Distribution Systems

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Distribution systems

- Distribution systems originate from distribution sub-station and terminate at consumer terminals.
- The distribution substation handovers power from transmission system to the distribution system of an area by stepping down the voltage levels, with the support of distribution transformer, appropriate for consumers.
- The functioning of the distribution system is largely affected by the category of consumers.

Block diagram of distribution systems

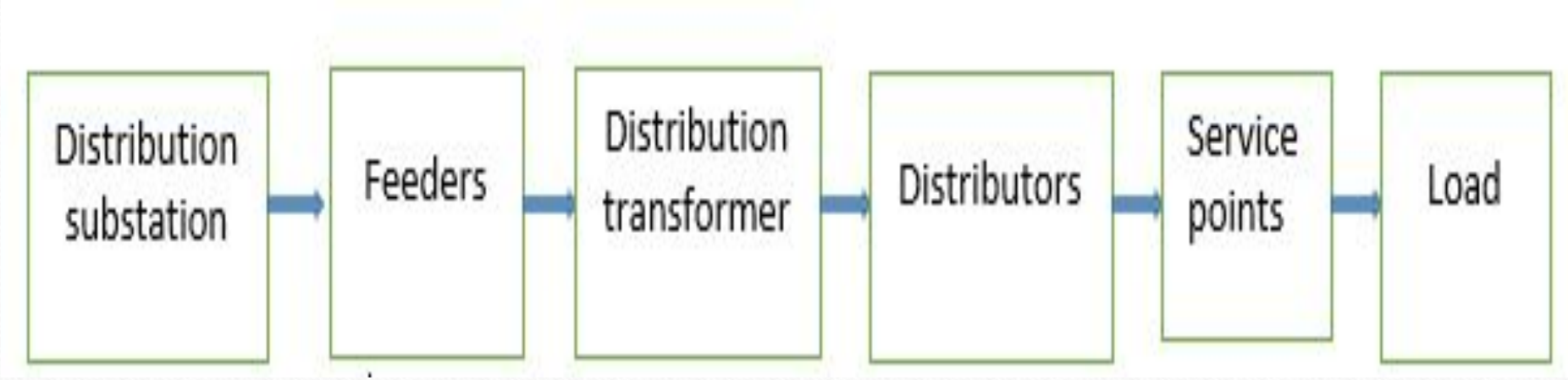


Figure7.1: Block diagram of distribution systems

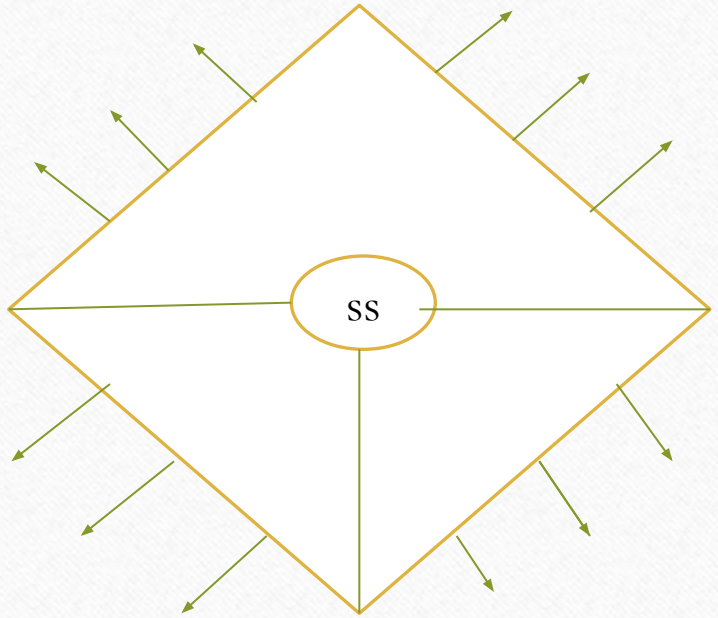


Figure 7.2: Elements of distribution systems

Feeder

- A feeder is a conductor which connects the substation to the area where power is to be delivered
- No tappings from feeder
- Same current flows through feeder
- Main consideration in the design of feeder is current carrying capacity

Distributor

- A distributor is a conductor from which tappings are taken for supply to consumers.
- Distributors are linked through secondary of the transformer and electric power is conveyed to diverse consumers by means of service mains.
- Due to various tappings, current through distributor is not constant
- While designing, voltage drop along its length is main consideration

Requirements of distribution system

- A good distribution system should ensure that the voltage variations at consumers terminals are within permissible limits.

