11	An electric supply company having a maximum load of 50 MW generates 18×10^7 units per annum and the supply consumers have an aggregate demand of 75 MW. The annual expenses including capital charges are: i. For fuel = Rs 90 lakhs ii. Fixed charges concerning generation = Rs 28 lakhs iii. Fixed charges concerning transmission and distribution = Rs 32 lakhs. Assuming 90% of the fuel cost is essential to running charges and the loss in transmission and distribution as 15% of kWh generated, deduce a two part tariff to find the actual cost of supply to the consumers.	L4	CO4	10 M

Code: 23EE3401

II B.Tech - II Semester – Regular Examinations - MAY 2025

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)	Judge why the overall efficiency of a steam power station is very low.	L4	CO1
1.b)	Examine why hydroelectric stations have high transmission and distribution costs?	L4	CO2
1.c)	Define Nuclear Fission.	L2	CO2
1.d)	Mention the function of Moderator in Nuclear power plant.	L3	CO3
1.e)	Infer the features of single bus bar and sectionalized single bus bar.	L3	CO3
1.f)	List out the advantages of gas insulated substations	L2	CO3
1.g)	Classify Cables.	L1	CO3
1.h)	Sketch the single line diagram of typical low tension distribution system.	L3	CO4
1.i)	Define economics of power generation.	L2	CO4

1.j)	A consumer has a maximum demand of 200kW at 40% load factor. If the tariff of Rs.100 per kW of maximum demand plus 10 paise per kWh, find the overall cost per kWh.	L4	CO5

PART – B

			BL	CO	Max. Marks
		UNIT-I			
2		Draw the schematic diagram of a modern Steam power station and explain its operation.	L3	CO2	10 M
		OR			
3	a)	Explain the functions of the following: i. Dam ii. Spilways iii. Surge tank iv. Headworks v. Draft tube	L3	CO2	5 M
	b)	Discuss the merits and demerits of a hydro electric plant.	L2	CO1	5 M
		UNIT-II			
4		Illustrate about Pressurized Water Reactor, Boiling water Reactor and Fluidized Bed Reactor.	L2	CO2	10 M
		OR			
5		Compare and analyze the operations of Hydroelectric, Thermal and Nuclear Power stations.	L4	CO2	10 M

			BL	CO	Max. Marks
		UNIT-III			
6		Examine the substations layout of 33/11 kV showing the location of all the substation equipment.	L4	CO3	10 M
		OR			
7	a)	Illustrate the key aspects of Gas Insulated Substations (GIS).	L2	CO3	5 M
	b)	Analyse air insulated substations and gas insulated substations by comparing their features and installations.	L4	CO3	5 M
		UNIT-IV			
8		Elaborate the capacitance and Intersheath grading with the derivation and Analyse disadvantages of both grading.	L3	CO4	10 M
		OR			
9	a)	Infer the connection schemes of Distribution system with relevant layouts.	L4	CO4	5 M
	b)	Illustrate the requirements of Distribution system.	L2	CO4	5 M
		UNIT-V			
10		Explain the following terms w.r.t economic of a plant i. Load factor ii. Diversity factor iii. Plant capacity factor iv. Plant use factor	L4	CO4	10 M
		OR			

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POWER SYSTEMS-I (23EE3401)

Scheme of Evaluation

1	A	The overall efficiency of a steam power station	2M
	B	Hydroelectric stations have high transmission and distribution costs	2M
	C	Nuclear fission	2M
	D	Function of Moderator in a nuclear power plant	2M
	E	Single bus bar system and Sectionalized bus bar	2M
	F	Advantages of gas insulated substations	2M
	G	Classify cables	2M
	H	Low tension distribution system	2M
	I	Economics of power generation 2M | j. problem solving —	2M
2		Schematic Diagram of a Modern Steam Power Plant Operation	5M 5M
3	A	Explain the Function of the Following. A) Dam B) Spillway C) Surge Tank D) Head works E) Draft Tube	5M
	B	Merits and Demerits of Hydro Power Plant	5M
4		Illustrate about PWR, BWR and FBR	4+3+3M
5		Hydro Electric, Thermal and Nuclear Power Stations	10M
6		Substation Layout of 33/11 KV Key Components and Their Locations	5M 5M
7	A	Key Aspects of GIS	5M
	B	Comparison of AIS and GIS	5M
8	A	Capacitance and Intersheath grading	10M
9	A	Connection Schemes of Distribution System	5M
	B	Requirements of Distribution Systems	5M
10		Explain the Following terms with Respect to Plant Economics A) Load Factor B) Diversity Factor C) Plant Capacity Factor D) Plant Use Factor	3M 3M 2M 2M
11		Annual Running Charges, Energy Supplied to Consumers, Fixed Charge per kW of Maximum Demand	10M

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CS – 1+10+10+18

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II B. Tech - II Semester - Regular Examinations

POWER SYSTEMS-I (23EE3401)

ANSWERS

PART - A

1.a) The overall efficiency of a steam power station is low (about 30–35%) because a large portion of heat energy is lost in the condenser and during conversion processes.

