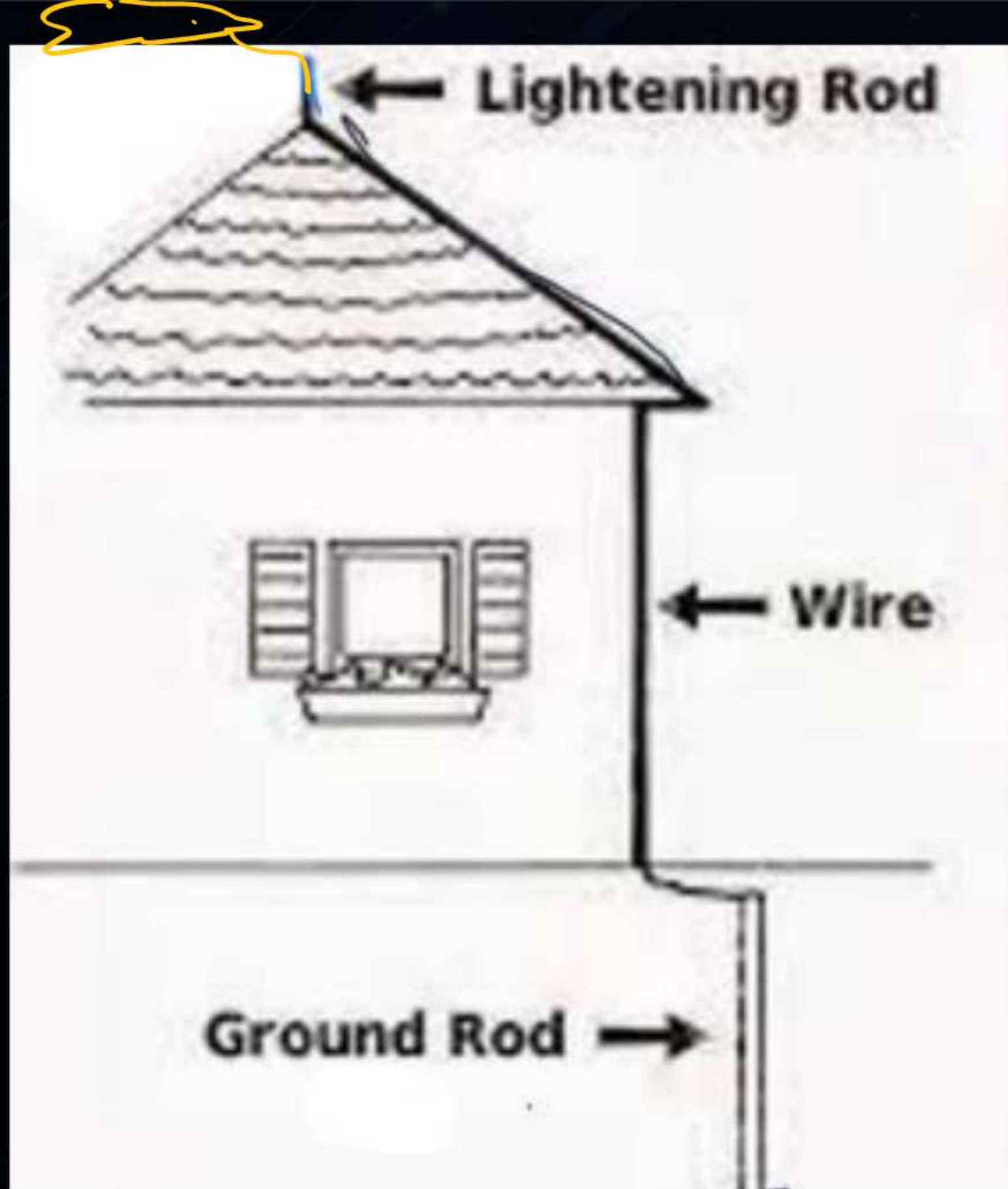


Arching horn

- It is a projected conductors used to protect insulator flash over.
- The distance between two conductor of arching horn is less, so at the time of high voltage, $E \uparrow = \frac{V}{d \downarrow}$
- The E between two projected conductor will be high. So Arc (flash over) occur between Arching horn only

Grounding wire Earth wire



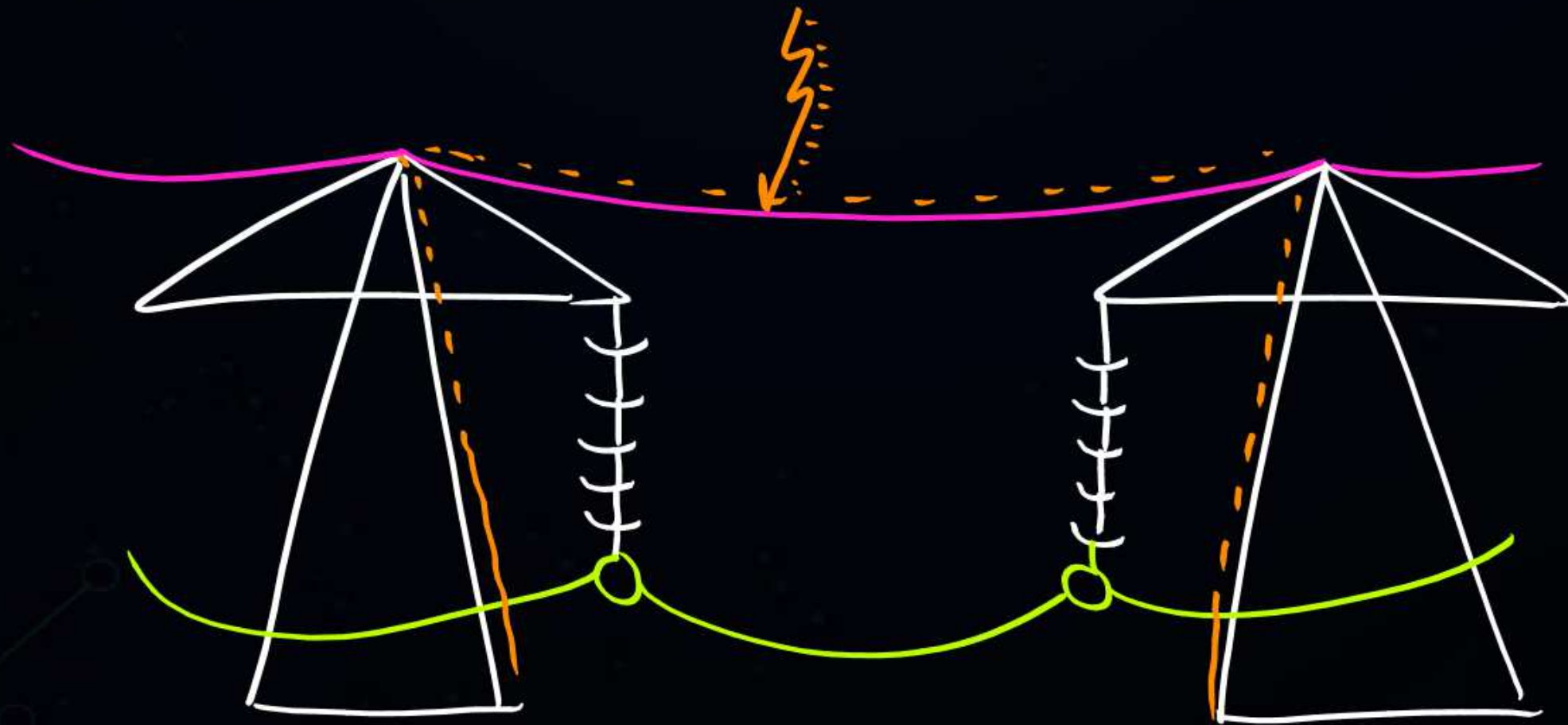


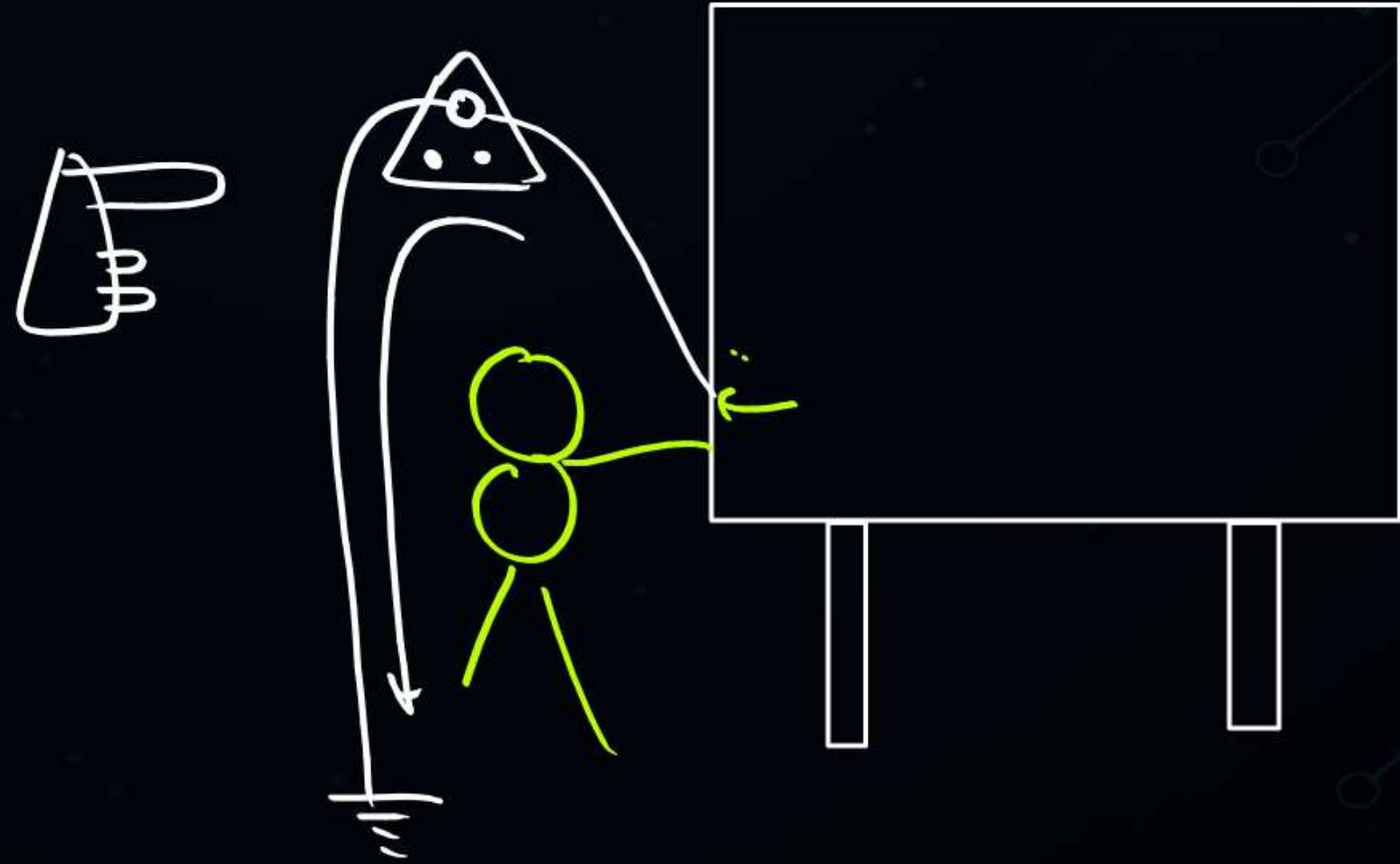
Grounding wire

- Grounding wire is placed in top most position of tower.
- It protect the TL from direct lighting stroke.
★★★★★★★★
- It divert the lighting charge to both side of tower, which ultimately direct it to earth.



$$R = \frac{P}{Q}$$





#Q. In case of fault which instrument operate first.

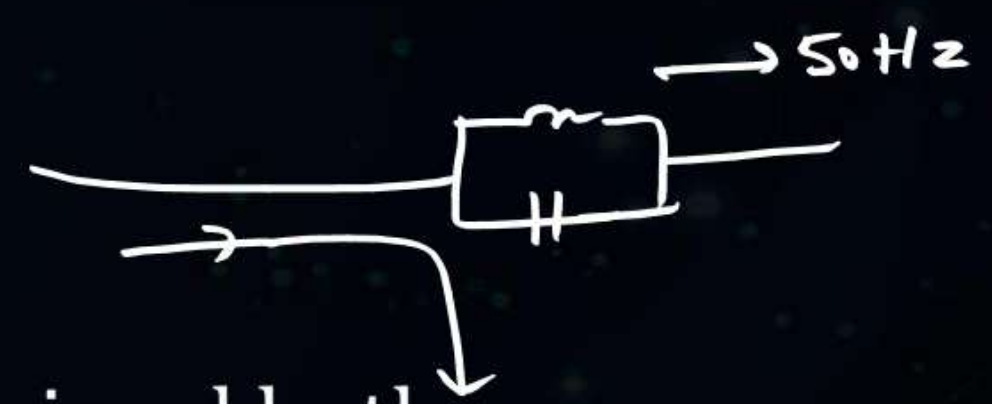
A Circuit breaker

B Earth switch

C Isolator

D Relay ✓

#Q. Wave trap allowed



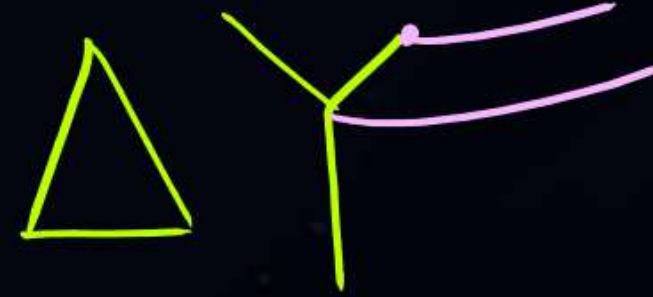
- A** 50 Hz power signal & high frequency carrier signal both.
- B** ✓ Only 50 Hz power signal it does not allowed high frequency carrier signal
- C** Only high frequency carrier signal, but does not allowed low frequency power signal
- D** None

#Q. In Nuclear power plant which alternator is used.

- ☐ **A** Salient pole alternator
- ☒ **B** Cylindrical rotor alternator
- ☐ **C** Any of these two
- ☐ **D** None

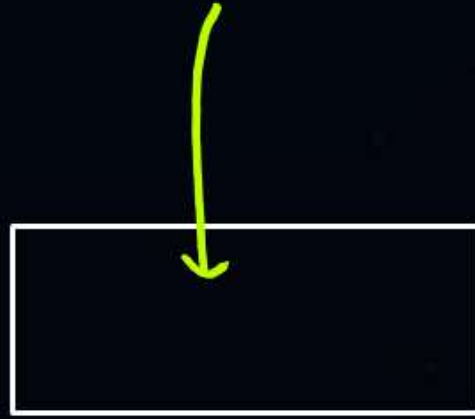
#Q. The distribution transformer has

- A** Star- Star connection
- B** Star – Delta connection
- C** ☒ Delta – Star connection
- D** Delta – Delta connection



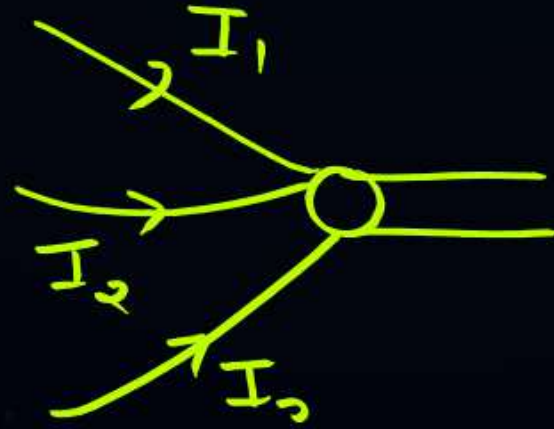
#Q. The generator used in solar power plant has

- A** Cylindrical rotor
- B** Salient pole rotor
- C** Any of these
- D** None



#Q. Which should have highest diameter

- A** T. L conductors
- B** Feeder
- C** Distributor
- D** ☒ Bus bar



#Q. The distance between projected conductor of arching horn should be

- A** Higher than the distance between T. L conductor & tower
- B** ✓ Lower than the distance between TL conductor and tower
- C** Equal to the distance between TL conductor and tower
- D** No relation between these



$$E \propto \frac{V}{d}$$

#Q. If isolator is get opened without opening of circuit breaker in sub-station.

- ☒ **A** Due to high Arc, isolator arcing will be melted.
- ☐ **B** It will isolate the circuit
- ☐ **C** It will damage the circuit breaker
- ☐ **D** Isolator should be opened only after earth switch.

#Q. The transmission voltage in India Are.

- A** 1200 kV, 765 kV, 400 kV, 220 kV, 132 kV, 33kV ✓
- B** 1100 kV, 765 kV, 400 kV, 220 kV, 132 kV 33kV
- C** 1100 kV, 765 kV, 440 kV, 220 kV, 132 kV, 33kV
- D** 1165 kV, 765 kV, 400 kV, 220 kV, 132 kV, 33kV

#Q. Which of these statements are correct regarding CVT.

1. It is generally used at low voltage sub-station ✗
2. It is generally used at high voltage sub-station ✓
3. It is reduced to voltage level for measurement & protection. ✓
4. It can also used as a coupling capacitor in PLCC ✓

A 1, 2, and 3

B ✓ 2, 3 and 4

C 1, 3 and 4

D All four

D.C. POWER:

$$P = VI$$



Active power, Apparent power, Reactive power, complex power

$$\bar{V} = |V| \angle \alpha \quad \bar{I} = |I| \angle \beta$$

Complex power

$$S = V I^*$$

$$I = |I| \angle \beta$$

$$I^* = |I| \angle -\beta$$

$$\bar{S} = [|V| \angle \alpha] [|I| \angle -\beta]$$

$$\bar{S} = |V| |I| \angle (\alpha - \beta)$$

$$\gamma \angle \theta = \gamma (\cos \theta + j \sin \theta)$$

$$\bar{S} = |V| |I| (\cos(\alpha - \beta) + j \sin(\alpha - \beta))$$

$$\bar{S} = P + jQ$$

$$V^* I$$

$$[|V| \angle -\alpha] [|I| \angle \beta]$$

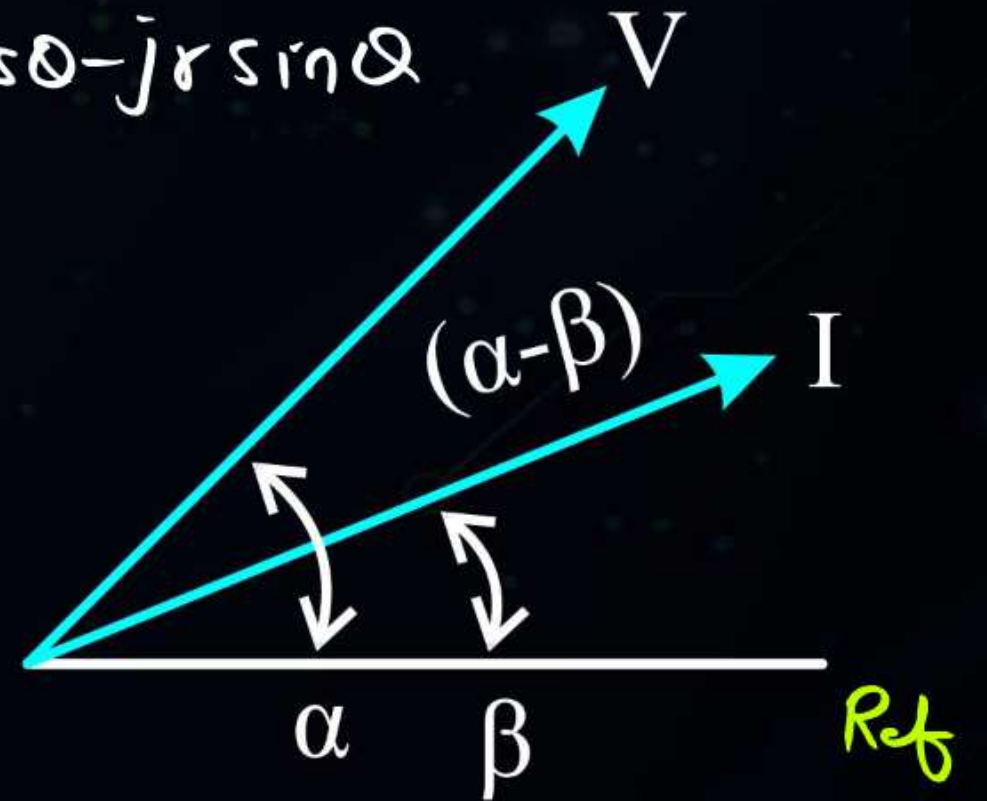
$$|V| |I| \angle (\beta - \alpha)$$

$$|V| |I| \angle -(\alpha - \beta)$$

$$|V| |I| (\cos(\alpha - \beta) - j \sin(\alpha - \beta))$$

$$S = P - jQ$$

$$r \angle -\theta = r \cos \theta - j r \sin \theta$$



$$\bar{S} = VI^* = P + jQ$$

➤ $\bar{S}$ is called complex power, its real part is active power & imaginary part is reactive power (it is vector quantity)

➤ The magnitude of complex power

$$S = \sqrt{P^2 + Q^2} = |V||I|$$

Is called apparent power

(it is scalar quantity)

$$Q = VI \sin(\alpha - \beta) = VI \sin \theta$$

So Q will be positive when $\alpha > \beta$.