- Availability of power on demand
- Reliability

Classification of distribution systems

- Nature of current- AC distribution and DC distribution
- Nature of installation-Overhead and underground distribution system
- Nature of wires

- Scheme of connection

- Radial type is most common type of distribution system in rural areas as it is simple and economical but less reliable.
- Ring main is used in urban areas as it deals with heavy loads. More reliable as compared to radial type but costly
- Interconnected system is costlier as compared to ring main but more reliable.

AC distribution

Primary distribution system:

- Primary distribution systems consist of feeders that deliver power from distribution substations to distribution transformers.
- 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.

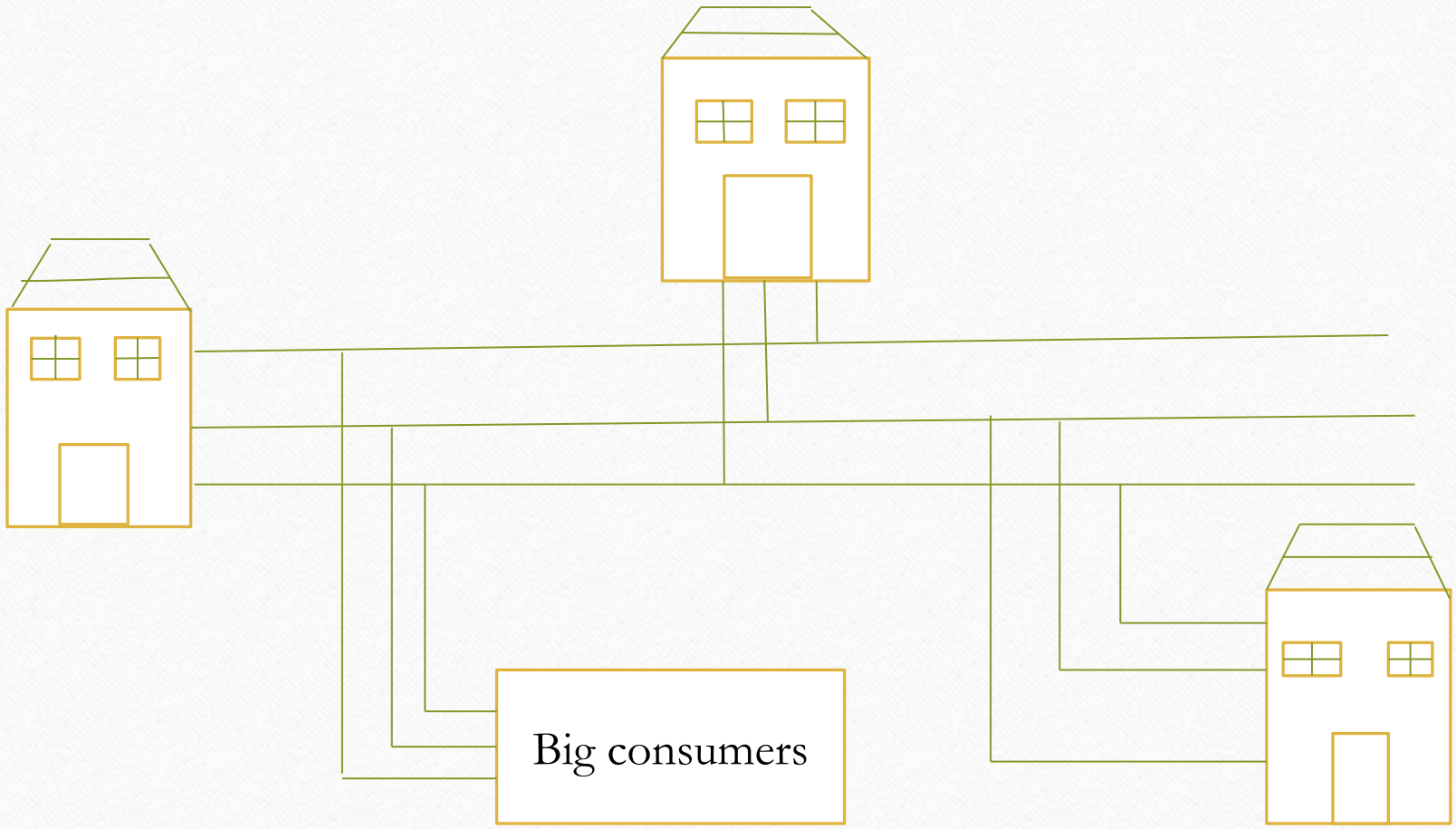


Figure 7.3 : Typical primary distribution system

Secondary distribution system

- It is that part of AC Distribution System which includes the range of voltages at which the consumer utilizes the delivered electrical energy
- Secondary distribution system consists of distributors from where service connections to the consumers are tapped off.
- The secondary distribution handles 400/230 V, 3-phase, 4-wire system.

