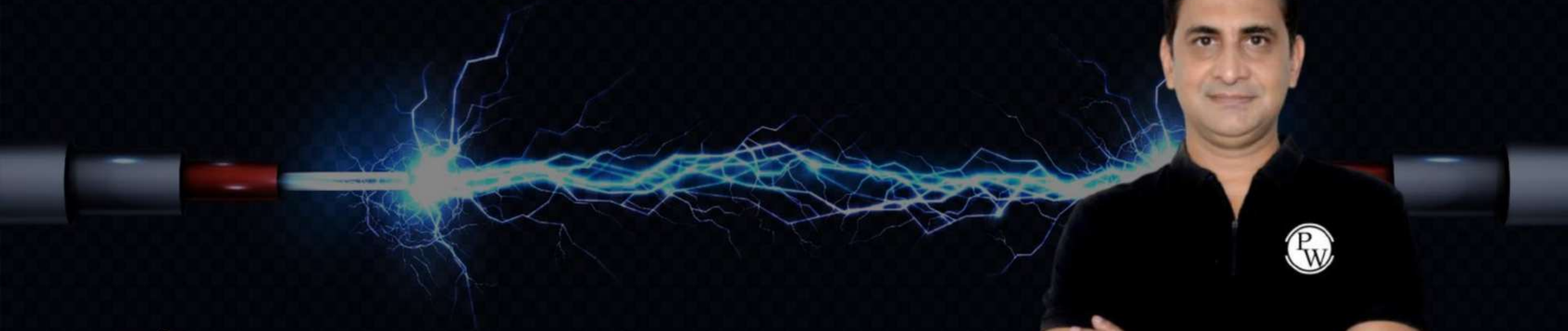


Electrical Engineering

Power System



Lecture No.-1
Distribution

By- Ajay Gupta Sir



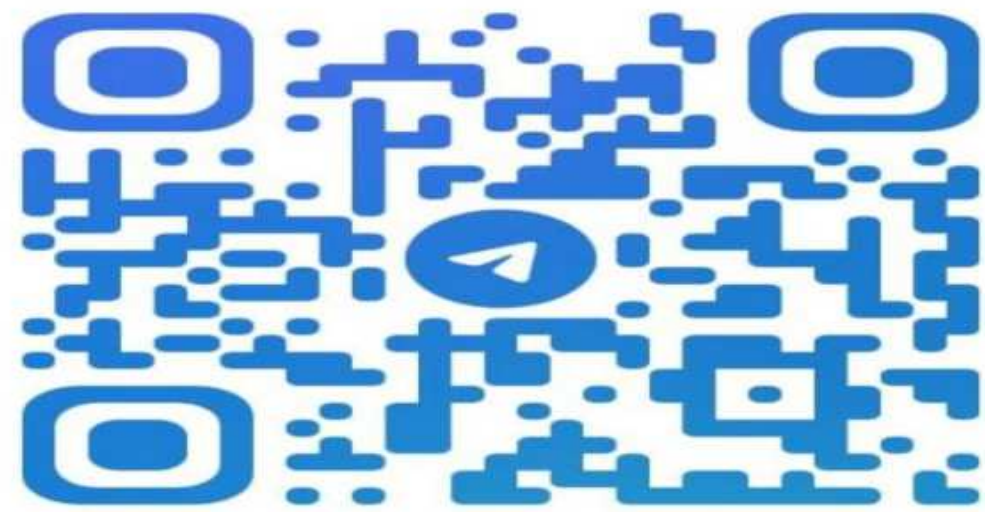
Recap of previous class

- ✓ 1. Why HVDC
- ✓ 2. Type of DC LINK
- ✓ 3. Equipment in HVDC station
- ✓ 4. Advantage of HVDC
- ✓ 5. Disadvantage of HVDC



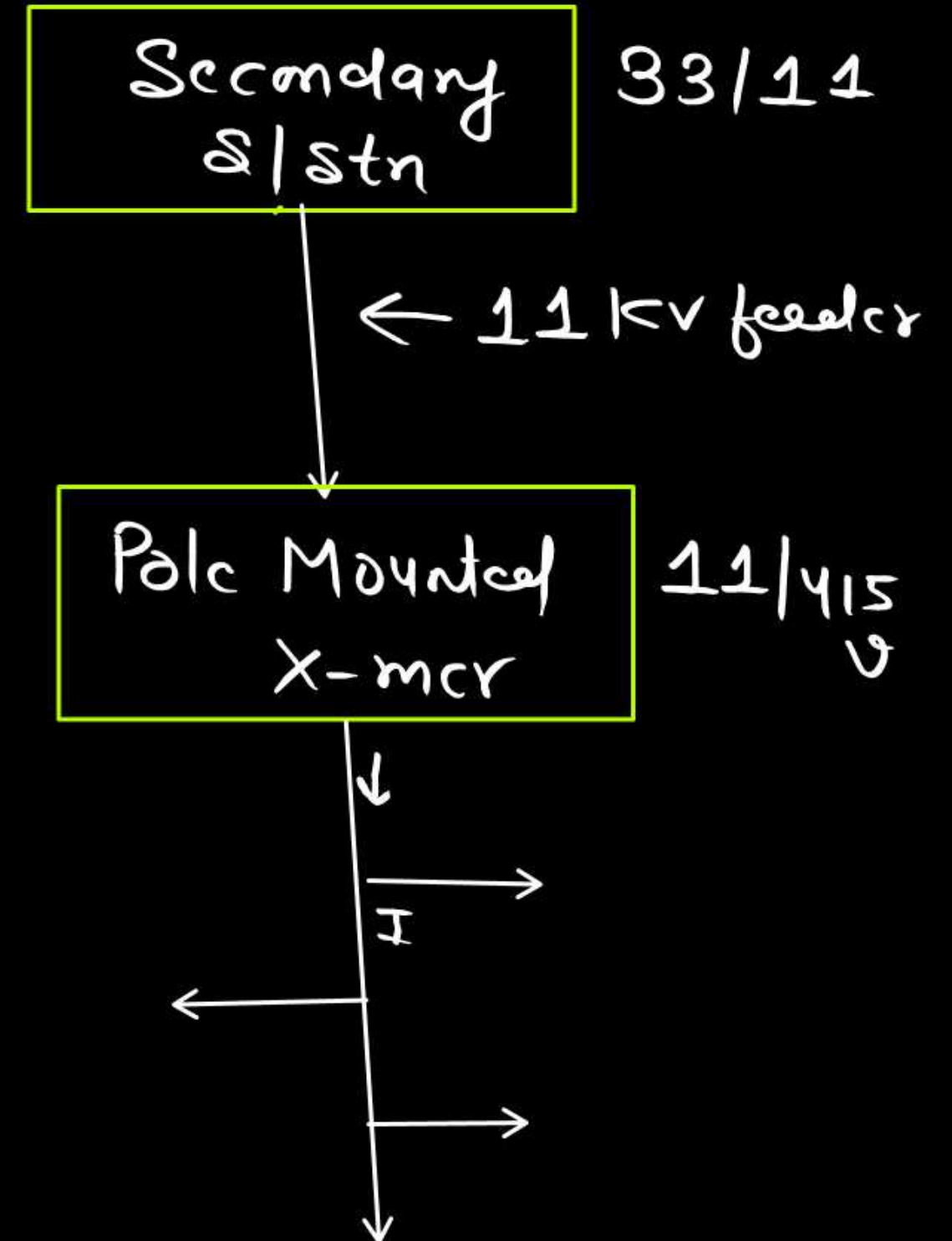
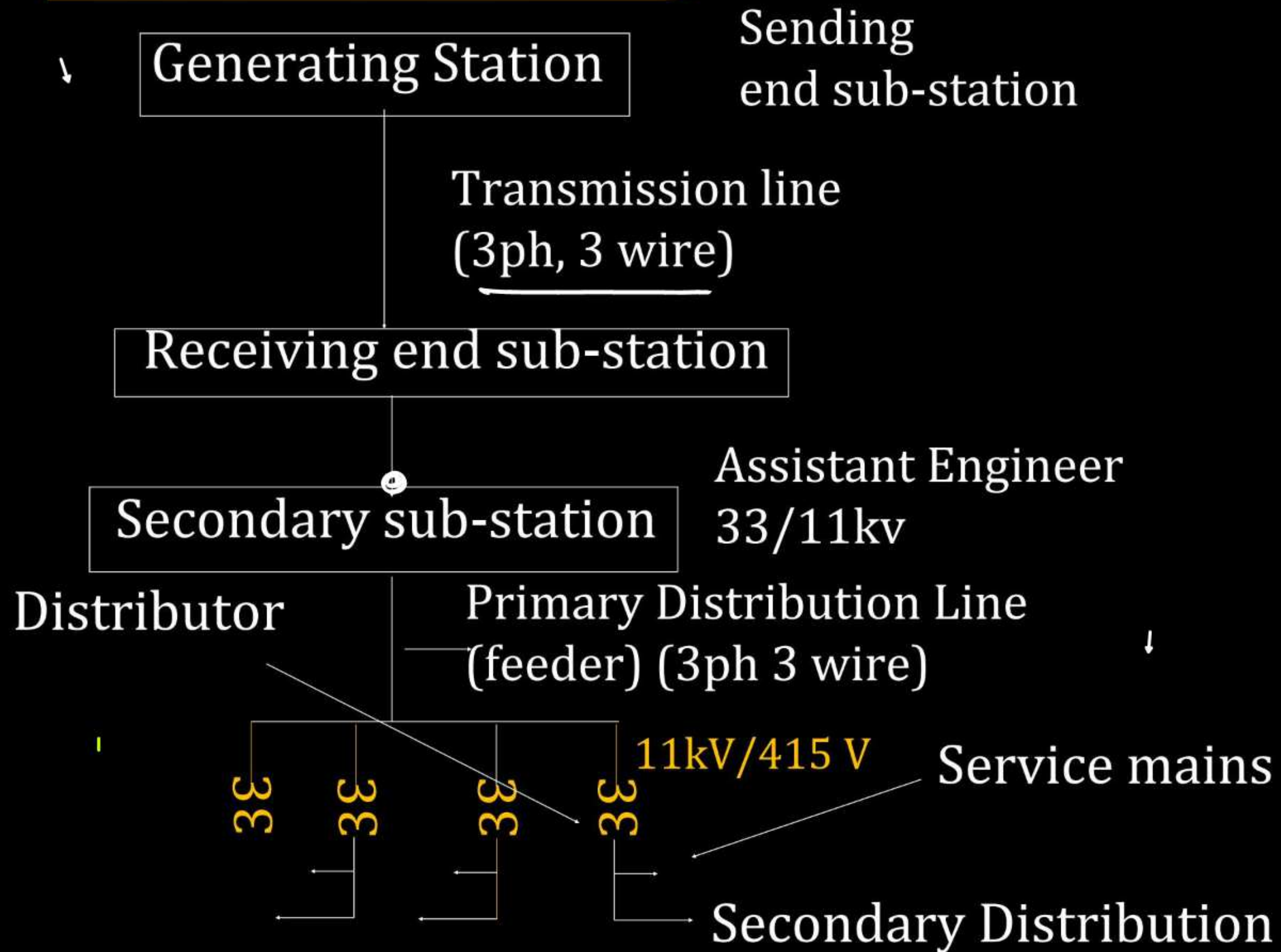
Topics to be Covered

- ✓ 1. distribution
- ✓ 2. Feeder and distributor
- ✓ 3. Types of feeder
- ✓ 4. Types of distributors
- ✓ 5. Comparision of volume of conductor



@AJAYGUPTASIRPW

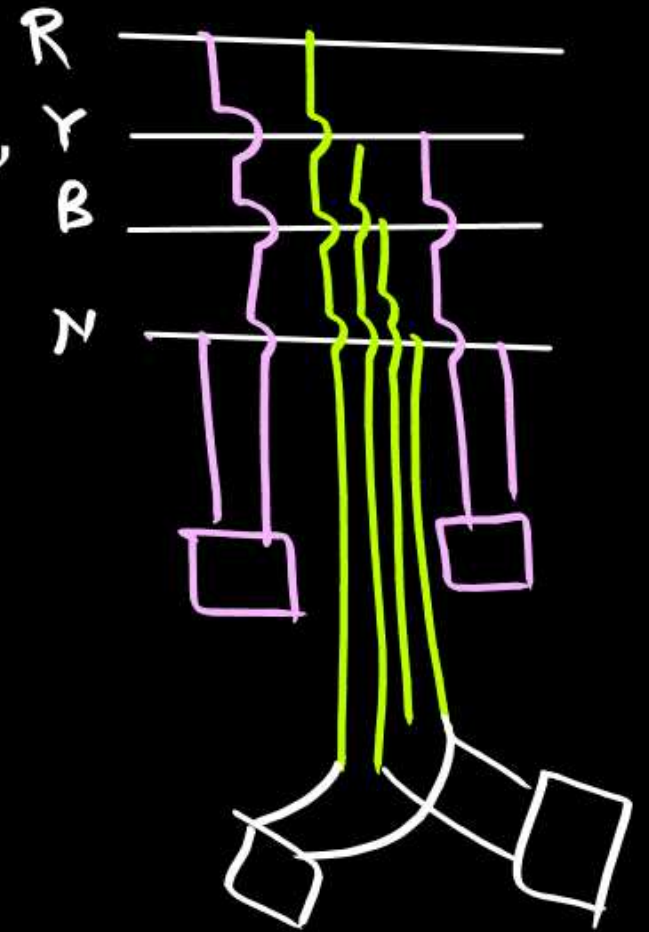
DISTRIBUTION



→ Distribution system is a system between secondary sub-station (feed by transmission system) & end Consumer

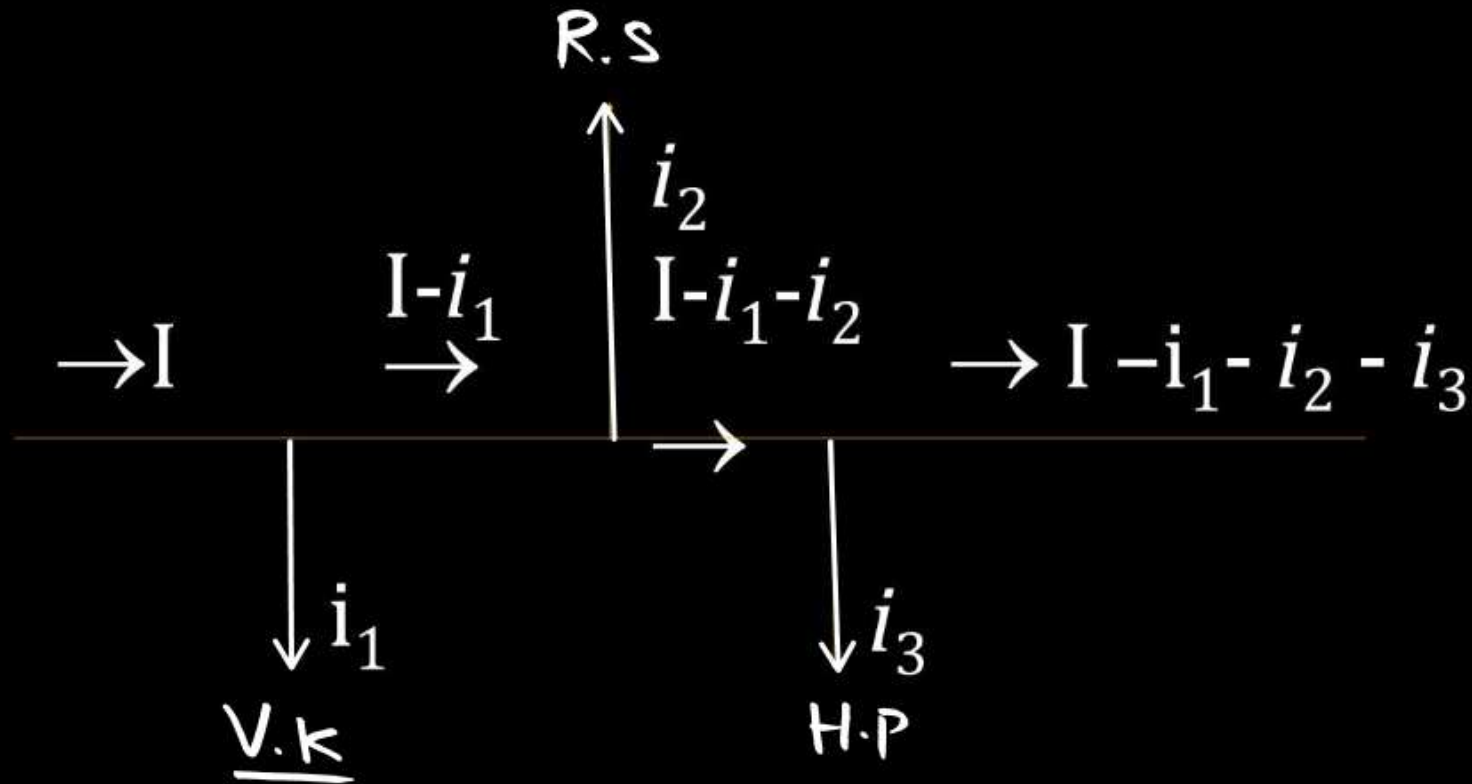
Feeder → Feeder is a conductor from which no tapping are taken, So current in feeder remain same throughout the length.

→ Feeder are design as per current carrying capacity.



Distributor:

It is a conductor from which tapping are taken to supply the end Consumer. So, current in Distributor throughout the length is not same



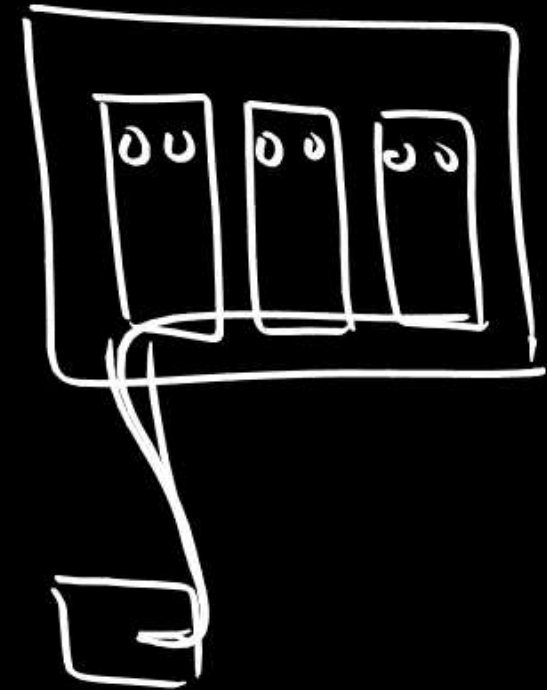
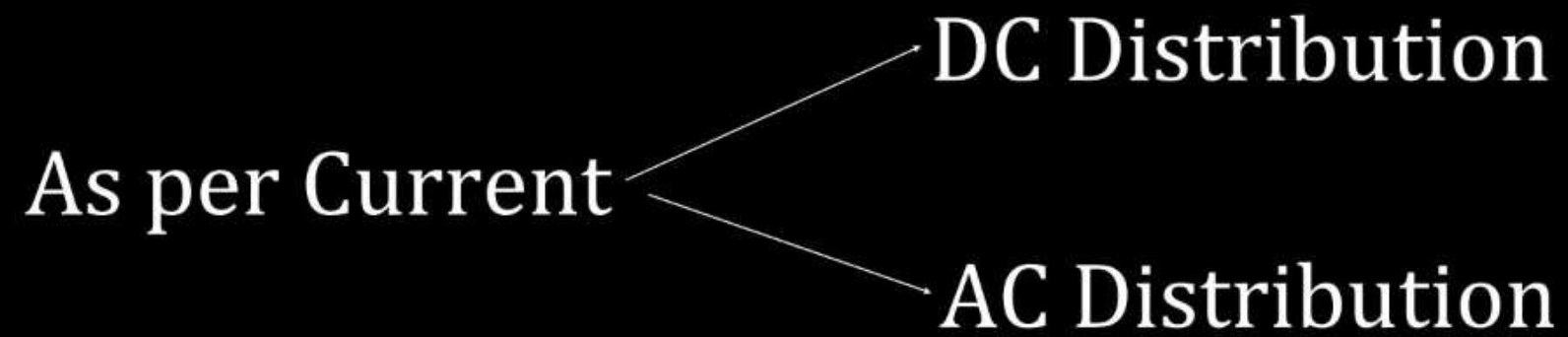
- Distributor is design as per voltage drop
- We use 3 Phase four wire (only in Secondary distribution)

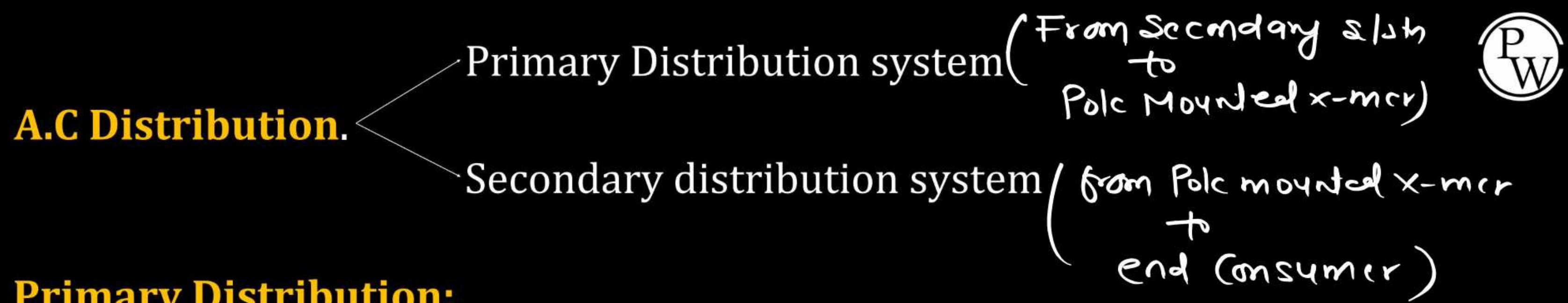


Service Main →

It is a small cable, which connect the Distributor to consumer terminal

Classification of Distribution System



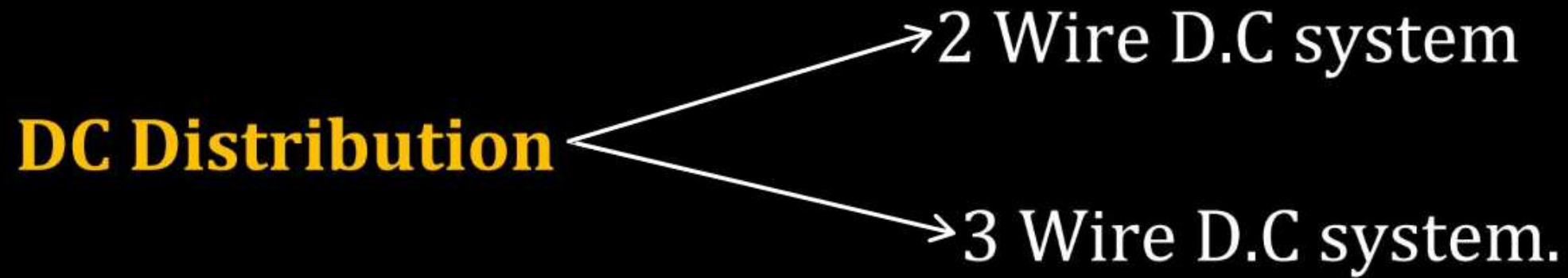


Primary Distribution:

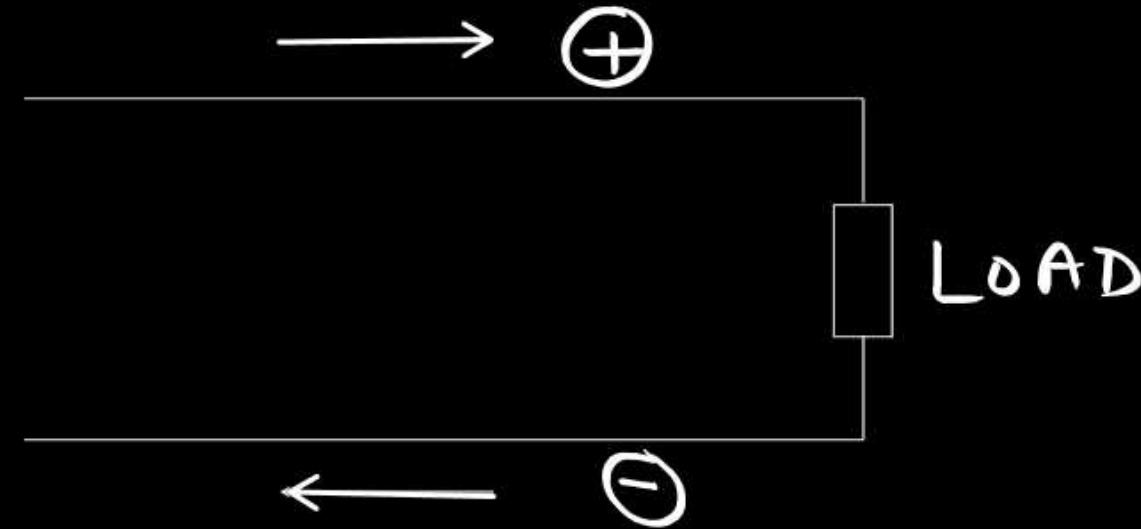
It is a system between secondary sub-station to distribution transformer.
It is carried out by 3 Ph, 3 wire system.