1.b) Hydroelectric stations have high transmission and distribution costs due to their remote locations, requiring long transmission lines and infrastructure.

1.c) Nuclear fission is the process of splitting a heavy atomic nucleus (like Uranium-235) into two lighter nuclei, releasing a large amount of energy.

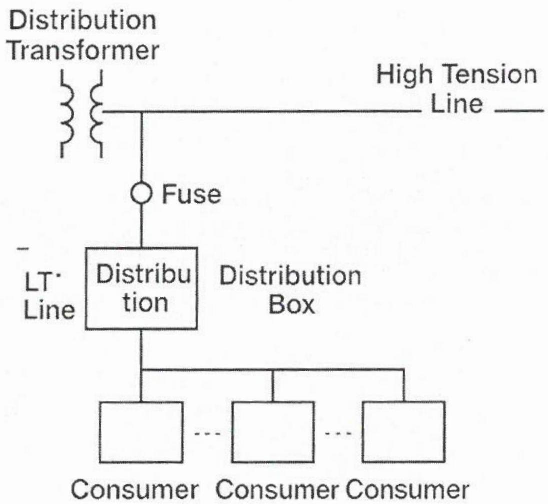
1.d) The moderator in a nuclear power plant slows down neutrons to increase the probability of fission in fuel nuclei like Uranium-235.

1.e) A single bus bar system is simple and economical but lacks flexibility, while a sectionalized bus bar improves reliability by isolating faults.

1.f) Advantages of gas insulated substations include compact size, reduced maintenance, enhanced safety, and higher reliability.

1.g) Cables are classified into low, medium, and high voltage cables based on voltage levels; types include PVC, XLPE, and oil-filled cables.

1.h)



1.i) Economics of power generation refers to cost analysis involving capital, operation, maintenance, and fuel costs to ensure economical electricity production.

1.j). Energy consumed: 200KW × 0.4 × 24 × 30 = 57,600 kWh

Fixed charges: 100 per KW × 200 KW = Rs: 20,000/-

Energy charge: Rs. 0.10 per kWh × 57000 = Rs: 5760

Total cost: 20,000 + 5760 = Rs: 25760/-

overall cost = 25760 = Rs. 0.4472 per kWh.

PART-B

UNIT-1

2) Schematic Diagram of a Modern Steam Power Plant and Operation

The power plant that uses coal to generate heat is known as the thermal power plant. The thermal power plant is a conventional power plant. In a thermal power plant, a very large amount of fuel (coal) is required. Therefore, the coal is transported via trains to the fuel storage space. The size of coal is very large that is not suitable for the boiler. So, the coal is crushed in small pieces via crusher and fed to the boiler. To produce steam in the boiler, a high amount of water is also required in the thermal power plant. The water is treated with filters and free from impurities and air. After that, the water is fed to the boiler drum. In the boiler drum, the combustion heat from the fuel is transferred to the water. And the water converts into steam.

