Course: Transmission and Distribution– BEE402

Module-5:Distribution System

Dr. Shakunthala C
Associate Professor
Dept. of Electrical and Electronics Engineering
ATME College of Engineering, Mysuru

Distribution System

- That part of power system which distributes electric power for local use is known as **distribution system.**
- In general, the distribution system is the electrical system between the sub-station fed by the transmission system and the consumers meters.
- It generally consists of feeders, distributors and the service mains.
- Fig 5.1 shows the single line diagram of a typical low tension distribution system.

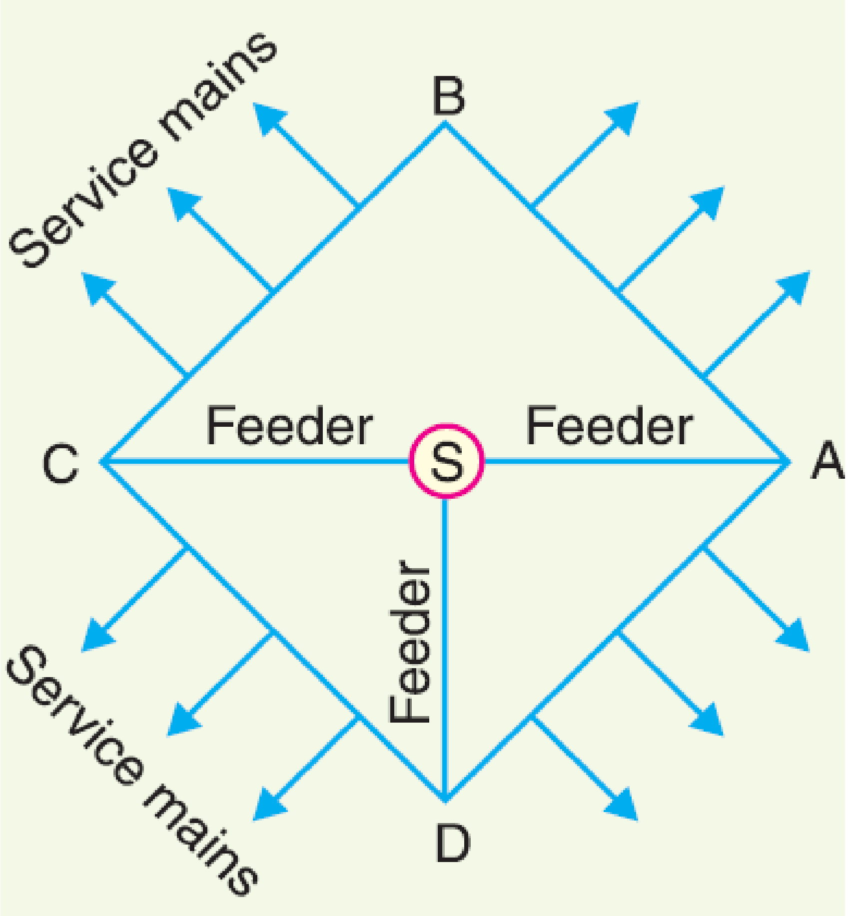


Fig 5.1

Feeders: A feeder is a conductor which connects the sub-station (or localised generating station) to the area where power is to be distributed. Generally, no tappings are taken from the feeder so that current in it remains the same throughout. *The main consideration in the design of a feeder is the current carrying capacity.*

Distributor: A distributor is a conductor from which tappings are taken for supply to the consumers. In Fig.1, AB, BC, CD and DA are the distributors.

The current through a distributor is not constant because tappings are taken at various places along its length.

While designing a distributor, voltage drop along its length is the main consideration since the statutory limit of voltage variations is ± 6% of rated value at the consumers' terminals.

Service mains: A service mains is generally a small cable which connects the distributor to the consumers' terminals.

Classification of Distribution Systems

A distribution system may be classified according to

(i) **Nature of current**: According to nature of current, distribution system may be classified as *(a) DC distribution system (b) AC distribution system.*

(ii) **Type of construction**: According to type of construction, distribution system may be classified as *(a) overhead system (b) underground system.*

The overhead system is generally employed for distribution as it is 5 to 10 times cheaper than the equivalent underground system.

(iii) **Scheme of connection**: According to scheme of connection, the distribution system may be classified as *(a) radial system (b) ring main system (c) inter-connected system.*

Connection Schemes of Distribution System

All distribution of electrical energy is done by constant voltage system.

In practice, the following distribution circuits are generally used:

Radial System

- In this system, separate feeders radiate from a single substation and feed the distributors at one end only.
- Fig. 5.2 (*i*) shows a single line diagram of a radial system for DC distribution where a feeder *OC* supplies a distributor *AB* at point *A*.

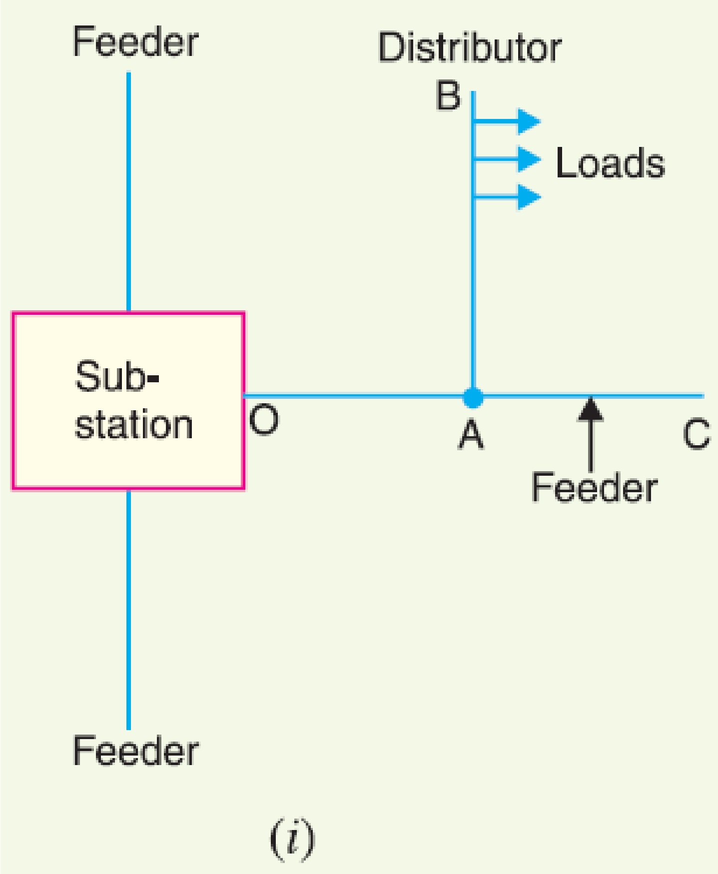


Fig 5.2

Obviously, the distributor is fed at one end only *i.e.*, point *A* is this case. Fig 5.2 (*ii*) shows a single line diagram of radial system for AC distribution.

The radial system is employed only when power is generated at low voltage and the substation is located at the centre of the load.

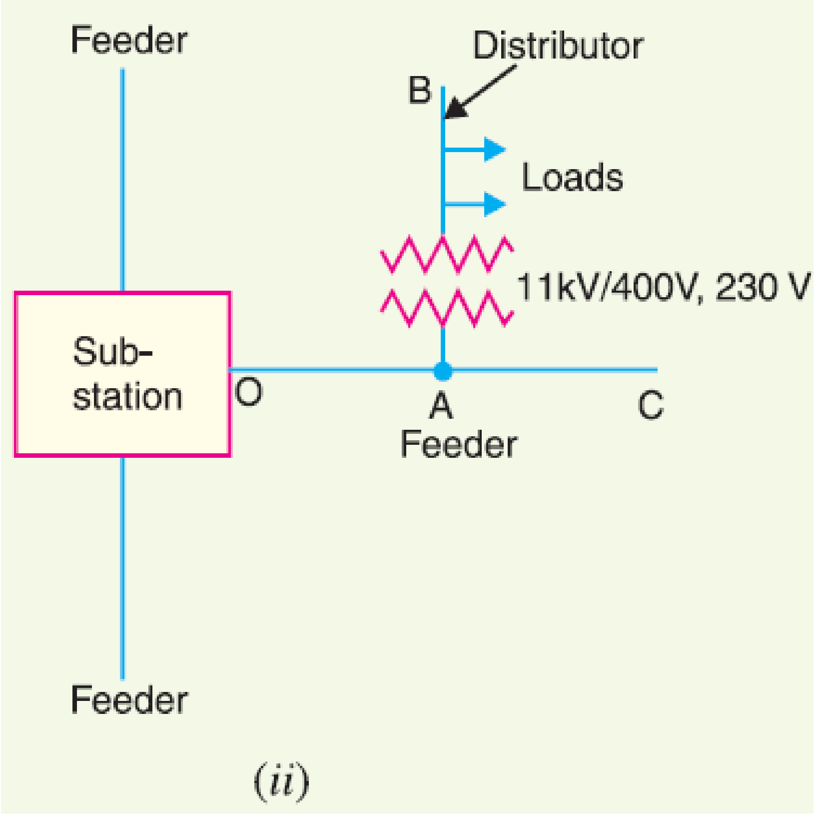


Fig 5.2

This is the simplest distribution circuit and has the lowest initial cost. However, it suffers from the following drawbacks :

(*a*) The end of the distributor nearest to the feeding point will be heavily loaded.

(*b*) The consumers are dependent on a single feeder and single distributor. Therefore, any fault on the feeder or distributor cuts off supply to the consumers who are on the side of the fault away from the substation.

(*c*) The consumers at the distant end of the distributor would be subjected to serious voltage fluctuations when the load on the distributor changes.

Due to these limitations, this system is used for short distances only.

Ring main system.

- In this system, the primaries of distribution transformers form a loop.
- The loop circuit starts from the substation bus-bars, makes a loop through the area to be served, and returns to the substation.
- Fig 5.3 shows the single line diagram of ring main system for AC distribution where substation supplies to the closed feeder LMNOPQRS.
- The distributors are tapped from different points *M*, *O* and *Q* of the feeder through distribution transformers.