Secondary Distribution:

Distribution transformer reduce the voltage from 11 kV to 415V from where distributor radiate out and feed line consumer. This is called secondary distribution



- In 2 wire D.C, we use one positive & one negative conductor. One is for incoming & another is for outgoing. Load is connected between these two wire.



- In 3 wire DC distribution. It consist 2 outer (one positive & another negative) & a middle neutral wire which is earth.

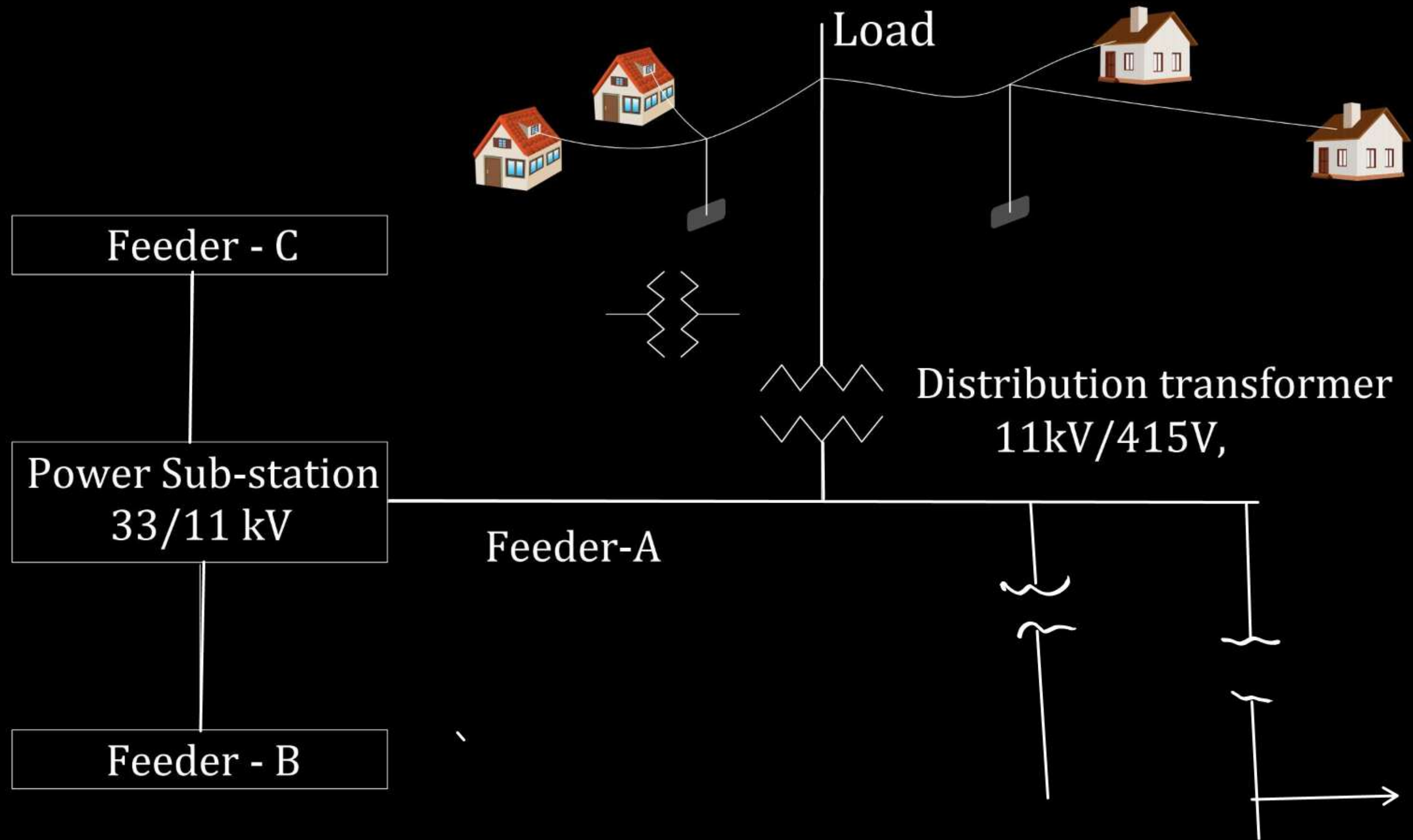


Classification of Feeder :



RADIAL FEEDER

- A separate feeder radiate from sub-station, this main feeder is further divided into sub feeder and supply the distribution transformer.
- It is a simplest distribution system, but reliability of system is Poor. A fault at any point on the feeder can interrupt the supply to all consumers beyond the fault location.
- This is mainly used in rural and low-density area.
- Since fewer conductors and switching devices are required, the installation cost is relatively low.
- Consumers located far from the substation may experience significant voltage drop, especially under heavy load conditions.



Parallel feeder :

- It has two radial feeder running in parallel.
- It may originate from either same sub-station or different sub-station.

Each feeder supply half of load but has the capability to supply entire load (In case of fault in the one feeder).

Load current is shared among the parallel feeders, resulting in lower voltage drop compared to a single feeder.

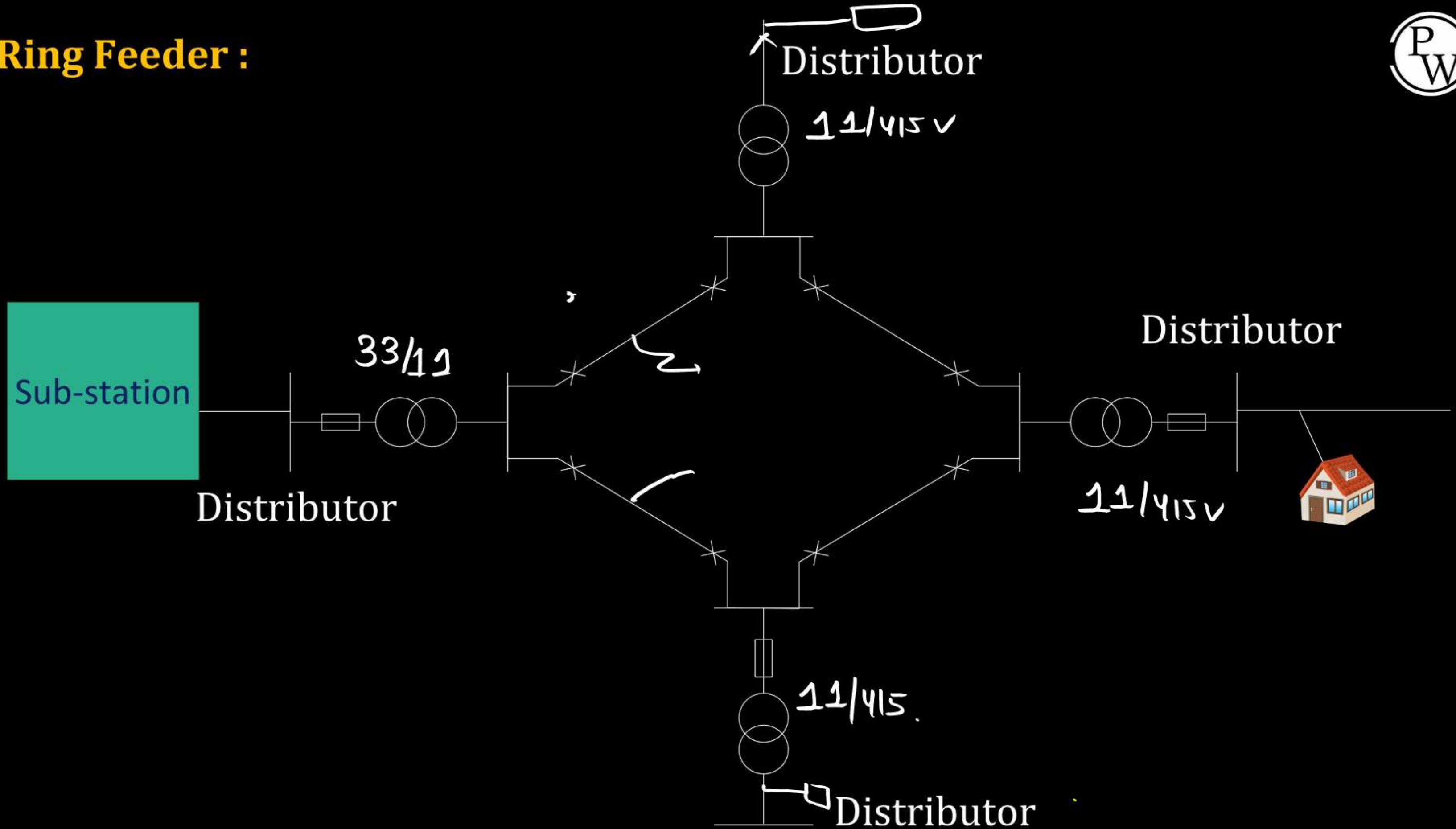
Parallel Feeder:



Ring Feeder :

- In this system primaries of the distribution transformers is connected through loop.
- The loop start from sub-station bus bar, Make a loop throughout the area to be served and return to sub-station.
- It is more Reliable.

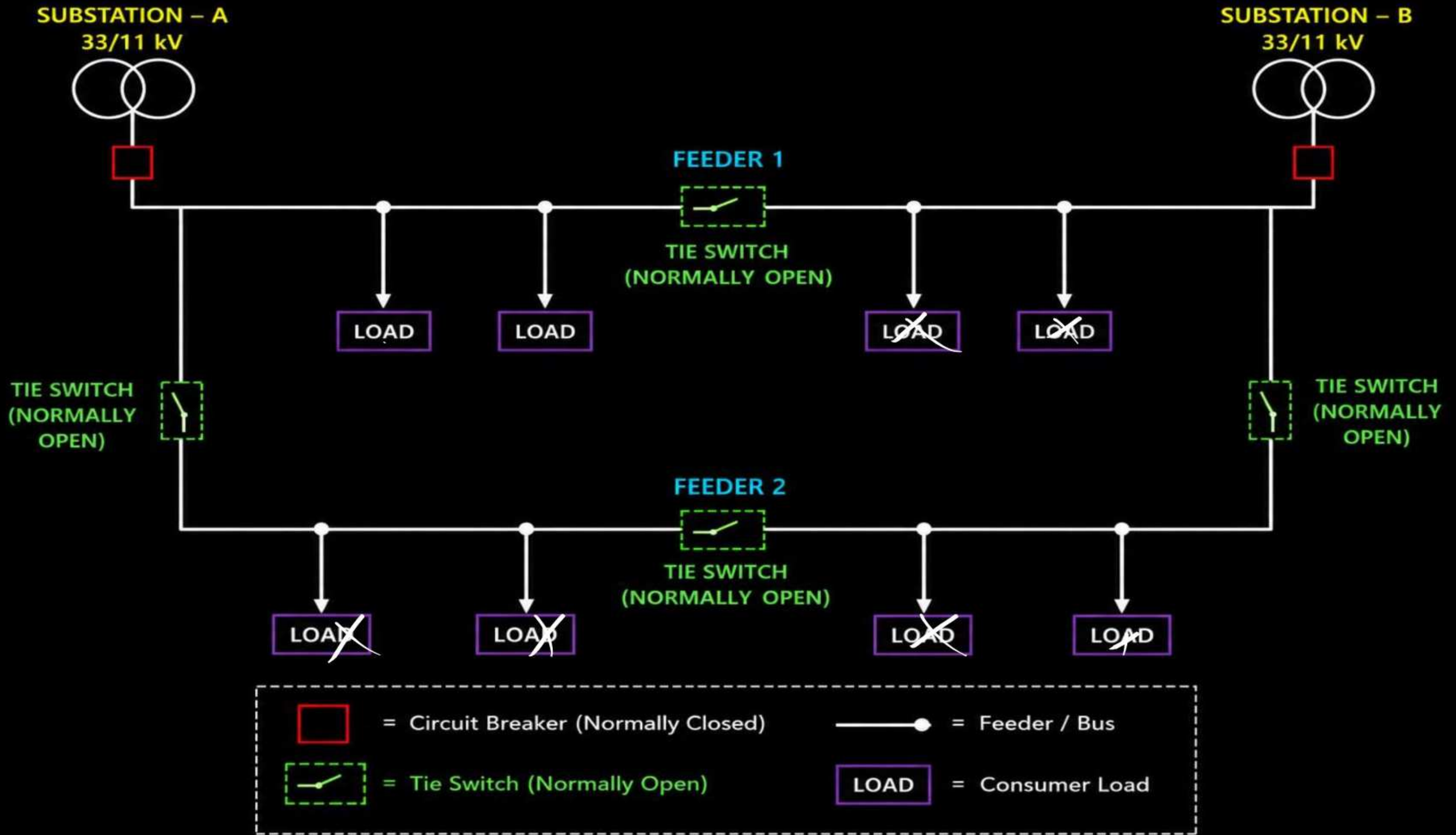
Ring Feeder :



Interconnected System:

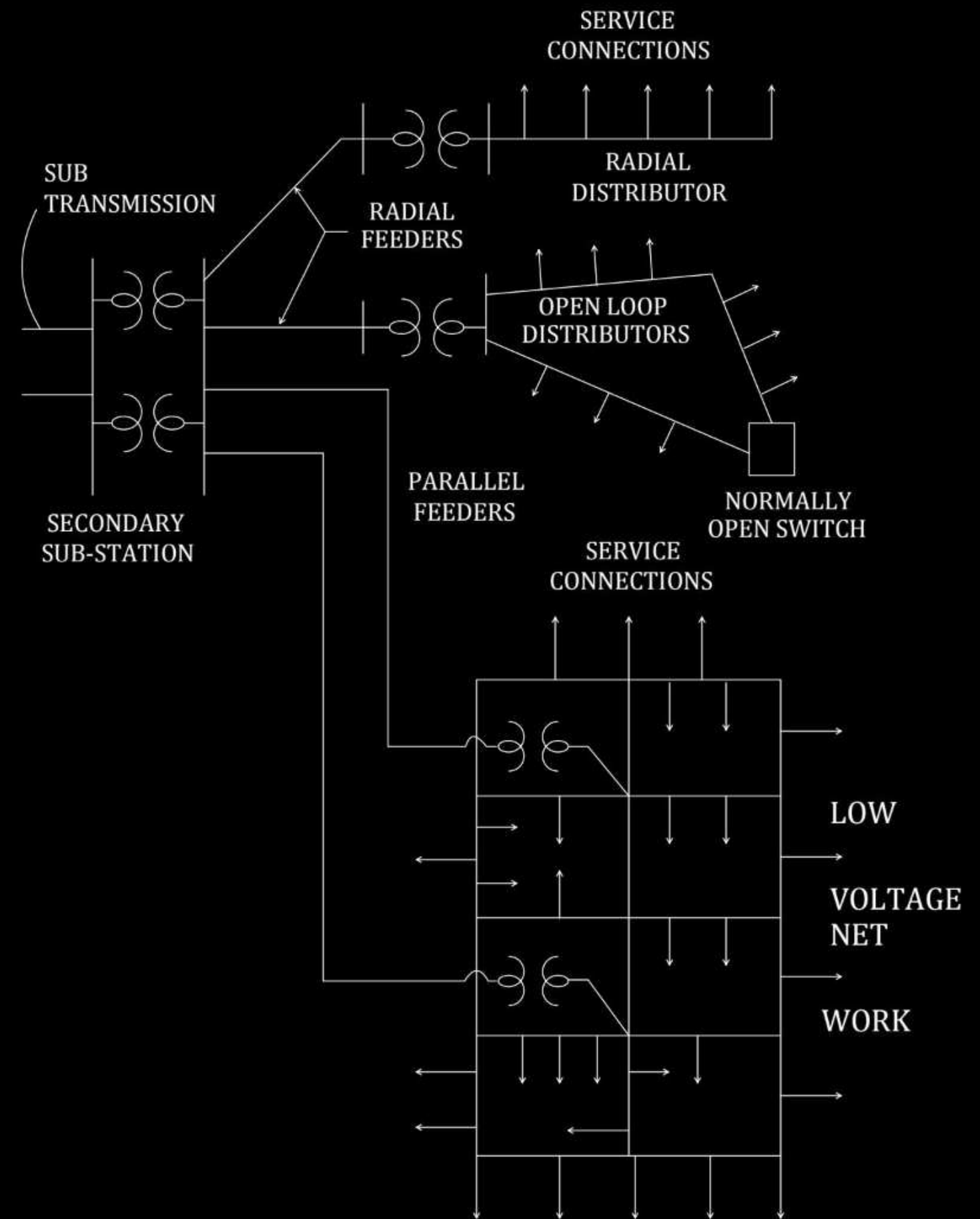
- It is like ring feeder, but ring are energized from two or more sub-station.
- It is most reliable.


INTERCONNECTED FEEDER (NETWORK) SYSTEM



Classification of Distributor :

- (1) Radial Distributor
- (2) Parallel Distributor
- (3) Ring Distributor
- (4) Network
(Inter connected) Distributor

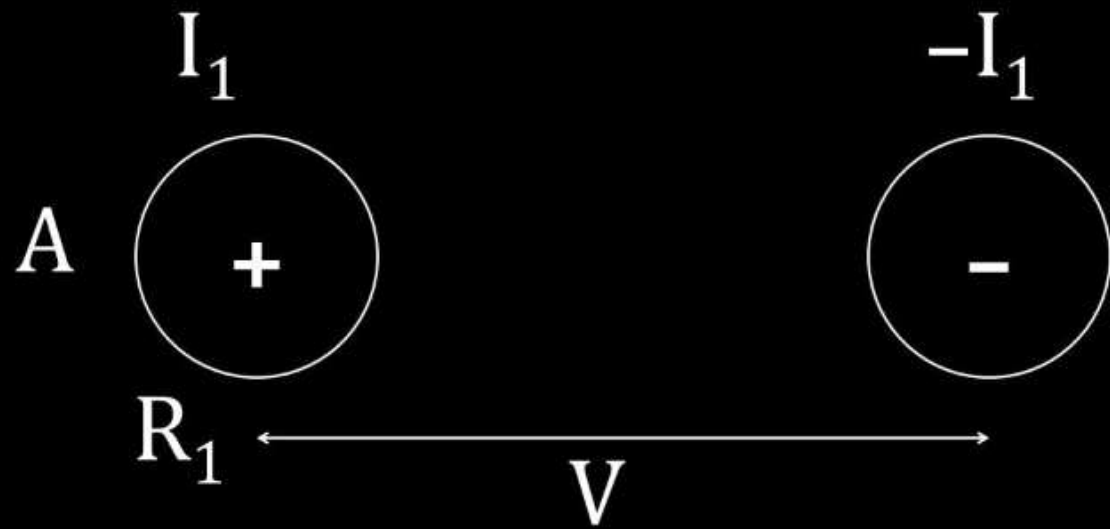


Comparison of Volume of conductor in various distribution system (for same loss and same insulation material):

Assumption	line length = ℓ	} Same
	Power transfer = P	
	Insulator cost (Max voltage) = v	
	current in neutral wire = 0	
	Loss	

Cost of conductor $\propto$ weight $\propto$ Volume

1. DC 2 Wire System:



$$P = V I_1$$

$$I_1 = \frac{P}{V}$$

$$\text{Loss} = I_1^2 R_1 + I_1^2 R_1$$

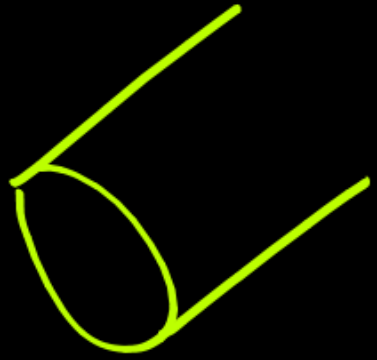
$$W = 2 I_1^2 R_1$$

$$W = 2 \left(\frac{P}{V} \right)^2 R_1$$

$$R_1 = \frac{W V^2}{2 P^2}$$

$$R_1 = \frac{\rho l}{a_1}$$

$$\frac{WV^2}{2\rho^2} = \frac{\rho l}{a_1}$$

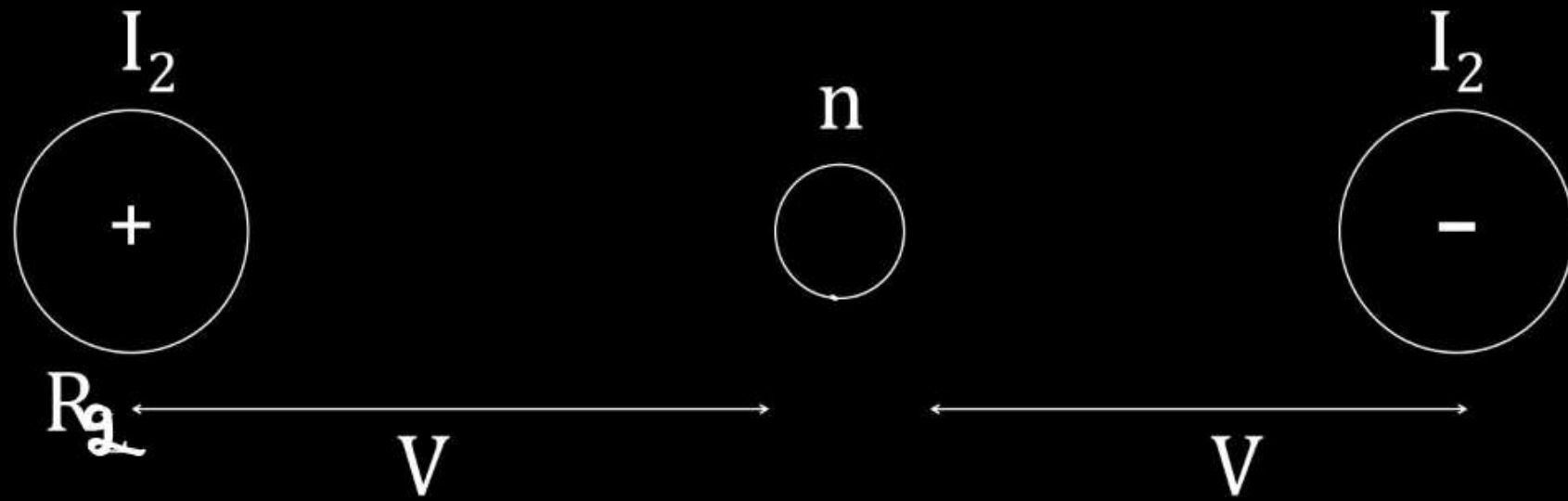


$$a_1 = \frac{2\rho^2 \rho l}{WV^2}$$

$$\text{Volume} = a_1 l + a_1 l$$

$$= 2a_1 l = 2 \cdot \frac{2\rho^2 \rho l}{WV^2} \cdot l = \frac{4\rho^2 \rho l^2}{WV^2} = k$$