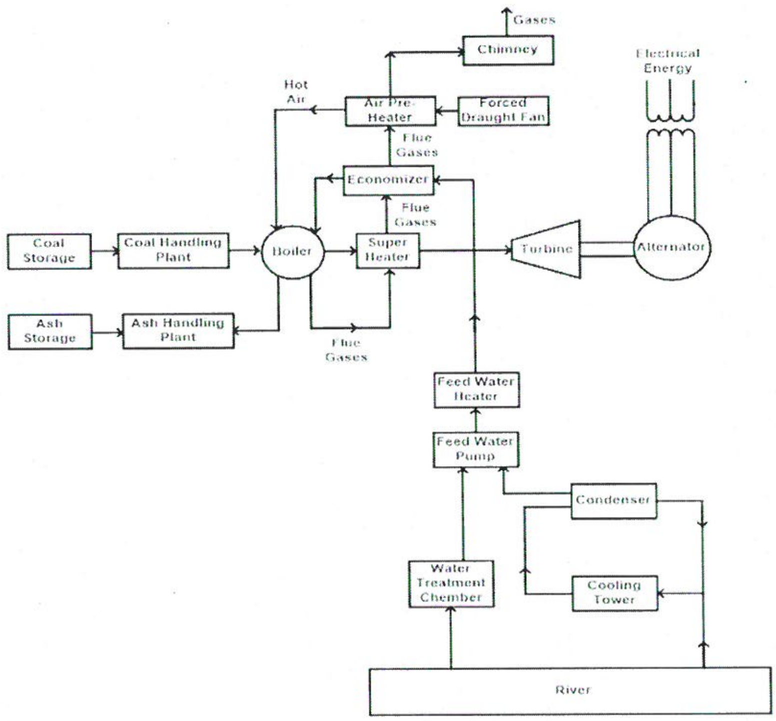


Figure: Thermal power plant Layout

This steam is high-pressure and high-temperature steam. Further, this steam is supplied to the superheater. And this super-heated steam is supplied to the turbine blades. So, the heat energy is converted into rotational energy of mechanical energy by the turbine. The turbine is mechanically connected to the same shaft as the alternator. So, the turbine rotates the rotor of the alternator. An alternator is used to convert mechanical energy into electrical energy. Further, the electrical energy is converted into high voltage using a transformer and transfer the electrical energy to the load via a transmission line in a typical power system. The steam released from the turbine is supplied to the condenser. In the condenser, the exhaust steam is condensed by means of cold-water circulation. And the steam releases pressure and temperature. This will increase the efficiency of the cycle. The condensed water again fed to the boiler with the help of the feedwater pump and used in the cycle. The ash is produced after the combustion of coal. So, it was taken out from the boiler furnace. And it is necessary to dispose of properly without damage the environment. While combustion of coal in a boiler, the flue gases exhaust the atmosphere from the chimney.

3) A. Explain the Function of the Following.

a) DAM b) SPILLWAY c) SURGE TANK d) HEADWORKS e) DRAFT TUBE

a) Dam: When we hear the word Dam that means sufficient water storage at some height. When the water from some height is released the velocity increases and is further used for the generation of electricity with the use of a turbine. The dam forms a large reservoir behind it. The height of the water level (called a water head) in the reservoir determines how much potential energy is stored in it.

b) Spillway: A spillway is a structure used to provide the controlled release of water downstream from a dam or levee, typically into the riverbed of the dammed river itself. In the United Kingdom, they may be known as overflow channels. Spillways ensure that water does not damage parts of the structure not designed to convey water.

c)Surgue Tank: The Surge tanks are usually provided in high or medium-head power plants when considerably long Penstock is required. A surge tank is a small reservoir or tank which is open at the top. It is fitted between the reservoir and the powerhouse. The water level in the surge tank rises or falls to reduce the pressure swings in the Penstock.

d)Head Works: Headworks is a civil engineering term for any structure at the head or diversion point of a waterway. It is smaller than a barrage and is used to divert water from a river into a canal or from a large canal into a smaller canal.

e) Draft Tube: A draft tube is a crucial component in hydraulic turbines used in dams, designed to convert kinetic energy from exiting water into useful pressure energy, enhancing turbine efficiency.

3. B) Merits and Demerits of Hydro Power Plant.

MERITS:

- This power plant is a renewable energy source. The water energy can be used again and again.
- They have high efficiency.
- The running cost of the Hydraulic turbine is less as compared to other turbines.
- The environmental pollution is negligible.
- The main advantage of the Hydraulic turbine is that at the turbine place, people can visit and observe & study all the main parts in detail.

DEMERITS:

- Initial cost of installation is very high.
- It takes several decades to make profit.
- It can be constructed only at a few sites or places where there is a good amount of water available.

UNIT - 2

4) Illustrate about PWR, BWR and FBR.

Pressurized Water Reactor (PWR): In a PWR the primary coolant (water) is pumped under high pressure to the reactor core where it is heated by the energy generated by the fission of atoms. The heated water then flows to a steam generator where it transfers its thermal energy to a secondary system where steam is generated and flows to turbines to rotate an electric generator. Nuclear fuel in the reactor vessel is engaged in a fission chain reaction, which produces heat, heating the water in the primary coolant loop by thermal conduction through the fuel casing. The hot primary coolant is pumped into a heat exchanger called the steam generator, where it flows through hundreds or thousands of tubes. Heat is transferred through the walls of these tubes to the lower pressure secondary coolant located on the sheet side of the exchanger where it evaporates to pressurized steam.