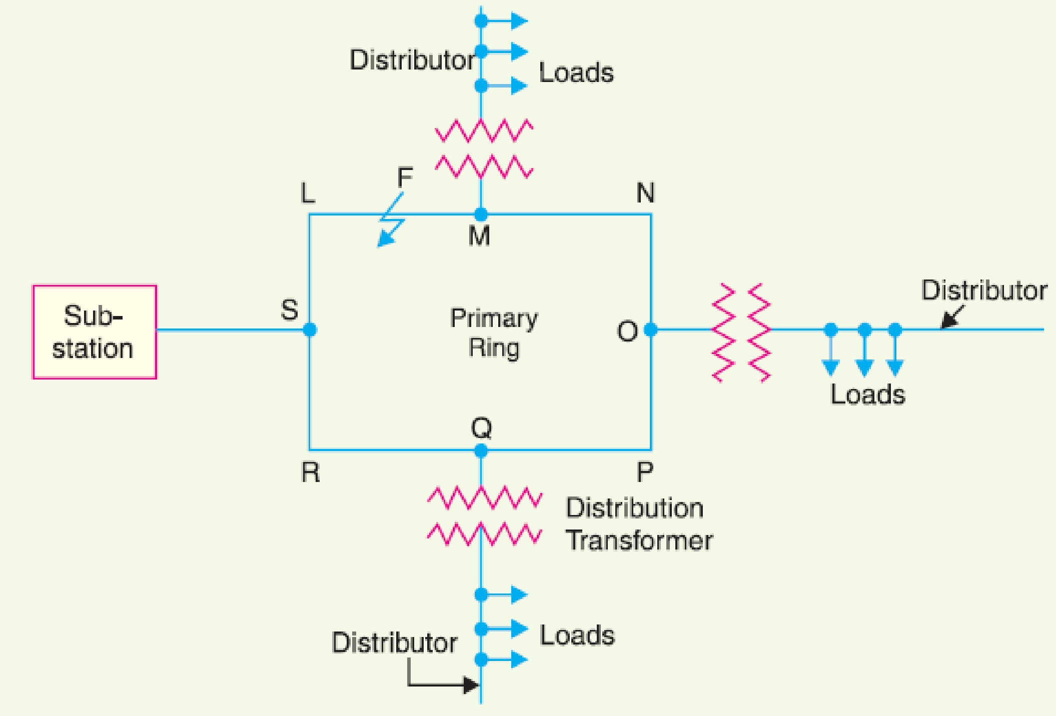


Fig 5.3

The ring main system has the following advantages :

(*a*) There are less voltage fluctuations at consumer's terminals.

(*b*) The system is very reliable as each distributor is fed *via* two feeders.

(iii) Interconnected system :

- When the feeder ring is energized by two or more than two generating stations or substations, it is called inter-connected system.
- Fig 5.4 shows the single line diagram of interconnected system where the closed feeder ring ABCD is supplied by two substations S1 and S2 at points D and C respectively.
- Distributors are connected to points O, P, Q and R of the feeder ring through distribution transformers.

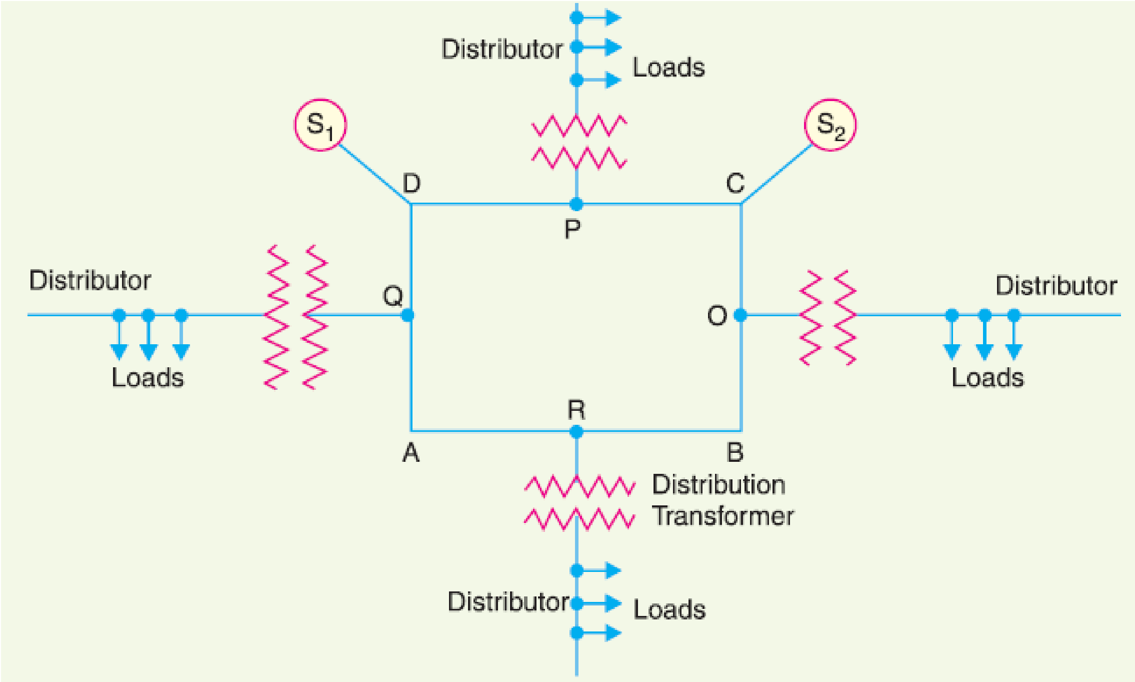


Fig 5.4

The interconnected system has the following advantages :

(a) It increases the service reliability.

(b) Any area fed from one generating station during peak load hours can be fed from the other generating station.

AC Distribution System

The AC distribution system is classified into

(i) Primary distribution system and (ii) Secondary distribution system.

Primary distribution system

- The voltage used for primary distribution depends upon the amount of power to be conveyed and the distance of the substation required to be fed.
- The most commonly used primary distribution voltages are 11 kV, 6·6 kV and 3·3 kV.
- Due to economic considerations, primary distribution is carried out by *3-phase,3-wire system.*
- At this substation, voltage is stepped down to 11 kV with the help of step-down transformer.

- Power is supplied to various substations for distribution or to big consumers at this voltage.
- This forms the high voltage distribution or primary distribution.

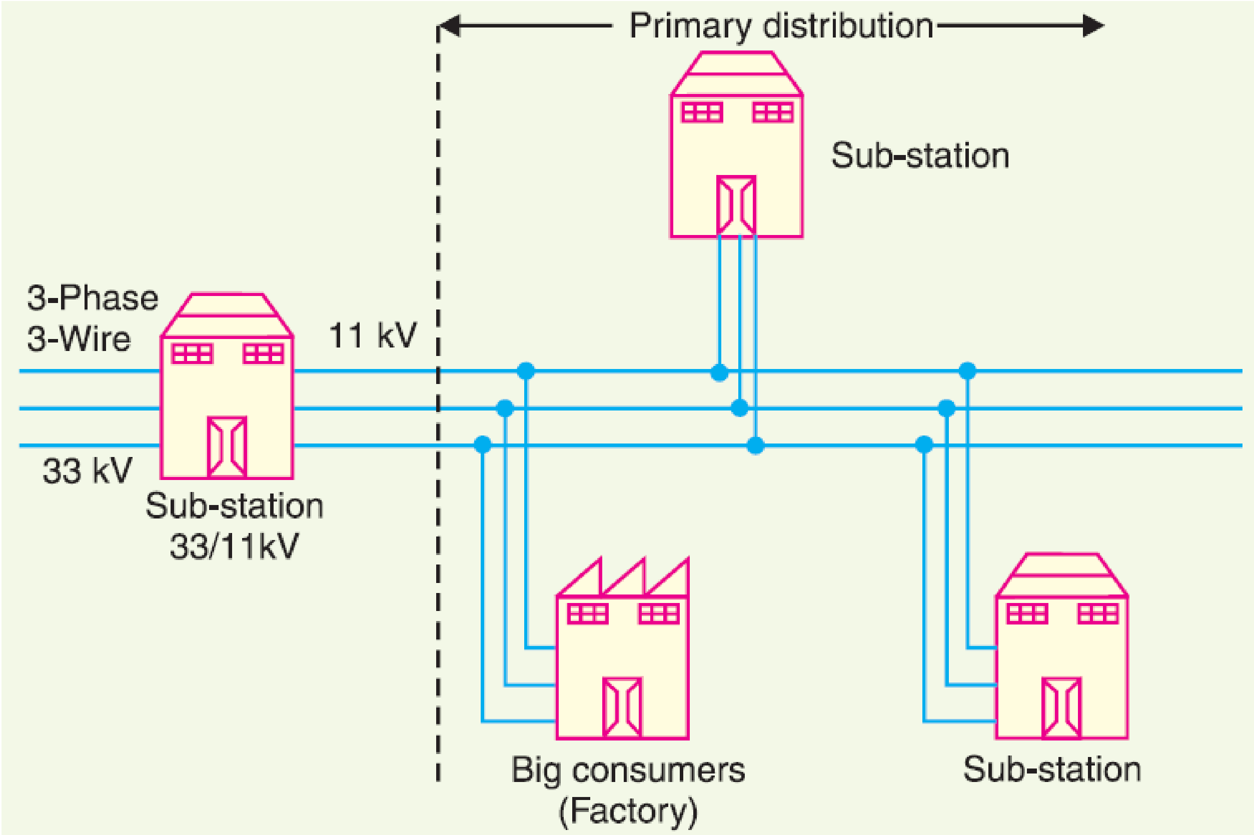


Fig 5.5

Secondary distribution system:

- It is that part of AC distribution system which includes the range of voltages at which the ultimate consumer utilizes the electrical energy delivered to him.
- The secondary distribution employs 400/230 V, 3-phase, 4-wire system.

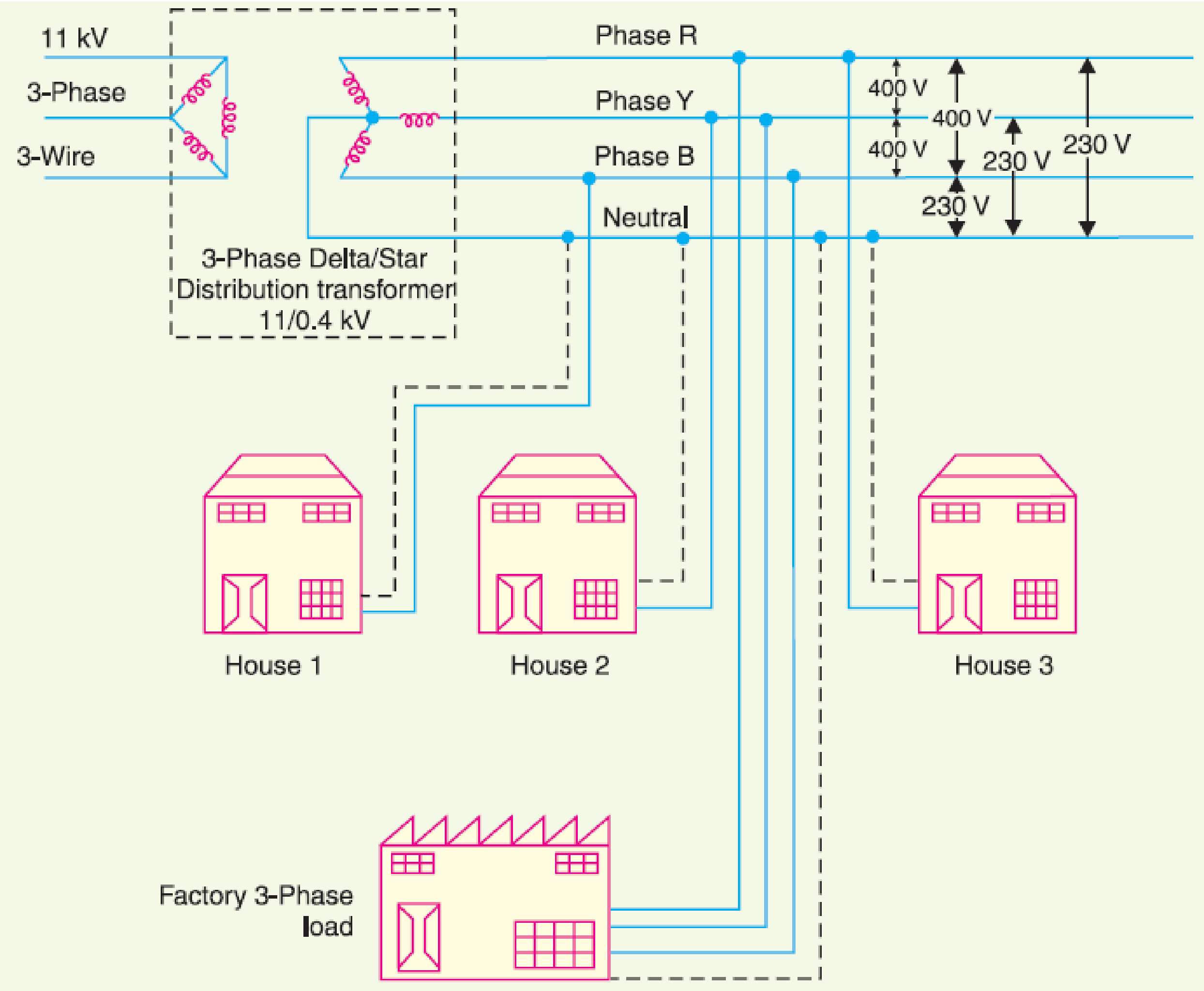


Fig 5.6

A.C. Distribution Calculations

A.C. distribution calculations differ from those of d.c. distribution in the following respects :