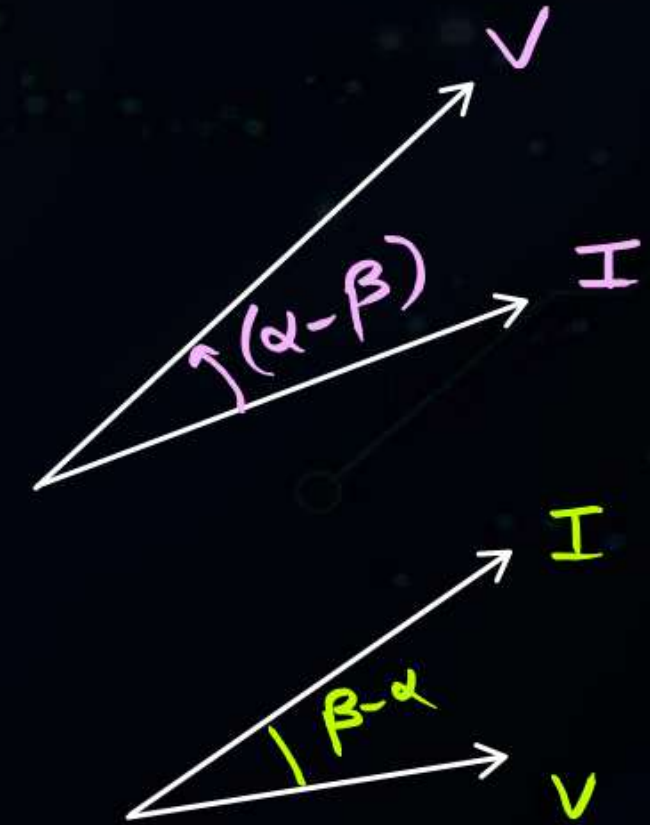
(when current lag the voltage)

$$\text{If } \beta > \alpha = VI \sin(-\theta) = \ominus Ve$$

So Q will be negative

(When current lead the voltage)

So lagging VAR = Positive reactive power



$$S = VI \quad . \quad VA, KVA, MVA$$

$$P = VI \cos \theta \quad . \quad W, KW, MW$$

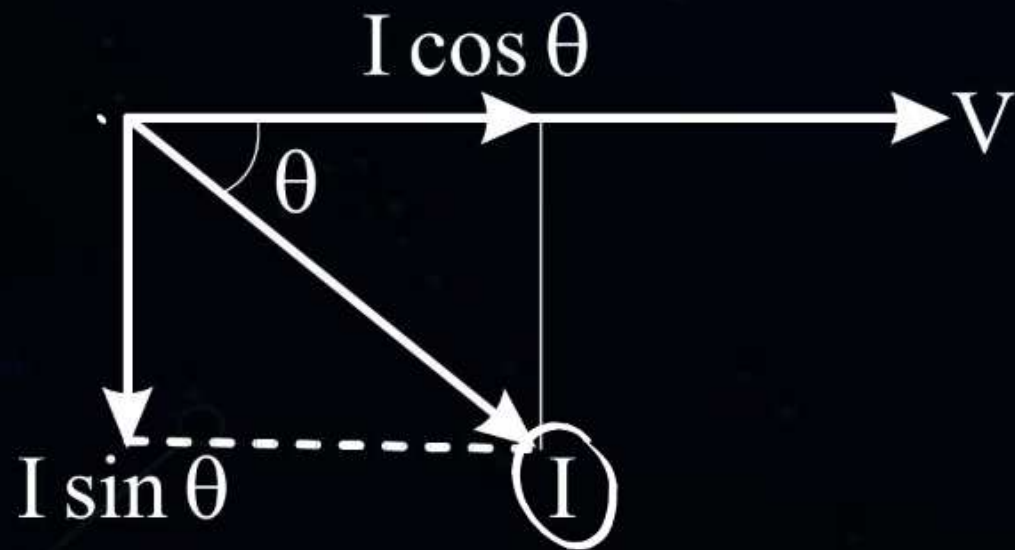
$$Q = VI \sin \theta \quad . \quad VAR, KVAR, MVAR$$

D.C. Power



$$\underline{P = VI}$$

AC Power



Active component of current = $I \cos \theta$

Reactive component of current = $I \sin \theta$

$$V(I \cos \theta) = VI \cos \theta$$

$$V(I \sin \theta) = VI \sin \theta$$

$$\begin{array}{ccccc} \text{P.f.} \uparrow & = & \cos \theta \uparrow & \Rightarrow & \sin \theta \downarrow \\ & & \downarrow & & \downarrow \\ & & \checkmark P \uparrow & & \checkmark Q \downarrow \end{array}$$

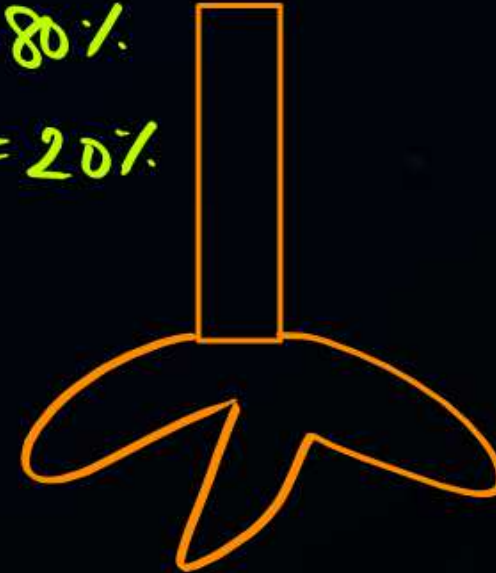
$$\sin \theta = \sqrt{1 - \cos^2 \theta}$$



$P = 60\% \downarrow$
 $Q = 40\%$



$P = 80\%$
 $Q = 20\%$



$$V = V_m \sin \omega t$$

$$I = I_m \sin (\omega t - \theta)$$

Instantaneous Power

$$P(t) = VI = V_m I_m \sin \omega t \sin (\omega t - \theta)$$

$$= \frac{V_m I_m}{2} (2 \sin \omega t \sin (\omega t - \theta))$$

$$= \frac{V_m I_m}{2} [\cos \theta - \cos (2\omega t - \theta)]$$

$$= \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} [\cos \theta - \cos 2\omega t \cos \theta - \sin 2\omega t \sin \theta]$$

$$2 \sin C \sin D = \cos(C-D) - \cos(C+D)$$

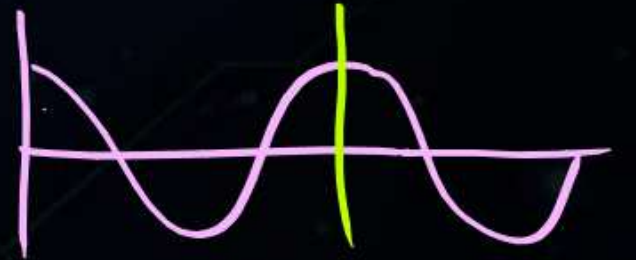
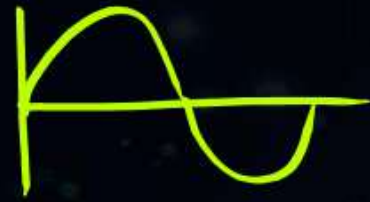
$$= V_r I_r [\cos\theta(1 - \cos 2\omega t) - \sin\theta \sin 2\omega t]$$

$$= \underline{V_r I_r \cos\theta(1 - \cos 2\omega t)} - \underline{V_r I_r \sin\theta \sin 2\omega t}$$

$$P(t) = \underline{P(1 - \cos 2\omega t)} - \underline{Q \sin 2\omega t}$$

Inst Active power

Inst Reactive power



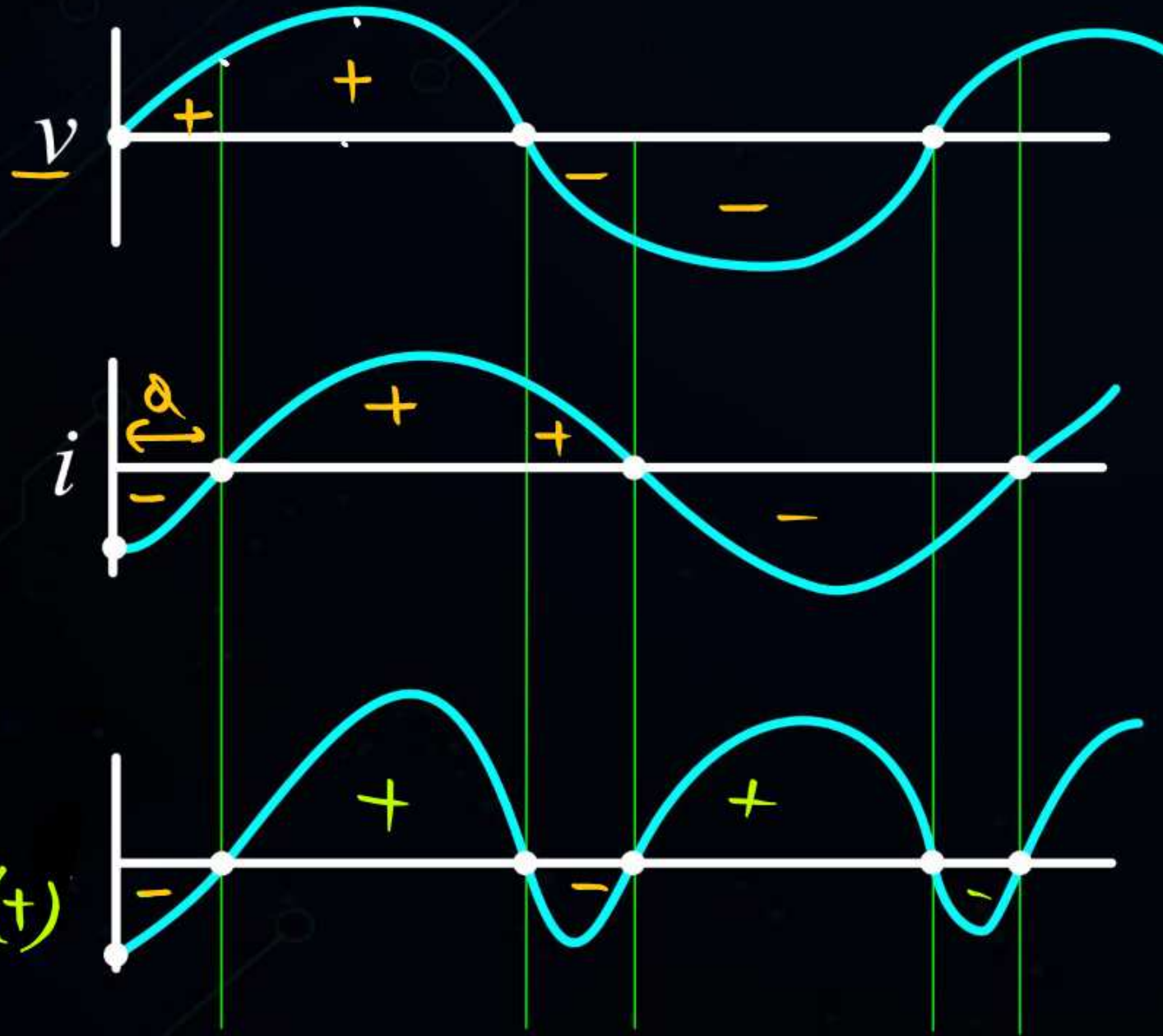
$$\text{Average Active power} = \text{Avg value of } P(1 - \cos 2\omega t) = \underline{P - \underbrace{P \cos 2\omega t}_0}$$

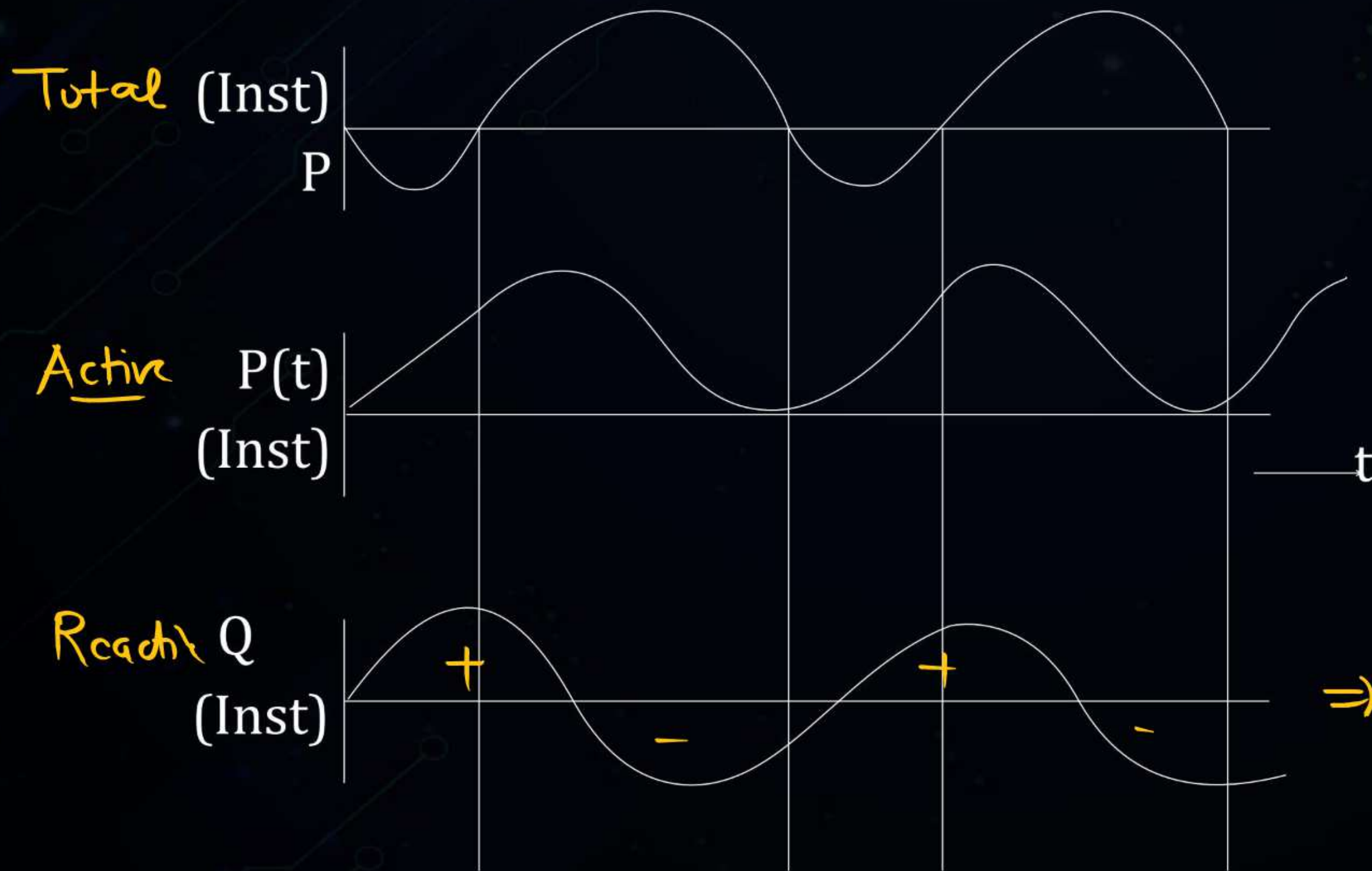
$$P_{av} = P = V_r I_r \cos\theta$$

$$Q_{av} = 0$$

$$\text{Avg value of Reactive power} = \text{Avg value of } \underline{Q \sin 2\omega t}$$

$$P = vi$$





$$\text{Avg value} = V_r I_r \cos \phi$$

$$\Rightarrow \text{Avg value} = 0$$

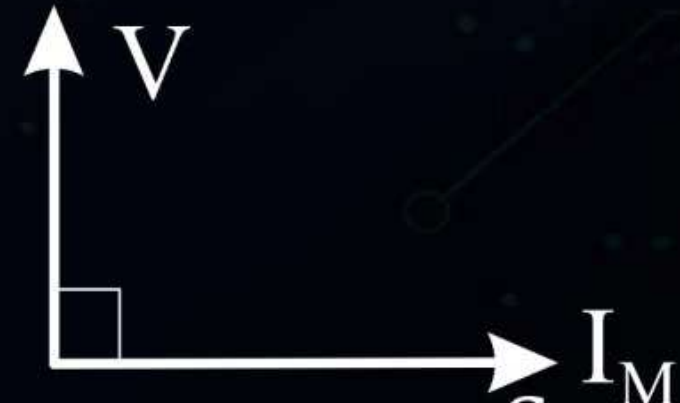
- So average value of Reactive power is zero i.e. it does not do any useful work, it only move forward & backward without doing necessary work.
- So Reactive power is exist only if reactive component is present in system.

- Only active power can be converted into one form to another form.
- Losses occur in system due to active power only.

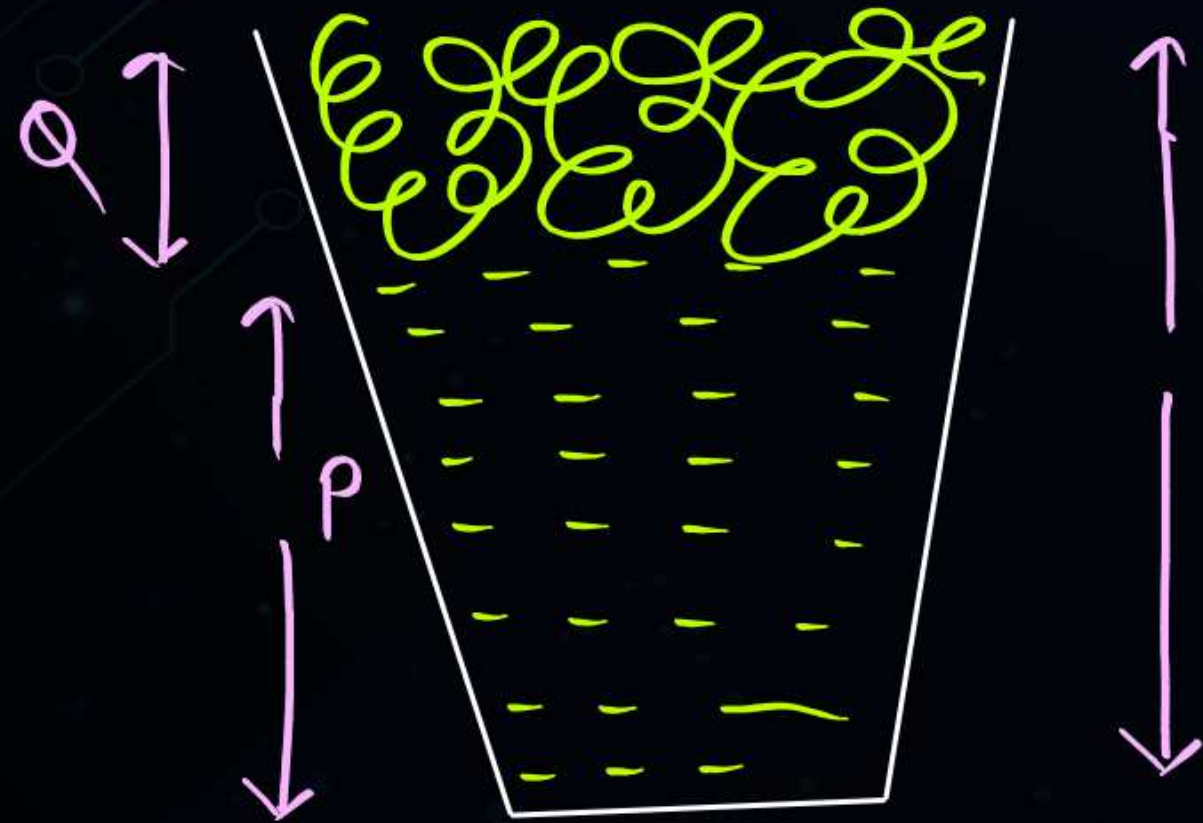

- Reactive power is a hypothetical power.
- We assume that power associated with reactive component is reactive power

$$\underline{P = I^2 R} \quad \underline{Q = I^2 X}$$

- Reactive component of current create the flux



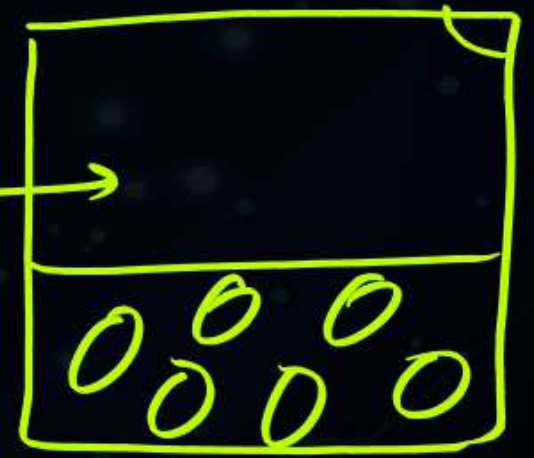
- If Reactive power is zero, the I_M of transformer is become zero. So transformer is become non operational & Active power cannot be flow.