2. DC 3 Wire System:



$$P = V I_2 + V I_2$$

$$P = 2V I_2$$

$$I_2 = \frac{P}{2V}$$

$$W = I_2^2 R_2 + I_2^2 R_2$$

$$W = 2 I_2^2 R_2$$

$$W = 2 \left(\frac{P}{2V} \right)^2 R_2 \Rightarrow R_2 = \frac{2 W V^2}{P^2}$$

$$R_2 = \frac{P_1}{q_2}$$

$$\frac{2WV^2}{P^2} = \frac{P_1}{q_2}$$

$$q_2 = \frac{P^2 P_1}{2WV^2}$$

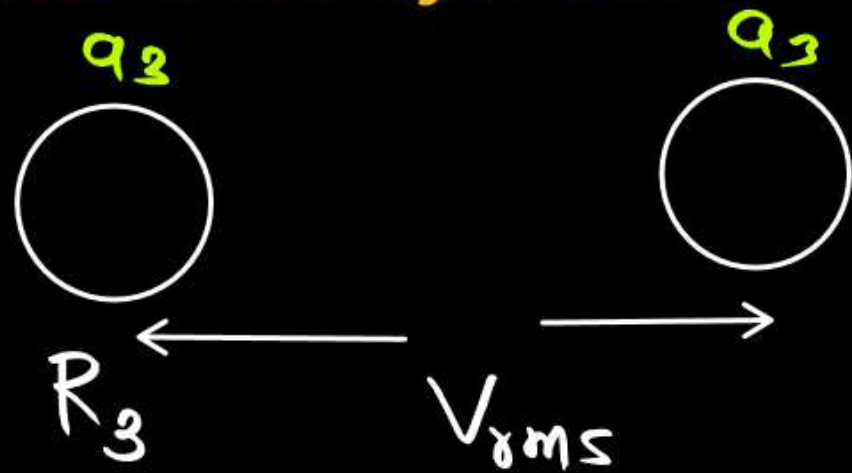
$$\text{Volume} = q_2 l + q_2 l$$

$$= 2q_2 l$$

$$= 2 \left(\frac{P^2 P_1}{2WV^2} \right) l$$

$$\begin{aligned} \text{Volume} &= \frac{P^2 P_1^2}{WV^2} = \frac{1}{4} \left(\frac{4P^2 P_1}{WV^2} \right) \\ &= \frac{1}{4} K \end{aligned}$$

1 phase AC System:



$$P = V_{rms} I_{rms} \cos \phi$$

$$P = \frac{V}{\sqrt{2}} \cdot I_{rms} \cos \phi$$

$$I_{rms} = \frac{\sqrt{2} P}{V \cos \phi}$$

$$\text{loss } W = I_{rms}^2 R_3 + I_{rms}^2 R_3$$

$$= 2 I_{rms}^2 R_3$$

$$W = 2 \left(\frac{\sqrt{2} P}{V \cos \phi} \right)^2 R_3 = \frac{4 P^2 R_3}{V^2 \cos^2 \phi}$$

$$P_3 = \frac{WV^2 \cos^2 \phi}{4P^2}$$

$$\frac{P_1}{a_3} = \frac{WV^2 \cos^2 \phi}{4P^2}$$

$$a_3 = \frac{4P^2 P_1}{WV^2 \cos^2 \phi}$$

$$\text{Volume} = a_3 l + a_3 l$$

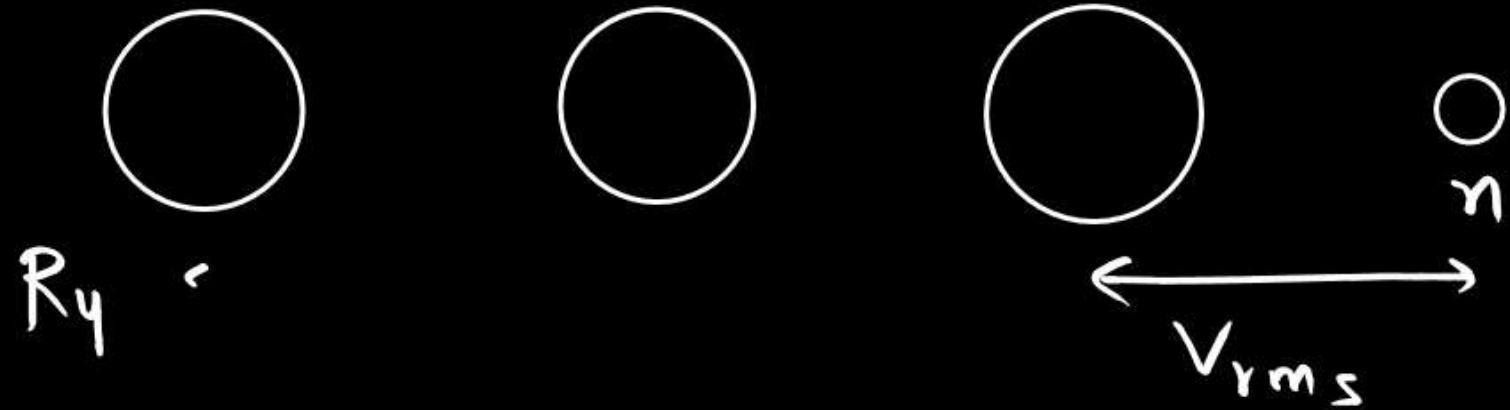
$$= 2a_3 l$$

$$= 2 \left(\frac{4P^2 P_1}{WV^2 \cos^2 \phi} \right) l$$

$$= \frac{2}{\cos^2 \phi} \left(\frac{4P^2 P_1^2}{WV^2} \right)$$

$$= \frac{2}{\cos^2 \phi} \cdot K$$

3 phase 4 wire AC System:



$$P = 3 V_{rms} I_{rms} \cos \phi$$

$$P = 3 \frac{V}{\sqrt{2}} \cdot I_{rms} \cos \phi$$

$$I_{rms} = \frac{\sqrt{2} P}{3 V \cos \phi}$$

$$\text{loss} = 3 I_{rms}^2 R_y$$

$$W = 3 \left(\frac{\sqrt{2} P}{3 V \cos \phi} \right)^2 R_y = \frac{2}{3} \frac{P^2}{V^2 \cos^2 \phi} R_y$$

$$R_y = \frac{3WV^2 \cos^2 \phi}{2P^2}$$

$$\frac{P_1}{a_y} = \frac{3WV^2 \cos^2 \phi}{2P^2}$$

$$a_y = \frac{2P^2 \lambda P}{3WV^2 \cos^2 \phi}$$

$$\text{Volume} = 3a_y \lambda$$

$$= 3 \left(\frac{2P^2 \lambda P}{3WV^2 \cos^2 \phi} \right) \lambda$$

$$= \frac{2P^2 P \lambda^2}{WV^2 \cos^2 \phi}$$

$$= \frac{1}{2 \cos^2 \phi} \left(\frac{4P^2 P \lambda^2}{WV^2} \right)$$

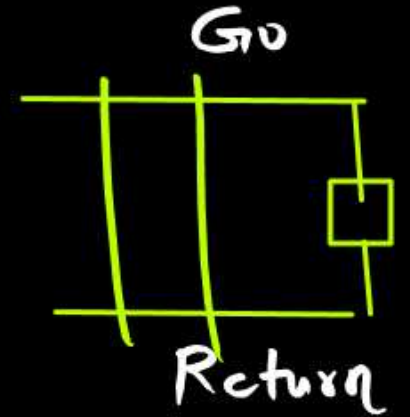
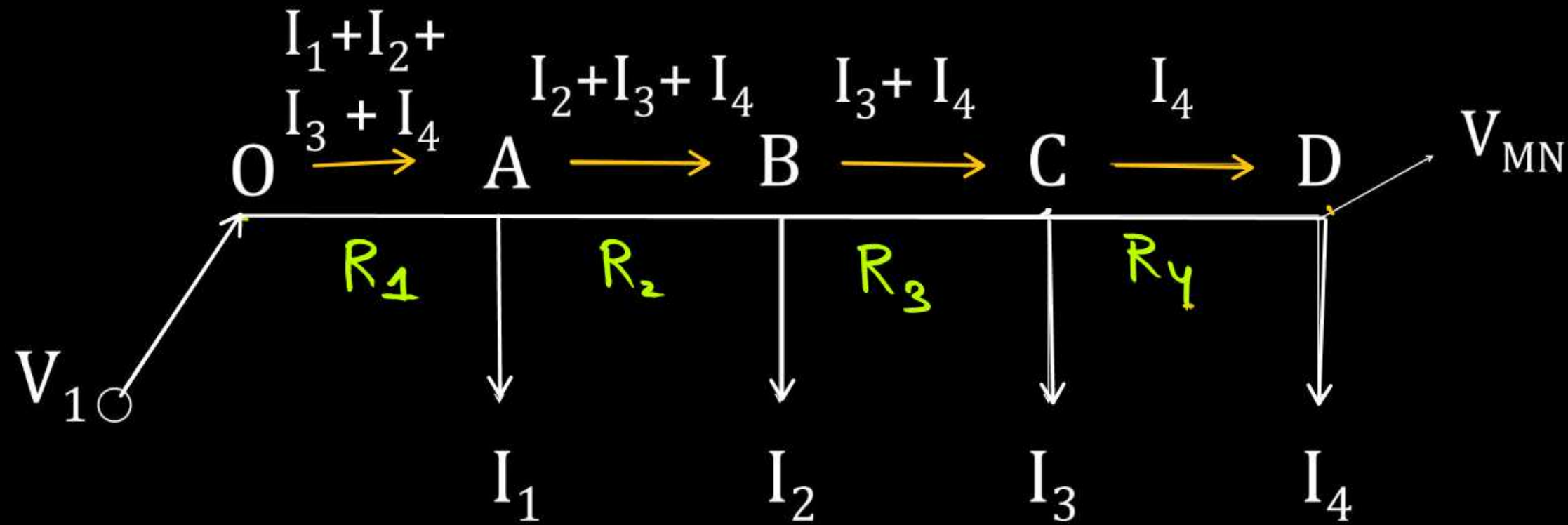
$$= \frac{k}{2 \cos^2 \phi}$$

- So, DC 3 Wire system is most economical distribution system.
- And In AC 3 phase 4 wire distribution is more economical than 1 Phase DC system.

<u>D.C 2 WIRE</u>	<u>D.C 3 WIRE</u>	<u>A.c 1 Phase</u>	<u>A.c 3 PHASE</u>
K	$\frac{K}{4}$	$\frac{2}{\cos^2 \phi} (K)$	$\frac{K}{2 \cos^2 \phi}$

Voltage Drop calculation in Distributor:-

1) Radial Distributor Feed From One End (D.C.);-



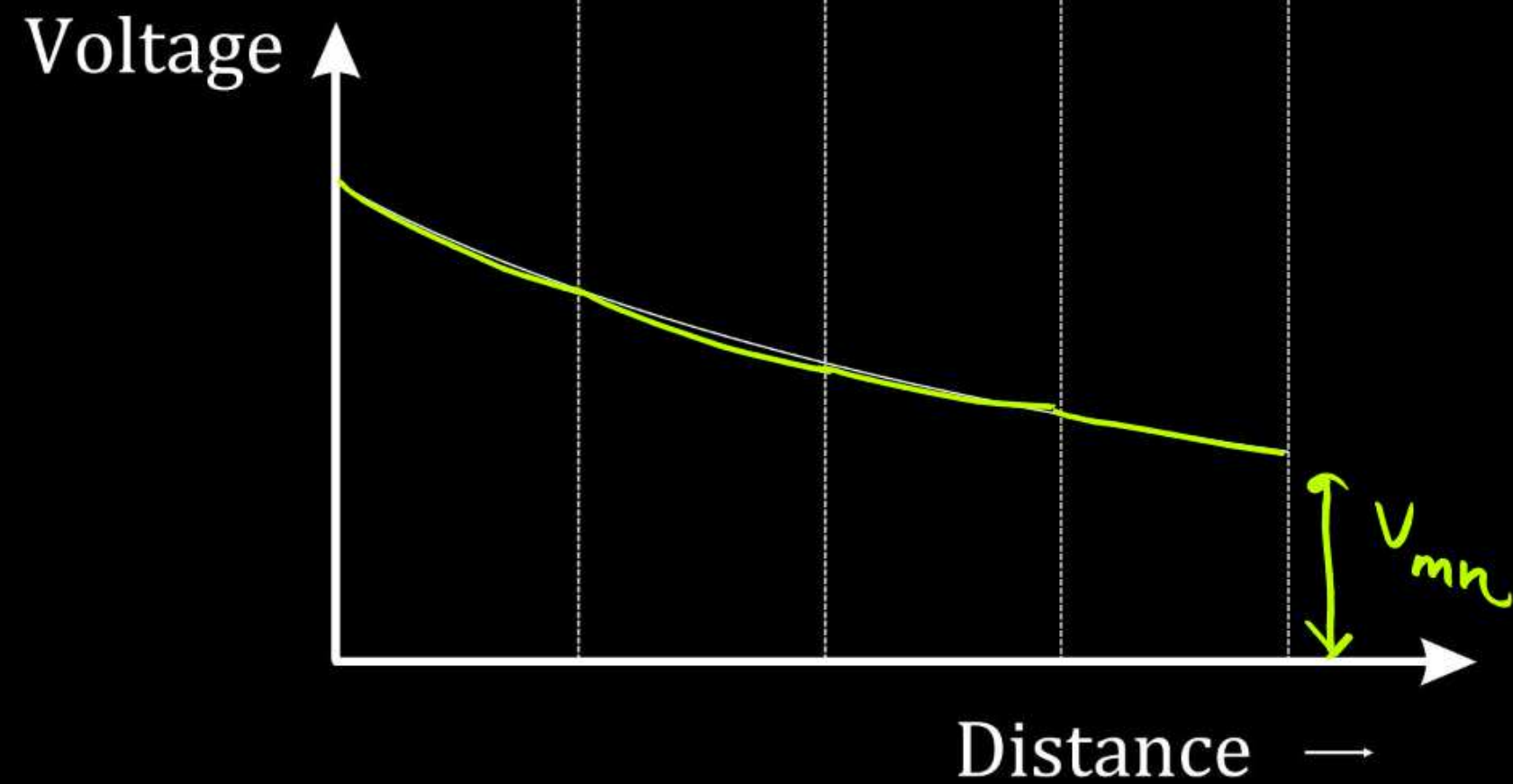
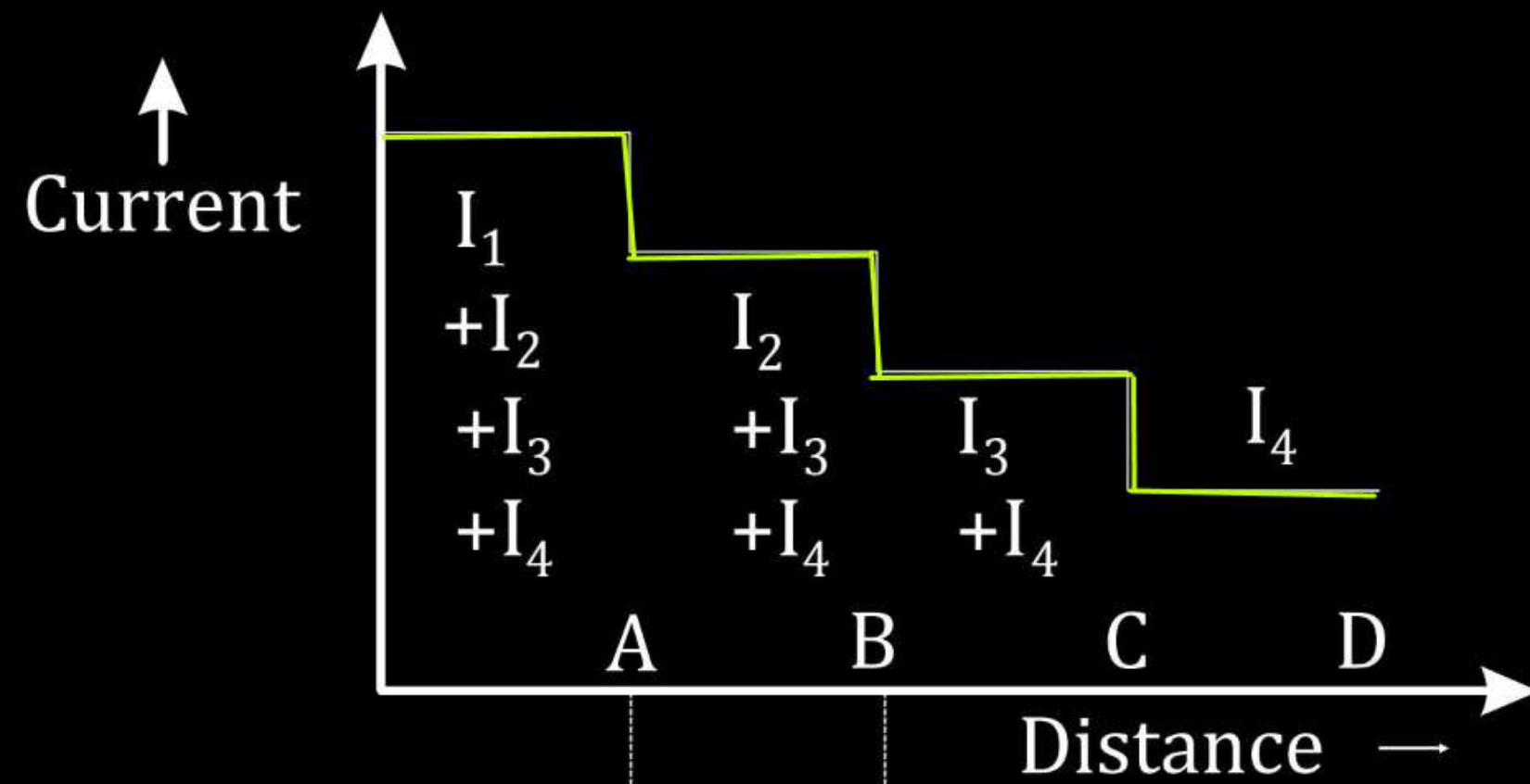
R_1 = is the Resistance of distributor from 0 to A
(Both "go" and "return" Conductor)

R_2 = is the resistance of distributor from A to B
(Both "go" and "return" Conductor)

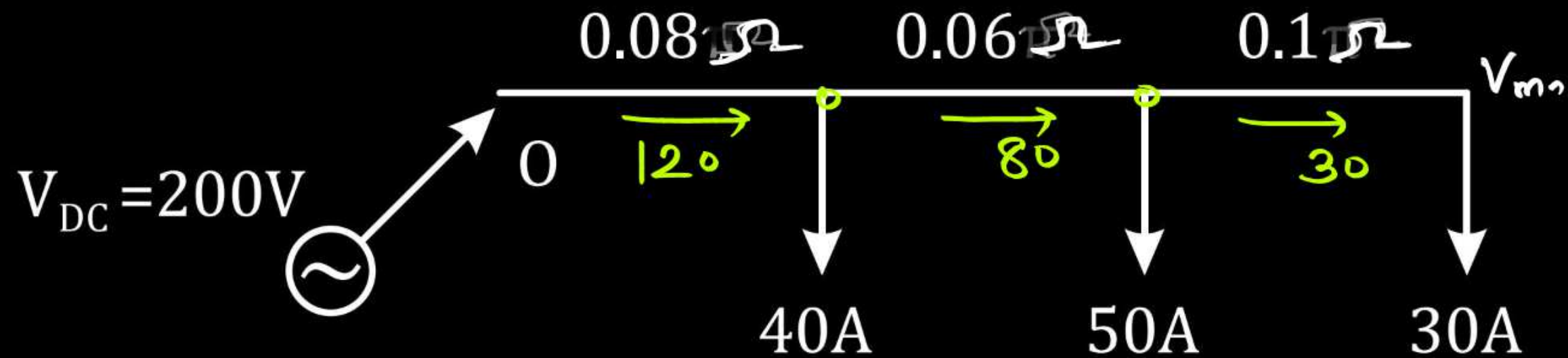
$$\begin{aligned}\text{Total voltage drop} &= (I_1 + I_2 + I_3 + I_4) R_1 + (I_2 + I_3 + I_4) R_2 \\ &\quad + (I_3 + I_4) R_3 + I_4 R_4.\end{aligned}$$

$$= I_1 R_1 + I_2 (R_1 + R_2) + I_3 (R_1 + R_2 + R_3) + I_4 (R_1 + R_2 + R_3 + R_4)$$

$$\begin{aligned}\text{Total Voltage drop} &= I_1 (\text{Total Resistance before } I_1) + I_2 (\text{Total Resistance before } I_2) \\ &\quad + I_3 (\text{total Resistance before } I_3) + I_4 (\text{Total Resistance before } I_4)\end{aligned}$$



Q.



The minimum voltage at Distributor is? The given resistance of go and return conductor both.

$$\begin{aligned}\text{Total Voltage drop} &= (120 \times 0.08) + (80 \times 0.06) + (30 \times 0.1) \\ &= 17.4\end{aligned}$$

$$V_{mn} = 200 - 17.4 = 182.6V$$

II Method.



$$\begin{aligned}\text{Total voltage drop} &= 40(0.08) + 50(0.08 + 0.06) + 30(0.08 + 0.06 + 0.1) \\ &= 40(0.08) + 50(0.14) + 30(0.24) \\ &= 17.4\end{aligned}$$

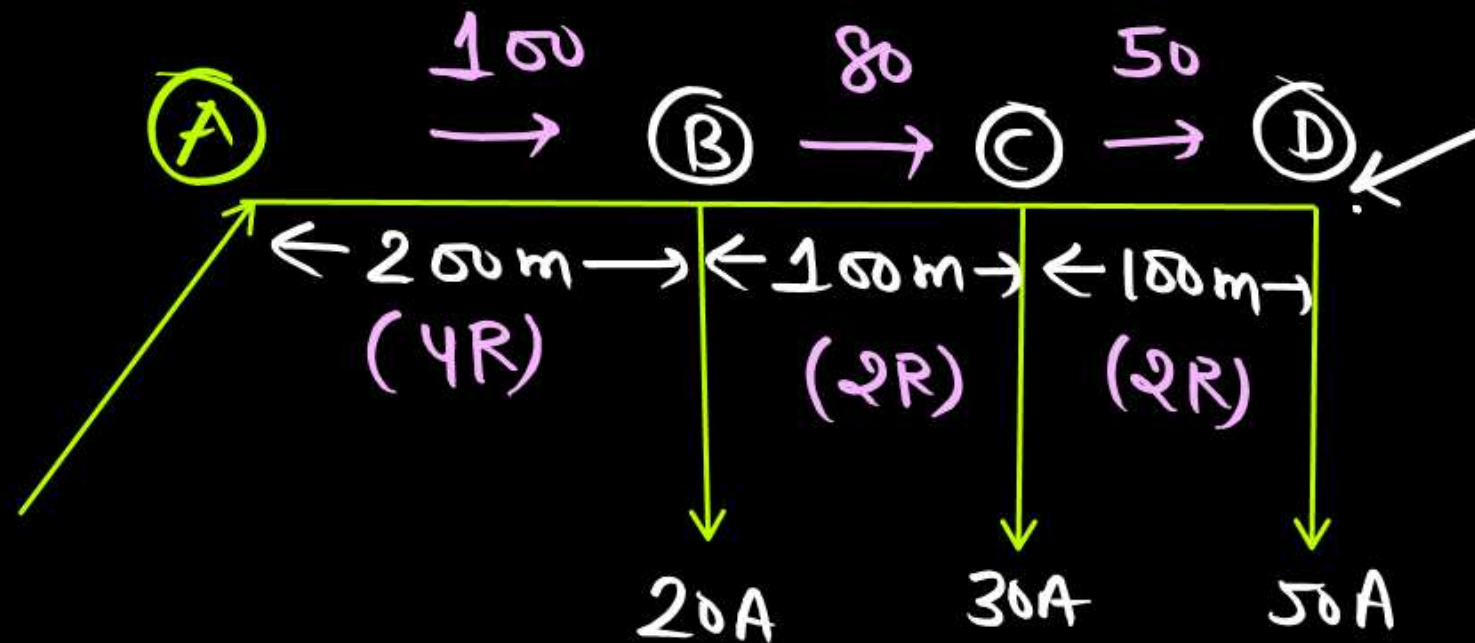
$$\begin{aligned}V_{\min} &= 200 - 17.4 \\ &= \underline{182.6}\end{aligned}$$

Question



A 2-wire d.c. distributor AB is 400 meters long. It is fed from point A. It supplies load of 20 A, 30 A and 50 A situated at 200-meter, 300 meter and 400 meter from feeding point A

If maximum voltage drop is not to be exceed 10 V. What is the cross-section area of distributor ? Take resistivity of conductor $1.8 \times 10^{-8} \Omega\text{-m}$



Suppose Resistance of 100m distributor = R

So Resistance of AB (Go + Return) = $(2R + 2R) = 4R$

" " BC (" + ") = $(R + R) = 2R$

" " CD (" + ") = $(R + R) = 2R$

$$\begin{aligned} \text{So Total Voltage drop} &= (100)(4R) + (80)(2R) + (50)(2R) \\ &= 400R + 160R + 100R \\ &= 660R \end{aligned}$$

$$660R = 10$$

$$R = \frac{1}{66} = \frac{\rho l}{a}$$

$$\frac{1}{66} = \frac{1.8 \times 10^{-8} \times (100)}{a}$$

$$a = 118.8 \times 10^{-6} \text{ m}^2$$

$$a = 1.188 \text{ cm}^2$$

2 Minute Summary

→ Type of feeder

→ Type of distributor

→ Voltage drop in d.c. distribution.