- In case of d.c. system, the voltage drop is due to resistance alone. However, in a.c. system, the voltage drops are due to the combined effects of resistance, inductance and capacitance.
- In a d.c. system, additions and subtractions of currents or voltages are done arithmetically but in case of a.c. system, these operations are done vectorially.
- In an a.c. system, power factor (p.f.) has to be taken into account. Loads tapped off form the distributor are generally at different power factors. There are two ways of referring power factor *viz*

  (*a*) It may be referred to supply or receiving end voltage which is regarded as the reference vector.

  (*b*) It may be referred to the voltage at the load point itself.

There are several ways of solving a.c. distribution problems. However, symbolic notation method has been found to be most convenient for this purpose.

Methods of Solving A.C. Distribution Problems

In AC distribution calculations, power factors of various load currents have to be considered since currents in different sections of the distributor will be the vector sum of load currents and not the arithmetic sum.

The power factors of load currents may be given

(i) w.r.t. receiving or sending end voltage

(ii) w.r.t. to load voltage itself.

Now let us discuss each case separately.

(i) Power factors referred to receiving end voltage

- Consider an a.c distributor AB with concentrated loads of I_1 and I_2 tapped off at points C and B as shown in Fig 5.7.
- Taking the receiving end voltage V_B as the reference vector, let lagging power factors at C and B be $\cos\varphi_1$ and $\cos\varphi_2$ w.r.t. V_B.
- Let R_1, X_1 and R_2, X_2 be the resistance and reactance of sections AC and CB of the distributor.

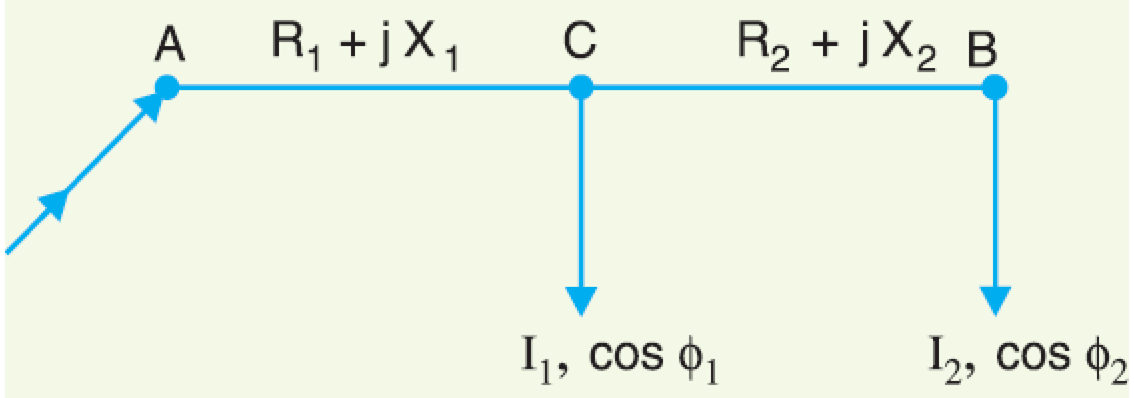
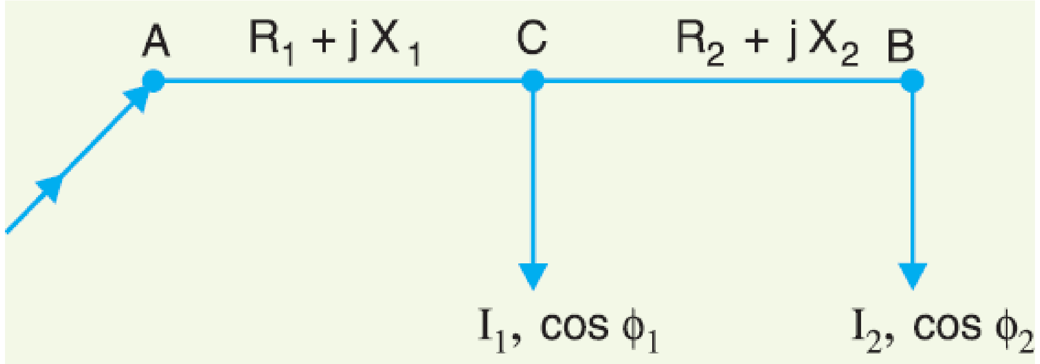


Fig 5.7



Impedance of section AC, $\overrightarrow{Z_{AC}} = R_1 + j X_1$

Impedance of section CB, $\overrightarrow{Z_{CB}} = R_2 + j X_2$

Load current at point C, $\overrightarrow{I_1} = I_1 (\cos \phi_1 - j \sin \phi_1)$

Load current at point B, $\overrightarrow{I_2} = I_2 (\cos \phi_2 - j \sin \phi_2)$

Current in section CB, $\overrightarrow{I_{CB}} = \overrightarrow{I_2} = I_2 (\cos \phi_2 - j \sin \phi_2)$

Current in section AC, $\overrightarrow{I_{AC}} = \overrightarrow{I_1} + \overrightarrow{I_2} = I_1 (\cos \phi_1 - j \sin \phi_1) + I_2 (\cos \phi_2 - j \sin \phi_2)$

Voltage drop in section CB, $\overrightarrow{V_{CB}} = \overrightarrow{I_{CB}}\, \overrightarrow{Z_{CB}} = I_2 (\cos \phi_2 - j \sin \phi_2)(R_2 + j X_2)$

Voltage drop in section AC, $\overrightarrow{V_{AC}} = \overrightarrow{I_{AC}}\, \overrightarrow{Z_{AC}} = \left(\overrightarrow{I_1} + \overrightarrow{I_2}\right) Z_{AC}$

$$= [I_1(\cos \phi_1 - j \sin \phi_1) + I_2 (\cos \phi_2 - j \sin \phi_2)]\,[R_1 + j X_1]$$

Sending end voltage, $\overrightarrow{V_A} = \overrightarrow{V_B} + \overrightarrow{V_{CB}} + \overrightarrow{V_{AC}}$

Sending end current, $\overrightarrow{I_A} = \overrightarrow{I_1} + \overrightarrow{I_2}$

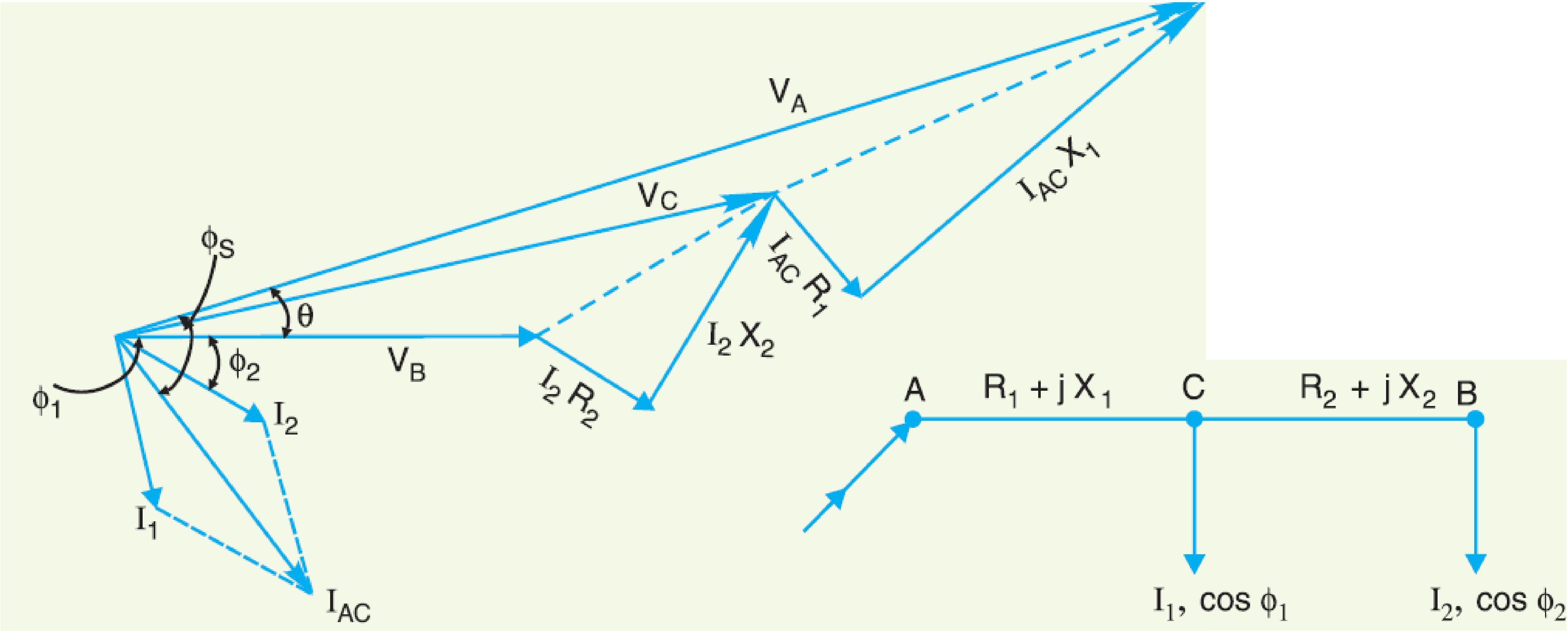


Fig 5.8

The vector diagram of the a.c. distributor under these conditions is shown in Fig 5.8. Here, the receiving end voltage V_B is taken as the reference vector. As power factors of loads are given *w.r.t.* V_B, therefore, I_1 and I_2 lag behind V_B by φ_1 and φ_2 respectively.