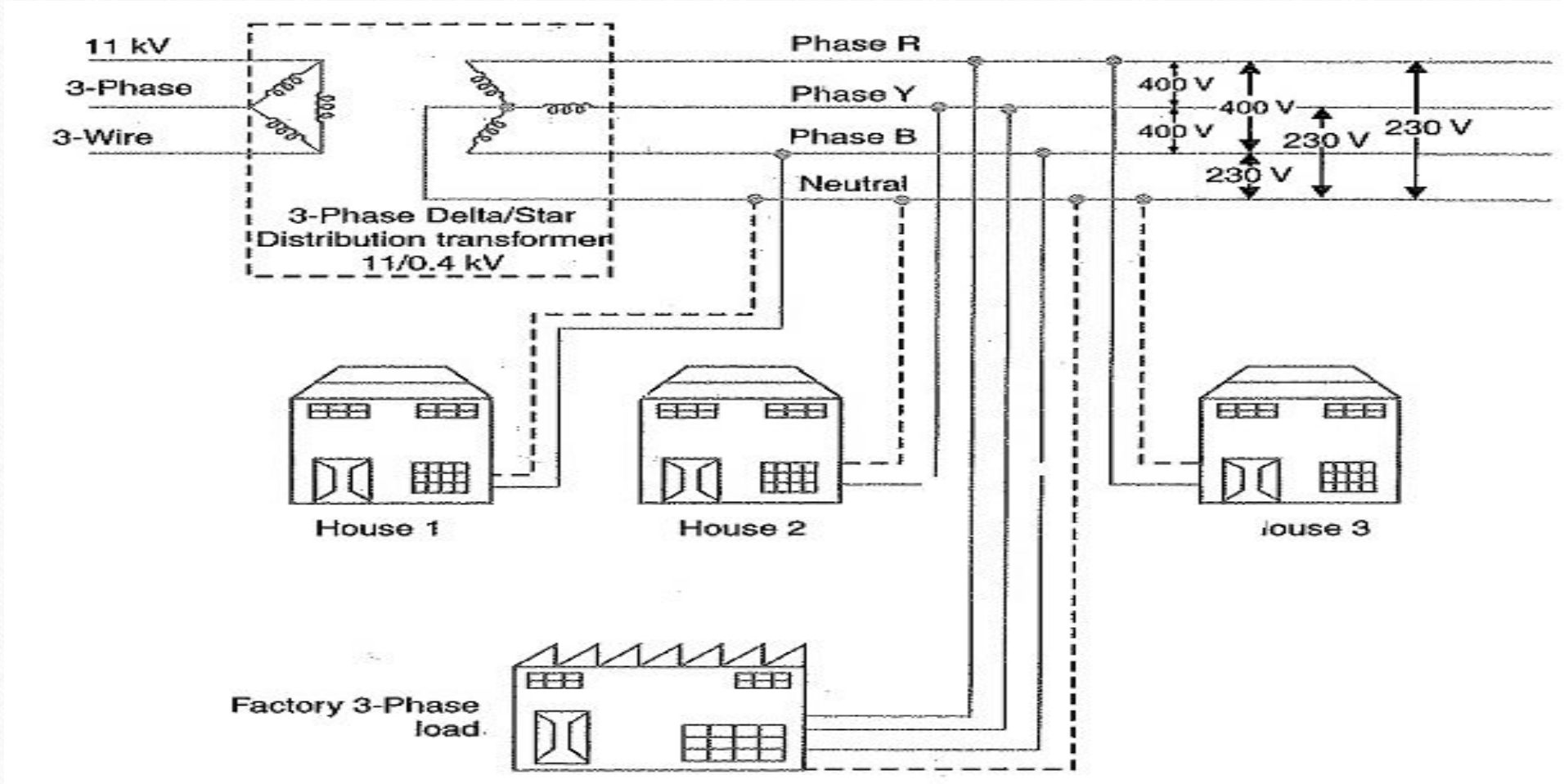


Figure 7.4 : Typical secondary distribution system

Advantages and constraints of of DC distribution

Advantages:

- Saving in conductor material

- No phase displacement problem
- No skin effect
- No charging current
- 0.707 times insulation stress as compared to AC
- Better voltage regulation

Major constraint: voltage can't be stepped up or down

Radial distribution systems

Advantages: Simplest system and low initial cost

Disadvantages:

- Less reliable
- Serious voltage fluctuations at the distant end of distributor
- End of distributor nearest to feeding point will be heavily loaded.