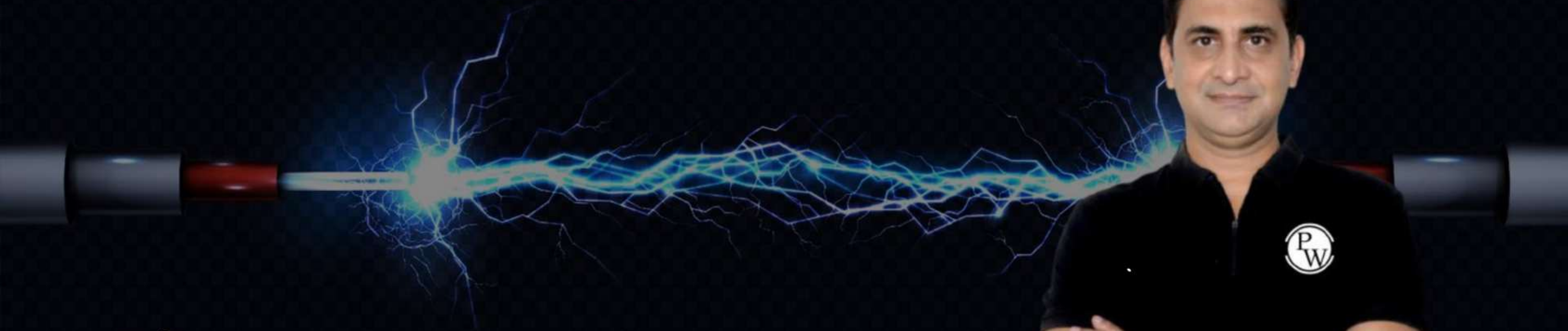
Thank you

GW
Soldiers !



Electrical Engineering

Power System



Lecture No.-2

Distribution

By- Ajay Gupta Sir



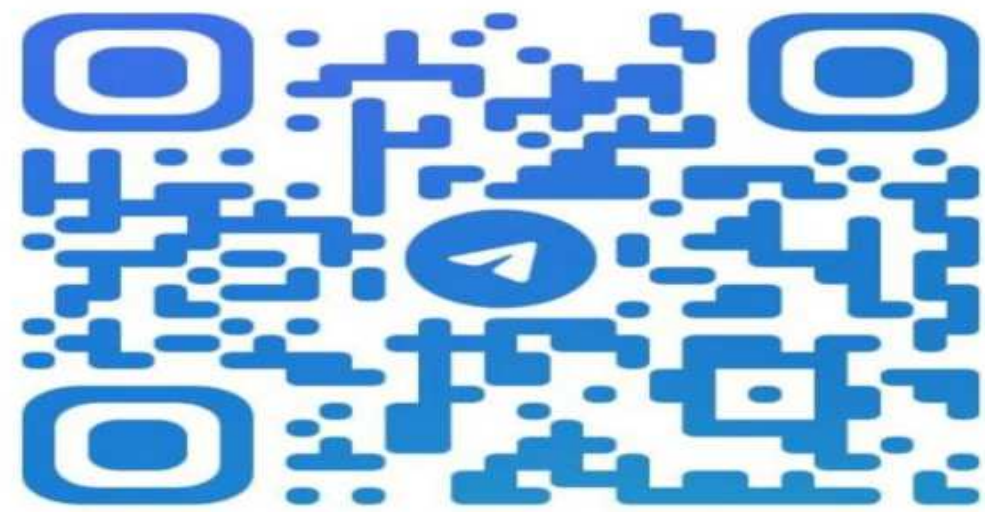
Recap of previous class

- ✓ 1. Distribution
- ✓ 2. Distributor and feeder
- ✓ 3. Comparison of cross section area
- ✓ 4. Voltage drop in radial distribution



Topics to be Covered

- ✓ 1. Radial distribution uniform loading
- ✓ 2. Radial distributor fed from both end
- ✓ 3. Radial uniform loading fed both end

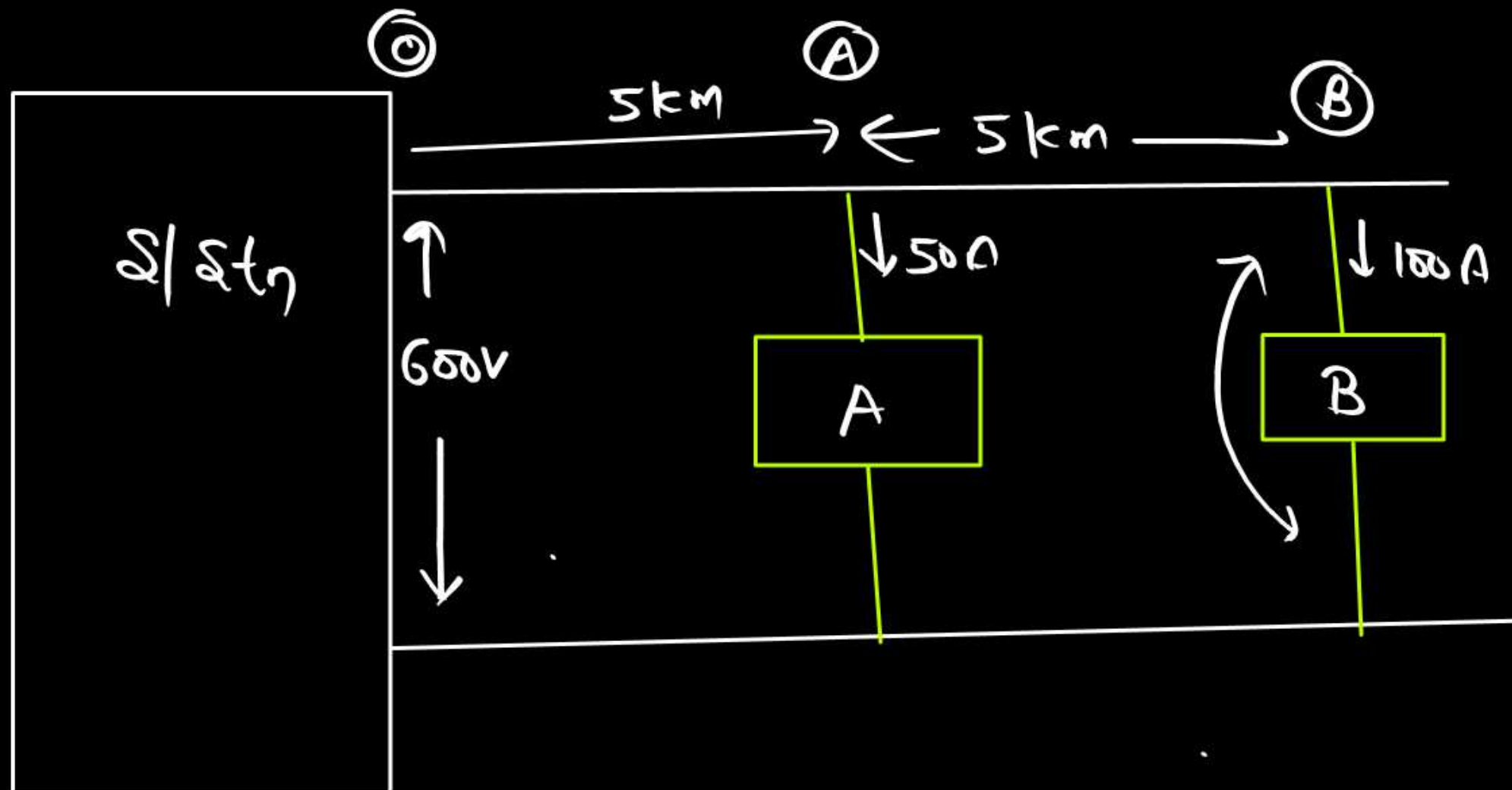


@AJAYGUPTASIRPW

Question



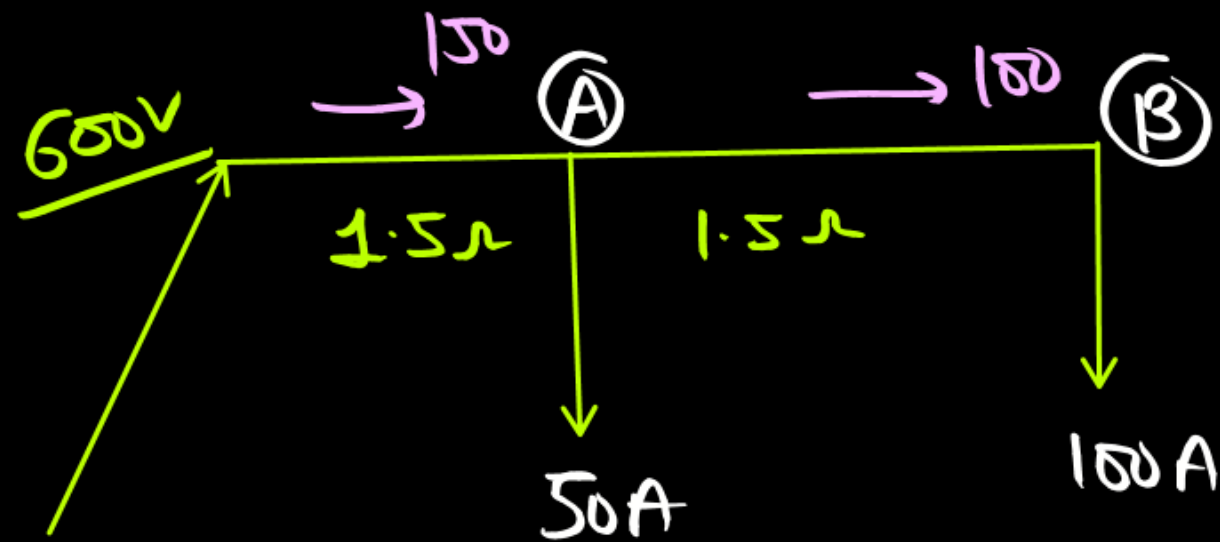
Two tram car A and B is 5 Km and 10 Km away from a sub station return 50 A and 100 A current to rails. The substation voltage is 600V D. C. the resistance of trolley wire is 0.25 ohm/km and resistance of track is 0.05 ohm/km . What is the voltage across tram B?



Total Resistance of 'go' + return = $0.25 + 0.05 = 0.3 \Omega/\text{km}$

Resistance from 0 to A = $0.3 \Omega/\text{km} \times 5 \text{ km} = 1.5 \Omega$

" from A to B = $0.3 \Omega/\text{km} \times 5 \text{ km} = 1.5 \Omega$



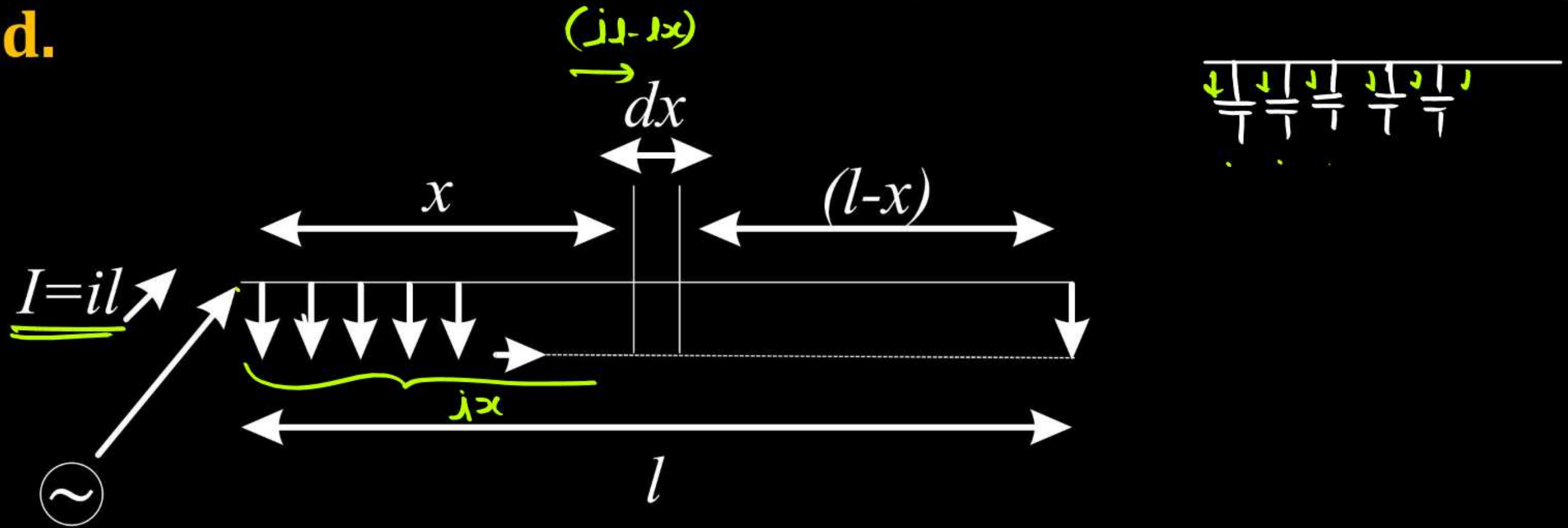
$$\begin{aligned}\text{Total voltage drop} &= (1.5 \times 150) + (1.5 \times 150) \\ &= 225 + 150 \\ &= 375.\end{aligned}$$

$$\begin{aligned}V_B &= 600 - 375 \\ &= 225.\end{aligned}$$

$$\text{Voltage drop up to A point} = 150 \times 1.5 = 225$$

$$\begin{aligned}V_A &= 600 - 225 \\ &= \underline{375}\end{aligned}$$

2. Radial Distributor with uniformly loading feeding from one end.



- Uniform loading Means current tapping is uniformly distributed
- Normally it is not possible.
- But charging current of cable or OH Line is the example of uniform loading.



Current = i Amp/ meter.

Resistance = r ohm/meter (Go + Return)

Total line length = l

Suppose, we take a differential element dx at a distance of x from the source.

Current entering at dx , differential element = $i(l - x)$

The Resistance of differential element = $r dx$

→ Voltage drop of differential element $dV = (i(1-x))(r dx)$

$$dV = ir(1-x)dx$$

→ Voltage drop up to x distance = $\int_0^x dV$

$$= \int_0^x ir(1-x)dx$$
$$= ir \left[1x - \frac{x^2}{2} \right]_0^x$$

$$V = ir \left[lx - \frac{x^2}{2} \right]$$

→ Total voltage drop in line of length l

Put $x = l$

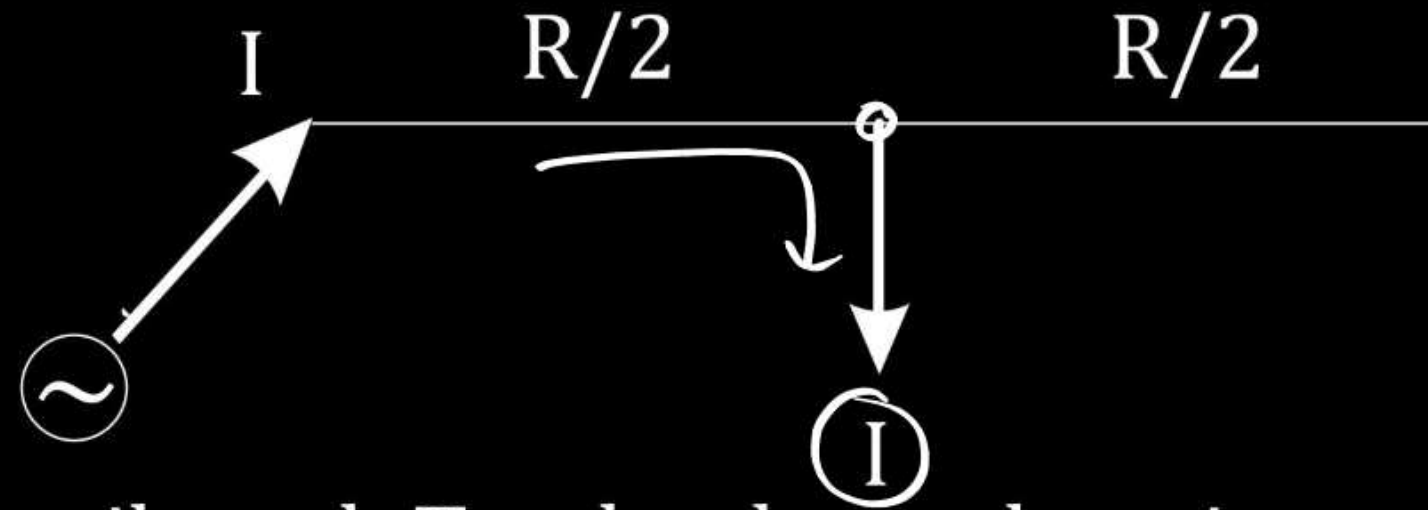
$$V = ir \left[l \cdot l - \frac{(l)^2}{2} \right]$$

$$V = ir \frac{l^2}{2} = \frac{(il)(rl)}{2}$$

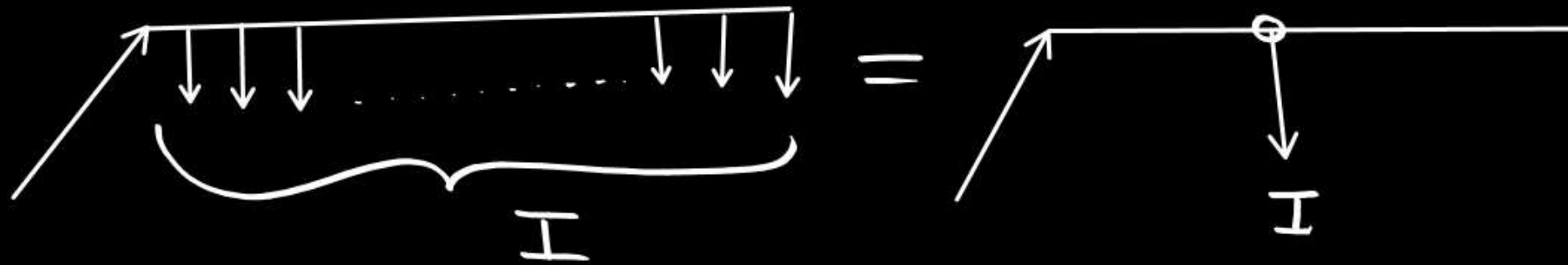
$$V = \frac{IR}{2}$$

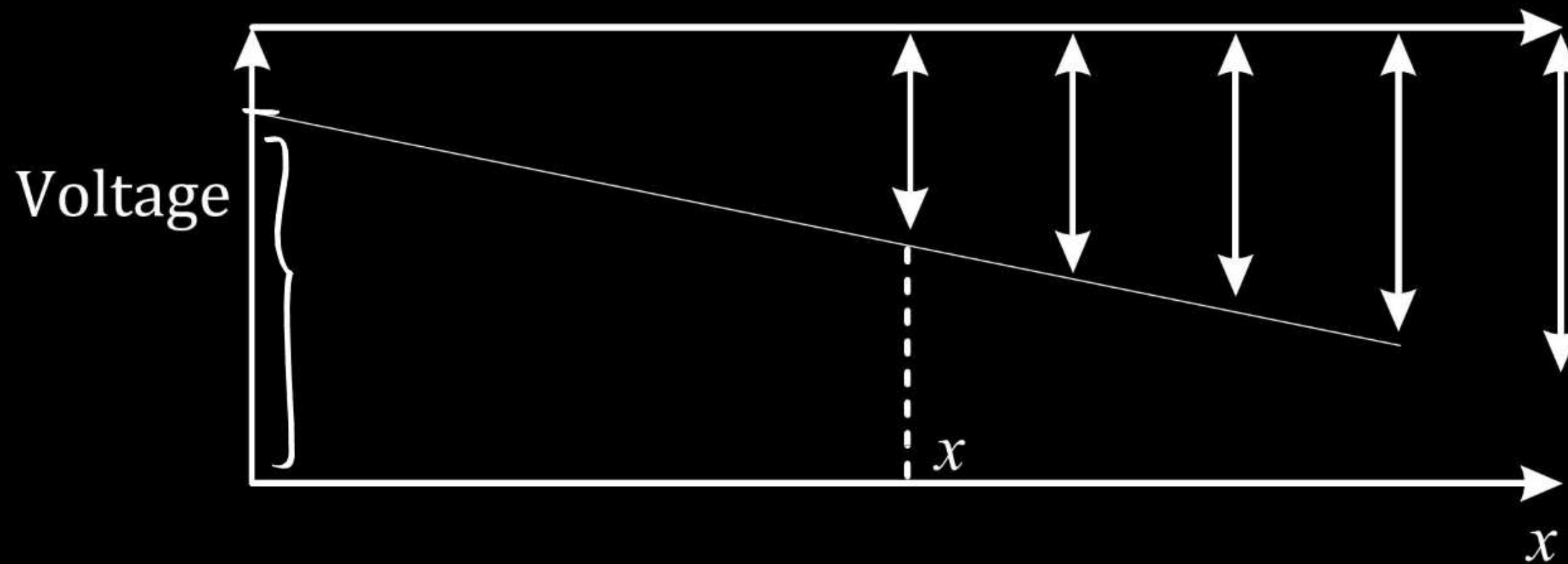
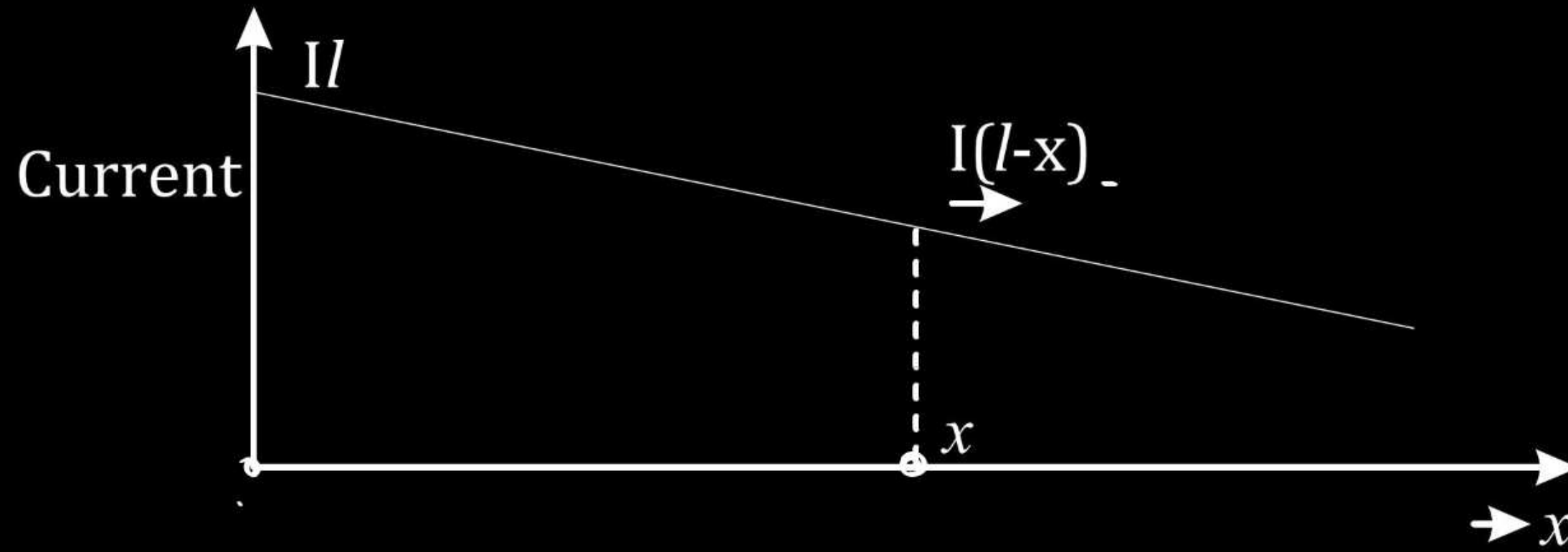
I = Total Current
 R = Total Resistance of line.