Example 1. *A single phase a.c. distributor AB 300 metres long is fed from end A and is loaded as under :*

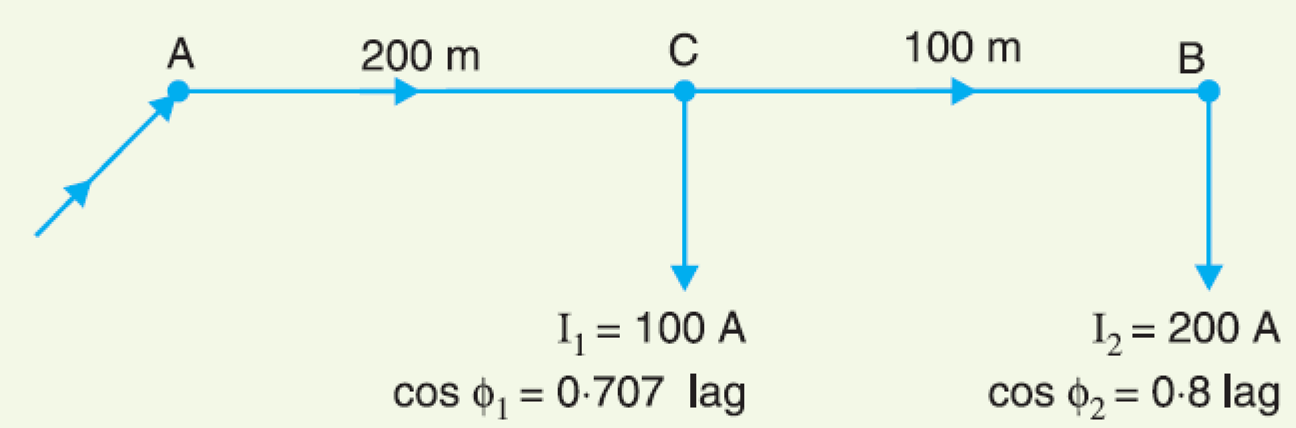
(i) 100 A at 0·707 p.f. lagging 200 m from point A

(ii) 200 A at 0·8 p.f. lagging 300 m from point A

The load resistance and reactance of the distributor is 0·2 Ω and 0·1 Ω per kilometre. Calculate the total voltage drop in the distributor. The load power factors refer to the voltage at the far end.

Solution. Fig. shows the single line diagram of the distributor.

Impedance of distributor/km = $(0{\cdot}2 + j\,0{\cdot}1)\ \Omega$



Impedance of section AC, $\overrightarrow{Z_{AC}} = (0{\cdot}2 + j\,0{\cdot}1) \times 200/1000 \quad = (0{\cdot}04 + j\,0{\cdot}02)\ \Omega$

Impedance of section CB, $\overrightarrow{Z_{CB}} = (0{\cdot}2 + j\,0{\cdot}1) \times 100/1000 \quad = (0{\cdot}02 + j\,0{\cdot}01)\ \Omega$

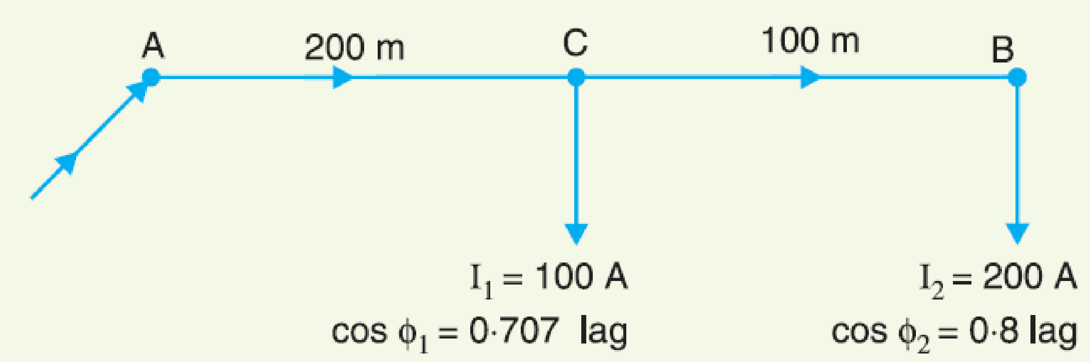
Taking voltage at the far end B as the reference vector, we have,

Load current at point B, $\overrightarrow{I_2} = I_2\,(\cos\phi_2 - j\sin\phi_2) = 200\,(0{\cdot}8 - j\,0{\cdot}6) = (160 - j\,120)$ A

Load current at point C, $\overrightarrow{I_1} = I_1\,(\cos\phi_1 - j\sin\phi_1) = 100\,(0{\cdot}707 - j\,0{\cdot}707) = (70{\cdot}7 - j\,70{\cdot}7)$ A

Current in section CB, $\overrightarrow{I_{CB}} = \overrightarrow{I_2} = (160 - j\,120)$ A

Current in section AC, $\overrightarrow{I_{AC}} = \overrightarrow{I_1} + \overrightarrow{I_2} = (70{\cdot}7 - j\,70{\cdot}7) + (160 - j\,120) = (230{\cdot}7 - j\,190{\cdot}7)$ A



Voltage drop in section CB, $\overrightarrow{V_{CB}} = \overrightarrow{I_{CB}}\,\overrightarrow{Z_{CB}} = (160 - j\,120)\,(0{\cdot}02 + j\,0{\cdot}01) = (4{\cdot}4 - j\,0{\cdot}8)$ volts

Voltage drop in section AC, $\overrightarrow{V_{AC}} = \overrightarrow{I_{AC}}\,\overrightarrow{Z_{AC}} = (230{\cdot}7 - j\,190{\cdot}7)\,(0{\cdot}04 + j\,0{\cdot}02)$

$$= (13{\cdot}04 - j\,3{\cdot}01) \text{ volts}$$

Voltage drop in the distributor $= \overrightarrow{V_{AC}} + \overrightarrow{V_{CB}} = (13{\cdot}04 - j\,3{\cdot}01) + (4{\cdot}4 - j\,0{\cdot}8)$

$$= (17{\cdot}44 - j\,3{\cdot}81) \text{ volts}$$

Magnitude of drop $= \sqrt{(17\cdot44)^2 + (3\cdot81)^2} =$ **17·85 V**

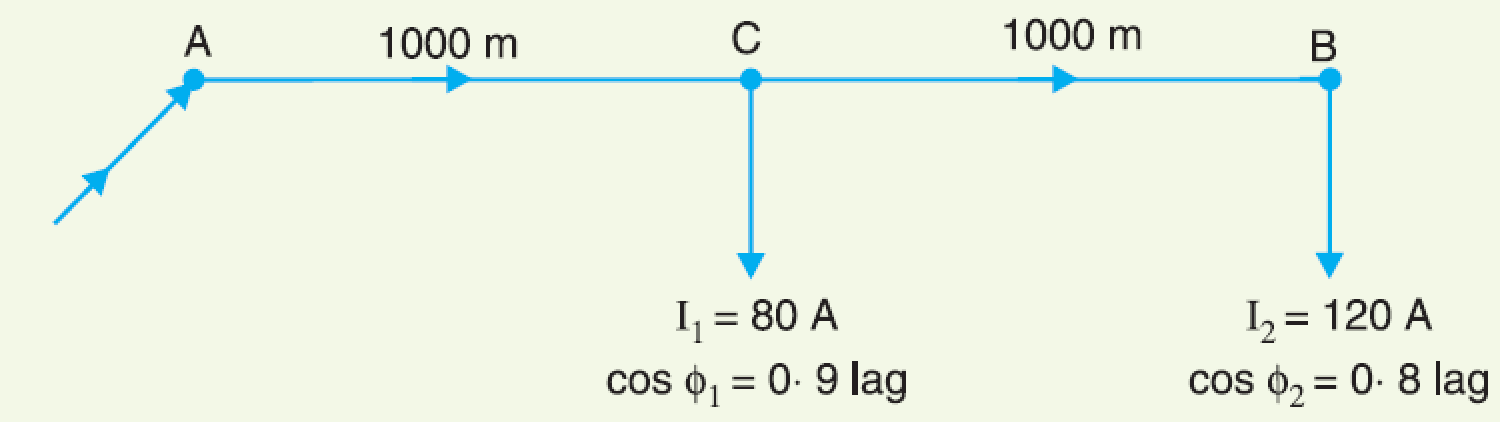
Example 14.2. *A single phase distributor 2 kilometres long supplies a load of 120 A at 0·8 p.f. lagging at its far end and a load of 80 A at 0·9 p.f. lagging at its mid-point. Both power factors are referred to the voltage at the far end. The resistance and reactance per km (go and return) are 0·05 Ω and 0·1 Ω respectively. If the voltage at the far end is maintained at 230 V, calculate :*

(*i*) *voltage at the sending end*

(*ii*) *phase angle between voltages at the two ends.*

Solution. Fig. shows the distributor *AB* with *C* as the mid-point

Impedance of distributor/km $= (0{\cdot}05 + j\,0{\cdot}1)\ \Omega$



Impedance of section AC, $\vec{Z}_{AC} = (0{\cdot}05 + j\,0{\cdot}1) \times 1000/1000 = (0{\cdot}05 + j\,0{\cdot}1)\ \Omega$

Impedance of section CB, $\vec{Z}_{CB} = (0{\cdot}05 + j\,0{\cdot}1) \times 1000/1000 = (0{\cdot}05 + j\,0{\cdot}1)\ \Omega$

Let the voltage V_B at point B be taken as the reference vector.

Load current at point B, $\vec{I}_2 = 120\,(0{\cdot}8 - j\,0{\cdot}6) = 96 - j\,72$

Load current at point C, $\vec{I}_1 = 80\,(0{\cdot}9 - j\,0{\cdot}436) = 72 - j\,34{\cdot}88$

Current in section CB, $\overrightarrow{I_{CB}} = \vec{I}_2 = 96 - j\,72$

Current in section AC, $\overrightarrow{I_{AC}} = \vec{I}_1 + \vec{I}_2 = (72 - j\,34{\cdot}88) + (96 - j\,72) = 168 - j\,106{\cdot}88$

Drop in section CB, $\overrightarrow{V_{CB}} = \overrightarrow{I_{CB}}\,\overrightarrow{Z_{CB}} = (168 - j\,106{\cdot}88)\,(0{\cdot}05 + j\,0{\cdot}1) = 12 + j\,6$

Drop in section AC, $\overrightarrow{V_{AC}} = \overrightarrow{I_{AC}}\,\overrightarrow{Z_{AC}} = (168 - j\,106{\cdot}88)\,(0{\cdot}05 + j\,0{\cdot}1) = 19{\cdot}08 + j\,11{\cdot}45$

$$\therefore \quad \text{Sending end voltage,} \quad \vec{V_A} = \vec{V_B} + \vec{V_{CB}} + \vec{V_{AC}}$$

$$= (230 + j\,0) + (12 + j\,6) + (19.08 + j\,11.45)$$

$$= 261.08 + j\,17.45$$

$$\text{Its magnitude is} = \sqrt{(261\cdot 08)^2 + (17\cdot 45)^2} = \mathbf{261\cdot 67\ V}$$

(ii) The phase difference θ between V_A and V_B is given by : $\tan\theta = \dfrac{17\cdot 45}{261\cdot 08} = 0\cdot 0668$

$$\theta = \tan^{-1} 0\cdot 0668 = \mathbf{3\cdot 82^o}$$

Example 14.5. *A 3-phase, 400V distributor AB is loaded as shown in Fig.14.8. The 3-phase load at point C takes 5A per phase at a p.f. of 0·8 lagging. At point B, a 3-phase, 400 V induction motor is connected which has an output of 10 H.P. with an efficiency of 90% and p.f. 0·85 lagging.*

