Chapter: 03

Electrical Supply Systems:

Lecture : 13

TOPIC:

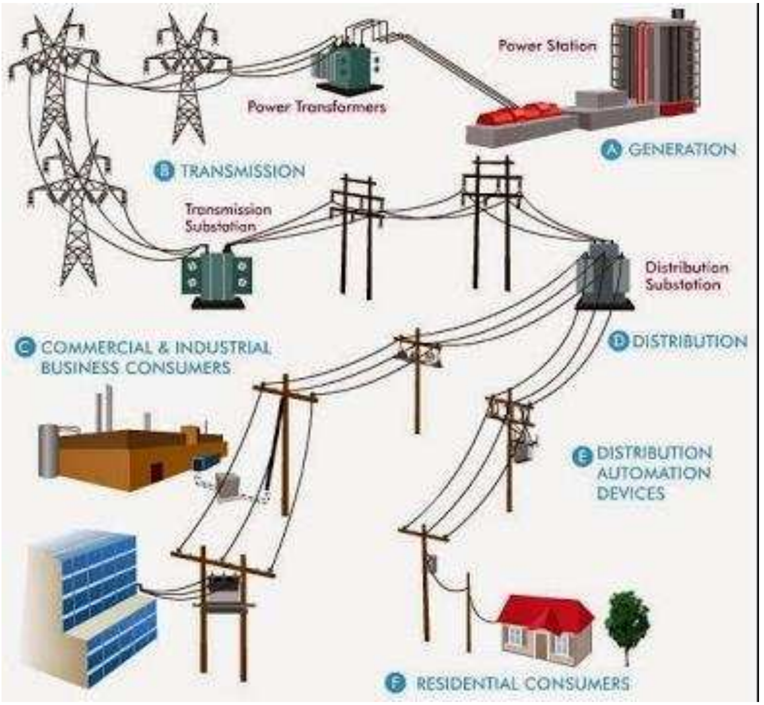
1. Electric supply system
2. Typical ac power supply scheme
3. Advantages of high transmission voltage

Chapter: 03
Electrical Supply Systems:

1. Electric supply system
2. Typical ac power supply scheme
3. Advantages of high transmission voltage
4. Overhead v/s underground systems
5. Requirements of a distribution system
6. Connection schemes of distribution system
7. AC Distribution – Methods of solving AC distribution problems
8. Four wires star connected unbalanced load, Examples.