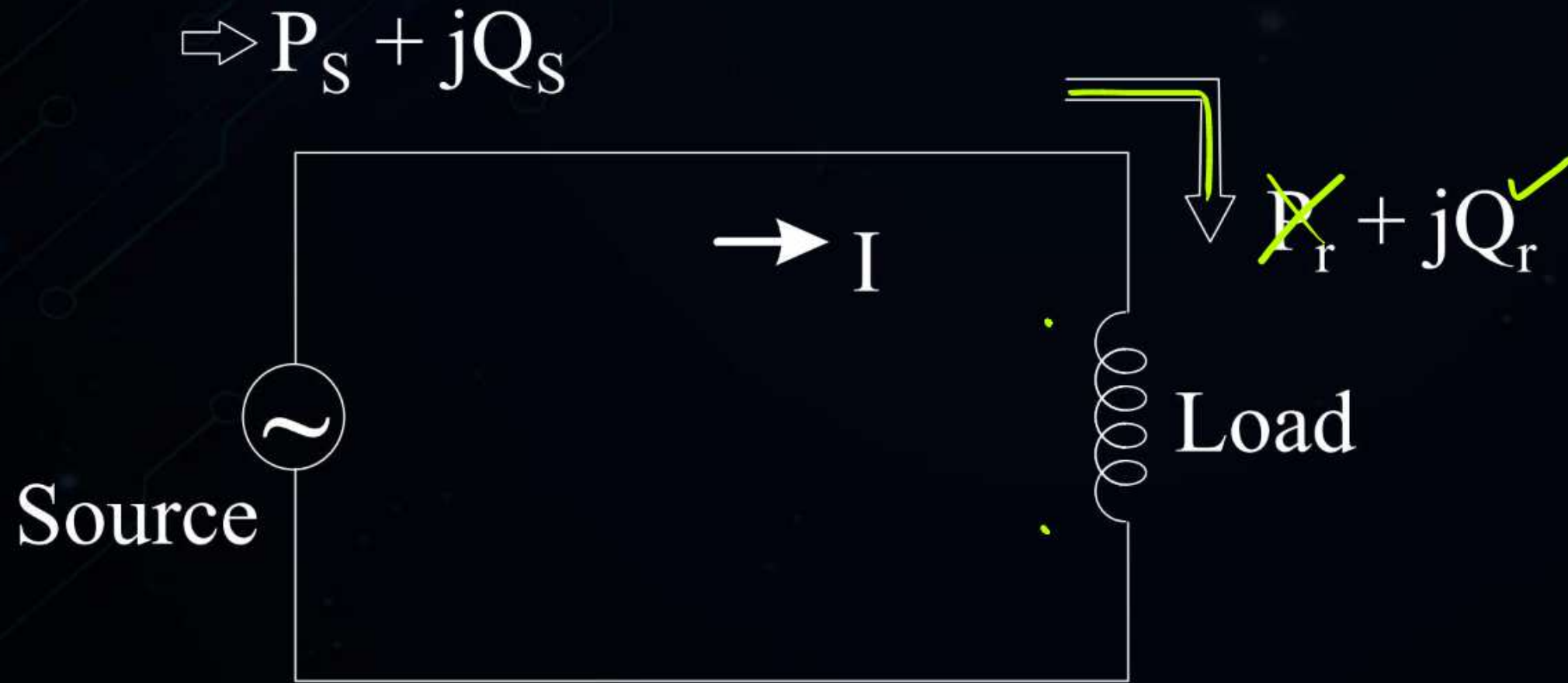
$$VI$$

$$VI \cos \phi \quad VI \sin \phi$$

Reactive



$$P = VI \cos 90 = 0$$

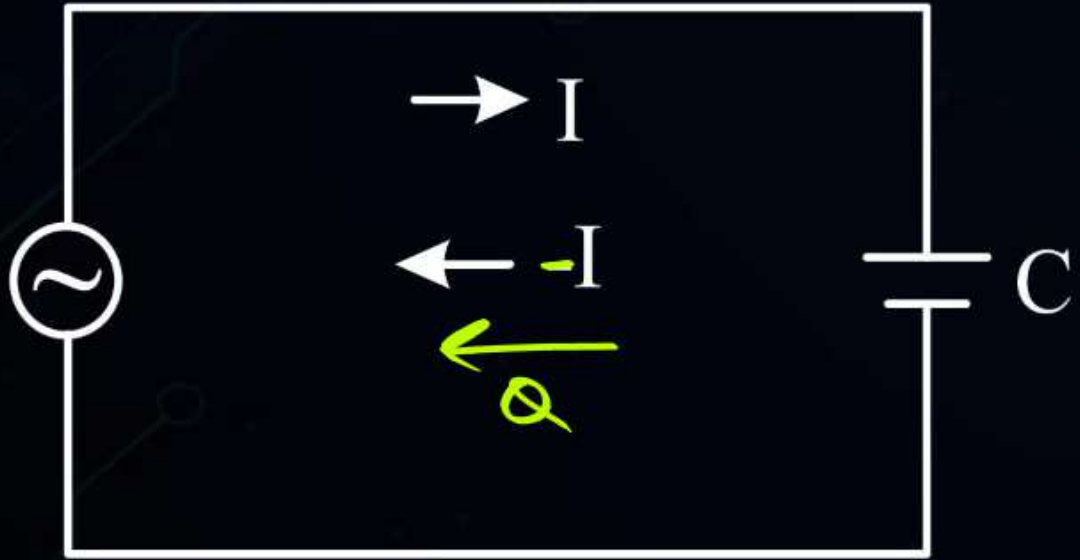


$$\underline{Q} = \underline{VI} \sin \theta \text{ (lag)} = VI \sin 90$$

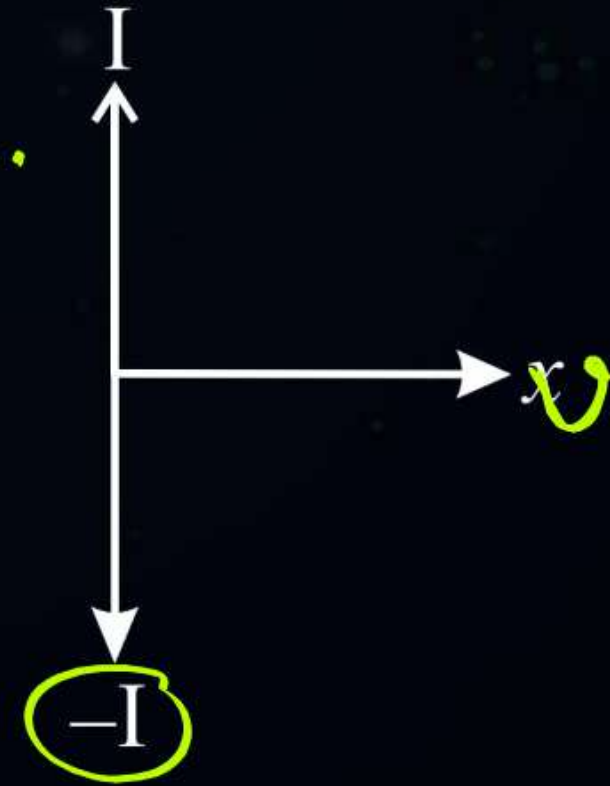
So it takes lagging VAR

it is taking positive reactive power

$$\Rightarrow P_s + jQ_s$$



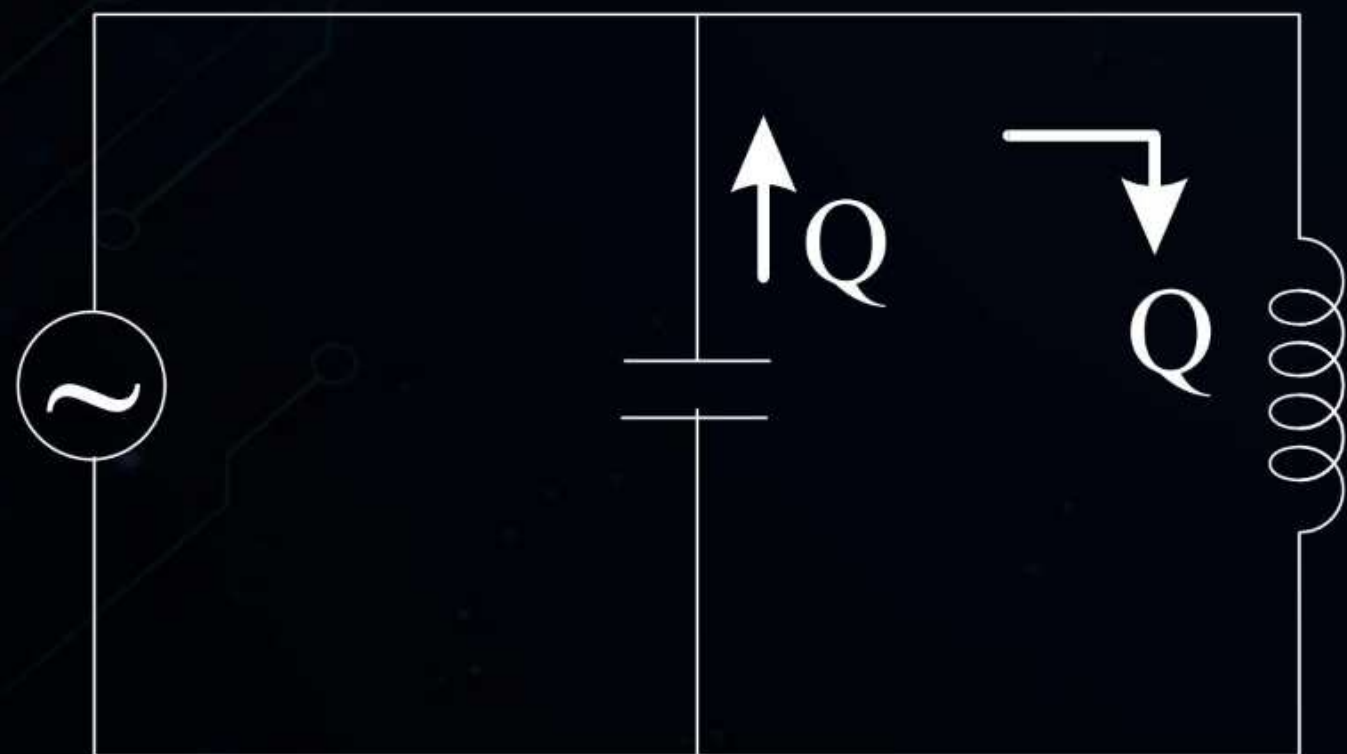
$$\Rightarrow P_s + jQ_s$$



$$P = 0$$

$$Q = VI \sin \theta \text{ (leading VAR)}$$

→ It delivered lagging VAR (Reactive power)





2 Minutes Summary

→ Active power

→ Reactive power

→ Apparant power

→ Complex power.

Thank you

GW
Soldiers !



Electrical Engineering

Power System



Lecture No.-05

Introduction

By- Ajay Gupta Sir



Recap of Previous Lecture

1. Active and reactive power ✓

2. Leading and lagging reactive power ✓



Topics to be Covered

1. Why 3 phase power is used ✓
2. 3 phase system ✓
3. 3 phase balance star connected ✓
4. 3 Phase balance delta connected ✓

Why we use 3 phase power



- If we use same alternator to create 3 phase power, then it will be able to produce 1.5 times 1ϕ power
- So, 3 phase power generations more economical than 1phase power
- In three single phase, we required 6 conductor for transmission but in 3 phase we required only 3 conductor for transmission.
- So, 3 phase power transmission is also more economical than 1phase power.
- 3 phase Instantaneous power is constant, If does not vary with time.

A.c.w angle is positive.

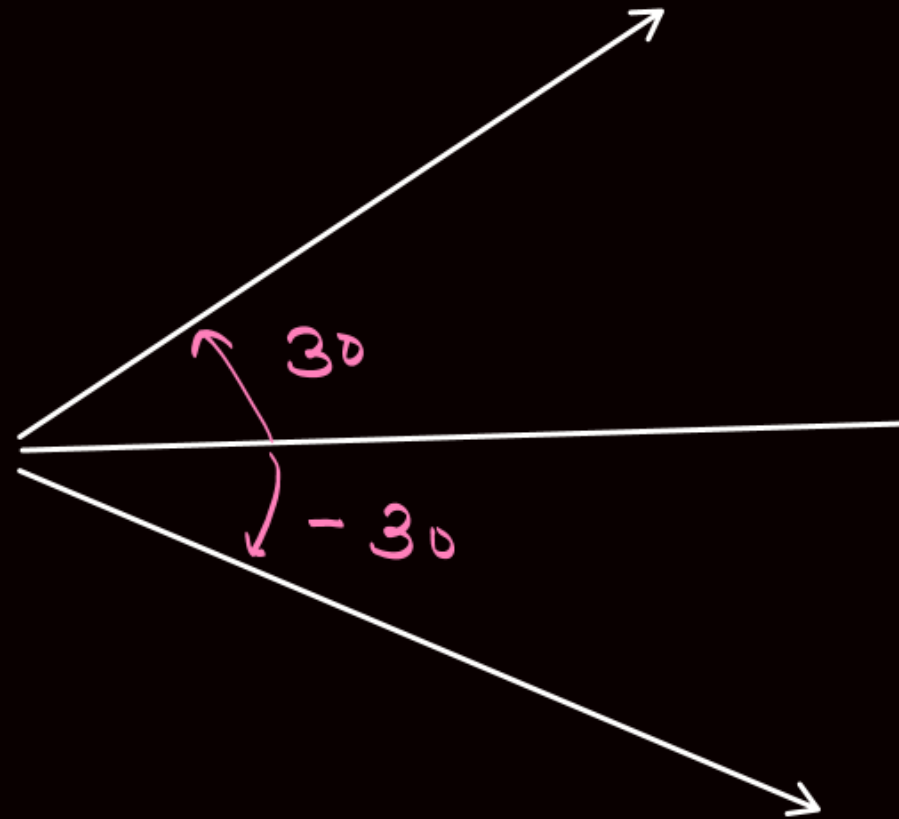
C.w angle is negative.

$$\theta + 360 = \theta$$

$$\theta - 360 = \theta$$

$$\underline{\underline{-240 + 360 = 120}}$$

$$V_m \sin(\omega t - 240) = V_m \sin(\omega t + 120)$$



$$30 + 360 = 30$$

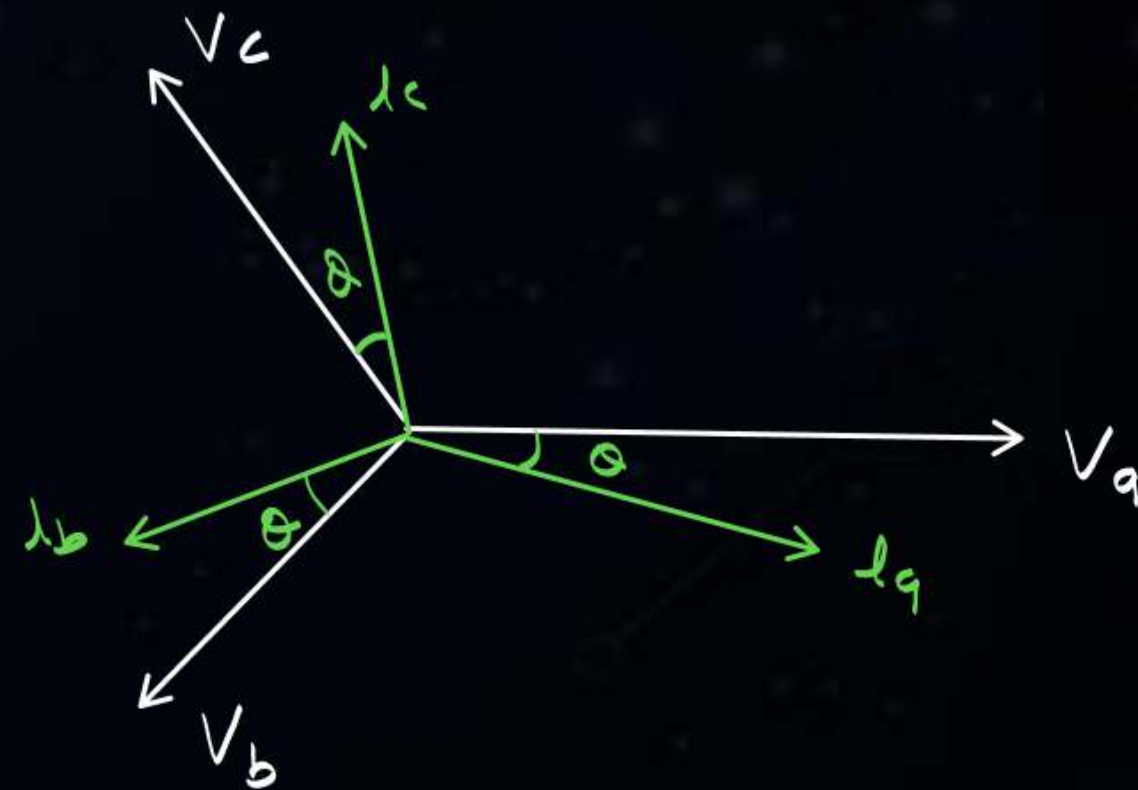
$$-180 = +180$$

$$\begin{cases} V_a = V_m \sin \omega t \\ V_b = V_m \sin(\omega t - 120) \\ V_c = V_m \sin(\omega t - 240) \end{cases} \checkmark$$

$$i_a = I_m \sin((\omega t - \theta))$$

$$i_b = I_m \sin(\omega t - 120 - \theta)$$

$$\checkmark i_c = I_m \sin(\omega t - 240 - \theta)$$



So Instantaneous power

$$= \underline{v_a} i_a + v_b i_b + v_c i_c$$

$$= V_m I_m \sin \omega t \sin(\omega t - 0) + V_m I_m \sin(\omega t - 120) \sin(\omega t - 120 - 0) \\ + V_m I_m \sin(\omega t - 240) \sin(\omega t - 240 - 0)$$

$$= \frac{V_m I_m}{2} \left[2 \sin \omega t \sin(\omega t - 0) + 2 \sin(\omega t - 120) \sin(\omega t - 120 - 0) + 2 \sin(\omega t - 240) \sin(\omega t - 240 - 0) \right]$$

$$= \frac{V_m I_m}{2} \left[\underline{\cos \theta} - \cos(\underline{2\omega t} - \theta) + \underline{\cos \theta} - \cos(\underline{2\omega t} - 240 - \theta) \right. \\ \left. + \underline{\cos \theta} - \cos(\underline{2\omega t} - 480 - \theta) \right]$$

$$= \frac{V_m I_m}{2} [3 \cos \theta] - \frac{V_m I_m}{2} \left[\cos(\underline{2\omega t} - \theta) + \cos(\underline{2\omega t} - 240 - \theta) \right. \\ \left. + \cos(\underline{2\omega t} - 480 - \theta) \right]$$

$$= \frac{V_m I_m}{2} [3 \cos \theta]$$



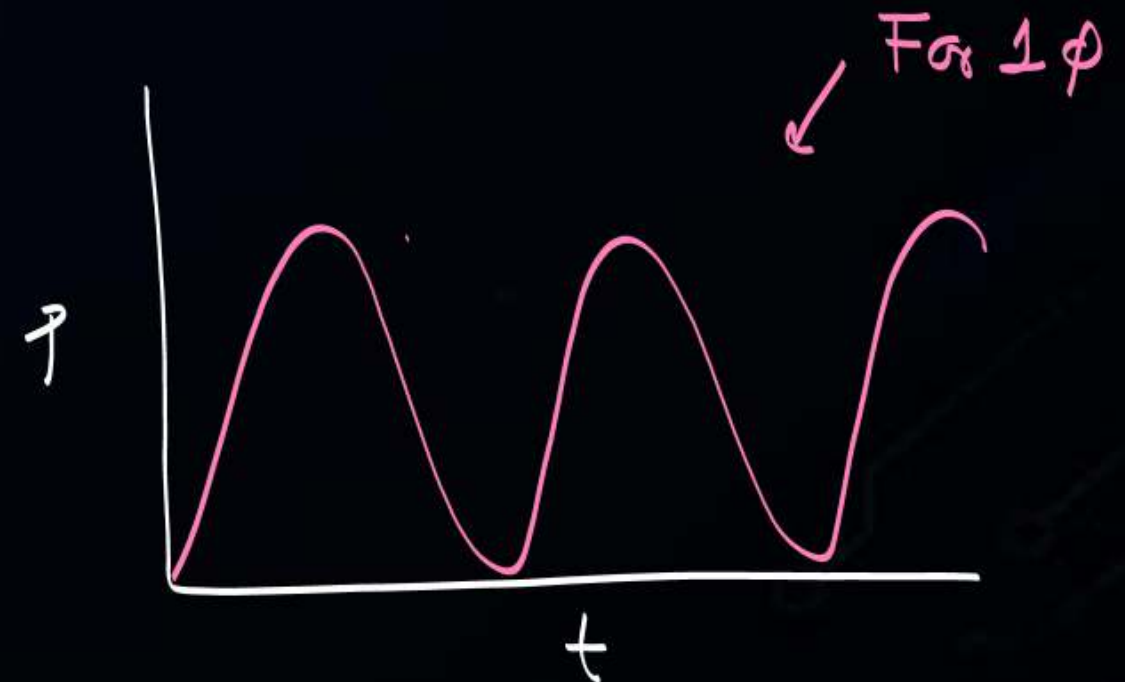
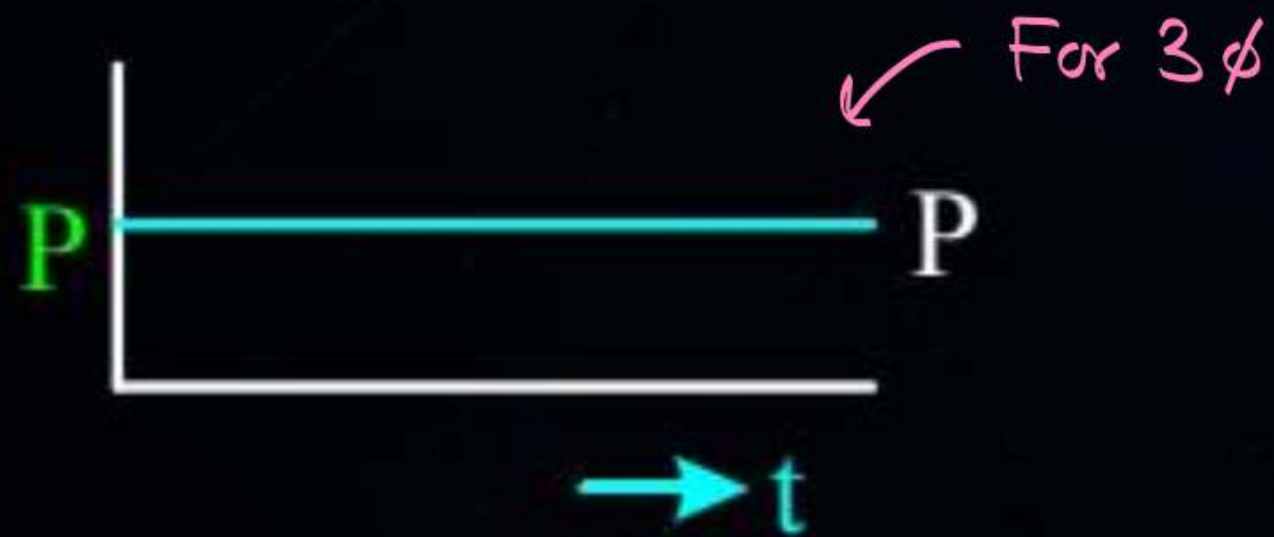
$$\downarrow \\ \cos(\underline{2\omega t} - 120 - \theta)$$

$$P(1 - \cos 2\omega t) \quad \cancel{Q \sin 2\omega t}$$

$$P = \frac{V_m I_m}{2} (3 \cos \theta) = 3 \cdot \left(\frac{V_m}{\sqrt{2}} \right) \cdot \left(\frac{I_m}{\sqrt{2}} \right) \cos \theta$$

$$V_r = \frac{V_m}{\sqrt{2}} \quad I_r = \frac{I_m}{\sqrt{2}}$$

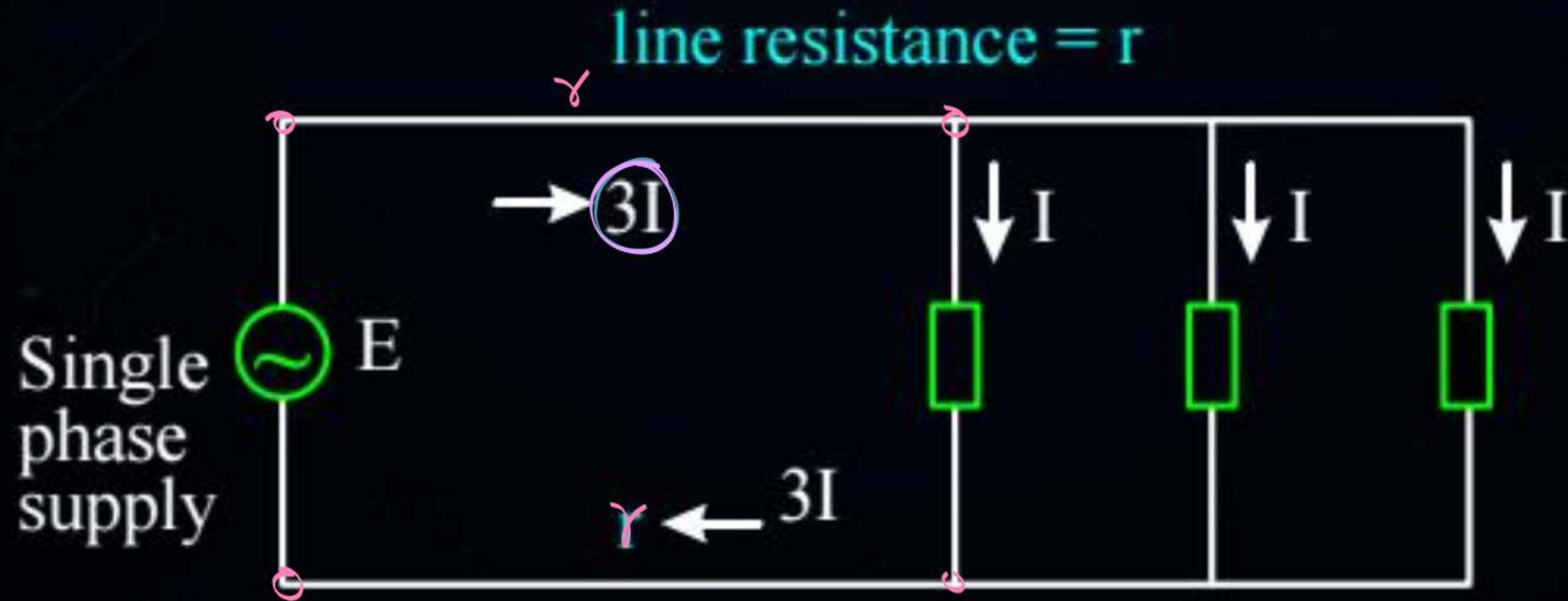
$$P = 3 V_r I_r \cos \theta \rightarrow \text{it does not depend on time}$$