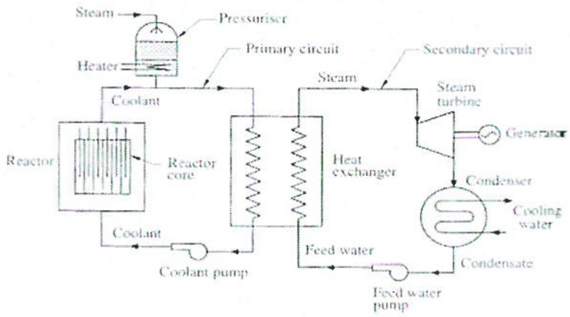


Fig. Pressurized Water Reactor.

The transfer of heat is accomplished without mixing the two fluids, which is desirable since the primary coolant might become radioactive. Some common steam generator arrangements are u-tubes or single pass heat exchangers. In a nuclear power station, the pressurized steam is fed through a steam turbine which drives an electrical generator connected to the electric grid for distribution. After passing through the turbine the secondary coolant (water-steam mixture) is cooled down and condensed in a condenser. The condenser converts the steam to a liquid so that it can be pumped back into the steam generator, and maintains a vacuum at the turbine outlet so that the pressure drop across the turbine, and hence the energy extracted from the steam, is maximized. Before being fed into the steam generator, the condensed steam (referred to as feed water) is sometimes preheated in order to minimize thermal shock.

Boiling Water Reactor (BWR): The BWR uses dematerialized water as a coolant and neutron moderator. Heat is produced by nuclear fission in the reactor core, and this causes the cooling water to boil, producing steam. The steam is directly used to drive a turbine, after which it is cooled in a condenser and converted back to liquid water. This water is then returned to the reactor core, completing the loop.

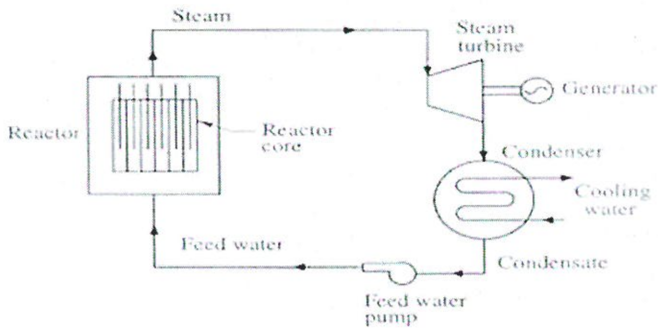


Fig. Boiling Water Reactor

Fluitized Bed Reactor: The Process of Converting More Fertile Material in to Fissile Material in a Reactor is Called Breeding. In fast breeder reactor the core containing U235 is surrounded by a blanket of fertile material U238. In this reactor no moderator is used the fast moving neutrons liberated due to fission of U235 are absorbed by U238 which gets converted in to Pu239 a fissile material. This reactor also uses two liquid metal coolants in which sodium is used as primary coolant and sodium potassium as secondary coolant.

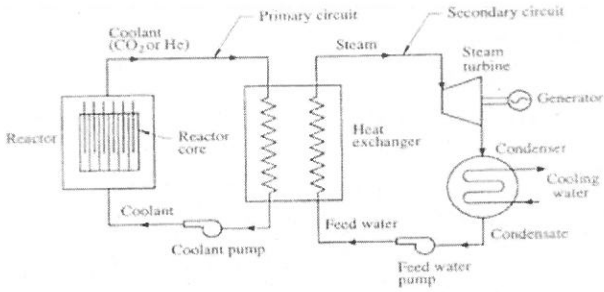


Fig. Fast Breeder Reactor

Fast Breeder Reactor Liquid sodium is circulated through the reactor to carry the heat produced. The heat produced by the sodium is transferred to secondary coolant sodium potassium. In the primary heat exchanger which in turn transfer the heat in secondary heat exchanger called steam generator.

5). Hydro Electric, Thermal and Nuclear Power Stations

Hydroelectric Power Plants: Utilize the kinetic energy of flowing or falling water to turn turbines connected to generators. High efficiency, often exceeding 90%, due to direct mechanical energy conversion.

• Advantages: Renewable, low operational costs, long lifespan, and rapid response to load changes.

Thermal Power Plants: Burn fossil fuels (coal, oil, or natural gas) to produce steam that drives turbines connected to generators. Fossil fuel combustion heats water in a boiler to produce steam, which drives a turbine to generate electricity. Generally low, around 30%, due to significant heat losses.

• Advantages: Established technology, capable of providing base-load power.

Nuclear Power Plants: Use nuclear fission reactions to generate heat, which produces steam to drive turbines connected to generators. Uranium nuclei undergo fission, releasing energy that heats water to produce steam for turbine operation. High thermal efficiency, similar to thermal plants, but with lower emissions.

