PVP 23

Code: 23EE3401

II B.Tech - II Semester – Regular / Supplementary Examinations
APRIL 2026

POWER SYSTEMS - I
(ELECTRICAL & ELECTRONICS ENGINEERING)

Duration: 3 hours Max. Marks: 70

Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

BL – Blooms Level CO – Course Outcome

PART – A

		BL	CO
1.a)	What are the types of water turbines used in hydroelectric power plants?	L1	CO1
1.b)	Define the thermal efficiency of a steam power plant.	L1	CO1
1.c)	Mention the main components of a nuclear power plant.	L1	CO1
1.d)	State the harmful effects of nuclear radiation.	L1	CO1
1.e)	List the components of a 33/11 kV substation.	L1	CO1
1.f)	Define Gas Insulated Substation (GIS).	L1	CO1
1.g)	List the advantages of underground cables.	L1	CO1
1.h)	What are the basic requirements of a good distribution system?	L1	CO1
1.i)	Define the load curve.	L1	CO1
1.j)	Mention the types of tariffs used for domestic and commercial consumers.	L1	CO1

PART – B

			BL	CO	Max. Marks
		UNIT-I			
2	a)	Enumerate and briefly explain the factors to be considered while selecting the site for a hydroelectric plant.	L2	CO1	5 M
	b)	With a neat sketch, explain the arrangement of components in a hydroelectric power station.	L3	CO2	5 M
		OR			
3	a)	What is the function of a condenser in a steam power plant? Describe with a neat sketch any one type of condenser commonly used in power plants.	L3	CO2	5 M
	b)	The overall efficiency of a 100 MW thermal power station is 30%. If the load factor of the station is 40% and the coal consumption is 0.9 kg/kWh, find the annual coal bill if the cost is Rs. 50 per tone	L3	CO2	5 M
		UNIT-II			
4	a)	What is nuclear fusion? How does it different from nuclear fission?	L3	CO2	5 M
	b)	What is a moderator? Name commonly used moderators and discuss their merits and limitations.	L2	CO1	5 M
		OR			
5	a)	Interpret the working of a PWR (pressurized water reactor). What are its advantages and disadvantages?	L3	CO2	5 M

	b)	Interpret the classification of nuclear waste and the disposal methods adopted for each type.	L3	CO2	5 M
UNIT-III					
6	a)	What is a substation? Explain the factors that should be taken care of while designing and erecting a substation.	L4	CO3	5 M
	b)	Explain the merits and demerits of indoor and outdoor substations for urban and rural installations.	L2	CO1	5 M
OR					
7	a)	Draw and explain the double bus bar with one circuit breaker system? List out its merits and demerits.	L4	CO3	5 M
	b)	Compare air insulated substations and Gas insulated substations.	L4	CO3	5 M
UNIT-IV					
8	a)	What do you understand be the term grading of cable? Interpret briefly any one method of grading.	L3	CO4	5 M
	b)	A 33kV, 3-phase, 2.5 km-long feeder consists of single-core cables with a conductor radius of 12mm and an insulation thickness of 8mm. The dielectric has a relative permittivity of 3, and the unloaded cable's power factor is 0.3. Determine the following (i) capacitance per phase (ii) charging current per phase.	L3	CO4	5 M
OR					
9	a)	Explain the radial distribution system with a neat diagram and list out its merits and demerits.	L3	CO4	5 M

	b)	Explain the classification of distribution systems in detail.	L2	CO1	5 M
		UNIT-V			
10	a)	Define the following (i) maximum demand (ii) demand factor (iii) load factor	L2	CO1	5 M
	b)	A generating station supplies four feeders with the maximum demands (in MW) of 16 MW; 10 MW; 12 MW and 7 MW. The overall maximum demand on the station is 20 MW and the annual load factor is 45%. Find the diversity factor and the number of units generated annually.	L4	CO5	5 M
		OR			
11	a)	What are the desirable characteristics of a tariff method?	L2	CO1	5 M
	b)	A factory has a maximum load of 240 kW at 0.8 p.f. lagging with an annual consumption of 50,000 units. The tariff is Rs 50 per kVA of maximum demand plus 10 paise per unit. Calculate the flat rate of energy consumption. What will be annual saving if p.f. is raised to unity?	L4	CO5	5 M