- The Instantaneous value of total reactive power is zero. It does not mean that reactive power is not flowing in Individual phase.
- Only their phasor sum at any Instant is zero.
- So, we say total magnitude of Reactive power is $3VI \sin\theta$.
- Due to constant power the Torque created by 3 phase motor will be constant

lalq	kalu	Bhalu
↓	↓	↓
10,000	10,000	-20,000

- In 3 phase transmission the power loss is reduced by 50% for same power transfer.



$$\text{Total power loss} = (3I)^2 r + (3I)^2 r = \underline{18 I^2 r} \checkmark$$

$$\frac{P_2}{A/3} = \frac{3P_2}{A} = 3\sigma$$

$$R = \frac{\rho \ell}{A/3}$$



Power loss

$$= I^2(3r) + I^2(3r) + I^2(3r) = \underline{9I^2r}$$



- Voltage drop in 3 phase line is less than that of 1 phase line. Voltage Regulation is better

For 1ϕ line Voltage drop per phase $= 3Ix + 3Iy = 6Ix$

For 3ϕ line Voltage drop per phase $= I(3x) = 3Ix$

$$V.R. = \frac{\text{No load voltage} - \text{F.L voltage}}{\text{Rated voltage}}$$

$$VR = \frac{6lr}{V} \quad (1\phi \text{ scheme})$$

$$VR = \frac{3lr}{V} \quad (3\phi \text{ scheme}).$$



- In 3ph power, Rotating Magnetic field is created, so motor is become self starting.

$$I_a + I_b + I_c = 0$$

Instantaneous Power

Balance

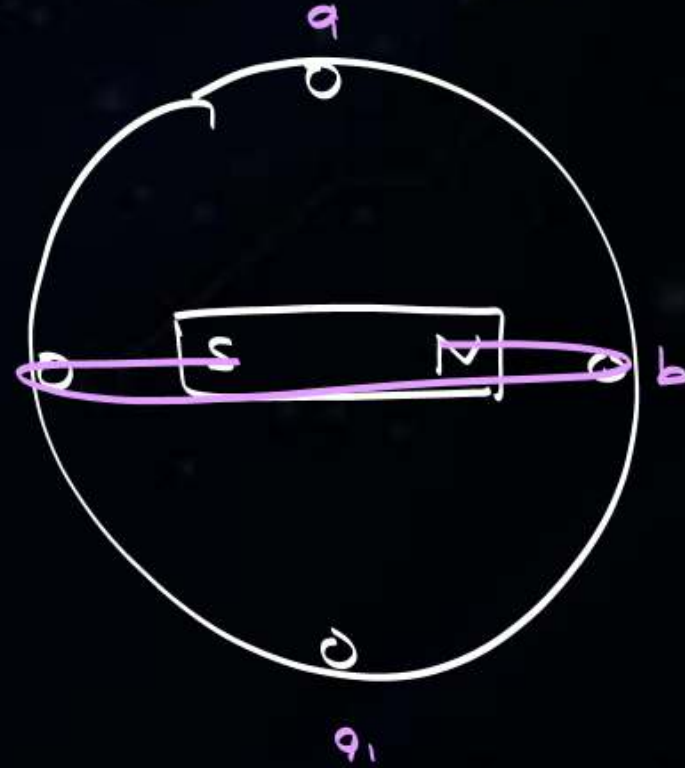
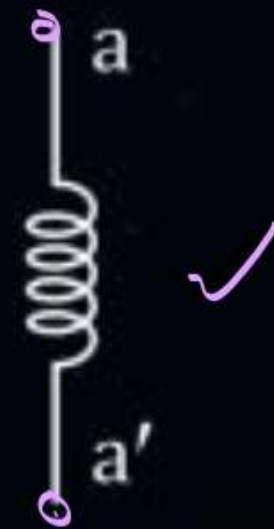
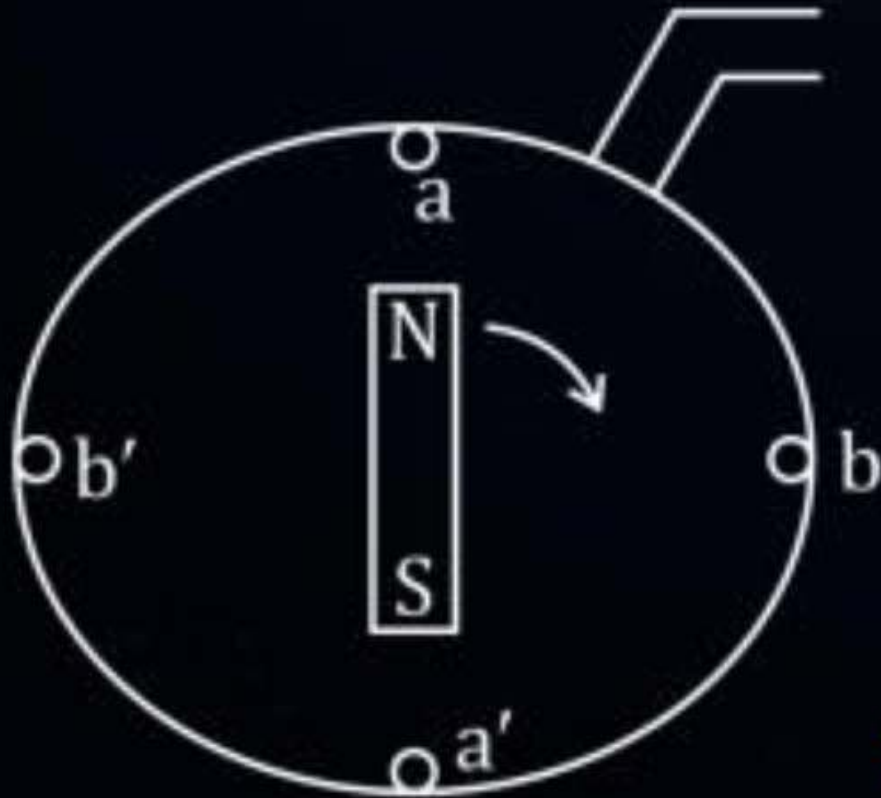
RMF

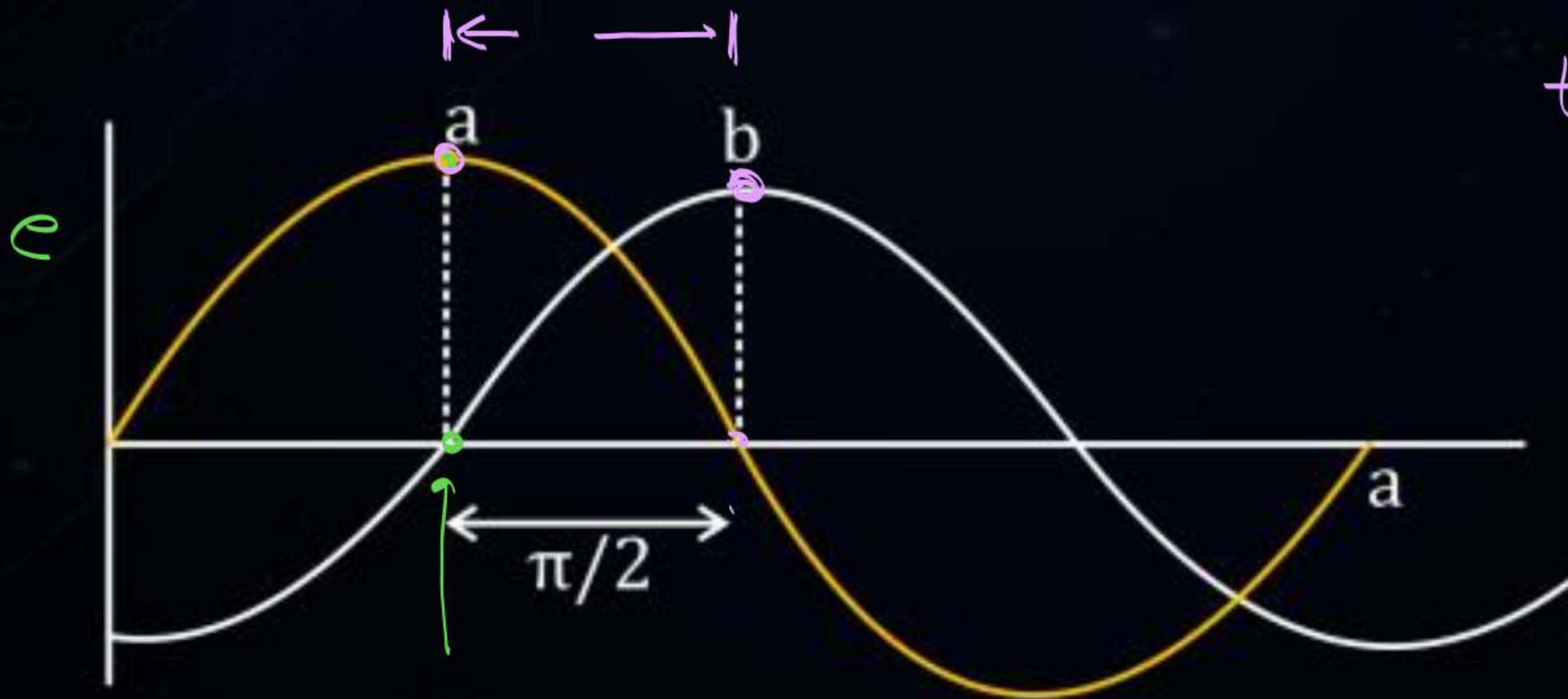
1 ϕ ✓	Pulsating	Return conductor <u>required</u>	X ✓
2 ϕ ✓	Constant ✓	Return conductor required	✓ ✓
3 ϕ	Constant ✓	No Return ✓	✓ ✓
4 ϕ]	Constant	No Return	✓
6 ϕ]	Constant	No Return	✓

2 Phase Circuit

2 Phase :

$$e = Blv$$



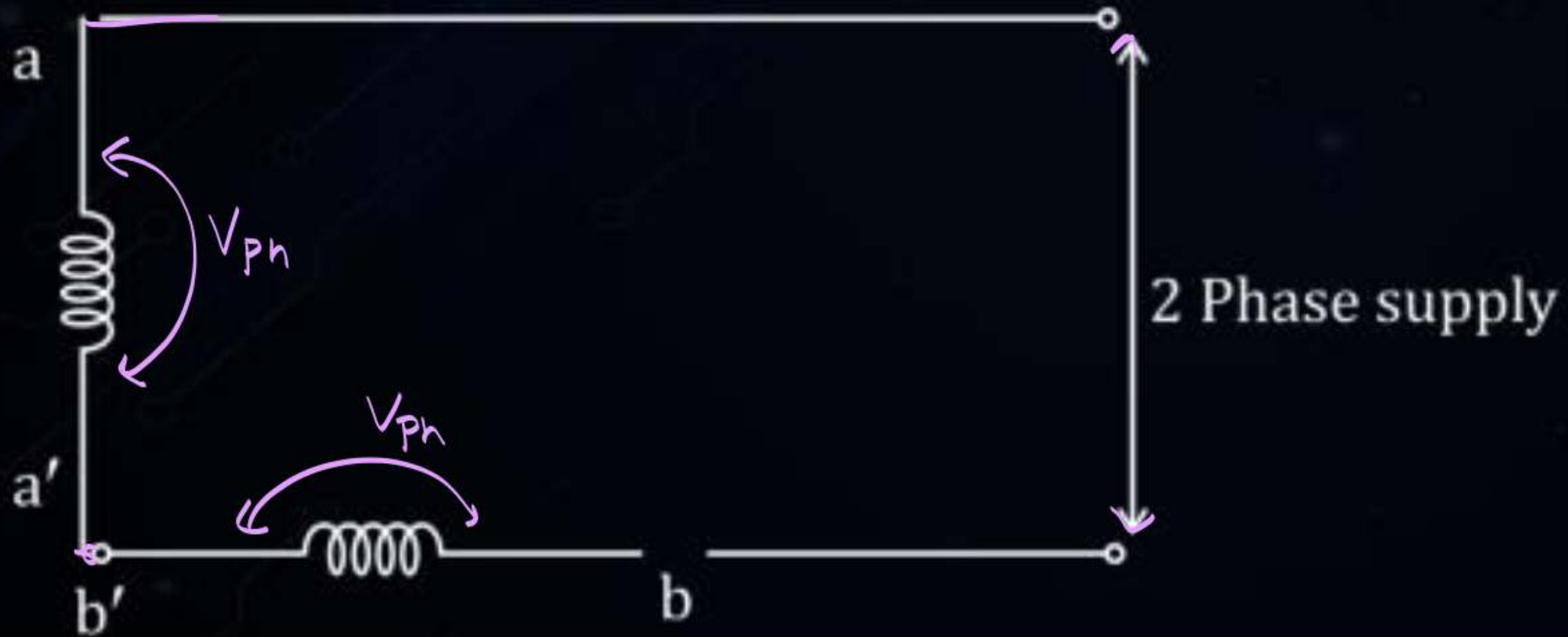


$$\omega t = \pi/2$$

$$t = \frac{\pi/2}{2\pi \times 50} = \frac{1}{200}$$

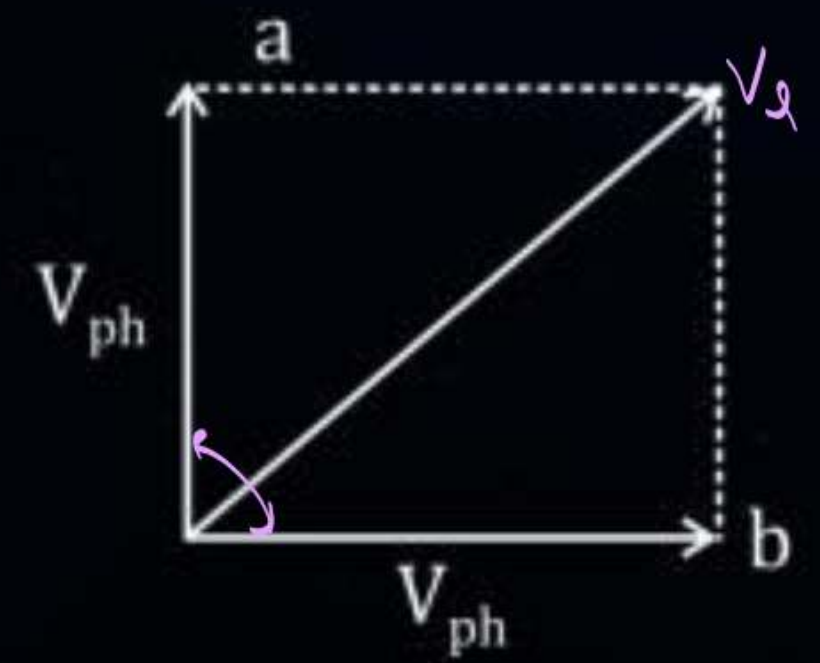
$$t = \underline{5 \text{ msec}}$$

$\rightarrow \underline{\omega t}$



$$V_a = V_m \sin \omega t$$

$$V_b = V_m \sin (\omega t - \pi / 2)$$



$$V_L = \sqrt{V_{Ph}^2 + V_{Ph}^2} = \sqrt{2} V_{Ph}$$

✶✶✶ The two-phase supply is having two voltage of equal magnitude and difference between two phase voltage is 90.

3 Phase Balance and Unbalance supply:

- ★ The 3 Phase supply mean three voltage of same frequency.
- ★ If the amplitude of all 3 voltage are same and there is a phase difference of 120 between them it is a 3 Phase balance supply
- ★ If Amplitude of all 3 Voltage are not equal or the phase difference between them are not 120 or both is not there. Then 3 phase unbalance supply



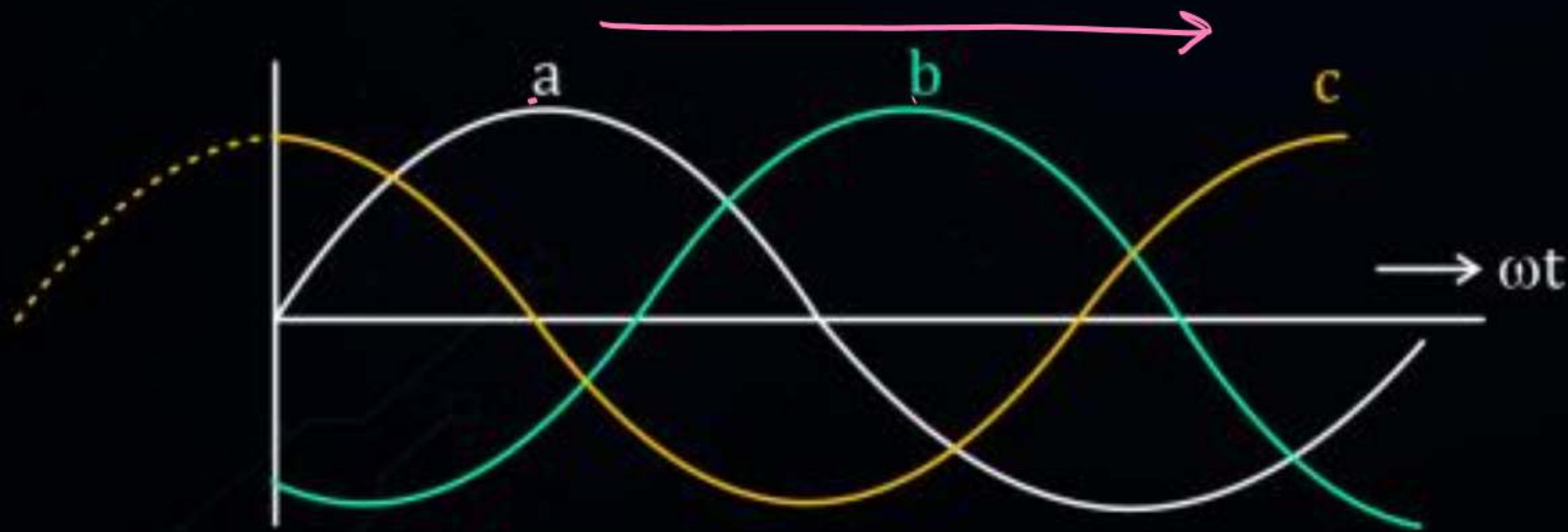
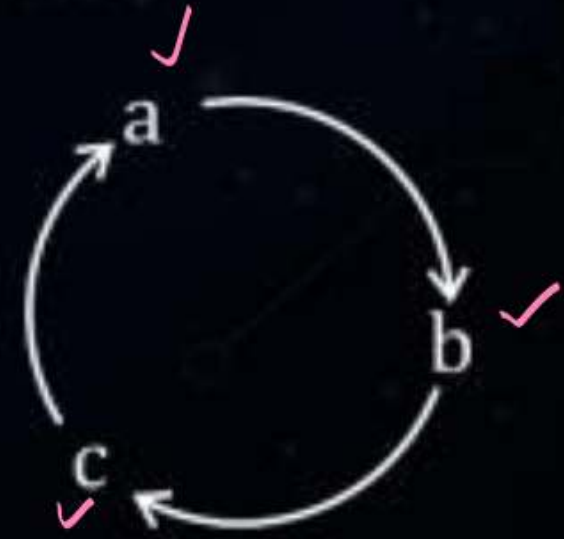
★ But in alternator we use similar winding for phase A, B & C and they are placed at 120 angle, so we get balance supply.