Ex.



So, In uniformly loaded Distributed. Total voltage drop is equal to that cause by whole load connected at the middle point of Distribution.





Power Loss:

→ Power loss in differential element $dP = [i(1-x)]^2 [r dx]$

$$dP = i^2 r (1-x)^2 dx$$

$$dP = i^2 r (1^2 + x^2 - 21x) dx$$

→ Power loss up to x distance $P = \int_0^x dP$

$$P = i^2 r \int_0^x (1^2 + x^2 - 21x) dx$$


$$P = j^2 \gamma \left[j^2 x + \frac{x^3}{3} - 2j \frac{x^2}{2} \right]_0^x$$

$$P = j^2 \gamma \left[j^2 x + \frac{x^3}{3} - jx^2 \right]$$

Total power Loss:

Total power loss in a line of l length

Put $x=l$

$$P = I_0^2 r \left[\cancel{I^2(1)} + \frac{(1)^3}{3} - \cancel{1(I^2)} \right]$$

$$P = I_0^2 r \frac{1^3}{3}$$

$$P = \frac{(I_0)^2 (r l)}{3} = \frac{I^2 R}{3}$$

Question



A 2-wire D.C. distributor 250 meters long is uniformly loaded with 2A/meter.

Resistance of single wire is $0.3 \Omega/\text{km}$ If the distributor is fed at one end, calculate:

- (i) the voltage drop upto a distance of 150 m from the feeding point
- (ii) the maximum voltage drop

$$l = 250 \text{ m}$$

$$x = 150$$

$$i^0 = 2 \text{ A/m}$$

$$r = 2 \times 0.3 = \frac{0.6 \Omega}{1000 \text{ m}}$$

$$V = j\omega \left[1x - \frac{x^2}{2} \right]$$

$$V = \frac{2 \times 0.6}{1000} \left[(250)(150) - \frac{(150)^2}{2} \right]$$

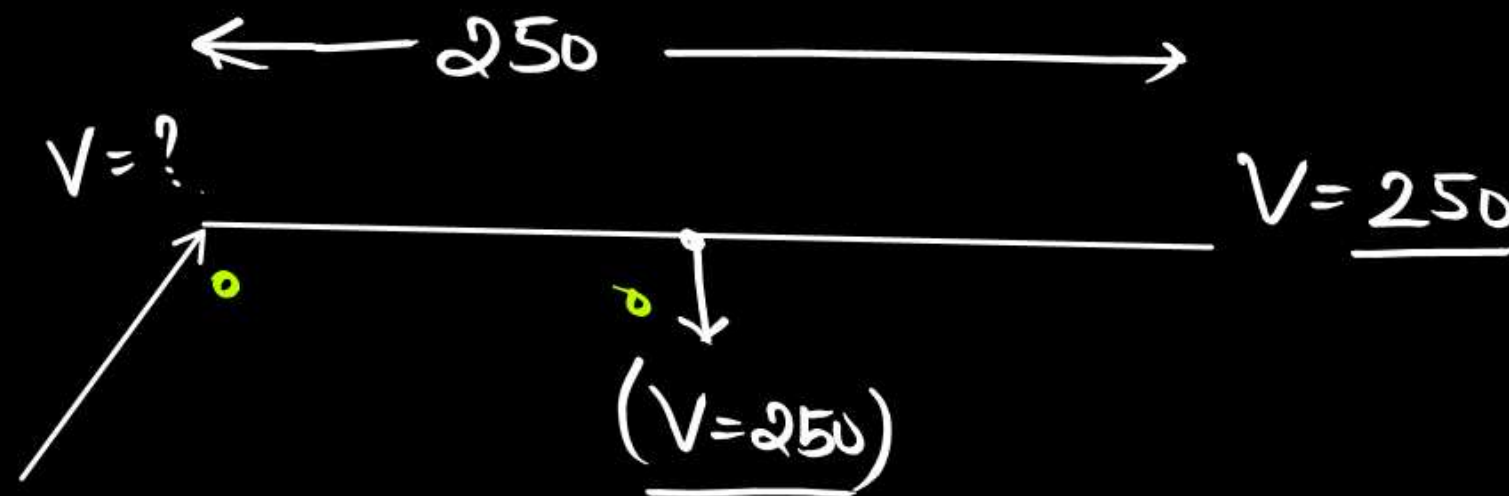
$$V = 31.5.$$

$$(11) \quad V = j\omega \frac{1^2}{2} = \frac{2 \times 0.6}{1000} \left(\frac{250^2}{2} \right)$$
$$= \underline{\underline{37.5}}$$

Question



A 250 m, 2-wire d. c. distributor fed from one end is loaded uniformly at the rate of 1.2 A/meter. The resistance of each conductor is 0.002 Ω per meter. Find the voltage necessary at feed point to maintain 250 V (i) at the far end (ii) at the mid-point of the distributor.



$$\begin{aligned} l &= 250 \text{ m} \\ i &= 1.2 \text{ A/m} \\ r &= 0.004 \end{aligned}$$

$$\begin{aligned}\text{Total voltage drop} &= I^2 \frac{l}{2} = (1.2)(0.004) \left(\frac{250^2}{2} \right) \\ &= 150\text{V}\end{aligned}$$

$$\begin{aligned}\text{So Voltage at Sending end} &= 250 + 150 \\ &= \underline{400}\end{aligned}$$

$$(11) \quad l = 250\text{m}$$

$$x = 125\text{m}$$

Voltage drop up to x distance

$$= I^0 r \left[lx - \frac{x^2}{2} \right]$$

$$= (1.2)(0.004) \left[(250)(125) - \frac{(125)^2}{2} \right]$$

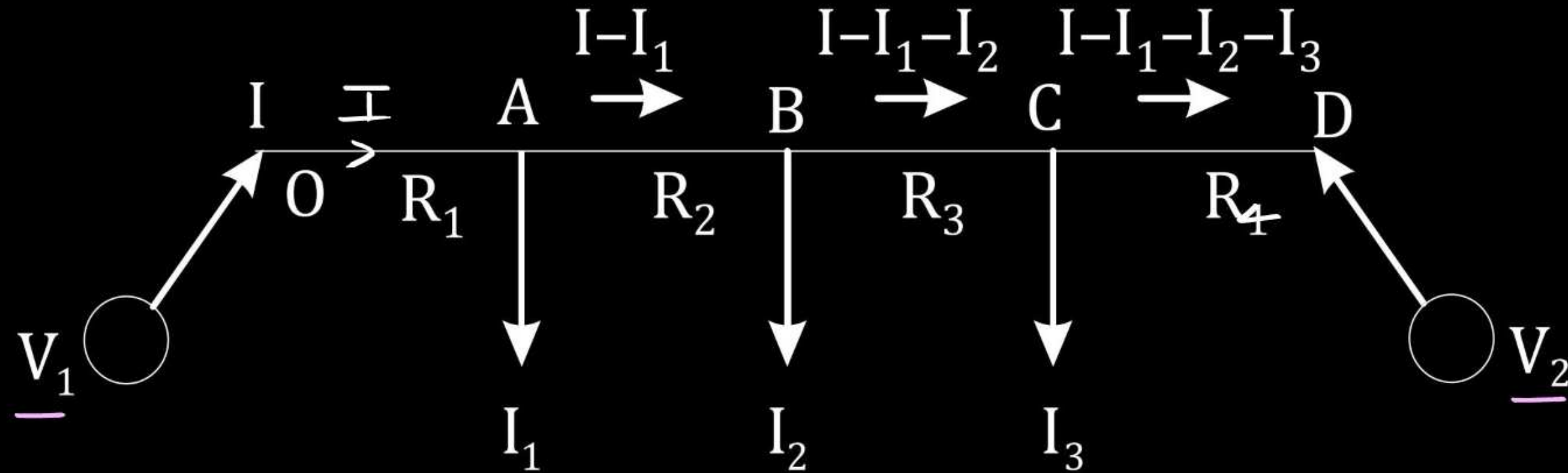
$$= \underline{112.5}$$

$$V = 250 + 112.5$$

$$= 362.5$$

Radial Distributor feeding from two end (D.C.) :

- If distributor is feed from one end. The voltage at far end from source will be Minimum.
- So now this Radial distributor supplied from two end (it may be at same voltage or may be at different voltage)
- When Radial Distributor is feed from two side Minimum voltage occur at a point. Where current direction reverses. After this point voltage start Increasing



Suppose we assume current entering at one point.

So Total voltage drop between 0 point & D point

$$(V_1 - V_2) = IR_1 + (I - I_1)R_2 + (I - I_1 - I_2)R_3 + (I - I_1 - I_2 - I_3)R_4$$

$$(V_1 - V_2) = I(R_1 + R_2 + R_3 + R_4) - I_1(R_2 + R_3 + R_4) - I_2(R_3 + R_4) - I_3 R_4$$

$$I = \frac{(V_1 - V_2) + I_1(R_2 + R_3 + R_4) + I_2(R_3 + R_4) + I_3 R_4}{R_1 + R_2 + R_3 + R_4}$$

$$I = \frac{(\text{Diff of voltage at both ends} + I_1(\text{Resistance after } I_1) + I_2(\text{Resistance after } I_2) + \dots)}{\text{Total Resistance}}$$

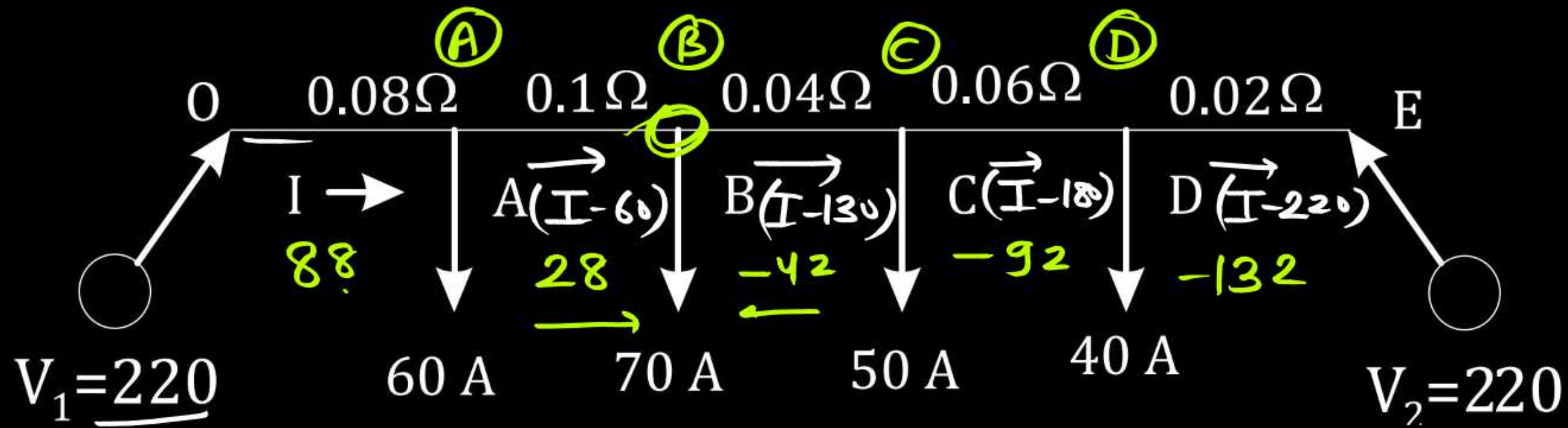
if $V_1 = V_2$

$$I = \frac{I_1(R_2 + R_3 + R_4) + I_2(R_3 + R_4) + I_3 R_4}{R_1 + R_2 + R_3 + R_4}$$

Steps :

- First find out the value of I .
- Now find out the current in the different part of distributor
- The point where the direction of current changes is the minimum voltage point

Q.

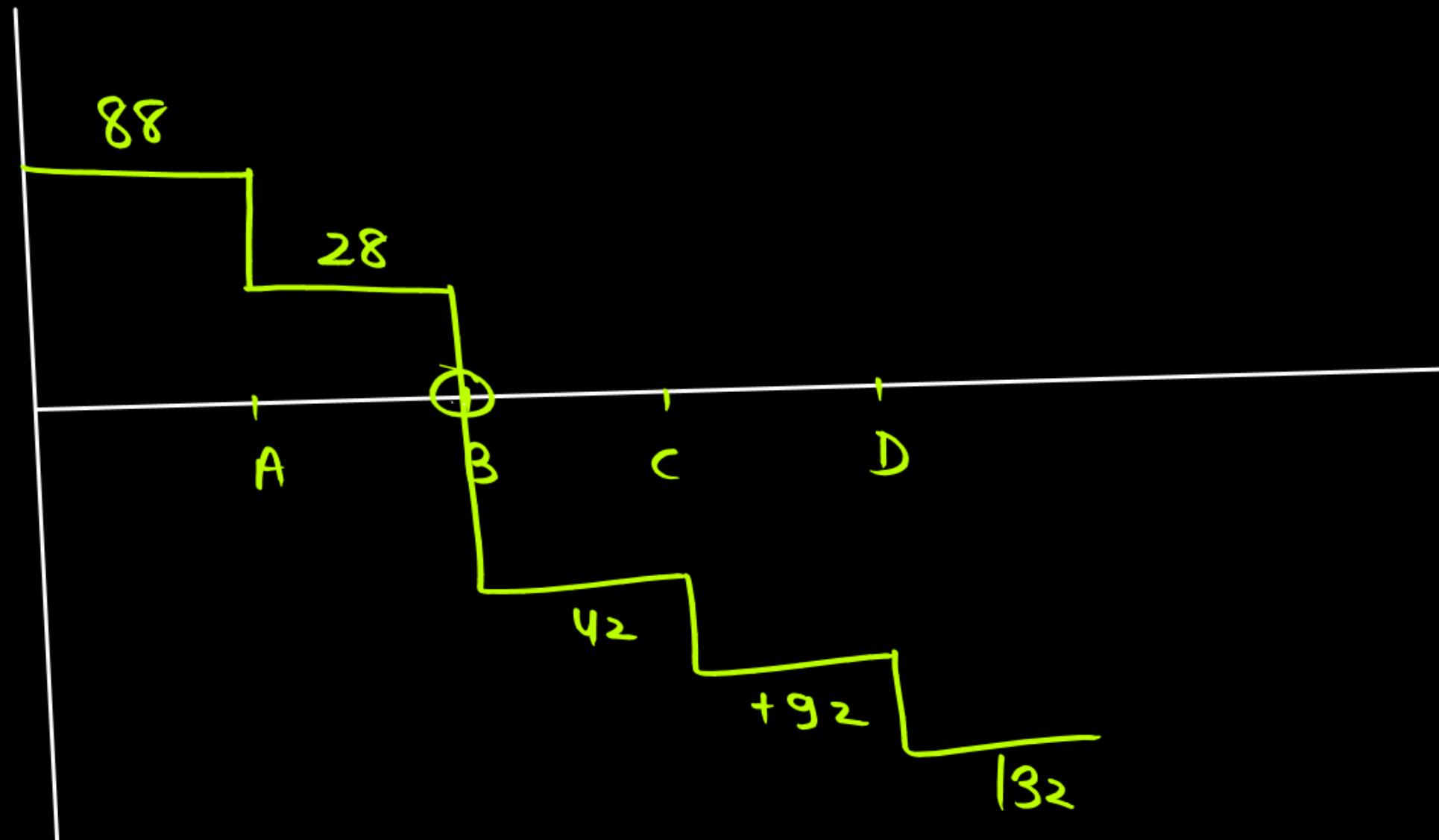


A, 2-wire d. c. distributor fed from both end is loaded as given in figure. The resistance of is given for both go and return conductors. Find out the location and magnitude of minimum voltage.

$$I = \frac{0 + 60(0.1 + 0.04 + 0.06 + 0.02) + 70(0.04 + 0.06 + 0.02) + 50(0.06 + 0.02) + 40(0.02)}{(0.08 + 0.1 + 0.04 + 0.06 + 0.02)}$$

$$I = \frac{0 + 60(0.22) + 70(0.12) + 50(0.08) + 40(0.02)}{0.3}$$

$$I = 88 \text{ Amp}$$



$$V_{mn} = 220 - (88)(0.08) - (28)(0.1)$$

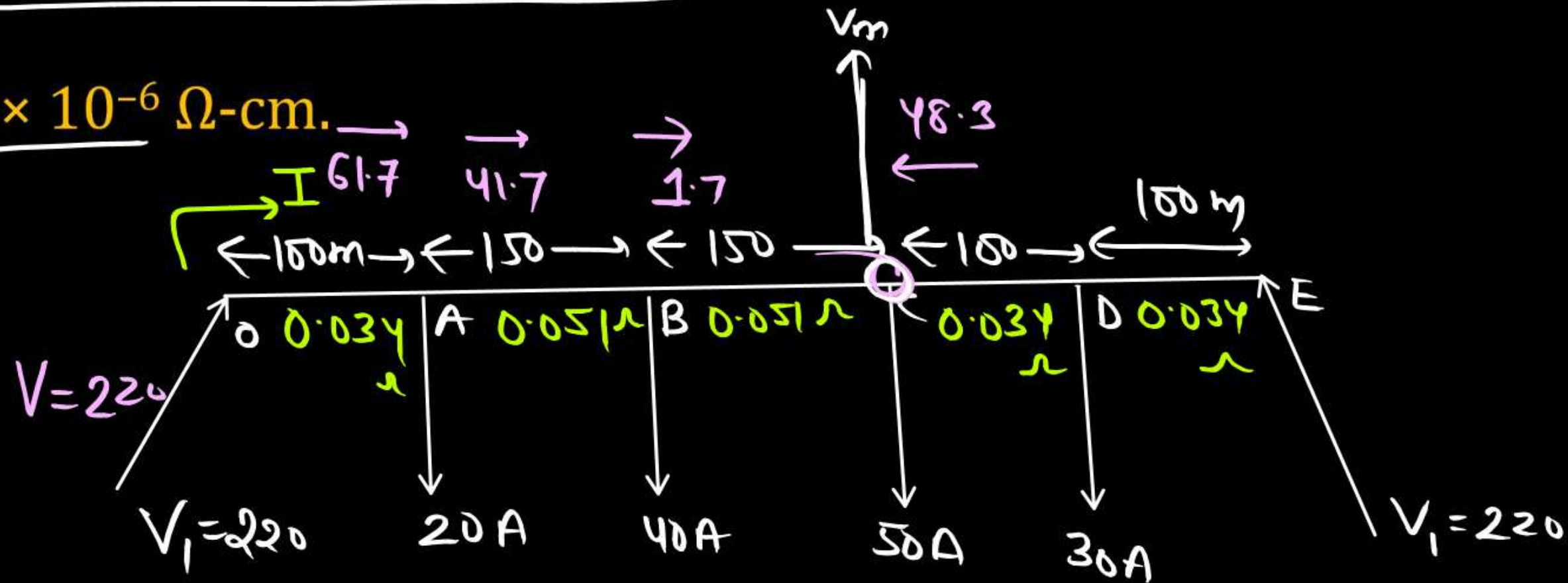
$$V_{mn} = 210.16$$

Question



A 2-wire d.c. street mains AB, 600 m long is fed from both ends at 220 V. Loads of 20 A, 40 A, 50 A and 30 A are tapped at distances of 100 m, 250 m, 400 m and 500 m from the end A respectively. If the area of X-section of distributor conductor is 1 cm², find the minimum consumer voltage.