• Advantages: Low greenhouse gas emissions, high energy density, and reliable base-load power.

Comparison of Power Plants

Feature	Hydroelectric	Thermal	Nuclear
Fuel Source	Water (renewable)	Fossil fuels	Uranium (non-renewable)
Greenhouse Gas Emissions	Very low	High	Very low
Efficiency	High (90%+)	Low (30%)	High
Operational Flexibility	High	Moderate	Low
Environmental Impact	Moderate (ecosystem disruption)	High (pollution, habitat destruction)	High (waste disposal, accident risk)
Capital Cost	High (dam construction)	Moderate	Very high
Fuel Availability	Abundant (rain-dependent)	Limited (fossil fuel reserves)	Limited (uranium mining)

UNIT - 3

6) Substation Layout of 33/11 KV

A 33/11 kV substation serves as a critical node in electrical distribution systems, stepping down high-voltage electricity from 33 kV to 11 kV for local distribution. Its layout is meticulously designed to ensure safety, reliability, and efficiency. Below is an overview of the typical equipment and their placement within the substation:

Key Components and Their Locations

1. Incoming 33 kV Lines: At the substation's boundary, typically on the periphery.
   Purpose: To receive high-voltage power from the transmission network.
2. 33 kV Busbar: Central position within the switchyard.
   Purpose: Distributes incoming power to various outgoing feeders.
3. Circuit Breakers (33 kV): Adjacent to the busbar.
   Purpose: Protects the substation by interrupting fault currents.
4. Isolators: Near circuit breakers.
   Purpose: Provides a visible break for maintenance purposes.
5. Power Transformers (33/11 kV): Close to the 33 kV busbar.
   Purpose: Steps down voltage from 33 kV to 11 kV.
6. 11 kV Busbar: In proximity to the power transformers.
   Purpose: Distributes 11 kV power to outgoing feeders.
7. Circuit Breakers (11 kV): Near the 11 kV busbar.
   Purpose: Protects the distribution network by interrupting fault currents.
8. Isolators (11 kV): Adjacent to 11 kV circuit breakers.
   Purpose: Facilitates safe maintenance by isolating sections of the network.
9. Feeder Panels: Connected to the 11 kV busbar.
   Purpose: Distributes power to various local areas.

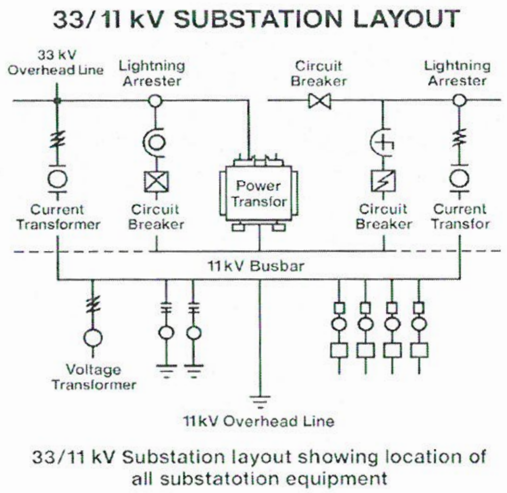


Figure: Substations layouts of 33/11 kV showing the location of all the substation equipment

10. Current Transformers (CTs): Installed on incoming and outgoing lines.
    Purpose: Measures current for protection and metering.
11. Potential Transformers (PTs): Connected to the busbars.
    Purpose: Provides voltage signals for metering and protection.
12. Lightning Arrestors: At the entry points of incoming lines.
    Purpose: Protects equipment from lightning strikes.
13. Earthing System: Throughout the substation.
    Purpose: Ensures safety by providing a path for fault currents to the ground.

7) A. Illustrate Key Aspects of GIS.