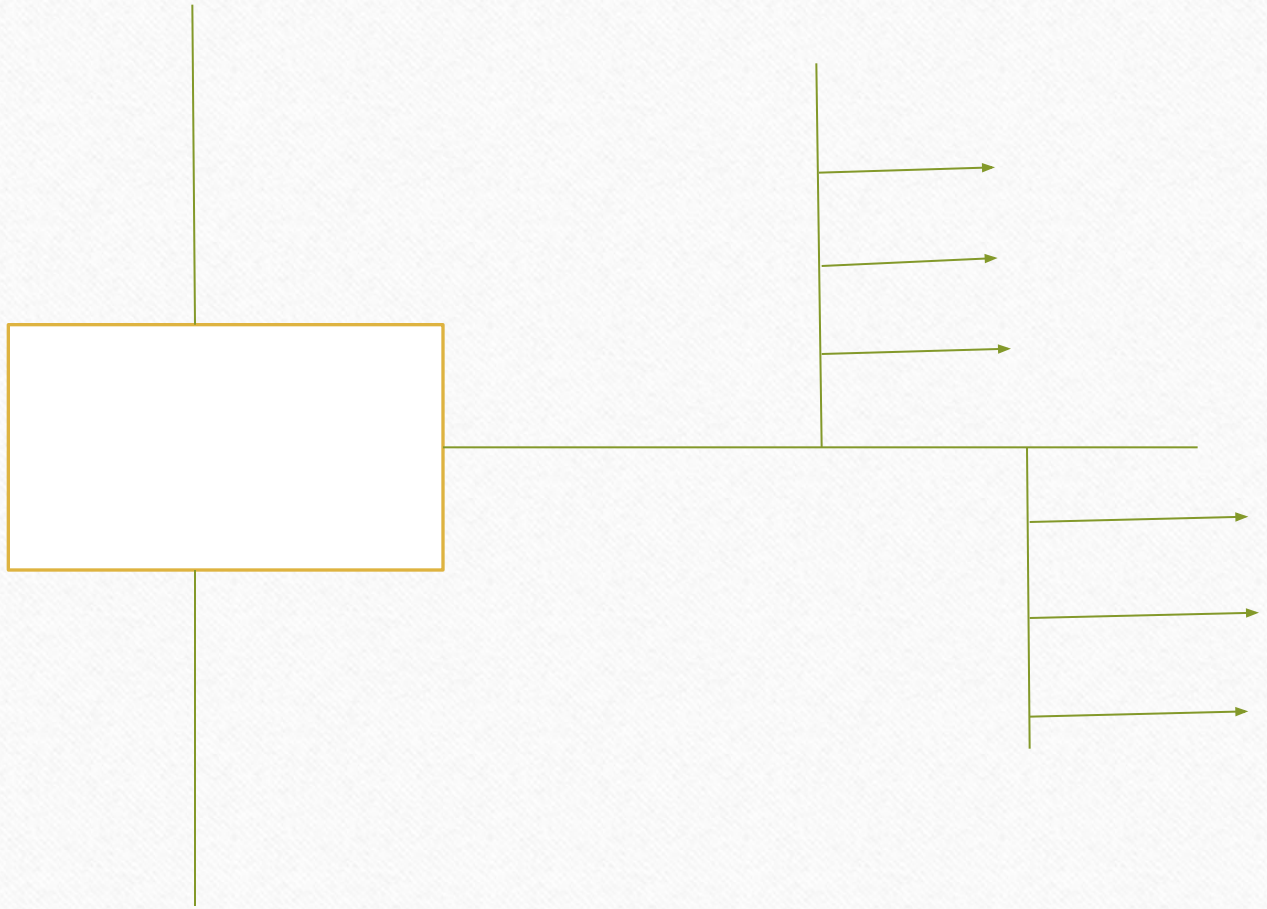


Figure 7.5: Radial distribution system

Ring main distribution system

- System forms a closed circuit and fed at one or more than one point

Advantages:

- Better voltage regulation at consumer terminals
- More reliable as each distributor is fed via two feeders

Constraints:

- complex and costly system