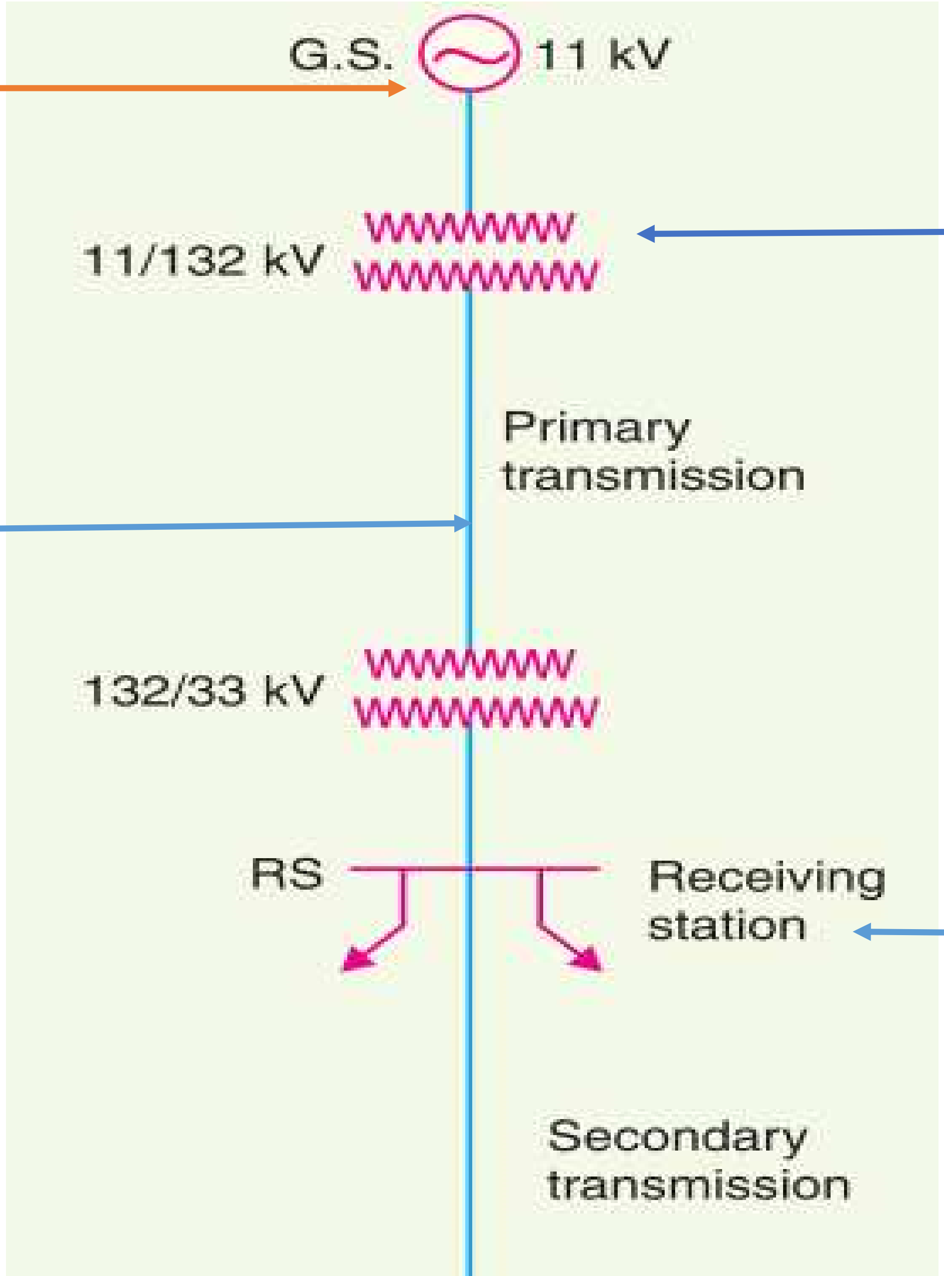
1. Electric supply system

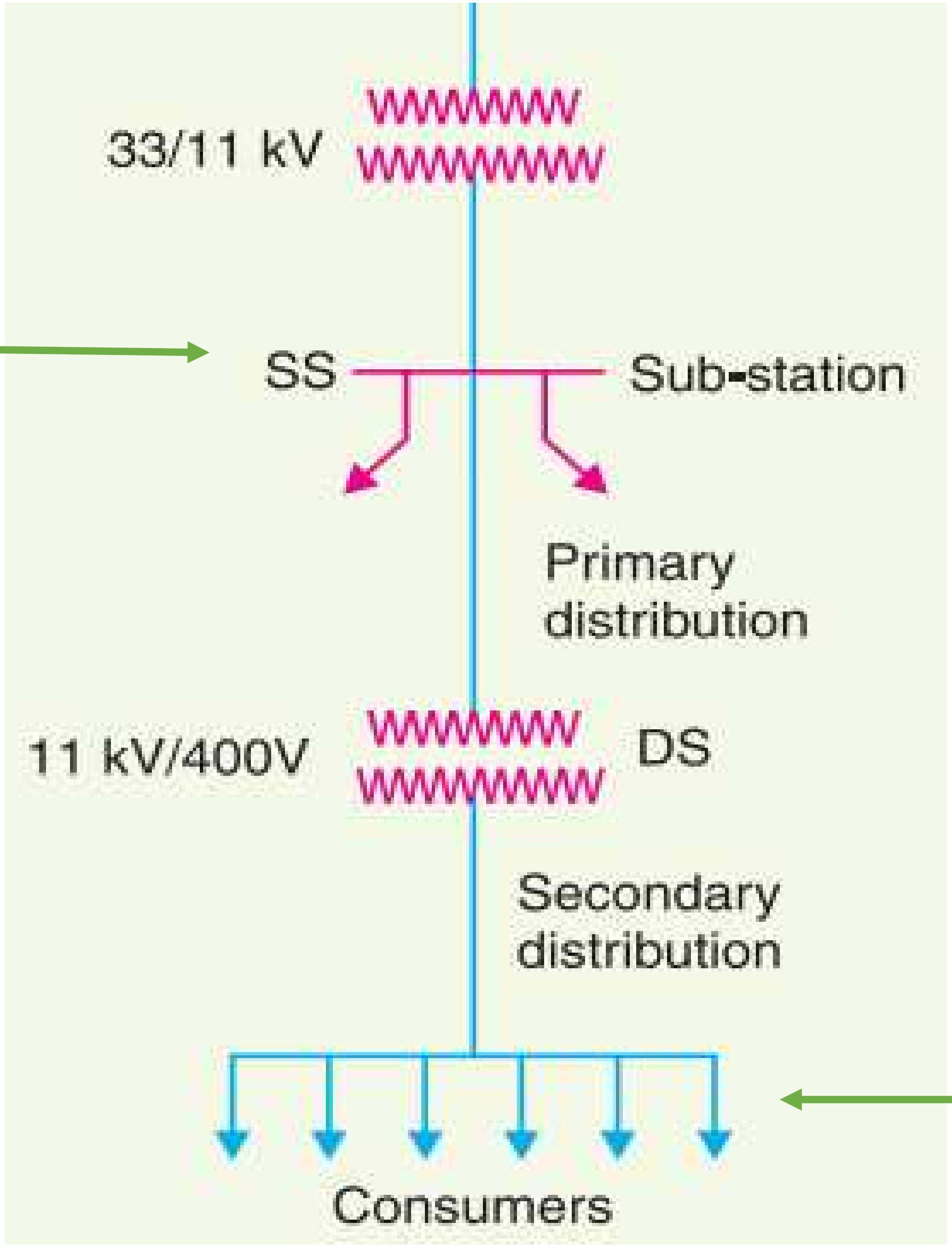
- *The conveyance of electric power from a power station to consumers' premises is known as* ***electric*** **supply system.**



An electric supply system consists of three principal components *viz.*, the power station, the transmission lines and the distribution system. Electric power is produced at the power stations which are located at favourable places, generally quite away from the consumers. It is then transmitted over large distances to load centres with the help of conductors known as transmission lines. Finally, it is distributed to a large number of small and big consumers through a distribution network.