Positive sequence

$$V_a = V_m \sin \omega t$$

$$V_b = V_m \sin (\omega t - 120^\circ)$$

$$V_c = V_m \sin (\omega t - 240) = V_m \sin (\omega t + 120)$$

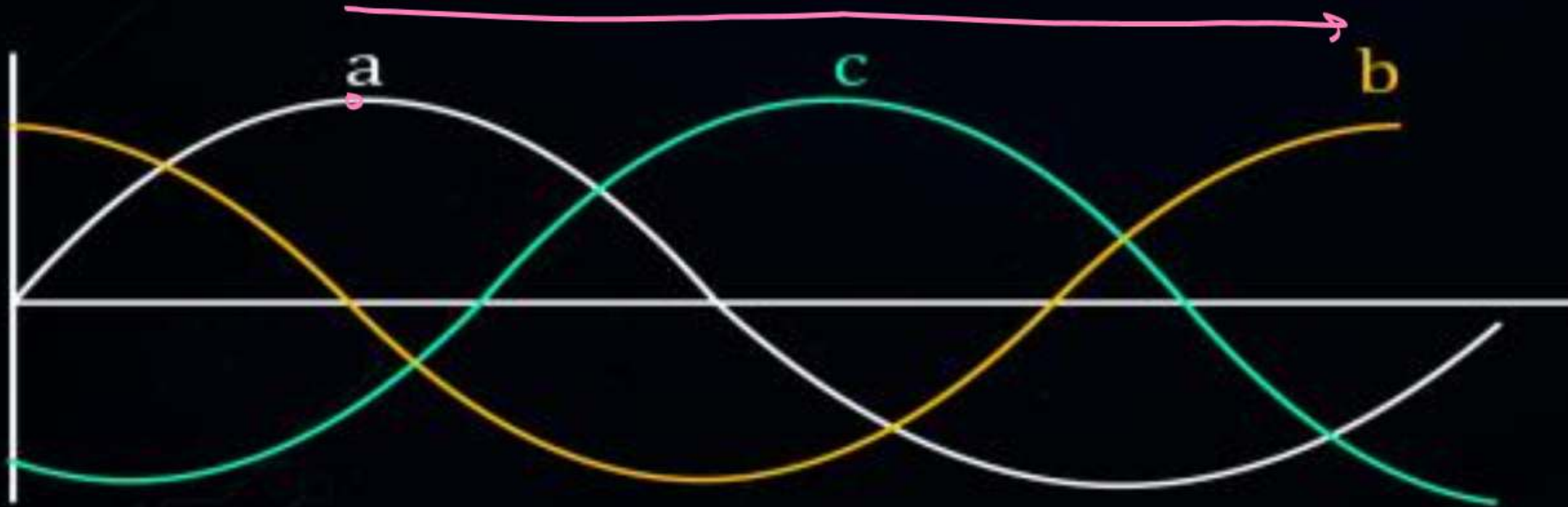
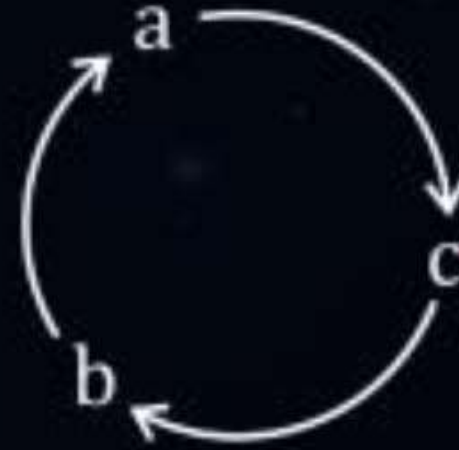


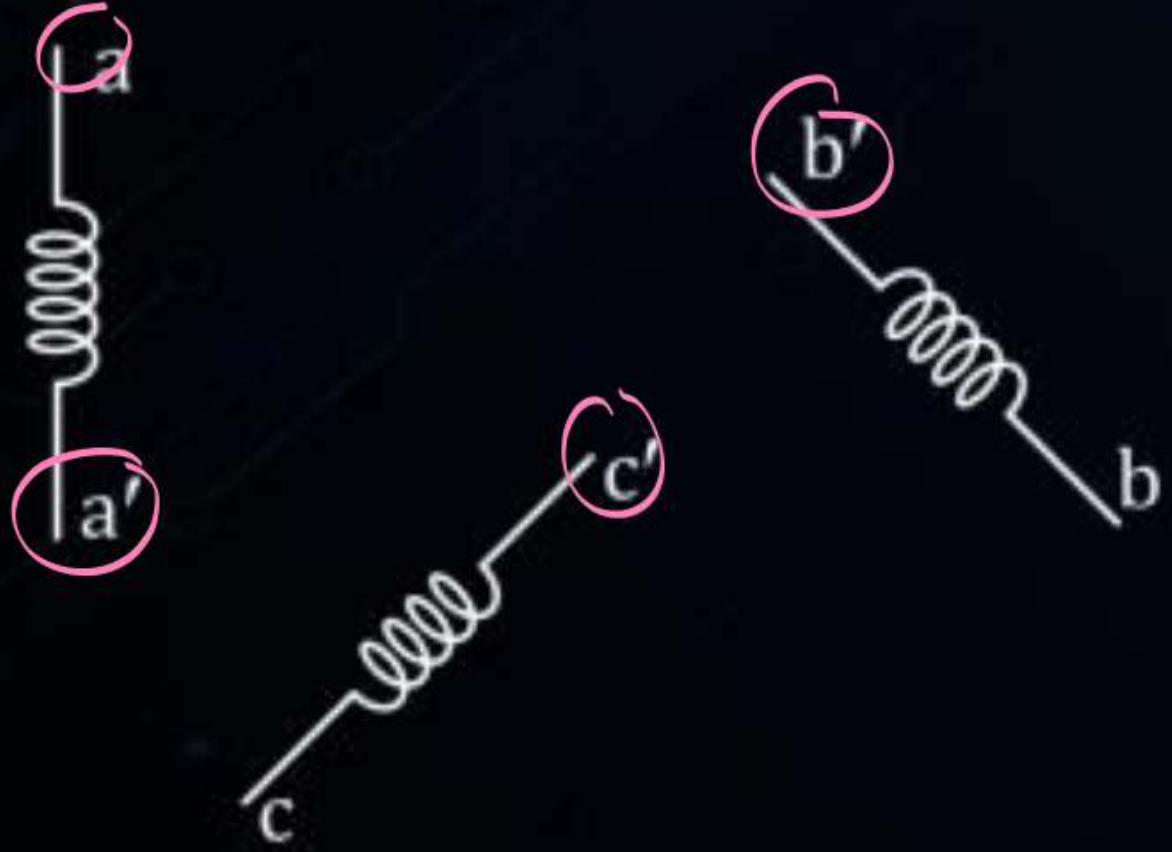
Negative sequence

✓ $V_a = V_m \sin \omega t$

✓ $V_c = V_m \sin(\omega t - 120)$

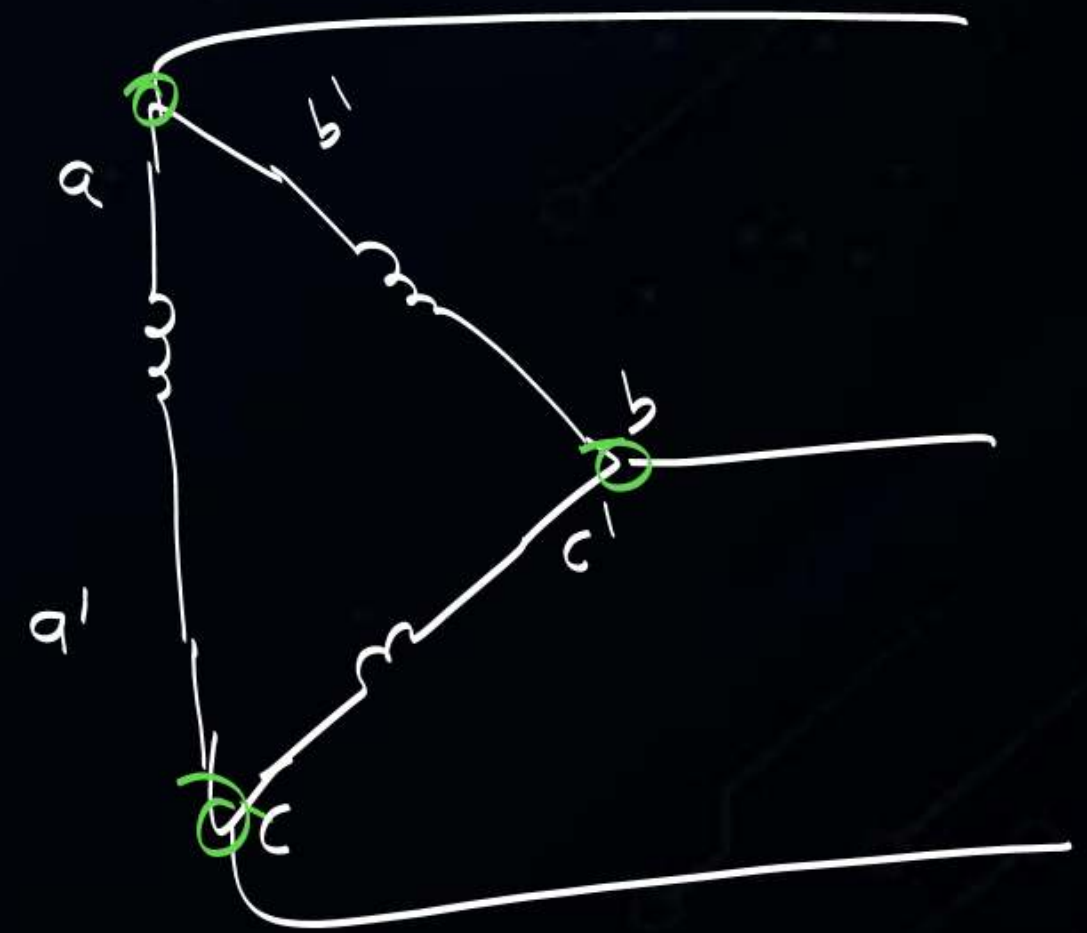
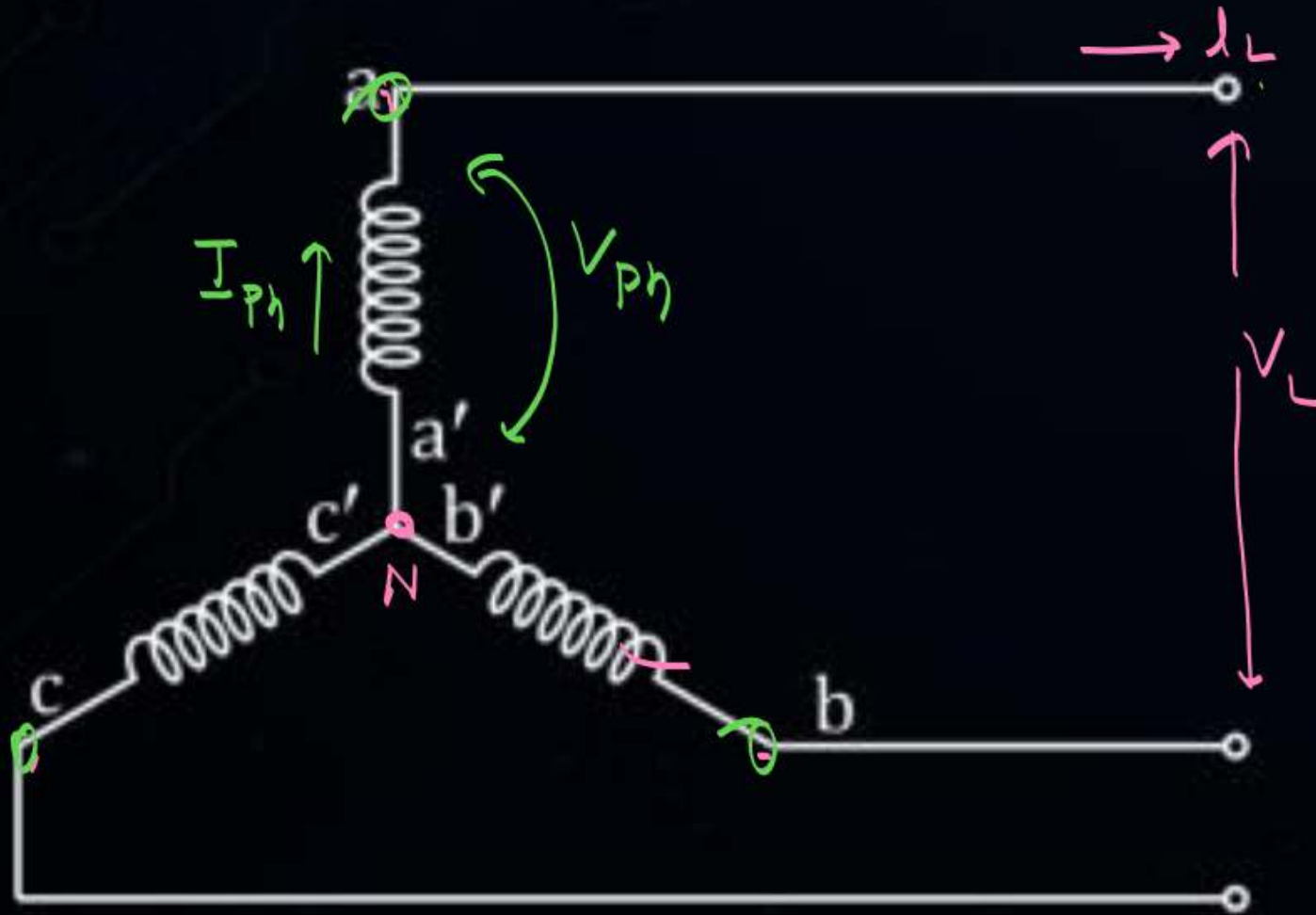
✓ $V_b = V_m \sin(\omega t - 240)$





Star connection :

If a' , b' , c' are connected together it formed star connection



Phase(Coil) voltage/Phase(Coil) current :

The voltage across any phase winding is called phase voltage and current through phase winding is phase current.

Line Voltage / Line Current :

The voltage between two-line terminal is line voltage and current flowing through line is line current.

Double Subscription:

V_{AB} = Voltage of point A with respect to B.



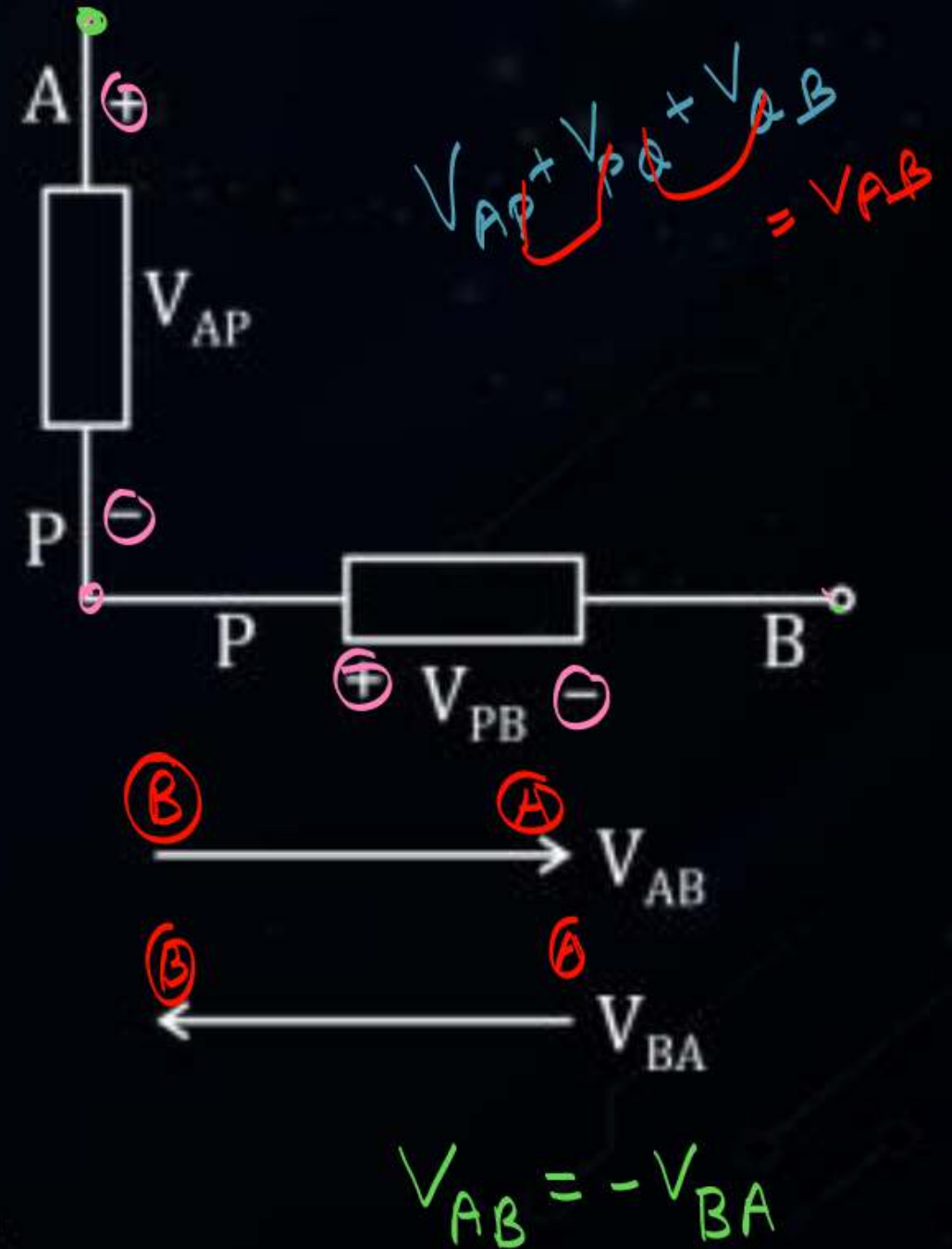
KVL

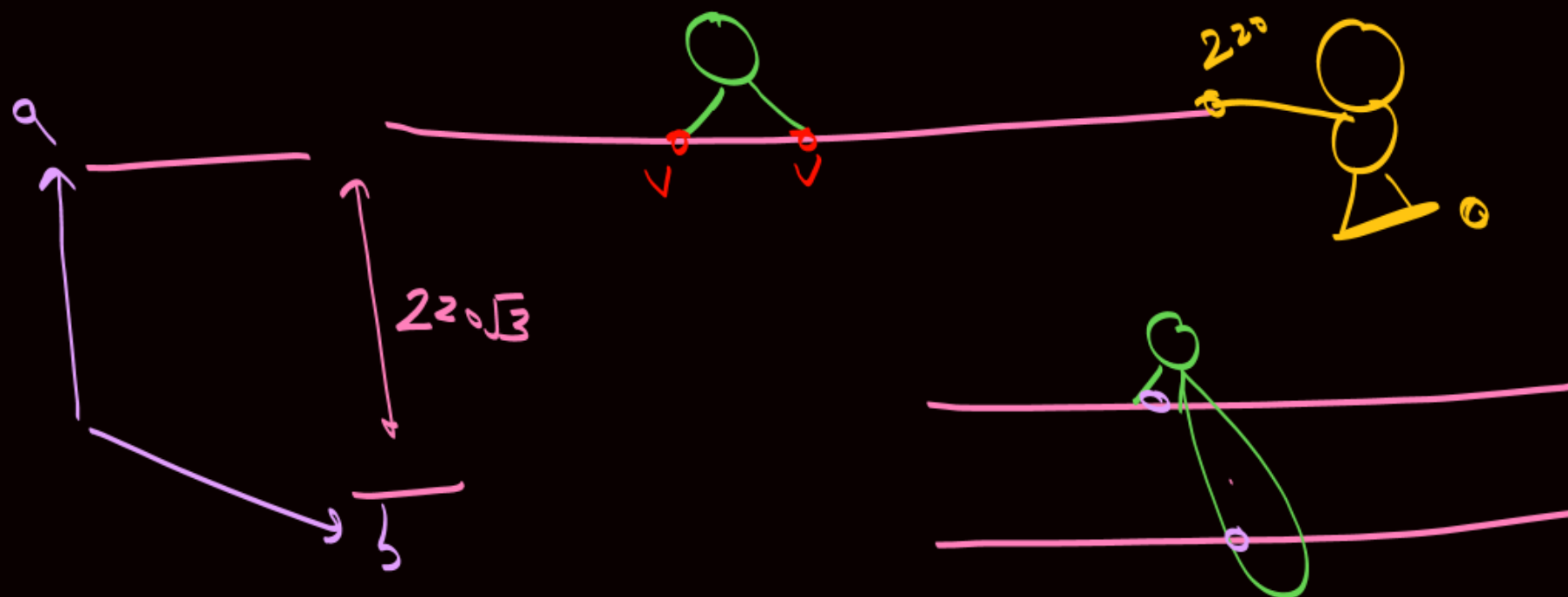
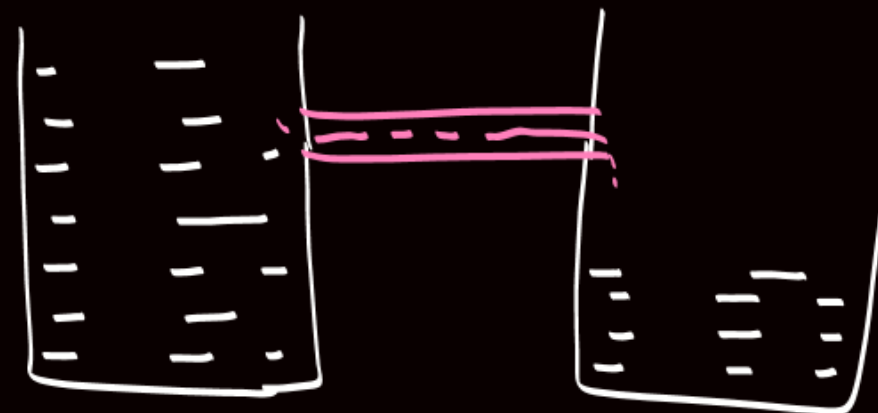
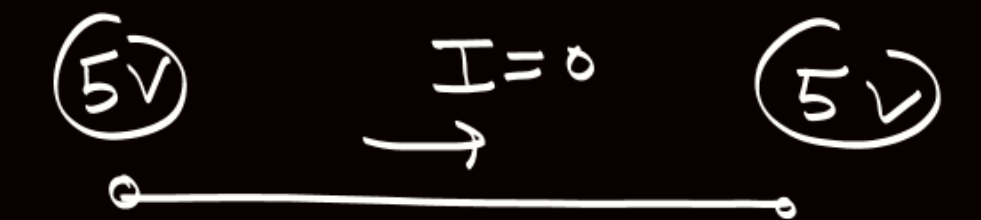
$$V_A - V_{AP} - V_{PB} = V_B$$

$$V_A - V_B = V_{AP} + V_{PB}$$

$$V_{AB} = V_{AP} + V_{PB}$$

I_{ab} = Current is flowing from *a* terminal to *b* terminal.