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POWER SYSTEMS – 1

(Electrical & Electronics Engineering)

PART A

1. a) Any two types ------ 2 M
   b) definition ------ 2 M
   c) Any 4 nuclear power plant components ------ 2 M
   d) Any 2 harmful effects ------ 2 M
   e) Any 4 components of 33KV/11KV ----- 2 M
   f) GIS Definition ------ 2 M
   g) Any two advantages ------ 2 M
   h) Any two requirements distribution system------ 2 M
   i) Definition ------- 2 M
   j) Any three types of tariff ----- 2M

2. a) Any 5 factors ------ 5 M
   b) Diagram ---- 3 M
   Explanation ------ 2 M

3. a) Function of Condenser ---- 3 M
   Explanation of any one type ----- 2 M
   b) Formula ---- 2 M
   Solution ----- 3 M

4. a) Nuclear Fusion ---- 1 M
   Nuclear fission ------ 2 M
   Any two differences ----- 2 M
   b) Moderator ---- 3 M
   Types ---- 1 M
   Merits and limitations --- 1 M

5. a) Working of PWR ------ 4 M
   Advantages and disadvantages ---- 1 M
   b) Classification of nuclear waste ----- 2 M
   Explanation ----- 3 M

6. a) Substation definition ------ 2 M
   Any three factors for designing and erecting a substation ------ 3 M

b) Merits of indoor substations and outdoor substations ------ 3 M
Demerits of indoor substations and outdoor substations ------ 2 M

7. a) Diagram ---- 2M
Explanation ----- 2 M
Merits and demerits---- 1 M

b) Any 5 comparisons between AIS and GIS ------ 5 M

8. a) What is meant by grading of cables ----- 2 M
Methods of Grading ---- 1 M
Explanation of any one method ----- 2 M
b) Formulas ----- 2 M
Calculation of capacitance /Phase --- 2 M
Calculation of charging current ---- 1 M

9. a) Diagram ---- 2 M
Explanation ---- 2 M
Merits and demerits---- 1 M
b) Classification based on
Nature of Current ---- 2 M
Type of Construction---- 2 M
Scheme of Connection ---- 1 M

10. a) Maximum demand --- 2 M
Demand factor --- 1.5 M
Load factor --- 1.5 M
b) Load factor and diversity factor formulas --- 2 M
calculation of diversity factor ---- 1.5 M
Calculation of no. of units generated ---- 1.5 M

11. a) Any five characteristics ----- 5 M
b) Calculation of Total annual cost when pf is 0.8 ----- 1.5 M
Calculation of total annual cost when pf ins unity --- 1.5 M
Calculation of flat rate of energy consumption ----- 1 M
calculation of annual saving --- 1 M

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POWER SYSTEMS – 1

(Electrical & Electronics Engineering)

Key

PART A

1. **a) What are the types of water turbines used in hydroelectric power plants?**
   - Impulse Turbines
   - Reaction Turbines

   b) Define the thermal efficiency of a steam power plant.

   It is the ratio of electrical energy output to heat energy input from the fuel.

$$\text{Thermal Efficiency} = \frac{\text{Electrical Energy Output}}{\text{Heat Energy Input from Fuel}}$$

   c) Mention the main components of a nuclear power plant.
   - Nuclear reactor
   - Fuel rods
   - Moderator
   - Control rods
   - Coolant
   - Steam generator (heat exchanger)
   - Turbine
   - Generator
   - Condenser

   d) State the harmful effects of nuclear radiation.
   - Damages body cells
   - Causes sickness and weakness
   - Leads to cancer
   - Causes of genetic changes
   - Skin burns and hair falls
   - May cause death in high exposure
   - Pollutes environment

e) List the components of a 33/11 kV substation.

- Power transformer
- Bus bars
- Circuit breakers
- Isolators
- Current transformers (CT)
- Potential transformers (PT)
- Lightning arresters

f) Define Gas Insulated Substation (GIS).

GIS is a type of substation in which all electrical are enclosed in a sealed chamber filled with insulating gas (usually SF_6) instead of air.

g) List the advantages of underground cables.

- Not easily damaged by storms or lightning
- Safer and fewer chances of faults
- Better appearance (no visible wires)
- Lower maintenance cost
- Less voltage drop

h) What are the basic requirements of a good distribution system?