2. Typical ac power supply scheme




33/11 kV
SS
Sub-station
Primary distribution
11 kV/400V
DS
Secondary distribution
Consumers

3. Advantages of high transmission voltage

(*i*) **Reduces volume of conductor material.** Consider the transmission of electric power by a three-phase line.

Let P = power transmitted in watts

V = line voltage in volts

$\cos \phi$ = power factor of the load

l = length of the line in metres

R = resistance per conductor in ohms

ρ = resistivity of conductor material

a = area of X-section of conductor

$$\text{Load current, } I = \frac{P}{\sqrt{3}\, V \cos\phi}$$

$$\text{Resistance/conductor, } R = \rho\, l/a$$

$$\text{Total power loss, } W = 3 I^2 R = 3\left(\frac{P}{\sqrt{3}\, V \cos\phi}\right)^2 \times \frac{\rho\, l}{a}$$

$$= \frac{P^2 \rho\, l}{V^2 \cos^2\phi\;a}$$

$$\therefore \quad \text{Area of X-section, } a = \frac{P^2 \rho\, l}{W V^2 \cos^2\phi}$$

Total volume of conductor material required

$$= 3\, a\, l = 3\left(\frac{P^2 \rho\, l}{W V^2 \cos^2\phi}\right) l \qquad = \frac{3 P^2 \rho\, l^2}{W V^2 \cos^2\phi}$$

It is clear from exp. (*i*) that for given values of P, l, ρ and W, the volume of conductor material required is inversely proportional to the square of transmission voltage and power factor. In other words, the greater the transmission voltage, the lesser is the conductor material required.

(*ii*) Increases transmission efficiency

$$\text{Input power} = P + \text{Total losses}$$

$$= P + \frac{P^2 \rho\, l}{V^2 \cos^2 \phi\; a}$$

Assuming J to be the current density of the conductor, then,

$$a = I/J$$

$$\text{Input power} = P + \frac{P^2 \rho\, l\, J}{V^2 \cos^2 \phi\; I} = P + \frac{P^2 \rho\, l\, J}{V^2 \cos^2 \phi} \times \frac{1}{I}$$

$$= P + \frac{P^2 \rho\, l J}{V^2 \cos^2 \phi} \times \frac{{}^{*}\sqrt{3}\, V \cos \phi}{P}$$

Input power $= P + \dfrac{\sqrt{3}\, P J \rho\, l}{V \cos \phi} = P\left[1 + \dfrac{\sqrt{3}\, J \rho\, l}{V \cos \phi}\right]$

$$\text{Transmission efficiency} = \frac{\text{Output power}}{\text{Input power}} = \frac{P}{P\left[1 + \dfrac{\sqrt{3}\, J \rho\, l}{V \cos \phi}\right]} = \frac{1}{\left[1 + \dfrac{\sqrt{3}\, J \rho\, l}{V \cos \phi}\right]}$$

$$= {}^{**}\left[1 - \frac{\sqrt{3}\, J \rho\, l}{V \cos \phi}\right] \text{ approx.} \qquad \ldots(ii)$$

As J, ρ and l are constants, therefore, transmission efficiency increases when the line voltage is increased.

(*iii*) Decreases percentage line drop

$$\text{Line drop} = I\,R = I \times \frac{\rho\, l}{a}$$

$$= I \times \rho\; l \times J/I = \rho\; l\,J \qquad [\because\; a = I/J]$$

$$\text{\%age line drop} = \frac{J\,\rho\; l}{V} \times 100 \qquad ...(iii)$$

As J, ρ and l are constants, therefore, percentage line drop decreases when the transmission voltage increases.

Limitations of high transmission voltage. From the above discussion, it might appear advisable to use the highest possible voltage for transmission of power in a bid to save conductor material. However, it must be realised that high transmission voltage results in

(*i*) the increased cost of insulating the conductors

(*ii*) the increased cost of transformers, switchgear and other terminal apparatus.

Therefore, there is a limit to the higher transmission voltage which can be economically employed in a particular case. This limit is reached when the saving in cost of conductor material due to

As the transmission voltage increases the volume of the conductor

a) Increases

b) **Decreases**

c) Will not change

d) Will increase proportionately

Precape

4. Overhead v/s underground systems
5. Requirements of a distribution system
6. Connection schemes of distribution system

Thank You