- serves heavy loads, hence protection and monitoring system should be designed properly.

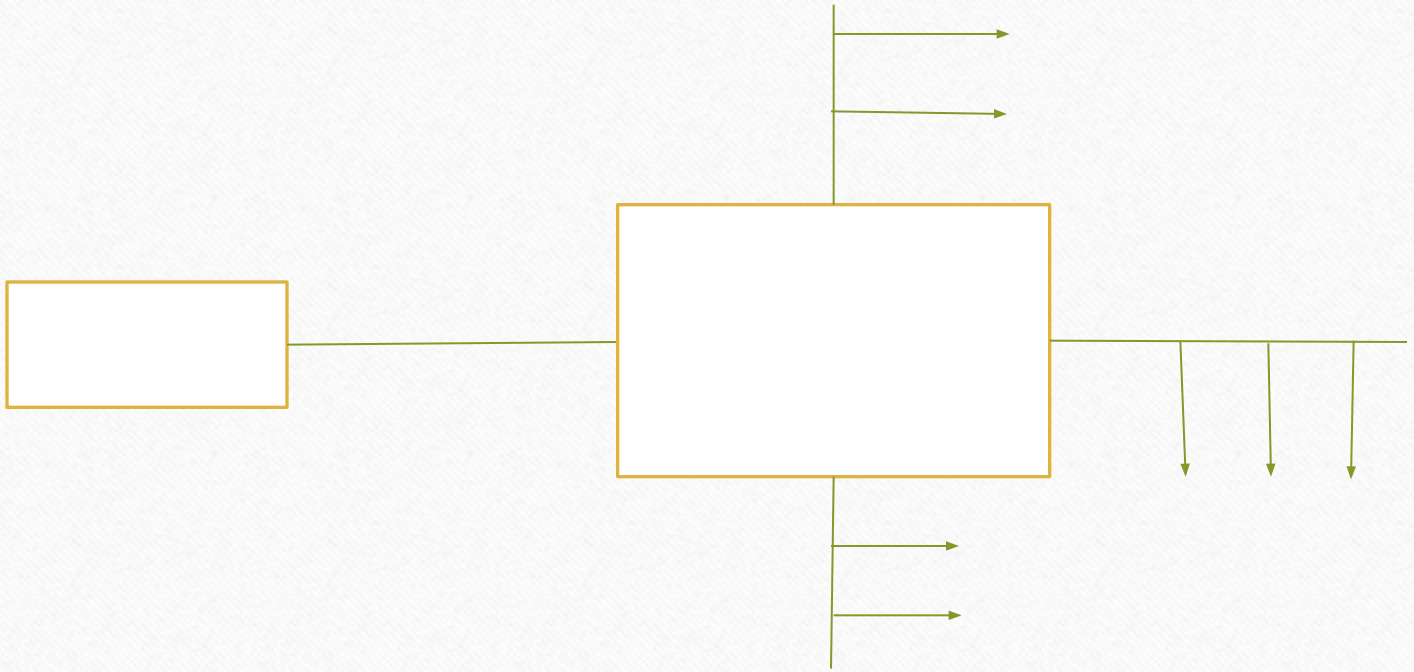


Figure 7.6: Ring main system

Interconnected system

- The feeder ring is energized by two or more than two sub-stations

Advantages:

- Increased service reliability
- Reduces reserve power capacity and increases efficiency.