- Proper Voltage
- Availability of Power on Demand
- Reliability

i) Define the load curve.

A load curve is a graph showing the variation of load (power demand) on a power station with respect to time.

j) Mention the types of tariffs used for domestic and commercial consumers.

- simple rate tariff
- flat rate tariff
- block-rate tariff
- two-part tariff
- three–part tariff
- Maximum demand tariff
- power factor tariff

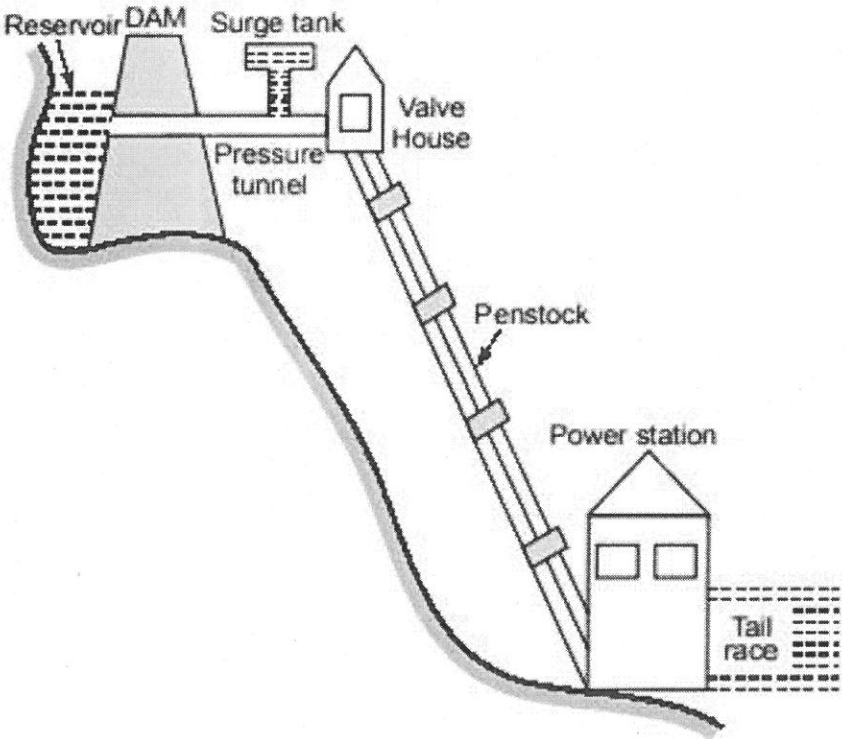
PART B

2. a) Enumerate and briefly explain the factors to be considered while selecting the site for a power plant.

Selecting a suitable site is the most important factor for an efficient and economical hydroelectric power station

- Availability of Water
- High Water Head
- Storage Facility
- Favorable Topography
- Accessibility of the site
- Distance from Load Centre
- Minimal Environmental and Social Impact
- Cost and Economics
- Large catchment area
- The area should also be free from earthquakes.

2. b) With a neat sketch, explain the arrangement of components in a hydroelectric power station.



i. Reservoir

- Stores a large amount of water at height (potential energy).

ii. Dam

- Built across a river to create the reservoir and control water flow.

iii. Spillway

- Releases excess water safely to avoid damage to the dam.

iv. Intake Structure

- Controls entry of water into the system.
- Removes debris using screens.

v. Penstock

- Large pipe that carries water from reservoir to turbine at high pressure.

vi. Turbine

- Water strikes turbine blades and converts hydraulic energy into mechanical energy.

vii. Generator

- Connected to turbine; converts mechanical energy into electrical energy.

viii. Draft Tube

- Carries water away from turbine to tailrace.

ix. Tailrace

- Channel that returns water back to the river.

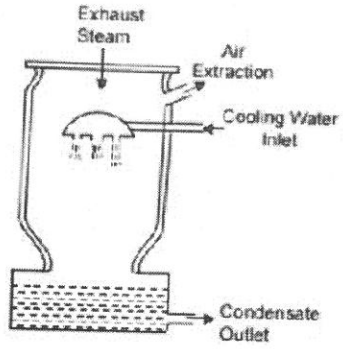
3. **a) What is the function of a condenser in a steam power plant? Describe with a neat sketch any one type of condenser commonly used in power plants.**

A condenser is an important component of a steam power plant used to convert the exhaust steam coming out of the turbine into water by removing heat from it.