Take $\rho = 1.7 \times 10^{-6} \Omega\text{-cm}$.



$$\begin{aligned} \text{Resistance of } 1^m \text{ length Distributor} &= \frac{\rho l}{a} \\ &= \frac{1.7 \times 10^{-6} \times 150}{1} = 1.7 \times 10^{-4} \end{aligned}$$

$$\text{(Go + Return) Resistance of OA} = 1.7 \times 10^{-4} \times 150 \times 2 = 0.034$$

$$,, \quad ,, \quad AB = 1.7 \times 10^{-4} \times 150 \times 2 = 0.051$$

$$,, \quad ,, \quad BC = 1.7 \times 10^{-4} \times 150 \times 2 = 0.051$$

$$,, \quad ,, \quad CD = 1.7 \times 10^{-4} \times 150 \times 2 = 0.034$$

$$DE = 1.7 \times 10^{-4} \times 150 \times 2 = 0.034$$

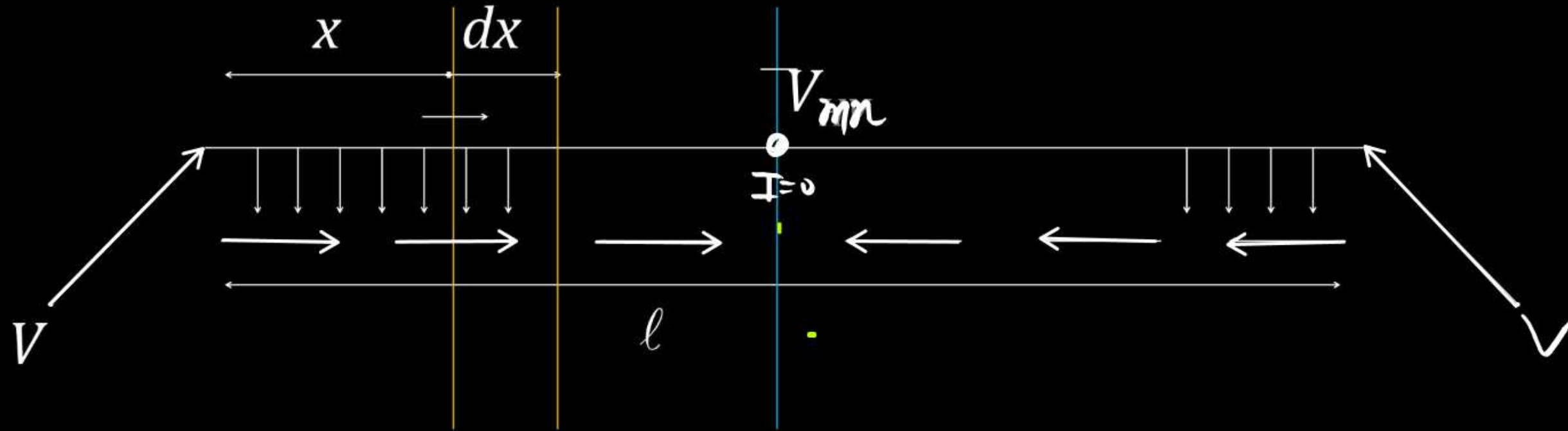
$$I = \frac{(0) + 20(0.051 + 0.051 + 0.034 + 0.034) + 40(0.051 + 0.034 + 0.034) + 50(0.034 + 0.034) + 30(0.034)}{(0.034 + 0.051 + 0.051 + 0.034 + 0.034)}$$

$$I = \underline{61.7}$$

$$V_{\min} = 220 - (61.7 \times 0.034) - (41.7 \times 0.051) - (1.7 \times 0.051)$$

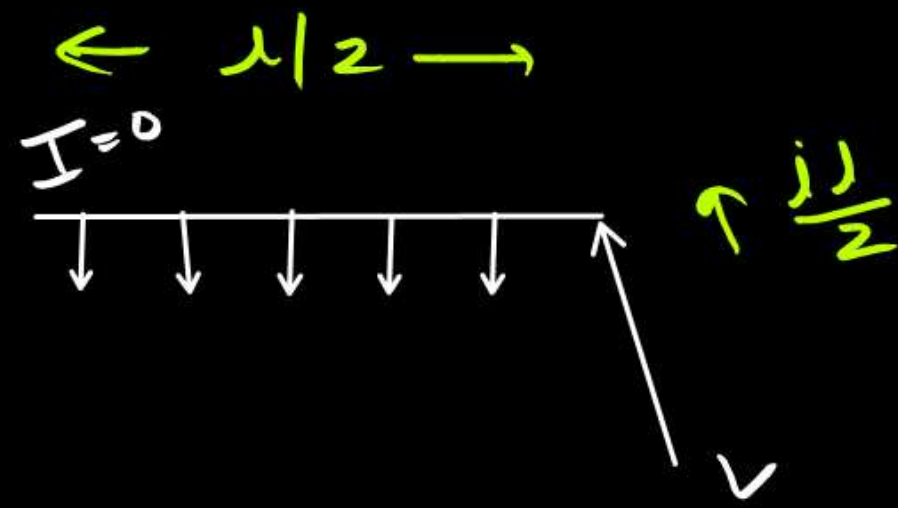
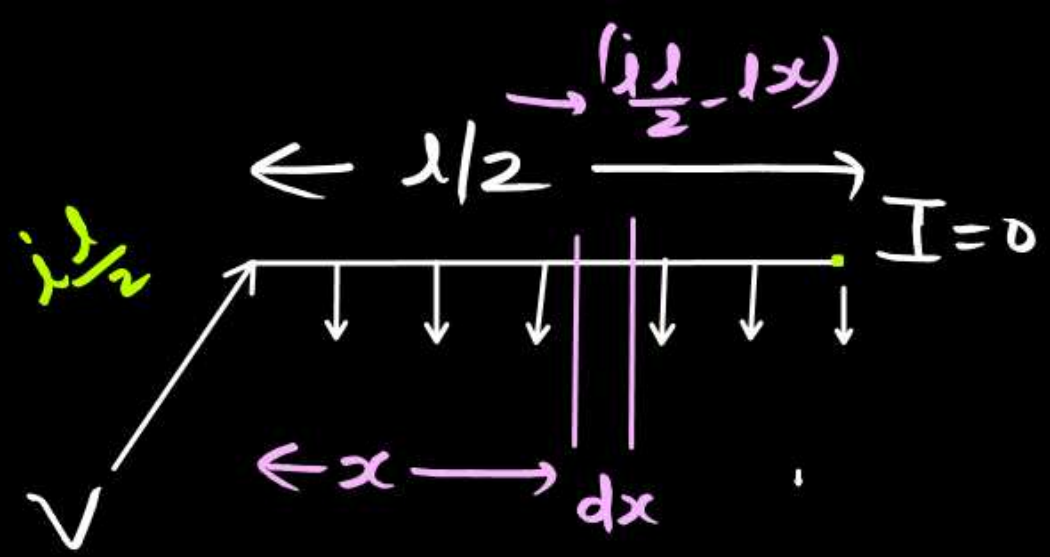
$$V_{\min} = 215.69.$$

Radial Distributor with uniform loading feeding from both side with equal voltage:



Resistance of distributor = r Ω /m.
 Current in distributor = i A/m.

Due to uniform loading, minimum voltage occur at the midpoint ($\ell/2$) distance from any end.



Both end voltage are equal so current supplied from each end = $\frac{i l}{2}$

Suppose, we take a differential element dx at a distance of x from the source.

Current entering at the differential element dx is $= i(l/2 - x)$

The Resistance of differential element $= r dx$

Voltage drop: :

Voltage drop of differential element $dV = \left[j\left(\frac{l}{2} - x\right) \right] [r dx]$

$$dV = jI_r \left(\frac{l}{2} - x \right) dx$$

Voltage drop up to x distance = $\int_0^x dV$

$$= jI_r \int_0^x \left(\frac{l}{2} - x \right) dx$$

$$V = jI_r \left(\frac{l}{2}x - \frac{x^2}{2} \right)$$

So minimum Voltage occur at $x = l/2$

So Max^m Voltage

$$V = I^0 r \left[\frac{l}{2} \left(\frac{l}{2} \right) - \frac{(l/2)^2}{2} \right]$$

$$V = I^0 r \left[\frac{l^2}{4} - \frac{l^2}{8} \right]$$

$$V = \frac{I^0 r l^2}{8}$$

$$V = \frac{(Il)(rI)}{8} = \frac{IR}{8}$$

Power loss :



Power loss of differential element $dP = \left[i \left(\frac{1}{2} - x \right) \right]^2 [r dx]$

$$dP = i^2 r \left(\frac{1}{4} + x^2 - 1x \right) dx$$

Power loss up to x distance = $\int_0^x dP = i^2 r \int_0^x \left(\frac{1}{4} + x^2 - 1x \right) dx$

$$P = i^2 r \left[\frac{1}{4}x + \frac{x^3}{3} - \frac{1x^2}{2} \right]$$

Total power loss :

Total power loss in l length line
 $x=l$

$$P = I^2 r \left[\frac{I^2}{4} \cdot l - \frac{I^3}{3} - \frac{I I^2}{2} \right]$$

$$P = I^2 r \left[\frac{I^3}{4} + \frac{I^3}{3} - \frac{I^3}{2} \right]$$

$$P = I^2 r \frac{I^3}{12}$$

$$P = \frac{(I l)^2 (r l)}{12} = \frac{I^2 R}{12}$$



2 Minutes Summary

→ D.C distributor uniform loading feed from one end.

→ D.C distributed feed from both ends $\begin{cases} \text{Concentric} \\ \text{Uniform.} \end{cases}$

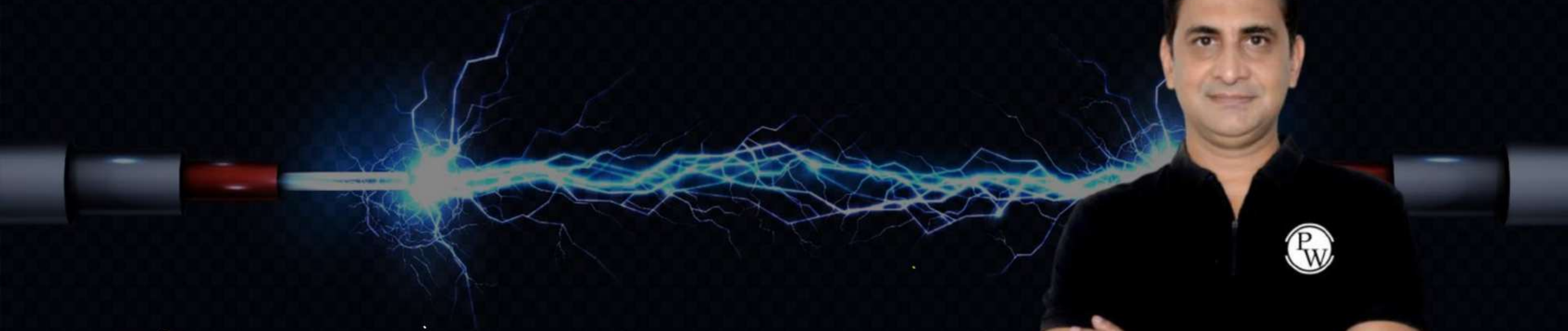
Thank you

GW
Soldiers !



Electrical Engineering

Power System



Lecture No.-3

Distribution

By- Ajay Gupta Sir



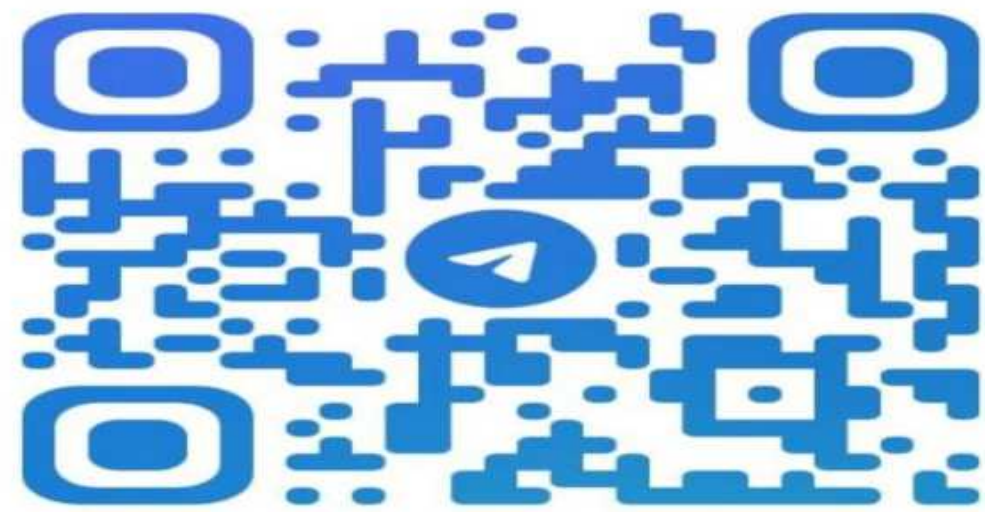
Recap Of previous class

- ✓ 1. Radial distribution uniform loading
- ✓ 2. Radial distributor fed from both end
- ✓ 3. Radial uniform loading fed both end



Topics to be Covered

- ✓ 1. Radial distribution uniform loading
Fed both end by different voltage
- ✓ 2. Ring distribution
- ✓ 3. Interconnected network
- ✓ 4. A.C. distribution



@AJAYGUPTASIRPW

Question



A two-wire D.C. distributor cable 800 meters long is loaded with 0.4 A/meter. Resistance of each conductor is $0.05 \Omega/\text{km}$. Calculate the maximum voltage drop if the distributor is fed from both ends with equal voltages of 200 V. What is the minimum voltage and where it occurs?

$$I = 0.4 \text{ A/m}$$

$$R(\text{Go + Return}) = 2 \times 0.05 = 0.1 \frac{\Omega}{\text{km}} = \frac{0.1 \Omega}{1000 \text{ m}}$$

$$\text{Max}^m \text{ Voltage drop} = \frac{IR}{8} = \frac{I^2 R}{8}$$

$$= 0.4 \times \frac{0.1}{1000} \times \frac{(800)^2}{8}$$

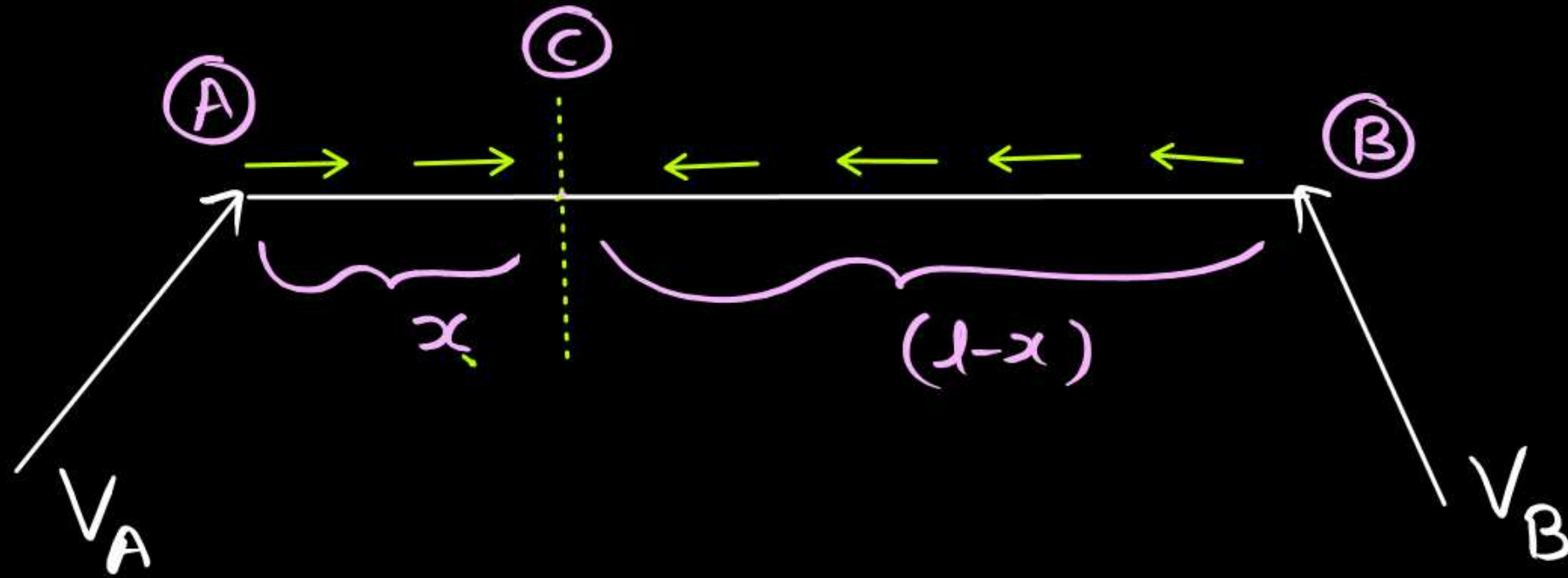
$$= 3.2 \text{ Volt}$$

$$\begin{aligned} V_{\min} &= 200 - 3.2 \\ &= 196.8 \end{aligned}$$

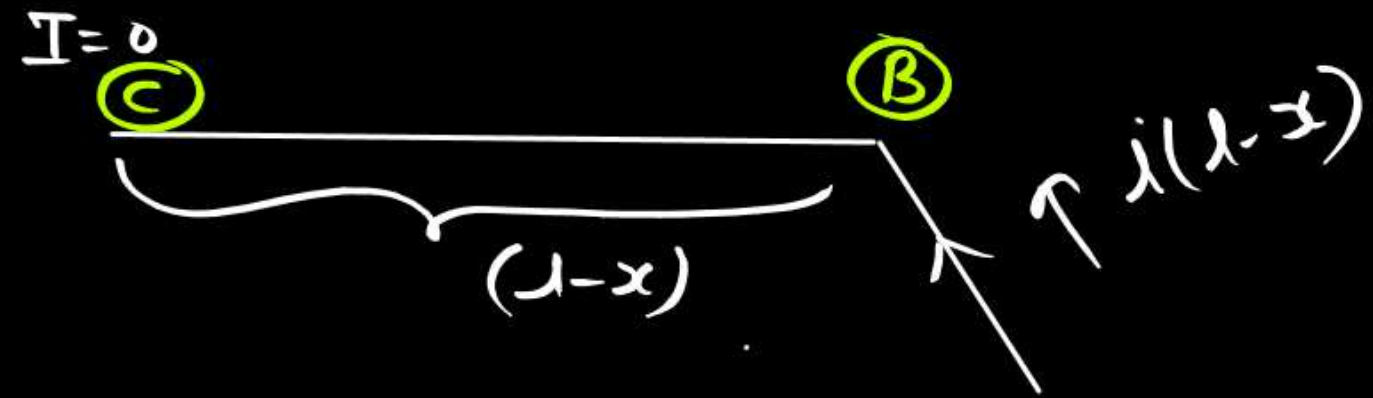
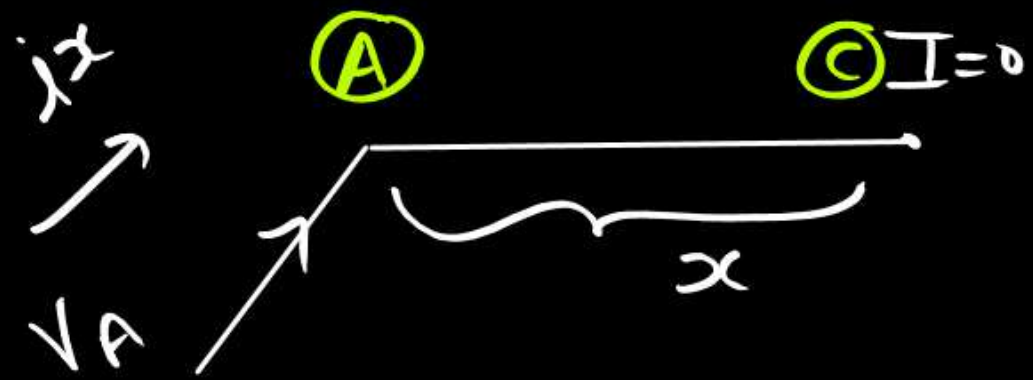
$$\text{Power loss} = \frac{I^2 R}{12}$$

$$= \frac{i^2 R l^3}{12} = \frac{(0.4)^2 (0.1) \times (800)^3}{12 \times 1000} = 682.66 \text{ W}$$

Radial Distributor with uniform loading feeding from both side with unequal voltage(D.C):



Resistance of distributor = $r \Omega/\text{m}$. Current in distributor = $i \text{ A/m}$.



$$\frac{IR}{2} = \frac{jxj^2}{2}$$

Let the distributor is fed from A and B point with V_A and V_B

Suppose, the point of minimum potential (point C) exist at a distance of x from the A point.

$$\text{Voltage drop in section AC} = \frac{j\gamma x^2}{2}$$

$$V_C = V_A - \frac{j\gamma x^2}{2} \quad \text{--- (1)}$$

$$\text{Voltage drop in section BC} = \frac{j\gamma (1-x)^2}{2}$$

$$V_C = V_B - \frac{j\gamma (1-x)^2}{2} \quad \text{--- (2)}$$

From eqn (1) and (2)

$$V_A - \frac{j\omega x^2}{2} = V_B - \frac{j\omega (1-x)^2}{2}$$

$$V_A - \frac{j\omega x^2}{2} = V_B - \frac{(j\omega 1^2 + j\omega x^2 - 2j\omega 1x)}{2}$$

$$V_A = V_B - \frac{j\omega 1^2}{2} + j\omega 1x$$

$$x = \frac{(V_A - V_B)}{j\omega l} + \frac{1}{2}$$

Steps:

1. First find out the value of x
2. Then find out the voltage drop in section $AC = irx^2/2$
3. So minimum voltage at the point $C = V_A - irx^2/2$

Question



A 2-wire D.C. distributor AB 400 meters long is fed from both ends and is loaded uniformly at the rate of 1.0 A/meter. At feeding point, A, the voltage is maintained at 250 V and at B at 240 V. If the resistance of each conductor is 0.1 Ω per kilometer, determine:

- (i) the minimum voltage and the point where it occurs
- (ii) the currents supplied from feeding points A and B

Step 1

$$j = 1 \text{ A/m}$$

$$r(\text{go + Return}) = \frac{0.2 \Omega}{1000} = 2 \times 10^{-4} \Omega/\text{m}$$

$$x = \frac{V_A - V_B}{j\omega L} + \frac{1}{2}$$

$$x = \frac{250 - 240}{1 \times 2 \times 10^{-4} \times 400} + \frac{400}{2}$$

$$x = 125 + 200 = 325$$

Step 2

Voltage drop in AC

$$= \frac{j\omega L x^2}{2}$$

$$= \frac{1 \times 2 \times 10^{-4} \times (325)^2}{2}$$

$$= 10.5625$$

$$V_C = V_A - 10.5625$$

$$= 250 - 10.5625$$

$$= 239.43$$

$$\begin{aligned}\rightarrow \text{Current feed from A point} &= i x \\ &= 1 \times 325 = 325 \text{ A}\end{aligned}$$

$$\begin{aligned}\rightarrow \text{Current feed from B point} &= i(1-x) \\ &= 1(400-325) \\ &= 75 \text{ Amp}\end{aligned}$$

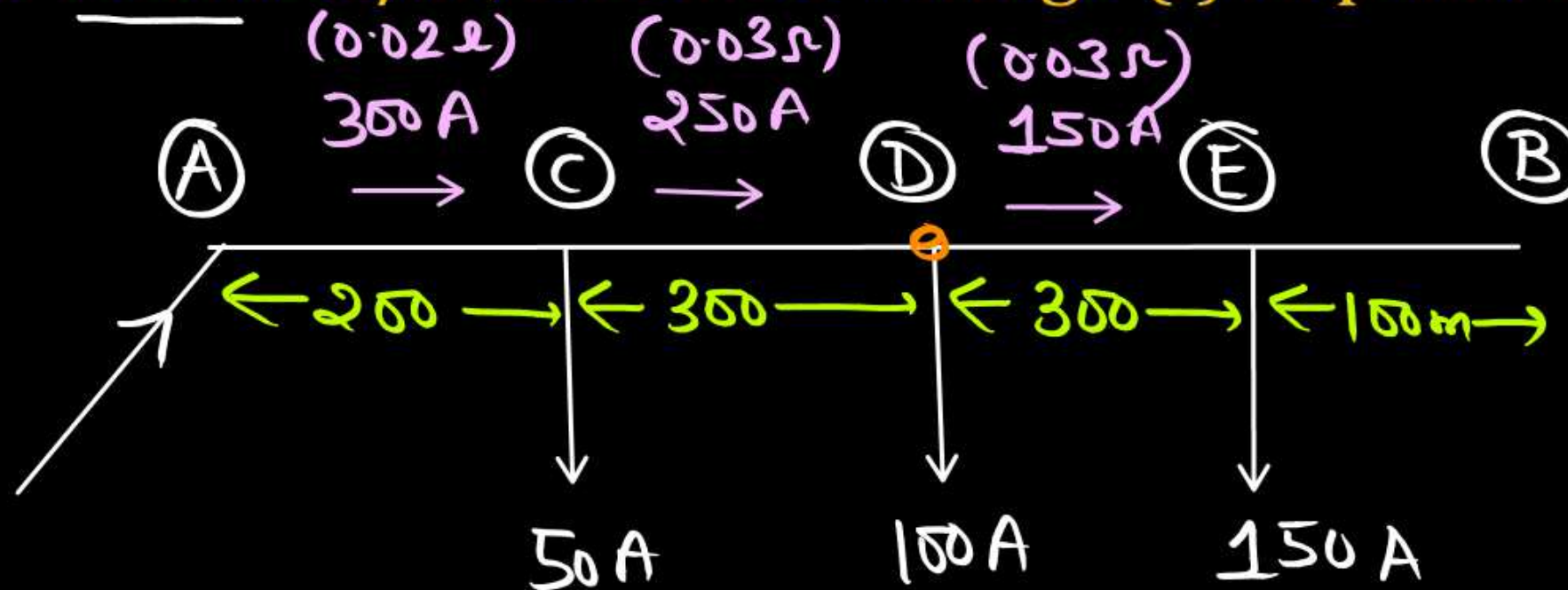
Radial Distributor with both uniform and concentric loading :