2 Minutes Summary



→ Why 3 ph power is used

→ 2 phase supply

→ 3 phase supply

→ phase & line voltage and current

Thank you

GW
Soldiers !



Electrical Engineering

Power System



Lecture No.-06

Introduction

By- Ajay Gupta Sir



1. Why 3 phase power is used ✓

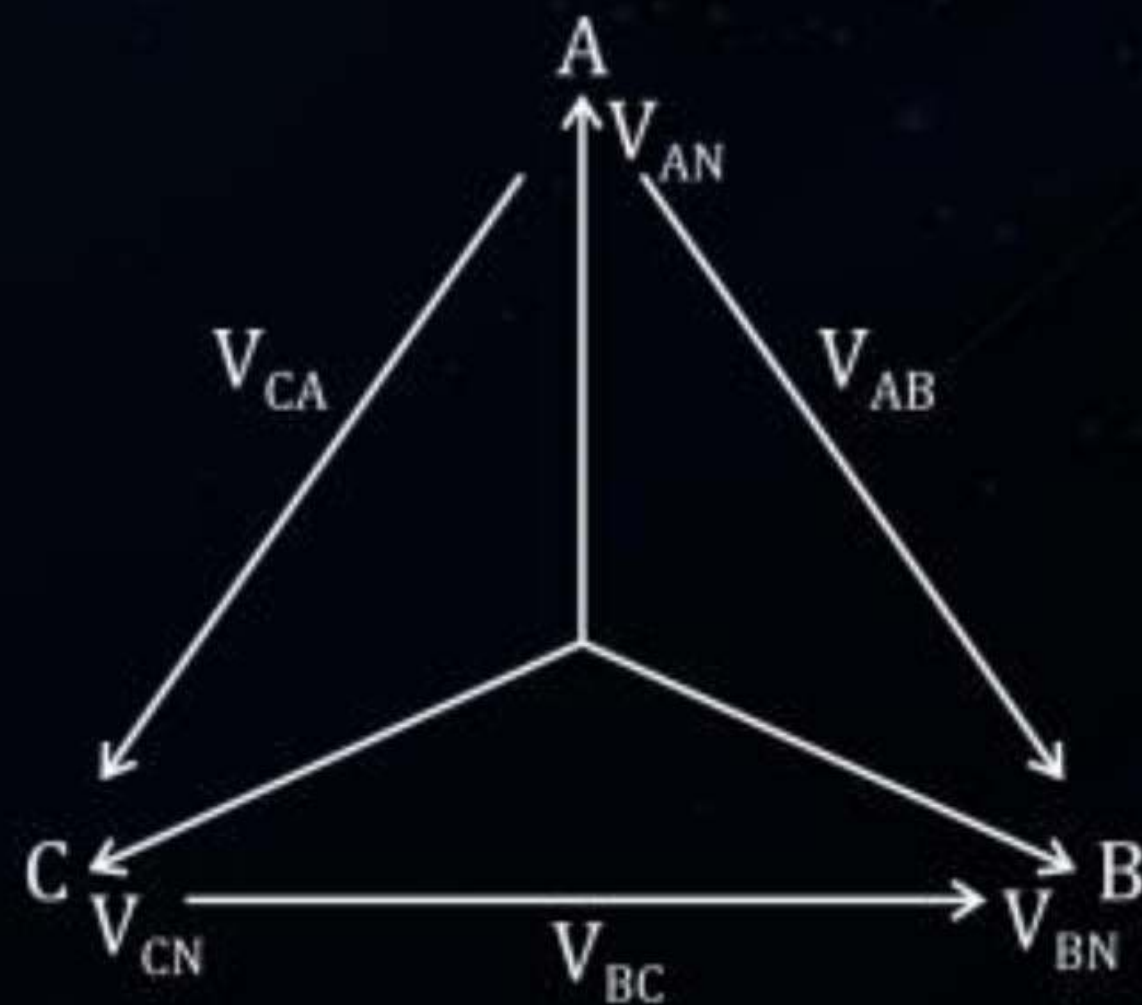
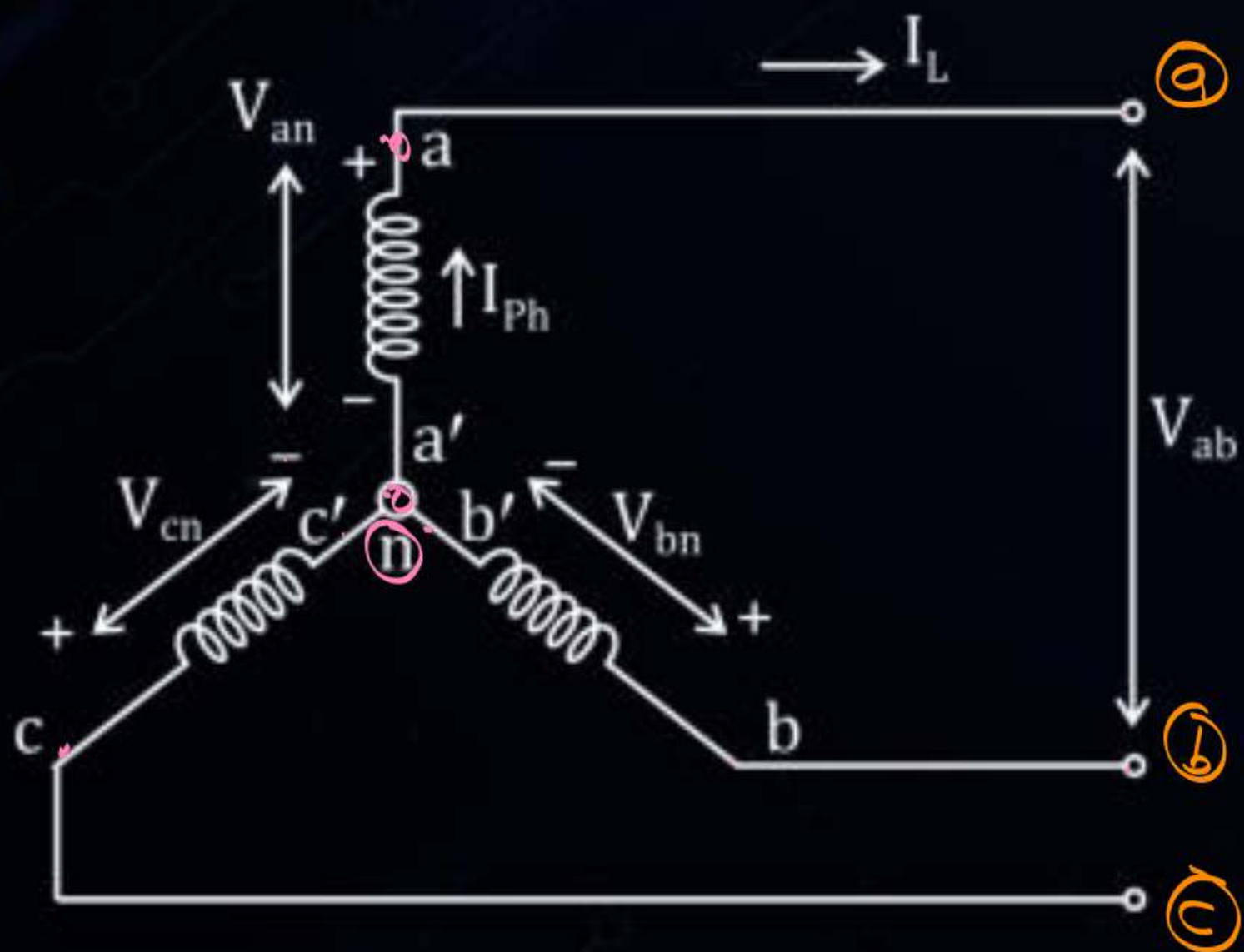
2. 3 phase system ✓

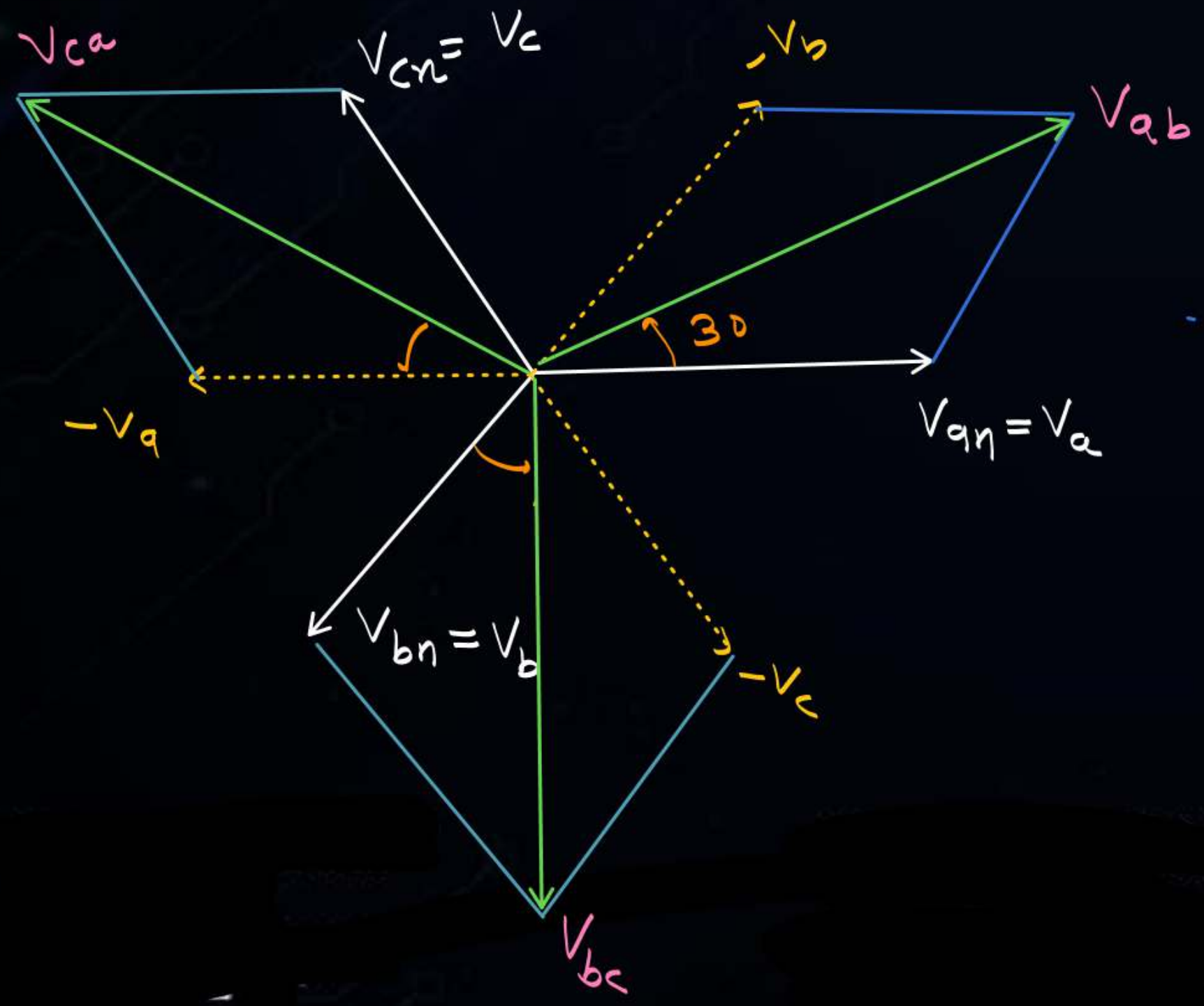


Topics to be Covered

1. Positive sequence star
2. Negative sequence star
3. Positive sequence delta
4. Negative sequence delta

Positive Sequence:





$$V_a - V_b = V_{ab}$$

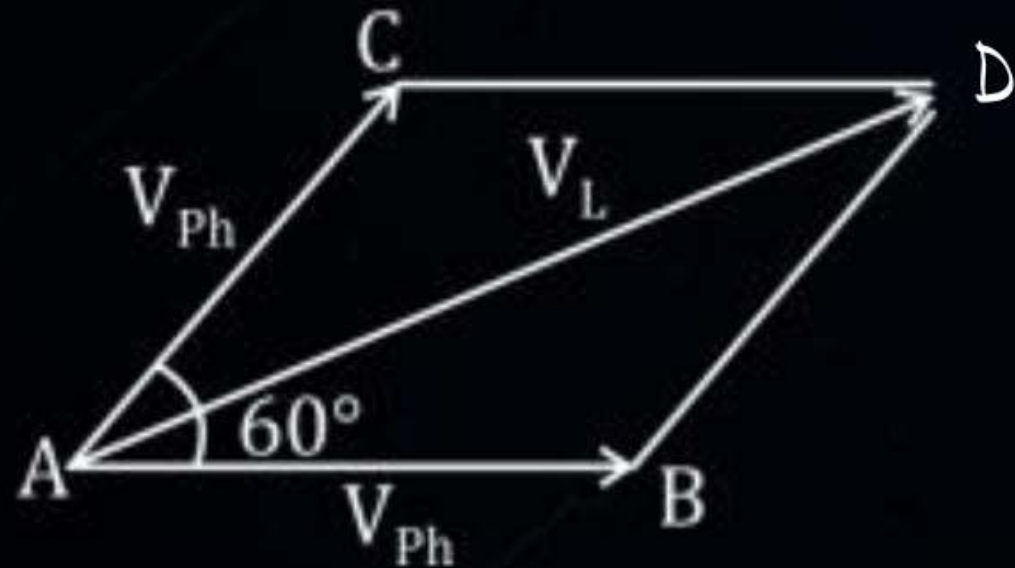
$$AD^2 = AB^2 + AC^2 + 2AB \cdot AC \cos \theta$$

$$V_L^2 = V_{Ph}^2 + V_{Ph}^2 + 2V_{Ph} V_{Ph} \cos 60$$

$$V_L^2 = V_{Ph}^2 + V_{Ph}^2 + 2V_{Ph}^2 \cdot \frac{1}{2}$$

$$V_L^2 = 3V_{Ph}^2$$

$$V_L = \sqrt{3} V_{Ph}$$



$$V_L^2 = V_{Ph}^2 + V_{Ph}^2 + 2V_{Ph} V_{Ph} \cos 60^\circ$$

$$V_L^2 = 3 V_{Ph}^2$$

$$V_L = \sqrt{3} V_{Ph}$$

In positive sequence star connection line current is same as phase current.

But line voltage is $\sqrt{3}$ time of phase voltage and it lead the phase voltage by 30°

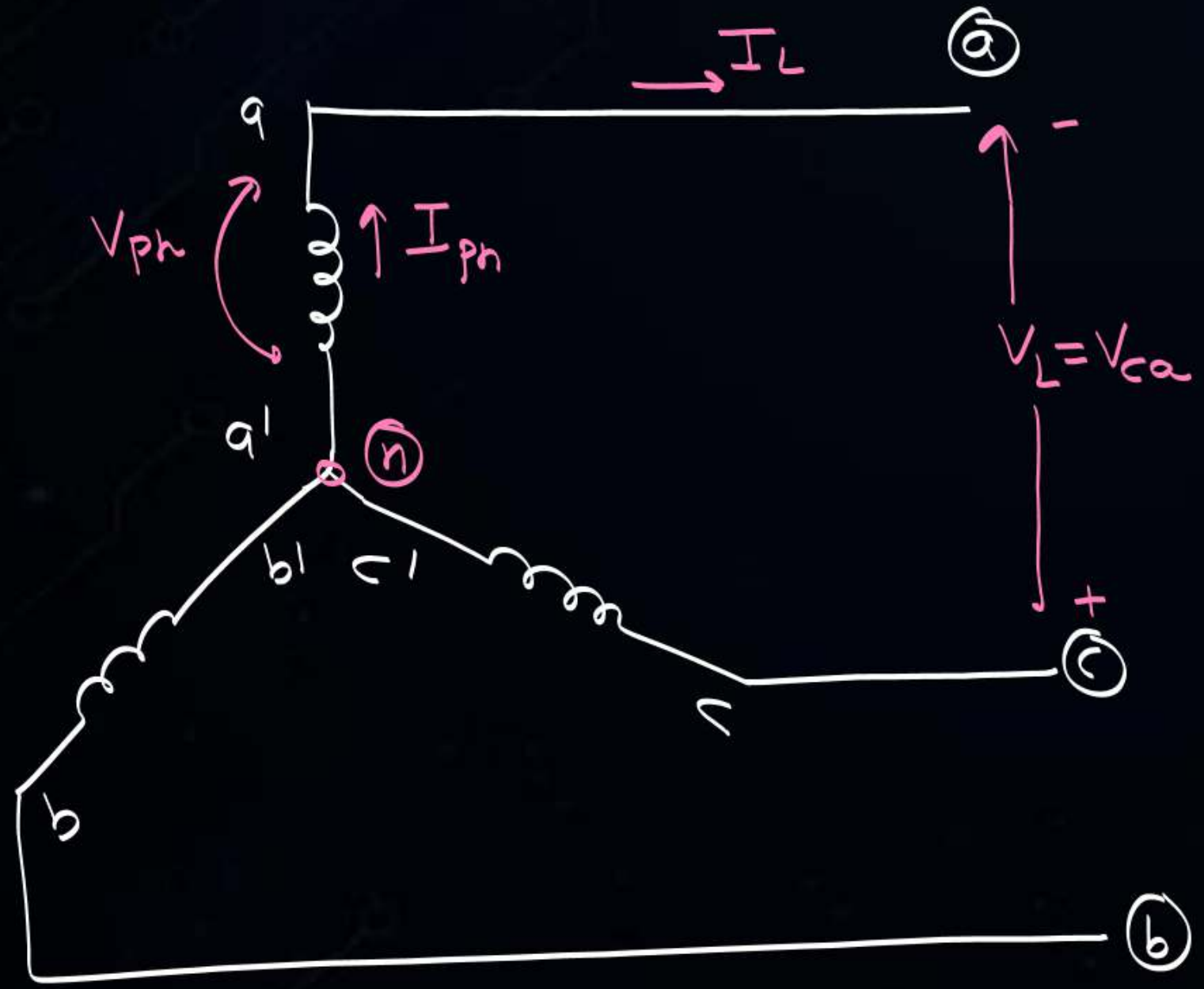
IMP Note: in positive sequence the phase voltage lag their respective line voltage by 30 degree.

$$V_{ab} = V_L \angle 0 \quad \Rightarrow \quad V_a = \frac{V_L}{\sqrt{3}} \angle 0 - 30$$

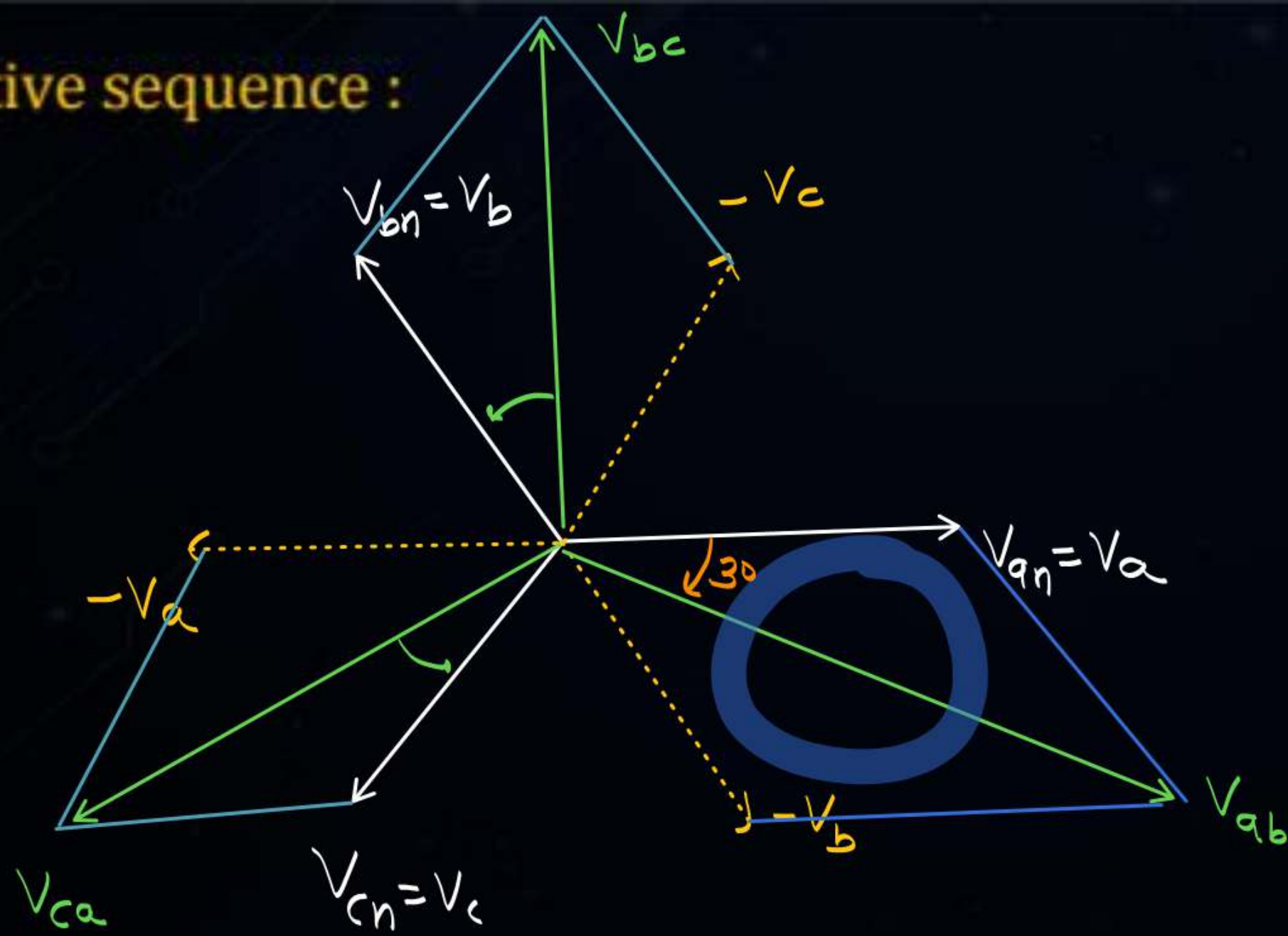
$$V_{bc} = V_L \angle 0 - 120 \quad \Rightarrow \quad V_b = \frac{V_L}{\sqrt{3}} \angle 0 - 120 - 30$$