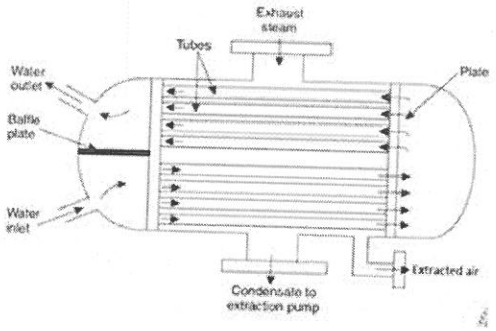
After expansion in the turbine, the steam still contains considerable heat energy and if it is directly released into the atmosphere, a large amount of heat and water will be wasted. By passing the exhaust steam through a condenser, it is condensed into water, which can be reused as boiler feed water. The presence of a condenser also helps in maintaining a high vacuum at the turbine exhaust, which reduces the back pressure on the turbine and increases the overall efficiency of the power plant.

Condensers are mainly classified into jet condensers and surface condensers.

In a jet condenser, the exhaust steam directly mixes with the cooling water and condensation takes place by direct contact. In this type, the temperature of condensate and cooling water is the same at the outlet, and the condensate cannot be reused as boiler feed water. Jet condensers are simple in construction and have low initial cost, but they require a large quantity of water and are generally used only in small plants.



jet condenser



surface condenser

In a surface condenser, the exhaust steam and cooling water do not mix with each other. The cooling water flows through a large number of tubes, while the exhaust steam condenses on the outer surface of these tubes. Heat transfer takes place through the tube walls. Since there is no mixing, the condensate obtained is pure and can be reused as boiler feed water. Surface condensers are widely used in modern steam power plants because they provide high efficiency and better vacuum, although their initial cost is high and they require more space.

3. **b) The overall efficiency of a 100 MW thermal power station is 30%. If the load factor of the station is 40% and the coal consumption is 0.9 kg/kWh, find the annual coal bill if the cost is Rs. 50 per ton.**

$$Load\ Factor = \frac{Average\ Load}{Maximum\ Demand}$$

Average load = Maximum Demand X Load Factor = $100 \times 0.4 = 40$ MW

Energy = $40 \times 8760 = 350400$ MWh = 350400000 kWh

Coal required = $350400000 \times 0.9 = 315360000$ kg = 315360 tons

Annual coal Cost = $315360 \times 50 = 15768000$

4. **a) What is nuclear fusion? How does it different from nuclear fission?**

Nuclear Fusion

Nuclear fusion is the process in which two light atomic nuclei combine to form a heavier nucleus, releasing a large amount of energy.

Nuclear Fission

Nuclear fission is the process in which a heavy nucleus splits into two smaller nuclei, releasing energy.

In nuclear fusion, two light nuclei combine to form a heavier nucleus, whereas in nuclear fission, a heavy nucleus splits into two smaller nuclei. Fusion requires extremely high temperature and pressure to occur, while fission can take place under controlled conditions in

a nuclear reactor. Fusion releases a larger amount of energy and produces very little radioactive waste, whereas fission produces comparatively less energy and generates significant radioactive waste. Additionally, fusion is not yet widely used for power generation, while fission is commonly used in nuclear power plants.

4. **b) What is a moderator? Name commonly used moderators and discuss their merits and limitations.**

A **moderator** is another essential part of the nuclear reactor. The fast neutrons released during fission are not effective in causing further fission. The moderator slows down these fast neutrons to thermal speed, making them more effective for sustaining the chain reaction.

Commonly Used Moderators

i. Ordinary water (H_2O)
ii. Heavy water (D_2O)
iii. Graphite

Ordinary Water (H_2O)

Ordinary water is cheap and easily available, and it is also used as a coolant. But it absorbs some neutrons, so efficiency decreases and enriched fuel is needed.

Heavy Water (D_2O)

Heavy water is a very good moderator because it does not absorb many neutrons and allows the use of natural uranium. But it is very costly and difficult to handle.

Graphite

Graphite is a good moderator with low neutron absorption. But it requires more space and may catch fire at high temperatures.