Gas Insulated Substations are used where there is space for providing the substation is expensive in large cities and towns. In normal substation the clearances between the phase to phase and phase to ground is very large. Due to this, large space is required for the normal or Air Insulated Substation (AIS). But the dielectric strength of SF6 gas is higher compared to the air, the clearances required for phase to phase and phase to ground for all equipment's are quite lower. Hence, the overall size of each equipment and the complete substation is reduced to about 10% of the conventional air insulated substation. Large cities and towns Underground Stations Highly polluted and saline environment Indoor GIS occupies very little space Substations and power stations located Off Shore Mountains and valley regions. The SF6 Gas Insulated Substation (GIS) contains the same compartments as in the conventional outdoor substations. All the live parts are enclosed in metal housings filled with SF6 gas. The live parts are supported on cast resin insulators. Some of the insulators are designed as barriers between neighboring modules such that the gas does not pass through them. The entire installation is sub divided into compartments which are gas tight with respect to each other. Thereby the gas monitoring system of each compartment can be independent and simpler. The enclosures are of non-magnetic materials such as aluminum or stainless steel and are earthed. The gas tightness is provided with static 'O' seals placed between the machined flanges. The 'O'- rings are placed in the grooves. 'O'-seals are important to ensure gas tight performance of Gas Insulated Substation. Gas Insulated Substation has gas monitoring system. Gas inside each compartment should have a pressure of about 3kg/cm2.The gas density in each compartment is monitored. If the pressure drops slightly, the gas is automatically trapped up. With further gas leakage, the low pressure alarm is sounded or automatic tripping or lock-out occurs.

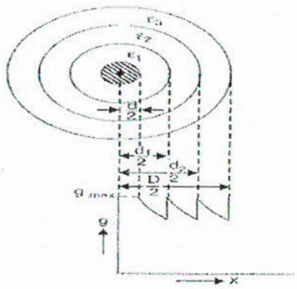
7. B) Comparison of AIS and GIS

Feature	AIS (Air-Insulated Switchgear)	GIS (Gas-Insulated Switchgear)
Insulation Medium	Ambient air	Sulfur hexafluoride (SF_6) gas
Size & Footprint	Larger; requires more space due to air clearance needs	Compact; requires less space due to gas insulation
Installation	Outdoor installations	Suitable for both indoor and outdoor installations
Maintenance	Requires regular inspection and maintenance	Requires less frequent maintenance; sealed units reduce exposure
Environmental Impact	Higher due to larger land use and exposure to elements	Lower; however, SF_6 is a potent greenhouse gas if leaked
Reliability	Susceptible to environmental factors like pollution	More reliable in harsh environmental conditions
Cost	Lower initial cost; higher land and maintenance costs	Higher initial cost; lower land and maintenance costs

UNIT - 4

8) Elaborate the Capacitance and Intersheath 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 > r of any layer is inversely proportional to its distance from the center. Under such conditions, the value of potential gradient any point in the dielectric is constant and is independent of its distance from the center. In other words, the dielectric stress in the cable is same everywhere and the grading is ideal one. However, ideal grading requires the use of an infinite number of dielectrics which is an impossible task. In practice, two or three dielectrics are used in the decreasing order of permittivity, the dielectric of highest permittivity being used near the core. The capacitance grading can be explained beautifully by referring to the above Figure. There are three dielectrics of outer diameter d1, d2 and D and of relative permittivity >1, >2 and >3 respectively. If the permittivity are such that >1 > 2 > 3 and the three dielectrics are worked at the same maximum stress, then

$$\varepsilon_1 d = \varepsilon_2 d_1 = \varepsilon_3 d_2$$

$$V_1 = \frac{g_{max}}{2} d \ln \frac{d_1}{d}$$

$$V_2 = \frac{g_{max}}{2} d_1 \ln \frac{d_2}{d_1}$$

$$V_3 = \frac{g_{max}}{2} d_2 \ln \frac{D}{d_2}$$

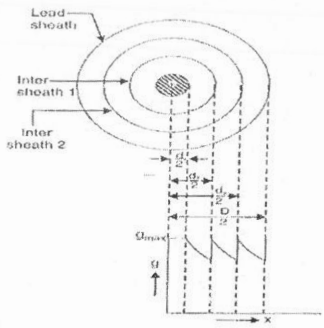
Total p.d. between core and earthed sheath is

$$V = V_1 + V_2 + V_3$$

$$V = \frac{g_{max}}{2}\left[d \ln \frac{d_1}{d} + d_1 \ln \frac{d_2}{d_1} + d_2 \ln \frac{D}{d_2} \right]$$

In this method of cable grading, a homogeneous dielectric is used, but it is divided into various layers by placing metallic inters heaths between the core and lead sheath. The inter sheaths 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.