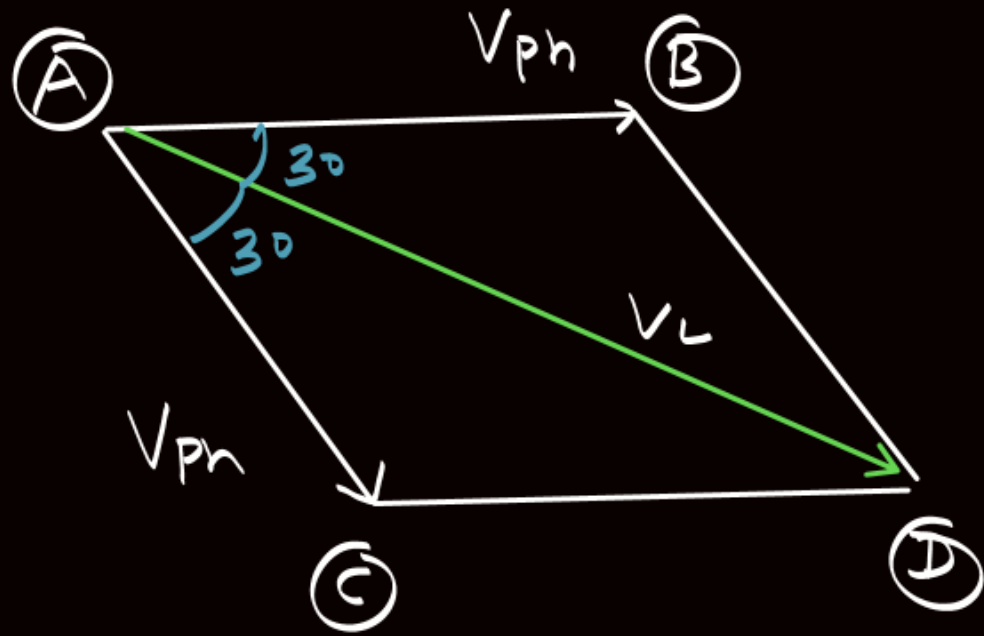
$$V_{ca} = V_L \angle 0 - 240 \quad \Rightarrow \quad V_c = \frac{V_L}{\sqrt{3}} \angle 0 - 240 - 30$$

Negative sequence :



Negative sequence :





$$AD^2 = AB^2 + AC^2 + 2AB \cdot AC \cos 60$$

$$V_L^2 = V_{ph}^2 + V_{ph}^2 + 2V_{ph} V_{ph} \cos 60$$

$$V_L^2 = V_{ph}^2 + V_{ph}^2 + 2V_{ph}^2 \cdot \frac{1}{2}$$

$$V_L^2 = 3V_{ph}^2$$

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

In negative sequence line voltage lag the phase voltage by 30°

IMP

Note: In negative sequence the phase voltage lead their respective line voltage by 30 degree

$$V_{ab} = V_L \angle \theta \Rightarrow V_a = \frac{V_L}{\sqrt{3}} \angle \theta + 30$$

$$V_{ca} = V_L \angle \theta - 120 \Rightarrow V_c = \frac{V_L}{\sqrt{3}} \angle \theta - 120 + 30$$

$$V_{bc} = V_L \angle \theta - 240 \Rightarrow V_b = \frac{V_L}{\sqrt{3}} \angle \theta - 240 + 30$$



Balance Load/Unbalance Load :

- If magnitude as well angle of load of all 3 phase are equal (same resistive & same reactance load) Then it is a balance load.
- Generally industrial load is a balance load, it run 3 Phase motor which have symmetrical 3 phase winding. So current draw by all 3 phase will be of same Ampere.
- The Domestic load is generally 1 ϕ load. So, it is very difficult to maintain same load in all 3 phase, so it is generally unbalance load.
- Due to unbalance load the current Ampere in all 3 phase may be differ & the phase difference between them may differ from 120.

Phasor Arithmetic →

$$30 \angle 130$$

$$\gamma \angle \theta \Rightarrow \text{Polar form}$$

$$a + jb \Rightarrow \text{rectangular form}$$

$$a + jb = \sqrt{a^2 + b^2} \angle \tan^{-1} \frac{b}{a} \quad [\text{Rectangular to polar form conversion}]$$

$$\gamma \angle \theta = \gamma \cos \theta + j \gamma \sin \theta$$

$$[\text{Polar to Rectangular form conversion}]$$

→ For Addition and Subtraction use Rectangular form.

$$(a_1 + jb_1) + (a_2 + jb_2)$$

$$= (a_1 + a_2) + j(b_1 + b_2)$$

Subtraction

$$(a_1 + jb_1) - (a_2 + jb_2)$$

$$(a_1 - a_2) + j(b_1 - b_2)$$

→ For Multiplication and division use polar form.

Multiplication

$$[r_1 \angle \theta_1] [r_2 \angle \theta_2]$$

$$= r_1 r_2 \angle (\theta_1 + \theta_2)$$

Division

$$\frac{r_1 \angle \theta_1}{r_2 \angle \theta_2} = \frac{r_1}{r_2} \angle (\theta_1 - \theta_2)$$

Q

$$i_a = 3 \sin(\omega t - 30^\circ) \quad i_b = 4 \sin(\omega t - 60^\circ)$$

What is $i_a + i_b = ?$

1> Convert instantaneous quantities in phasor form

$$i_a = 3 \sin(\omega t - 30^\circ) = \frac{3}{\sqrt{2}} \angle -30^\circ$$

$$i_b = 4 \sin(\omega t - 60^\circ) = \frac{4}{\sqrt{2}} \angle -60^\circ$$

2> Convert polar form into Rectangular form.

$$I_a = \frac{3}{\sqrt{2}} \angle -30 = \frac{3}{\sqrt{2}} \cos 30 - j \frac{3}{\sqrt{2}} \sin 30 = 1.837 - j 1.060$$

$$I_b = \frac{4}{\sqrt{2}} \angle -60 = \frac{4}{\sqrt{2}} \cos 60 - j \frac{4}{\sqrt{2}} \sin 60 = 1.414 - j 2.45$$

3> Add $I_a + I_b$ in Rectangular form

$$\begin{aligned} I_a + I_b &= (1.837 + 1.414) - j(1.060 + 2.45) \\ &= 3.251 - j 3.51 \end{aligned}$$

4> Convert Rectangular form into phasor form

$$I_a + I_b = 3.251 - j3.51$$

$$= \sqrt{(3.251)^2 + (-3.51)^2} \angle \tan^{-1} \frac{(-3.51)}{3.251}$$

$$= \underline{4.784} \angle -47.193$$

5> Convert current into instantaneous form

$$= (4.784 \sqrt{2}) \sin(\omega t - 47.193)$$

$$I_a + I_b = 6.765 \sin(\omega t - 47.193)$$

Q

$$I_a = I_m \sin \omega t = \frac{I_m}{\sqrt{2}} \angle 0$$

$$I_b = I_m \sin(\omega t - 120) = \frac{I_m}{\sqrt{2}} \angle -120$$

$$I_c = I_m \sin(\omega t - 240) = \frac{I_m}{\sqrt{2}} \angle -240$$

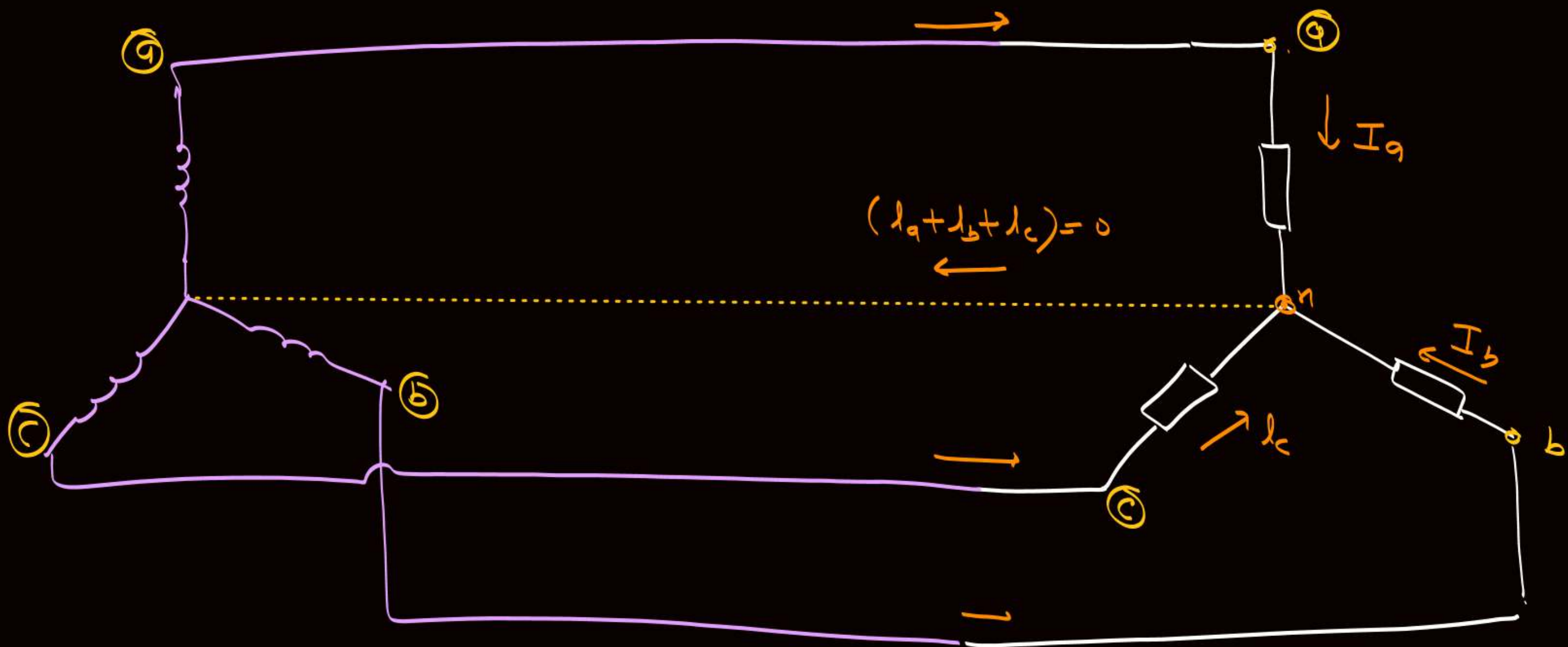
$$I_a + I_b + I_c = \frac{I_m}{\sqrt{2}} \angle 0 + \frac{I_m}{\sqrt{2}} \angle -120 + \frac{I_m}{\sqrt{2}} \angle -240$$

$$= \left[\frac{I_m}{\sqrt{2}} \right] + \left[\frac{I_m}{\sqrt{2}} (-0.5) - \frac{I_m}{\sqrt{2}} (0.866) \right] + \left[\frac{I_m}{\sqrt{2}} (-0.5) - \frac{I_m}{\sqrt{2}} (-0.866) \right]$$

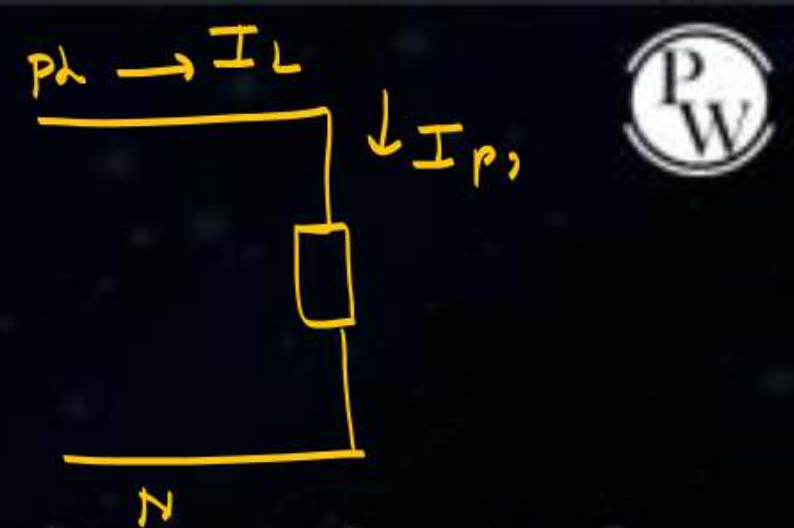
$$= 0$$

Types of Load:

1. 3 phase 4 wire star connected balance load
 2. 3 Phase 3 wire star connected balance load
 3. 3 phase delta connected balance load
 4. 3 phase delta connected unbalance load
 5. 3 phase 4 wire star connected unbalance load
 6. 3 phase 3 wire star connected unbalance load
- Same



Y Connection Balance Circuit 3 wire/ 4 wire ckt



1. First draw single line diagram by taking phase to neutral voltage take angle as 0.
2. Now find out line current $I_L = \frac{V \angle 0}{Z \angle \theta} = \frac{V}{Z} \angle -\theta$
3. Now each phase current (line current) lag their respective phase voltage by θ angle.

Y Connection Balance Circuit(2 method)

1. First Find out phase voltage from line voltage.
2. Now find out phase current by dividing phase voltage with impedance.
3. Line current is same as phase current.

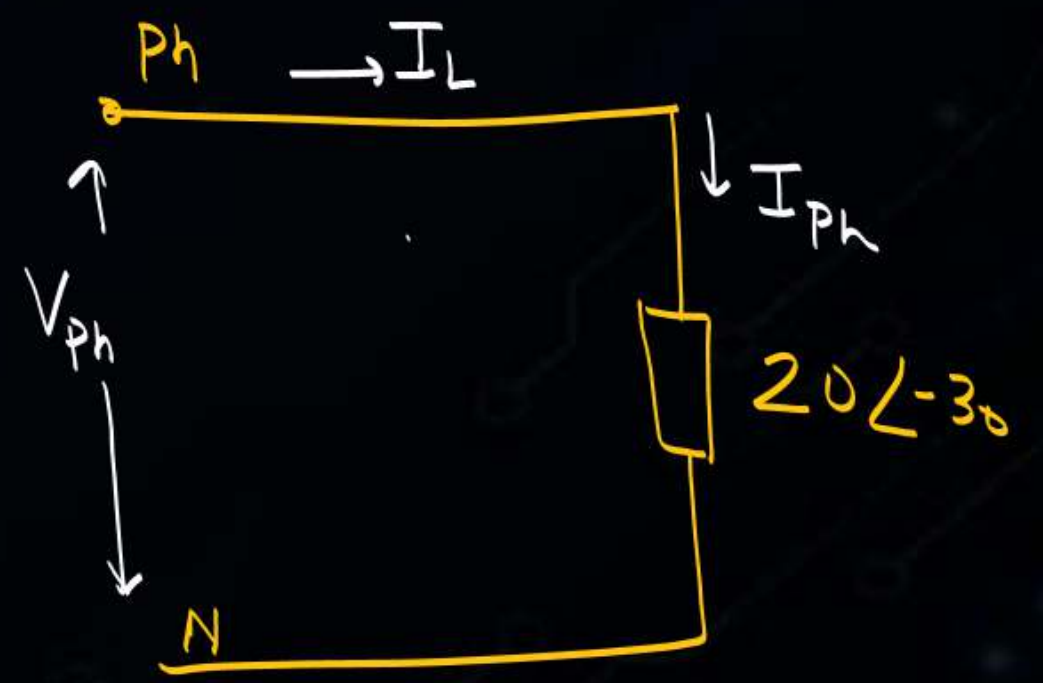
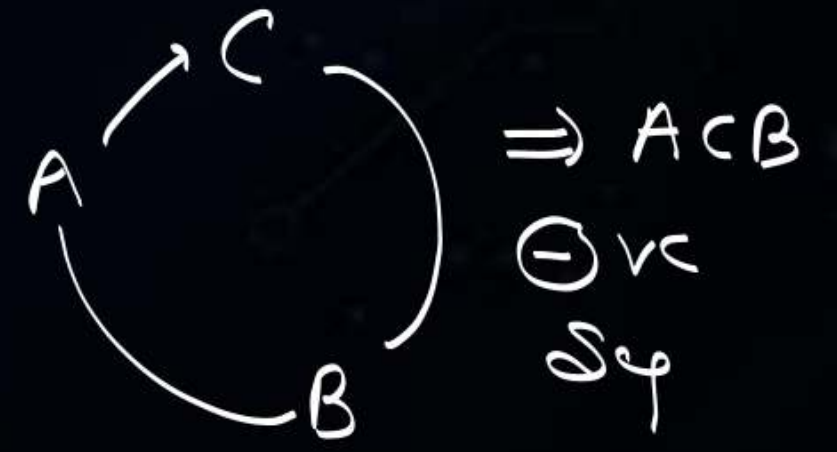
Q. A 3 phase 4 wire 208 voltage CBA system serve a balance Y connected load with Impedance of $20 \angle -30^\circ$. Find the line current if $V_{ab} = 208 \angle 0$.

Method $\rightarrow$ 1

$$V_{ph} = \frac{208}{\sqrt{3}} \angle 0$$

$$I_L = I_{ph} = \frac{V_{ph}}{Z} = \frac{\frac{208}{\sqrt{3}} \angle 0}{20 \angle -30} = \underline{6 \angle 30}$$

$\rightarrow$ So phase current lead their respective phase voltage by 30° angle



$$V_{ab} = 208 \angle 0 \implies V_a = \frac{208}{\sqrt{3}} \angle 30 \implies I_a = 6 \angle 30 + 30 = 6 \angle 60$$

$$V_{ca} = 208 \angle -120 \Rightarrow V_c = \frac{208}{\sqrt{3}} \angle -120 + 30 \Rightarrow I_c = 6 \angle -120 + 30 + 30 = 6 \angle -60$$

$$V_{bc} = 208 \angle -240 \Rightarrow V_b = \frac{208}{\sqrt{3}} \angle -240 + 30 \Rightarrow I_b = 6 \angle -240 + 30 + 30 = 6 \angle -180$$

