Lecture 5: Supply Systems

The electrical energy produced at the power stations has to be supplied to the consumers. There is a large network of conductors between the power station and the consumers. This network can be broadly divided into two parts *viz*., transmission and distribution.

5.1 Electric Supply System

It refers to the conveyance of electric power from a power station to consumers' *premises.*

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.

The electric supply system can be broadly classified into:

a) d.c or a.c. system
b) Overhead or underground system.

Now-days, 3-phase, 3-wire a.c. system is universally adopted for generation and transmission of electric power as an economical proposition. However, distribution of electric power is done by 3-phase, 4-wire a.c. system. The underground system is more expensive than the overhead system. Therefore, in our country, overhead system is mostly adopted for transmission and distribution of electric power.

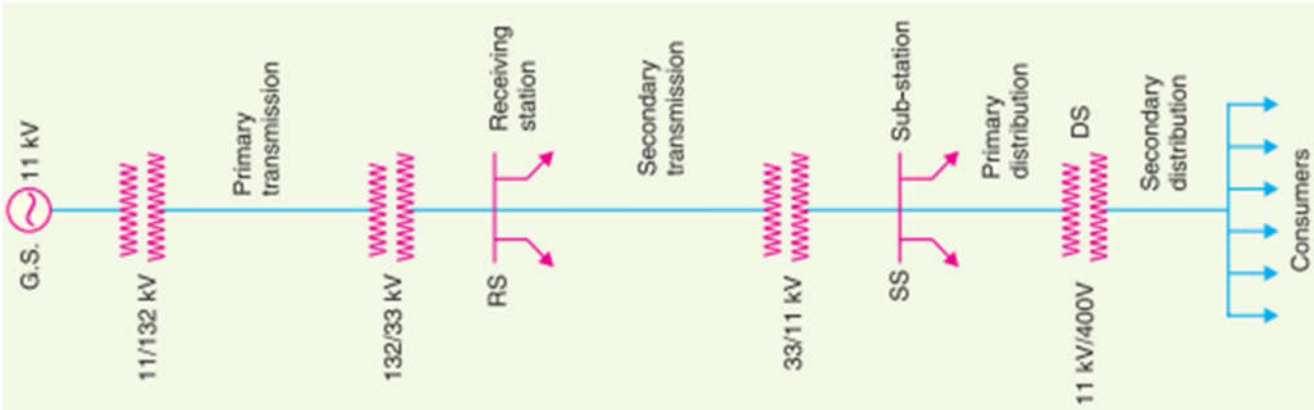


Figure 5.1 Typical Electrical Supply Systems

5.2 Typical a.c. Power Supply Scheme

The large network of conductors between the power station and the consumers can be broadly divided into two parts viz.

- Transmission system and
- Distribution system.

Each part can be further sub-divided into two—primary transmission and secondary transmission and primary distribution and secondary distribution.

Fig. 5.1. Shows the layout of a typical a.c. power supply scheme by a ***single line diagram***.

(*i*) *Generating station.*

In Fig 5.1, G.S. represents the generating station where electric power is produced by 3-phase alternators operating in parallel. The usual generation voltage is †11 kV. For economy in the transmission of electric power, the generation voltage (i.e., 11 kV) is stepped up to 132 kV (or more) at the generating station with the help of 3-phase transformers. The transmission of electric power at high voltages has several advantages including the saving of conductor material and high transmission efficiency. It may appear advisable to use the highest possible voltage for transmission of electric power to save conductor material and have other advantages. But there is a limit to which this voltage can be increased. It is because increase in transmission voltage introduces insulation problems as well as the cost of switchgear and transformer equipment is increased. Therefore, the choice of proper transmission voltage is essentially a question of economics. Generally the primary transmission is carried at 66 kV, 132 kV, 220 kV or 400 kV.

(*ii*) *Primary transmission.* The electric power at 132 kV is transmitted by 3-phase, 3-wire overhead system to the outskirts of the city. This forms the primary transmission.

(*iii*) *Secondary transmission.* The primary transmission line terminates at the receiving station (*RS*) which usually lies at the outskirts of the city. At the receiving station, the voltage is reduced to 33kV by step-down transformers. From this station, electric power is transmitted at 33kV by 3-phase, 3-wire overhead system to various sub-stations (*SS*) located at the strategic points in the city. This forms the secondary transmission.