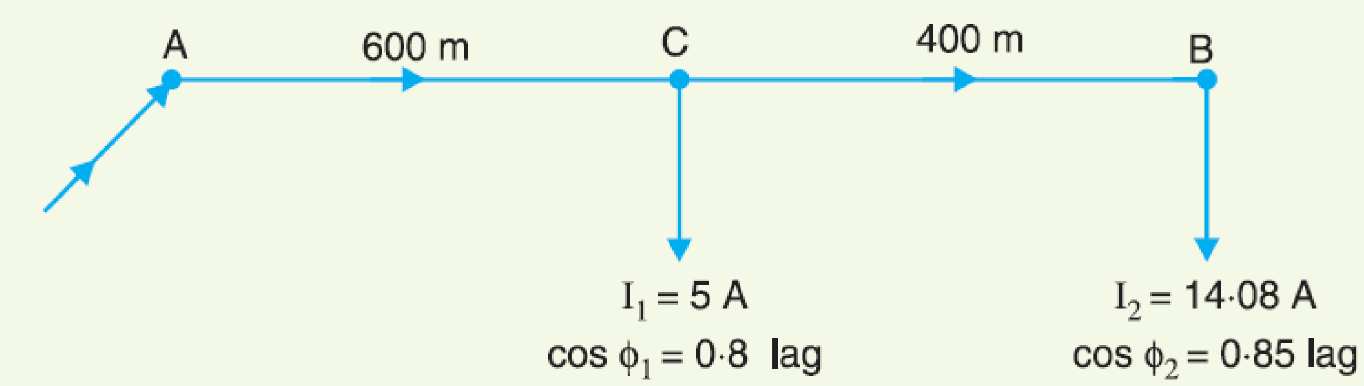
If voltage at point B is to be maintained at 400 V, what should be the voltage at point A ? The resistance and reactance of the line are 1Ω and 0·5Ω per phase per kilometre respectively.

Solution. It is convenient to consider one phase only. Fig. shows the single line diagram of the distributor.

Impedance of the distributor per phase per kilometer = $(1 + j\,0{\cdot}5)\ \Omega$.

$$\text{Impedance of section } AC,\ \overrightarrow{Z_{AC}} = (1 + j\,0{\cdot}5) \times 600/1000 = (0{\cdot}6 + j\,0{\cdot}3)\ \Omega$$

$$\text{Impedance of section } CB,\ \overrightarrow{Z_{CB}} = (1 + j\,0{\cdot}5) \times 400/1000 = (0{\cdot}4 + j\,0{\cdot}2)\ \Omega$$



Phase voltage at point B, $V_B = 400/\sqrt{3} = 231$ V

Let the voltage V_B at point B be taken as the reference vector.

Then, $\overrightarrow{V_B} = 231 + j\,0$

$$\text{Line current at } B = \frac{\text{H.P.} \times 746}{\sqrt{3} \times \text{line voltage} \times \text{p.f.} \times \text{efficiency}}$$

$$= \frac{10 \times 746}{\sqrt{3} \times 400 \times 0{\cdot}85 \times 0{\cdot}9} = 14{\cdot}08 \text{ A}$$

$\therefore$ *Current/phase at B, $I_2 = 14{\cdot}08$ A

Load current at B, $\overrightarrow{I_2} = 14{\cdot}08\,(0{\cdot}85 - j\,0{\cdot}527) = 12 - j\,7{\cdot}4$

Load current at C, $\overrightarrow{I_1} = 5\,(0{\cdot}8 - j\,0{\cdot}6) = 4 - j\,3$

Current in section AC, $\overrightarrow{I_{AC}} = \overrightarrow{I_1} + \overrightarrow{I_2} = (4 - j\,3) + (12 - j\,7{\cdot}4) = 16 - j\,10{\cdot}4$

Current in section CB, $\vec{I}_{CB} = \vec{I}_2 = 12 - j\,7{\cdot}4$

Voltage drop in CB, $\vec{V}_{CB} = \vec{I}_{CB}\vec{Z}_{CB} = (12 - j\,7{\cdot}4)\,(0{\cdot}4 + j\,0{\cdot}2) = 6{\cdot}28 - j\,0{\cdot}56$

Voltage drop in AC, $\vec{V}_{AC} = \vec{I}_{AC}\vec{Z}_{AC} = (16 - j\,10{\cdot}4)\,(0{\cdot}6 + j\,0{\cdot}3) = 12{\cdot}72 - j\,1{\cdot}44$

Voltage at A per phase, $\vec{V}_A = \vec{V}_B + \vec{V}_{CB} + \vec{V}_{AC}$

$$= (231 + j\,0) + (6{\cdot}28 - j\,0{\cdot}56) + (12{\cdot}72 - j\,1{\cdot}44) = 250 - j\,2$$

Magnitude of V_A/phase $= \sqrt{(250)^2 + (2)^2} = 250$ V

$\therefore$ Line voltage at A $= \sqrt{3} \times 250 =$ **433 V**

Three Phase Three Wire System

- The three phase three wire system may be star or delta connected. If it is star connected, then its neutral is grounded.
- The Fig shows the scheme of three phase three wire system for the primary distribution.
- The large consumers like factories which need bulk supply are directly supplied from the substations.
- The power is also distributed to other substations and distribution centres.

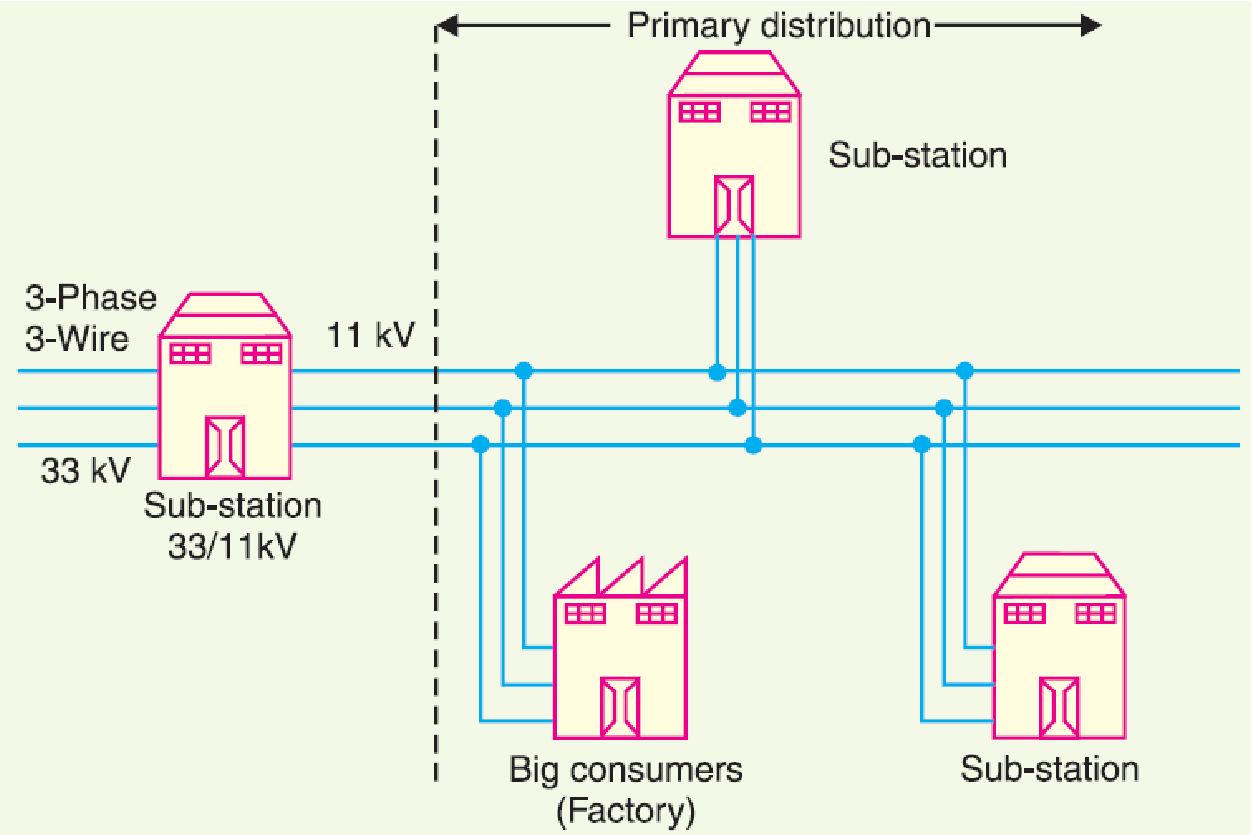


Fig 5.9

Three Phase Four Wire System

- This system is generally preferred for the secondary distribution.
- The single phase loads are connected between one of the three lines and a neutral while the three phase loads can be given three phase supply directly, along with the provision of neutral for the internal distribution.
- The voltage between any of the lines and a neutral is 230 V while the voltage between any two lines is 400 V.