- These are several cases in which distributor have both concentric and uniform loading both.
- In that case total voltage drop in any section of the distributor is equal to the sum of voltage drop due to concentric and uniform loading in that section

Question



A 2-wired.c. distributor AB, 900 meters long is fed at A at 400 V and loads of 50 A, 100 A and 150 A are tapped off from C, D and E which are at 200 m, 500 m and 800 m from point A respectively. The distributor is also loaded uniformly at the rate of 0.5 A/m. If the resistance of distributor per meter (go and return) is $0.0001 \Omega/\text{m}$, calculate voltage (i) at point B and (ii) at point D.



$$\rightarrow \text{Resistance of AC} = 250 \times 1 \times 10^{-4} = 0.02$$

$$\rightarrow \text{Resistance of CD} = 300 \times 1 \times 10^{-4} = 0.03$$

$$\rightarrow \text{Resistance of DE} = 300 \times 1 \times 10^{-4} = 0.03$$

$$\rightarrow \text{Voltage drop due to concentric loading} =$$

$$= (150 \times 0.03) + (250 \times 0.03) + (300 \times 0.02) = 18$$

$$\begin{aligned}\rightarrow \text{Voltage drop due to uniform loading} &= \frac{18l^2}{2} \\ &= \frac{(0.5 \times 1 \times 10^4 \times (900)^2)}{2} \\ &= 20.25.\end{aligned}$$

$$\text{So Total voltage drop} = 18 + 20.25 = 38.25.$$

$$\begin{aligned}V_B &= 400 - 38.25 \\ &= 361.75\end{aligned}$$

(11) Voltage drop due to Concentric loading up to D point

$$= (300 \times 0.02) + (250 \times 0.03) = 13.5$$

Voltage drop due to uniform loading

$$= ir \left[lx - \frac{x^2}{2} \right]$$

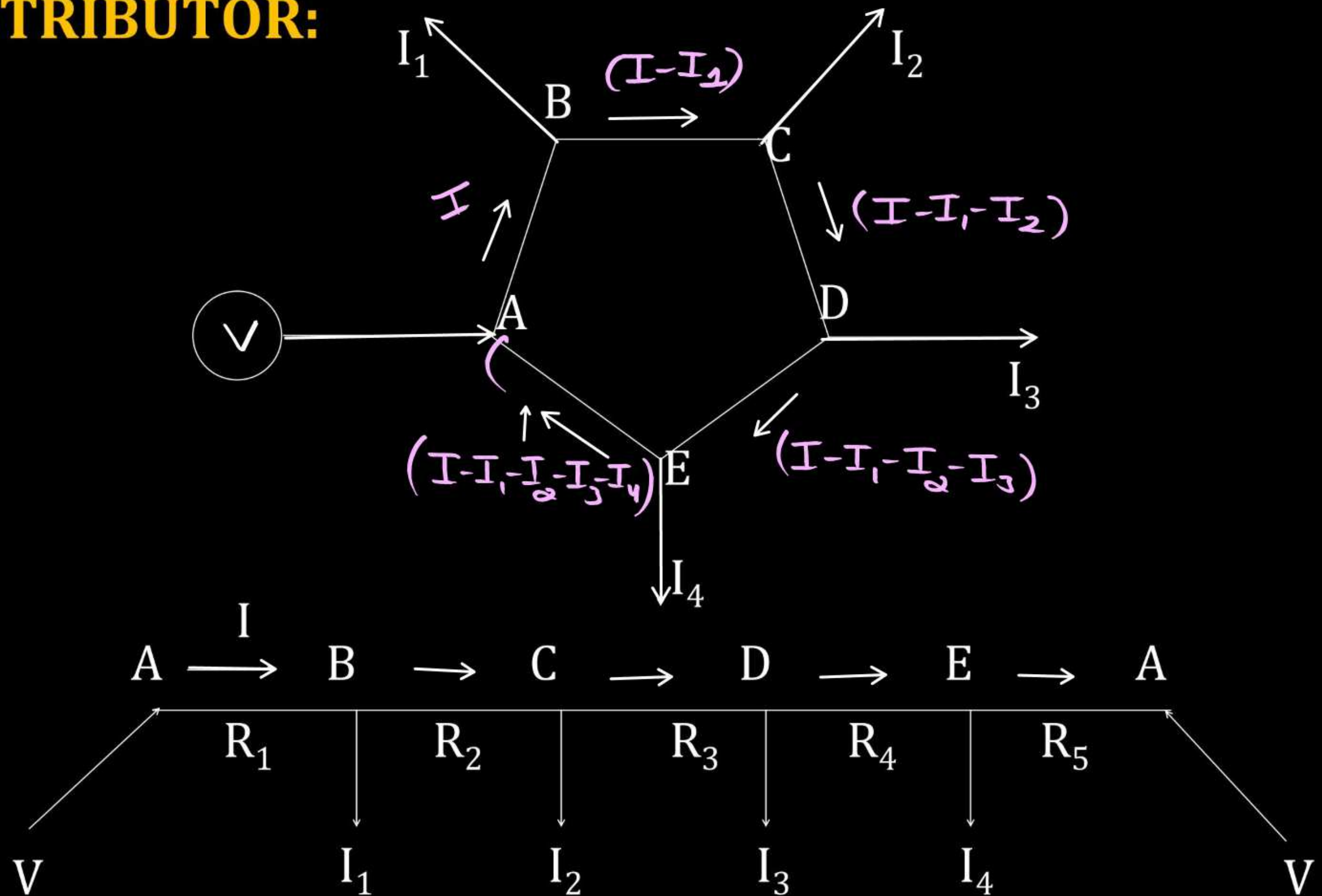
$$= 0.5 \times 1 \times 10^{-4} \left[(900)(500) - \frac{(500)^2}{2} \right] = 16.25$$

$$\text{Total Voltage drop} = 13.5 + 16.25 = 29.75$$

$$V_C = 400 - 29.75$$

$$V_C = 370.25 \text{ V}$$

RING DISTRIBUTOR:



First Method:



- Convert the ring distributor feed from one source into radial distributor having same voltage at both the end.
- Find out the value of I
- Now find out current in all the distributor branch
- When direction of current reverse, we will get minimum voltage.

Second Method:

- First mark the current in one branch of Ring
- Now mark the current in the remaining branches using KCL.
- Now apply the KVL in the loop.
- Find out the value of current and the currents in the remaining branches..

Question

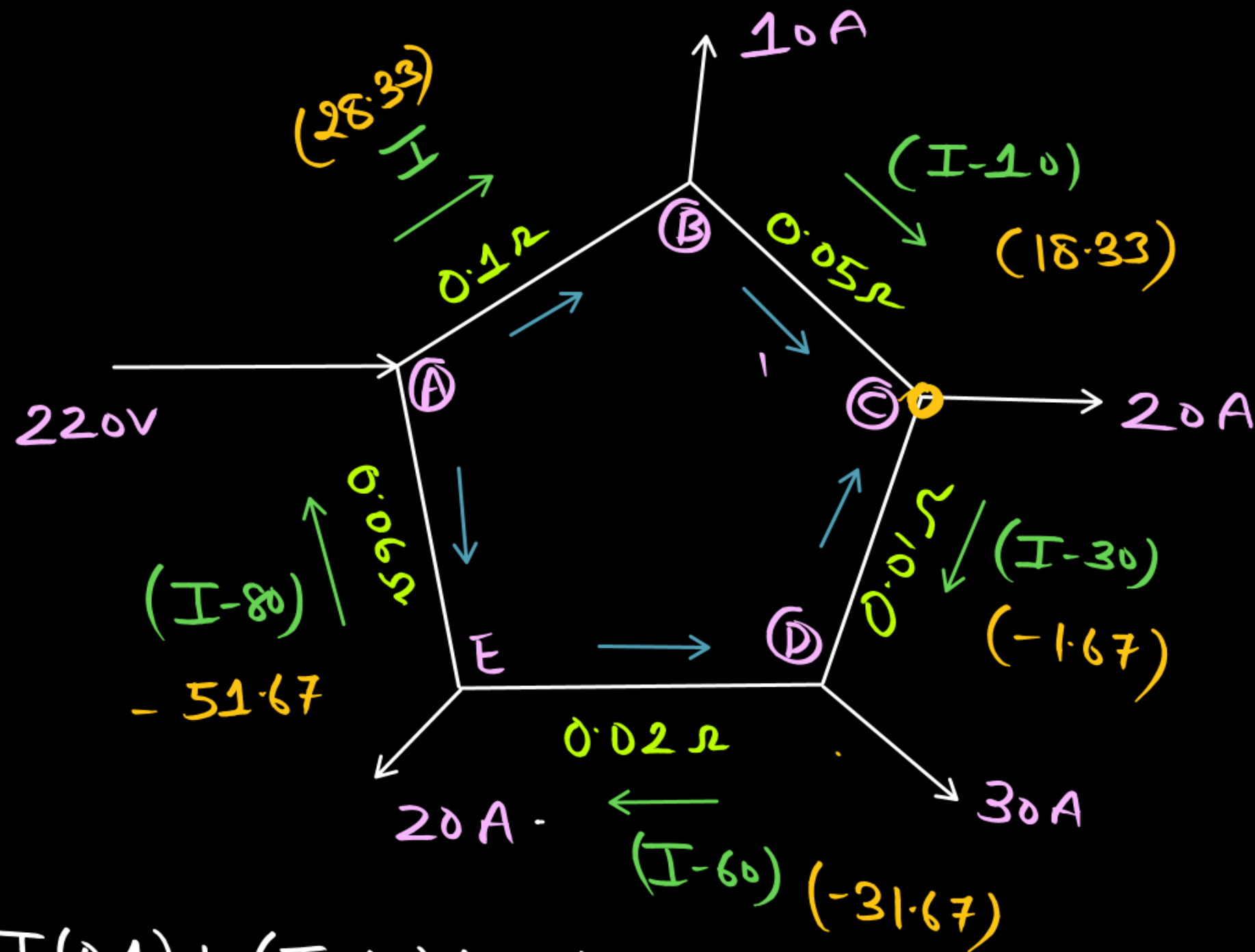


A 2-wire D.C. distributor ABCDEA in the form of a ring main is fed at point A at 220 V and is looked as under :

10 A at B; 20 A at C; 30 A at D and 20 A at E.

The resistances of various sections (go and return) are $AB = 0.1 \Omega$; $BC = 0.05 \Omega$; $CD = 0.01 \Omega$; $DE = 0.02 \Omega$ and $EA = 0.06 \Omega$. Determine:

- (i) the point of minimum potential
- (ii) current in each section of distributor



KVL

$$I(0.1) + (I-10)(0.05) + (I-30)(0.01) + (I-60)(0.02) + (I-80)(0.06)$$

$$0.24I - 6.8 = 0$$

$$I = 28.33$$

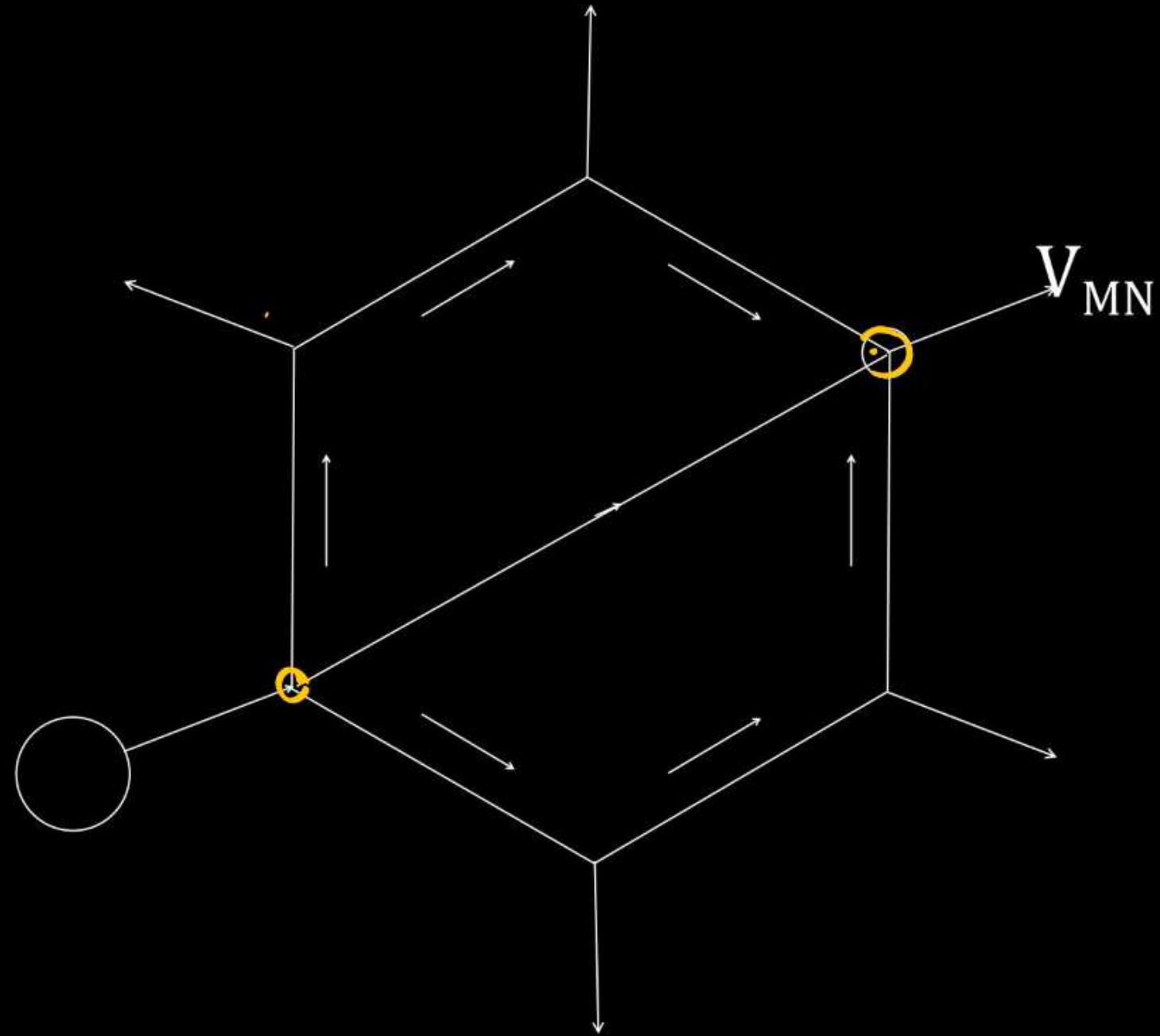
At point direction of current change. So c is min.

Voltage point

$$V_c = 220 - (28.33)(0.1) - (18.33)(0.05)$$

$$V_c = 216.25.$$

INTERCONNECTED DISTRIBUTOR:



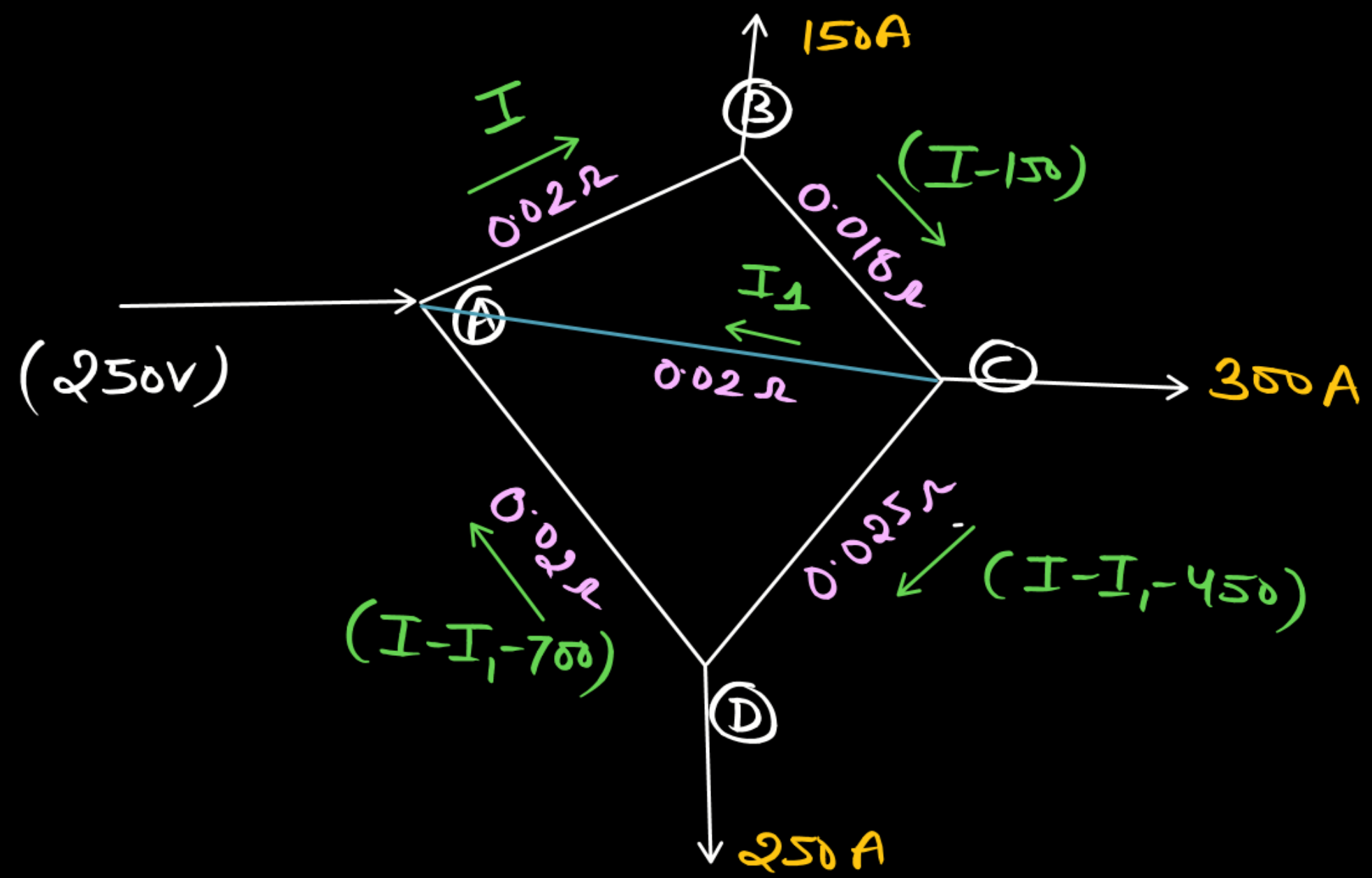
- If ring distributor fed from one source, there is a possibility that voltage magnitude of a point (Where minimum potential occur) is below the permissible limit.
- In order to increase this voltage, it is proposed to connected a interconnector between source and minimum potential point so some current from source directly flow to this point and increase its voltage magnitude.
- Generally, the size of interconnector is about 50% of size of original distributor.

Question



A d.c. ring main ABCDA is fed from point A from a 250 V supply and the resistances (including both lead and return) of various sections are as follows : $AB = 0.02 \, \Omega$; $BC = 0.018 \, \Omega$; $CD = 0.025 \, \Omega$ and $DA = 0.02 \, \Omega$. The main supplies loads of 150 A at B; 300 A at C and 250 A at D. Determine the voltage at each load point.

If the points A and C are linked through an interconnector of resistance $0.02 \, \Omega$, determine the new voltage at each load point.



KVL in ABCA

$$(I)(0.02) + (I - 150)(0.018) + I_1(0.02) = 0 \quad \text{--- (1)}$$

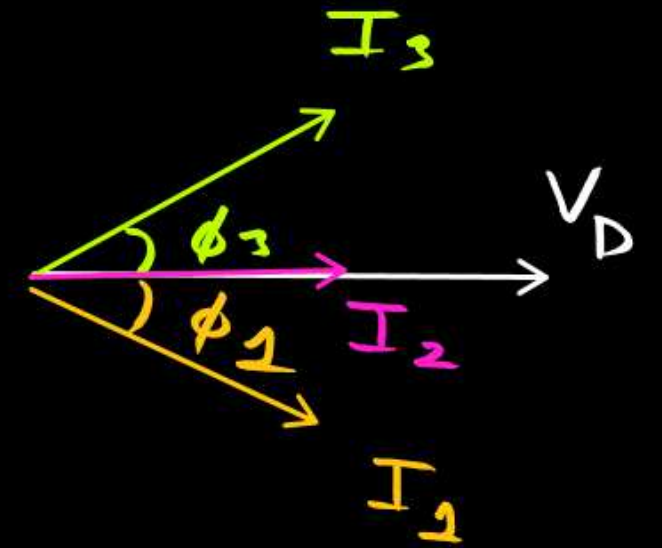
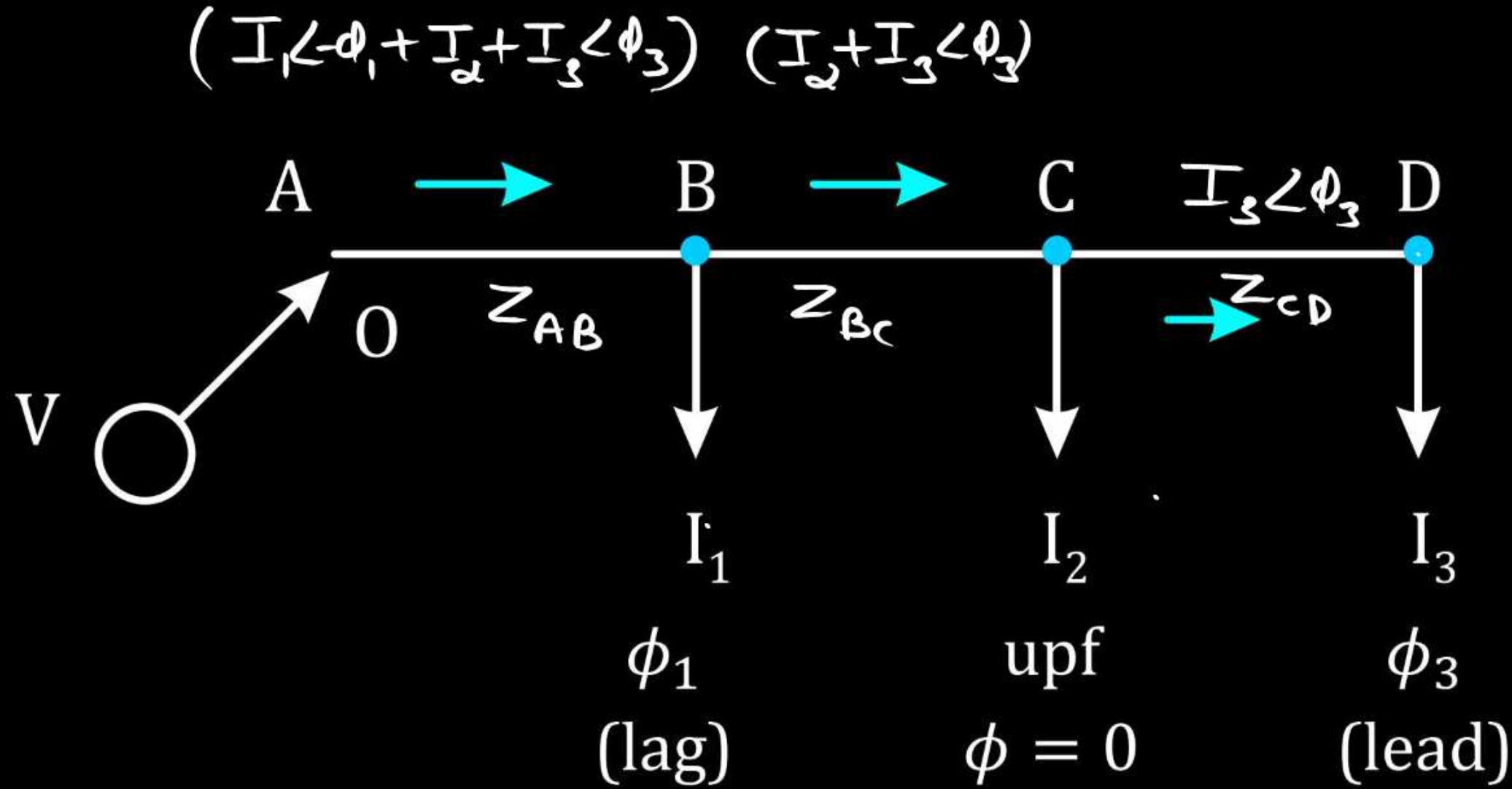
KVL in ACDA

$$-(I_1)(0.02) + (I - I_1 - 450)(0.025) + (I - I_1 - 750)(0.02) = 0 \quad \text{--- (2)}$$