Constraints:

- Complex system
- Costlier as compared to other two types

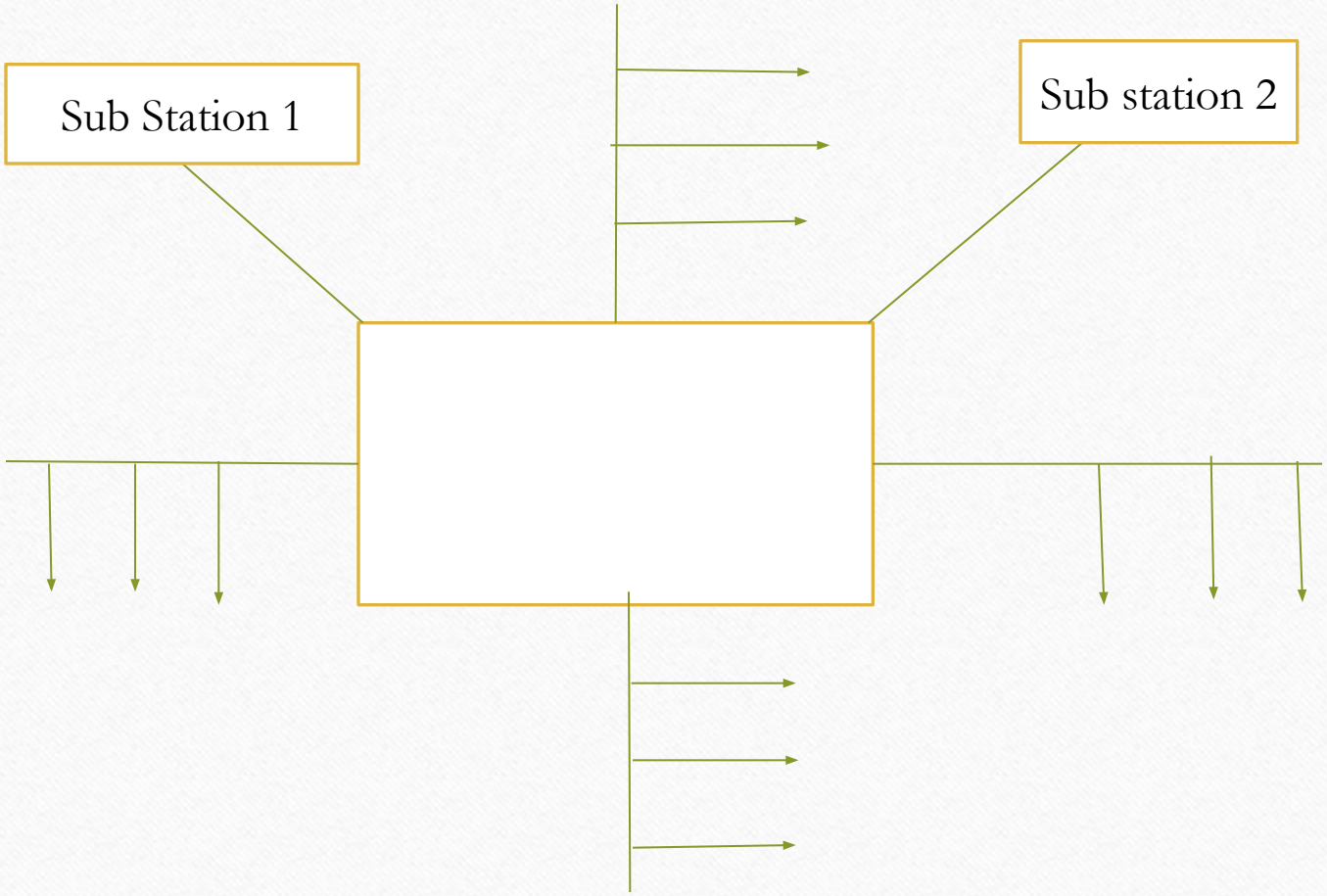


Figure 7.7: Interconnected system

Distribution systems

Part II

Comparison of various distribution systems

Assumptions:

- ~~Same distance over which same power is to be transmitted~~
- Line losses are same
- Maximum voltage between two conductors or between conductor and earth is same.