(*iv*) *Primary distribution.* The secondary transmission line terminates at the sub-station (*SS*) where voltage is reduced from 33 kV to 11kV, 3-phase, 3-wire. The 11 kV lines run along the important road sides of the city. This forms the primary distribution. It may be noted that big consumers (having demand more than 50 kW) are generally supplied power at 11 kV for further handling with their own sub-stations.

(*v*) *Secondary distribution.* The electric power from primary distribution line (11 kV) is delivered to distribution sub-stations (*DS*). These sub-stations are located near the consumers' localities and step down the voltage to 400 V, 3-phase, 4-wire for secondary distribution. The voltage between any two phases is 400 V and between any phase and neutral is 230 V. The single-phase residential lighting load is connected between any one phase and neutral, whereas 3-phase, 400 V motor load is connected across 3-phase lines directly.

Secondary distribution system consists of *feeders*, *distributors and service mains*.

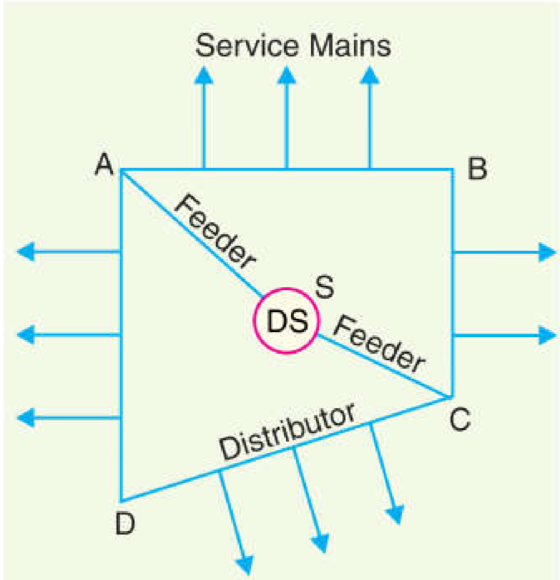


Figure 5.2 low voltage distribution system

Feeders (*SC* or *SA*) radiating from the distribution sub-station (*DS*) supply power to the distributors (*AB*, *BC*, *CD* and *AD*). No consumer is given direct connection from the feeders. Instead, the consumers are connected to the distributors through their service mains.

5.3 Comparison of D.C. and A.C. Transmission

1. D.C. transmission.

For some years past, the transmission of electric power by d.c. has been receiving the active consideration of engineers due to its numerous advantages.

Advantages.

The high voltage d.c transmission has the following advantages over high voltage a.c. transmission :

(*i*) It requires only two conductors as compared to three for a.c. transmission.

(*ii*) There is no inductance, capacitance, phase displacement and surge problems in d.c. transmission.

(*iii*) Due to the absence of inductance, the voltage drop in a d.c. transmission line is less than the a.c. line for the same load and sending end voltage. For this reason, a d.c. transmission line has better voltage regulation.

(*iv*) There is no skin effect in a d.c system. Therefore, entire cross-section of the line conductor is utilized.

(*v*) For the same working voltage, the potential stress on the insulation is less in case of d.c. system than that in a.c. system. Therefore, a d.c. line requires less insulation.

(*vi*) A d.c. line has less corona loss and reduced interference with communication circuits.

(*vii*) The high voltage d.c. transmission is free from the dielectric losses, particularly in the case of cables.

(*viii*) In d.c. transmission, there are no stability problems and synchronizing difficulties.

Disadvantages

(*i*) Electric power cannot be generated at high d.c. voltage due to commutation problems.

(*ii*) The d.c. voltage cannot be stepped up for transmission of power at high voltages.

(*iii*) The d.c. switches and circuit breakers have their own limitations.

2. A.C. transmission.

Now-a-days, electrical energy is almost exclusively generated, transmitted and distributed in the form of a.c.

Advantages

(*i*) The power can be generated at high voltages.

(*ii*) The maintenance of a.c. sub-stations is easy and cheaper.

(*iii*) The a.c. voltage can be stepped up or stepped down by transformers with ease and efficiency. This permits to transmit power at high voltages and distribute it at safe potentials.