Consider a cable of core diameter d and outer lead sheath of diameter D. Suppose that two intersheaths of diameters d1 and d2 are inserted into the homogeneous dielectric and maintained at some fixed potentials. Let V1, V2 and V3 respectively be the voltage between core and intersheath 1, between inter sheath 1 and 2 and between inter sheath 2 and outer lead sheath. As there is a definite potential difference between the inner and outer layers of each inter sheath, therefore, each sheath can be treated like a homogeneous single core cable Maximum stress between core and inter sheath 1 is



$$g_{1max} = \frac{V_1}{\frac{d}{2}\log_e \frac{d_1}{d}}$$

$$g_{2max} = \frac{V_2}{\frac{d_1}{2}\log_e \frac{d_2}{d_1}}$$

$$g_{3max} = \frac{V_3}{\frac{d_2}{2}\log_e \frac{D}{d_2}}$$

Since the dielectric is homogeneous, the maximum stress in each layer is the same i.e.,

$$g_{1\max} = g_{2\max} = g_{3\max} = g_{\max}$$

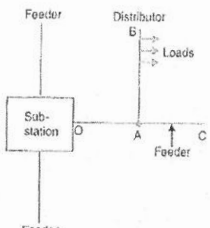
$$\frac{V_1}{\frac{d}{2}\ln\frac{d_1}{d}} = \frac{V_2}{\frac{d_1}{2}\ln\frac{d_2}{d_1}} = \frac{V_2}{\frac{d_2}{2}\ln\frac{D}{d}}$$

As the cable behaves like three capacitors in series, therefore, all the potentials are in phase i.e. Voltage between conductor and earthed lead sheath is Inter sheath grading has three principal disadvantages. Firstly, there are complications in fixing the sheath potentials. Secondly, the inter sheaths are likely to be damaged during transportation and installation which might result in local concentrations of potential gradient. Thirdly, there are considerable losses in the inter sheaths due to charging currents. For these reasons, inter sheath grading is rarely used.

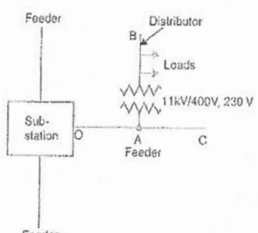
9) A. Infer the Connection Schemes of Distribution System with Relevant Layouts

Radial System:

In this system, separate feeders radiate from a single substation and feed the distributors at one end only. Fig. (i) shows a single line diagram of a radial system for D.C distribution where a feeder OC supplies a distributor A B at point A. Obviously, the distributor is fed at one end only i.e., point A is this case. Fig. (ii) shows a single line diagram of radial system for A.C 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. This is the simplest distribution circuit and has the lowest initial cost.



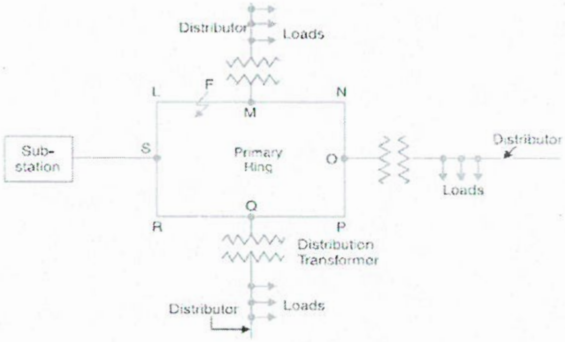
(i)



(ii)

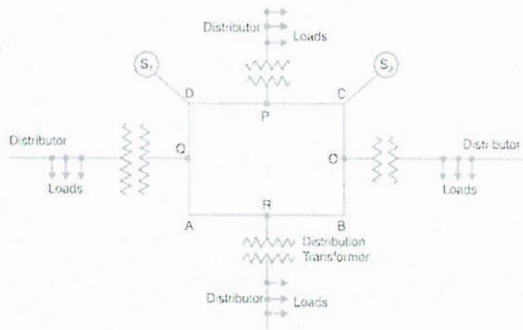
Ring Main System:

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. shows the single line diagram of ring main system for a.c. distribution where substation supplies to the closed feeder LMNOPQRS.



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. shows the single line diagram of interconnected system where the closed feeder ring ABCD is supplied by two substations S and S at points D and C respectively. Distributors are connected to points O, P, Q and R of the feeder ring through distribution transformers.



9. B) Illustrate the Requirements of Distribution Systems.

Requirements of a good distribution system are: proper voltage, availability of power on demand and reliability.

Proper voltage: One important requirement of a distribution system is that voltage variations at consumer's terminals should be as low as possible. The changes in voltage are generally caused due to the variation of load on the system. Low voltage causes loss of revenue, inefficient lighting and possible burning out of motors. High voltage causes lamps to burn out permanently and may cause failure of other appliances. Therefore, a good distribution system should ensure that the voltage variations at consumer's terminals are within permissible limits. The statutory limit of voltage variations is $\pm$ 6% of the rated value at the consumer's terminals. Thus, if the declared voltage is 230 V, then the highest voltage of the consumer should not exceed 244 V while the lowest voltage of the consumer should not be less than 216 V.