DC distribution system

- DC 2-wire system
- Neutral acts as return conductor and carries same current

- DC 3-wire system
- Currents flow in outer conductors are in opposite direction due to opposite polarity of voltage to neutral

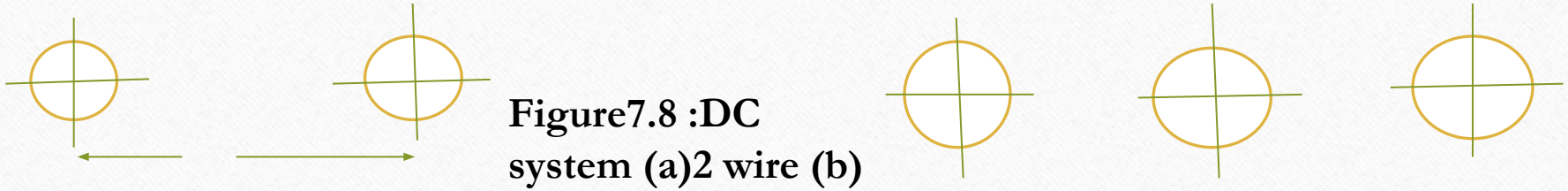
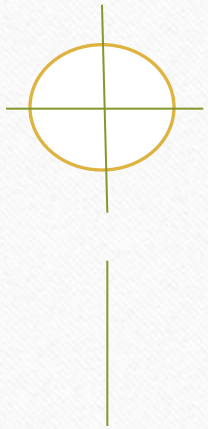
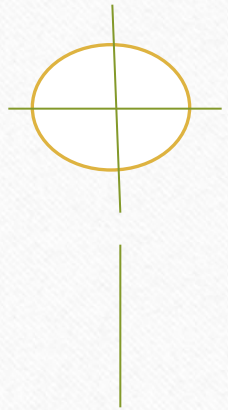
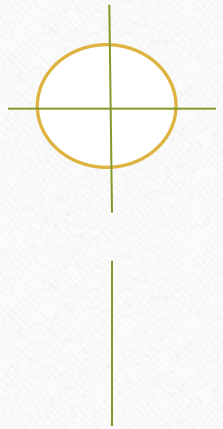


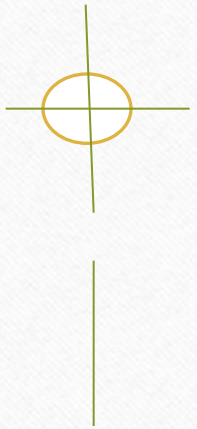
Figure7.8 :DC system (a)2 wire (b) 3 wire

Figure7.9 (a)Single phase system (a)three phase system









Systematic design of distribution systems

- Economical and Should be designed as per Indian Electricity Rules
- Feeders are designed based on current carrying capacity and distributors are designed on the basis of voltage drop.
- It is essential to design each distributor with the minimum volume of conductor material consistent with specified voltage regulation.
- Size of the distributor should be such that voltage at the consumer terminals remains within permissible limits (∓6%).

Main consideration in design of feeders

- The cross sectional area of feeder is determined by current carrying capacity
- The current carrying capacity depends upon the conductor losses and surroundings.
- Current carrying capacity is determined for maximum temperature limits by keeping an eye on voltage regulation.
- If voltage drop is not within permissible limits, conductor size is increased to next standard value.
- Check for tensile strength- if mechanically weaker, then considering practical and economic aspects, either span is reduced or conductor size is increased to next standard value .

Main considerations in design of DC distribution system

- Identify the DC distributor fed at one end/both ends/ middle/ring distributor.
- Type of loading on distributor-concentrated, uniform or combination of both
- Applying KCL, calculate currents flowing in different sections of distributor
- Calculate resistances and voltage drops of various sections of distributor
- Calculate the total voltage drop in the distributor
- Based on voltage drops, locate the point of minimum voltage

Main considerations in design of AC distribution system

- Similar to DC distribution system.
- For all sections, consider impedances in place of resistances.
- Do calculations taking sending end or receiving voltage as reference quantity.
- Add or subtract quantities by using vectors.