Disadvantages

(*i*) An a.c. line requires more copper than a d.c. line.

(*ii*) The construction of a.c. transmission line is more complicated than a d.c. transmission line.

(*iii*) Due to skin effect in the a.c. system, the effective resistance of the line is increased.

(*iv*) An a.c. line has capacitance. Therefore, there is a continuous loss of power due to charging current even when the line is open.

From the above comparison, it is clear that high voltage d.c. transmission is superior to high voltage a.c. transmission. Although at present, transmission of electric power is carried by a.c., there is an increasing interest in d.c. transmission.

5.4 Advantages of High Transmission Voltage

(i) Reduces volume of conductor material. The greater the transmission voltage, the lesser is the conductor material required.

(ii) Increases transmission efficiency. Transmission efficiency increases when the line voltage is increased.

(iii) Decreases percentage line drop.

Limitations of high transmission voltage

(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 higher voltage is offset by the increased cost of insulation, transformer, switchgear etc. Hence, the choice of proper transmission voltage is essentially a question of economics.

5.5 Various Systems of Power Transmission

1. D.C. system

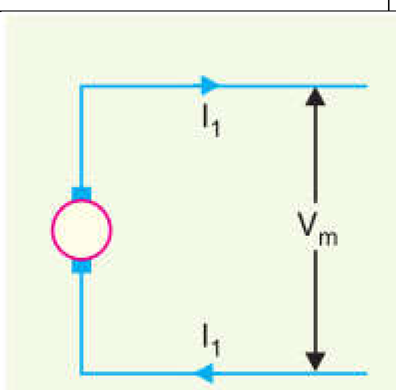
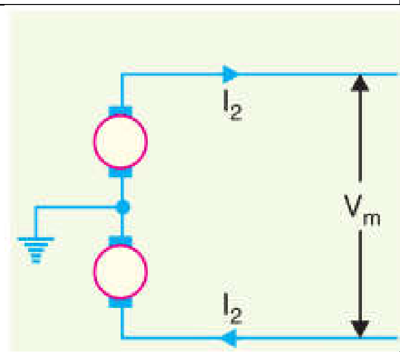
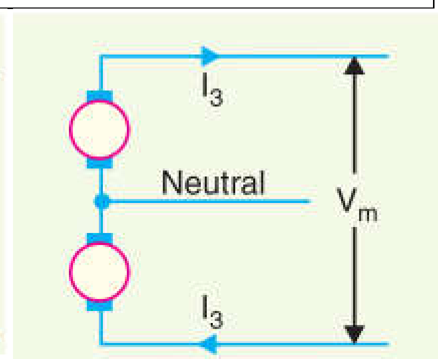
(*i*) D.C. two-wire.	(*ii*) D.C. two-wire with mid-point earthed.	(*iii*) D.C. three-wire.
		

Figure 5.3

2. Single-phase A.C. system

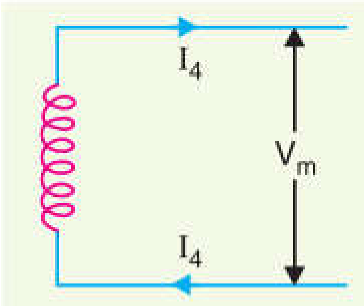
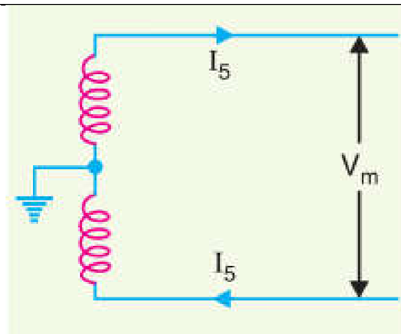
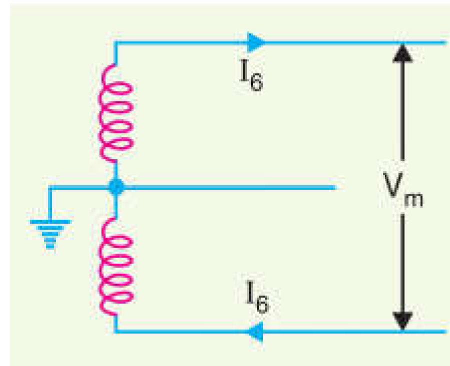
(*i*) Single-phase two-wire.	(*ii*) Single-phase two-wire with mid-point earthed.	(*iii*) Single-phase three-wire.
		