From eqn (1) and (2) $I = 202$

$$I_1 = -249.66$$

3) Radial Distributor fed from one end (A.C.) → (power factor referred to receiving end voltage:



$$\longrightarrow \text{Total Voltage drop} = (I_1 \angle \phi_1 + I_2 + I_3 \angle \phi_3) Z_{AB} + \\ (I_2 + I_3 \angle \phi_3) Z_{BC} + (I_3 \angle \phi_3) Z_{CD}$$

$$\longrightarrow = (I_1 \angle \phi_1) (Z_{AB}) + I_2 (Z_{AB} + Z_{BC}) + (I_3 \angle \phi_3) (Z_{AB} + Z_{BC} + Z_{CD})$$

↑

Note :

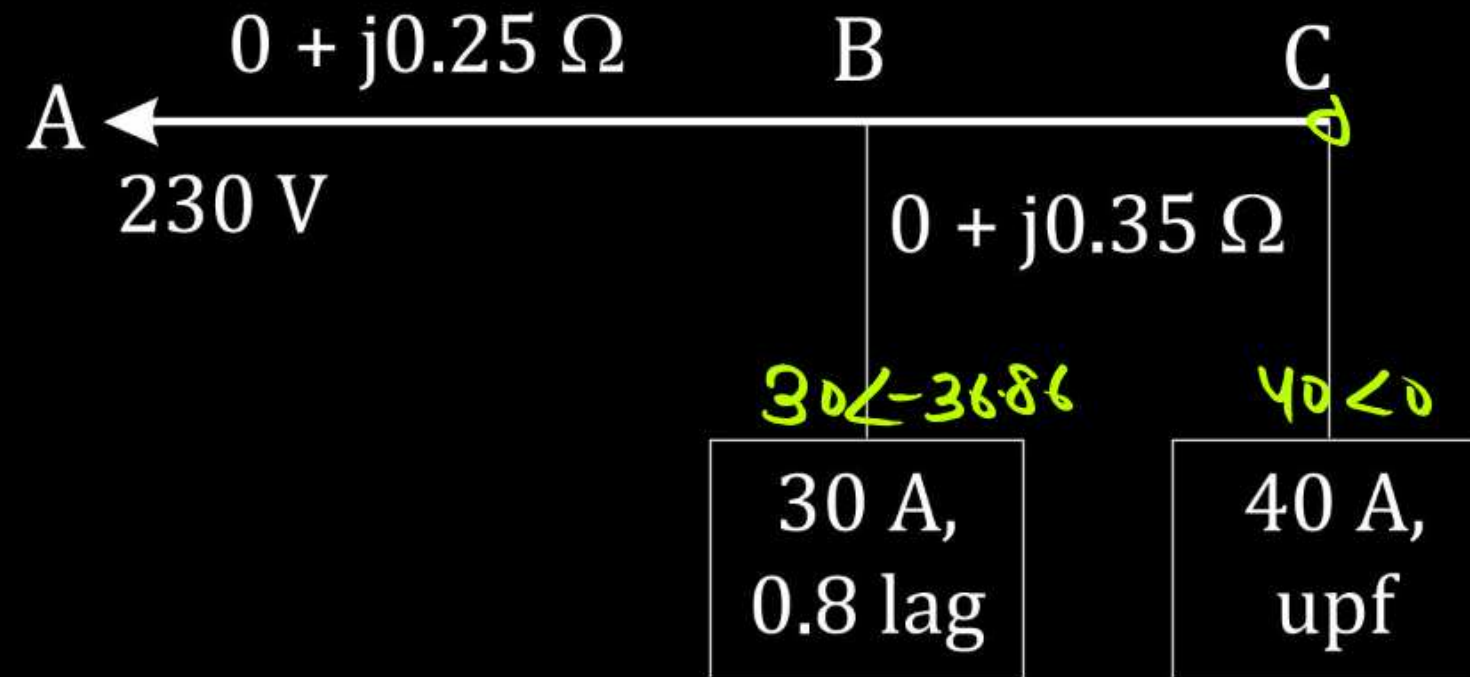
Generally if not given then we take all voltage angle same (Angle of V_C, V_D, V_B) are same

$$\delta_B = \delta_C = 0$$

Q.

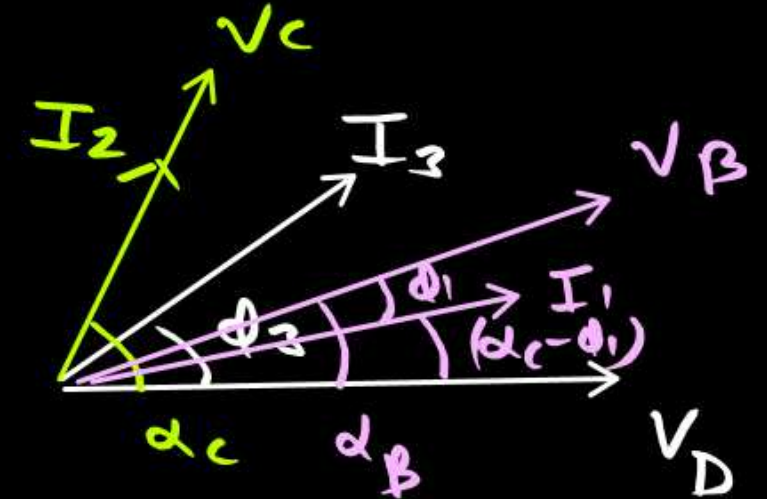
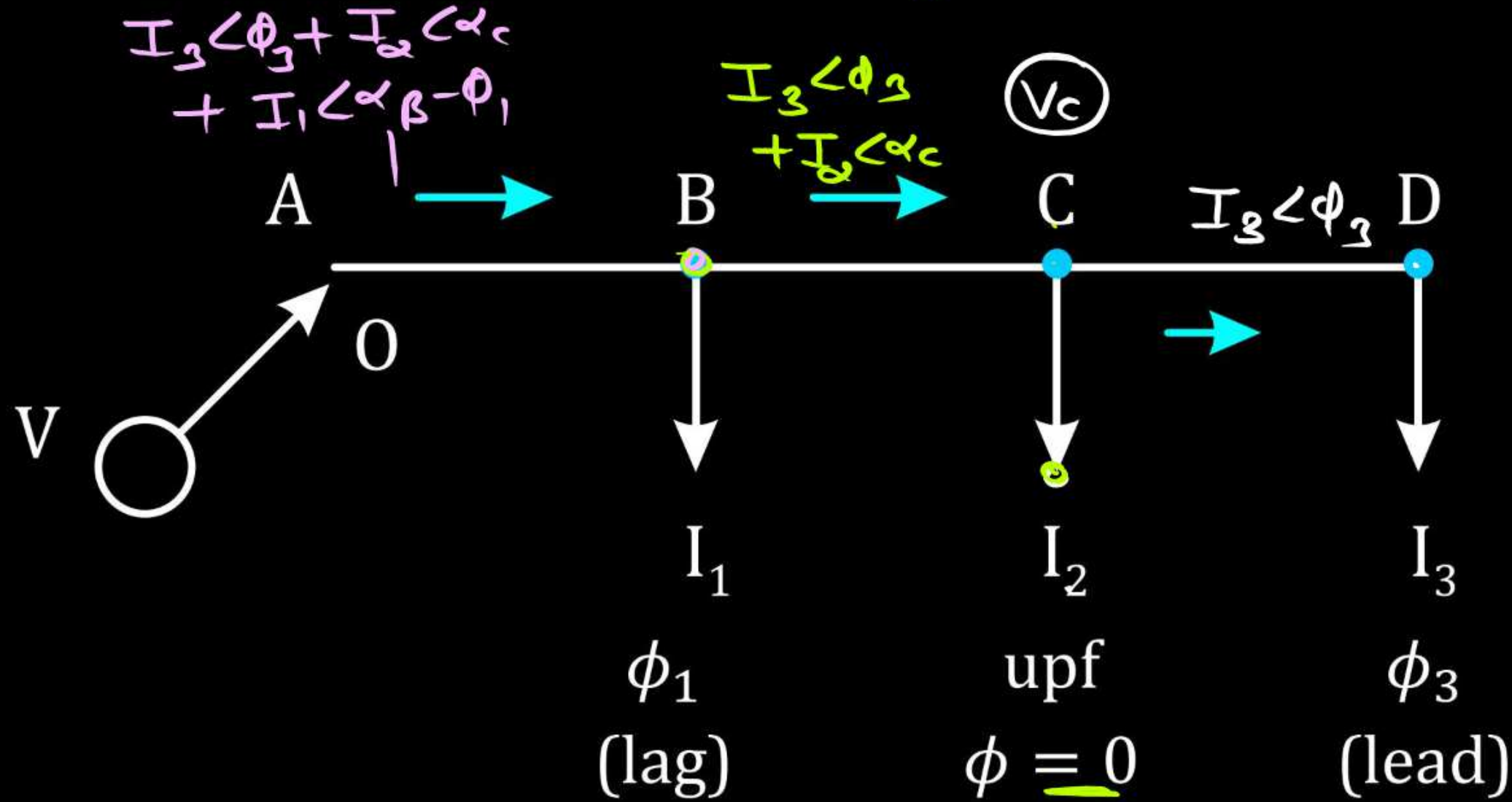
A single phase AC distributor supplies two single phase loads as shown in figure. The voltage drop from A to C is

- A** 4.5 V
- B** 31.5 V
- C** 30.34 V
- D** 20 V



$$\begin{aligned}
 \text{Total voltage drop} &= (30 \angle -36.87)(j0.25) + 40(j0.25 + j0.35) \\
 &= (7.5 \angle 53.17) + (24 \angle 90) \\
 &\approx 30.34 \angle 81.47
 \end{aligned}$$

3) Radial Distributor fed from one end (A.C.) → (power factor referred to respective load end voltage:



$$V_C \angle \alpha_C = V_D + (I_3 \angle \phi_3) (Z_{CD})$$

$$\bar{I}_2 = I_2 \angle \alpha_C$$

$$V_B \angle \alpha_B = V_C \angle \alpha_C + (I_3 \angle \phi_3 + I_2 \angle \alpha_C) Z_{BC}$$

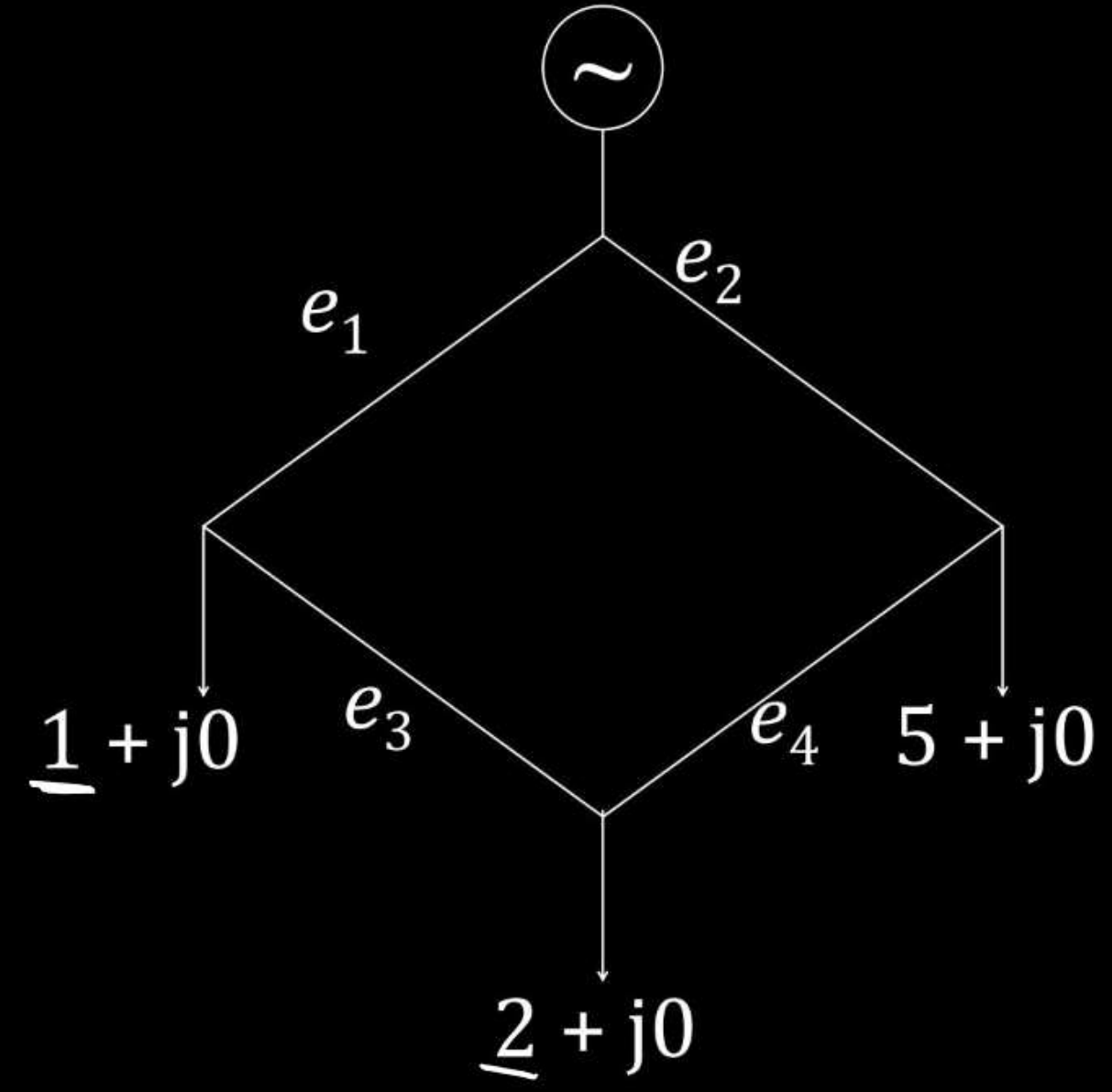
$$V_A \angle \alpha_A = V_B \angle \alpha_B + [I_3 \angle \phi_3 + I_2 \angle \alpha_C + I_1 \angle (\alpha_B - \phi_1)] Z_{AB}$$

Q.



Signal line diagram of a 4-bus single source distribution system is shown below. Branches e_1 , e_2 , e_3 and e_4 have equal impedance. The load current values indicated in the figure are in per unit. The distribution company's policy requires radial system with minimum loss. This can be achieved by removing the branch

- A e_1
- B e_2
- C e_3
- D e_4

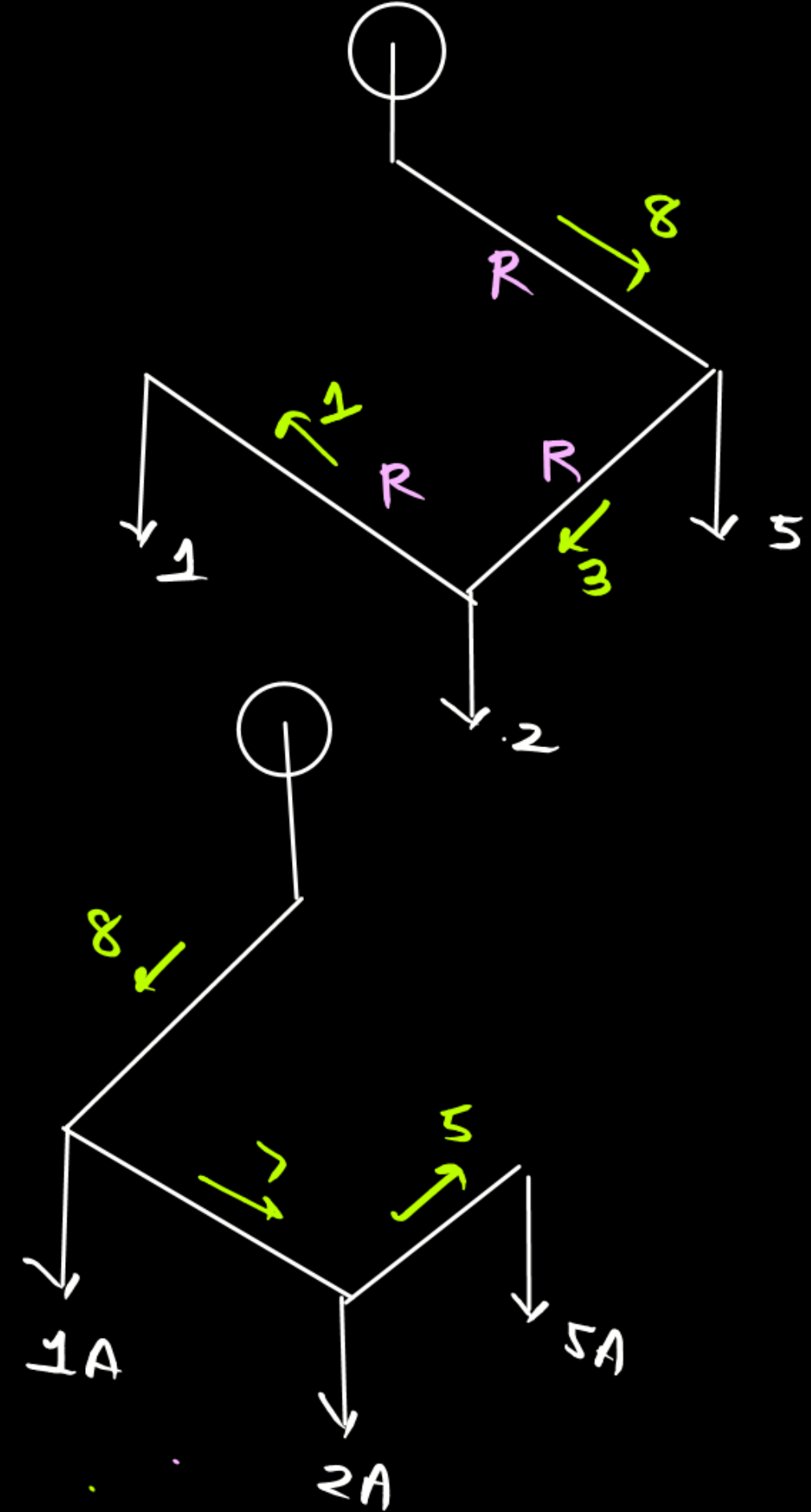


if e_1 is removed.

$$\text{Total power loss} = (8)^2 R + (3)^2 R + (1)^2 R \\ = 74R$$

if e_2 is removed

$$(8)^2 R + (7)^2 R + (5)^2 R \\ = 138R$$



if e_3 is removed

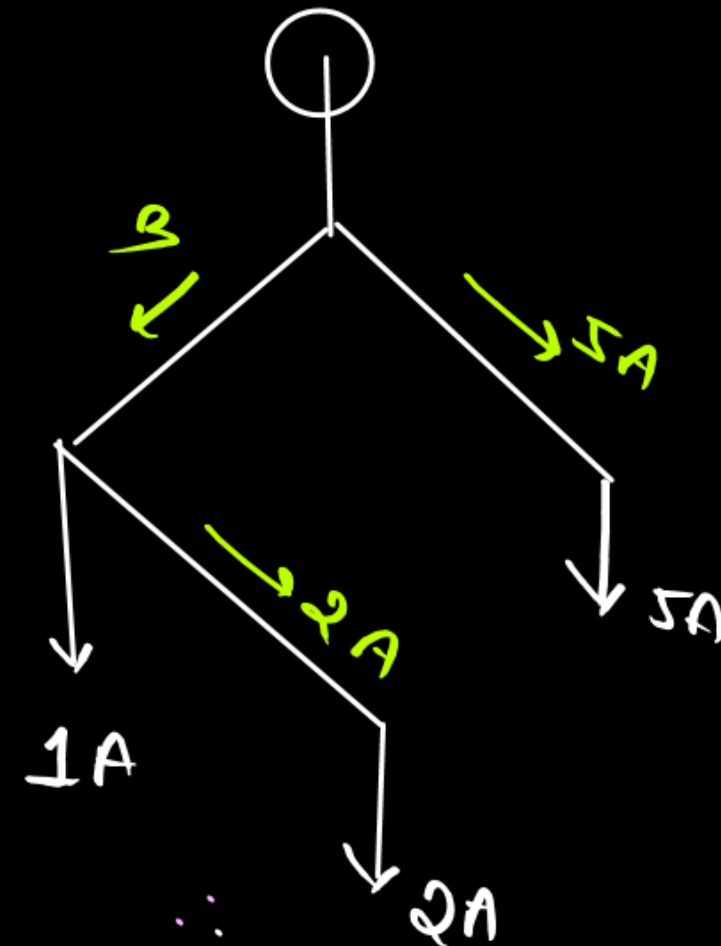
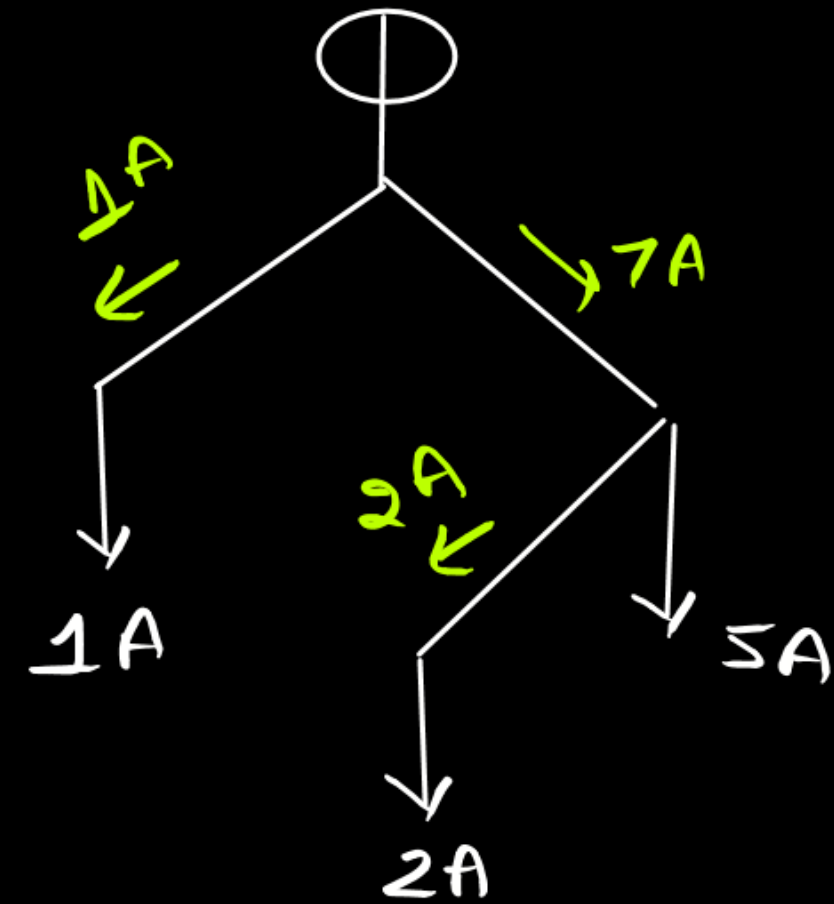
$$(1)^2 R + (2)^2 R + (7)^2 R$$

$$= 54R$$

if e_4 is removed

$$(3)^2 R + (2)^2 R + (5)^2 R$$

$$= 38R$$





2 Minutes Summary

→ Ring Distribution

→ Interconnectors

Thank you

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