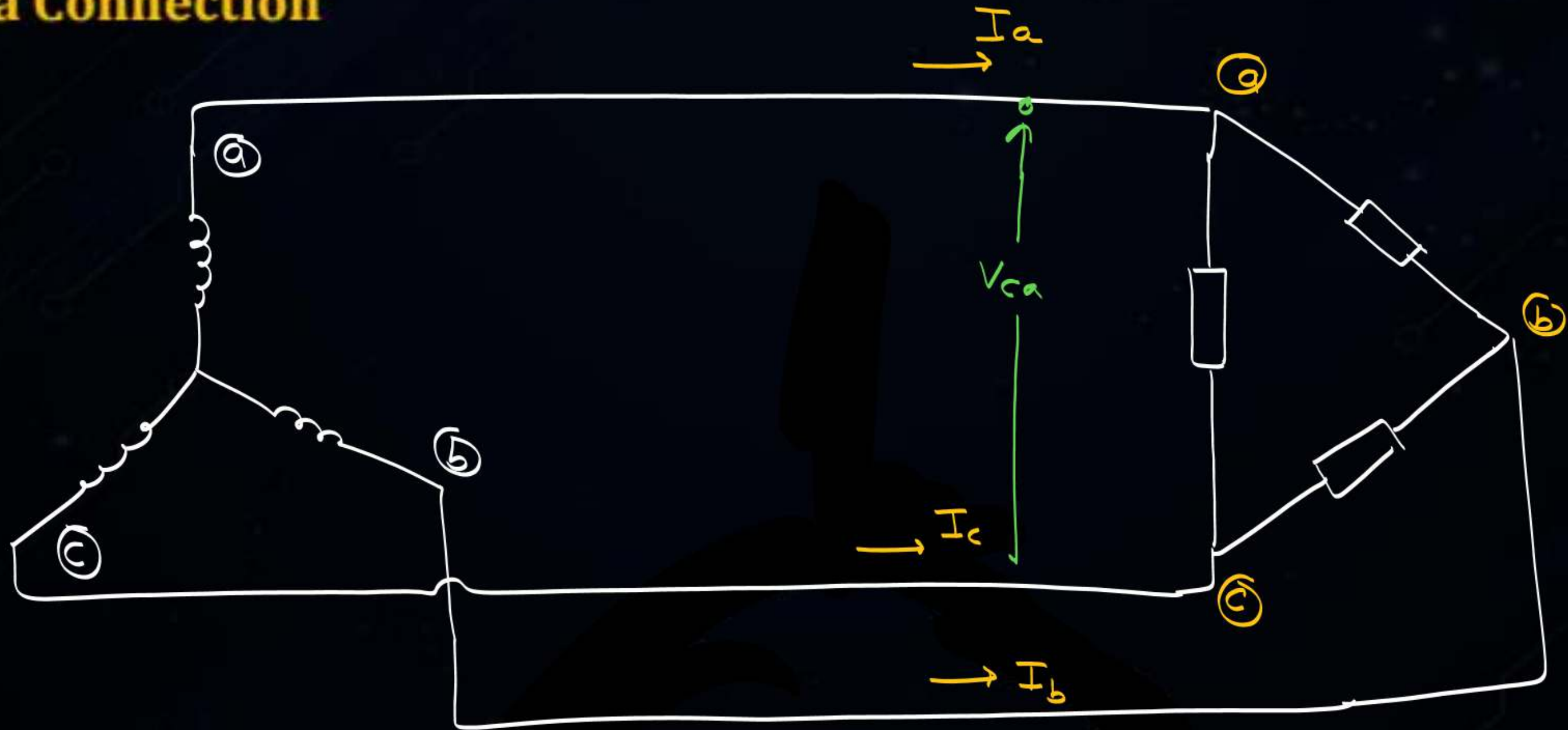
Method II

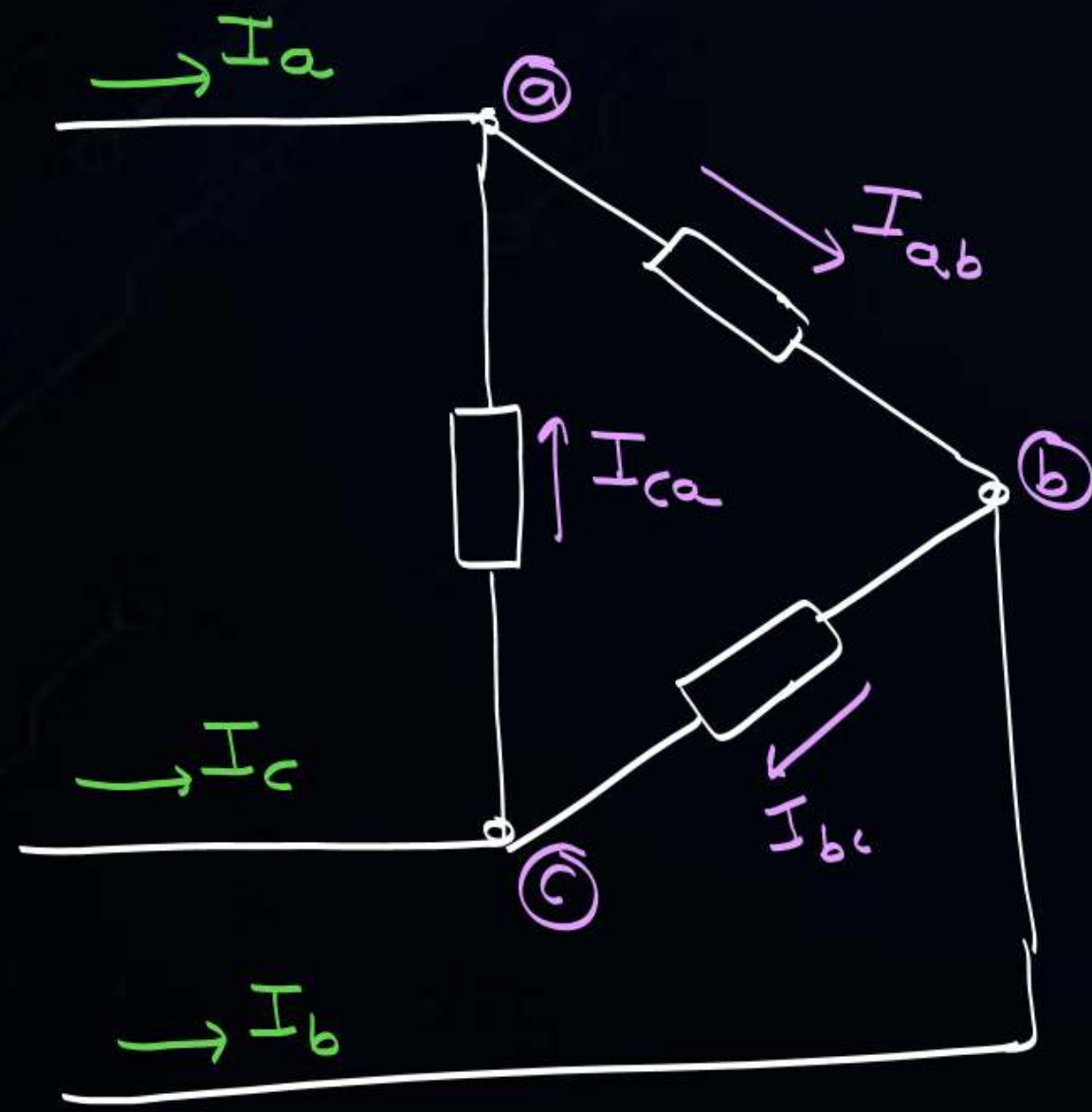
$$V_{ab} = 208 \angle 0 \implies V_a = \frac{208}{\sqrt{3}} \angle 30 \implies I_a = \frac{\frac{208}{\sqrt{3}} \angle 30}{20 \angle -30} = 6 \angle 60$$

$$V_{ca} = 208 \angle -120 \implies V_c = \frac{208}{\sqrt{3}} \angle -120 + 30 \implies I_c = \frac{\frac{208}{\sqrt{3}} \angle -90}{20 \angle -30} = 6 \angle -60$$

$$V_{bc} = 208 \angle -240 \implies V_b = \frac{208}{\sqrt{3}} \angle -240 + 30 = I_b = \frac{\frac{208}{\sqrt{3}} \angle -210}{20 \angle -30} = 6 \angle -180$$

Delta Connection





KCL

→

$$I_a + I_{ca} = I_{ab}$$

$$I_a = I_{ab} - I_{ca} = I_{ab} + I_{ac}$$

→

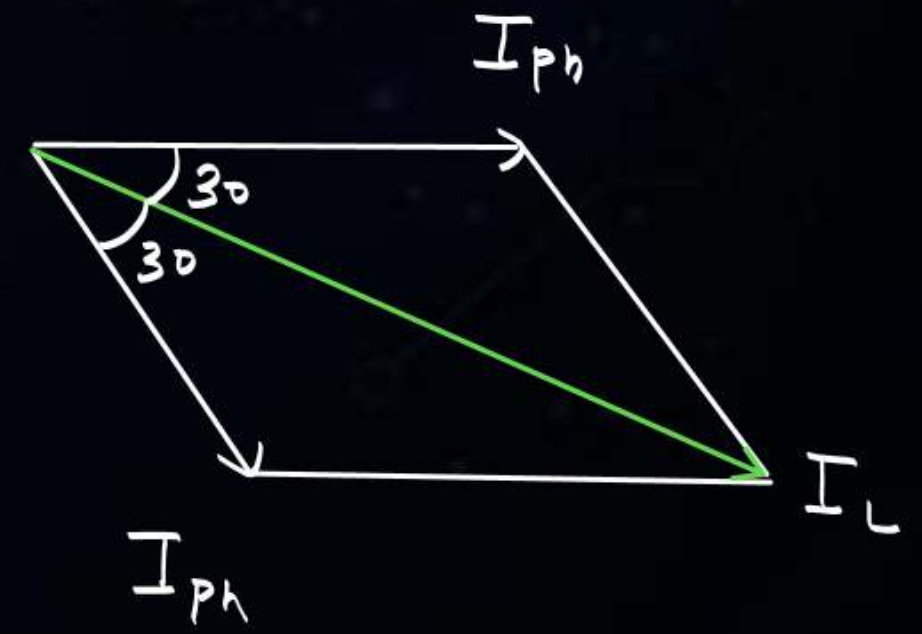
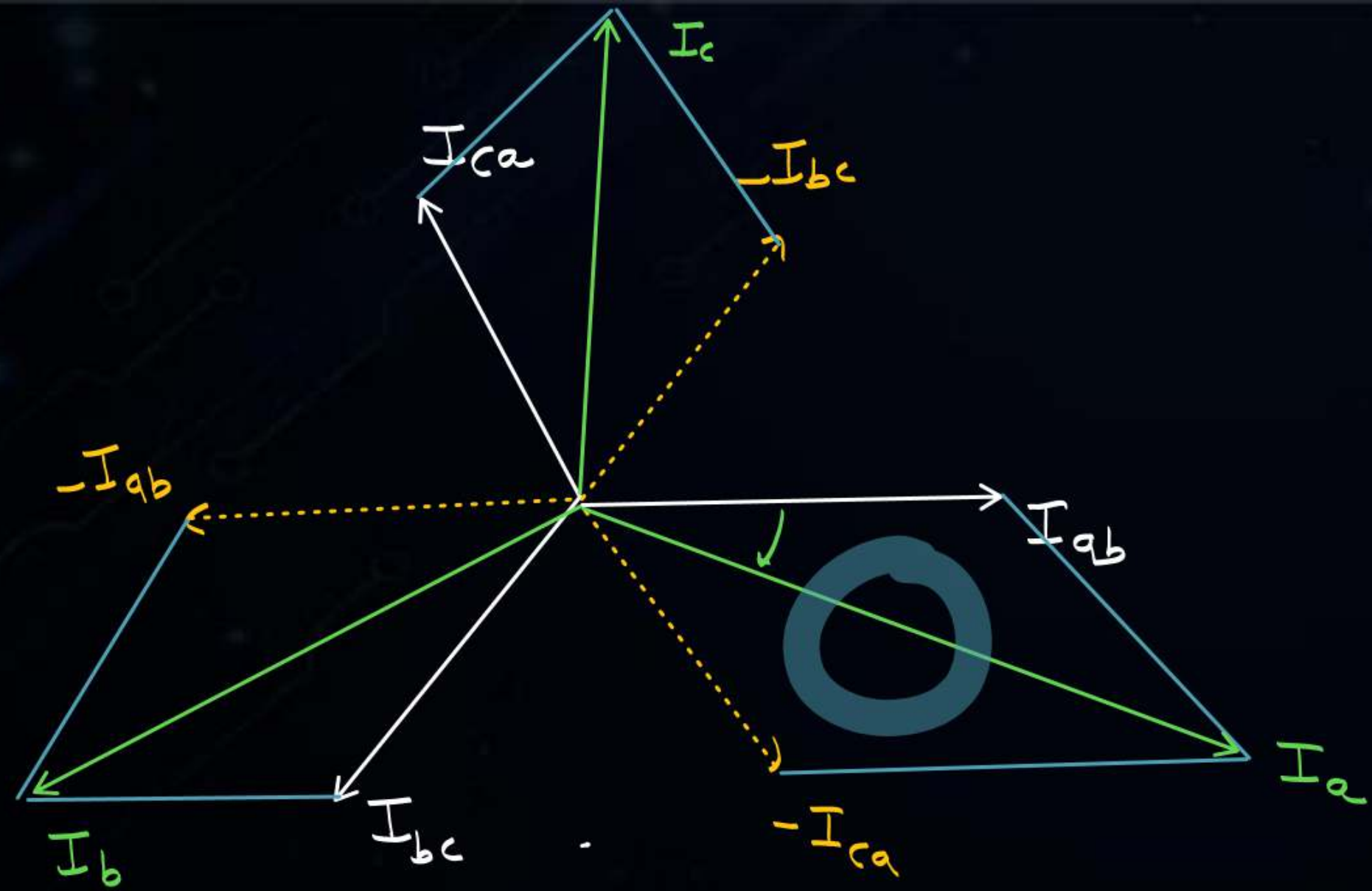
$$I_b + I_{ab} = I_{bc}$$

$$I_b = I_{bc} - I_{ab} = I_{bc} + I_{ba}$$

→

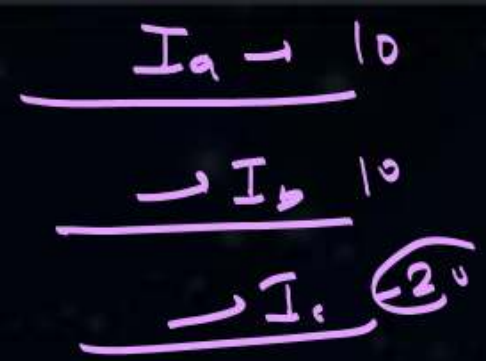
$$I_c + I_{bc} = I_{ca}$$

$$I_c = I_{ca} - I_{bc} = I_{ca} + I_{cb}$$



$$I_L^2 = I_{Ph}^2 + I_{Ph}^2 + 2I_{Ph}I_{Ph} \cos 60^\circ$$

$$I_L = \sqrt{3} I_{Ph}$$



So, in delta connection phase voltage is equal to line voltage. But line current is $\sqrt{3}$ time of phase current. And the current lag the phase current by 30°

Note → Phase current lead their respective line current by 30°

$$I_a = I_L \angle 0 \rightarrow I_{ab} = \frac{I_L}{\sqrt{3}} \angle 0 + 30$$

$$I_b = I_L \angle 0 - 120 \rightarrow I_{bc} = \frac{I_L}{\sqrt{3}} \angle 0 - 120 + 30$$

$$I_c = I_L \angle 0 - 240 \rightarrow I_{ca} = \frac{I_L}{\sqrt{3}} \angle 0 - 240 + 30$$

Step to solve delta connected load:

1. Convert delta connected into star equivalent impedance $Z_Y = Z_D/3$.
2. Now draw signal line diagram by taking phase voltage as source
3. Take angle of voltage as zero.
4. Now find out line current

$$\overline{I}_{ph} = I_L = \frac{V \angle 0}{Z \angle \theta} = \frac{V}{Z} \angle -\frac{\theta}{1}$$

- ★ Now phase current (line current) lag the respectively phase voltage by θ angle.



Step to solve delta connected load(2 method):

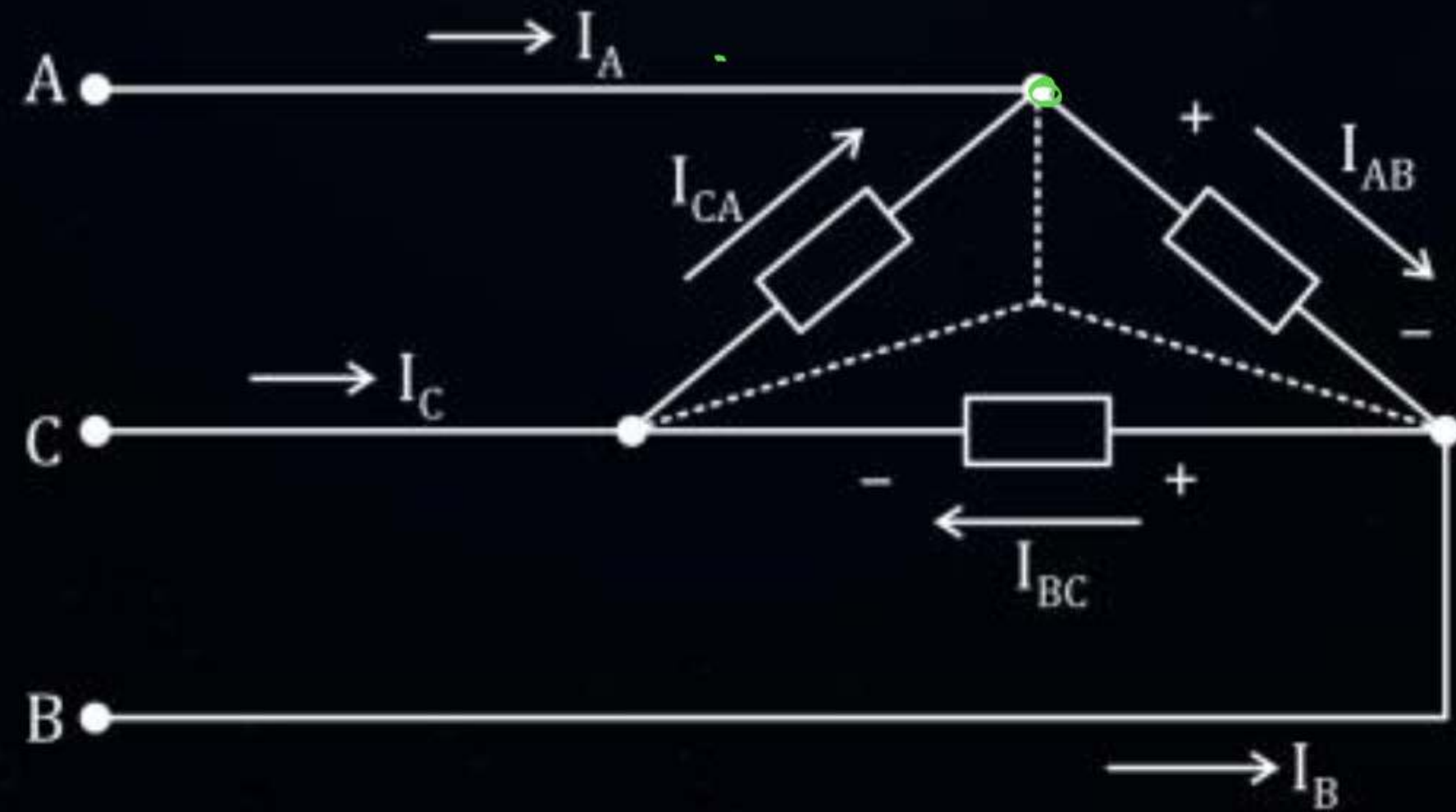
1. The given line voltage is equal to phase voltage.
2. Find out phase current first.
3. Now find out line current which is $\sqrt{3}$ times phase current and lag by 30 degree

Q.



A 3 Phase 3 wire 110 V, ABC system supply a delta connection of 3 equal impedance of $5 \angle 45$. Determine I_A , I_B & I_C .

$V_{AB} = 110 \angle 0$ $V_{BC} = 110 \angle -120$ $V_{CA} = 110 \angle -240$

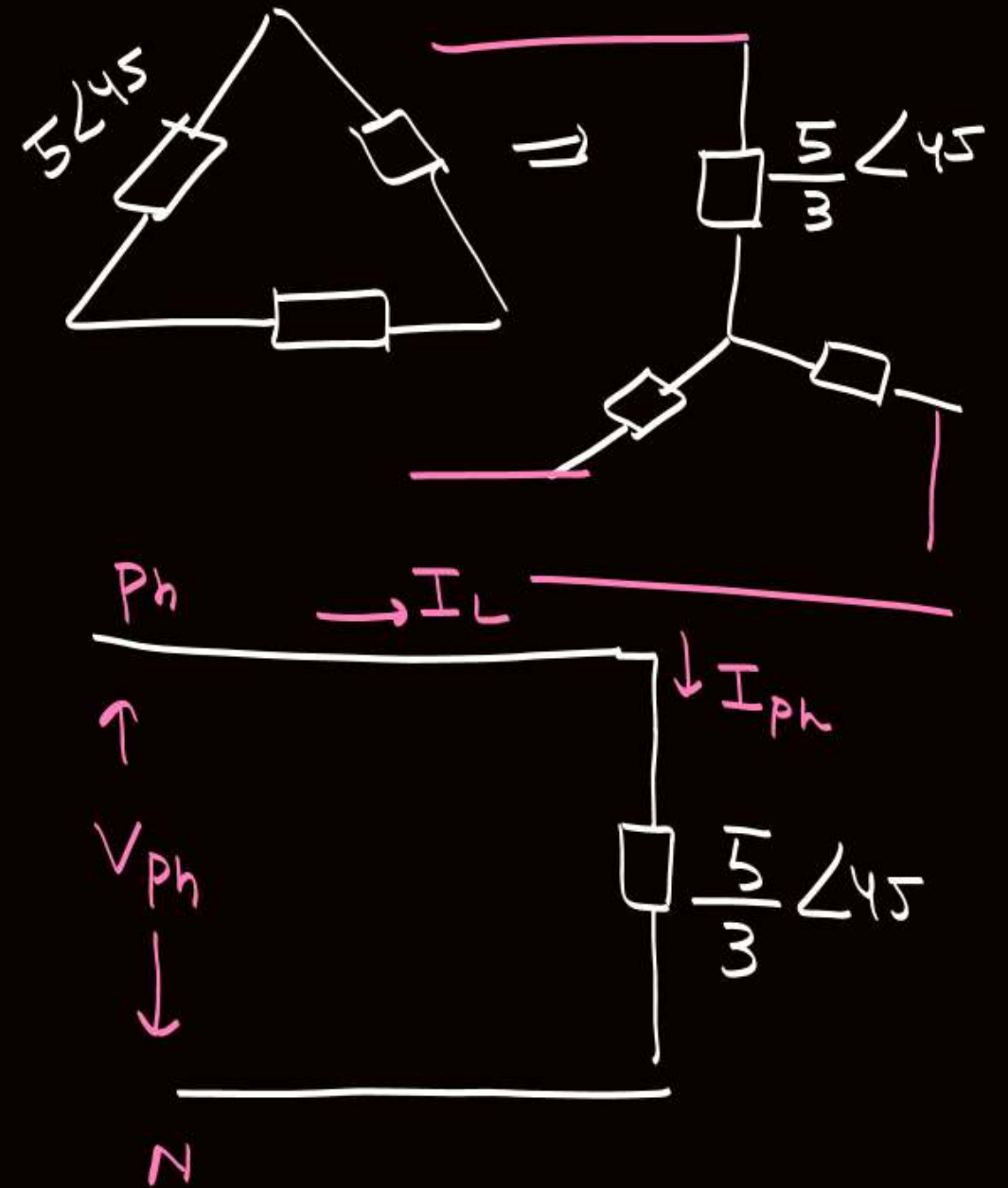


Method 1

$$V_{ph} = \frac{110}{\sqrt{3}} \angle 0$$

$$I_{ph} = I_L = \frac{\frac{110}{\sqrt{3}} \angle 0}{\frac{5}{3} \angle 45} = 38.1 \angle -45$$

So in Δ Star, Phase Current (line current) lag
their respective phase voltage by 45



$$V_{AB} = 110 \angle 0 \Rightarrow V_A = \frac{110}{\sqrt{3}} \angle -30 \Rightarrow 38.1 \angle -30 - 45 = 38.1 \angle -75$$

$$V_{BC} = 110 \angle -120 \Rightarrow V_B = \frac{110}{\sqrt{3}} \angle -120 - 30 \Rightarrow 38.1 \angle -150 - 45 \Rightarrow 38.1 \angle -195$$

$$V_{CA} = 110 \angle -240 \Rightarrow V_C = \frac{110}{\sqrt{3}} \angle -240 - 30 \Rightarrow 38.1 \angle -270 - 45 \Rightarrow 38.1 \angle -315$$

Method II →

$$I_{AB} = \frac{V_{AB}}{Z} = \frac{110 \angle 0}{5 \angle 45} = 22 \angle -45 \Rightarrow I_A = 22\sqrt{3} \angle -45 - 30 = 38.1 \angle -75$$

$$I_{BC} = \frac{V_{BC}}{Z} = \frac{110 \angle -120}{5 \angle 45} = 22 \angle -165 \Rightarrow I_B = 22\sqrt{3} \angle -165 - 30 = 38.1 \angle -195$$

$$I_{CA} = \frac{V_{CA}}{Z} = \frac{110 \angle -240}{5 \angle 45} = 22 \angle -285 \Rightarrow I_C = 22\sqrt{3} \angle -285 - 30 = 38.1 \angle -315$$

or $I_A = I_{AB} - I_{CA} = (22 \angle -45) - (22 \angle -285)$



A 3 Phase system supplies 110 V to a delta connected load whose phase impedance $(3.54 + j 3.54)$. Determine $I_R = ?$



$$V_{RY} = 110 \angle 0$$

$$V_{YB} = 110 \angle -120$$

$$V_{BR} = 110 \angle 120$$

Home work

- A** $38.5 \angle 75$
- B** $38.5 \angle -75$
- C** $22 \angle -165$
- D** $22 \angle 75$



2 Minutes Summary

→ Positive Sepⁿ supply

→ Negative Sep supply

→ Types of load

→ Balance γ load

→ Balance Δ load.

Thank you

GW
Soldiers !