Figure 5.4

3. Two-phase A.C. system

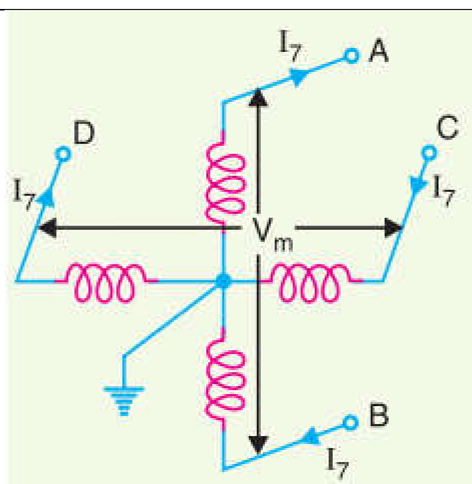
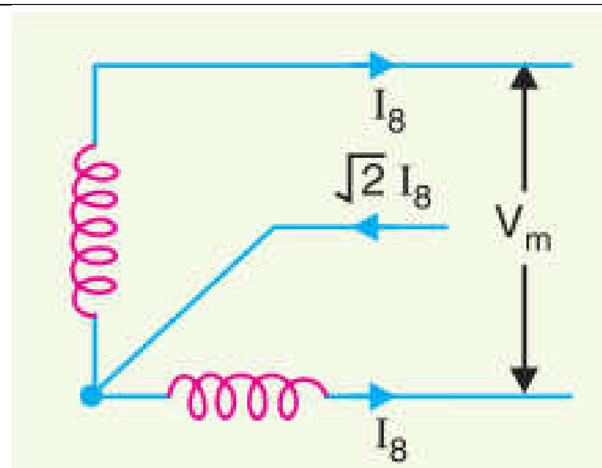
(*i*) Two-phase four-wire.	(*ii*) Two-phase three wire.
	

Figure 5.5

4. Three-phase A.C. system

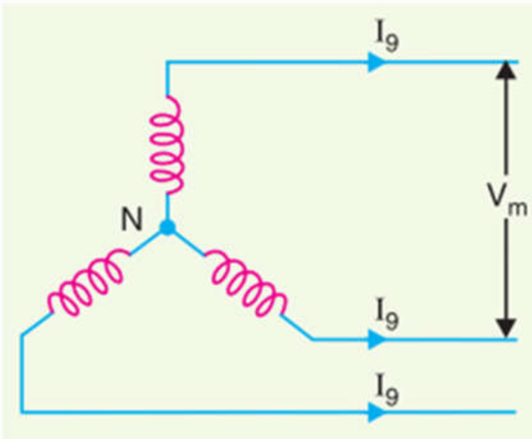
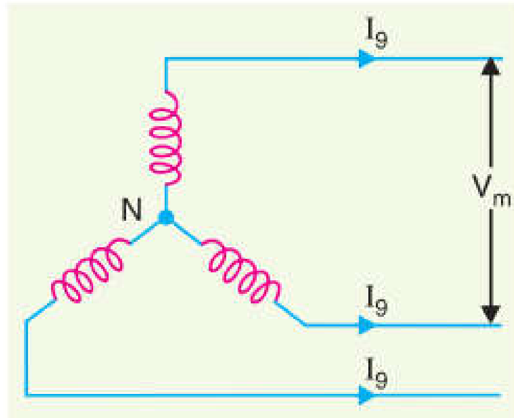
(*i*) Three-phase three-wire.	(*ii*) Three-phase four-wire.
	

Figure 5.6

Points to note:

(*i*) There is a great saving in conductor material if d.c. system is adopted for transmission of electric power. However, due to technical difficulties, d.c. system is not used for transmission.

(*ii*) Considering the a.c. system, the 3-phase a.c. system is most suitable for transmission due to two reasons. Firstly, there is considerable saving in conductor material. Secondly, this system is convenient and efficient.