Availability of power on demand: Power must be available to the consumers in any amount that they may require from time to time. For example, motors may be started or shut down, lights may be turned on or off, without advance warning to the electric supply company. As electrical energy cannot be stored, therefore, the distribution system must be capable of supplying load demands of the consumers. This necessitates that operating staff must continuously study load patterns to predict in advance those major load changes that follow the known schedules.

Reliability: Modern industry is almost dependent on electric power for its operation. Homes and office buildings are lighted, heated, cooled and ventilated by electric power. This calls for reliable service. Unfortunately, electric power, like everything else that is man-made, can never be absolutely reliable.

UNIT - 5

10) Explain the Following terms with Respect to Plant Economics

A) Load Factor

B) Diversity Factor

C) Plant Capacity Factor

D) Plant Use Factor

a) Load Factor: The Load Factor is the ratio of the average load supplied over a period to the maximum demand during that period.

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

$$\text{Average Load} = \frac{\text{Area (in kWh) under daily load curve}}{\text{Total area of rectangle in which the load curve is contained}}$$

A higher Load Factor indicates efficient utilization of the plant's capacity, leading to reduce per-unit generation costs. It reflects how consistently a plant operates near its maximum capacity.

b) Diversity Factor: Definition: The Diversity Factor is the ratio of the sum of the individual maximum demands of various subdivisions of a system to the maximum demand of the entire system.

$$Diversity\ factor = \frac{Sum\ of\ individual\ maximum\ demands}{Maximum\ demand\ on\ power\ station}$$

$$= \frac{1}{Coincidence\ factor}$$

Diversity Factor greater than 1 indicates that not all consumers' maximum demands occur simultaneously, allowing for a smaller overall system capacity. Higher Diversity Factors can lead to cost savings in generation and distribution.

c) Plant Capacity Factor: The Plant Capacity Factor is the ratio of the actual energy produced by a plant over a period to the maximum possible energy that could have been produced if the plant had operated at full capacity during that period.

$$Plant\ capacity\ factor = \frac{Actual\ energy\ produced}{Maximum\ energy\ that\ could\ have\ been\ produced}$$

$$= \frac{Average\ demand}{Plant\ capacity}$$

It indicates how effectively a plant utilizes its installed capacity. A lower Capacity Factor may suggest underutilization or frequent downtimes.

d) Plant Use Factor: Plant Use Factor is the ratio of the actual energy produced by a plant to the product of its capacity and the number of hours it was in operation during a period.

$$\text{Plant use factor} = \frac{\text{Station output in kWh}}{\text{Plant capacity} \times \text{Hours of use}}$$

It measures the extent to which the plant's capacity is utilized during its operational hours.

11.Problem

Given Data:

Maximum Load: 50 MW

Energy Generated Annually: 18×10^7 units (18 million units)

Consumer Demand: 75 MW

Annual Expenses:

Fuel Cost: ₹90 lakhs

Fixed Charges for Generation: ₹28 lakhs

Fixed Charges for Transmission & Distribution: ₹32 lakhs

Fuel Cost Allocation: 90% of fuel cost is for running charges

Transmission & Distribution Losses: 15% of energy generated

Total Annual Fixed Charges:

Total Fixed Charges = Fixed Charges for Generation + Fixed Charges for Transmission & Distribution + 10% of Fuel Cost

= ₹28 lakhs + ₹32 lakhs + (10% of ₹90 lakhs)

= ₹28 lakhs + ₹32 lakhs + ₹9 lakhs

= ₹69 lakhs

Annual Running Charges: Running charges are costs that vary with the amount of electricity generated and consumed.

Running Charges = 90% of Fuel Cost

= 90% of ₹90 lakhs

= ₹81 lakhs

Energy Supplied to Consumers: Considering the 15% transmission and distribution losses:

Energy Supplied to Consumers = (1 - 15%) × Energy Generated

= $0.85 \times 18 \times 10^7$ units

= 15.3×10^7 units

Cost per kWh Supplied

Cost per kWh = Running Charges / Energy Supplied to Consumers

= ₹81 lakhs / 15.3×10^7 units

= ₹0.053 (or 5.3 paise) per kWh

Fixed Charge per kW of Maximum Demand

Fixed Charge per kW = Total Fixed Charges / Consumer Demand

= ₹69 lakhs / 75,000 kW

= ₹92 per kW of maximum demand

Two-Part Tariff:

Fixed Charge: ₹92 per kW of maximum demand

Variable Charge: ₹0.053 per kWh (5.3 paise per unit)