5. **a) Interpret the working of a Pressurized Water Reactor (PWR). What are its advantages and disadvantages?**

A Pressurized Water Reactor is the most commonly used nuclear reactor in the world. In this reactor, ordinary water is used both as a coolant and as a moderator. The water in the reactor core is kept under very high pressure, so it does not boil even at high temperatures. Heat produced by nuclear fission is carried by this hot water to a steam generator, where it transfers heat to another water circuit.

This secondary water turns into steam and rotates the turbine to generate electricity. Since the radioactive water does not directly come in contact with the turbine, PWRs are considered safe and reliable. Many modern nuclear power plants use this type of reactor. The main disadvantages of a Pressurized Water Reactor are that it requires very high pressure to operate, which increases the cost and complexity of the equipment. Also, its efficiency is slightly lower compared to some other types of nuclear reactors.

5. **b) Interpret the classification of nuclear waste and the disposal methods adopted for each type.**

Nuclear waste disposal deals with safe handling and long-term storage of radioactive wastes produced in nuclear power plants. Waste is generated from used fuel rods, contaminated equipment, cooling water, laundry effluents, sludge, and filters.

During operation and maintenance, Nuclear power plants generate solid, liquid, and gaseous radioactive wastes. Safe disposal of these wastes is essential to protect the environment and human health.

Solid radioactive wastes such as used filters, sludge, discarded fuel element cans, and contaminated equipment are first embedded in borosilicate glass to immobilize radioactivity. These glass capsules are then stored in sealed steel containers and placed in deep geological repositories, such as salt mines or deep ocean beds, where they remain isolated for thousands of years.

Liquid radioactive wastes from laundry, decontamination processes, and fuel element corrosion are treated chemically and passed through ion-exchange columns to remove radioactive ions. Before discharge, the liquids are diluted so that activity levels remain well below permissible limits. Cleaned and diluted liquid effluents are released safely below the maximum drinking-water limit.

Gaseous radioactive wastes are filtered before being released into the atmosphere. High-efficiency filters remove radioactive iodine and other fission products. If leaks occur, gases are routed through cleanup systems to reduce hazard levels before discharge.

6. **a) What is a substation? Explain the factors that should be taken care while designing and erecting a substation?**

A substation is a place in the power system where electricity is controlled, protected, and changed to suitable voltage levels before being sent to consumers.

Factors to be considered while designing and erecting a substation

Location:

Should be near the load center.

Type:

Indoor or outdoor depending on voltage and space.

Future expansion:

Provision should be made for future load growth.

Safety:

Proper earthing and protection should be provided.

Reliability:

Ensure continuous and reliable supply.

Economy:

Design should be economical.

Environmental conditions:

Consider weather and surroundings.

Maintenance:

Equipment should be easily accessible.

6. **b) Explain the merits and demerits of indoor and outdoor substations for urban and rural installations.**

Indoor Substation

Merits

- Protected from **rain, dust, pollution, and animals**
- **Higher safety** for operators
- Requires **less land area**
- Suitable for **urban and industrial locations**

Demerits

- Higher **construction cost** due to building
- Limited space for **future expansion**
- Heat dissipation is a concern
- Maintenance may be difficult in confined spaces

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Outdoor Substation:

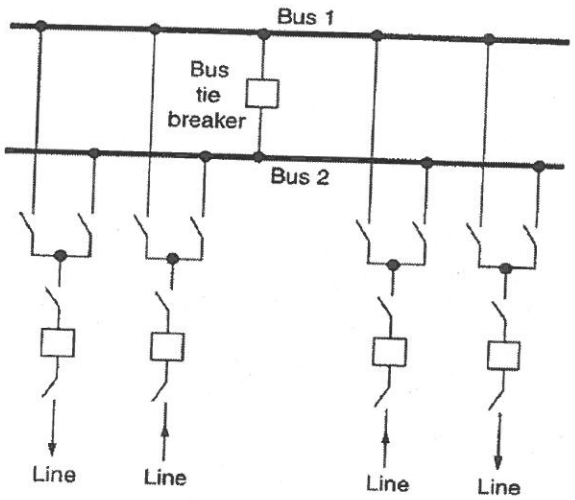
Merits

- Lower **initial cost** (no building required)
- Easy **inspection and maintenance**
- Suitable for **very high voltages**
- Easy **extension and modification**

Demerits

- Requires **large land area**
- Affected by **weather, dust, fog, and pollution**
- Lower safety compared to indoor substations
- Not suitable for crowded areas

7. **a) Draw and explain the double bus bar with one circuit breaker system. List out its merits and demerits.**



A typical double bus-single breaker scheme.