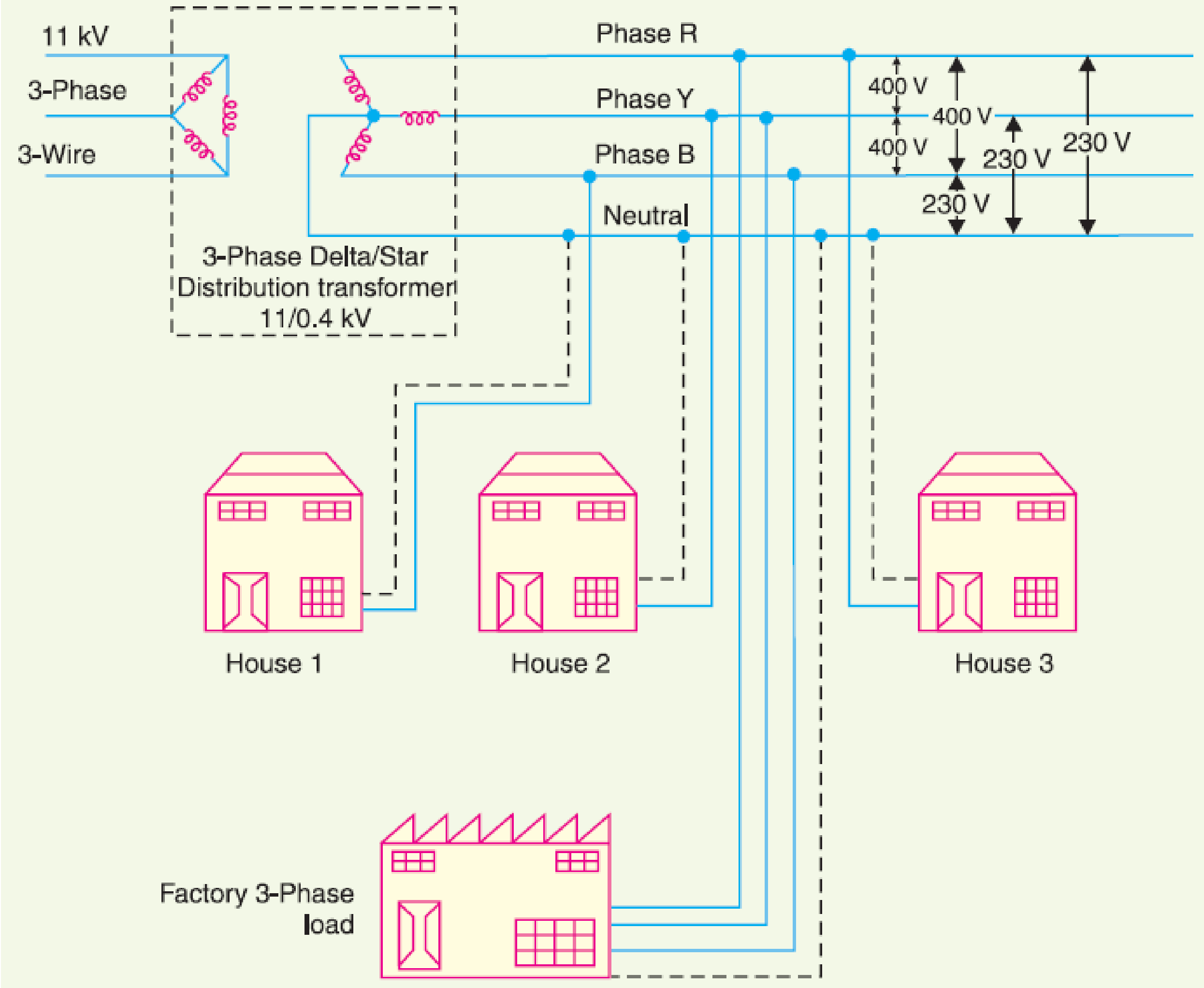
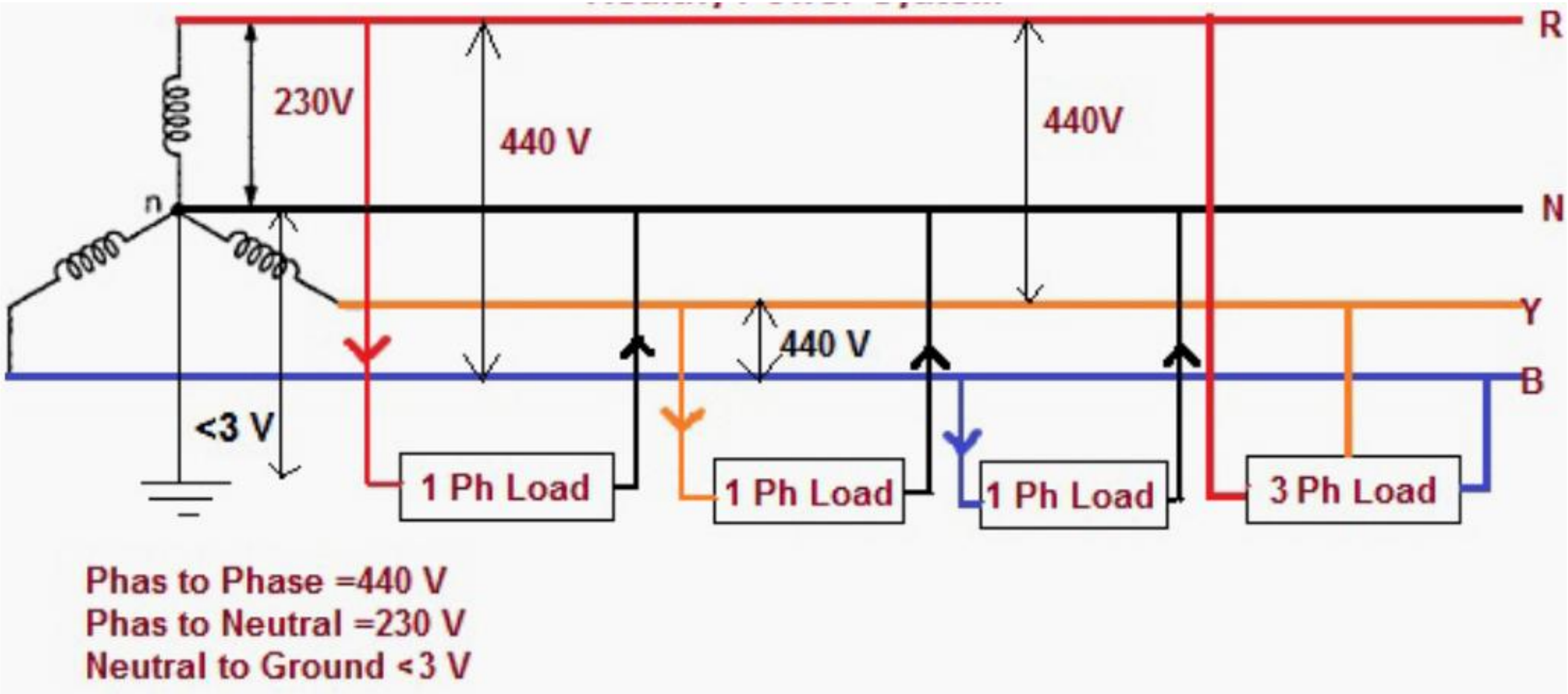
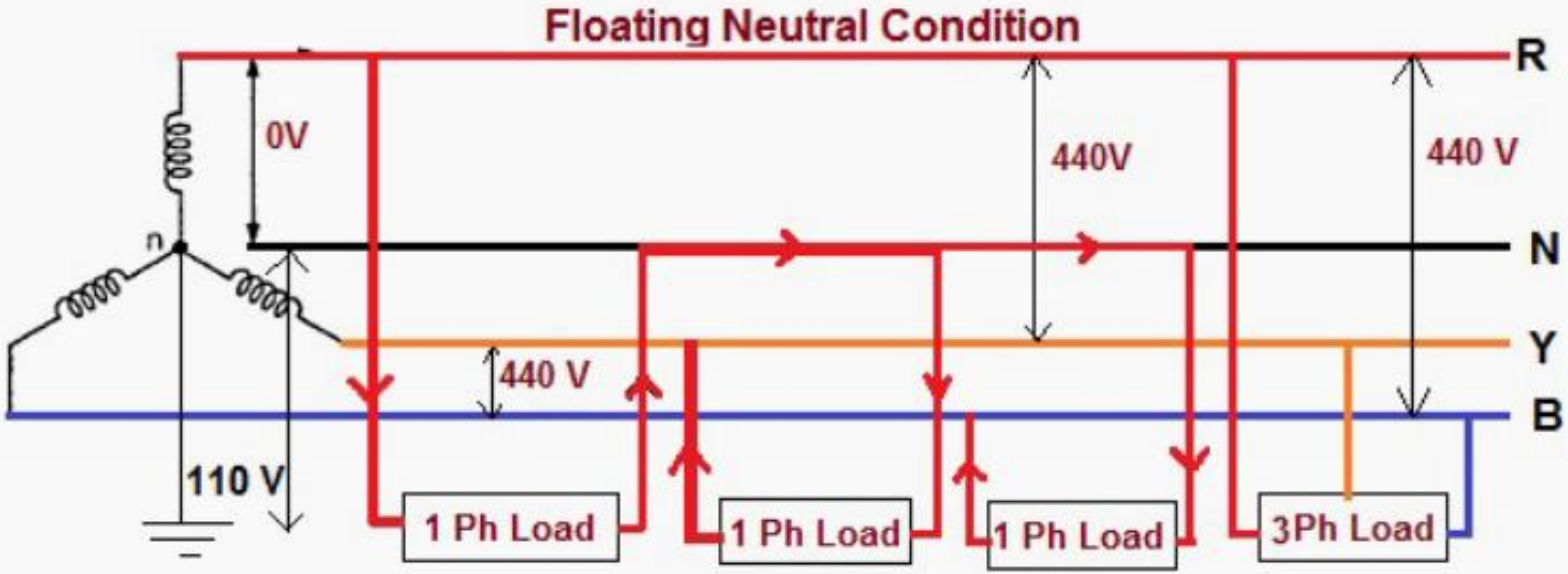


Fig 5.10

Effect of disconnection of Neutral in 3 phase 4 wire system

Healthy Power System





Phase to Pahse =440 V (No effect on 3 Phase Load)
Phase to Neutral = 110 V to 330 V (Min 0 V to Max 440 V Depend upon Load
Phase to Ground = 120 V
Neutral to Ground =110 V

The various effects of disconnection of neutral are

- The potential of neutral point is always changing and not fixed.
- The neutral point floats loads upto line voltage.
- It causes large changes in the current and phase voltages.
- It creates the situation where power flow entering in phase returns through remaining two phases which is dangerous.
- The connected load may get damaged.
- The customer may receive serious electric shocks if they touch the equipment body.
- Hence it is necessary to identify broken neutral and as a Thumb Rule the neutral to ground voltage must be 2 volt are less.
- Thus the disconnection of the neutral is very unsafe condition and must be corrected as early as possible.

Reliability

- The goal of power system is to supply electricity to its customers in an economical and reliable manner.
- It is important to plan and maintain reliable power system because cost of interruptions and power outages can have severe economic impact on utility and customers.
- The reliability associated with a power system is a measure of the overall ability of the system to satisfy the customer demand for electrical energy.
- Power system reliability can be further subdivided into two different categories.

  i. System Adequacy

  ii. System Security

System adequacy

Related to the sufficient facilities within the system to satisfy customer demand.

System security

Related to the ability of the system to respond to disturbances arising within that system.

System Wide Indices

This indices used to give insight of the overall system performance.

System Average Interruption Frequency Index (SAIFI)

$$\text{SAIFI} = \frac{\text{Total no. of customer interruptions}}{\text{Total no. of customers served}}$$

System Average Interruption Duration Index (SAIDI)

$$\text{SAIDI} = \frac{\text{Customer interruption duration}}{\text{Total no. of customers served}}$$

Customer Indices

It reflects what the individual customer experiences.

Customer Average Interruption Duration Index (CAIDI)

The Customer Average Interruption Duration Index (CAIDI) is a reliability index commonly used by electric power utilities.

$$\text{CAIDI} = \frac{\Sigma \text{ Customer interruptions duration}}{\text{Total no. of customer interruptions}} = \frac{\text{SAIDI}}{\text{SAIFI}}$$

Customer Average Interruption Frequency Index (CAIFI)

$$\text{CAIFI} = \frac{\text{Total no. of customer interruptions}}{\text{Total no. of customer interrupted}}$$

Average Service Availability Index

$$\text{ASAI} = \frac{\text{Customer hours service availability}}{\text{Customer hours service demand}}$$

Distribution Reliability

Following are the some importance or uses of studying reliability.

Analyse and improve system performance:

Reliability assessment helps in the identification of weak areas in terms of frequency of failing and duration of failure of the system.

Enhance customer satisfaction :

- Customer satisfaction is prime important.
- Reliability helps in identifying potential load points with poor reliability and take necessary action to retain customer satisfaction.

As a tool for planning expansion of the system:

- Growing energy need and loads requires expansion and development of existing system.
- Reliability models help the utility to compare the various proposed projects and choose best one.

Maintenance scheduling and resource allocation :

- Distribution systems are comprised of thousands of components that tend to fail and require maintenance.
- Reliability centered maintenance is a technique that utilities use to schedule maintenance and resource allocation.

Bath Tub Curve

The typical hazard function of many devices is shown in Fig 5.11. As its shape resembles a bath tub it is known as **Bath Tub Curve**.

The curve shows the three different regions in the total life of a component.

- The initial period is known as debugging period or the period of infant mortality.
- These failures may be high due to errors in design or manufacturing.
- These errors are detected or removed in an initial period. This region shows a decreasing failure rate..

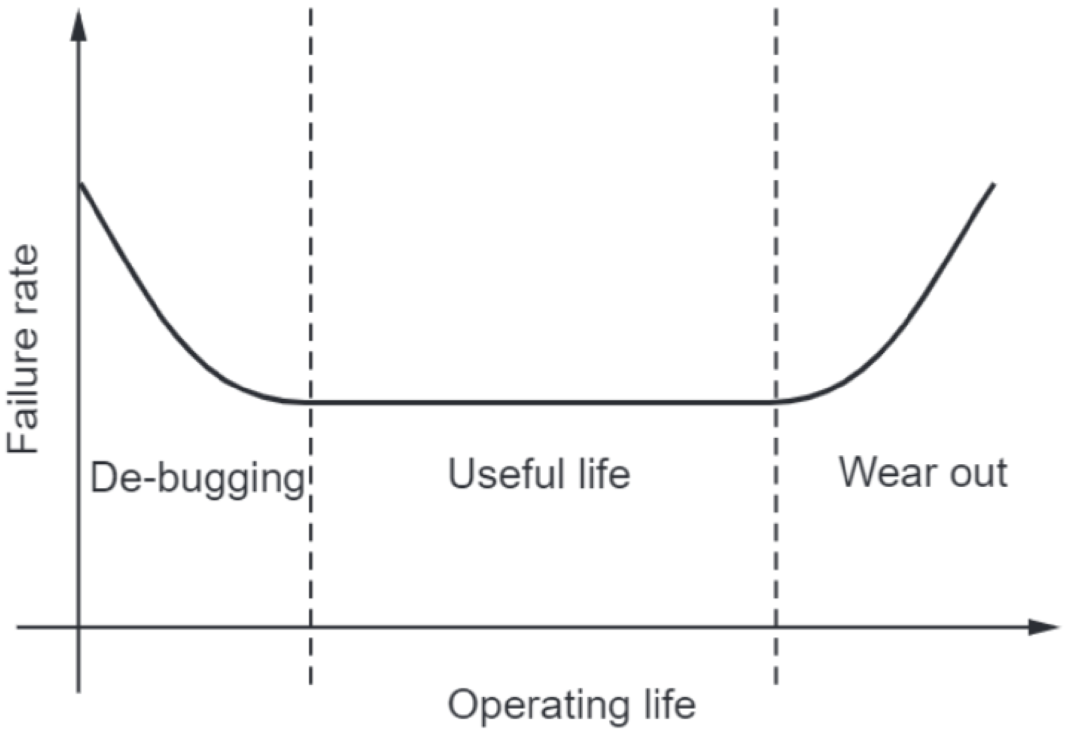
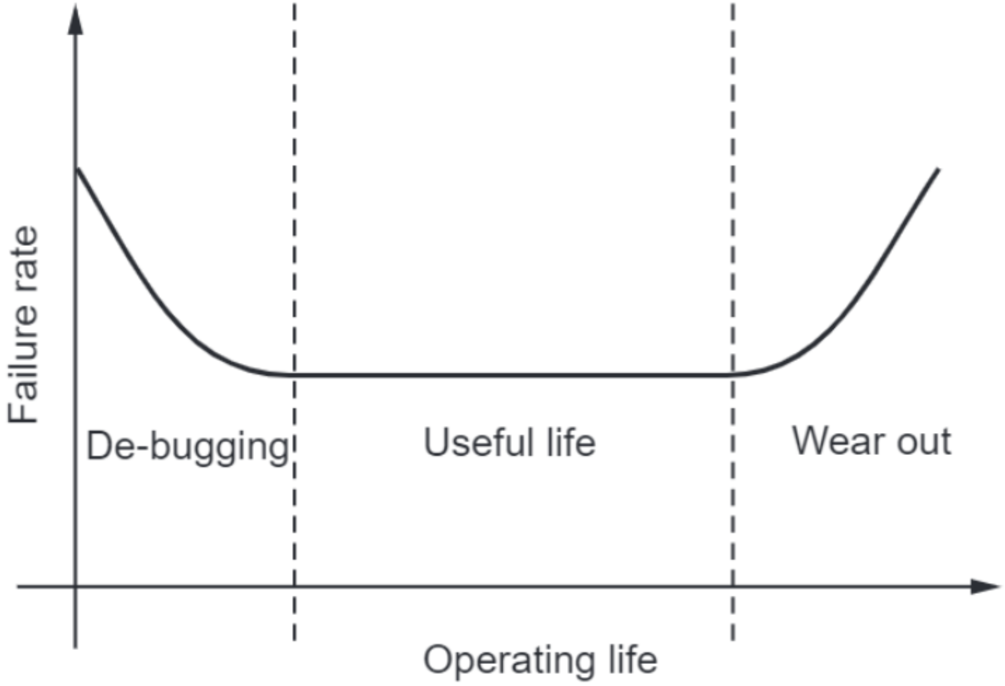


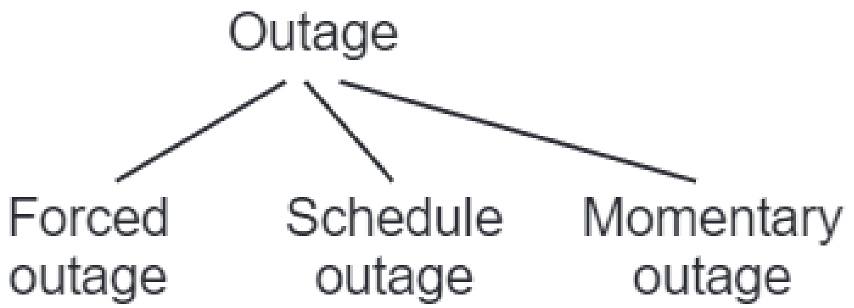
Fig 5.11

- The middle portion is normal operating life or useful life.
- In useful life period failure rate is only due to chance and failure is comparatively low and failure rate is nearly constant.
- Last region is wear out period or old age.
- In this period failure rate increases and usually repairs in this period are very costly.
- Therefore it is preferable to replace component by a new one.
- Power systems components can be kept within useful life period for long time by useful and proper periodic maintenance.



Outage

- It is the state of the device when it is unavailable to perform its specified function due to some problem or event which is directly associated with that device.
- An outage of the component may or may not cause interruption of service depending on system configuration.



Forced outage.

Results from emergency conditions.

Schedule outage.

- Also called maintenance outage
- Deliberately taken out for service at a selected time. Usually for preventive maintenance or repair.

Momentary Outage

- Caused by reclosing of CB to clear temporary fault. This outage lasts for very short, only a few seconds.
- Forced outage and momentary outage in system are due to different reasons. Some of these are lightening, tree contact, wind, vehicle accidents etc.

Limitation of Distribution System

The limitations must be taken into consideration for the correct, reliable and qualitative working of distribution system.

Thermal limit

Temperature determines the limiting load current. The loading for typical system elements are set by temperature rather than mechanical considerations.

Economic limit

Heat is dissipated in the system components which is termed as losses. It leads to increase in cost. When the cost of losses equals to the cost of reducing losses it is said to be economic level of loading.

Voltage drop

Thermal and economic limits are directly related to the magnitude of the load. One more determining factor in system component design is voltage drop.

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Overvoltages

Apart from voltage drops, components must be capable of withstanding voltage surges (overvoltages) generated from within the system or by external sources.

Voltage flicker and dips

The magnitude and frequent fluctuation in voltage can result in disturbances which can affect the performances of the devices connected.

Harmonic interference

It is essential that equipment which generates harmonics higher than the accepted levels are isolated from general supplies.

Power Quality

Power quality is broadly defined as characteristic of power supply necessary for better performance of equipments.

Major criteria of specifying good quality power is that *"The wave shape should be pure sine wave within allowable limits of distortions"*.

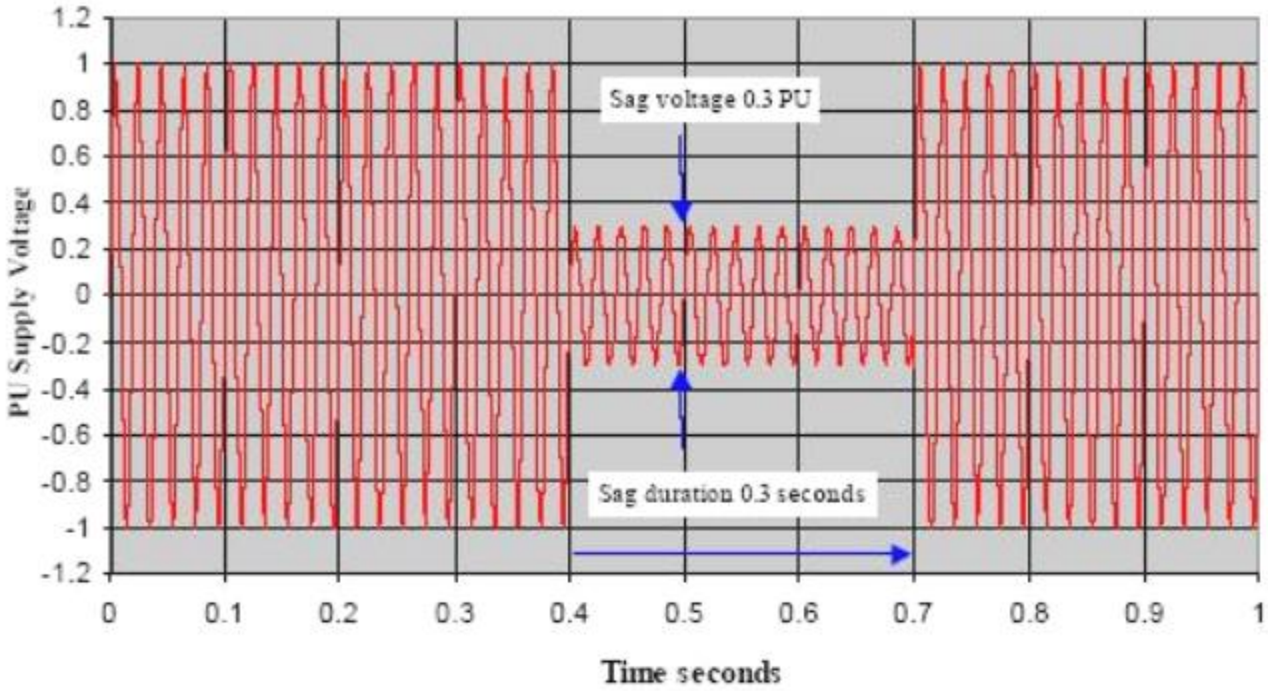
Power quality problems

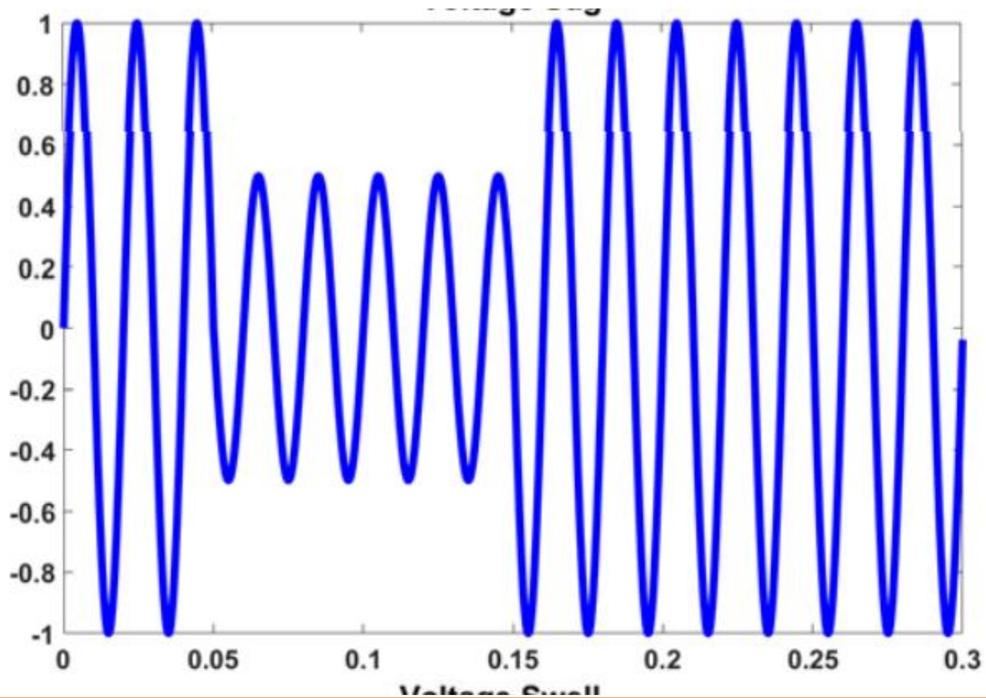
The most common types of power quality problems are:

- Voltage dip
- Voltage swell
- Harmonic distortion
- Noise
- Voltage unbalance

Voltage dip

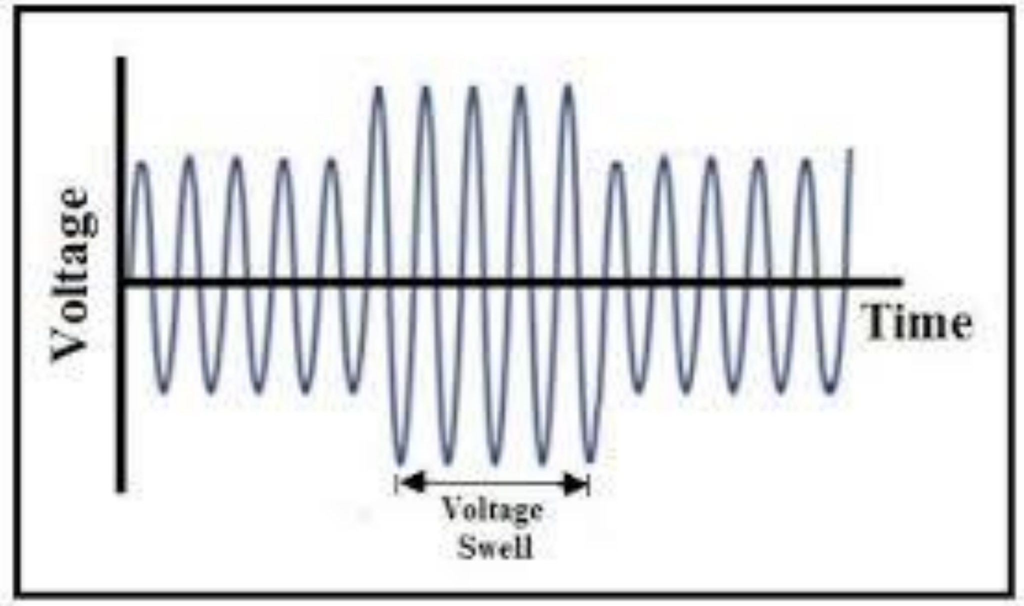
- A decrease of voltage level between 10 % to 90% of normal voltage at power frequency can be called as **voltage dip or voltage sag.**
- This may be due to faults on transmission or distribution network, in consumer installation or may be due to switching on of heavy loads or large motors.





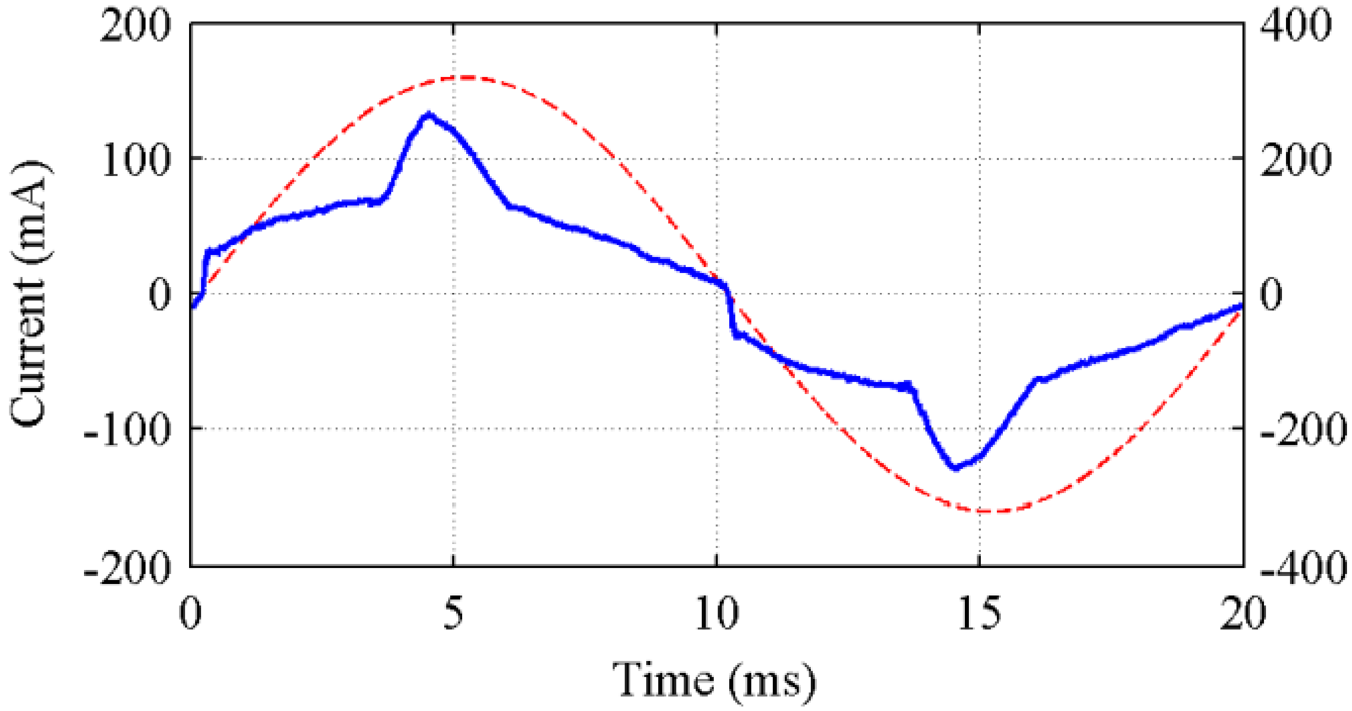
Voltage swell

- It is momentary increase of the voltage, which is outside the normal tolerances, which exist for more than one cycle and typically less than a few seconds.
- ***It is due to start or stop of heavy loads.***



Harmonic distortion

- A Harmonic is defined as a sinusoidal component of a periodic wave or quantity having a frequency that is integer multiples of the fundamental frequency.
- Harmonics can be voltage and/or current related and present in an electrical system in multiples of the fundamental frequency.



Noise

- Superimposing of high frequency signals on the waveform of power frequency is noise.
- Some of the causes are microwaves, welding machine, arc furnace, improper grounding etc.
- It can cause data processing errors, data loss.

Voltage unbalance

- If the voltage variations in 3 phase in which voltage magnitudes and phase angle difference between them are not equal. It is termed as voltage unbalance.
- Causes are incorrect distribution of loads on 3 phases and it may occur due to fault in the system.

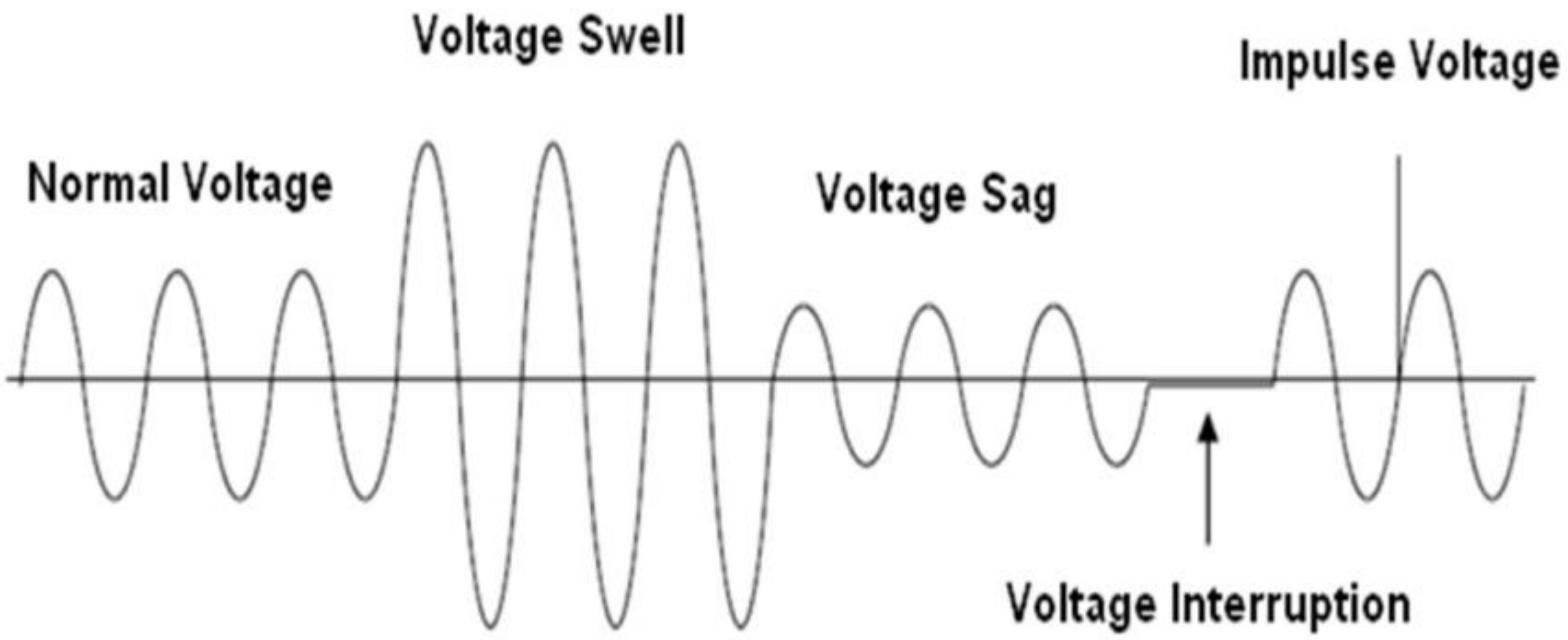


Figure representing Power Quality issues

THANK YOU