- The substation is provided with two bus bars.
- Each circuit has one circuit breaker and is connected to both buses through isolators.
- A bus tie (tie breaker) connects the two buses and is normally kept closed to provide operational flexibility.
- If a fault occurs on one bus, that bus is isolated and the circuits are supplied from the other bus.
- Compared to a single bus scheme, this arrangement is more expensive and requires more space.

7. **b) Compare Air insulated substations and Gas insulated substations.**

Parameter	AIS (Air-Insulated Substation)	GIS (Gas-Insulated Substation)
Insulation medium	Uses air for insulation	Uses SF_6 gas for insulation
Space requirement	Requires large land area	Requires very less space
Size of substation	Large and spread-out layout	Compact and enclosed layout
Installation	Mostly outdoor	Indoor, outdoor, or underground
Initial cost	Low initial cost	High initial cost
Maintenance	High maintenance due to exposure	Very low maintenance
Reliability	Affected by weather and pollution	Highly reliable under all conditions
Safety	Live parts are exposed	Live parts are fully enclosed and earthed
Environmental impact	Environment-friendly	SF_6 gas has greenhouse effect
Fault detection	Faults are easy to locate and repair	Fault location is difficult
Service continuity	Lower operational availability	High operational availability
Suitability	Suitable where land is easily available	Ideal for urban and space-constrained areas

8. **a) What do you understand be the term grading of cable? Interpret briefly any one method of grading.**

The process of achieving uniform electrostatic stress in the dielectric of cables is known as grading of cables.

In a single-core cable, the stress is maximum at the conductor surface and decreases towards the outer sheath. This uneven distribution is not desirable because it requires more insulation thickness and may cause breakdown. To overcome this, stress is distributed more evenly across the insulation, which is called grading of cables.

The main methods of grading are

i) Capacitance grading
ii) Intersheath grading.

Capacitance Grading

The process of achieving uniformity in the dielectric stress by using layers of different dielectrics is known as capacitance grading.

In capacitance grading, the homogeneous dielectric is replaced by a composite dielectric. The composite dielectric consists of various layers of different dielectrics in such a manner that relative permittivity ε_r of any layer is inversely proportional to its distance from the centre.

Under such conditions, the value of potential gradient at any point in the dielectric is *constant and is independent of its distance from the centre.

Intersheath Grading

In this method of cable grading, a homogeneous dielectric is used, but it is divided into various layers by placing metallic intersheaths between the core and lead sheath. The intersheaths are held at suitable potentials which are in between the core potential and earth potential. This arrangement improves voltage distribution in the dielectric of the cable and consequently more uniform potential gradient is obtained.

8. **b) A 33kV, 3-phase, 2.5 km-long feeder consists of single-core cables with a conductor radius of 12mm and an insulation thickness of 8mm. The dielectric has a relative permittivity of 3, and the unloaded cable's power factor is 0.3. Determine the following**
   (i) capacitance per phase
   (ii) charging current per phase.

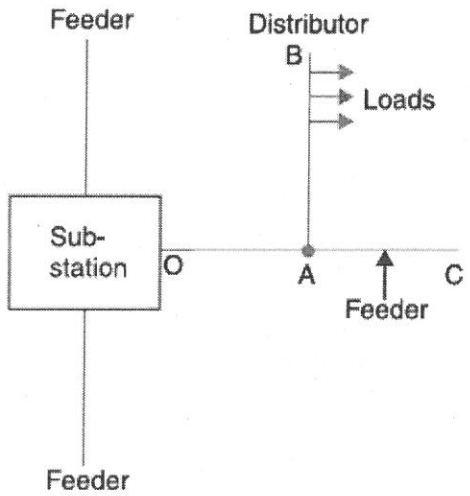
   Capacitance of the cable is $= \frac{2\pi\varepsilon_0\varepsilon_r}{\ln(\frac{D}{d})} = \frac{2\pi\ X\ 8.854\ X\ 10^{-12} X3}{\ln(\frac{20X2}{12X2})} = 3.27\times10^{-10}$ F/m

   For 2.5 km:

$$C = 3.27 \times 10^{-10} \times 2500$$
$$= 8.17 \times 10^{-7} \text{ F}$$

   Charging Current $I_C = 2\pi fCV = 2\pi\ X\ 50\ X\ 8.17 \times 10^{-7} X\ \frac{33000}{\sqrt{3}} = 4.9$ A

9. **a) Explain the radial distribution system with a neat diagram and list out its merits and demerits.**
   - In this system, separate feeders radiate from a single substation and feed the distributors at one end only.



- Fig. shows a single line diagram of a radial system distribution where a feeder OC supplies a distributor AB at point A. Obviously, the distributor is fed at one end only i.e., point A is this case.

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

- The part near the supply gets more load.
- If a fault occurs, consumers on that side lose supply.
- Voltage at the far end changes a lot when load varies.

9. b) Explain the classification of distribution systems in detail.

A distribution system may be classified according to:

(i) Nature of current:

According to nature of current, distribution system may be classified as

(a) d.c. distribution system (b) a.c. distribution system.

(ii) Type of construction:

According to type of construction, distribution system may be classified as

(a) overhead system (b) 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.

10. a) Define the following:

I. Maximum demand

II. Demand factor

III. Load factor

Maximum demand :

Maximum load is the highest power demand on a power system during a given period of time.

Demand factor.

It is the ratio of maximum demand on the power station to its connected load

$$\text{Demand factor} = \frac{\text{Maximum demand}}{\text{Connected load}}$$

Load Factor

Load factor is the ratio of average load to the maximum demand during a given period.

$$Load\ factor = \frac{Average\ load}{Maximum.\ demand}$$

10. b) A generating station supplies four feeders with the maximum demands (in MW) of 16 MW, 10 MW, 12 MW, and 7 MW. The overall maximum demand on the station is 20 MW and the annual load factor is 45%. Find the diversity factor and the number of units generated annually.

$$Diversity\ factor = \frac{Sum\ of\ individual\ max\ demands}{\text{Maximum demand of the whole system}}$$

$$= \frac{16 + 10 + 12 + 7}{20}$$

$$= 2.25$$

$$Load\ factor = \frac{Average\ load}{Maximum\ demand}$$

$$Annual\ Load\ factor = \frac{\text{energy generated annually}}{Maximum\ demand\ X\ 8760}$$

$$0.45 = \frac{\text{number of units generated annually}}{20\ X\ 8760}$$

Energy generated annually = 78840 MWh = 78840 X 10^3 KWh

11. a) What are the desirable characteristics of a tariff method.

1. Proper Return

The tariff should cover all costs and give a reasonable profit so that the company can provide reliable supply.

2. Fairness

The tariff should be fair to all consumers. Large users and those with steady loads are usually charged less.

3. Simplicity

The tariff should be easy to understand so consumers can know how their bill is calculated.

4. Reasonable Profit

The company should earn only a reasonable profit, not excessive.

5. Attractive

The tariff should be affordable to encourage more use of electricity.

11. b) A factory has a maximum load of 240 kW at 0.8 p.f. lagging with an annual consumption of 50,000 units. The tariff is Rs 50 per kVA of maximum demand plus 10 paise per unit. Calculate the flat rate of energy consumption. What will be annual saving if p.f. is raised to unity?

Maximum demand in kVA $= \frac{\text{kW}}{\text{p.f.}} = \frac{240}{0.8} = 300$ kVA

Total annual cost $= 300\ X\ 50 + 50000\ X\ 0.1 = 15{,}000 + 5{,}000 =$ Rs 20,000

Flat rate of energy consumption $= \frac{\text{Total cost}}{\text{Total units}} = \frac{20{,}000}{50{,}000} =$ Rs 0.40 per unit

If power factor is improved to unity

New kVA = 240 kVA

New total cost $= 240\ X\ 50 + 50000\ X\ 0.1 = 12{,}000 + 5{,}000 =$ Rs 17,000

Annual saving $= 20{,}000 - 17{,}000 =$ Rs 3,000